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Report

WHITE BAY CRUISE TERMINAL: AIR QUALITY AND METEOROLOGICAL MONITORING REPORT – APRIL 2017

Port Authority of NSW

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GLOSSARY

Term	Description
AS	Australian Standard
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
BAM	Beta attenuation monitor
DEFRA	Department for Environment, Food and Rural Affairs, United Kingdom
EnviroSuite	Pacific Environment's proprietary data management software
EPA	(New South Wales) Environment Protection Authority
$\mu g/m^3$	Micrograms per cubic metre
GLB	Glebe Island berths
GMR	(New South Wales) Greater Metropolitan Region
m/s	Metres per second
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NSW EPA	New South Wales Environmental Protection Agency
NSW DEC	New South Wales Department of Environment and Conservation
OEH	(New South Wales) Office of Environment and Heritage
ppb	Parts per billion
$PM_{2.5}$	Airborne particulate matter with an aerodynamic diameter of less than 2.5 microns (µm)
QA	Quality assurance
QC	Quality control
SO_2	Sulfur dioxide
TEOM	Tapered element oscillating microbalance
US EPA	United States Environmental Protection Agency
WBCT	White Bay Cruise Terminal
W/m^2	Watts per square metre

1 INTRODUCTION

The Port Authority of NSW has committed to undertaking air quality monitoring in the residential area adjacent to the White Bay Cruise Terminal (WBCT). Pacific Environment has been commissioned to provide monthly monitoring reports from September 2015 onwards. This report provides the monitoring results for the month of April 2017.

The Port Authority of NSW has worked with NSW Environment Protection Authority (EPA) to determine the parameters to be monitored, an appropriate location for the monitoring station, and the duration of the monitoring programme. The pollutants being monitored are sulfur dioxide (SO_2) and particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$). Meteorological parameters are also being measured.

The monitoring data are used to assess compliance with local air quality standards. In February 2016 the National Environment Protection Council (NEPC) released a variation to the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) which includes formal standards for $PM_{2.5}$ (**NEPC, 2016**). The AAQ NEPM standard for the 24-hour average $PM_{2.5}$ concentration is 25 µg/m^3. In January 2017 the NSW Environmental Protection Agency (EPA) revised their assessment criteria to align with this national standard. Thus the NSW EPA standard for the 24-hour average $PM_{2.5}$ concentration is 25 µg/m^3 (**NSW DEC, 2017**). The NSW air quality criteria for SO_2 and $PM_{2.5}$ are provided in **Table 1-1** (**NSW EPA, 2017**).

Table 1-1: Assessment Criteria (NSW EPA, 2017)

Pollutant	Averaging Period	Concentration (µg/m^3)
Sulfur Dioxide (SO_2)	10 minute	712
	1 hour	570
	24 hour	228
$PM_{2.5}$	24 hour	25

Any exceedance of the NSW air quality criteria or the AAQ NEPM standard have been reported and discussed within this report. The $PM_{2.5}$ and SO_2 concentrations at WBCT are also compared with those at monitoring sites around Sydney operated by the NSW Office of Environment and Heritage (OEH). These sites are located at Bargo, Bringelly, Campbelltown West, Chullora, Camden, Earlwood, Lindfield, Liverpool, Randwick, Richmond and Rozelle.

2 METHODOLOGY

The monitoring station was installed following consultation with the EPA and Leichhardt Municipal Council to measure $PM_{2.5}$ and SO_2, as well as local wind speed and direction. The monitoring station is located immediately north of WBCT on the corner of Adolphus Street and Grafton Street, Balmain (33.860142° S, 151.187413°E), approximately 14 m above sea level (**Figure 2-1**).

Figure 2-1: Location of White Bay Cruise Terminal monitoring station and berths

As far as practicable, the monitoring station complies with the requirements of *Australian Standard AS/NZS 3580.1.1:2007 - Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment*. The site represents the best available location, but does not fully comply as there are trees within 20 m of the site. However, the trees present on the street are not expected to significantly affect the results from the monitoring station.

The parameters being monitored are SO_2, $PM_{2.5}$, wind speed, and wind direction. The monitoring station samples SO_2 every ten seconds and records data at 5-minute averaging periods. $PM_{2.5}$ concentrations are measured as one-hour averages.

Instrument calibration is performed in accordance with relevant Australian Standards and National Association of Testing Authorities (NATA) procedures. Details of the quality assurance procedures, including calibration and equipment maintenance, are given in **Appendix B**.

3 MONITORING DATA

The monitoring results are presented below and are compared with the EPA ambient air quality criteria for SO_2 and $PM_{2.5}$. The relevant averaging periods are 10 minutes, 1 hour and 24 hours for SO_2, and 24 hours for $PM_{2.5}$.

The 24-hour average SO_2 and $PM_{2.5}$ concentrations are also compared with the data from several OEH monitoring sites. Polar bivariate plots show 10-minute average SO_2 and 1-hour average $PM_{2.5}$ concentrations as a function of wind speed and wind direction.

3.1 Cruise ship days

Cruise ship days are shown in **Table 3-1**. There were 8 cruise ship days and no cruise ship nights in April.

