



Final Report

WHITE BAY CRUISE TERMINAL: AIR QUALITY AND METEOROLOGICAL MONITORING REPORT – OCTOBER 2015

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Final	03/12/15	Final version incorporating PANSW comments	Ashley Martin	Damon Roddis

Pacific Environment Operations Pty Ltd: ABN 86 127 101 642

BRISBANE

Level 1, 59 Melbourne Street, South Brisbane Qld 4101
PO Box 3306, South Brisbane Qld 4101
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

Unit 1, 22 Varley Street
Yeerongpilly, Qld 4105
Ph: +61 7 3004 6460

ADELAIDE

35 Edward Street, Norwood SA 5067
PO Box 3187, Norwood SA 5067
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

SYDNEY

Suite 1, Level 1, 146 Arthur Street
North Sydney, NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

MELBOURNE

Level 10, 224 Queen Street
Melbourne Vic 3000
Ph: +61 3 9036 2637
Fax: +61 2 9870 0999

PERTH

Level 1, Suite 3
34 Queen Street, Perth WA 6000
Ph: +61 8 9481 4961
Fax: +61 2 9870 0999

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GLOSSARY

Term	Description
AS	Australian Standard
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
BAM	Beta attenuation monitor
EnviroSuite	Pacific Environment's proprietary data management software
EPA	New South Wales Environment Protection Authority
µg/m ³	Micrograms per cubic metre
GLB	Glebe Island berths
GMR	NSW Greater Metropolitan Region
m/s	Metres per second
NATA	National Association of Testing Authorities
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
OEH	NSW Office of Environment and Heritage
ppb	Parts per billion
PM _{2.5}	Airborne particulate matter with an aerodynamic diameter of less than 2.5 micrometres (µm)
QA	Quality assurance
QC	Quality control
SO ₂	Sulfur dioxide
TEOM	Tapered Element Oscillating Microbalance
WBCT	White Bay Cruise Terminal
WHT	White Bay berths
W/m ²	Watts per square metre

1 INTRODUCTION

The Port Authority has committed to undertaking additional air quality monitoring in the residential area adjacent to the WBCT, and has worked with the EPA to determine: the parameters to be monitored, an appropriate location for the monitoring station, and the duration of the monitoring programme. The monitored parameters are sulfur dioxide (SO₂) and particulate matter less than 2.5 micrometres in diameter (PM_{2.5}). The monitoring also includes local wind speed and direction.

The monitoring station samples SO₂ data every ten seconds and records data at 5-minute averaging periods. PM_{2.5} is observed as hourly averages. These data are used to assess whether local air quality standards are met.

The NSW air quality criteria for SO₂ are 712, 570, and 228 µg/m³ for 10-minute, 1-hour and 24-hour averages respectively (**NSW DEC, 2005**). For PM_{2.5}, the National Environment Protection Council (NEPC) released a variation to the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) to include advisory reporting standards for PM_{2.5} (**NEPC, 2003**). The AAQ NEPM advisory standard for the 24-hour average is 25 µg/m³.

Pacific Environment has been commissioned to provide monthly reports for 12 months from September 2015 onwards. Any exceedances of the NSW air quality criteria or the AAQ NEPM advisory standard for ground-level concentrations will be reported and discussed. The PM_{2.5} and SO₂ concentrations at WBCT will be compared with those at monitoring sites around Sydney operated by the NSW Office of Environment and Heritage (OEH). These are located at Bargo, Bringelly, Campbelltown West, Chullora, Earlwood, Liverpool, Richmond and Rozelle.

This report provides the monitoring results for the period from 1 October 2015 to 31 October 2015. This represents the first month after the introduction of the Protection of the Environment Operations (Clean Air) Amendment (Cruise Ships) Regulation 2015, which requires cruise ships to use low sulfur fuel while berthed in Sydney Harbour from 1 October 2015 onwards. This will include any place within the boundaries of Sydney Harbour from 1 July 2016. Results from September 2015 are also presented in this report to assess the impact of the introduction of the Protection of the Environment Operations (Clean Air) Amendment (Cruise Ships) Regulation 2015.

2 METHODOLOGY

A monitoring location was installed following consultation with the EPA and Leichhardt Municipal Council to measure PM_{2.5} and SO₂, 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**).

As far as practicable, this site 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. The non-compliance is not expected to significantly affect the results from the monitoring station.

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**.



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

3 MONITORING DATA

The results of the monitoring are presented below and are compared to EPA ambient air quality criteria. These are 10-minute, 1-hour and 24-hour average concentrations for SO₂, and 24-hour average concentrations for PM_{2.5}.

