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Tallawarra B Permit Modification: Air Quality Assessment

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Final

Prepared by:

Katestone Environmental Pty Ltd
ABN 92 097 270 276
Ground Floor, 16 Marie Street | PO Box 2217
Milton, Brisbane, Queensland, 4064, Australia

www.katestone.com.au
admin@katestone.com.au
Ph +61 7 3369 3699
Fax +61 7 3369 1966

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Contents

Tables

Figures

Contour Plates

Glossary

Term	Definition
$\mu g/m^3$	micrograms per cubic metre
°C	degrees Celsius
g/s	gram per second
kg	kilogram
kg/year	kilogram/year
km	kilometre
m	metre
mm	millimetre
m/s	metres per second
mg/m^3	milligram per cubic metre
MW	megawatt
m^3/s	cubic metres per second
%	percent
Nomenclature	**Definition**
CO	carbon monoxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
PM_{10}	particulate matter with a diameter less than 10 micrometres
$PM_{2.5}$	particulate matter with a diameter less than 2.5 micrometres
VOC	volatile organic compound
Abbreviations	**Definition**
Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
BACT	Best Available Control Technology
BoM	Bureau of Meteorology
CCGT	Combined Cycle Gas Turbine
Clean Air Regulation	*Protection of the Environment Operations (Clean Air) Regulation 2010*
DPIE	NSW Department of Planning, Industry and Environment
EES	Environment, Energy and Science Group
EIS	Environmental Impact Statement
EPA	New South Wales Environmental Protection Authority
EPL	Environmental Protection Licence
MEL	Minimum Environmental Load – minimum load at which compliance with NOx limits can be maintained
NSW	New South Wales
OCGT	Open Cycle Gas Turbine
PDD	Plume Dispersion Device
POEO Act	*Protection of the Environment (Operations) Act 1997*
TAPM	The Air Pollution Model
TAPS	Tallawarra A Power Station
TBPS	Tallawarra B Power Station

EXECUTIVE SUMMARY

Katestone Environmental Pty Ltd (Katestone) was commissioned by EnergyAustralia to prepare an air quality assessment to support its Tallawarra B Power Station (TBPS) Project approval modification application. TBPS is an approved but not yet built peak load gas-fired power station with a nominal output of up to 450 megawatts (MW), to be located on the western edge of Lake Illawarra, approximately 12km southwest of Wollongong in New South Wales (NSW).

A permit modification is required to extend the lapse date for TBPS approval and to amend certain approval conditions that align with the current design. EnergyAustralia has identified that one single open cycle gas turbine (OCGT) with a nominal output of up to 400 MW best meets the operational objectives of TBPS. Further to this, to ensure compliance with aviation safety requirements, a plume dispersion device (PDD) will be fitted to the exhaust stack.

This air quality assessment aims to quantify the TBPS's effect on air quality using site representative data and information, including the proposed turbine configuration, PDD, meteorology and a range of operating loads. The assessment has used a dispersion modelling approach conducted in accordance with the NSW Environmental Protection Authority's (EPA) *Approved Methods for Modelling and Assessment of Air Pollutants in NSW (EPA, 2016)* (Approved Methods). A site-specific meteorological data file for 2018 has been generated using the TAPM meteorological model and local observations. The meteorological modelling has accounted for local terrain and land use features of the region.

EnergyAustralia is currently conducting a bidding process to select a supplier for the Tallawarra B OCGT with PDD. Exhaust characteristics and air pollutant emissions information for input into the TAPM dispersion model were reviewed from four potential suppliers and worst-case information were selected for use in the assessment.

Exhaust characteristics include PDD release height, exit diameter, velocity, temperature, flow and exhaust gas composition. The air pollutants considered are the main products of gas combustion, namely: oxides of nitrogen (NO_x) and particulate matter (PM) (as PM_{10} and $PM_{2.5}$), which were identified in the original TBPS approval as most critical air pollutants with other air pollutants found to be well below impact assessment criteria. The air quality assessment has considered potential emissions of air pollutants associated with three operational scenarios, namely: 100% load, minimum environmental load (MEL) and start up.

The TAPM dispersion model has been used to predict ground-level concentrations of pollutants that will be generated by TBPS. A cumulative assessment that includes modelling emissions from Tallawara A power Station (TAPS) and addition of ambient backgrounds has been conducted. The results of the dispersion modelling have been assessed against the relevant impact assessment criteria in NSW.

The dispersion modelling results for NO_2 showed the following:

- Predicted ground-level concentrations of NO_2 for TBPS in isolation, operating at either 100% load or MEL, were below the relevant impact assessment criteria at all locations.
- The sensitive receptor with the highest 1-hour average ground-level concentration of NO_2 due to TBPS in isolation at 100% load was South Dapto, to the west of TBPS, with a concentration of 87.9µg/m^3 or 36% of the impact assessment criterion (246µg/m^3).
- Predicted ground-level concentrations of NO_2 for the cumulative assessment including TAPS, with TBPS operating at either 100% load or MEL, were below the relevant assessment criteria at all locations.

- The sensitive receptor with the highest 1-hour average NO_2 ground-level concentration in the cumulative assessment with TBPS at 100% load was South Dapto, to the west of TBPS, with a concentration of 170µg/m³ or 69% of the impact assessment criterion (246µg/m³).

The dispersion modelling results for PM_{10} and $PM_{2.5}$ showed the following:

- Predicted ground-level concentrations of PM_{10} and $PM_{2.5}$ from the proposed TBPS in isolation, operating at either 100% load or MEL, were less than 8% of the relevant assessment criteria at all locations.
- Ambient air quality monitoring conducted by the NSW Department of Industry, Planning and Environment (DPIE) at Kembla Grange shows that there were 10 days in 2018 when the concentration of PM_{10} was above 50µg/m³. The cumulative PM_{10} assessment, using a contemporaneous approach, predicted no additional days above the 50µg/m³ assessment criterion.
- Predicted maximum 24-hour average ground-level concentrations of $PM_{2.5}$ due to TBPS in isolation operating at either 100% load or MEL plus background, were below the impact assessment criterion of 25 µg/m³ at all locations.
- Predicted annual average ground-level concentrations of PM_{10} and $PM_{2.5}$ due to TBPS operating at either 100% load or MEL plus background, were below the relevant impact assessment criteria at all locations.

A regional air quality assessment has also been undertaken to determine the potential for increase in ozone formation due to TBPS. This has been conducted through a level 1 screening ozone assessment following methods in the report prepared on behalf of EPA titled: *A Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (Environ Australia Pty Ltd, 2011) (Tiered Ozone Procedure).

The regional air quality screening assessment showed the following:

- The maximum 1-hour and 4-hour incremental concentrations of ozone calculated for TBPS were 0.39 ppb and 0.26 ppb, respectively.
- The incremental concentrations are below the maximum allowable increment of 1 ppb and, therefore, the potential impact is insignificant, and a detailed ozone assessment is not required.
- Compared to the two E-Class OCGT in the original EIS, annual emissions of NOx from the modified proposal are anticipated to be lower by about 15%.

GHG emissions associated with the operation of the Project are predominantly associated with the combustion of natural gas to produce electricity. GHG emissions and energy use per year of operations of the Project are summarised in the following table:

Parameter	Quantity	Units
Electricity production	1,177,804	MWh/y
Natural gas consumption	11,420,342	GJ/y
GHG emissions	588,490	tCO_2-e/y

Compared to the two E-Class OCGT in the original EIS, annual GHG emissions from the modified proposal are anticipated to be lower by 20%.

1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was commissioned by EnergyAustralia to prepare an air quality assessment to support its application to modify the Tallawarra B Power Station (TBPS) Project approval. TBPS is an approved but not yet built peak load gas-fired power station with a nominal output of up to 450 megawatts (MW).

A modification of the Project approval is required to extend the lapse date for TBPS approval and to amend certain approval conditions that align with the current design. EnergyAustralia has identified that one single open cycle gas turbine (OCGT) with a nominal output up to 400 MW best meets the operational objectives of TBPS. Further to this, to ensure compliance with aviation safety requirements, a plume dispersion device (PDD) will be fitted to the exhaust stack.

This report details an air quality assessment of the proposed TBPS for inclusion with an application to modify the Project approval. The air quality assessment has been prepared in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (*Approved Methods*)* (EPA, 2017) and aims to quantify the effect of TBPS on air quality using site representative data and information, including the proposed turbine configuration, PDD, meteorology and a range of operating loads. The following air pollutants associated with emission from TBPS have been assessed and were identified in the original TBPS approval as most important, namely:

- Potential impacts on local air quality:
  - Oxides of nitrogen (NO_x) as nitrogen dioxide (NO_2)
  - Solid particles as PM_{10} and $PM_{2.5}$
- Potential impact on regional air quality:
  - Ozone (O_3) (includes consideration of emissions of carbon monoxide (CO) and volatile organic compounds (VOCs)).

2. PROJECT DESCRIPTION

2.1 Overview

TBPS is an approved but not yet built peak load power station with a nominal output of up to 450 megawatts (MW) in open cycle. The power station was granted approval in 2010 following the completion of an Environmental Impact Statement (EIS) (SKM, 2010).

TBPS is proposed to be built to the immediate east of EnergyAustralia's existing Tallawarra A Power Station (TAPS) on the western edge of Lake Illawarra, approximately 12km southwest of Wollongong in New South Wales (NSW).

EnergyAustralia is now proposing to modify the Project approval to extend the TBPS approval lapse date and to amend approval condition 1.5, which relates to the turbine configuration. An extension of time is proposed to address the lapsing of the TBPS approval which occurs on 21 December 2020. A two-year extension is sought, which would extend the lapse date to 21 December 2022. The proposed extension to the lapse date would allow EnergyAustralia further time to complete final design and begin construction of TBPS.

Condition of approval 1.5 allows for the construction and operation of a two- or three-unit open cycle gas turbine (OCGT) power plant. Recent design developments for TBPS have identified that one single OCGT with a nominal output up to 400 MW best meets the operational objectives of the power station. Accordingly, a modification to the Project approval is required to amend condition of approval 1.5. EnergyAustralia proposes that condition 1.5 be updated to read:

> *"The project shall comprise up to a three-unit gas turbine power plant with a total nominal output of up to 450 megawatts operating in open cycle mode or a single unit gas turbine plant with a nominal output of 400 megawatts operating in combined cycle mode."*

Further to the above, the proposed TBPS exhaust stack would incorporate a plume dispersion device (PDD). A PDD ensures no impact to the safety of aircraft using the nearby Illawarra Airport, a requirement of condition of approval 1.6.

2.2 TBPS infrastructure

The current design for TBPS is for a single OCGT. OCGT is proven technology that is commercially viable and suited to providing for peak load requirements, with high reliability and safety, good efficiency and environmental performance and able to perform fast start ups. EnergyAustralia forecasts that future electricity demand would require TBPS to operate with a capacity factor of 35% at times of peak demand.

Gas will be supplied to TBPS from the existing gas pipeline that supplies the adjacent TAPS. Gas will be delivered directly into the OCGT and so no storage will be required on site.

The primary air pollutants that are generated by a gas turbine are oxides of nitrogen (NO_X), particulate matter (PM), carbon monoxide (CO), and to a lesser extent volatile organic compounds (VOC). As a design measure to control the formation of NO_X, dry low NO_X (DLN) burners will be installed at TBPS. Greenhous gases will also be generated by the combustion of natural gas.

The exhaust gases from the OCGT will be discharged via an approximately 50m tall exhaust stack. The exhaust stack will have a PDD to minimise the vertical velocity of exhaust gases and potential impacts to the safety of aircraft using the nearby Illawarra Airport. The PDD will be integral to the exhaust stack and will be installed on top of the exhaust stack. The design of the PDD would include a number of outlets, angled away from the vertical and each other. Exhaust gases from the gas turbine will travel up the stack and discharge via the PDD outlets.

3. ASSESSMENT METHODOLOGY

This air quality assessment aims to quantify the proposed TBPS's effect on air quality using site representative data and information, including the proposed turbine configuration, PDD, meteorology and a range of operating loads. The following section provides an overview of the TBPS Project approval modification air quality assessment methodology that has been constructed following the requirements in the Approved Methods.

3.1 Legislative requirements

The regulation of air pollution in NSW is provided for in the *Protection of the Environment (Operations) Act 1997* (POEO Act), which is underpinned by a number of regulatory instruments that address air quality. A summary of the relevant instruments is provided in Section 4, including:

- *Protection of the Environment Operations (Clean Air) Regulation 2010* (Clean Air Regulation) – imposes generic operational requirements for activities and plant.
- Environmental Protection Licence (EPL) – A licence held by the operator of a scheduled activity that details the activities that may be carried out at the premises and the conditions that must be met to retain that permission.
- *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (Approved Methods) – provides statutory requirements for the assessment and modeling of air emissions from a premises.

3.2 Surrounding environment

The location of TBPS and its surrounding environment is described in terms of land use, terrain, climate, meteorology, existing air quality and location of sensitive receptors. Details are provided in Sections 5.

3.3 Site specific meteorology

A site representative three dimensional meteorological windfield was developed using the TAPM model, in accordance with Level 2 requirements stipulated in the Approved Methods. The 2018 calendar year was selected for meteorological modelling as this was considered a representative year based on an analysis of data between January 2015 to December 2019 from the Bureau of Meteorology's monitoring station at Albion Park and the NSW Department of Planning, Industry and Environment (DPIE) monitoring stations at Kembla Grange and Wollongong.

A summary of the site specific meteorology used in TAPM is detailed in Section 6. The configuration of TAPM is detailed in Appendix A along with a summary of the analysis used to select a representative year and an evaluation of the TAPM output.

3.4 Emission rates

EnergyAustralia is currently conducting a bidding process to select a supplier for the Tallawarra B OCGT with PDD. Exhaust characteristics and air pollutant emissions information for units that could be provided by four potential suppliers were reviewed. The units from one supplier have been selected for use in the assessment as they are likely to produce marginally higher ground-level concentrations of air pollutants than the units from the other suppliers.

Exhaust characteristics include PDD release height, exit diameter, velocity, temperature, flow and exhaust gas composition. The air pollutants considered are the main products of gas combustion, namely; oxides of nitrogen (NO_x) and particulate matter (PM) (as either PM_{10} and $PM_{2.5}$), which were identified in the original TBPS approval as most important. NO_x and PM emission rates have been used as input into the dispersion model to predict ground-level concentrations of NO_2, PM_{10} and $PM_{2.5}$.

The following scenarios represent the the expected range of TBPS operations:

- Maximum load (100% Load)
- Minimum Environmental Load (MEL) – minimum load at which compliance with NOx limits can be maintained
- Start up.

Carbon monoxide (CO) and volatile organic compounds (VOCs) are also found in the exhaust of OCGTs. Emissions of these air pollutants have not been considered in the dispersion model as the previous air quality assessment found ground-level concentrations to be negligible. However, CO and VOCs assist in the formation of atmospheric ozone (in combination with NOx) and their emissions have been quantified for use in the regional air quality assessment. Emissions of sulfur dioxide (SO_2) are not expected from TBPS running on gas.

Exhaust characteristics and air pollutant emissions information are detailed in Section 7.

3.5 Local air quality assessment

Dispersion modelling of the TBPS operations were conducted using TAPM to predict ground-level concentrations of NO_2 and PM (as PM_{10} and $PM_{2.5}$) across a 40km by 40km model domain centred on TBPS and at discrete locations representative of the nearest sensitive receptors.

The TBPS TAPM dispersion model configuration is detailed in Appendix A, including the methodology used to account for the angular release of exhaust plumes created by the PDD.

3.5.1 Cumulative impacts

Cumulative concentrations of air pollutants have been assessed by including the air pollutant emissions associated with TAPS in the TAPM dispersion model. An ambient air quality background concentration has then been added to TAPM dispersion modelling predictions.

Ambient air quality background levels have been determined from data collected at NSW DPIE monitoring stations at Albion Park South, Kembla Grange and Wollongong (as described in Section 5.4).

The assessment of cumulative ground-level concentrations of PM_{10} has been conducted using the Level 2 assessment methodology outlined in the Approved Methods, that is; the hourly average background concentration is added to the hourly dispersion model predictions for the modelled calendar year (2018) (contemporaneous assessment).