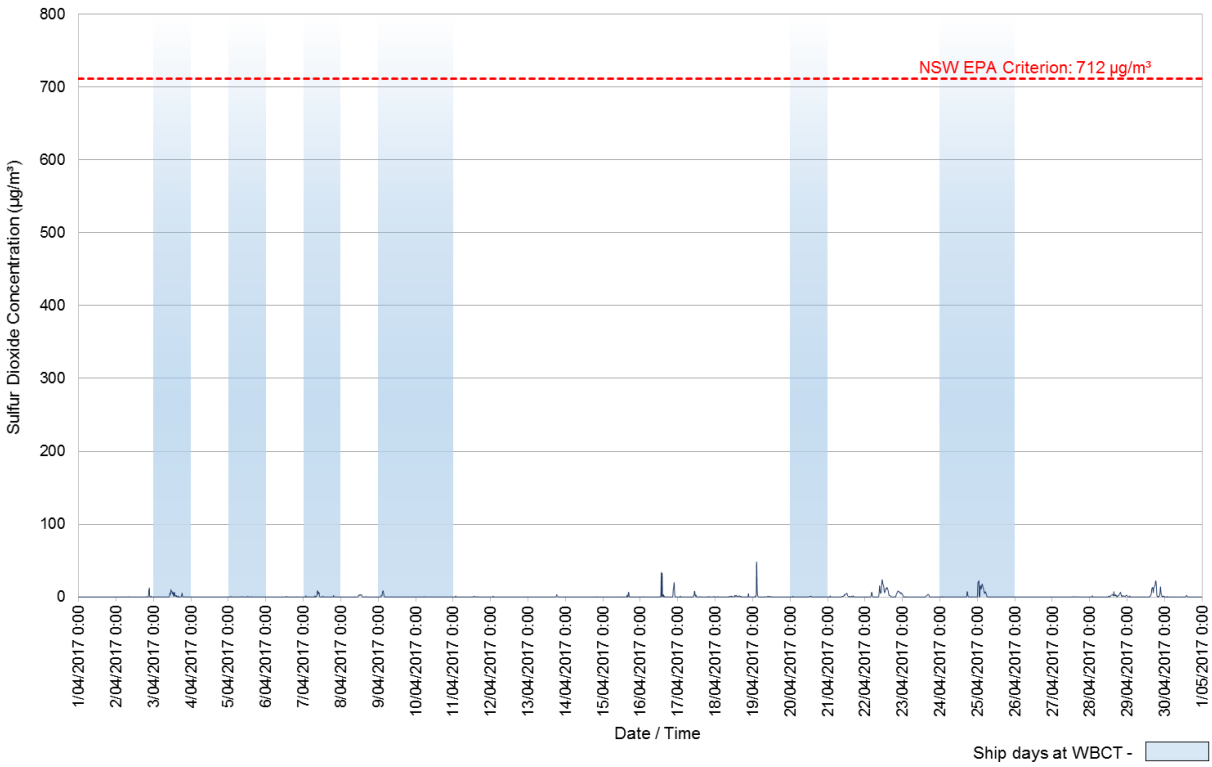
Table 3-1: Cruise ship days

Arrival	Departure	Vessel Name	Berth
3/04/2017 6:51	3/04/2017 15:58	Pacific Jewel	WHT5
5/04/2017 6:48	5/04/2017 16:00	Sun Princess	WHT5
7/04/2017 7:49	7/04/2017 16:56	Pacific Jewel	WHT5
9/04/2017 6:41	9/04/2017 17:01	Sirena	WHT5
10/04/2017 6:52	10/04/2017 16:07	Pacific Jewel	WHT5
20/04/2017 7:42	20/04/2017 16:05	Pacific Jewel	WHT5
24/04/2017 7:39	24/04/2017 15:57	Pacific Jewel	WHT5
25/04/2017 6:53	25/04/2017 15:59	Sun Princess	WHT5

3.2 10-minute average sulfur dioxide concentrations

A time-series plot of 10-minute average SO_2 concentrations for April 2017 is shown in **Figure 3-1**. No exceedances of the 10-minute average air quality criterion for SO_2 were recorded during the reporting period.

The highest 10-minute average SO_2 concentration (47 µg/m^3) was recorded on 19 April, which occurred when a cruise ship was not berthed at WBCT. This maximum represents approximately 7% of the NSW EPA criterion as seen in **Figure 3-1**. Several other minor peaks in SO_2 concentration occurred on other days, some with cruise ships berthed at WBCT and some during times at which no cruise ships were present.



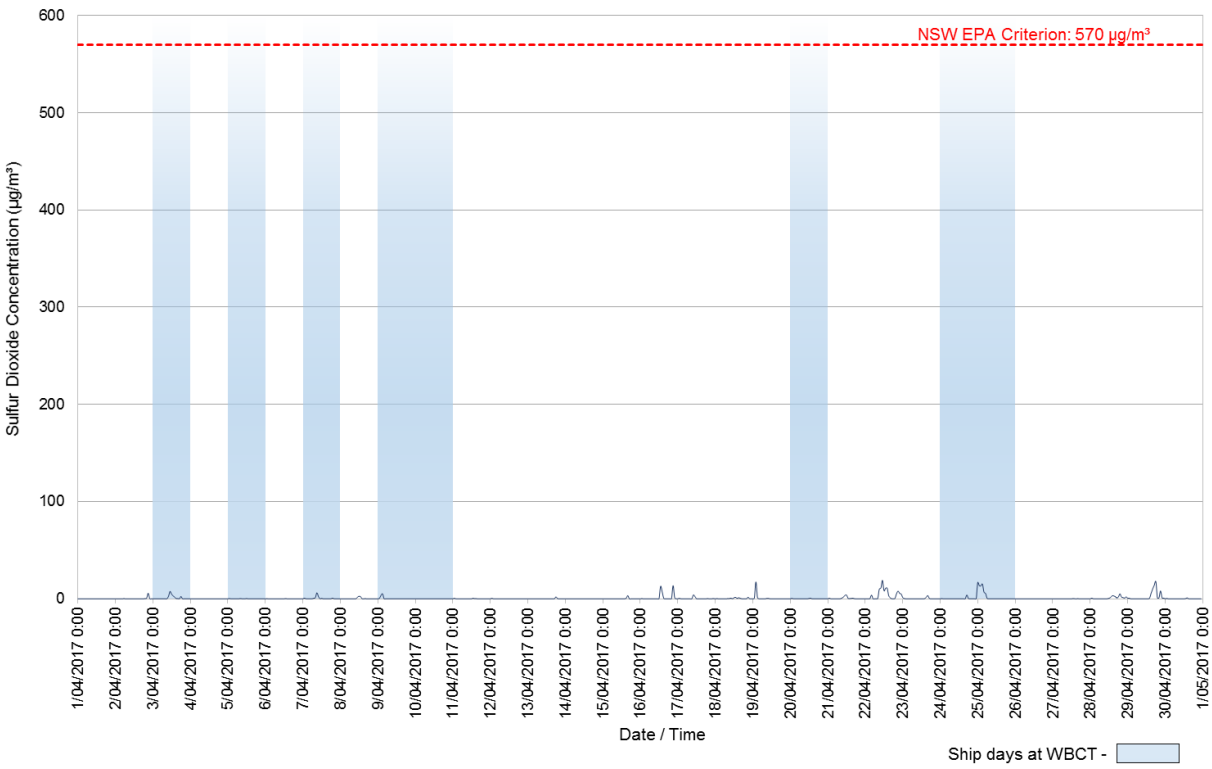
Note: Blue shading indicates ship days, not arrival and departure times. Arrival and departure times are provided in **Table 3-1.**