The 24-hour average SO₂ and PM_{2.5} are compared with data from OEHL monitoring sites. Polar bivariate plots are also presented that show 5-minute average SO₂ and PM_{2.5} concentrations as a function of wind speed and wind direction.

Results from September 2015 are also presented to evaluate the impact of the introduction of the Protection of the Environment Operations (Clean Air) Amendment (Cruise Ships) Regulation 2015 (i.e. switch to low sulfur fuel).

3.1 10-minute average sulfur dioxide concentrations

A time-series plot of 10-minute average SO₂ concentrations for September 2015 and October 2015 is shown in **Figure 3-1**.

There was no exceedance of the 10-minute average air quality criterion for SO₂ during the reporting period as 10-minute-average SO₂ concentrations were generally less than 10 µg/m³.

The maximum 10-minute-average SO₂ concentration in October 2015 decreased significantly from around 500 in September to 300 µg/m³, which was measured on 15 October 2015. There were no other instances of SO₂ concentrations greater than 100 µg/m³ in October. Peaks in SO₂ concentration seen in October 2015 (including 6 and 15 October) did not occur on days that cruise ships were berthed at the WBCT.

Significantly lower SO₂ concentrations in October compared to September are anticipated to be as a result of the introduction of the Protection of the Environment Operations (Clean Air) Amendment (Cruise Ships) Regulation 2015.

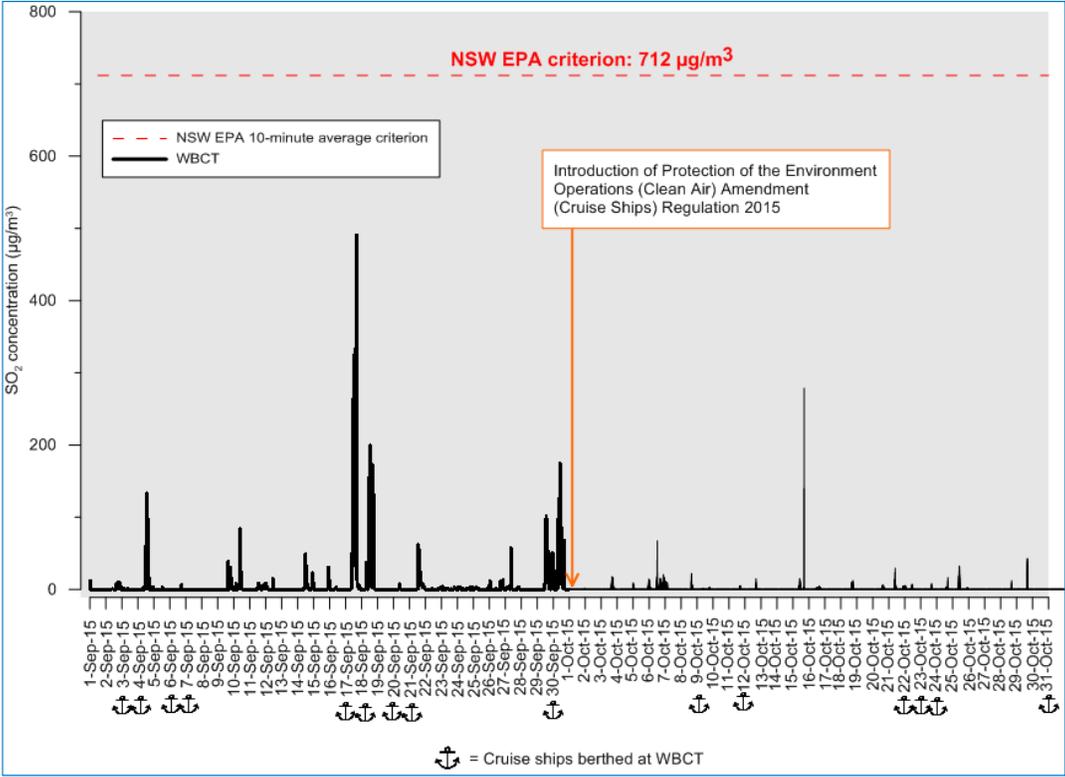


Figure 3-1: 10-minute average SO₂ concentrations for September and October 2015

3.2 1-hour average sulfur dioxide concentrations

A time series plot of the 1-hour average SO₂ concentration in September 2015 and October 2015 is shown in **Figure 3-2**.

