Alspec Industrial Business Park On-site Sewer Management Facility

Odour impact assessment

Prepared for HBB Property Pty Ltd

August 2024

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Odour impact assessment

HBB Property Pty Ltd

E240557 RP1

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TABLE OF CONTENTS

1 Introduction **1**

1.1 Background/overview 1

1.2 Proposed development 4

2 Site setting and sensitive receptors **6**

2.1 Site and surrounding area 6

2.2 Assessment locations 6

3 Assessment criteria **9**

4 Existing environment **10**

4.1 Existing sources of odour 10

4.2 Dispersion meteorology 10

5 Emissions inventory **17**

5.1 Odour emission calculations 17

5.2 Peak-to-mean 18

6 Dispersion modelling **19**

6.1 Dispersion model selection and configuration 19

6.2 Predicted odour concentrations 20

7 Conclusion **23**

References **24**

Abbreviations **25**

Appendices

Appendix A Meteorological analysis A.1

Tables

Table 2.1 Assessment locations 6

Table 3.1 Impact assessment criteria for complex mixtures of odorous air pollutants 9

Table 4.1 Summary of average wind speed, percentage of calms and data recovery for BoM Badgerys Creek AWS 11

Table 5.1 Odour emission calculations 18

Table 6.1 Predicted 99th percentile 1-second odour concentration (ou) 21

Table A.1 Monthly surface roughness length values by sector A.8

Table A.2 Monthly Bowen ratio and albedo values (all sectors) A.8

Figures

Figure 1.1	Regional setting	2
Figure 1.2	Local setting	3
Figure 1.3	Proposed facility layout	5
Figure 2.1	Assessment locations	8
Figure 4.1	Annual wind speed and direction – Badgerys Creek AWS – 2021	12
Figure 4.2	Seasonal wind speed and direction – BoM Badgerys Creek – 2019 to 2023	13
Figure 4.3	Diurnal wind speed and direction – BoM Badgerys Creek -2019 to 2023	13
Figure 4.4	AERMET-generated diurnal variation in atmospheric stability – BoM Badgerys Creek AWS - 2021	15
Figure 4.5	AERMET-generated diurnal variation in atmospheric boundary layer depth – BoM Badgerys Creek AWS - 2021	16
Figure 6.1	Predicted 99th percentile 1-second odour concentration (ou) contours	22
Figure A.1	Data completeness analysis plot – BoM Badgerys Creek AWS – 2019 to 2023	A.2
Figure A.2	Inter-annual variability in diurnal wind speed – Badgerys Creek– 2019 to 2023	A.3
Figure A.3	Inter-annual variability in diurnal wind direction – Badgerys Creek– 2019 to 2023	A.3
Figure A.4	Inter-annual variability in diurnal air temperature – Badgerys Creek– 2019 to 2023	A.4
Figure A.5	Inter-annual variability in diurnal relative humidity – Badgerys Creek– 2019 to 2023	A.4
Figure A.6	Inter-annual comparison of recorded wind speed and direction – Badgerys Creek AWS – 2019 to 2023	A.5
Figure A.7	Land use map for AERSURFACE processing	A.7

1 Introduction

1.1 Background/overview

HB+B Property Pty Ltd (HBB) is seeking development approval from Penrith City Council (Council) for a proposed on-site sewer management facility (the facility) at the Alspec Industrial Business Park (AIBP) at 221–235 Luddenham Road, Orchard Hills. The proposed development will be located at the northern end of the AIBP adjacent to the warehouse lot 2.

It is understood that collected blackwater to be treated by the facility will be sourced from toilets, showers, basins and drains (other than stormwater drains) across the AIBP. The treated water will be held in holding tanks and reused at the AIBP for cooling tower make-up water, for toilet flushing in each of the warehouses and for irrigation of landscaping on each of the lots.

The regional setting and local setting of the facility are shown in Figure 1.1 and Figure 1.2 respectively.

HBB has engaged EMM Consulting Pty Ltd (EMM) to undertake an odour impact assessment in support of the development application for the facility to be submitted to Council.

Figure 1.1 Regional setting

Figure 1.2 Local setting

1.2 Proposed development

Blackwater from the AIBP is directed to a wet well adjacent to the treatment plant. Effluent from the wet well is pumped to a pre-screen and the directed to 1,000 kilolitre (kL) buffer tank. The treatment plant draws water from the buffer tank based on treated water demand, storing the final treated water in a 1,000 kL treated water storage tank.

The proposed treatment system consists of the following units:

- Wet Well
- Pre-screen
- Buffer tank for collection of blackwater
- Two identical process trains with the following process units
  - Anoxic Tank
  - Aerobic Tank
  - Membrane bioreactor treatment system (MBR)
  - Filtrate tank
  - Ozonation
  - Biological activated carbon filter (BAC)
  - Ultraviolet light disinfection (UV)
  - Chlorine disinfection
- Off-spec water holding tank
- Treated water storage tank
- Treated water chlorination
- Waste activated sludge (WAS) holding tank
- Screw press
- Vents connected to an odour scrubber for odour control
- Overflows and drains to wet well
- Chemical dosing systems

The layout of the proposed facility is illustrated in Figure 1.3.

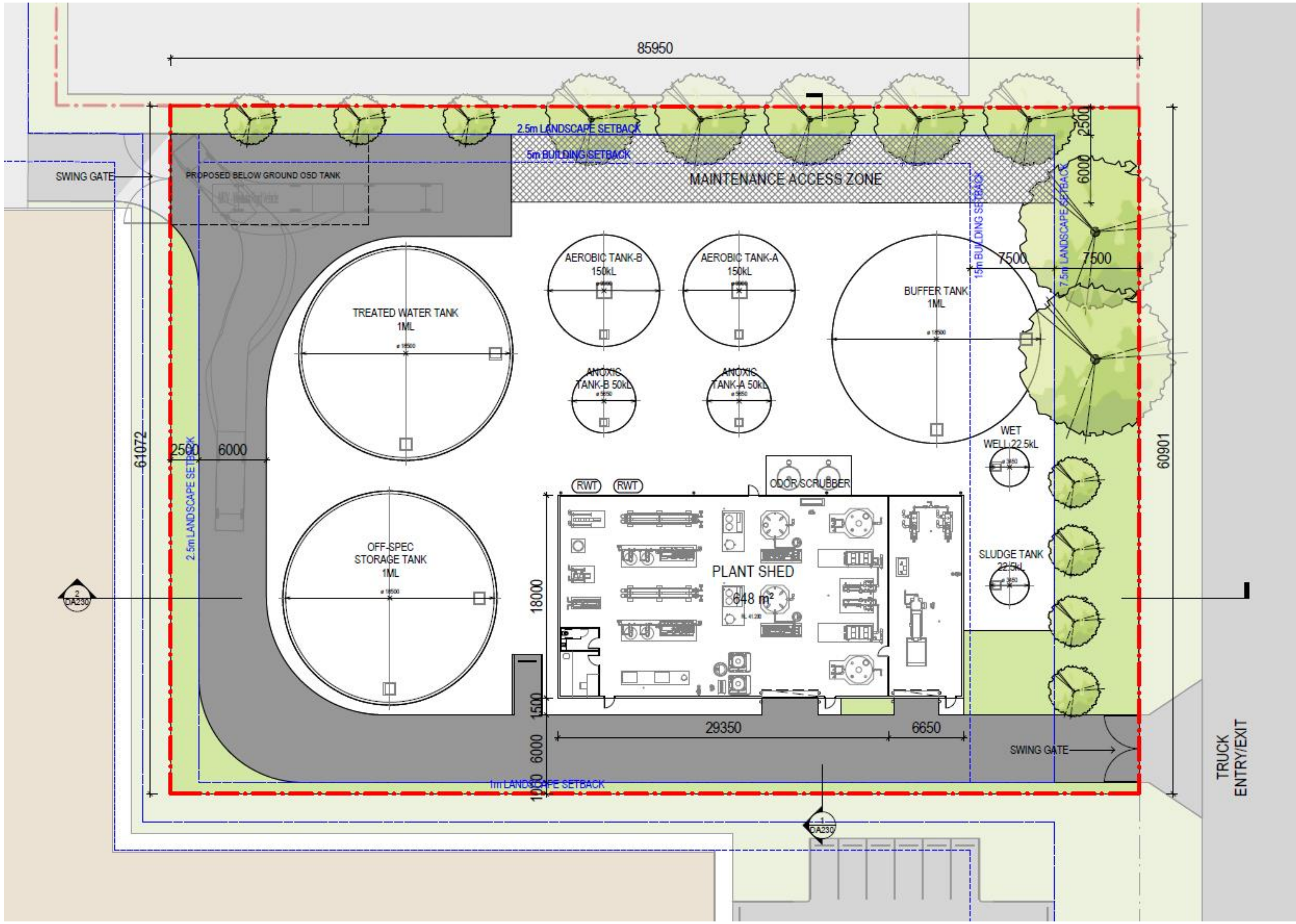


Figure 1.3 **Proposed facility layout**

Source: Nettleton Tribe 2024

2 Site setting and sensitive receptors

2.1 Site and surrounding area

The AIBP is located at 221–235 Luddenham Road, Orchard Hills, approximately 41 kilometres (km) west of the Sydney CBD in the Greater Western Sydney region. The AIBP has recently been rezoned from RU2 Rural landscape to E4 General Industrial, with land classifications in the surrounding area including C2 Environmental Conservation and RU2 Rural landscape. The nearest residential zone is an area of R2 Low Density Residential within the suburb of St Clair, approximately 1.6 km north-east of the AIBP and an area of C4 Environmental Living within the Twin Creeks residential neighbourhood, approximately 1.0 km south of the AIBP.