3.5.2 NOx conversion to NO_2

NO_x in exhaust plumes is made up of both nitric oxide (NO) and nitrogen dioxide (NO_2). Typical NO/NO_2 ratios at the point of release to the atmosphere are 90%/10%. Once in the atmosphere NO can undergo chemical transformation to form NO_2. The rate at which this conversion occurs depends on the reactivity of the atmosphere and time since release from the source.

NO_2 is more toxic than NO and is the reason why NO_2 has air quality assessment criteria rather than NO. As NO_x emitted from TBPS is primarily NO, it is important to adequately quantify the transformation of NO to NO_2 for comparison with the assessment criteria.

The Approved Methods has a tiered methodology for quantifying the NO/NO_2 reactions. In this assessment the conservative Approved Method 1 has been used, that is; NOx to NO_2 conversion is assumed to be 100% and instantaneous.

3.5.3 Presentation of results

TAPM dispersion model predictions for TBPS operations in isolation have been presented as ground-level concentrations across the model domain (contour plots) and at locations indicative of sensitive receptors. A cumulative assessment that includes TAPS and ambient background concentrations has been conducted at the locations indicative of sensitive receptors. The predicted ground-level concentrations have been assessed by comparison with the relevant impact assessment criteria for NSW that are contained in the Approved Methods (detailed in Section 4).

3.6 Regional air quality assessment

Ozone is a secondary air pollutant formed in the atmosphere from reactions of NOx, CO and VOCs with sunlight. Assessment of TBPSs potential to increase ozone formation has been conducted through a level 1 screening ozone assessment. The level 1 assessment has been conducted following the report prepared on behalf of EPA titled: *A Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (Environ Australia Pty Ltd, 2011) (Tiered Ozone Procedure).

The level 1 screening level ozone assessment for provides an assessment of the incremental change in ozone due to a new emission source and the cumulative ozone concentrations due to the new emission source in conjunction with existing sources within the Sydney Greater Metropolitan Region (GMR) Airshed (which includes the Illawarra region).

3.7 Limitations and uncertainty

A limitation of this study is that it relies on the accuracy of a number of data sets that feed into the dispersion model. These data sets have been sourced from the following:

- Meteorological monitoring observations from the Bureau of Meteorology and NSW Environment, Energy and Science Group (EES)
- Air quality monitoring observations from the NSW EES sites
- Synoptic and surface information datasets from CSIRO
- Land-use from aerial imagery
- OCGT emissions information and design provided by the bidders (through EnergyAustralia).

The assessment also requires a methodology to assess the angular release of the exhaust from TBPS considering the limitation that dispersion models can only account for a vertical release. The methodology involves calculating the vertical component of the flow vector and using that as the exit velocity in the model. A limitation of this method is that any significant downward travel is not accounted for in the model. However, due to the high temperatures of the exhaust plumes from TBPS, the thermal buoyancy would be expected to result in initial plume rise. Therefore, reducing the initial velocity is seen as an appropriate method to account for the angular release.

It is also important to note that numerical models are based on an approximation of governing equations and will inherently be associated with some degree of uncertainty. The more complex the physical model, the greater the number of physical processes that must be included. There may be physical processes that are not explicitly accounted for in the model and, in general, these approximations tend to lead to an over prediction of air pollutant levels.

4. LEGISLATIVE FRAMEWORK FOR AIR QUALITY

4.1 Protection of the Environment (Operations) Act 1997

The POEO Act provides a framework for the:

- Licensing and imposition of licence conditions by EPA in relation to activities that are defined under Schedule 1 of the POEO Act
- Development of Protection of the Environment Policies
- Definition of offences and penalties in relation to air pollution under Sections 124-129
- Definition of offences relating to licensing and conditions
- Development of regulations and guidelines that promulgate impact assessment criteria and emission standards for industry
- Provision of a mechanism for public participation in the environmental assessment of activities that may be licensed by EPA, in conjunction with the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The management of air pollution in NSW is dealt with in *Part 5.4 (sectio*ns 124-135) of the POEO Act. This includes the general requirement that non-residential premises do not cause air pollution by failing to operate or maintain plant, carry out work or deal with materials in a proper and efficient manner (sections 124-126).

Section 128 of the POEO Act requires each premises to comply with any air emission standards prescribed by applicable regulations; where standards are not prescribed for a particular air impurity, all practical means must be taken to prevent or minimise air pollution.

4.2 Clean Air Regulation

Section 128 of the POEO Act relates to standards of concentration that apply to point sources:

> *128 Standards of air impurities not to be exceeded*
>
> > *(1) The occupier of any premises must not carry on any activity, or operate any plant, in or on the premises in such a manner as to cause or permit the emission at any point specified in or determined in accordance with the regulations of air impurities in excess of:*
> >
> > > *(a) the standard of concentration and the rate, or*
> > >
> > > *(b) the standard of concentration or the rate,*
> >
> > *prescribed by the regulations in respect of any such activity or any such plant.*

The Clean Air Regulation prescribes standards of concentration for certain activities and plant in NSW. The standards of concentration are in-stack emission limits and are the maximum emissions permissible from prescribed activities anywhere in NSW. Limits are based on levels that are achievable through the application of reasonably available technology and good environmental practices. The standard of concentration depends on the Group, which is defined by Section 32 of the Clean Air Regulation. The following Group is relevant to the subject premises:

> *(f) belongs to Group 6 if it commenced to be carried on, or to operate, on or after 1 September 2005, as a result of an environment protection licence granted under the Protection of the*

Environment Operations Act 1997 pursuant to an application made on or after 1 September 2005.

The Clean Air Regulation defines standard fuels as follows:

standard fuel means any unused and uncontaminated solid, liquid or gaseous fuel that is:

(a) a coal or coal-derived fuel (other than any tar or tar residues), or

(b) a liquid or gaseous petroleum-derived fuel, or

(c) a wood or wood-derived fuel, or

(d) bagasse.

While the Clean Air Regulation prescribes a minimum level of performance for plant and equipment, stricter limits can be applied by the EPA through the conditions of an EPL.

The Clean Air Regulation standards of concentration for electricity generation for Group 6 activities are summarised in Table 1. The Clean Air Regulation standards of concentration apply at all times except during start-up and shutdown. Whilst regulations in other jurisdictions (e.g. Industrial Emissions Directive 2010/75/EU) allow exceedances to occur for short time periods, the Clean Air Regulation does not allow exceedances to occur. The Clean Air Regulation does provide an exemption to compliance with the standards of concentration during start-up and shutdown.

Table 1 Clean Air Regulation standards of concentration for electricity generation for Group 6 Activities

Air impurity	Activity or plant	Standard of concentration
Solid particles (Total)	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel	50 [a] mg/m^3
Nitrogen dioxide (NO_2) or nitric oxide (NO) or both, as NO_2 equivalent	Any turbine operating on gas, being a turbine used in connection with an electricity generating system with a capacity of 30 MW or more	70 [a] mg/m^3
	Any turbine operating on a fuel other than gas, being a turbine used in connection with an electricity generating system with a capacity of 30 MW or more	90 [a] mg/m^3
Fluorine (F2) and any compound containing fluorine as total fluoride (HF equivalent)	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel	50 [a] mg/m^3
Smoke	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel	Ringelmann 1 or 20% opacity

Table note:

[a] Reference conditions are dry, 273K, 101,3kPa, 15% O_2

4.3 Environmental Protection License

An EPL permits the holder of the licence to undertake an activity that is included in Schedule 1 of the POEO Act. The EPL specifies the intensity of the activity that can be undertaken and the conditions that must be met whilst the activity is undertaken with respect to regulating the activity's environmental impact.

EnergyAustralia operates TAPS under EPL 555 which includes the following in relation to air quality:

- Identification of discharge points for setting emission limits and monitoring requirements
- Limit conditions that specify the maximum concentration that may be emitted from a discharge point
- Load limits that specify the maximum annual pollutant discharge allowed from the premises
- Operating conditions that, for activities utilising standard fuels, tend to reflect the requirements of the to maintain plant and equipment and deal with materials in a proper and efficient manner
- Monitoring conditions that specify the frequency and method required to monitor emissions of air pollutants from discharge points
- Reporting conditions.

4.4 Assessment requirements

In NSW, air quality impact assessments of new activities or amendments to existing activities are carried out in accordance with the Approved Methods, which lists the statutory methods for modelling and assessing emissions of air pollutants from stationary sources. The Approved Methods is subordinate legislation under Part 4 of the Clean Air Regulation.

The purpose of an air quality impact assessment is to demonstrate that the proposed project is designed, constructed and operated in a manner that minimises air quality impacts (including nuisance dust and odour) and minimises risks to human health and the environment to the greatest extent practicable.

This air quality assessment has been conducted in accordance with the Approved Methods. Impact assessment criteria detailed in the Approved Methods that are relevant to the assessment are reproduced in Table 2. Compared with the original EIS, the impact assessment criteria have change as follows:

- Introduction of an annual average criterion for PM_{10}
- Introduction of 24-hour and annual average criteria for $PM_{2.5}$, although these criteria were already specified as reporting standards under the National Environment Protection (Ambient Air Quality) Measure.

Table 2 Impact assessment criteria (Approved Methods)

Pollutant	Averaging Period	Impact Assessment Criteria (µg/m³)
NO_2	1-hour	246
	Annual	62
PM_{10}	24-hour	50
	Annual	25
$PM_{2.5}$	24-hour	25
	Annual	8
Photochemical oxidants (as O_3)	1-hour	214
	4-hour	171

5. EXISTING ENVIRONMENT

5.1 Climate

A summary of climate statistics from the closest Bureau of Meteorology (BoM) weather station to TBPS, Albion Park Airport (4km south), is provided in Table 3.

The Illawarra region is classed as having a temperate climate with warm summers and cool winters. This is shown in the Albion Park Airport data (1999-2020) with January being the warmest month with a mean maximum temperature of 27°C. July is the coldest month with a mean minimum temperature of 6°C.

Rainfall occurs all year round and averages almost 900mm per year and 120 rain days. Whilst the number of rain days is fairly consistent throughout the year, rainfall is typically heaviest in the warmer months of November to April.

Table 3 Climate statistics from BoM Albion Park (1999 -2020)

Climate Summary	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C)	27.1	26.4	25.3	23.3	20.7	18.1	17.8	18.8	21.3	23.1	24.1	25.7	22.6
Mean minimum temperature (°C)	17.1	17.2	15.6	12.2	8.8	7.2	6.2	6.5	8.5	10.8	13.3	15.3	11.6
Mean daily solar exposure MJ/(m*m)	21.9	18.9	16.2	13.2	10.2	8.2	9.6	12.9	16.6	19.4	20.3	22	15.8
Mean rainfall (mm)	74	145	121	72	53	94	48	53	43	65.7	80.2	63	893
Mean number of days of rain	11	12	12.7	10.8	7.7	10.2	7.2	7.6	8	9.9	12.1	11.2	120.4

5.2 Local terrain and land-use

TBPS is situated 12 km southwest of Wollongong and on the western shore of Lake Illawarra. The area has a distinct geography due to the Pacific Ocean to the east and the Illawarra Escarpment running from the north to southwest.

The Escarpment has a peak elevation of 750m but rises sharply to over 450m. A coastal strip separates the Escarpment and the Pacific Ocean and is where the urban areas of Wollongong, Port Kembla, Shellharbour and Albion Park are located. These areas are to the northeast, east, southeast and south of TBPS, respectively.

To the northwest, west and southwest of TBPS are areas of shrubland and agricultural lands leading to the foothills of the Escapement. A number of small hills (<100m elevation) are located throughout the coastal strip along with the Lake Illawarra saltwater lagoon.

A map of the elevation in the region surrounding TBPS is shown in Figure 1.

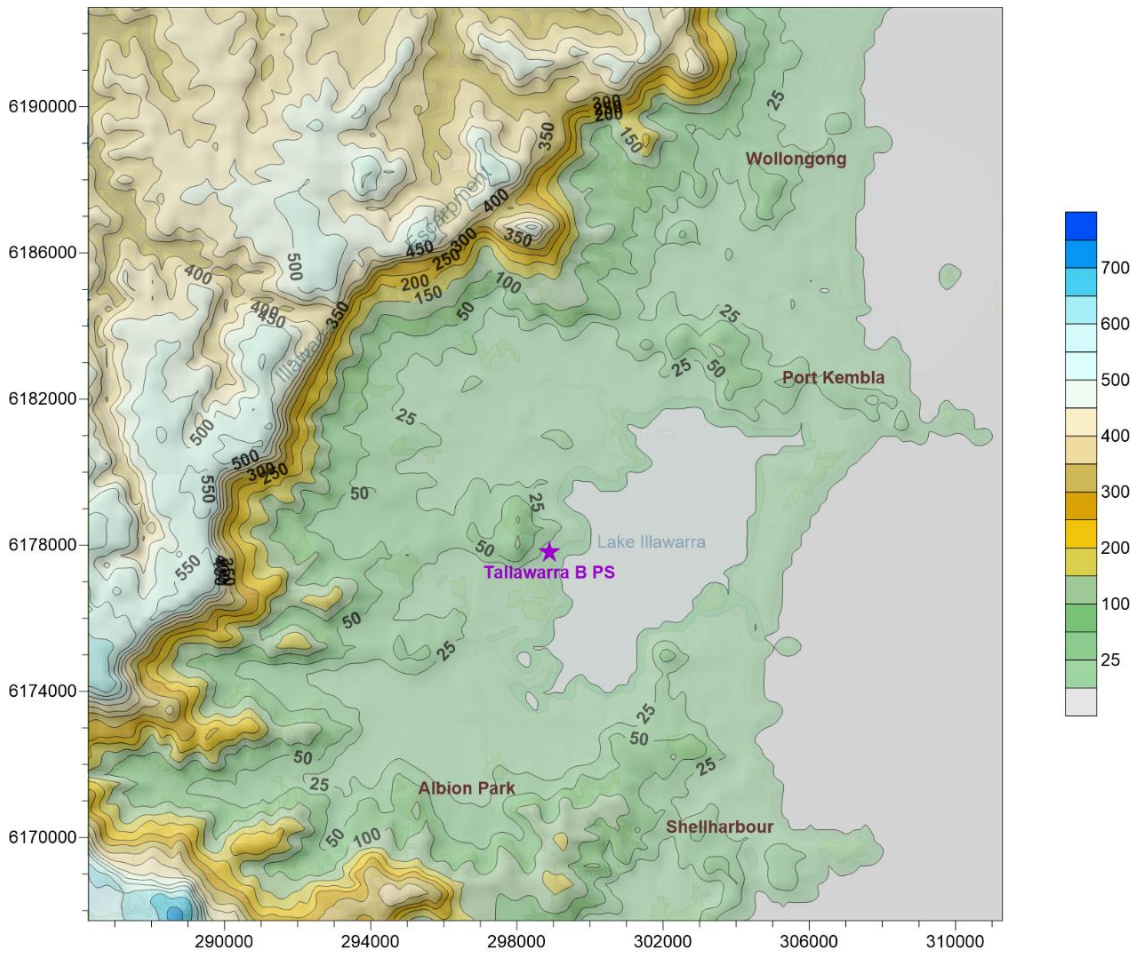


Figure 1 **Elevation (m) across the TBPS air quality assessment model domain**

5.3 Meteorology

Meteorological conditions in the region are measured by BoM at Albion Park Airport as well by the DPIE at three sites, namely, Albion Park South, Kembla Grange and Wollongong. A map of the BoM and DPIE monitoring station locations with respect to TBPS is shown in Figure 2.