As discussed in **Section 3.1**, lower SO₂ concentrations in October compared to September can be attributed to the introduction of the Protection of the Environment Operations (Clean Air) Amendment (Cruise Ships) Regulation 2015. Maximum 1-hour SO₂ concentrations were recorded on the 15 October 2015, but were relatively low (less than 100 µg/m³). Peaks in SO₂ concentration seen in October 2015 (including 15 October) did not occur on days that cruise ships were berthed at the WBCT.

No exceedances of the 1-hour air quality criterion for SO₂ were recorded during the reporting period.

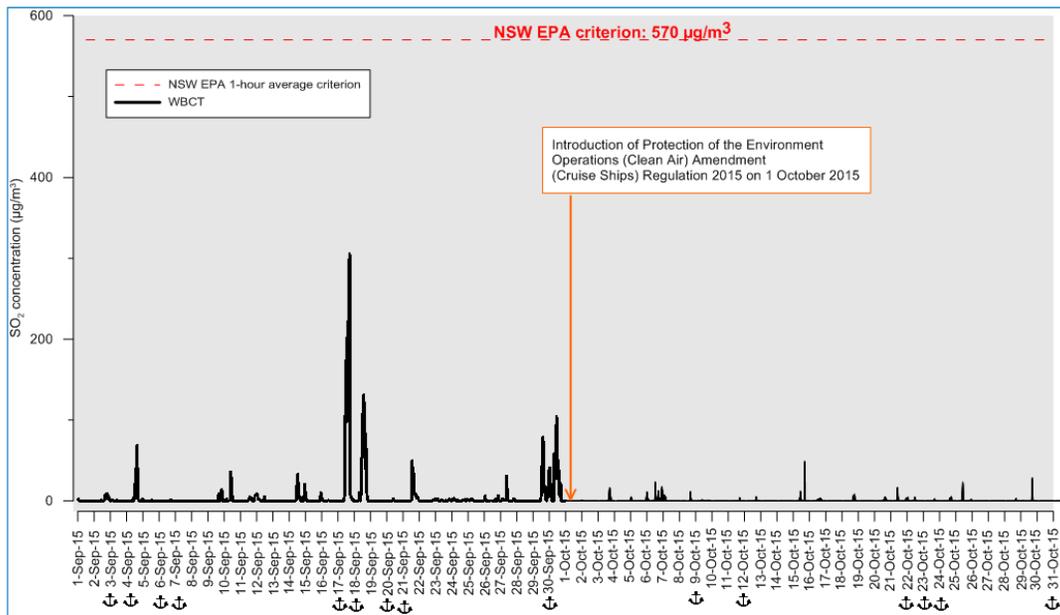


Figure 3-2: 1-hour average SO₂ concentrations for September and October 2015

3.3 24-hour average sulfur dioxide concentrations

Time-series plots of 24-hour average SO₂ concentrations at WBCT and selected OEH sites in Sydney are shown in **Figure 3-3**. The selected OEH sites that measure SO₂ include Rozelle, Bargo, Bringelly, Campbelltown West, Chullora, Earlwood, Liverpool and Richmond.

During October 2015, 24-hour average SO₂ concentrations at WBCT were very low and less than 4 µg/m³, including days when cruise ships were berthed at WBCT. Furthermore, SO₂ concentrations at WBCT were similar to those at the selected OEH monitoring sites in Sydney and generally lower than the 24-hour observations at OEH comparative sites.

The maximum 24-hour average SO₂ concentrations in October were an order of magnitude lower compared to September. This is anticipated to be attributable to the introduction of the Protection of the Environment Operations (Clean Air) Amendment (Cruise Ships) Regulation 2015.

No exceedances of the 24-hour air quality criterion for SO₂ were recorded during the reporting period.