Figure 3-1: 10-minute average SO_2 concentrations

3.3 1-hour average sulfur dioxide concentrations

A time series plot of the 1-hour average SO_2 concentration for April 2017 is shown in **Figure 3-2**. No exceedances of the 1-hour air quality criterion for SO_2 were recorded during the reporting period.

The highest 1-hour average SO_2 concentration (19 µg/m^3) was recorded on 22 April, which occurred when a cruise ship was not berthed at WBCT. This maximum represents approximately 3% of the NSW EPA criterion as seen in **Figure 3-2**. Several other minor peaks in SO_2 concentration occurred on other days, some with cruise ships berthed at WBCT and some during times at which no cruise ships were present.



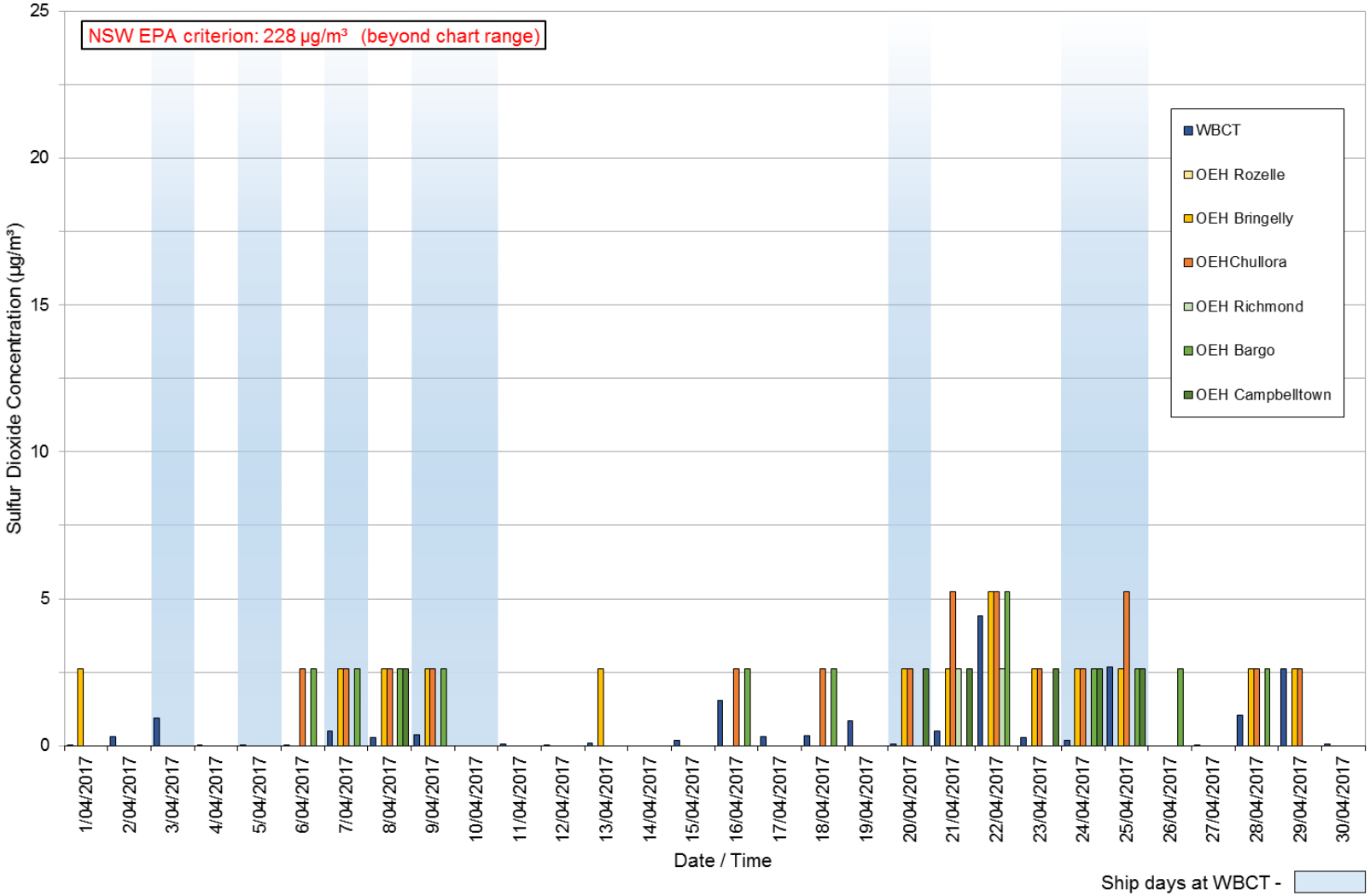
Note: Blue shading indicates ship days, not arrival and departure times. Arrival and departure times are provided in **Table 3-1.**

Figure 3-2: 1-hour average SO_2 concentrations

3.4 24-hour average sulfur dioxide concentrations

Time-series plots of 24-hour average SO_2 concentrations at WBCT and selected OEH urban background sites in Sydney are shown in **Figure 3-3**. The selected OEH sites that measure SO_2 include Rozelle, Bargo, Bringelly, Campbelltown West, Chullora and Richmond.