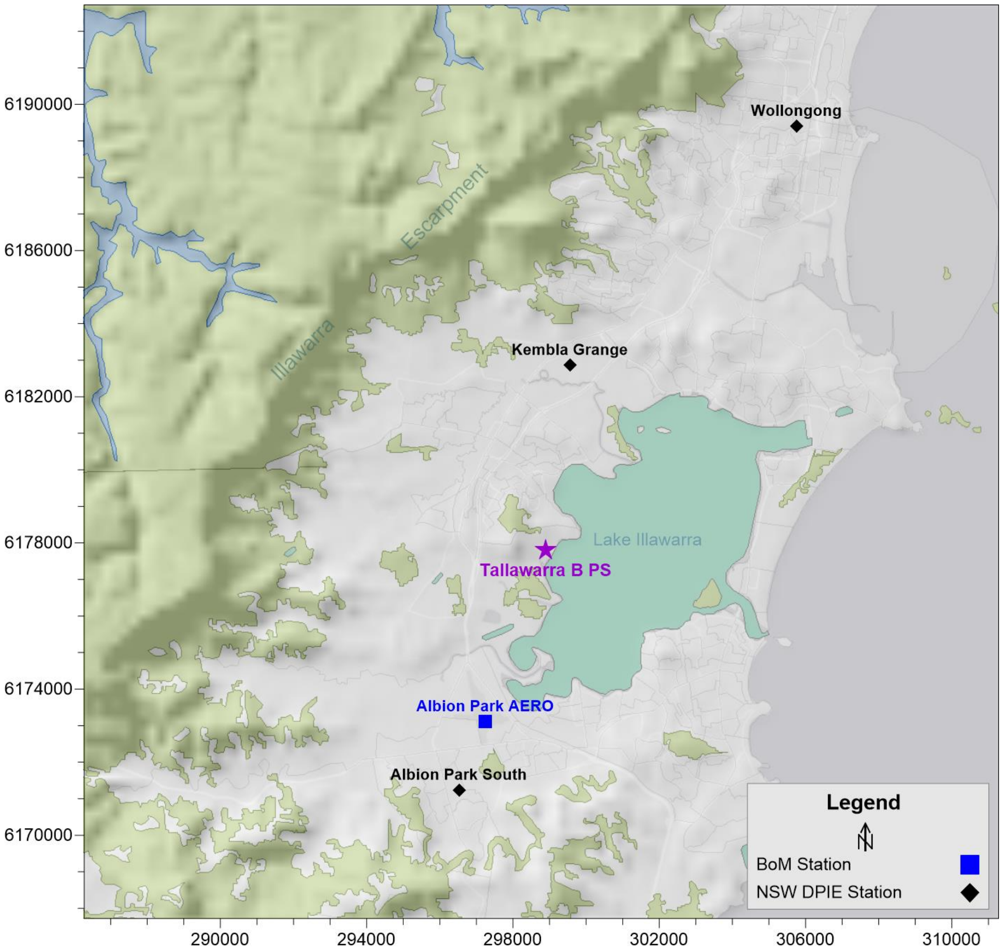


Figure 2 **Location of ambient air quality and meteorological monitoring stations (coordinates: UTM metres z56S)**

A summary of winds from three sites (BoM Albion Park Airport and DPIE Kembla Grange and Wollongong) for the past five years (2015-2019) has been provided in the form of annual seasonal and diurnal wind roses in Figure 3 to Figure 5, respectively. A summary of winds from DPIE Albion Park South has not been provided as the BoM Albion Park Airport site is in proximity.

The data shows the following:

- Winds at BoM Albion Park Airport and DPIE Kembla Grange and Wollongong show similar distributions.
- Stronger winds are recorded at the BoM site due to the exposed nature of the airport site and DPIE Kembla Grange has stronger winds than DPIE Wollongong due to the more rural location being more exposed.
- Diurnal winds show the land breeze occurring in the morning and late evening and the sea breeze occurring in the afternoon.
- Seasonal distributions show the land breeze is stronger in winter and the sea breeze stronger in summer.
- Annual distributions of winds are generally consistent across the years at each site.

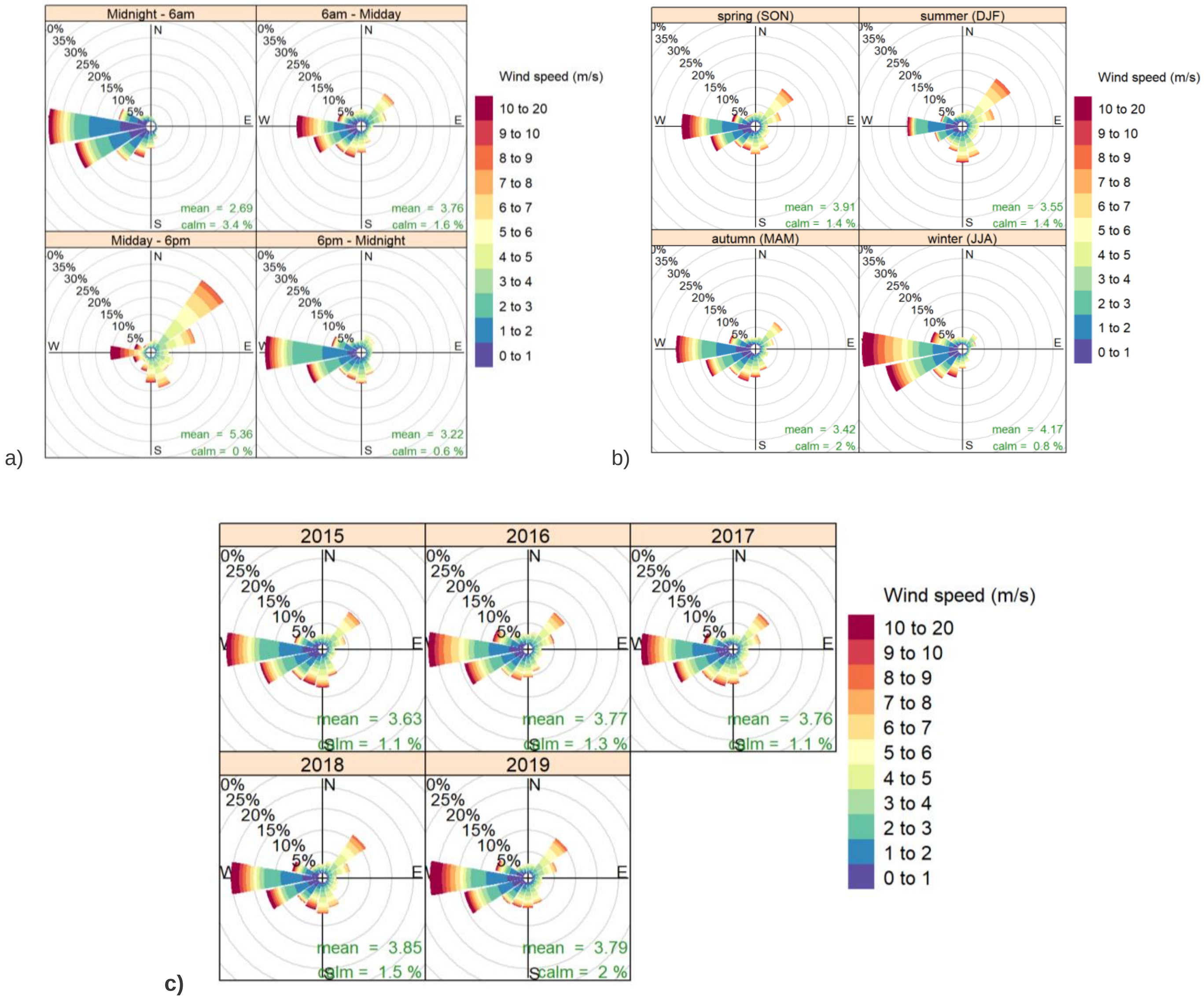


Figure 3 **Distribution of winds for 2015 – 2019 at BoM Albion Park Airport for a) Diurnal, b) Seasonal and c) Annual**

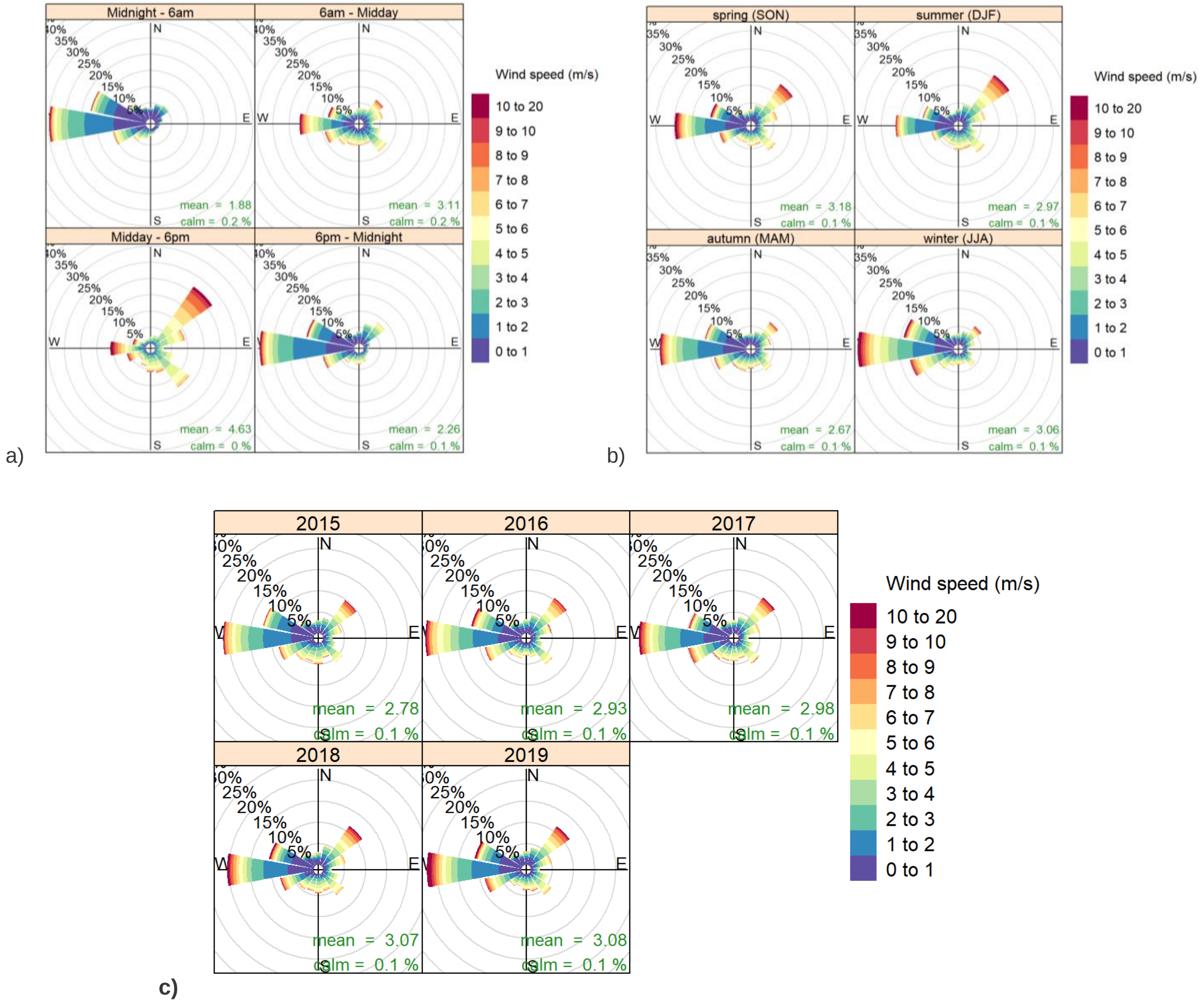


Figure 4 **Distribution of winds for 2015 – 2019 at DPIE Kembla Grange for a) Diurnal, b) Seasonal and c) Annual**

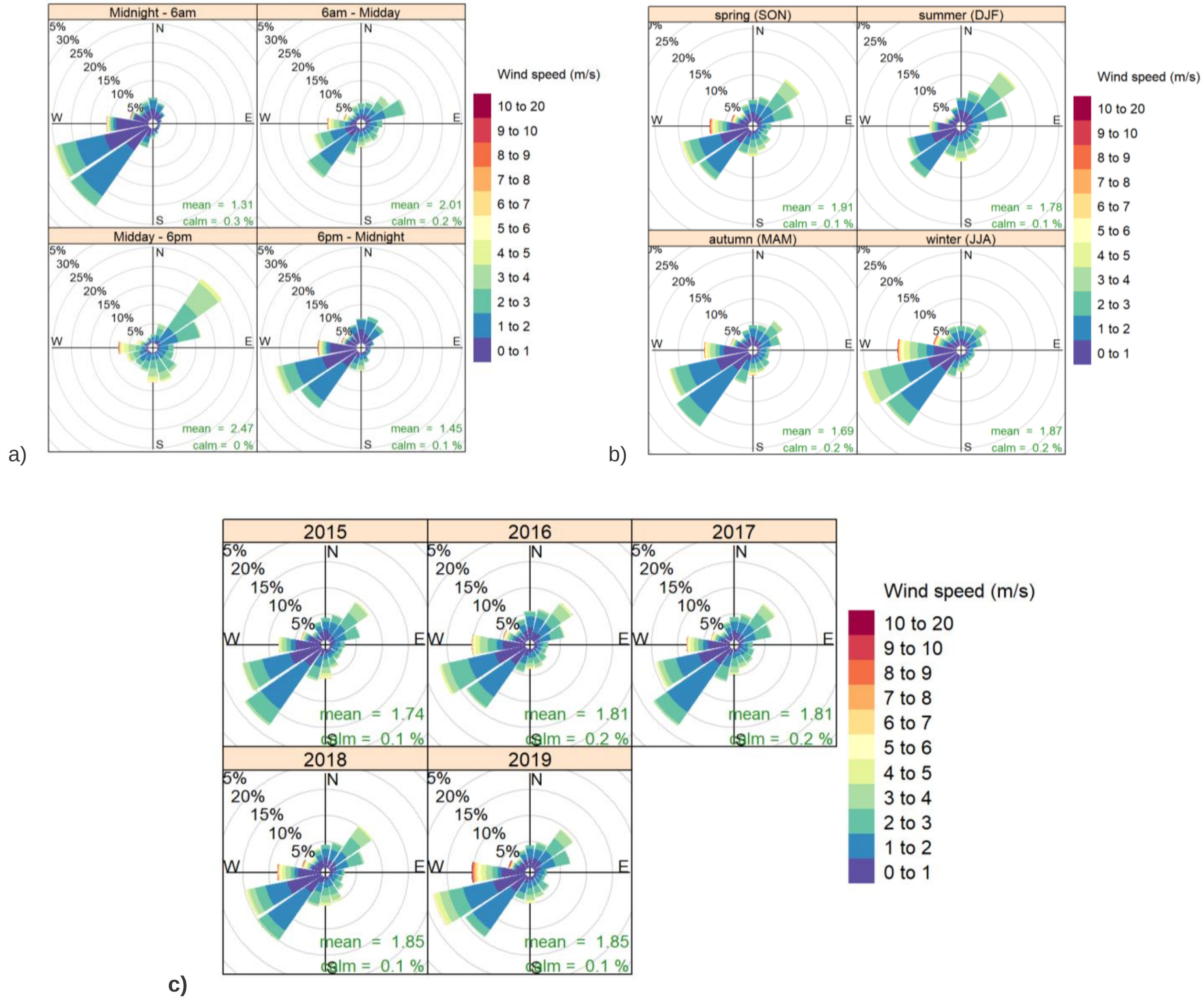


Figure 5 **Distribution of winds for 2015 – 2019 at DPIE Wollongong for a) Diurnal, b) Seasonal and c) Annual**

5.4 Existing air quality

5.4.1 Existing sources of emissions

EnergyAustralia's TAPS combined cycle gas turbine (CCGT) power station is located adjacent to the proposed TBPS site. Emissions of air pollutants from TAPS have been assessed in the cumulative assessment by including the emissions and source characteristics in the TAPM dispersion model.

Other existing sources in the area that generate air emissions have been identified through a review of the National Pollutant Inventory (NPI) for the 2018-2019 reporting year. Facilities within 20km of TBPS that reported emissions of pollutants relevant to this assessment are summarised in Table 4. Existing sources include manufacturing, storage, wastewater treatment, mining, energy generation, and construction. The other major source of air emissions in the region are vehicles using the local road network. These existing sources have not been modelled explicitly, rather they have been accounted for in the cumulative assessment through the background monitoring data.