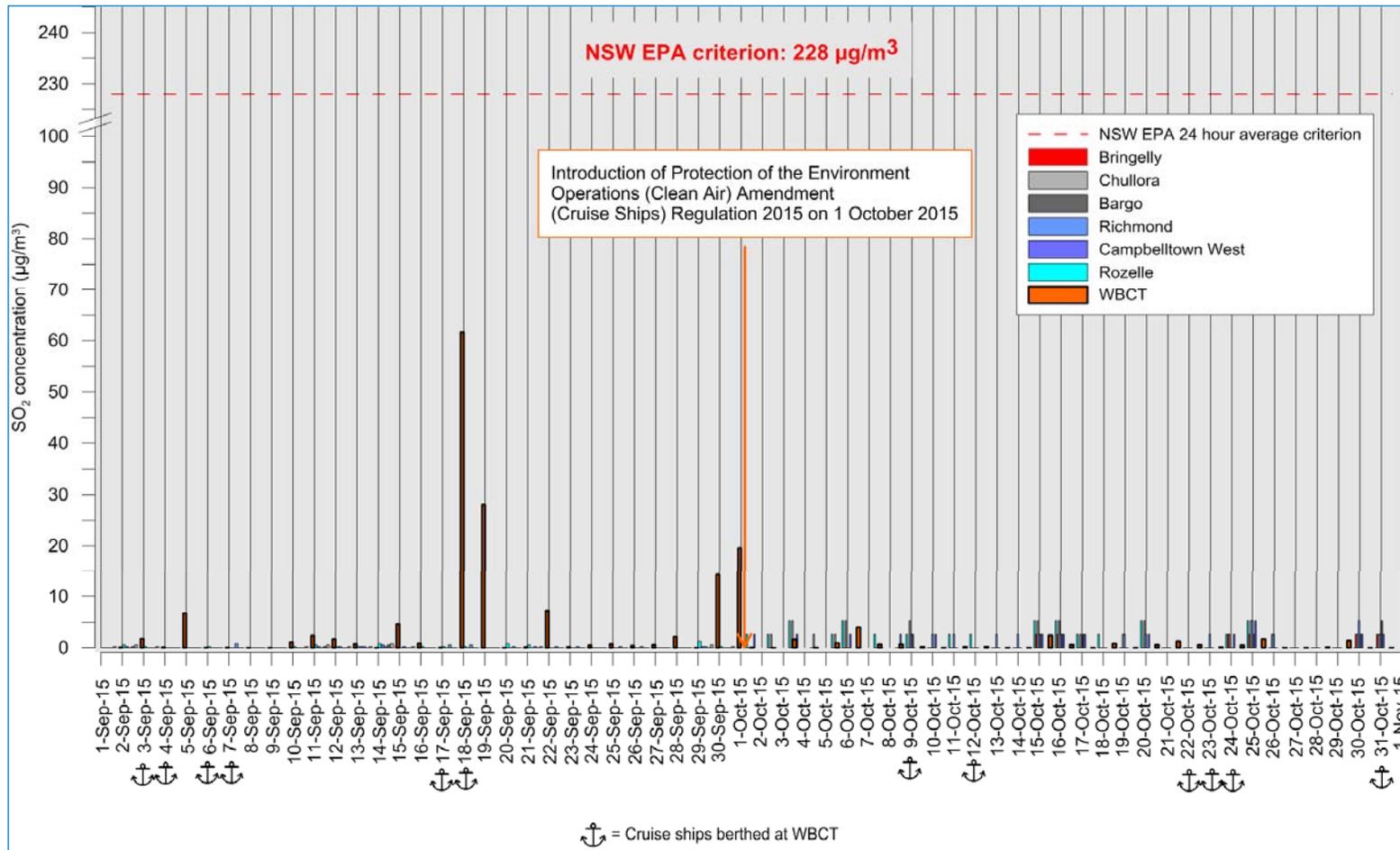


Figure 3-3: 24-hour average SO₂ concentrations at WBCT and nearby OEH monitoring sites in September and October 2015. Note the broken axis from 100 – 220 $\mu\text{g}/\text{m}^3$.

3.4 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, PM_{2.5} is measured at Chullora, Earlwood, Liverpool, Richmond and Rozelle.

The 24-hour average PM_{2.5} concentrations at WBCT were similar to those at the OEH sites, and maximum concentrations at all sites were less than 20 µg/m³. The data show that PM_{2.5} levels at WBCT are often lower than some of the OEH reference sites, regardless of whether or not a cruise ship is at berth. The PM_{2.5} concentrations in October were similar to September, indicating that the introduction of Protection of the Environment Operations (Clean Air) Amendment (Cruise Ships) Regulation 2015 on 1 October 2015 had little effect on local ambient PM_{2.5} concentrations. This is attributed to the number of potential PM_{2.5} sources in the Sydney airshed which will likely confound any signal from an individual source.

No exceedances of the 24-hour average NEPM air quality advisory standard for PM_{2.5} were recorded during the reporting period.