No exceedances of the 24-hour air quality criterion for SO_2 were recorded during the reporting period. The 24-hour average SO_2 concentrations were low, constituting a maximum of 2% of the NSW EPA criterion. Measured concentrations were generally similar to, or lower than the OEH reference sites. The highest 24-hour average SO_2 concentration (4 µg/m^3) was recorded on 22 April, which occurred when a ship was not berthed at WBCT.



Note: Blue shading indicates ship days, not arrival and departure times. Arrival and departure times are provided in **Table 3-1.**

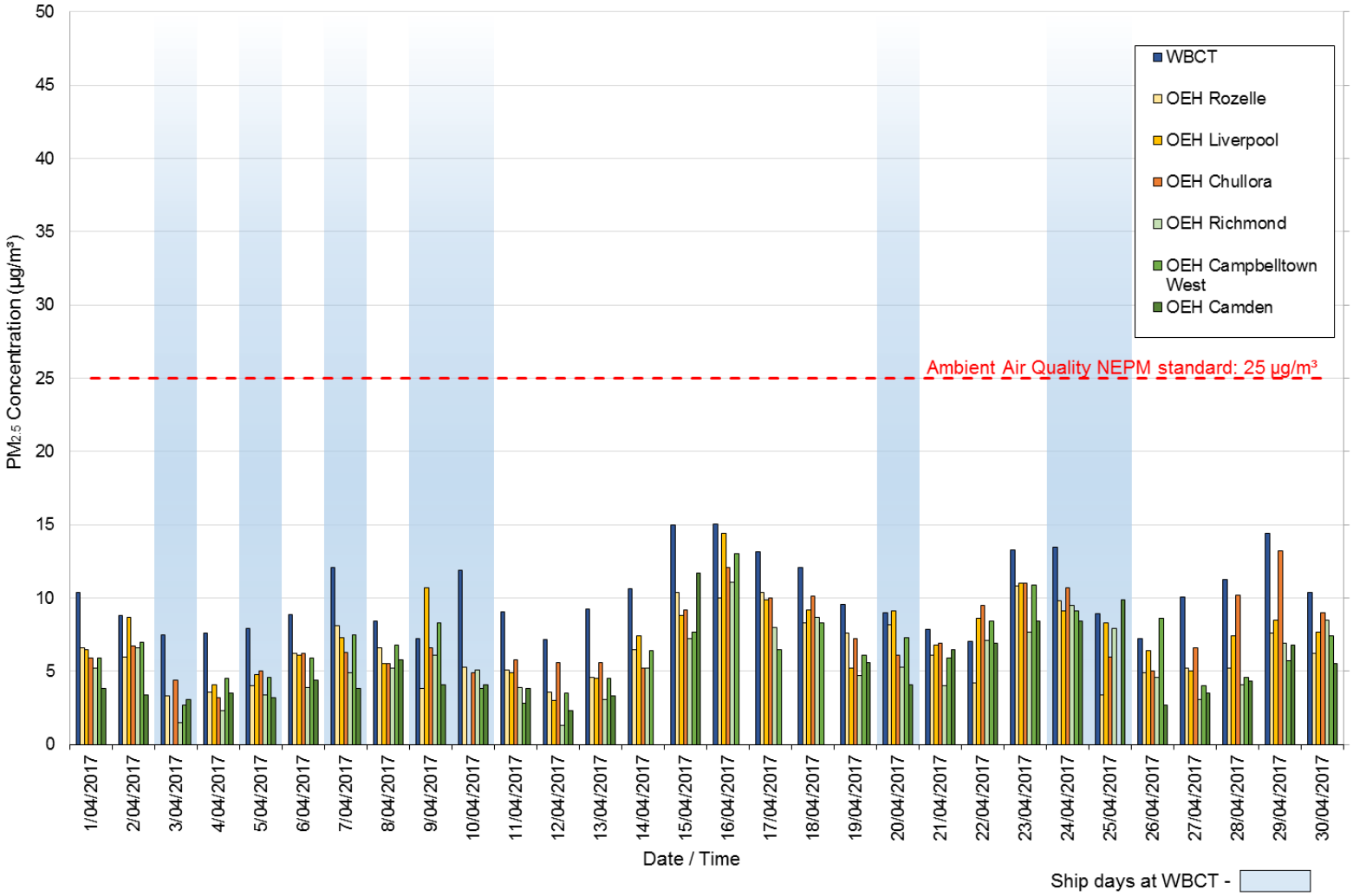
Figure 3-3: 24-hour average SO_2 concentrations at WBCT and OEH monitoring sites

3.5 24-hour average $PM_{2.5}$ concentrations

Time-series plots of 24-hour average $PM_{2.5}$ concentrations at WBCT and selected OEH sites are shown in **Figure 3-4**. Of the OEH sites in Sydney, $PM_{2.5}$ is measured at Chullora, Earlwood, Liverpool, Richmond, Rozelle and Campbelltown West.

The maximum (WBCT) 24-hour $PM_{2.5}$ concentration of 15 µg/m^3 was recorded on 15 April at a time when a cruise ship was not berthed at WBCT. On several occasions (including cruise and non-cruise days) $PM_{2.5}$ levels at WBCT were higher than the various OEH sites. It is anticipated that this may be due to localised sources of air emissions to the west and north-west of WBCT. Further discussion is provided in **Section 3.6**.

No exceedances of the 24-hour average AAQ NEPM air quality standard for $PM_{2.5}$ were recorded at WBCT during April.



Note: Blue shading indicates ship days, not arrival and departure times. Arrival and departure times are provided in **Table 3-1**.

Figure 3-4: 24-hour average $PM_{2.5}$ concentrations at WBCT and OEH sites

3.6 Polar bivariate plots

Polar bivariate plots that show statistics of the 10-minute average SO_2 and 1-hour average $PM_{2.5}$ records as a function of wind speed and wind direction are presented in **Figure 3-5** and **Figure 3-6** respectively. These plots interpolate between data points to show concentrations as a continuous surface, and represent the average concentration at a given wind speed and wind direction for the reporting period. The monitoring station is located at the origin of each plot. Note that there is no 1-hour average air quality criterion for $PM_{2.5}$ referenced in NSW (or elsewhere).