Table 4 **Emissions to air from facilities within 20km of TBPS, as reported to the NPI for the 2018/2019 reporting year**

Facility name	Main activity	Distance and direction from TBPS	NOx (kg/yr)	PM10 (kg/yr)	PM2.5 (kg/yr)
Albion Park Quarry	construction material mining	10 km, S	123,030	151,693	8,705
BANZ, Manufacturing – Springhill	basic ferrous metal manufacturing	9 km, NE	38,400	3,317	3,317
Bass Point Quarry	construction material mining	10km, SE	72,248	108,335	4,974
BlueScope Steel Port Kembla Steelworks	basic ferrous metal manufacturing	10 km, S	6,731,913	1,243,019	186,183
BOC Gases Port Kembla	basic chemical manufacturing	8 km, NE	899	67	67
Boral Asphalt Port Kembla	petroleum and coal product manufacture	9 km, NE	1,530	1,721	31
Boral Dunmore Quarry	construction material mining	10 km, NE	66,498	246,044	4,451
Dendrobium Mine	coal mining	10 km, N	79,323	31,082	6,278
Dunmore Sand and Soil	construction material mining	10 km, S	19,765	47,862	1,455
IXOM Port Kembla Site	basic chemical manufacturing	10 km, NE	3,542	215	151
Kembla Grange Asphalt Plant	petroleum and coal product manufacture	6 km, N	2,250	107	86
Port Kembla Milling	cement, lime, plaster & concrete manufacture	10 km, NE	13,528	17,224	602
Shellharbour Sewage Treatment System	water supply, sewerage and drainage services	7 km, SE	1,370	103	103
TAPS	electricity generation	Adjacent	120,000	1,800	1,700
Wollongong Sewage Treatment System	water supply, sewerage, and drainage services	12 km, NE	16,922	540	539

5.4.2 Existing air quality

DPIE operates three air quality monitoring stations in the Illawarra region, namely, Albion Park South, Kembla Grange and Wollongong, as shown in Figure 2. The three DPIE sites measure ambient concentrations of air pollutants relevant to this assessment, namely: NO_2, PM_{10}, $PM_{2.5}$ and O_3.

Concentrations of NO_2, PM_{10}, $PM_{2.5}$ and O_3 recorded between 2015 and 2019 at each DPIE site have been analysed and detailed in Table 5, Table 6, Table 7 and Table 8, respectively. The data shows the following:

- Maximum 1-hour average and annual average concentrations of NO_2 were below the impact assessment criteria for all sites and all years (Table 5).
- Maximum 24-hour average concentrations of PM_{10} were above the impact assessment criteria for all sites and all years expect Albion Park South in 2015-2017 and Wollongong in 2015 (Table 6).
- The number of days that concentrations of PM_{10} exceeded the impact assessment criterion were as follows:
    - Albion Park: 2 days in 2018 and 14 days in 2019
    - Kembla Grange: 1 day in 2015, 4 days in 2016, 4 days in 2017, 10 days in 2018 and 21 days in 2019
    - Wollongong: 2 days in 2016, 1 day in 2017, 5 days in 2018 and 17 days in 2019.
- Annual average concentrations of PM_{10} were below the impact assessment criterion for all sites and all years expect Kembla Grange in 2019 (Table 6).
- Maximum 24-hour average concentrations of $PM_{2.5}$ were above the impact assessment criterion for a number of sites and years, namely: Albion Park South in 2016 & 2018-2019, Kembla Grange in 2016 & 2019 and Wollongong in all years expect 2017 (Table 7).
- The number of days that concentrations of $PM_{2.5}$ exceeded the impact assessment criterion were as follows:
    - Albion Park: 2 days in 2016, 1 day in 2018 and 12 days in 2019
    - Kembla Grange: 2 days in 2016 and 12 days in 2019
    - Wollongong: 1 day in 2015, 3 days in 2016, 3 days in 2018 and 14 days in 2019.
- Annual average concentrations of $PM_{2.5}$ were below the impact assessment criterion for all sites in years 2015-2018. In 2019, all sites were above the impact assessment criterion (Table 7).
- Maximum 1-hour average concentrations of O_3 was above the impact assessment criterion on a number of occasions including: Albion Park in 2017, Kembla Grange in 2016 & 2017 and Wollongong in 2019 (Table 8).
- The number of hours that the concentration of O_3 exceeded the 1-hour average impact assessment criterion were as follows:
    - Albion Park: 1 hour in 2017
    - Kembla Grange: 1 hour in 2016 and 3 hours in 2017
    - Wollongong: 1 hour in 2019.
- Maximum 4-hour average concentrations of O_3 were above the impact assessment criterion on a number of occasions including: Albion Park in 2016 & 2017, Kembla Grange in 2016, 2017 & 2019 and Wollongong in 2017 & 2019 (Table 8).

- The number of times that the 4-hour average concentration of O_3 exceeded the 4-hour average impact assessment criterion were as follows:
    - Albion Park: 4 times in 2016 and 2017
    - Kembla Grange: 4 times in 2016, 3 times in 2017 and 2019
    - Wollongong: 4 times in 2017 and 3 times in 2019.

Table 5 Ambient concentrations of NO_2, measured at Albion Park South, Kembla Grange and Wollongong (µg/m^3)

Year	Maximum 1-hour average NO_2 (µg/m^3)			Annual average NO_2 (µg/m^3)		
	Albion Park South	Kembla Grange	Wollongong	Albion Park South	Kembla Grange	Wollongong
2015	88.4	64.0	112.9	6.5	8.9	15.1
2016	80.9	73.4	80.9	7.1	9.2	11.9
2017	71.5	69.6	107.2	6.8	8.5	11.9
2018	73.4	69.6	80.9	7.5	9.1	12.2
2019	77.1	79.0	75.3	7.2	9.5	11.2
Criteria	**246**			**62**		

Table 6 Ambient concentrations of PM_{10} measured at Albion Park South, Kembla Grange and Wollongong (µg/m^3)

Year	24-hour average			Annual average		
	Albion Park South	Kembla Grange	Wollongong	Albion Park South	Kembla Grange	Wollongong
2015	41.2	**62.8 (1)**	45.8	14.0	17.8	16.9
2016	43.1	**56.3 (4)**	**52.9 (2)**	14.9	20.0	17.3
2017	44.6	**67.7 (4)**	**55.2 (1)**	15.3	20.5	18.1
2018	**94.4 (2)**	**71.8 (10)**	**59.7 (5)**	17.8	22.7	19.8
2019	**104.3 (14)**	**115.8 (21)**	**117.6 (17)**	19.5	**25.5**	22.6
Criteria	**50**			**25**		
Table note - values in brackets denote the number of 24-hr averages above the criteria						

Table 7 Ambient concentrations of $PM_{2.5}$ measured at Albion Park South, Kembla Grange and Wollongong (µg/m^3)

Year	24-hour average			Annual average		
	Albion Park South	Kembla Grange	Wollongong	Albion Park South	Kembla Grange	Wollongong
2015	21.1	23.8	**31.6 (1)**	6.4	6.7	7.6
2016	**30.7 (2)**	**32.0 (2)**	**33.7 (3)**	7.2	6.6	7.4
2017	19.3	21.3	24.7	6.6	6.9	7.1
2018	**29.4 (1)**	21.9	**47.6 (3)**	6.8	7.1	7.3
2019	**49.4 (12)**	**70.1 (12)**	**81.5 (14)**	**8.6**	**8.8**	**9.0**

Criteria	25	8
Table note - values in brackets denote the number of 24-hr averages above the criteria		

Table 8 Ambient concentrations of O_3 measured at Albion Park South, Kembla Grange and Wollongong (µg/m^3)

Year	1-hour average			4-hour average		
	Albion Park South	Kembla Grange	Wollongong	Albion Park South	Kembla Grange	Wollongong
2015	155.1	204.2	180.6	146.7	156.1	162.0
2016	204.2	**223.8 (1)**	186.5	**192.4 (4)**	**199.3 (4)**	167.4
2017	**229.7 (1)**	**239.5 (3)**	210.1	**199.8 (4)**	**193.4 (3)**	**184.0 (4)**
2018	149.2	137.4	129.6	143.8	116.8	121.7
2019	194.4	196.3	**217.9 (1)**	152.6	**180.1 (3)**	**185.0 (3)**
Criteria	**214**			**171**		
Table note - values in brackets denote the number of 1-hr or 4hr averages above the criteria						

5.4.3 Background levels for the cumulative assessment

The cumulative assessment for TBPS includes the addition of ambient background concentrations derived from the above data. The dispersion modelling has considered the 2018 calendar year and, therefore, an hourly average background concentration for the relevant pollutants for 2018 has been used. The selection of the 2018 calendar year is discussed in Appendix A, Section A1.2.

Data from Albion Park South or Kembla Grange were considered more representative than data from Wollongong. Albion Park South and Kembla Grange have recorded similar levels; however, as Kembla Grange is closer to TBPS and the majority of sensitive receptors it was selected to provide data for the cumulative assessment.

It should be noted that the outcome of the assessment would not change if the Albion Park South data had been used.

5.5 Sensitive receptors

Sensitive receptor locations within the assessment domain and are presented in Figure 6 and Table 9 and have been used to assess air quality impacts from TBPS. The receptors represent the surrounding residential and industrial areas of the Illawarra region.

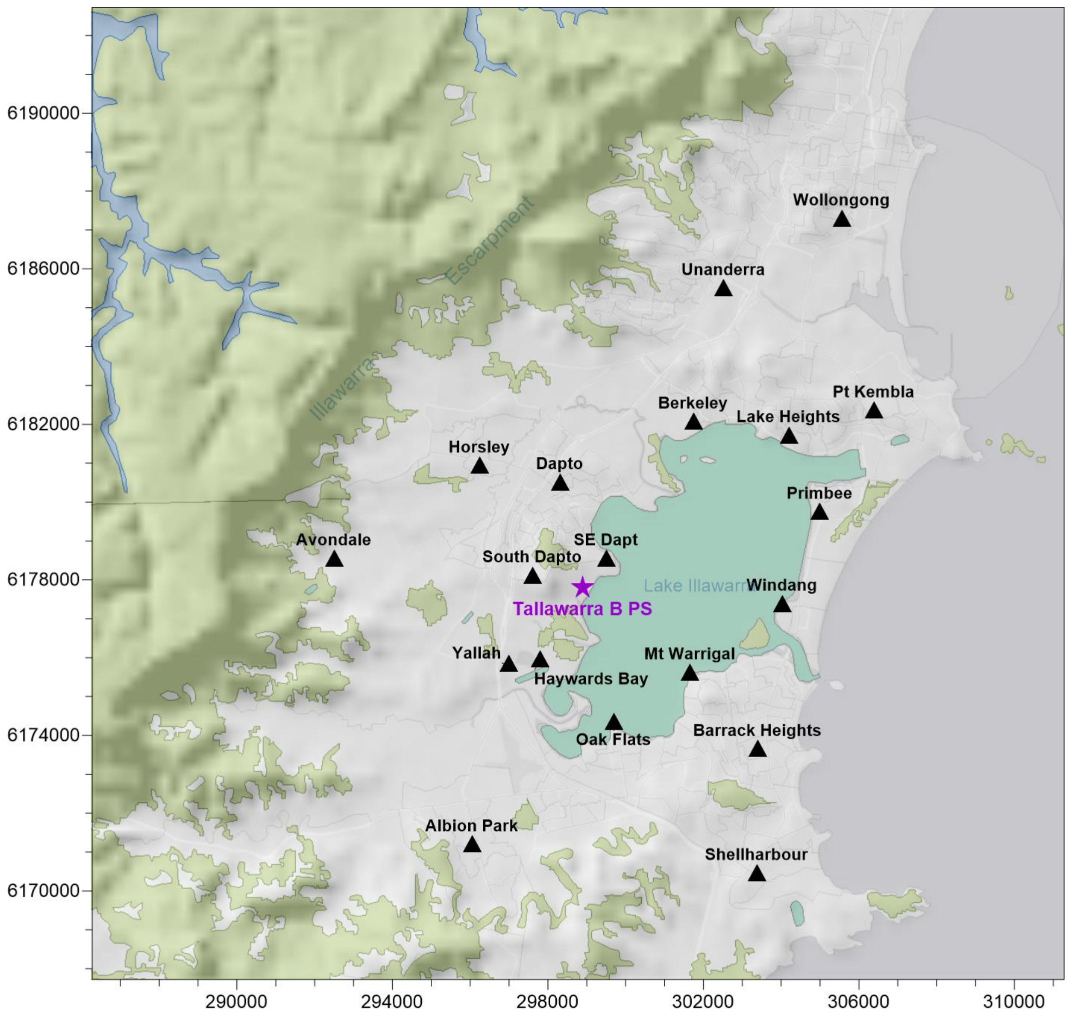


Figure 6 **Location of sensitive receptors considered in the TBPS air quality assessment (coordinates: UTM metres z56S)**

Table 9 **Nearest sensitive receptors to the TBPS**

Sensitive Receptor	Description	Easting (m)	Northing (m)	Distance (km) and direction from TBPS	
Albion Park	Residential	296051	6171146	5.6	S
Avondale	Residential	292500	6178500	6.4	WNW
Barrack Heights	Residential	303400	6173600	6.2	SE
Berkeley	Residential	301742	6182021	4.6	NE
Dapto	Residential	298312	6180462	2.8	N
Haywards Bay	Residential	297805	6175901	2.1	S
Horsley	Residential	296246	6180890	4.0	NW
Lake Heights	Residential	304198	6181670	5.1	NE
Mt Warrigal	Residential	301663	6175568	3.6	SE
Oak Flats	Residential	299699	6174298	3.6	SSE
Primbee	Residential	305000	6179700	6.4	ENE
Pt Kembla	Industrial	306388	6182309	8.8	NE
SE Dapto	Residential	299500	6178500	1.0	NNE

Sensitive Receptor	Description	Easting (m)	Northing (m)	Distance (km) and direction from TBPS	
Shellharbour	Residential	303379	6170406	7.6	SE
South Dapto	Residential	297604	6178064	1.3	WNW
Unanderra	Residential	302522	6185451	7.4	NE
Windang	Residential	304029	6177337	5.2	ESE
Wollongong	Residential	305562	6187244	10.0	NE
Yallah	Residential	297000	6175785	2.8	SW

6. DISPERSION METEOROLOGY

The following sections describe the meteorology at the TBPS site, as extracted from TAPM, focusing on parameters that are important for dispersion of air pollutants. The data presented is for the 2018 calendar year that was used in the assessment. 2018 was selected as a representative year as a result of the analysis that is detailed in Appendix A.

2018 observational data from DPIE monitoring sites at Kembla Grange and Wollongong, and the BoM monitoring site at Albion Park Airport were assimilated into the TAPM predictions to depict conditions at the TBPS site more accurately.

6.1 Wind speed and wind direction

Wind speed and direction distributions at the TBPS site as predicted by TAPM are summarised annually, seasonally, and diurnally in Figure 7 to Figure 9.

Annual wind directions show major contributions from west-southwest to west-northwest and the northeast. Diurnally, the western dominance in wind direction occurs from 6 pm to 6 am (land breeze), weakening between 6 am to midday and shifting to the northeast from midday to 6 pm (sea breeze). Autumn and winter show the strongest westerlies, with a major shift to winds from the northeast during summer. The annual mean wind speed was 3.74 ms^{-1}.