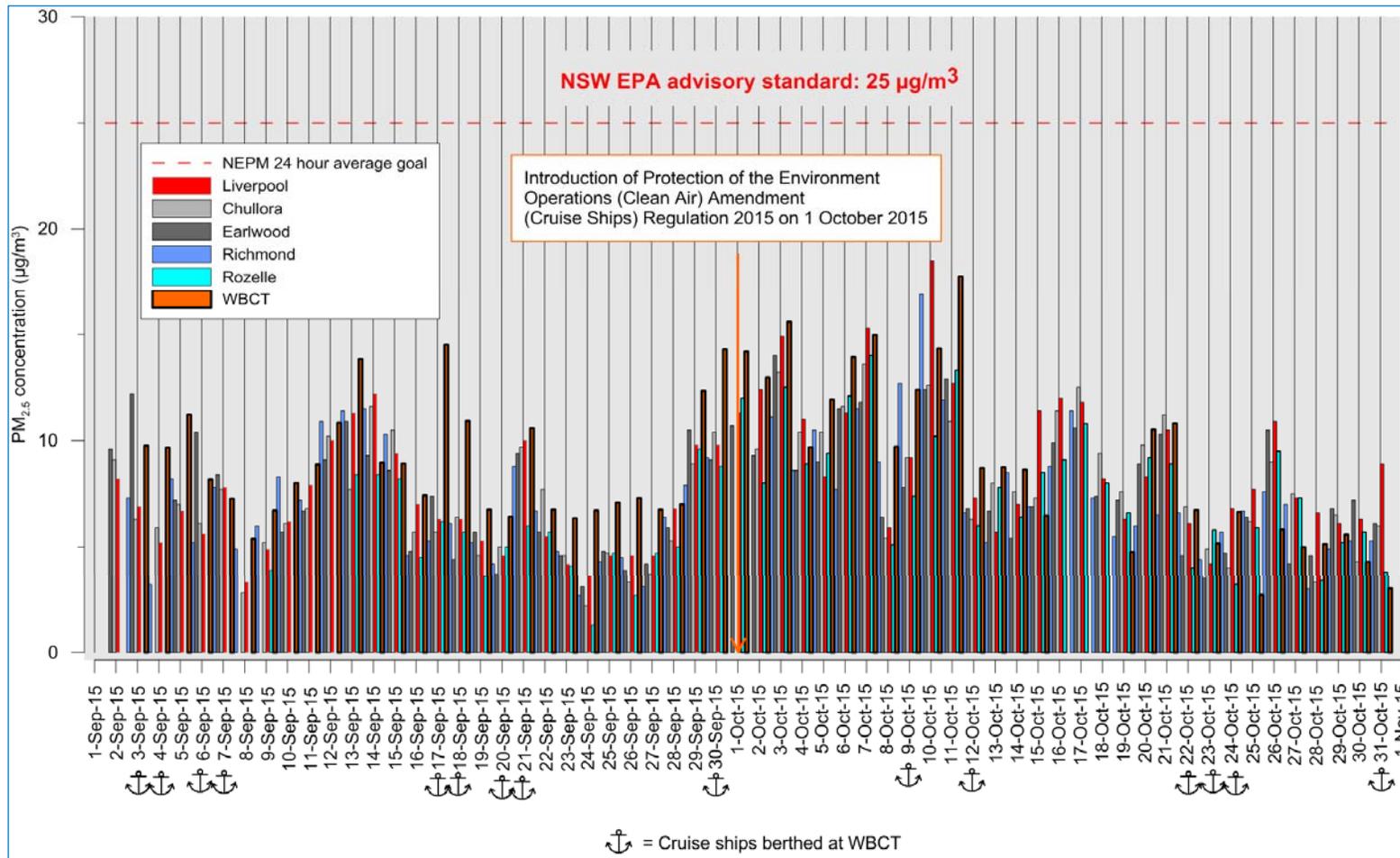


Figure 3-4: 24-hour average PM_{2.5} concentrations at WBCT and nearby OEH sites in September and October 2015

3.5 Polar bivariate plots

Polar bivariate plots that show 10-minute average SO₂ concentrations and 1-hour average PM_{2.5} as a function of wind speed and wind direction are presented in **Figure 3-5** and **Figure 3-6**. 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 given period. Note that there is no 1-hour average air quality criterion for PM_{2.5} referenced in NSW.

Average SO₂ concentrations (interpolated from 10-minute average values) were highest (around 0.8 µg/m³) with light (0 – 2 m/s) south-easterly winds (**Figure 3-5**). These SO₂ concentrations are likely attributable to cruise ships berthed at WBCT (berth WHT5, **Figure 2-1**). It is noted that an average SO₂ concentration of 0.8 µg/m³ is extremely low compared to the 10-minute average health criterion of 712 µg/m³.