2.2 Assessment locations

A selection of representative residential properties and future industrial properties surrounding and within the AIBP have been chosen as assessment locations for this modelling study, these are presented in Table 2.1 and shown in Figure 2.1.

Table 2.1 Assessment locations

Location ID	Classification	Coordinate (MGA, 56)	
		Easting	Northing
R1	Residential	292749	6255740
R2	Residential	292736	6255687
R3	Residential	292758	6255639
R4	Residential	292763	6255603
R5	Residential	292762	6255547
R6	Residential	292772	6255509
R7	Residential	292780	6255456
R8	Residential	292793	6255410
R9	Residential	292797	6255354
R10	Residential	292825	6255304
R11	Residential	292824	6255246
R12	Residential	292823	6255209
R13	Residential	293251	6255198
R14	Residential	293264	6255156
R15	Residential	293248	6255109
R16	Residential	292662	6254625
R17	Residential	292537	6254646
R18	Residential	292378	6254671
R19	Residential	292502	6254384

Location ID	Classification	Coordinate (MGA, 56)	
		Easting	Northing
R20	Residential	292568	6254244
R21	Residential	292559	6254199
R22	Residential	292560	6254162
R23	Residential	292589	6254136
R24	Residential	292618	6254105
R25	Residential	291970	6254195
R26	Residential	292724	6255925
R27	Residential	292676	6255360
R28	Residential	292647	6255254
R29	Residential	292597	6255025
R30	Residential	292646	6254976
R31	Residential	291436	6254625
R32	Recreational	292498	6255414
R33	Industrial*	292342	6255519
R34	Industrial*	292179	6255490
R35	Industrial*	292193	6255617
R36	Industrial*	292550	6255695

*Location of future industrial development within ABIP

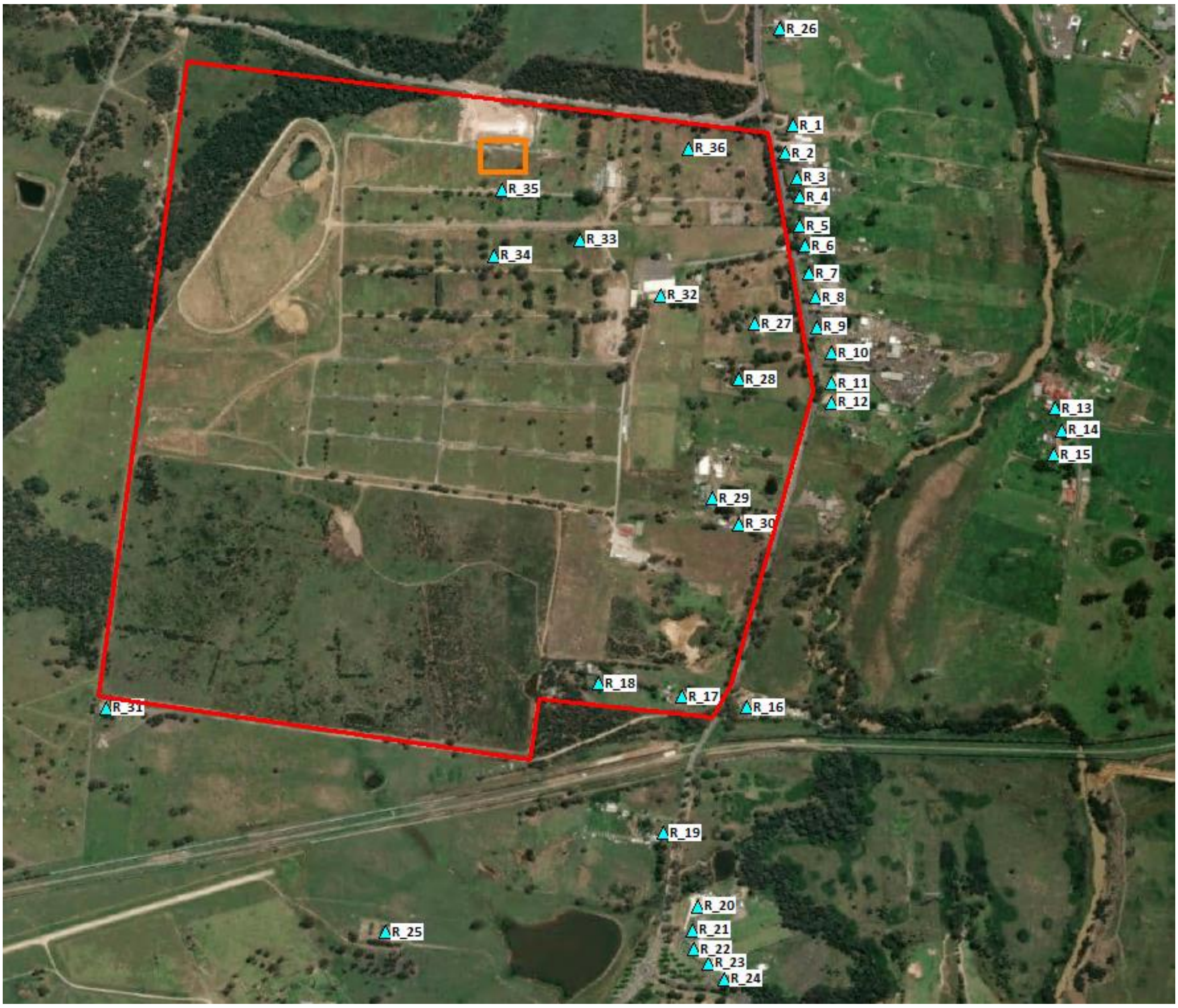


Figure 2.1 Assessment locations

3 Assessment criteria

No instrument-based method can measure an odour response in the same way as the human nose. Therefore "dynamic olfactometry" is typically used as the basis of odour quantification by regulatory authorities. Dynamic olfactometry is the measure of odour by presenting a sample of odorous air to a panel of people with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. The correlations between the known dilution rations and the panellists' responses are then used to calculate the number of dilutions of the original sample required to achieve the odour detection threshold. The units for odour measurement in dynamic olfactometry are "odour units" (ou), which are dimensionless and are effectively "dilutions to threshold".

The odour nuisance level can be as low as 2 ou and as high as 10 ou (for less offensive odours), whereas an odour assessment criterion of 7 ou is likely to represent the level below which 'offensive' odours should not occur. The *Technical Framework: Assessment and Management of Odour from Stationary Sources in NSW* (NSW DECC 2006a) recommends that, as a design criterion, no individual should be exposed to ambient odour levels greater than 7 ou.

The EPA (2022) prescribes odour goals which take into account the population density for a particular area. A summary of the EPA's population-based odour assessment criteria is presented in Table 3.1.

Table 3.1 Impact assessment criteria for complex mixtures of odorous air pollutants

Population of affected community	Odour units (ou), 1-second nose response time average*(99th percentile)
~ 2	7
~ 10	6
~ 30	5
~ 125	4
~ 500	3
Urban (2,000) and/or schools and hospitals	2

Note:*a nose response average refers to the instantaneous perception of odours by the human nose and is derived using peak-to-mean ratios, described in Section 5.2.

In the interests of conservatism, the most stringent odour goal of 2 ou has been adopted in this assessment for all surrounding assessment locations.

4 Existing environment

4.1 Existing sources of odour

The proposed development is located in western Sydney, predominantly surrounded by rural landscapes and residential properties. Regarding neighbouring sources of industrial air pollutant emissions, the facility is approximately 0.8 km south-east of Bingo Industries' Patons Lane Resource Recovery Facility.

An odour impact assessment was completed for the Patons Lane Resource Recovery Facility by RWDI Australia Limited [1] in 2022. The results of the dispersion modelling undertaken in that report show predicted odour concentrations across the AIBP and adjacent existing residential receptors of less than 0.3 ou. On the basis of these predicted odour concentrations, it is unlikely that cumulative odour impacts with the facility would occur. No further consideration of odour emissions from the Patons Lane Resource Recovery Facility is made in this report.

4.2 Dispersion meteorology

4.2.1 Monitoring data resources

Meteorological mechanisms govern the generation, dispersion, transformation, and eventual removal of pollutants from the atmosphere. To adequately characterise the dispersion meteorology of a region, information is needed on the prevailing wind regime, ambient temperature, rainfall, relative humidity, mixing depth and atmospheric stability.

There are no meteorological measurements taken at the AIBP. In reviewing the meteorological environment of the local area, the following publicly available data sources were analysed:

- Bureau of Meteorology (BoM) Automatic weather station (AWS) at Badgerys Creek (station 067108), located approximately 9.0 km south-west of the AIBP. One-hour average measurements of wind speed, wind direction, standard deviation of wind direction, temperature, station-level barometric pressure and relative humidity were sourced from this AWS
- BoM Bankstown Airport AWS (station 066137) located approximately 23.4 km east of the AIBP. One-hour average measurements of cloud observations were sourced from this AWS.

Data from these stations were analysed for use in this assessment and are documented in the proceeding sections.

4.2.2 Prevailing winds and selection of a representative year

The meteorological data recorded by the BoM Badgerys Creek AWS were analysed for the five-year period between 2019 and 2023 (see Appendix A). The analysis demonstrated a similarity across years in the most important parameters for dispersion, such as wind speed and wind direction winds. The inter-annual profiles for air temperature and relative humidity were also generally comparable between 2019 and 2023 (Appendix A). The 2019 dataset showed higher daytime temperatures and lower relative humidity, which are indicative of the strong drought conditions experienced in 2019.

A summary of the annual average wind speed, percentage of calms (wind speeds less than 0.5 metres per second (m/s)), and data recovery for each year is presented in Table 4.1.