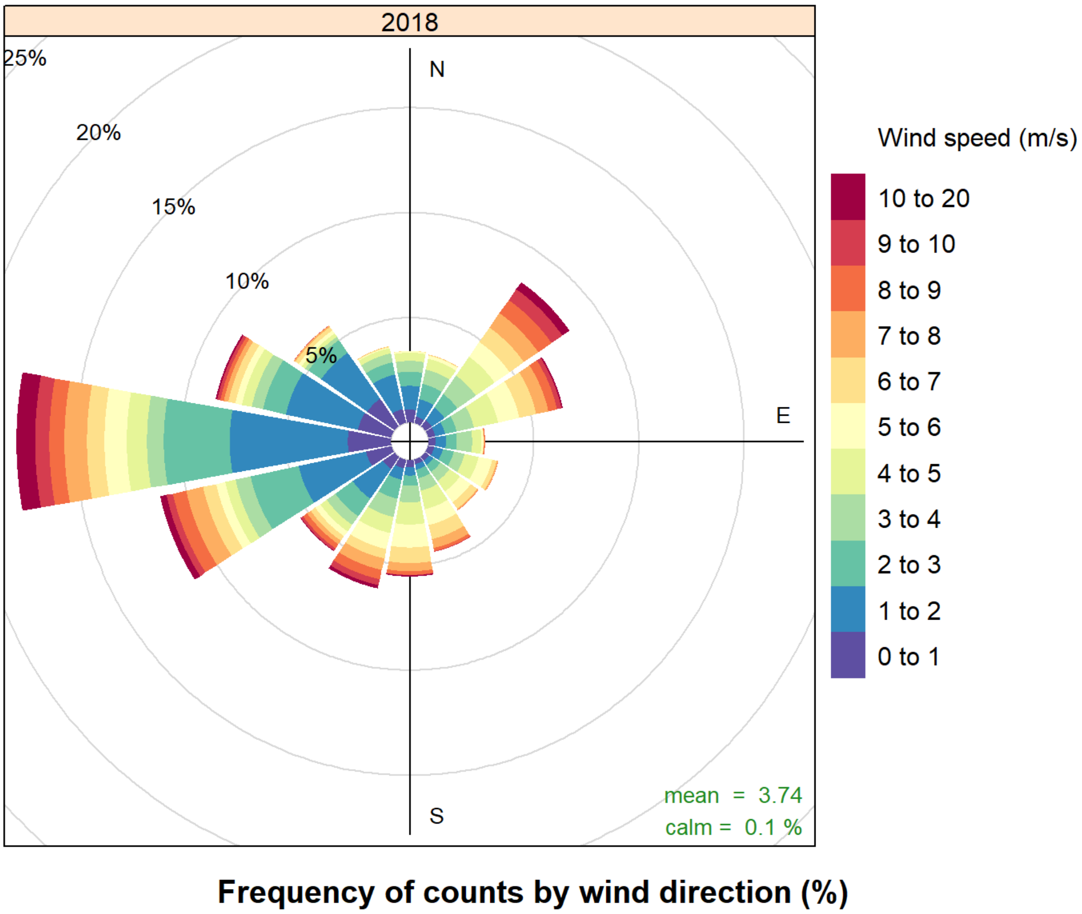


Figure 7 Annual distribution of winds at the TBPS site (TAPM)

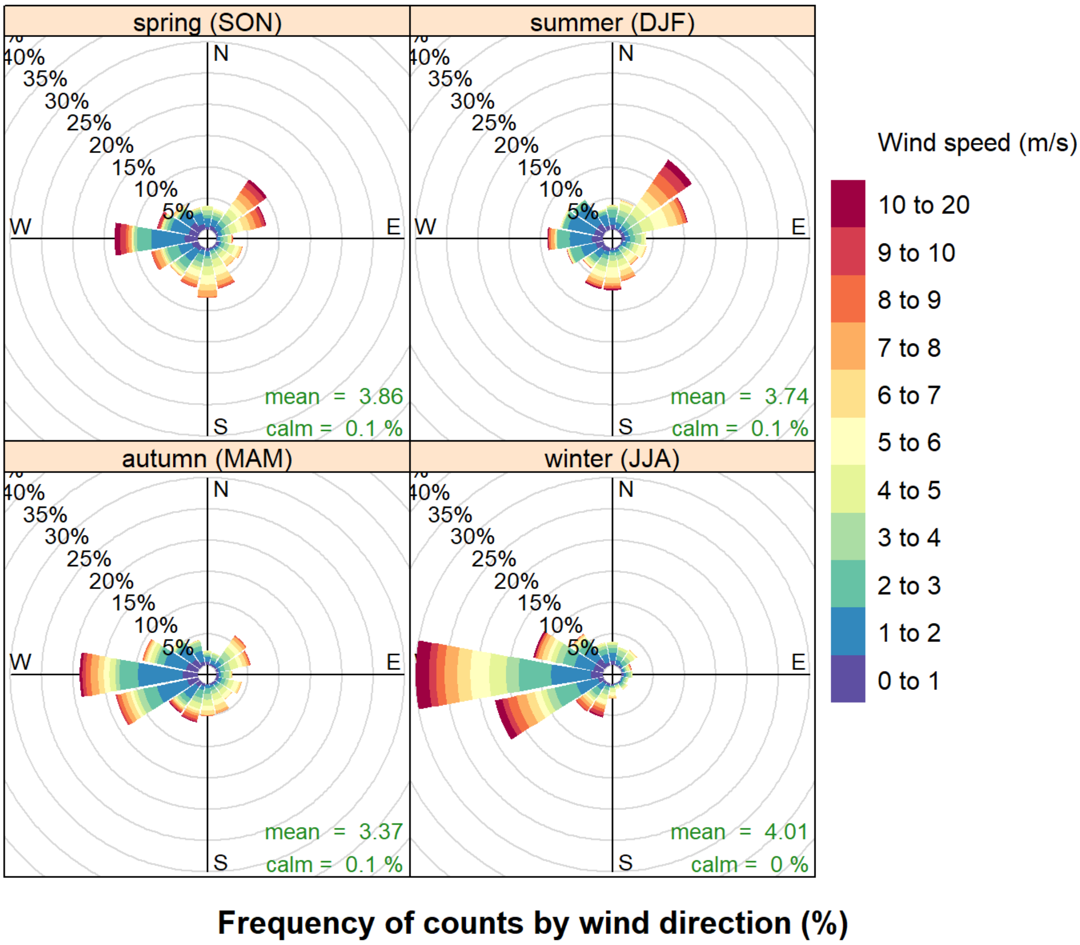


Figure 8 Seasonal distribution of winds at the TBPS site (TAPM)

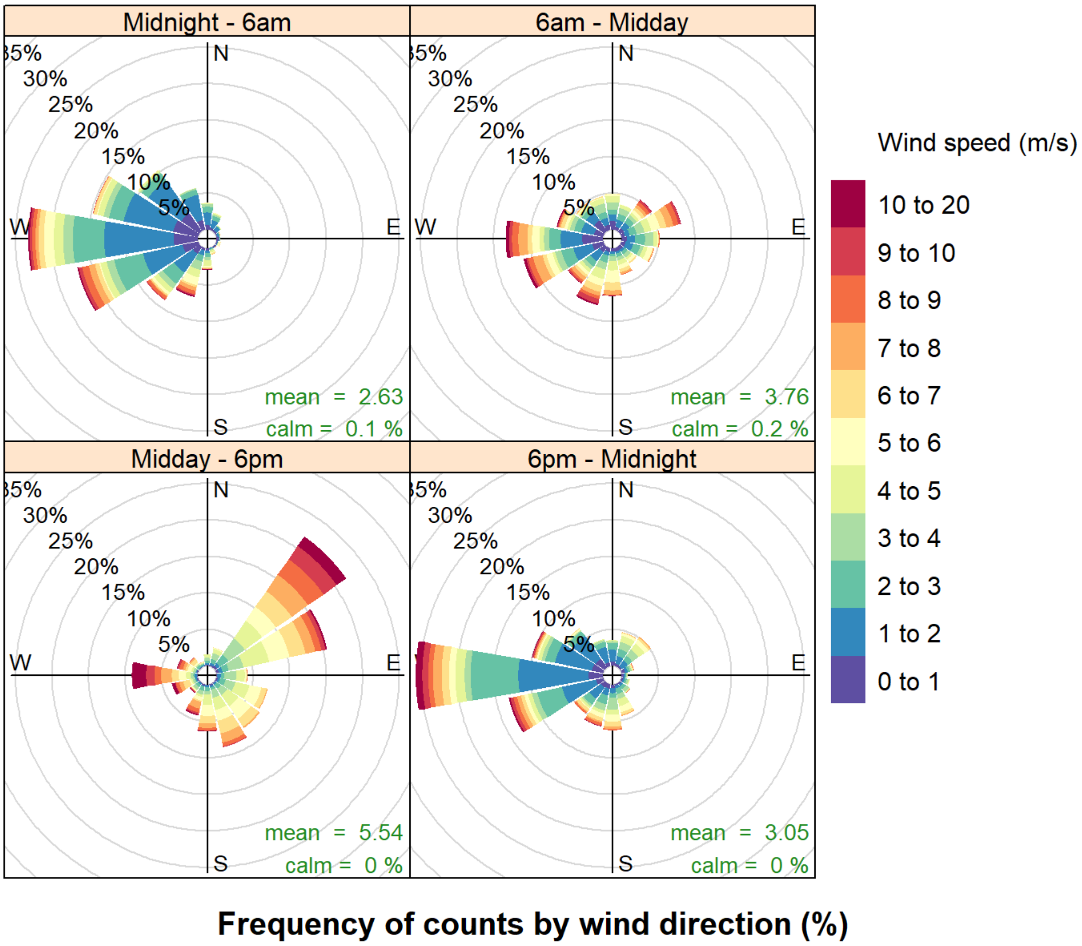


Figure 9 Diurnal distribution of winds at the TBPS site (TAPM)

6.2 Atmospheric stability

Stability classification is a measure of the stability of the atmosphere and can be determined from wind measurements and other atmospheric observations. The stability classes range from A class, which represents very unstable atmospheric conditions that may typically occur on a sunny day to F class stability, which represents very stable atmospheric conditions that typically occur during light wind conditions at night. Unstable conditions (Classes A to C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground. This turbulent mixing is the main driver of dispersion during unstable conditions. Dispersion processes for the most frequently occurring Class D conditions are dominated by mechanical turbulence generated as the wind passes over irregularities in the local surface. During the night, the atmospheric conditions are generally stable (often classes E and F).

Table 10 shows the overall percentage of stability classes at the TBPS site, and Figure 10 illustrates the diurnal distribution of stability classes. Class D stability occurs approximately 63% of the time due to moderate wind speeds. Class E stability occurs approximately 23% of the time and represents calmer evening conditions. Some unstable (Class B) conditions occur between 6 am and 4 pm.

Table 10 **Frequency of occurrence (%) of surface atmospheric stability at the TBPS site under the Pasquil-Gifford stability classification scheme (as predicted by TAPM)**

Pasquil-Gifford stability class	Classification	Frequency (%)
A	Extremely unstable	0.1%
B	Unstable	4.6%
C	Slightly unstable	9.9%
D	Neutral	62.7%
E	Slightly stable	22.6%
F	Stable	0.1%

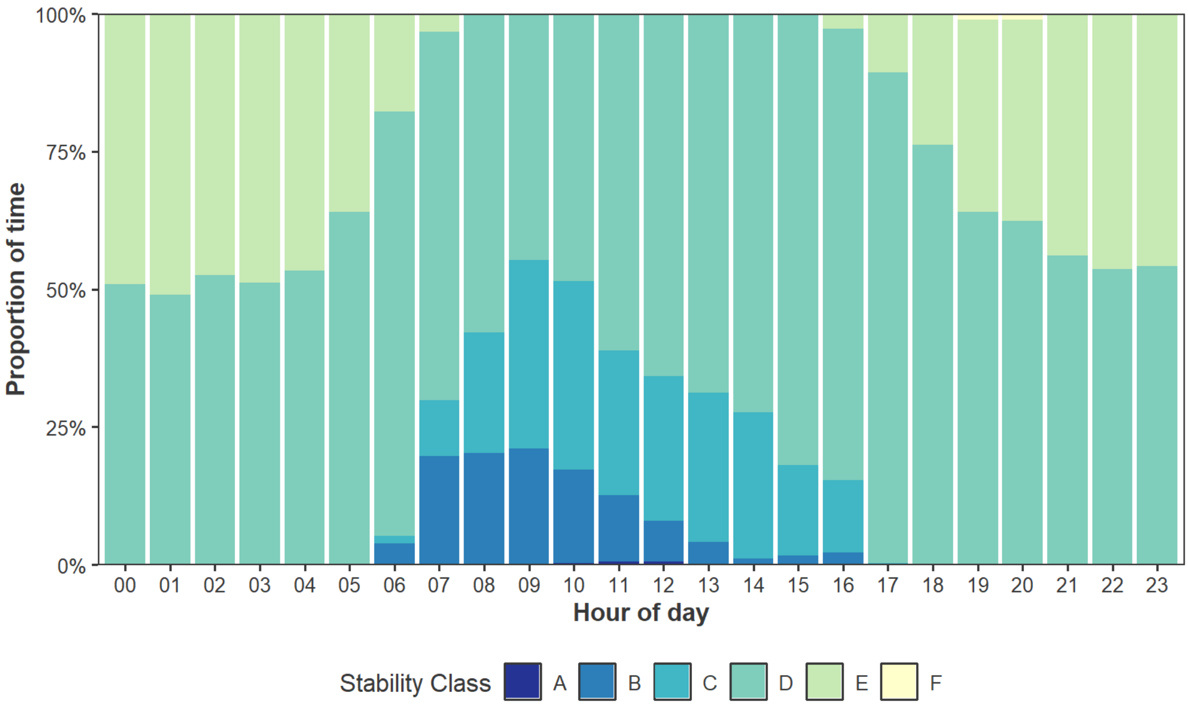


Figure 10 **Diurnal distribution of stability classes at the TBPS site (TAPM)**

6.3 Mixing height

The mixing height refers to the height above ground within which air pollutants released at or near ground can mix with ambient air. During stable atmospheric conditions, the mixing height is often quite low, and dispersion is limited to within this layer. During the day, solar radiation heats the air at the ground level and causes the mixing height to rise. The air above the mixing height during the day is generally cooler. The growth of the mixing height is dependent on how well the air can mix with the cooler upper level air and therefore depends on meteorological factors such as the intensity of solar radiation and wind speed. During strong wind speeds, the air will be well mixed, resulting in a high mixing height.

Mixing height information at the TBPS site is presented in Figure 11. The data shows that the mixing height remains consistent throughout a typical day, developing marginally around 8am and reaching a peak around 11 am before descending slightly.

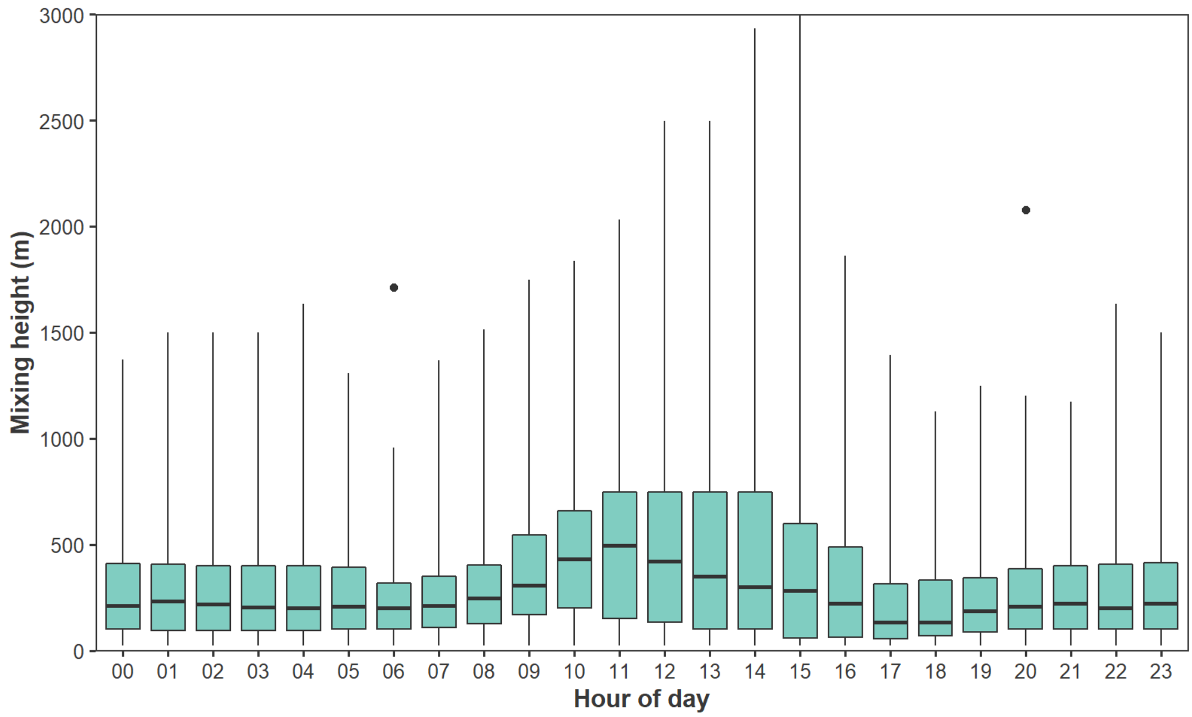


Figure 11 **Diurnal profile of modelled mixing height at the TBPS site (TAPM)**

7. EMISSIONS TO THE ATMOSPHERE

EnergyAustralia is conducting a bidding process to select a supplier for the TBPS OCGT with PDD. Notwithstanding this, exhaust characteristics and air pollutant emissions information was reviewed from four potential suppliers and worst-case information were selected for use in this air quality assessment.