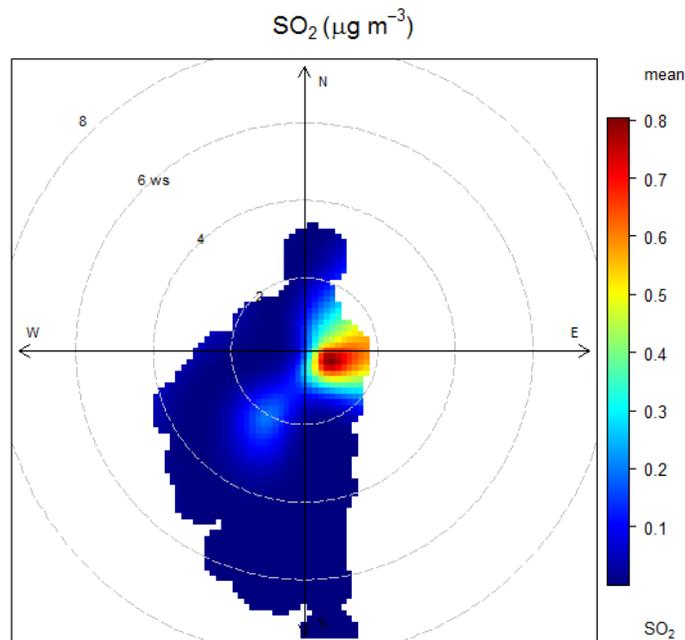


Figure 3-5: Polar bivariate plot for 10-minute average SO₂ concentrations in October 2015

Average PM_{2.5} concentrations (interpolated from 1-hour average values) were higher (greater than 15 µg/m³) with moderate (2 – 4 m/s) south-southeasterly winds, moderate northerly winds, and strong southerly winds (**Figure 3-6**). As with SO₂ concentration data, the south-easterly source of PM_{2.5} emissions may be attributable to cruise ships berthed at WBCT (berth WHT5, **Figure 2-1**).

However, the upwind sources under southerly and northerly wind conditions are unknown and likely not related to cruise ships berthed at WBCT.

Compared to the SO₂ concentration data, the polar bivariate plots show that PM_{2.5} sources are more diverse.

PM_{2.5} concentrations were low (less than 5 µg/m³) when westerly winds were recorded.

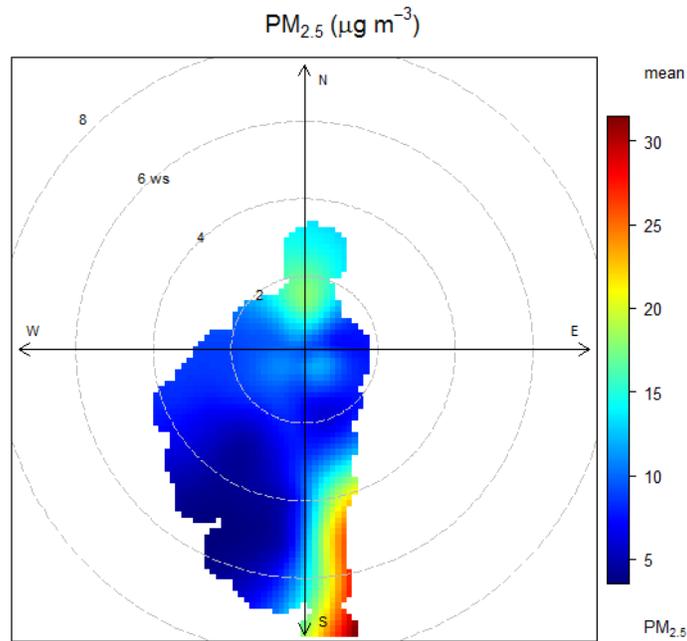


Figure 3-6: Polar bivariate plot for 1-hour average PM_{2.5} concentrations in October 2015

3.6 Summary Statistics

Summary statistics for average values of SO₂ and PM_{2.5} concentrations are shown in **No exceedances** of air quality criteria or AAQ NEPM advisory standard were recorded for SO₂ or PM_{2.5} during the reporting period.

Table 3.1.

No exceedances of air quality criteria or AAQ NEPM advisory standard were recorded for SO₂ or PM_{2.5} during the reporting period.

Table 3.1: Summary statistics for SO₂ and PM_{2.5} concentrations at WBCT

Pollutant:	SO ₂			PM _{2.5}
Units:	µg/m ³			µg/m ³
Averaging period:	10 min	1 h	24 h	24 h
Criterion:	712	570	228	25 ^a
Mean	1	1	1	9
Median	0	0	0	9
Standard deviation	5	3	1	4
Sample variance	26	12	1	18
Range	279	72	4	15
Minimum	0	0	0	3
Maximum (cruise ship day)	14	4.5	1	12
Maximum (non-cruise ship day)	279	72	4	18

^aNEPM Advisory Reporting Standard

4 REFERENCES

NEPC (2003). National Environment Protection Measure for Ambient Air Quality, 1988, with amendment in 2003.