Average SO_2 concentrations (derived from 10-minute average values) were higher (0.8 µg/m^3) with mild southerly winds in the vicinity of 2 m/s (**Figure 3-5**). As noted in **Section 3.2**, there were no exceedances of the 10-minute average air quality criterion for SO_2 during the reporting period. SO_2 concentrations at WBCT were generally lower for other wind directions, with a minor accentuation of SO_2 concentrations associated with winds from south and south-easterly directions.

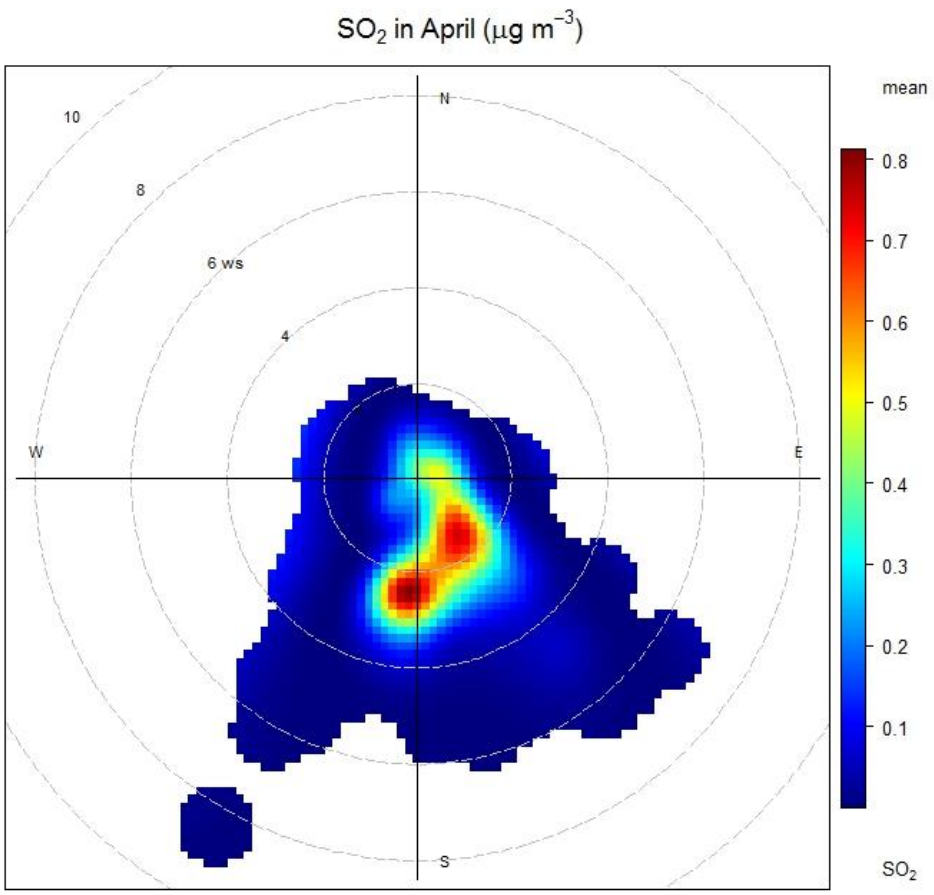


Figure 3-5: Polar bivariate plot for 10-minute average SO_2 concentrations as a function of wind speed (in m/s) and direction

Average $PM_{2.5}$ concentrations (derived from 1-hour average values) were higher (up to ~12.0 µg/m³) with lower winds (0-2 m/s) from the west and north-west (**Figure 3-6**).

It is expected that higher $PM_{2.5}$ concentrations are associated with localised emission sources to the west and north-west of the WBCT monitoring site, as indicated by:

- The presence of elevated $PM_{2.5}$ concentrations under westerly and north-westerly winds.
- The elevation of WBCT $PM_{2.5}$ concentrations above regional OEH monitoring sites[a], which implies the presence of localised sources.
- The absence of a correlation between elevated WBCT $PM_{2.5}$ levels and the presence of ships at WBCT.
- The differences in directional trends between the $PM_{2.5}$ and SO_2 polar bivariate plots, which implies that higher $PM_{2.5}$ and SO_2 concentrations are not associated with a common emission source.

As noted in **Section 3.5**, there were no exceedances of the 24-hour average NSW EPA air quality standard for $PM_{2.5}$ at WBCT within the month of April.