7.1 Normal load operations (100% and MEL)

Stack characteristics and emission rates for TBPS, operating at either 100% Load or MEL, used in the dispersion modelling assessment are presented in Table 11. For each load, the dispersion modelling assessment has been assumed that TBPS operates continuously, that is 24 hours per day for every hour of the year for modelling purposes. However, TBPS will be a peaker plant and is anticipated at times of peak electricity demand with a capacity factor of 35%.

Table 11 TBPS with PDD stack characteristics and emission rates used in the assessment

Parameter	**Value**	**Gas fired**	
		100% Load	**MEL**
Stack characteristics			
Stack height	m	48	
Number of PDD outlets	#	4	
PDD angle of release	°	50	
PDD outlet diameter (per PDD)	M	4.6	
PDD exhaust temperature	°C	614	623
PDD exhaust velocity	m/s	27.8	18.8
Vertical component of PDD exhaust velocity	m/s	17.8	12.1
Moisture content	Volume %	12.0	8.5
Oxygen content	Volume %, dry	12.4	14.8
Flow rate (wet, stack °C, 101.3 kPa) (total)	m^3/s	1,853	1,253
Flow rate (dry, 0 °C, 101.3 kPa) (total)	Nm^3/s	502	349
Emission concentrations			
NOx	mg/Nm^3 (dry, 15% O_2)	50	50
PM	mg/Nm^3 (dry, 15% O_2)	5	5
Emission rates (total)			
NOx	g/s	35.8	18.2
PM_{10} *	g/s	3.6	1.8
$PM_{2.5}$ *	g/s	3.6	1.8

Table note:
* Emissions of $PM_{2.5}$ have been estimated by assuming that all PM_{10} is $PM_{2.5}$.

7.2 Start up

The TBPS OCGT will start up within 30 minutes. A typical OCGT start up procedure is shown in Figure 12 and is described as follows:

- Start-up begins with 9 minutes of bringing the gas turbine up to full speed with no load.
- During this time NOx concentrations start at 60 mg/Nm³ and increase to 80 mg/Nm³ when the gas turbine reaches full speed.
- The gas turbine is run at full speed for a period of 2 minutes with no load.
- Load is then gradually increased with 50% load reached after 15-25 minutes.
- When the GT load reaches 50% the NOx concentration stabilises to 50 mg/Nm³.
- The gas turbine load is then steadily increased until 100% load reached in under 30 minutes.

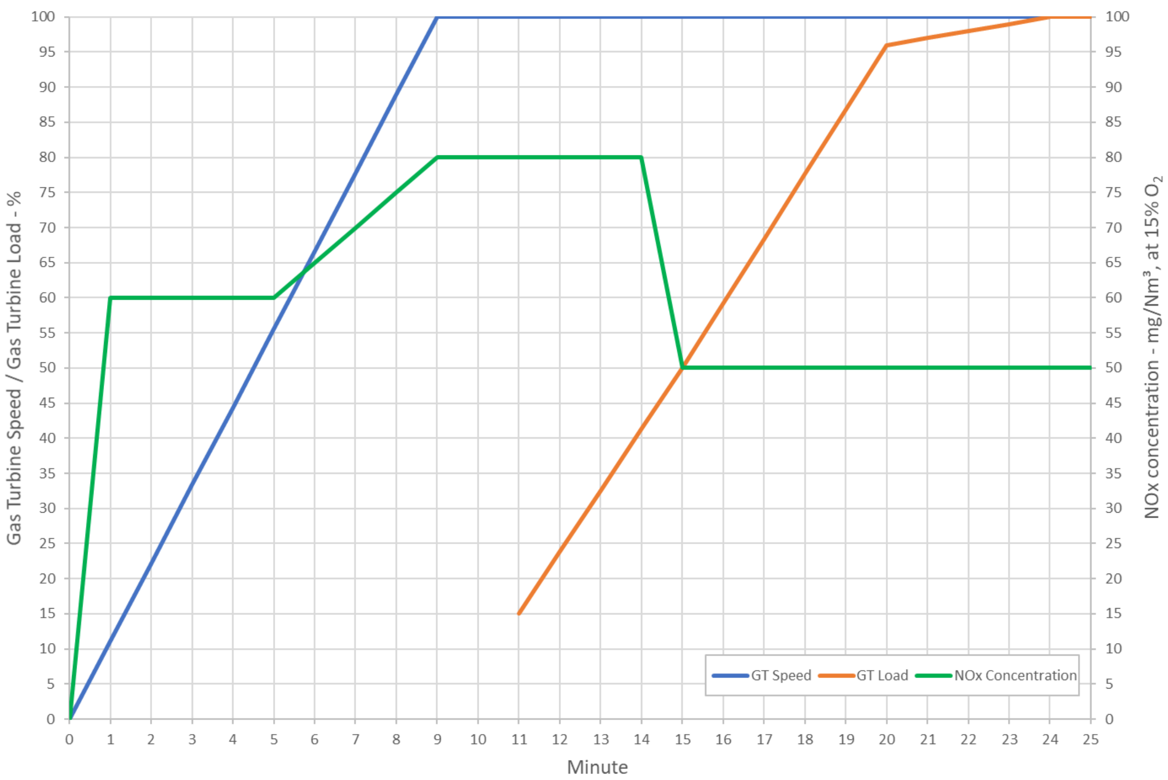


Figure 12 **Example of an OCGT start-up**

Emissions of NO_x will vary over the first 15 minutes of start up in line with the varying NOx concentration and exhaust volume before stabilising to 50 mg/Nm³ at 50% load. The mass emission rate NO_x for the first 15 minutes is likely to be lower than the mass emissions for 100% load given the difference in exhaust volume.

Therefore, the hourly emissions considered in the 100% load and MEL operations are likely to produce higher or similar ground-level concentrations of air pollutants than emissions during an hour with a start-up. Accordingly, start-up emissions have not been explicitly assessed in the dispersion model.

7.3 Tallawarra A Power Station

Stack characteristics and emission rates for TAPS that were used in the cumulative dispersion modelling assessment are presented in Table 12. The cumulative dispersion modelling assessment has been assumed that the TAPS operates continuously, 24 hours/day for every hour of the year for modelling purposes.

Table 12 TAPS stack characteristics and emission rates used in the assessment

Parameter	Value	TAPS
Stack characteristics		
Stack height	m	60
Exhaust stack diameter	m	7
Exhaust temperature	°C	87
Exhaust velocity	m/s	19
Moisture content	Volume %	10
Oxygen content	Volume %, dry	13.3
Flow rate (wet, stack °C, 101.3 kPa) (total)	m^3/s	700
Flow rate (dry, 0 °C, 101.3 kPa) (total)	Nm^3/s	477
Emission concentrations		
NOx	mg/m^3 (dry, 15% O_2)	51.4
PM	mg/m^3 (dry, 15% O_2)	10
Emission rates (total)		
NOx	g/s	31.6
PM_{10}	g/s	6.2
$PM_{2.5}$	g/s	6.2

The emission concentrations are the emission limits specified in the TAPS EPL, which also includes a maximum emission limit from the site of 900 kg/annum. The stack characteristics and emission rates for TAPS described above are conservative for the purpose of the air quality assessment. This is based on a review of the past three TAPS annual returns submitted to EPA as detailed in Table 13. The annual return information shows the following:

- Annual emissions of NO_x are significantly below the 900 tonnes site limit.
- TAPS utilisation ranges from 35% to 50%.
- Hourly emissions of NOx reported in the annual returns are less than the conservative emission rate used in the TBPS cumulative assessment (Table 13).

Table 13 TAPS annual return information

Parameter	Units	FY16/17	FY 17/18	FY8/19
NOx emission	kg/annum	45,469	179,812	127,649
	tonnes/annum	45	180	128
NOx emissions site limit	tonnes/annum		900	
NOx emissions percentage	%	5	20	14
Hours of operation	#	3084	4252	3060
Number of starts	#	178	116	170
TAPS utilisation		35%	49%	35%
Average NOx emission rate	g/s	4.1	11.7	11.6

8. LOCAL AIR QUALITY IMPACT ASSESSMENT

8.1 Nitrogen Dioxide

TAPM dispersion modelling results for maximum 1-hour average and annual average ground-level concentrations of NO_2 are shown in Table 14.

The concentrations are presented at the location of the sensitive receptors and the highest in the modelling domain for 100% load and MEL operations and for TBPS in isolation and cumulatively with TAPS and an ambient background.

Plate 1 and Plate 2 present contour plots of the modeling domain for the predicted maximum 1-hour average ground-level concentration of NO_2 from the proposed TBPS in isolation, operating at 100% load and MEL, respectively.

Plate 3 and Plate 4 present contour plots of the modeling domain for the predicted annual average ground-level concentrations of NO_2 from the proposed TBPS in isolation, operating at 100% load and MEL, respectively.

The dispersion modelling results for NO_2 show the following:

- Predicted ground-level concentrations of NO_2 for TBPS in isolation, operating at either 100% load or MEL, were below the relevant impact assessment criteria at all locations.
- TBPS operations at 100% load result in higher ground-level concentrations that operations at MEL
- The sensitive receptor with the highest 1-hour average ground-level concentration of NO_2 due to TBPS in isolation at 100% load was South Dapto, to the west of TBPS, with a concentration of 87.9µg/m³ or 36% of the impact assessment criterion (246µg/m³).
- The contour plots due to TBPS in isolation at 100% load show that highest 1-hour average ground level concentrations occur to the west (Plate 1) while the highest annual average concentrations occur to the southwest (Plate 3).
- Predicted ground-level concentrations of NO_2 for the cumulative assessment, with TBPS operating at either 100% load or MEL, were below the relevant assessment criteria at all locations.
- The sensitive receptor with the highest 1-hour average NO_2 ground-level concentration in the cumulative assessment with TBPS at 100% load was South Dapto, to the west of TBPS, with a concentration of 170µg/m³ or 69% of the impact assessment criterion (246µg/m³).

Table 14 Predicted maximum 1-hour average and annual ground-level concentrations of NO_2 from the proposed TBPS (µg/m)

Receptor	Maximum 1-hour Average (µg/m³)				Annual Average (µg/m³)			
	100% Load		MEL		100% Load		MEL	
	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative
Albion Park	22.29	35.20	11.63	29.83	0.13	8.47	0.07	0.23
Avondale	31.34	70.78	14.07	69.61	0.23	8.66	0.12	8.60
Barrack Heights	12.36	70.37	6.71	70.23	0.07	8.39	0.04	8.37
Berkeley	18.54	69.61	8.74	69.61	0.13	8.44	0.07	8.44
Dapto	36.96	79.15	18.61	69.61	0.19	8.54	0.11	8.53
Haywards Bay	20.88	69.80	11.37	69.83	0.16	8.49	0.09	8.49
Horsley	30.43	73.46	15.74	70.87	0.25	8.66	0.14	8.61
Lake Heights	14.15	69.61	8.02	69.61	0.13	8.43	0.07	8.44
Mt Warrigal	29.17	71.55	16.09	71.37	0.10	8.43	0.06	8.41
Oak Flats	18.57	70.82	8.98	70.69	0.10	8.41	0.06	8.41
Primbee	20.33	69.61	11.91	69.61	0.28	8.64	0.16	8.64
Pt Kembla	13.41	69.61	7.81	69.61	0.11	8.41	0.06	8.42
SE Dapto	21.78	69.61	15.76	69.61	0.10	8.39	0.07	8.42
Shellharbour	14.98	70.05	7.50	69.96	0.08	8.38	0.04	8.38
South Dapto	87.93	170.22	40.93	125.35	0.30	8.69	0.17	8.69
Unanderra	11.97	69.61	6.45	69.61	0.10	8.42	0.05	8.40
Windang	22.82	80.68	12.49	75.90	0.28	8.69	0.16	8.65
Wollongong	7.95	69.61	4.34	69.61	0.07	8.37	0.04	8.37
Yallah	25.45	69.62	13.19	69.62	0.36	8.83	0.21	8.80
Highest on domain	91.92	172.92	44.72	127.29	6.56	19.05	3.74	17.39
Impact Assessment Criteria	*246*				*62*			

8.2 Particulate Matter (as PM_{10} or $PM_{2.5}$)

TAPM dispersion modelling results for maximum 24-hour average and annual average ground-level concentrations of PM_{10} and $PM_{2.5}$ are shown in Table 15 and Table 16, respectively.

The concentrations are presented at the location of the sensitive receptors and the highest in the modelling domain for 100% load and MEL operations and for TBPS in isolation and cumulatively with TAPS and an ambient background.

Contour plots for PM_{10} and $PM_{2.5}$ have not been provided as predicted concentrations detailed below are significantly below the assessment criteria.

The dispersion modelling results for PM_{10} show the following:

- Predicted ground-level concentrations of PM_{10} from the proposed TBPS in isolation, operating at either 100% load or MEL, were less than 4% of the relevant assessment criteria at all locations.
- Ambient air quality monitoring conducted by the NSW Department of Industry, Planning and Environment (DPIE) at Kembla Grange shows that there were 10 days in 2018 when the concentration of PM_{10} was above 50µg/m³. The cumulative PM_{10} assessment, using a contemporaneous approach, predicted no additional days above the 50µg/m³ assessment criterion.
- Predicted annual average ground-level concentrations of PM_{10} due to TBPS operating at either 100% load or MEL plus background, were below the relevant impact assessment criteria at all locations.
- Predicted annual average ground-level concentrations of PM_{10} for the cumulative assessment, with TBPS operating at either 100% load or MEL, are below the relevant assessment criteria at all locations in the modelling domain including all sensitive receptors.

The dispersion modelling results for $PM_{2.5}$ show the following:

- Predicted ground-level concentrations $PM_{2.5}$ from the proposed TBPS in isolation, operating at either 100% load or MEL, were less than 8% of the relevant assessment criteria at all locations.
- Predicted ground-level concentrations of $PM_{2.5}$ due to TBPS in isolation operating at either 100% load or MEL plus background, were below the impact assessment criterion of 25 µg/m³ at all locations.