NSW DEC (2005). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. August, 2005.

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 3580.4.1-1990	UV Fluorescence	Serinus 50
PM _{2.5}	AS/NZS 3580.9.13-2013	Beta Attenuation Monitor (BAM) ¹	Spirant
Meteorological metric			
Wind speed	AS 3580.14-2011	Ultrasonic	Gill
Wind direction			
Temperature		Temperature sensor	Ecotech Met Station One
Pressure		Barometric pressure sensor	
Relative humidity			
Solar radiation			
Rainfall		Tipping bucket rain gauge	

Equipment that is required in the monitoring station both to meet the relevant Australian Standards and to enable real-time data interrogation/interpretation is outlined in **Table A-2**. All 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	WinAQM
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 EPA's *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*. However, there are Australian Standards that are applicable to this parameter. A Beta Attenuation Monitor (BAM) was 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

- o All NSW Roads and Maritime Services particulate monitoring adopted for the WestConnex road tunnel study (twelve locations measuring PM₁₀ 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 monthly 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 500ppb is used to challenge the SO₂ instrument.

A.3 EnviroSuite

Data from the monitoring station is recorded to a local data logger and is then uploaded 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 Limited provides and hosts a website that is dedicated to providing air quality and meteorological monitoring data for the project. This webpage 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 is 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 SO₂ and PM_{2.5} during the reporting period, based on the 5-minute average values, is shown in **Table C-1**. Summary and distribution of measurements for SO₂, PM_{2.5}, wind speed and wind direction are shown in **Figure C-1**.

A high proportion of PM_{2.5} data for October 2015 were unavailable due to instrument calibration and maintenance. A zero background test for the BAM was conducted from Thursday 15/10/15 15:00 to 19/10/15 16:00 pm and PM_{2.5} concentrations from this period were considered invalid. Instrument maintenance on the BAM also means that PM_{2.5} data was unavailable on 15/10/15 17:00 – 17:55, 19/10/15 13:05 – 16:55, and 23/10/15 09:00 – 09:55.

The majority of SO₂ data were available for October and missing data are attributed to routine instrument maintenance.

Table C-1: Data availability and summary statistics for SO₂ and PM_{2.5} (5-minute average reported values)

Statistic	SO ₂	PM _{2.5}
Valid values	8329	6963
Missing values	311	1697
Availability (%)	96.5%	81%
Minimum (µg/m ³)	0.0	0.8
Maximum (µg/m ³)	278.8	40.8
Mean (µg/m ³)	0.6	12.6
Median (µg/m ³)	0.0	11.8
95 th percentile (µg/m ³)	3.1	25.8