[1] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=MP09_0074-MOD-2%2120230110T054030.327%20GMT

The statistics in Table 4.1 show that there was a general inter-annual consistency in the recorded annual average wind speed and annual percentage of calms for each year.

Table 4.1 Summary of average wind speed, percentage of calms and data recovery for BoM Badgerys Creek AWS

Year	Average wind speed (m/s)	Calms (%)	Data recovery (%)*
2019	2.6	8.2%	95
2020	2.4	11.8%	100
2021	2.4	7.9%	99
2022	2.5	7.8%	99
2023	2.4	8.6%	85

*Note: based on availability of wind speed data.

On the basis of similarities in inter-annual trends with wind speed and direction for the years between 2019 and 2023, the 2021 calendar year was adopted as the 12-month modelling period for the purpose of this odour impact assessment and is considered suitably representative of meteorological conditions recorded at the BoM Badgerys Creek AWS.

It is noted that 2022 was affected by the La Niña phenomenon which resulted in significantly higher than average rainfall across the region and was therefore excluded. While the 2023 calendar year is the most recent at the time of reporting, the meteorological dataset was below the data completeness threshold of 90% required for dispersion modelling, as set out in the Approved Methods for Modelling.

Annual, seasonal and diurnal wind roses created from wind speed and direction data collected at the BoM Badgerys Creek AWS are presented in Figure 4.1 to Figure 4.3, respectively.

Annually the wind rose shows a prevailing wind alignment from the north-east and the south to south-west. On a seasonal basis, the autumn and winter months show prevailing south-westerly winds, while winds from the north-east through to the south-east are more dominant in the summer months. Diurnally, the wind direction patterns during the night hours are dominant from the south-west, while a notable north-east and south-west is experienced during the day. Average wind speeds were higher during the day and the percentage of calms was higher at night-time.