Table 15 Predicted maximum 24-hour average and annual ground-level concentrations of PM_{10} from the proposed TBPS (µg/m)

Receptor	Maximum 24-hour average (µg/m³)						Annual average (µg/m³)			
	100% Load			MEL			100% Load		MEL	
	Isolation	Cumulative	Number of days above 50µg/m³	Isolation	Cumulative	Number of days above 50µg/m³	Isolation	Cumulative	Isolation	Cumulative
Albion Park	0.16	71.80	10	0.10	71.80	10	0.01	19.77	0.01	19.77
Avondale	0.49	71.80		0.27	71.80		0.02	19.89	0.01	19.86
Barrack Heights	0.28	71.99		0.17	71.96		0.01	19.75	0.00	19.75
Berkeley	0.32	71.96		0.20	71.93		0.01	19.78	0.01	19.78
Dapto	0.49	71.80		0.28	71.80		0.02	19.78	0.01	19.77
Haywards Bay	0.22	71.80		0.14	71.80		0.02	19.77	0.01	19.77
Horsley	0.47	71.80		0.26	71.80		0.02	19.78	0.01	19.78
Lake Heights	0.29	71.81		0.18	71.81		0.01	19.75	0.01	19.75
Mt Warrigal	0.50	72.00		0.31	71.97		0.01	19.75	0.01	19.75
Oak Flats	0.22	71.81		0.13	71.81		0.01	19.75	0.01	19.75
Primbee	1.00	71.86		0.61	71.86		0.03	19.76	0.02	19.76
Pt Kembla	0.29	71.81		0.19	71.81		0.01	19.74	0.01	19.74
SE Dapto	0.40	72.23		0.37	72.23		0.01	19.78	0.01	19.78
Shellharbour	0.41	71.83		0.24	71.84		0.01	19.75	0.00	19.75
South Dapto	0.77	71.80		0.42	71.80		0.03	19.93	0.02	19.92
Unanderra	0.34	71.86		0.21	71.85		0.01	19.77	0.01	19.76
Windang	1.03	71.93		0.62	71.91		0.03	19.78	0.02	19.78
Wollongong	0.19	71.84		0.11	71.83		0.01	19.75	0.00	19.75
Yallah	0.37	71.80		0.24	71.80		0.04	19.93	0.02	19.91
Highest on domain	1.95	72.77		0.10	71.80		0.66	23.62	0.41	23.37
Impact Assessment Criteria	*50*						*25*			

Table 16 Predicted maximum 24-hour average and annual ground-level concentrations of $PM_{2.5}$ from the proposed TBPS (µg/m)

Receptor	Maximum 24-hour Average (µg/m³)				Annual Average (µg/m³)			
	100% Load		MEL		100% Load		MEL	
	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative	Isolation	Cumulative
Albion Park	0.16	21.95	0.10	21.95	0.01	6.89	0.01	6.89
Avondale	0.49	21.90	0.27	21.90	0.02	6.92	0.01	6.91
Barrack Heights	0.28	21.90	0.17	21.90	0.01	6.88	0.00	6.87
Berkeley	0.32	21.90	0.20	21.90	0.01	6.89	0.01	6.89
Dapto	0.49	21.90	0.28	21.90	0.02	6.90	0.01	6.90
Haywards Bay	0.22	21.92	0.14	21.92	0.02	6.90	0.01	6.89
Horsley	0.47	21.90	0.26	21.90	0.02	6.92	0.01	6.91
Lake Heights	0.29	21.90	0.18	21.90	0.01	6.89	0.01	6.88
Mt Warrigal	0.50	21.90	0.31	21.90	0.01	6.88	0.01	6.88
Oak Flats	0.22	21.90	0.13	21.90	0.01	6.88	0.01	6.88
Primbee	1.00	21.90	0.61	21.90	0.03	6.92	0.02	6.92
Pt Kembla	0.29	21.90	0.19	21.90	0.01	6.88	0.01	6.88
SE Dapto	0.40	21.90	0.37	21.90	0.01	6.88	0.01	6.88
Shellharbour	0.41	21.90	0.24	21.90	0.01	6.88	0.00	6.88
South Dapto	0.77	21.90	0.42	21.90	0.03	6.93	0.02	6.92
Unanderra	0.34	21.90	0.21	21.90	0.01	6.88	0.01	6.88
Windang	1.03	21.90	0.62	21.90	0.03	6.93	0.02	6.92
Wollongong	0.19	21.90	0.11	21.90	0.01	6.88	0.00	6.87
Yallah	0.37	22.53	0.24	22.49	0.04	6.95	0.02	6.94
Highest on domain	1.95	22.31	1.50	22.17	0.66	7.16	0.41	7.05
Impact Assessment Criteria	*25*				*8*			

9. REGIONAL AIR QUALITY ASSESSMENT

9.1 Methodology

Assessment of the potential for TBPS to increase ozone formation in the Wollongong airshed has been conducted through a level 1 screening ozone assessment. The level 1 assessment has been conducted following the methodology in a report prepared on behalf of EPA titled: *A Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (Environ Australia Pty Ltd, 2011) (Tiered Ozone Procedure).

A level 1 screening ozone assessment provides an assessment of the incremental change in ozone due to a new emission source and the cumulative ozone concentrations due to the new emission source in conjunction with existing sources within the Sydney Greater Metropolitan Region (GMR) Airshed (which includes the Wollongong region).

The methodology uses the Ozone Procedure Tool to calculate the incremental change in ozone and requires:

- Source region (Newcastle, Sydney Central/East/West or Wollongong)
- Daily emissions of NOx, CO and VOCs.
- VOC input options (default reactivities or users specified).
- Whether the source in an ozone attainment or non-attainment area.

The assessment criteria that determine whether a level 2 ozone assessment is required are:

- Maximum allowable increment (1-hour average) – 1 ppb
- Maximum allowable increment (4-hour average) – 1 ppb.

9.2 Input data

The input data for the level 1 ozone assessment are provided in Table 17. Emissions of NOx, CO and VOCs have been calculated for expected operations of 8 hours operation per day.

Table 17 Input data used in the TBPS level 1 screening ozone assessment

Parameter	Value	Unit
Source region	Wollongong	-
VOC input option	Default VOC Reactivities	-
Ozone attainment area	Non-attainment	-
NOx	1.03	tonnes/day
CO	0.14	tonnes/day
VOC	0.15	tonnes/day

9.3 Results

The maximum 1-hour and 4-hour incremental concentrations of ozone calculated for TBPS are 0.39 ppb and 0.26 ppb, respectively. The incremental concentrations are below the maximum allowable increment of 1 ppb and therefore no further ozone assessment is required.

Emissions of NOx from the two E-Class OCGT in the original EIS were 466 tonnes per year. Annual emissions of NOx from the modified proposal are estimated to 395 tonnes per year, which is lower by about 15%.

10. GREENHOUSE GAS ASSESSMENT

10.1 Regulatory framework

10.1.1 National policy

Australia will meet its GHG emissions reduction targets through the Government's Direct Action Plan. The Emissions Reduction Fund (ERF) is a central component of the Direct Action policies that is made up of an element to credit emissions reductions, a fund to purchase emissions reductions, and a Safeguard Mechanism.

The Safeguard Mechanism has been put in place to ensure that emissions reductions purchased by the Government through the ERF are not offset by significant increases in emissions by large emitters elsewhere in the economy. The Safeguard Mechanism commenced on 1 July 2016 and requires Australia's largest emitters to keep emissions within baseline levels. It applies to around 140 large businesses that have facilities with direct emissions (Scope 1 Emissions) of more than 100,000 tonnes of carbon dioxide equivalent (t CO_2-e) a year and is expected to cover approximately half of Australia's emissions.

Direct emissions associated with the Project are anticipated to exceed 100,000 tCO_2-e per year for all years of operations. As a result, the Project would be subject to the requirements of the Safeguard Mechanism.

10.1.2 National Greenhouse and Energy Reporting (NGER)

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) established a national framework for corporations to report GHG emissions and energy consumption.

The *National Greenhouse and Energy Reporting Regulations 2006* (NGER Regulations) recognises Scope 1 and Scope 2 emissions as follows:

- Scope 1 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility.
- Scope 2 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

Registration and reporting are mandatory for corporations that have energy production, energy use or GHG emissions that exceed specified thresholds. GHG emission thresholds include Scope 1 and Scope 2 emissions. NGER reporting thresholds are summarised in Table 18. Energy Australia currently has corporate reporting obligations under the NGER scheme associated with existing operations.

Table 18 NGER annual reporting thresholds – greenhouse gas emissions and energy use

Threshold level	Threshold type	
	GHG (kt CO_2-e)	Energy consumption (TJ)
Facility	25	100
Corporate	50	200
Notes: kt CO_2-e = kilotonnes of carbon dioxide equivalent. TJ = terajoules.		

10.1.3 NSW context

The NSW Government endorses the Paris Agreement and has committed to taking action that is consistent with the level of effort required to achieve Australia's commitments to the Paris Agreement. This includes a goal to reach net zero emissions by 2050. NSW planned response to complement national action includes expanding renewable energy and energy efficiency for households and businesses.

10.2 Assessment methodology

Pollutants of importance to climate change, associated with TBPS are CO_2, CH_4 and N_2O. This study will assess the emissions of GHG from the TBPS during operation based on activity data representative of the proposed activities and the methods described in the following resources:

- The National Greenhouse Accounts, July 2019 (Commonwealth Department of the Environment and Energy, 2017)
- *National Greenhouse and Energy Reporting Regulations 2008* (NGER Regulations)
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (NGER Determination)
- The Greenhouse Gas Protocol.

Scope 1 emissions result predominantly from the combustion of natural gas for electricity generation. The Project does not require the use of grid electricity and hence there are no Scope 2 emissions associated with the Project. Emissions factor (EF) and energy content factors used for this assessment are summarised in Table 19.

Table 19 Emission factor summary (Schedule 1, *NGER Determination*)

Emission source description	Scope	Energy content[1]	Units	Emission Factor	Units
Natural Gas	1	39.3×10^{-3}	GJ/m^3	51.53	$kgCO_2$-e/GJ

Sources: NGER Determination

Notes:
[1]Gross calorific value

GJ/m^3 = gigajoules per cubic metre. kg CO_2-e/GJ = kilograms of carbon dioxide equivalent per gigajoule

10.3 GHG Assessment

Construction activities will be minor and short-lived. Preliminary estimates indicate that GHG emissions associated with the construction of the TBPS will be insignificant on an annual basis.

Table 20 provides an upper bound estimate of annual GHG emissions from the TBPS based on data from various technology suppliers. Annual GHG emissions associated with the operation of the TBPS are predominantly associated with the combustion of natural gas to produce electricity. The annual capacity factor for the power station has been estimated to be 35% on average.

Table 20 Annual GHG emissions and energy use associated with the Project

Parameter	Quantity	Units
Electricity production	1,177,804	MWh/y
Natural gas consumption	11,420,342	GJ/y
GHG emissions	588,490	tCO_2-e/y

GHG emissions from the TBPS would contribute to Australia's and New South Wales' annual GHG emissions inventories. A summary of the contribution to annual GHG emissions due to the TBPS at a state and national scale is provided in Table 21.

Table 21 Project contribution to annual GHG emissions for Australia and New South Wales

Category	Australia		New South Wales	
	Emissions ($MtCO_2$-e)	Project %	Emissions ($MtCO_2$-e)	Proposal %
Inventory total	554.1	0.11%	144.1	0.52%
Notes: State and Territory Greenhouse Gas Inventories 2017 (Commonwealth of Australia, 2019b)				

The maximum annual GHG emissions and energy use associated with the Project (588,490 tCO_2-e and 11,420,342 GJ) exceed the NGER program facility thresholds of 25 $ktCO_2$-e and 100 TJ, respectively. In terms of reporting obligations to the NGER program, Energy Australia will be required to report annual GHG emissions and energy use for the Project as a component of its corporate NGER reporting obligations.

The two E-Class OCGT in the original EIS were estimated to emit 735 $ktCO_2$-e per year of GHG. The annual GHG emissions from the modified proposal are anticipated to be up to 588 $ktCO_2$-e, which is 20% lower.

11. CONCLUSIONS

This air quality assessment aims to quantify the TBPS's effect on air quality using site representative data and information, including the proposed turbine configuration, PDD, meteorology and a range of operating loads. The assessment has used a dispersion modelling approach conducted in accordance with the Approved Methods.

The dispersion modelling results for NO_2 showed the following:

- Predicted ground-level concentrations of NO_2 for TBPS in isolation, operating at either 100% load or MEL, were below the relevant impact assessment criteria at all locations.
- The sensitive receptor with the highest 1-hour average ground-level concentration of NO_2 due to TBPS in isolation at 100% load was South Dapto, to the west of TBPS, with a concentration of 87.9µg/m³ or 36% of the impact assessment criterion (246µg/m³).
- Predicted ground-level concentrations of NO_2 for the cumulative assessment, with TBPS operating at either 100% load or MEL, were below the relevant assessment criteria at all locations.
- The sensitive receptor with the highest 1-hour average NO_2 ground-level concentration in the cumulative assessment with TBPS at 100% load was South Dapto, to the west of TBPS, with a concentration of 170µg/m³ or 69% of the impact assessment criterion (246µg/m³).

The dispersion modelling results for PM_{10} and $PM_{2.5}$ showed the following:

- Predicted ground-level concentrations of PM_{10} and $PM_{2.5}$ from the proposed TBPS in isolation, operating at either 100% load or MEL, were less than 8% of the relevant assessment criteria at all locations.
- Ambient air quality monitoring conducted by the NSW Department of Industry, Planning and Environment (DPIE) at Kembla Grange shows that there were 10 days in 2018 when the concentration of PM_{10} was above 50µg/m³. The cumulative PM_{10} assessment, using a contemporaneous approach, predicted no additional days above the 50µg/m³ assessment criterion.
- Predicted maximum 24-hour average ground-level concentrations of $PM_{2.5}$ due to TBPS in isolation operating at either 100% load or MEL plus background, were below the impact assessment criterion of 25 µg/m³ at all locations.
- Predicted annual average ground-level concentrations of PM_{10} and $PM_{2.5}$ due to TBPS operating at either 100% load or MEL plus background, were below the relevant impact assessment criteria at all locations.

A regional air quality assessment has also been undertaken to determine the potential for increase in ozone formation due to TBPS. This has been conducted through a level 1 screening ozone assessment following methods in the report prepared on behalf of EPA titled: *A Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (Environ Australia Pty Ltd, 2011) (Tiered Ozone Procedure).

The regional air quality screening assessment showed the following:

- The maximum 1-hour and 4-hour incremental concentrations of ozone calculated for TBPS were 0.39 ppb and 0.26 ppb, respectively.
- The incremental concentrations are below the maximum allowable increment of 1 ppb and, therefore, the potential impact is insignificant, and a detailed ozone assessment is not required.
- Compared to the two E-Class OCGT in the original EIS, annual emissions of NOx from the modified proposal are anticipated to be lower by about 15%.

GHG emissions associated with the operation of the Project are predominantly associated with the combustion of natural gas to produce electricity. GHG emissions and energy use per year of operations of the Project are summarised in the following table:

Parameter	Quantity	Units
Electricity production	1,177,804	MWh/y
Natural gas consumption	11,420,342	GJ/y
GHG emissions	588,490	tCO_2-e/y

Compared to the two E-Class OCGT in the original EIS, annual GHG emissions from the modified proposal are anticipated to be lower by 20%.

12. REFERENCES

Environ Australia Pty Ltd, 2011, A Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources, prepared for NSW EPA

NSW EPA, 2017, Approved Methods for the Modelling and Assessment of Air Pollutants in NSW. Available online; https://www.epa.nsw.gov.au/publications/air/approved-methods-modelling-assessment-air-pollutants-160666

NPI, 2018/19 National Pollutant Inventory Database (website), Australian Government, Department of the Environment and Energy, http://www.npi.gov.au/npidata/action/load/map-search (accessed April 2020).

SKM, 2010, Tallawarra B Power Station Environmental Impact Statement, prepared for TruEnergy.