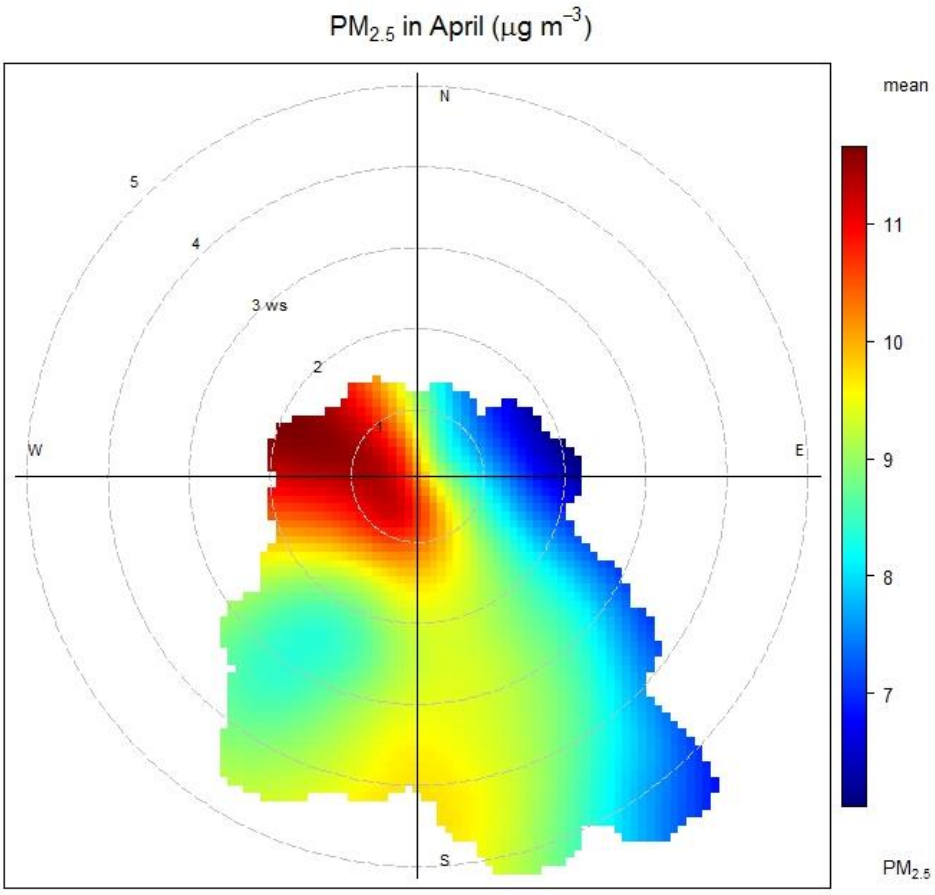


Figure 3-6: Polar bivariate plot for 1-hour average $PM_{2.5}$ concentrations as a function of wind speed (in m/s) and direction

[a] OEH monitoring locations are sited for the purposes of measuring ambient air quality within the airshed. As such that they are typically isolated from the direct influence of near-field emission sources.

3.7 Summary statistics

Summary statistics for the SO_2 and $PM_{2.5}$ concentrations at WBCT are shown in **Table 3-2**. No exceedances of the NSW EPA air quality criteria were recorded for SO_2 during the reporting period. No exceedances of the 24-hour average NSW EPA air quality criteria for $PM_{2.5}$ were recorded at WBCT during the reporting period.

Table 3-2: Summary statistics for SO_2 and $PM_{2.5}$ concentrations at WBCT (µg/m³)

Pollutant:	SO_2			$PM_{2.5}$
Averaging period:	10 minute	1 hour	24 hour	24 hour
Criterion:	712	570	228	25
Mean	1	1	1	10
Median	0	0	0	9
Standard deviation	3	2	1	2
Sample variance	6	5	1	6
Range	47	19	4	8
Minimum	0	0	0	7
Maximum	47	19	4	15
Maximum (cruise ship day)	22	17	3	14

4 REFERENCES

Australian/New Zealand Standard (2013). Method 9.12: Determination of suspended particulate matter – PM2.5 beta attenuation monitors. Methods for sampling and analysis of ambient air, AS/NZS 3580.9.12:2013.

Australian Standard (2008). Method 4.1: Determination of sulphur dioxide – Direct reading instrument method. Methods for sampling and analysis of ambient air, AS 3580.4.1 – 2008.

NEPC (2016). National Environment Protection (Ambient Air Quality) Measure as amended.

NSW EPA (2017). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. NSW Environmental Protection Authority, Sydney. January, 2017.

NSW DEC (2007) Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales. Department of Environment and Conservation NSW, Sydney. January, 2007.

Appendix A Monitoring station equipment and technology

A.1 Equipment

Equipment at the WBCT monitoring station and measured parameters are summarised in **Table A-1**.

Table A-1: Parameters and instrumentation for the monitoring station at WBCT

Parameter	Australian Standard	Measurement method	Instrument
Air quality metric			
SO_2	AS 3580.4.1-2008	UV Fluorescence	Ecotech Serinus 50
$PM_{2.5}$	AS/NZS 3580.9.13-2013	Beta Attenuation Monitor (BAM)	Spirant
Meteorological metric			
Wind speed	AS 3580.14-2014	Ultrasonic	Gill Windsonic 1405-PK-040
Wind direction			
Temperature		Resistive platinum sensor	Ecotech Met Station One
Pressure		Transducer	
Relative humidity		Capacitive	

Table A-2 outlines equipment that is used in the monitoring station both to meet the relevant Australian Standards and to enable real-time data interrogation/interpretation. All air quality instrumentation was installed in an air-conditioned, weather-proof shelter with instrument rack.

Table A-2: Additional equipment provided within air pollution monitoring station

Instrument type / component	Proposed instrument / supplier
Dynamic dilution calibrator	Gascal 1100
Zero air generator	Model 8301
Data Logger	WinAQMS
3G Cellular Modem	Netcomm
SO_2 calibration gas bottle	Coregas
Gas bottle regulator	Coregas

There is no current approved method for ambient air quality monitoring of $PM_{2.5}$ contained within the NSW Department of Environment and Conservation's *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* **(NSW DEC, 2007)**. However, there are Australian Standards that are applicable to this parameter. A Beta Attenuation Monitor (BAM) has been installed to measure $PM_{2.5}$, as opposed to a Tapered Element Oscillating Microbalance (TEOM) – for the following reasons:

- BAMs have a proven track record as being highly robust and reliable;
- BAM technology is more cost-effective than using TEOMs;
- The use of a BAM removes the known measurement issues associated with using TEOMs for $PM_{2.5}$ monitoring (the TEOM heated inlet is known to remove the semi-volatile component within this size fraction);
- BAM instruments are used for regulatory reporting by the NSW government, and are used for $PM_{2.5}$ monitoring at the following OEH ambient air quality monitoring stations:
    - Chullora, Earlwood, Liverpool, Rozelle and Richmond in Sydney;
    - All sites in OEH's Upper Hunter Ambient Air Quality Monitoring Network; and
    - All NSW Roads and Maritime Services particulate monitoring adopted for the WestConnex M4 East and New M5 projects (twelve locations measuring PM_{10} and $PM_{2.5}$; twenty-four BAMs in total).