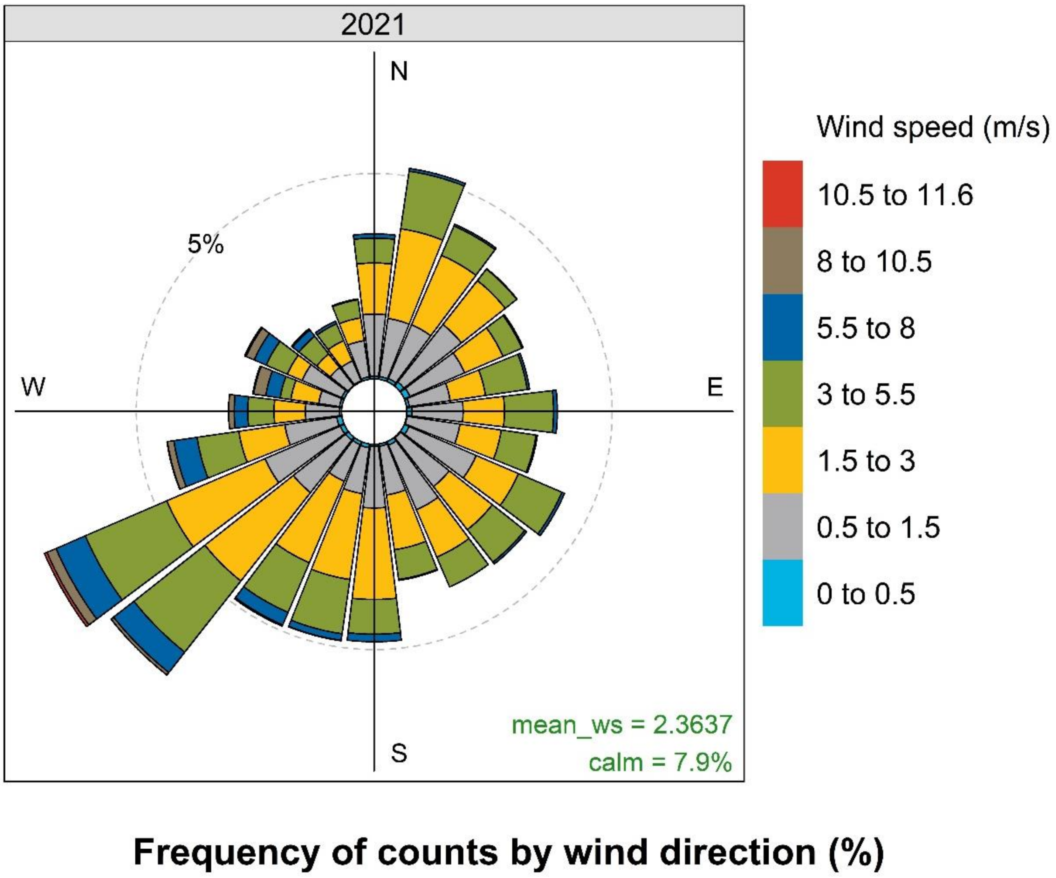


Figure 4.1 Annual wind speed and direction – Badgerys Creek AWS – 2021

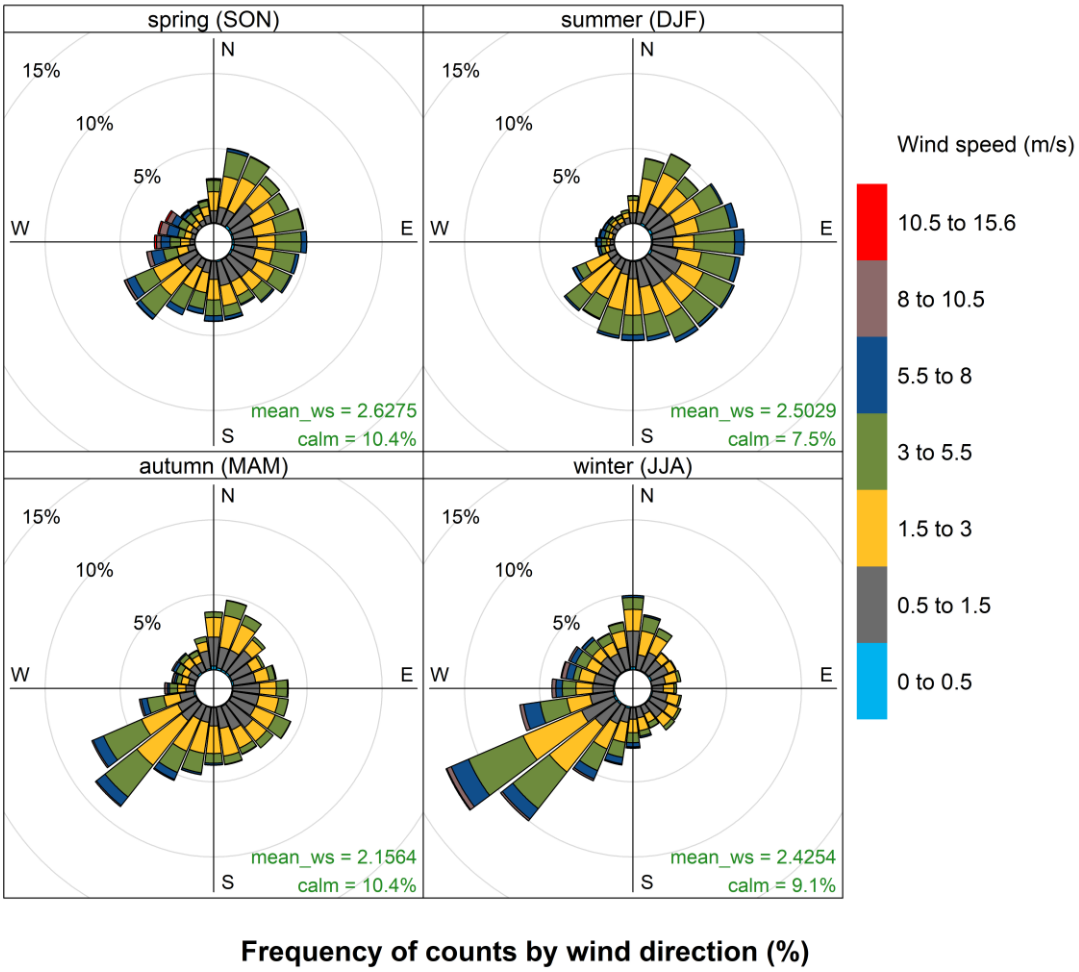


Figure 4.2 Seasonal wind speed and direction – BoM Badgerys Creek – 2019 to 2023

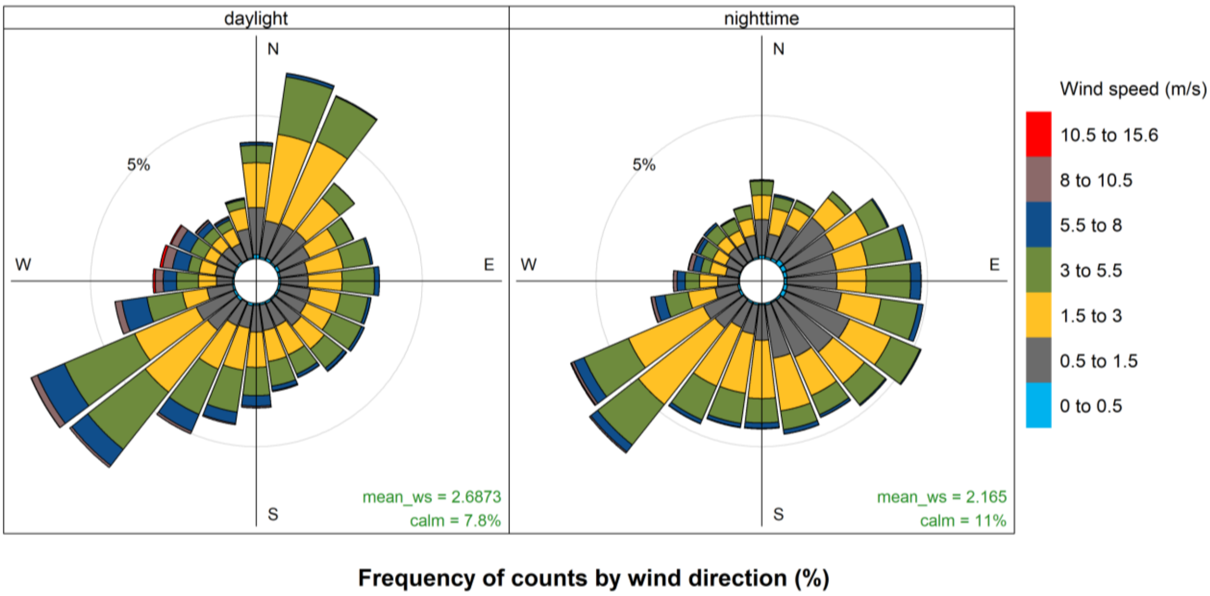


Figure 4.3 Diurnal wind speed and direction – BoM Badgerys Creek -2019 to 2023

4.2.3 Meteorological modelling

Atmospheric dispersion modelling for this assessment has been completed using the AMS[2]/USEPA[3] regulatory model (AERMOD) (model version v23132). The meteorological inputs for AERMOD were generated using the AERMET meteorological processor (model version v23132), using local surface observations from the BoM Badgerys Creek AWS and upper air profiles generated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) TAPM meteorological modelling module.

Further details of the TAPM meteorological modelling and AERMET data processing completed to prepare the inputs for AERMOD are documented in Appendix A.

4.2.4 Atmospheric stability and mixing depth

Atmospheric stability refers to the degree of turbulence or mixing that occurs within the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants.

The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically about 10% of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions.

Figure 4.4 illustrates the diurnal variation of atmospheric stability, derived from the Monin-Obukhov length calculated by AERMET based on observation data collected from the BoM Badgerys Creek AWS in 2021.

The diurnal profile presented illustrates that atmospheric instability increases during daylight hours as convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for atmospheric dispersion of emissions would be greatest during daytime hours and lowest during evening through to early morning hours.

[2] AMS – American Meteorological Society

[3] USEPA – United States Environmental Protection Agency

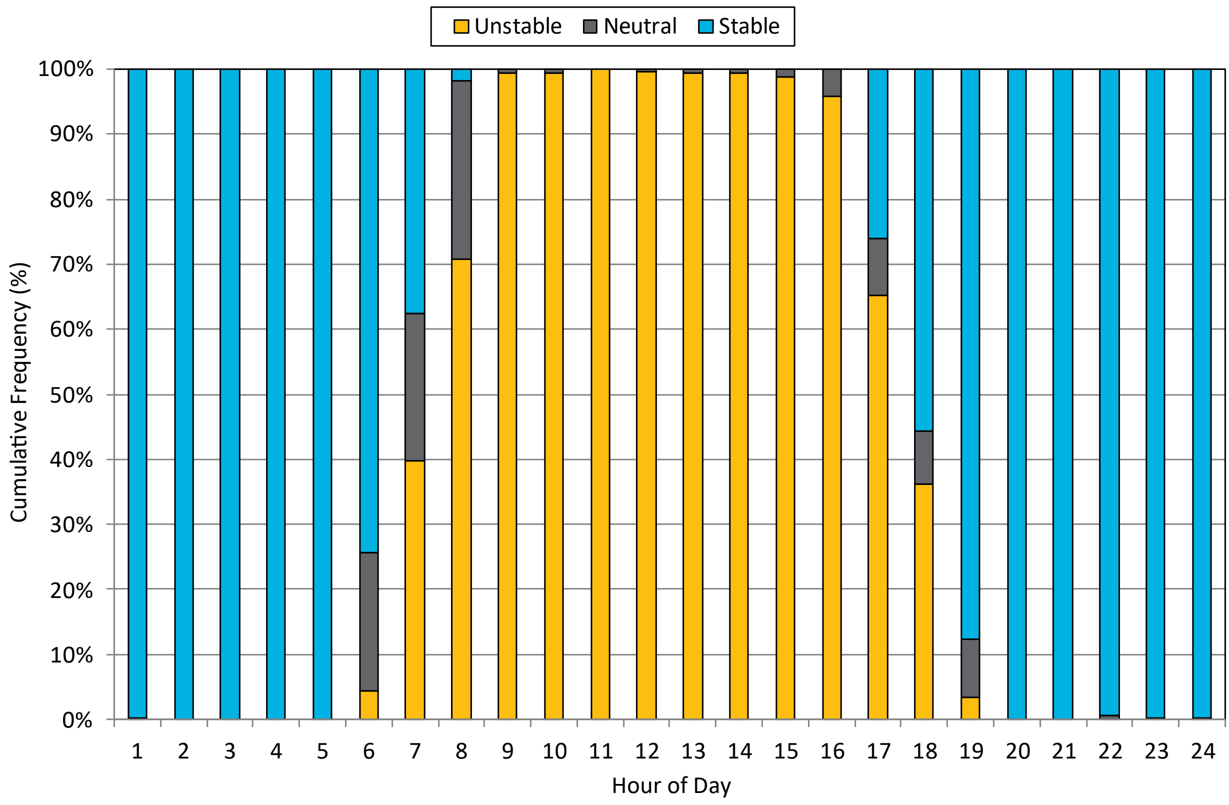
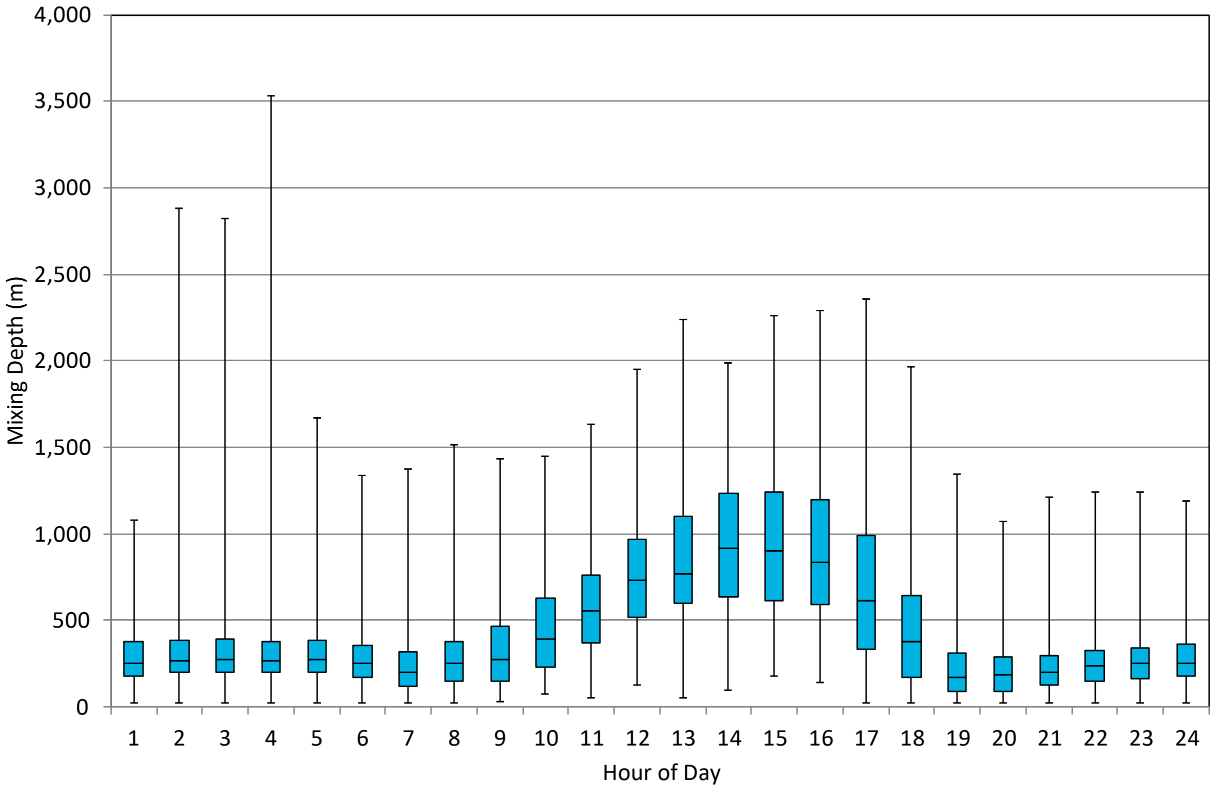


Figure 4.4 **AERMET-generated diurnal variation in atmospheric stability – BoM Badgerys Creek AWS - 2021**

Hourly-varying atmospheric boundary layer depths were calculated by AERMET and refers to the height of the atmosphere above ground level within which the dispersion of air pollution occurs. The variation in boundary layer depth by hour of the day is illustrated in Figure 4.5. The profile presented Figure 4.5 shows that greater boundary layer depths are experienced during the daytime hours between mid-morning and late afternoon. Higher day-time wind velocities and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases so too does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for atmospheric dispersion of pollutants.



Note: blue bars indicate the interquartile range (IQR), or middle 50% of the data, while the whiskers indicate highest and lowest values.

Figure 4.5 AERMET-generated diurnal variation in atmospheric boundary layer depth – BoM Badgerys Creek AWS - 2021

5 Emissions inventory

5.1 Odour emission calculations

Details of the project have been provided by the design engineer firm, Aquacell Pty Ltd (Aquacell).