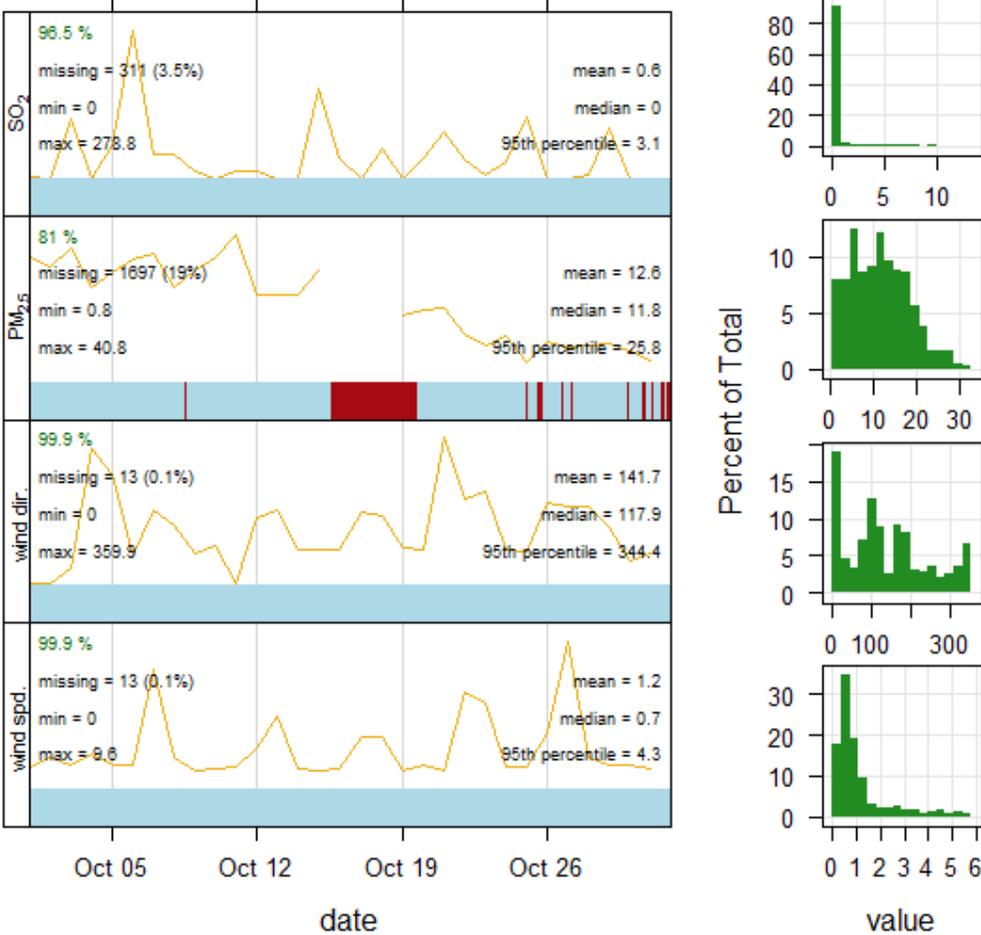


Figure C-1: Output summary and data distribution for 5-minute average SO₂ and PM_{2.5} concentrations in October 2015

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**.

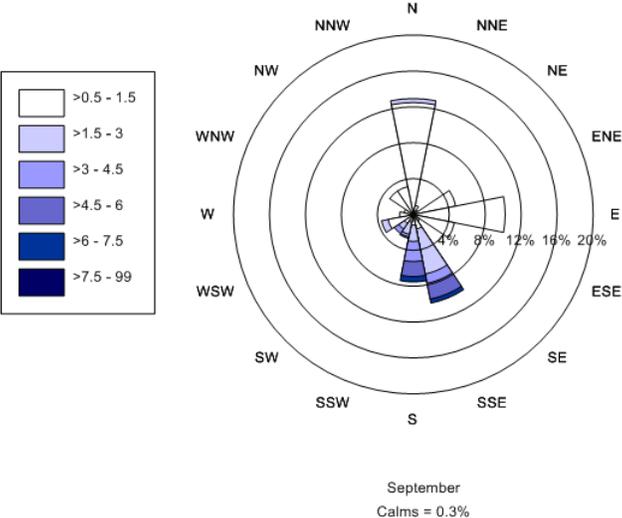


Figure D-1: Wind rose for the WBCT in October 2015

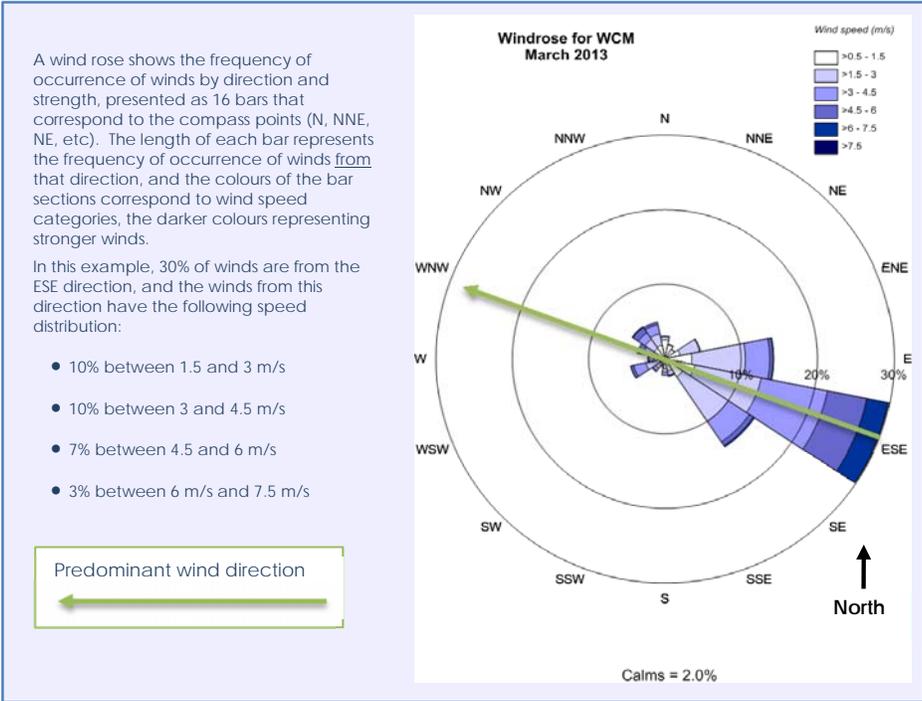


Figure D-2: Interpretation of a wind rose