A.2 Servicing, maintenance and calibration

Routine preventative maintenance is carried out at one, three, six and twelve month intervals, as stipulated by the relevant Australian Standards and Pacific Environment's commitment to work to NATA standards. The regular maintenance program includes, but is not limited to:

- Daily remote data check and attend to any fault identified within 24 hours;
- Filter changes;
- Leak checks;
- Single point calibration;
- Multipoint linearity check;
- Visual inspection;
- Cleaning of sample lines and particulate (BAM) inlet head;
- Advanced six and twelve monthly analyser service and overhaul;
- Annual calibration of meteorological sensors; and
- Alignment check for wind speed/direction sensor.
- Remote daily data checks are performed by a Pacific Environment consultant to ensure the integrity of the system.
- A calibrations span value of 500 ppb is used to challenge the SO_2 instrument.

A.3 EnviroSuite

Data from the monitoring station are recorded to a local data logger and then uploaded in near real-time via a secured virtual private network (VPN) to Pacific Environment's proprietary data management software, EnviroSuite. Any instrument or system fault is captured by the data logger and relayed in real time via email and SMS, and/or flagged by EnviroSuite.

Pacific Environment provides and hosts a website that is dedicated to providing air quality and meteorological monitoring data for the project. This web page for reporting data in near real-time, includes a map of the project area, icons showing the locations of monitoring equipment and recent monitoring data readings. Data for comparison with compliance limits are also presented. The web address for this is: https://es2.envirosuite.com/monitoring/pansw/.

As requested by the Port Authority, public-facing data contains a disclaimer, similar to that presented on the OEH air quality monitoring website:

Disclaimer: The data used in the compilation of this page have undergone only preliminary quality assurance checks. These data may require modification during final stages of validation as a result of calibration changes, power failures, instrument failures etc.

Appendix B Quality assurance and control

B.1 National Association of Testing Authorities accreditation

Pacific Environment is pursuing accreditation by the National Association of Testing Authorities (NATA) for the measurement of all ambient air quality and meteorological parameters. All monitoring is being conducted in accordance with the NATA requirements.

B.2 Data storage and ratification

All monitoring and calibration data are stored on a central software system and on a cloud-based server with multiple replicas. The data are also stored internally on the analysers.

Currently, there are no Australian guidelines for the ratification of air quality monitoring data. The data ratification process has therefore been developed in keeping with best practice guidelines from the USEPA and DEFRA in the UK. The data ratification process involves steps such as:

- Removal of clearly incorrect data.
- Corrections for instrument drift.
- Corrections for offsets.
- Removal of calibration points.
- Removal of data during servicing and maintenance periods.

Appendix C Data availability and summary

Data availability for SO_2 and $PM_{2.5}$ during the reporting period, based on the 5-minute average values, is shown in **Table C-1**. A summary and distribution of measurements for SO_2, $PM_{2.5}$, wind speed and wind direction are shown in **Figure C-1**.

Data were invalidated due to instrument monthly maintenance on the 4th of April.

Table C-1: Data availability and summary statistics for SO_2 and $PM_{2.5}$[a] (5-minute reported values)

Statistic	SO_2	$PM_{2.5}$
Possible values	8640	8640
Missing values	301	39
Availability (%)	97%	100%
95th percentile (µg/m³)	3	19