Based on advice from Aquacell, the potentially odour emission generating processes at the project are the following:

- Three external in-ground storage tanks, specifically the buffer tank, the wet well tank and sludge storage tank.
- Two waste activated sludge (WAS) holding tanks within the main shed.
- Two pre-screens and one dewatering screen, and associated screenings storage bins, within the main shed.

The following odour mitigation methods apply to the above processes:

- The external tanks will be enclosed and fitted with passive carbon filters to treat potential fugitive odour emissions.
- The two WAS holding tanks within the main building will be vented to passive carbon filters.
- The area of the pre-screens and dewatering screen will be ducted, with collected air diverted to two scrubber devices to be located on the northern wall of the main shed.

Aquacell have advised that the following odour emission reductions apply to the above mitigation methods:

- Passive carbon filters – 99% reduction.
- Scrubber device – greater than 95% reduction.

Aquacell have advised that all other components of the project will be sealed or have negligible odour generation potential. Therefore, no other odour emission sources are characterised in this report.

In order to estimate odour emissions from the project, EMM have reviewed the Sydney Water Corporation (SWC) odour emissions database, which is based on historical odour emissions sampling data from operational wastewater treatment facilities in the SWC network.

The following odour emission source resources were adopted:

- External storage tanks (buffer tank, wet well tank, sludge storage tank) – average normalised odour emission rate from “Sludge Storage” samples.
- WAS holding tanks – average normalised odour emission rate from “Sludge Storage” samples.
- Pre-screens - – average normalised odour emission rate from “Screenings Bins” samples.
- Dewatering screen - – average normalised odour emission rate from “Sludge Dewatering Building” samples.

Details of the odour emissions calculations are presented in Table 5.1.

Table 5.1 Odour emission calculations

Emission source	Diameter (m)	Area (m^2)	Air flow (m^3/hr)	Exit diameter (m)	Velocity (m/s)	Specific Odour Emission Rate (ou.m^3/m^2/s)	Emission reduction	Odour emission rate (ou.m^3/s)
Wet well	3.5	9.3	-	-	-	12.336	99%	1.153
Sludge tank	3.5	9.3	-	-	-	12.336	99%	1.153
Buffer tank	18.5	268.8	-	-	-	12.336	99%	33.159
Pre-screen 1 + bin		2.5				0.0694	-	-
Pre-screen 2 + bin		2.5				0.0694	-	-
Dewatering screen		10				0.3631	-	-
Scrubber #1 and #2			18	0.15	0.3	-	95%	0.0995
WAS holding tank #1 and #2	2.4	4.5	-	-	-	12.336	99%	0.558

Note: Emissions from Pre-screen 1 + bin, Pre-screen 2 + bin and Dewatering screen are captured by Scrubber #1 and #2

5.2 Peak-to-mean

The calculated hourly odour emission rates were paired with the appropriate near field peak-to-mean ratios from Table 6.1 of the NSW EPA Approved Methods for Modelling. The EPA-recommended peak-to-mean ratios are designed to convert the predicted one-hour average odour concentrations to a 1-second nose response concentration for comparison with the appropriate impact assessment criterion for odour. For the type of emission source adopted in the modelling (wake affected point source or volume source) a peak-to-mean ratio of 2.3 has been applied.

6 Dispersion modelling

6.1 Dispersion model selection and configuration

The atmospheric dispersion modelling completed for this assessment used the AERMOD dispersion model (version v23132). AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain.

In addition to the 36 individual assessment locations (documented in Section 2.2), odour concentrations were predicted over a nested grid domain of 10 km by 10 km with spacing ranging from 50 to 500 decreasing with proximity to the AIBP (totalling 5,770 receptor points).

The BPIP PRIME model in AERMOD was used for future proposed buildings within 100 m of the proposed scrubber stacks. These were implemented to account for building wake effects from the proposed development and surrounding building structures.

Modelling was undertaken using a combination of area sources (for external tanks), point sources (scrubbers) and volume sources (for WAS holding tank carbon filters). The location of model emission sources are aligned with the site layout shown in Figure 1.3.

Simulations were undertaken for the 12-month period for January to December 2021 using the AERMET-generated meteorological domain file (see Section 4.2 for a description of input meteorology).

6.2 Predicted odour concentrations

Predicted 99th percentile 1-second odour concentrations from the facility are presented in Table 6.1 for each of the adopted assessment locations. A contour plot illustrating the spatial variation in predicted odour concentrations is presented in Figure 6.1.

It is noted that the isopleth plots of the 1-second average odour concentrations do not represent the dispersion pattern for any individual time period, but rather illustrate the highest concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2021 modelling period.

The results of the dispersion modelling show that the operation of the facility is unlikely to generate adverse odour impacts in the surrounding environment. The proposed odour emission mitigation measures (discussed in Section 5.1) are therefore likely to be effective at limiting the potential odour emission generation from the facility.

Table 6.1 Predicted 99th percentile 1-second odour concentration (ou)

Assessment location ID	Predicted 99th percentile 1-second odour concentration (ou)
Criterion	**2**
R1	<1
R2	<1
R3	<1
R4	<1
R5	<1
R6	<1
R7	<1
R8	<1
R9	<1
R10	<1
R11	<1
R12	<1
R13	<1
R14	<1
R15	<1
R16	<1
R17	<1
R18	<1
R19	<1
R20	<1
R21	<1
R22	<1
R23	<1
R24	<1
R25	<1
R26	<1
R27	<1
R28	<1
R29	<1
R30	<1
R31	<1

Assessment location ID	Predicted 99th percentile 1-second odour concentration (ou)
Criterion	**2**
R32	<1
R33	<1
R34	<1
R35	<1

Figure 6.1 Predicted 99th percentile 1-second odour concentration (ou) contours

7 Conclusion

This odour impact assessment presents a quantitative modelling assessment of potential odour emissions and impacts from the proposed facility.

Meteorological modelling was completed using AERMET, with observations incorporated primarily from the BoM Badgerys Creek AWS recorded during 2021.

Odour emissions were estimated using conservative odour monitoring sample from the SWC odour emissions database. Atmospheric dispersion modelling of odour emissions was undertaken using the AERMOD dispersion model.

The results of the modelling showed that the predicted odour concentrations from the facility were below the applicable NSW EPA odour impact assessment criteria for urbanised areas at all assessment locations.

The results of the dispersion modelling show that the operation of the facility is unlikely to generate adverse odour impacts in the surrounding environment. The proposed odour emission mitigation measures (discussed in Section 5.1) are therefore likely to be effective at limiting the potential odour emission generation from the facility.

References

Aquacell 2024, *Recycled Water Quality Management Plan Alspec Industrial Business Park Blackwater Treatment Plant Luddenham Rd, Orchard Hills*, June 2024.

Department of Environment and Climate Change:

- 2006a, Technical Framework: Assessment and management of odour from stationary sources in NSW

- 2006b, Technical Notes: Assessment and management of odour from stationary sources in NSW.

NSW EPA 2022, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*. New South Wales Environment Protection Authority, Sydney.

RWDI 2022, *Patons Lane Resource Recovery Facility – Integrated Water and Leachate Plant Modifications Air Quality Impact Assessment* December 2022

Abbreviations

AERMOD	AMS /USEPA regulatory model
AIBP	Alspec industrial business park
AWS	Automatic weather station
BAC	Biological activated carbon filter
BoM	Bureau of Meteorology
Council	Penrith City Council
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	development application
DCCEEW	NSW Department of Climate Change, Energy, the Environment and Water
EMM	EMM Consulting Pty Limited
Facility	Proposed on-site sewer management facility
km	kilometres
kL	kilolitre
LGA	local government area
MBR	Membrane bioreactor
NSW EPA	NSW Environment Protection Authority
ou	odour units
SWC	Sydney Water Corporation
UV	Ultraviolet light
WAS	waste activated sludge

Appendix A
Meteorological analysis

EMM
creating opportunities

A.1 Meteorological data analysis for the Badgerys Creek AWS – 2019 to 2023

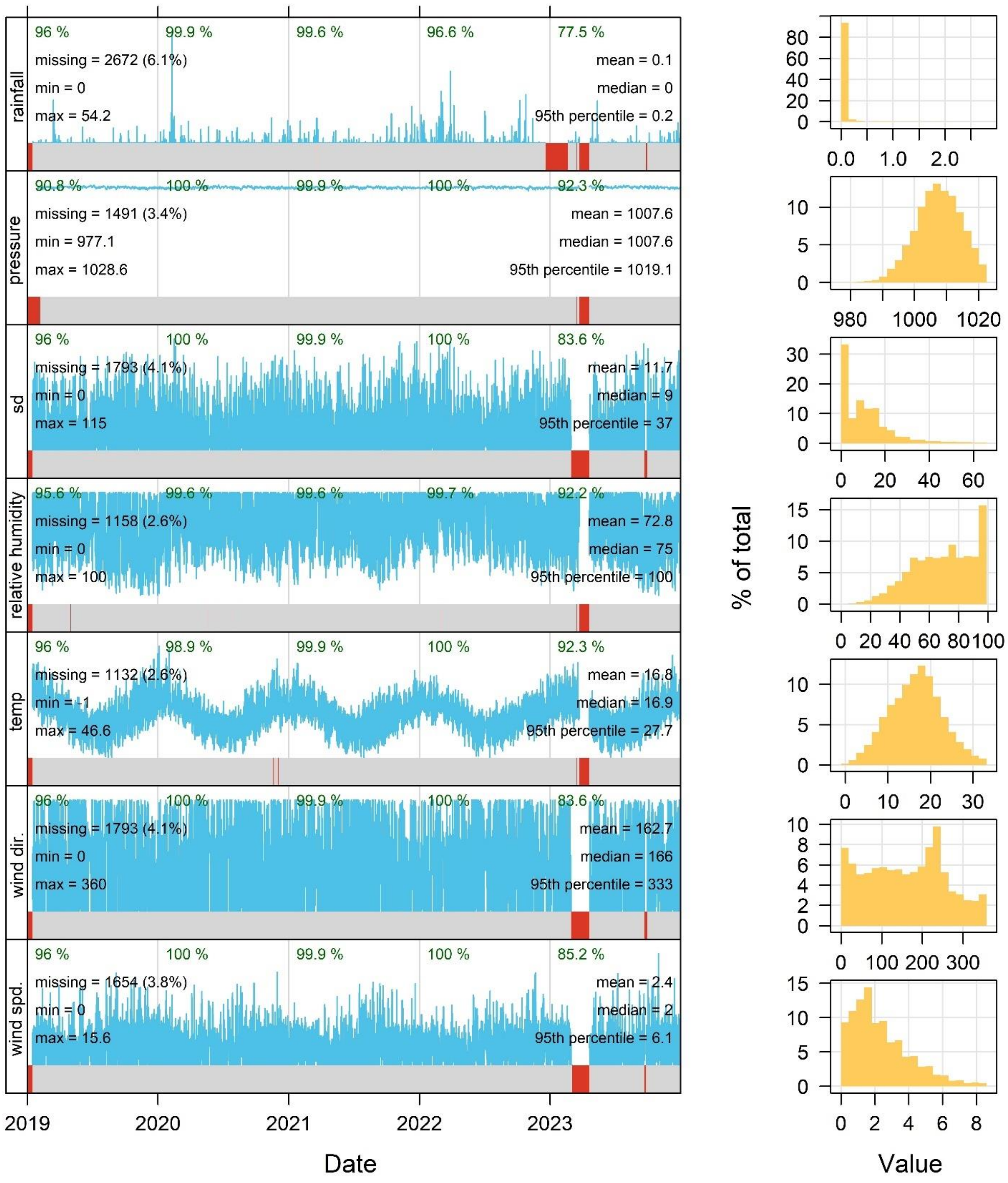


Figure A.1 Data completeness analysis plot – BoM Badgerys Creek AWS – 2019 to 2023

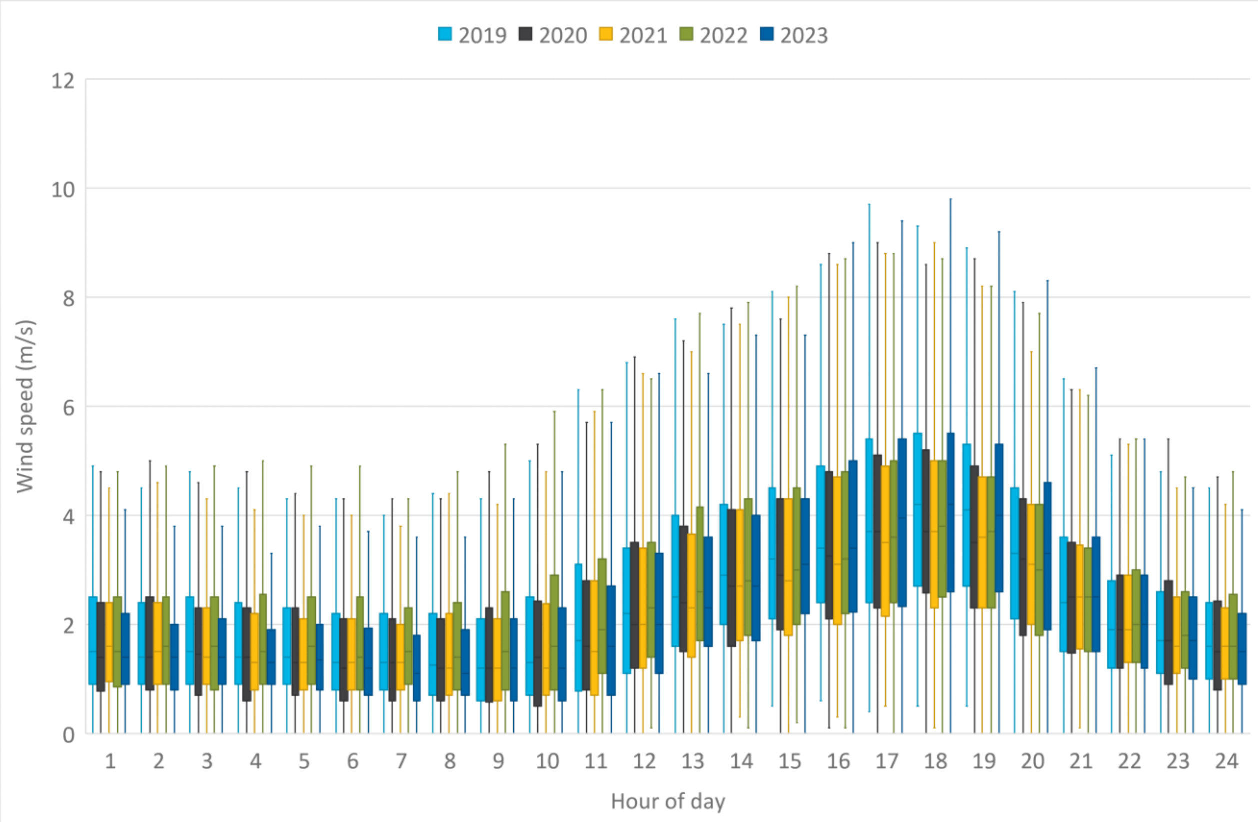


Figure A.2 Inter-annual variability in diurnal wind speed – Badgerys Creek– 2019 to 2023

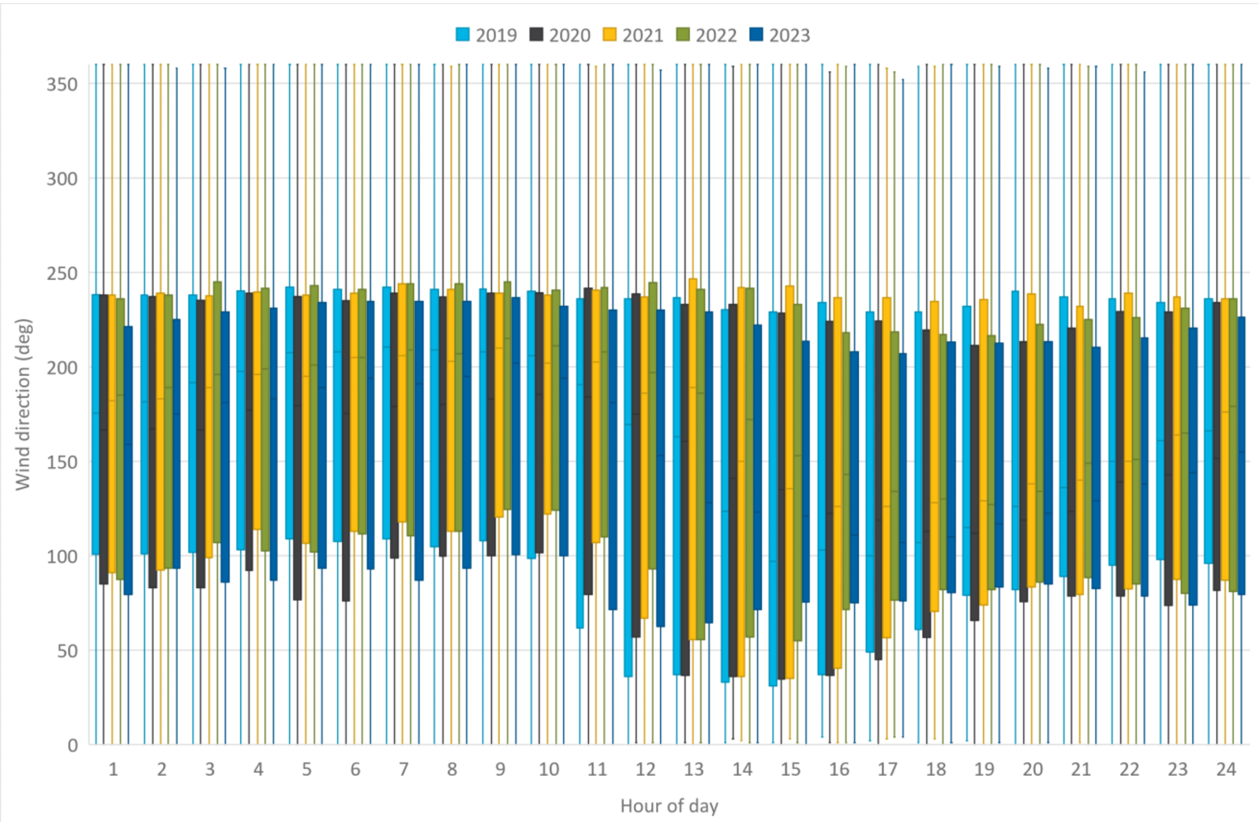


Figure A.3 Inter-annual variability in diurnal wind direction – Badgerys Creek– 2019 to 2023