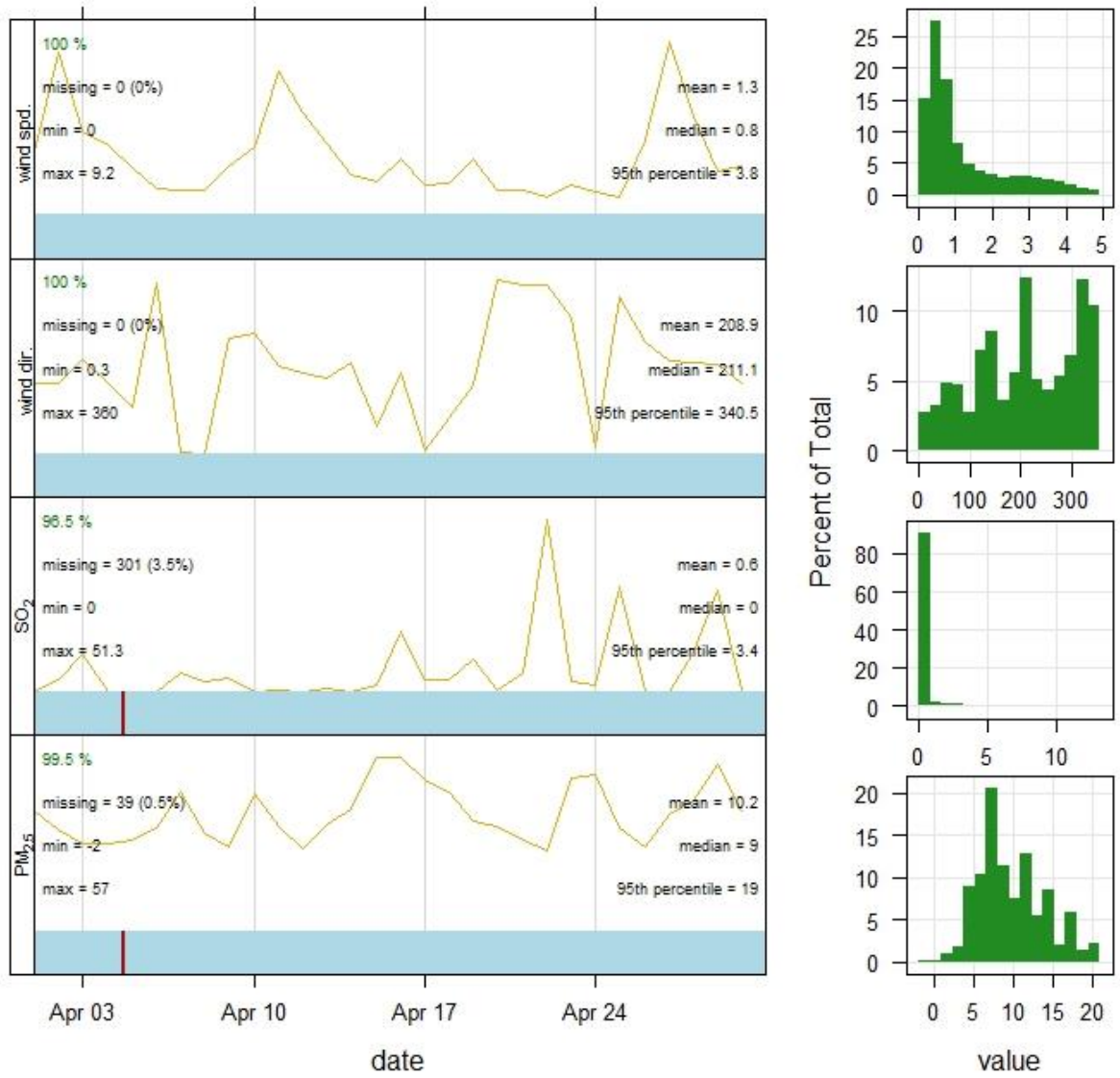


Figure C-1: Output summary and data distribution for 5-minute values of wind speed (in m/s), wind direction, SO_2 (in µg/m³) and $PM_{2.5}$ (in µg/m³) concentrations. Blue bars represent captured data and red bars represent missing data

Appendix D Wind roses

A wind rose showing the frequency of counts by wind direction for the reporting period are shown in **Figure D-1**. Some guidance on the interpretation of wind roses is provided in **Figure D-2**.

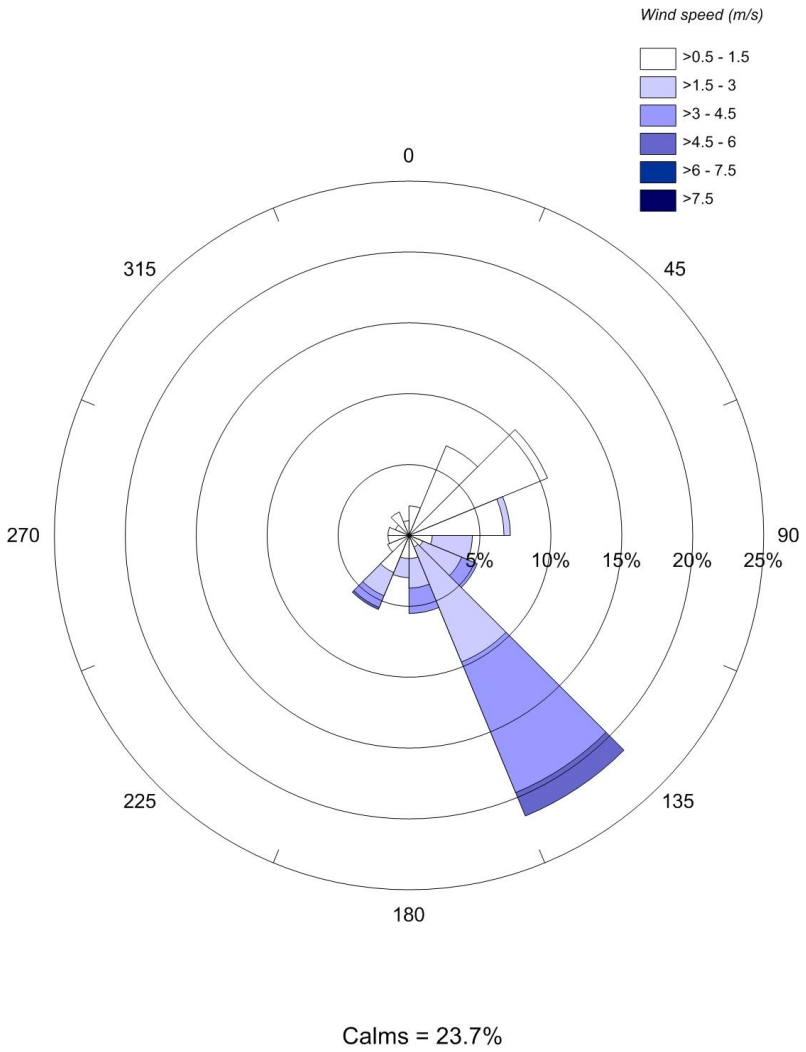


Figure D-1: Wind rose for the WBCT

A wind rose shows the frequency of occurrence of winds by direction and strength, presented as 16 bars that correspond to the compass points (N, NNE, NE, etc). The length of each bar represents the frequency of occurrence of winds from that direction, and the colours of the bar sections correspond to wind speed categories, the darker colours representing stronger winds.

In this example, 30% of winds are from the ESE direction, and the winds from this direction have the following speed distribution:

- 10% between 1.5 and 3 m/s
- 10% between 3 and 4.5 m/s
- 7% between 4.5 and 6 m/s
- 3% between 6 m/s and 7.5 m/s

Predominant wind direction

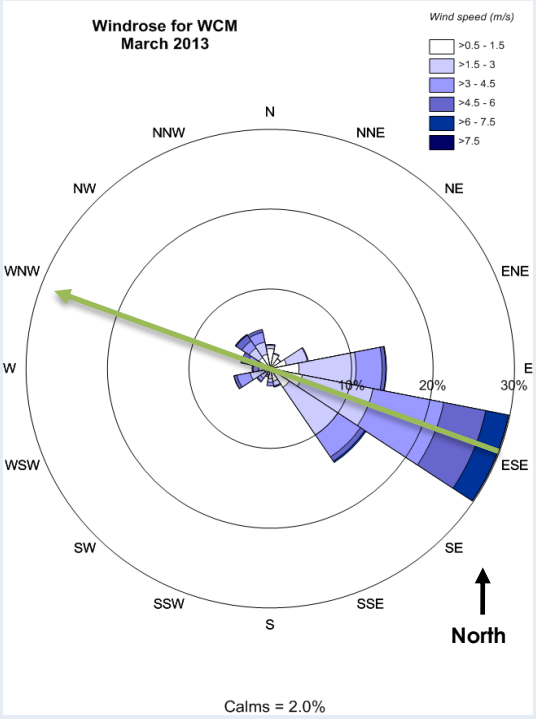


Figure D-2: Interpretation of an example wind rose