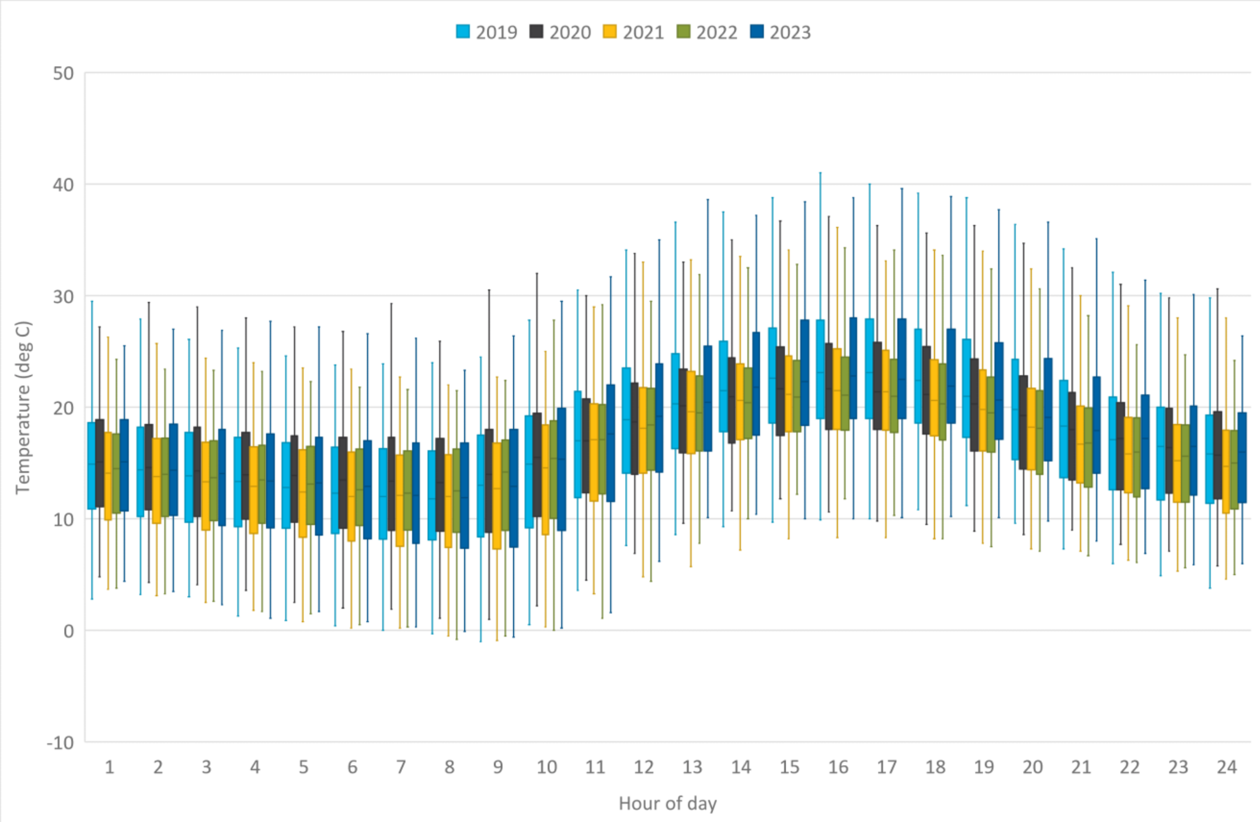


Figure A.4 **Inter-annual variability in diurnal air temperature – Badgerys Creek– 2019 to 2023**

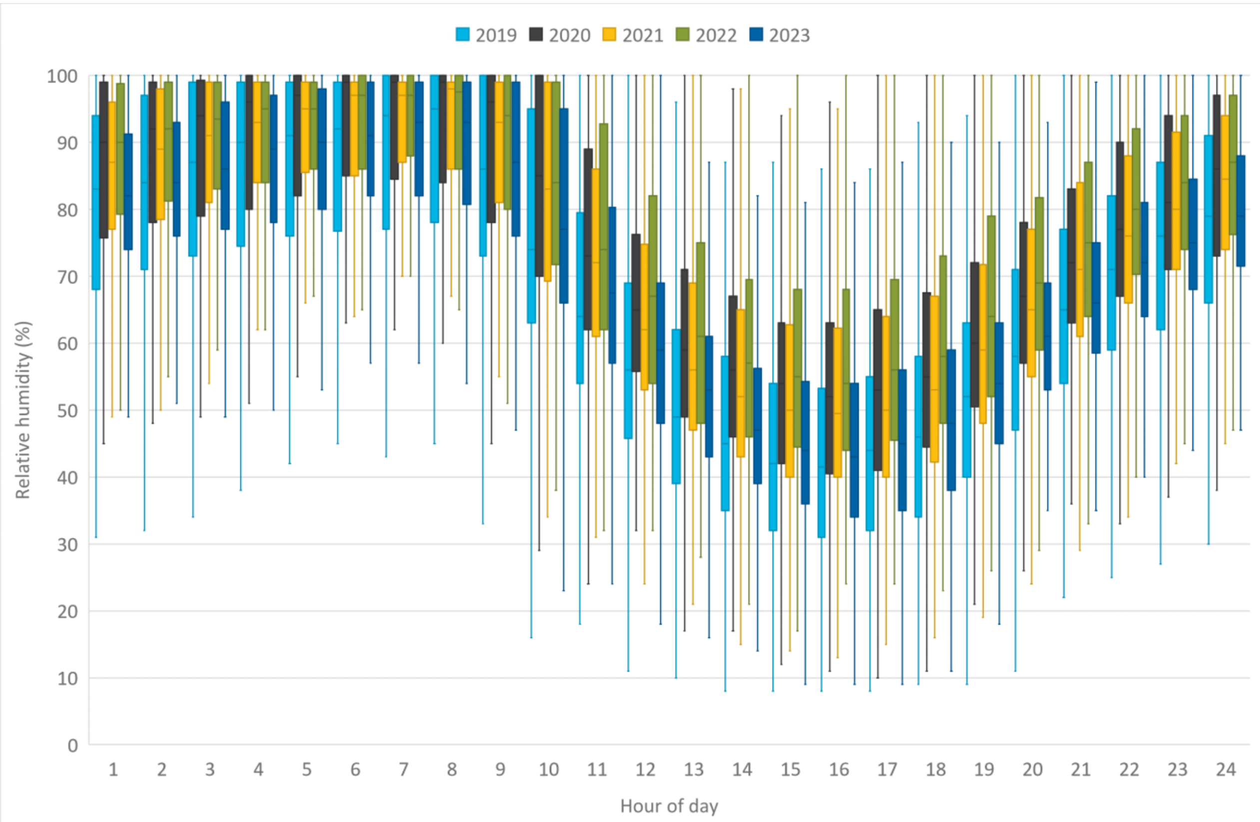


Figure A.5 **Inter-annual variability in diurnal relative humidity – Badgerys Creek– 2019 to 2023**

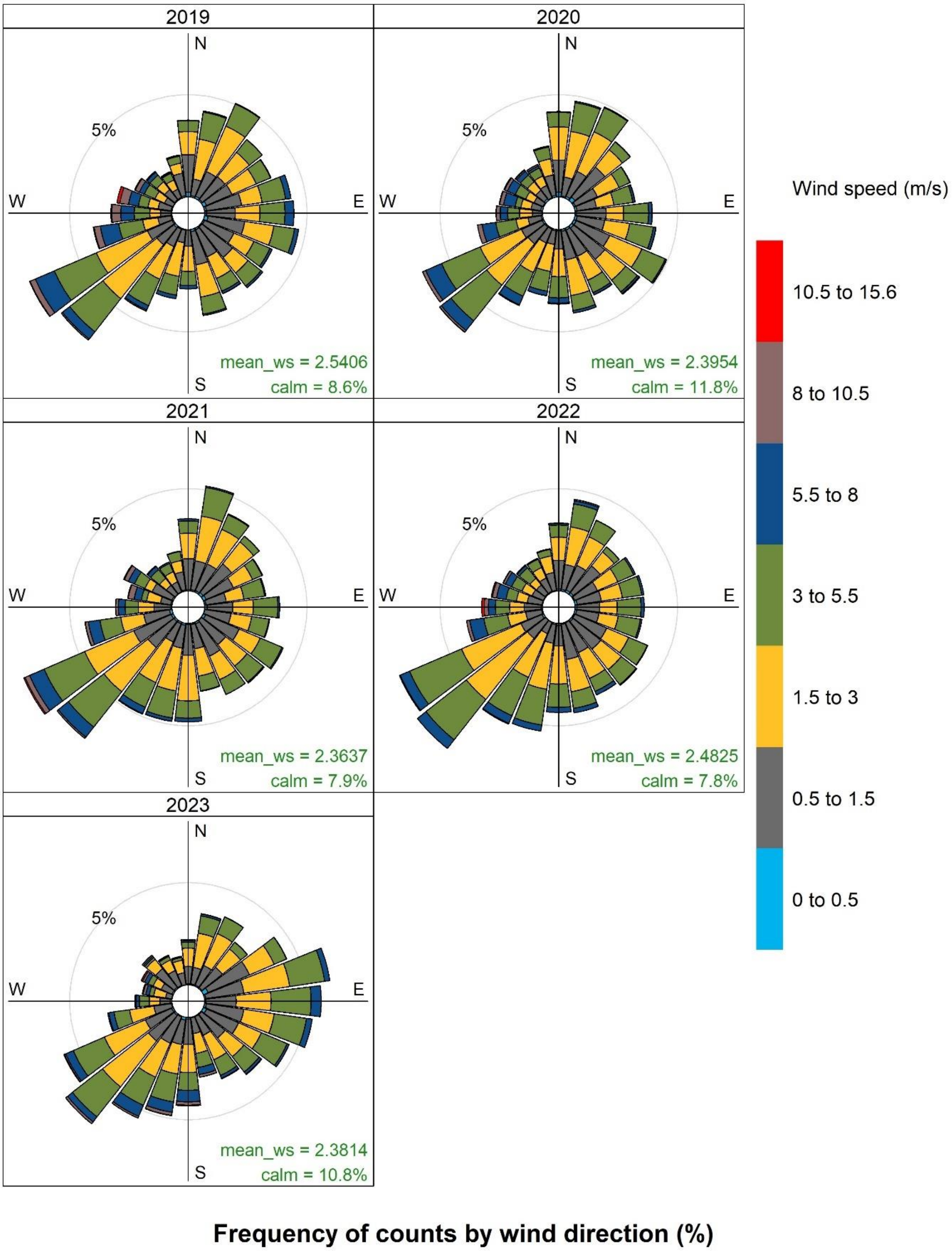


Figure A.6 Inter-annual comparison of recorded wind speed and direction – Badgerys Creek AWS – 2019 to 2023

A.2 Meteorological modelling

A.2.1 TAPM modelling

The CSIRO prognostic meteorological model TAPM was used to generate the required upper air prognostic dataset required for AERMET modelling.

TAPM was configured and run as follows:

- TAPM version 4.0.4
- inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data)
- grid domains with cell resolutions of 30 km, 10 km, 3 km, 1 km and 0.3 km. Each grid domain features 25 x 25 horizontal grid points and 25 vertical levels
- TAPM default databases for land use, synoptic analyses and sea surface temperature;
- TAPM defaults for advanced meteorological inputs
- surface meteorological data from the BoM Badgerys Creek AWS location were incorporated into the modelling
- two 'spin-up' days allowed at the beginning and end of the run.

A.2.2 AERMET meteorological processing

The meteorological inputs for AERMOD were generated using the AERMET meteorological processor. The following sections provide an overview of meteorological processing completed for this assessment.

A.2.3 Surface characteristics

Prior to processing meteorological data, the surface characteristics of the area surrounding the adopted monitoring station require parameterisation. The following surface parameters are required by AERMET:

- surface roughness length
- albedo
- Bowen ratio.

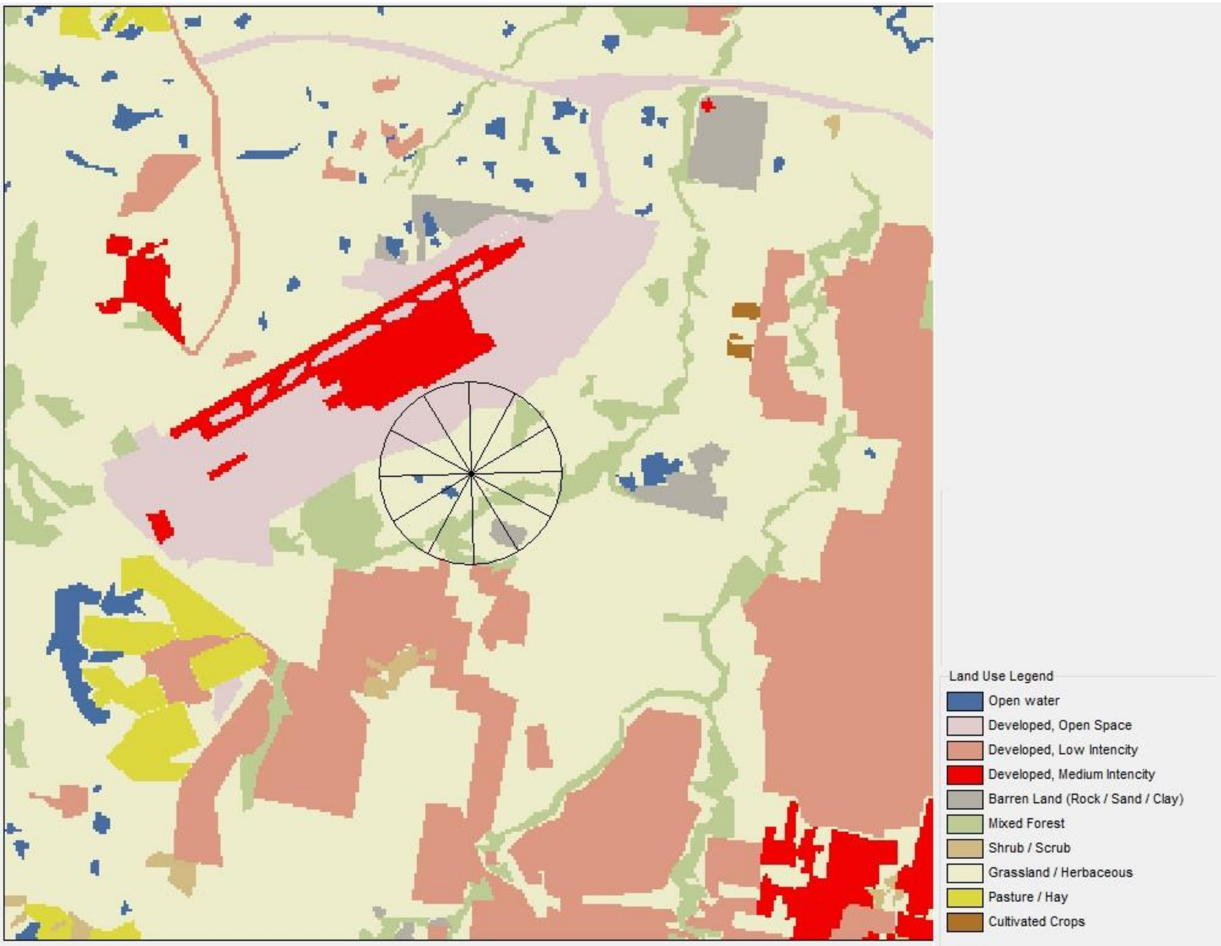
As detailed by USEPA (2013), the surface roughness length is related to the height of obstacles to the wind flow (e.g. vegetation, built environment) and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

The land cover of the 10 km by 10 km area surrounding the BoM Badgerys Creek AWS was mapped (see Figure A.7). Using the AERSURFACE tool and following the associated guidance of USEPA (2013), surface roughness was determined for 12 (30 degree) sectors grouped by similar land use types within a 1 km radius around the BoM Badgerys Creek AWS, while the Bowen ratio and albedo were determined for the total area. Monthly-varying values for surface roughness, Bowen ratio and albedo were allocated to each sector based on the values prescribed by USEPA (2013).

Surface moisture characteristics for the 2021 modelling period was determined by comparing the period rainfall total to the previous 30-year rainfall records from the following BoM long term rainfall stations:

- Badgerys Creek AWS (067108)
- Bringelly (Maryland) (067015)
- Orchard Hills Treatment Works (067084).

Annual rainfall modelling was 1,064 mm, which places the 12-month period wetter than average with the 70th percentile rainfall totals for the previous 30 years. A 'wet' surface moisture classification was allocated. It is noted that the rainfall records are not incorporated into dispersion model predictions (i.e. no wet deposition is modelled).



Note: Marked in figure are the 1 km radius for surface roughness (12 sectors defined) and 10 km x 10 km for albedo/Bowen ratio (total image shown)

Figure A.7 Land use map for AERSURFACE processing

Table A.1 Monthly surface roughness length values by sector

Month	Surface roughness length (m) by sector (degrees)											
	0-30	30-60	60-90	90-120	120-150	150-180	180-210	210-240	240-270	270-300	300-330	330-0
Jan	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Feb	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Mar	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Apr	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
May	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Jun	0.119	0.060	0.032	0.057	0.049	0.016	0.145	0.134	0.163	0.076	0.023	0.219
Jul	0.119	0.060	0.032	0.057	0.049	0.016	0.145	0.134	0.163	0.076	0.023	0.219
Aug	0.119	0.060	0.032	0.057	0.049	0.016	0.145	0.134	0.163	0.076	0.023	0.219
Sep	0.185	0.129	0.092	0.125	0.116	0.039	0.169	0.167	0.190	0.114	0.057	0.254
Oct	0.185	0.129	0.092	0.125	0.116	0.039	0.169	0.167	0.190	0.114	0.057	0.254
Nov	0.185	0.129	0.092	0.125	0.116	0.039	0.169	0.167	0.190	0.114	0.057	0.254
Dec	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271

Table A.2 Monthly Bowen ratio and albedo values (all sectors)

Month	Monthly value (all sectors)	
	Bowen ratio	Albedo
January	1.03	0.18
February	1.03	0.18
March	1.13	0.18
April	1.13	0.18
May	1.13	0.18
June	1.13	0.18
July	1.13	0.18
August	1.13	0.18
September	0.98	0.18
October	0.98	0.18
November	0.98	0.18
December	1.03	0.18

A.2.4 Meteorological inputs

Monitoring data from the Canterbury Racecourse AWS were combined with TAPM meteorological modelling outputs for input to AERMET. The following parameters were input as input data to AERMET:

- wind speed and directions – Badgerys Creek AWS
- temperature (heights of 10 m and 50 m) – Badgerys Creek AWS (10 m) and TAPM (50 m)
- relative humidity – Badgerys Creek AWS
- station level pressure – Badgerys Creek AWS
- cloud cover – Bankstown Airport AWS (in absence of measurements at Badgerys Creek)
- solar insolation – TAPM
- mixing depth – TAPM.

The period of meteorological data input to AERMET was 1 January 2021 to 31 December 2021.

A.2.5 Upper air profile

Due to the absence of necessary local upper air meteorological measurements, the hourly profile generated by TAPM at the Badgerys Creek AWS location was adopted. Using the temperature difference between levels, the TAPM-generated vertical temperature profile for each hour was adjusted relative to the hourly surface (10 m) temperature observations from the Badgerys Creek AWS.

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