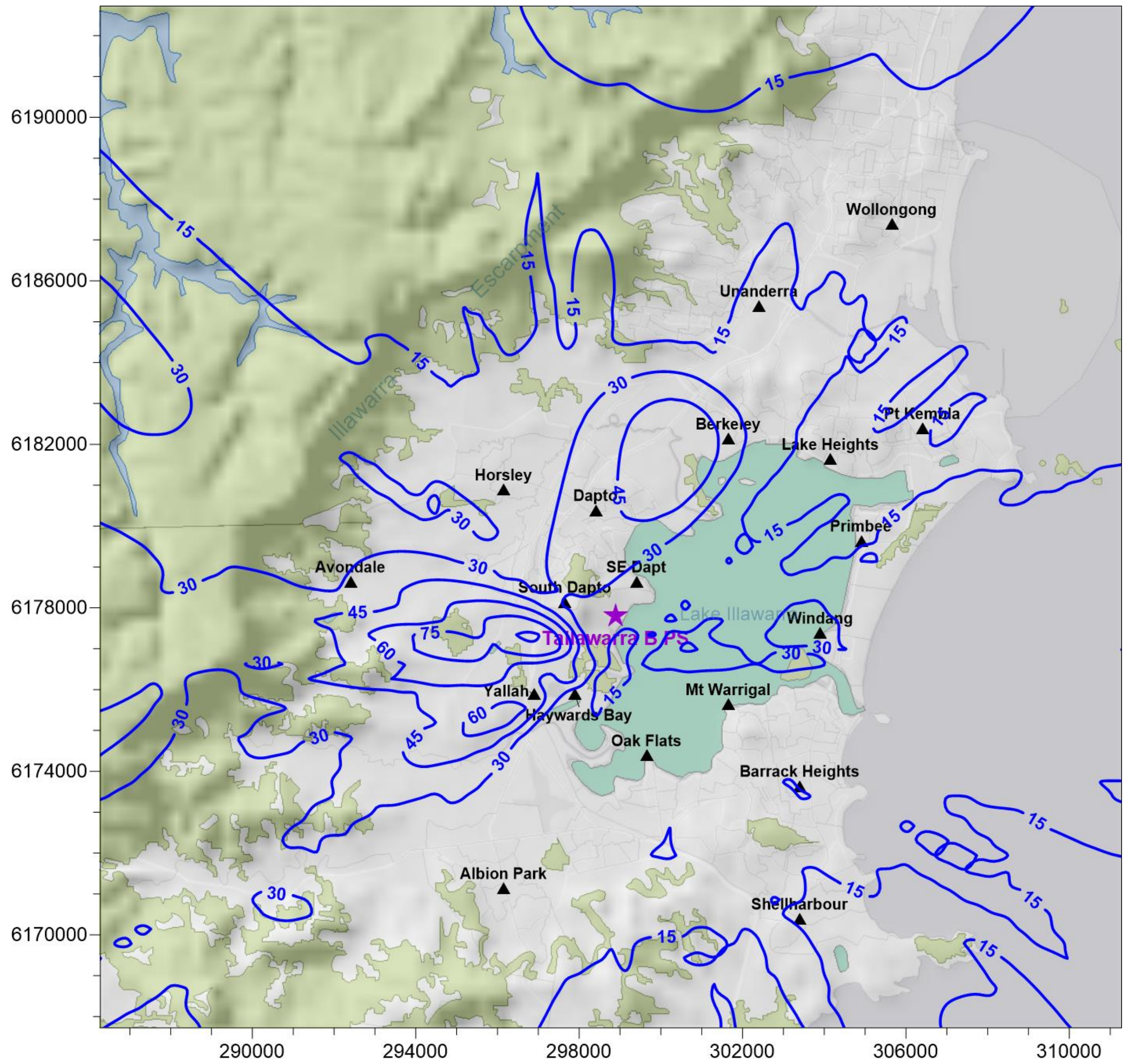


Plate 1	**Maximum 1-hour average ground-level concentrations of NO_2 due to TBPS in isolation operating at 100% Load**

Location:	**Averaging period:**	**Data source:**	**Units:**
Wollongong	1-hour	TAPM	µg/m³
Type:	**Criteria:**	**Prepared by:**	**Date:**
Maximum	246 µg/m³	D. Gallagher	May 2020

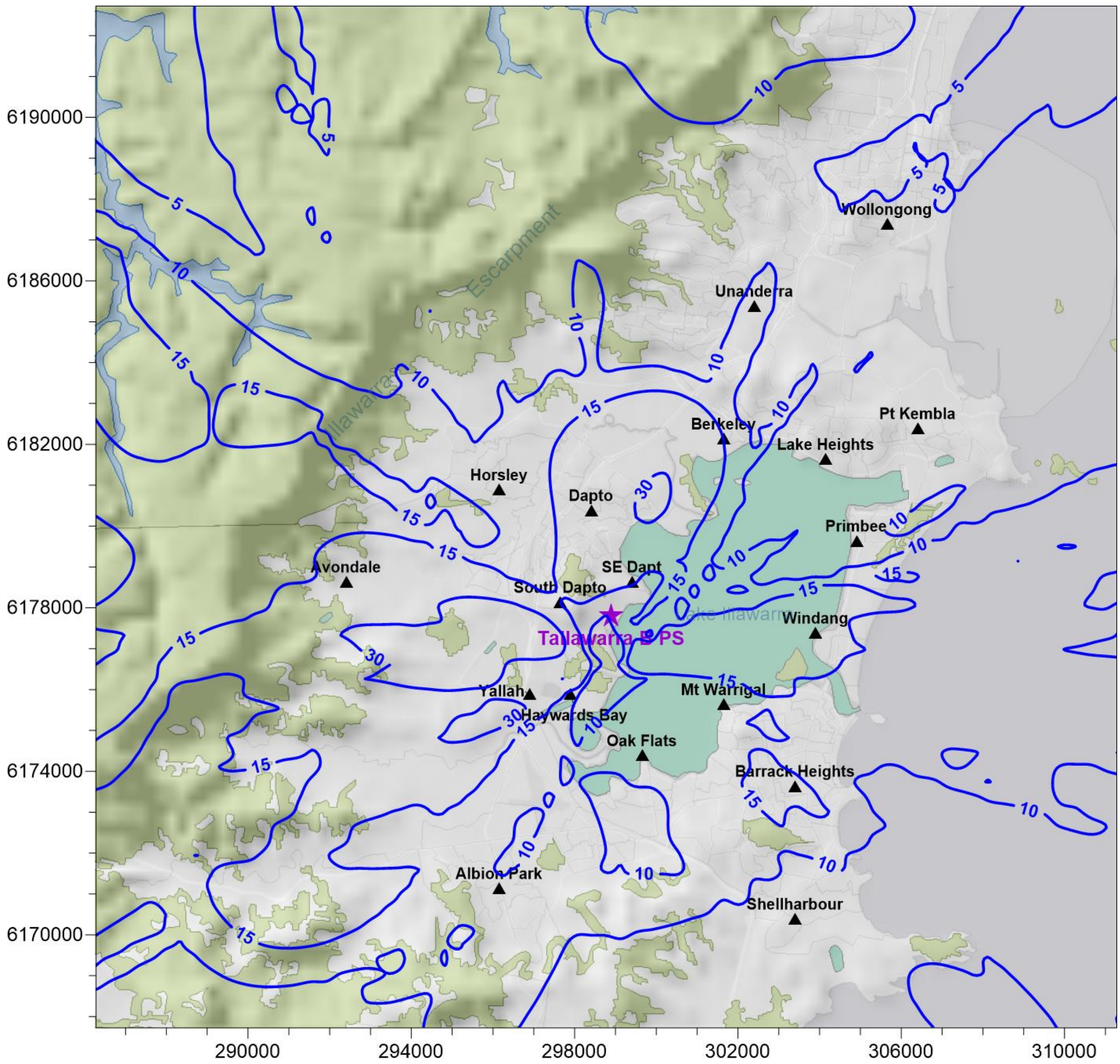


Plate 2	**Maximum 1-hour average ground-level concentrations of NO_2 due to TBPS in isolation operating at MEL**

Location: Wollongong	**Averaging period:** 1-hour	**Data source:** TAPM	**Units:** µg/m^3
Type: Maximum	**Criteria:** 246 µg/m^3	**Prepared by:** D. Gallagher	**Date:** May 2020

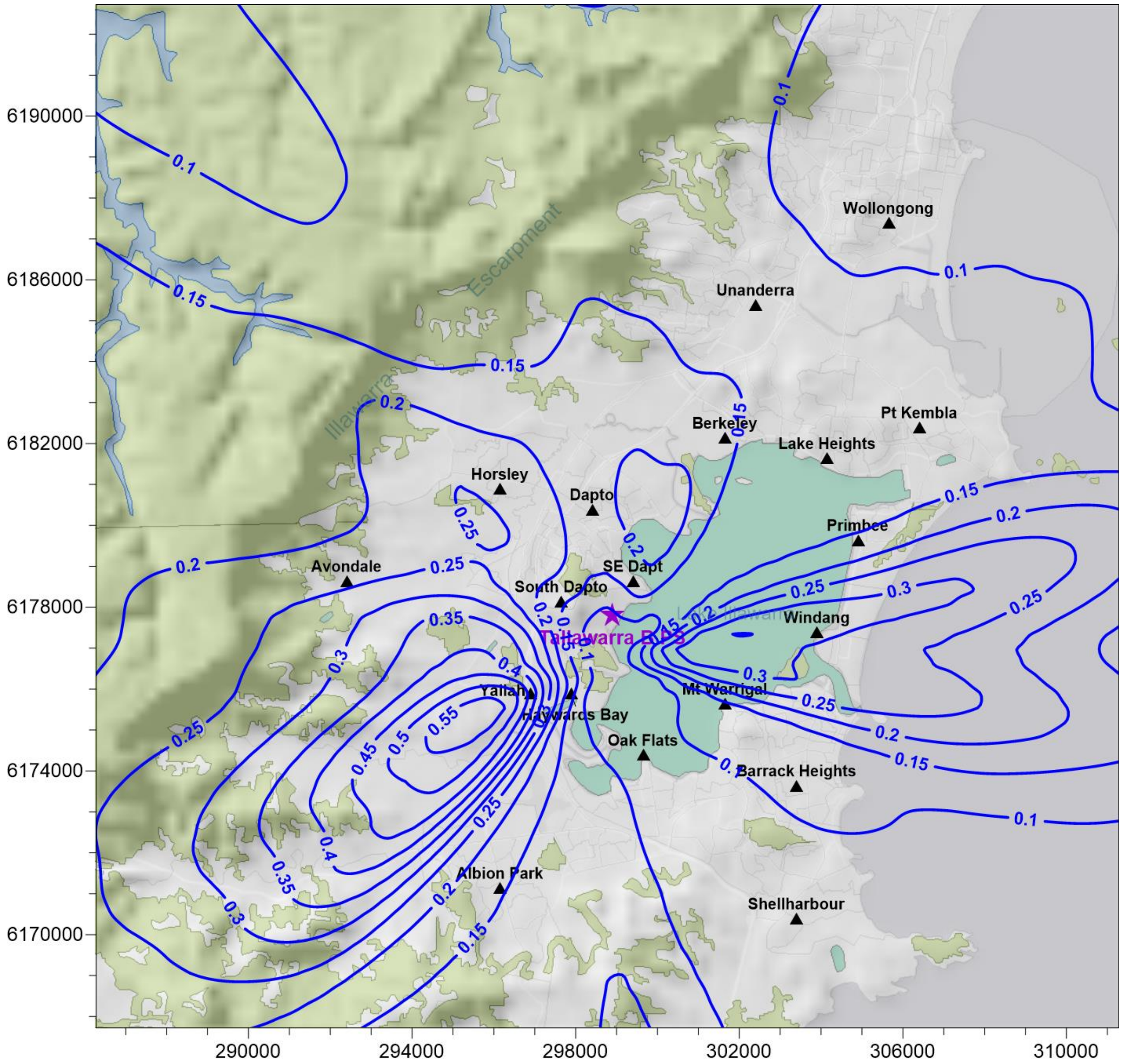


Plate 3	**Annual average ground-level concentrations of NO_2 due to TBPS in isolation operating at 100% Load**

Location: Wollongong	**Averaging period:** 1-year	**Data source:** TAPM	**Units:** µg/m³
Type: Annual	**Criteria:** 62 µg/m³	**Prepared by:** D Gallagher	**Date:** May 2020

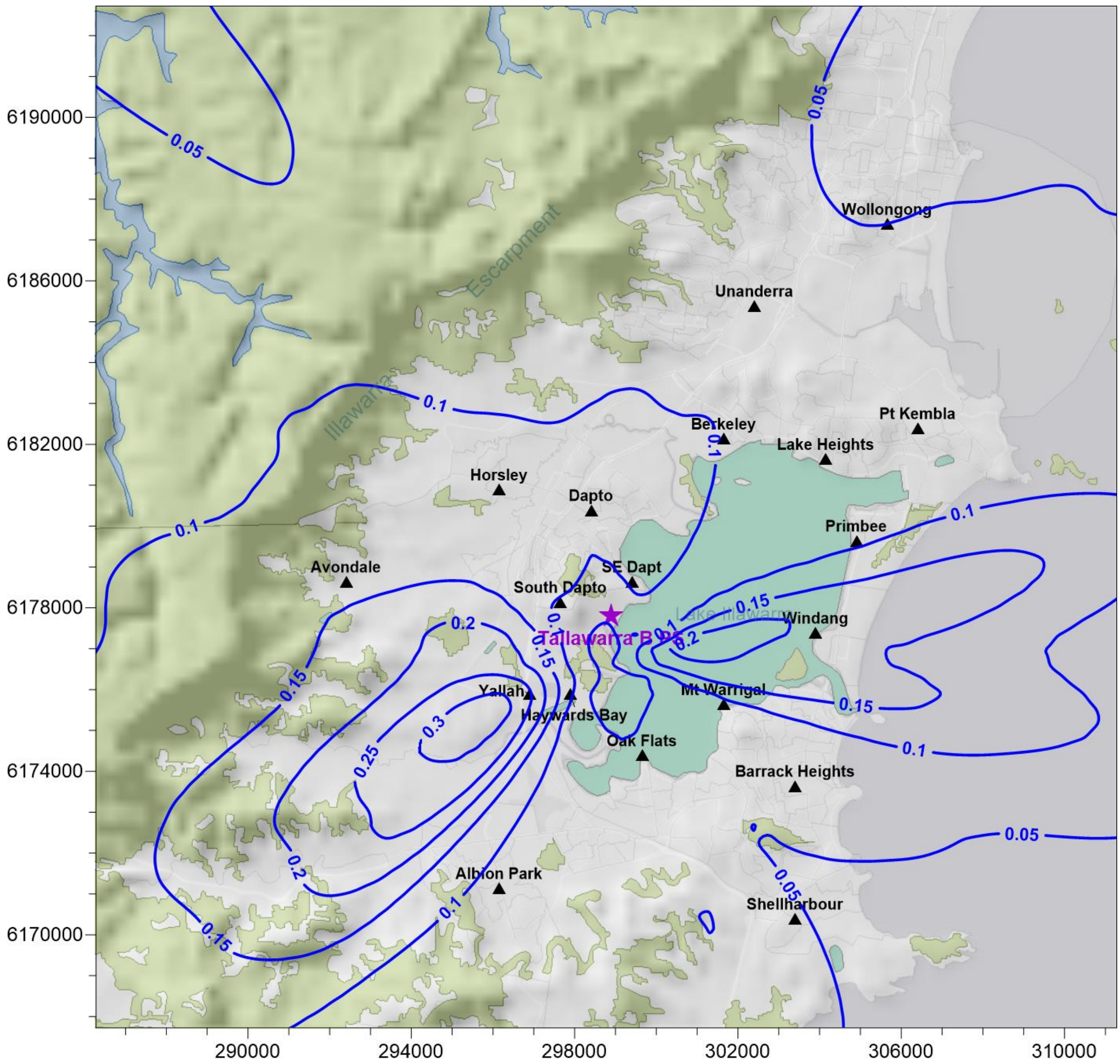


Plate 4	**Annual average ground-level concentrations of NO_2 due to TBPS in isolation operating at MEL**

Location:	**Averaging period:**	**Data source:**	**Units:**
Wollongong	1-year	TAPM	µg/m³
Type:	**Criteria:**	**Prepared by:**	**Date:**
Annual	62 µg/m³	D Gallagher	May 2020

APPENDIX A METEOROLOGICAL AND DISPERSION MODELLING METHODOLOGY

A1 METEOROLOGY

A1.1 TAPM meteorology

The meteorological model, TAPM (The Air Pollution Model) Version 4.0.5, was developed by the CSIRO and has been validated by the CSIRO, Katestone and others for many locations in Australia, in southeast Asia and in North America (see www.cmar.csiro.au/research/tapm for more details on the model and validation results from the CSIRO). Katestone has used the TAPM model throughout Australia and has performed well for simulating regional winds patterns. TAPM has proven to be a useful model for simulating meteorology in locations where monitoring data is unavailable.

TAPM was configured as follows:

- 1 January 2018 to 31 December 2018 modelled.
- 36 x 36 grid point domain with an outer grid of 30 km and nesting grids of 10 kilometres, 3 kilometres, and 1 kilometre.
- Grid centred at -34º -30' latitude and 150º 48.5' longitude.
- Geoscience Australia 9-second digital elevation model terrain data.
- 25 vertical grid levels.
- Advanced options set to default.
- 2018 monitoring data from DPIE sites at Kembla Grove and Wollongong, and the BoM site at Albion Park assimilated with a 10 km radius of influence.

A1.2 Selection of representative year

The closest automatic weather station to the Tallawarra B Power Station is operated by the BoM at Albion Park, adjacent to Shellharbour Airport. The meteorological station is approximately 4.5km to the south-southwest of the proposes power station. Hourly average wind speed, wind direction and ambient temperature data from the Albion Park meteorological station was purchased from the BoM covering the period of TAPM modelling.

Wind roses of the BoM Albion Park data for 2015 to 2019 are shown in Figure A1. The wind roses show predominantly westerly winds with winds occasionally from the northeast. Wind speeds are also strongest from the west and south.

Calendar year 2018 was selected as a representative year for meteorological modelling based on analysis of the last five complete years (2015 to 2019) of observations at the BoM Albion Park monitoring station. This indicated 2018 was the most recent year with the closest to average wind speed and direction, making it most representative of typical conditions.

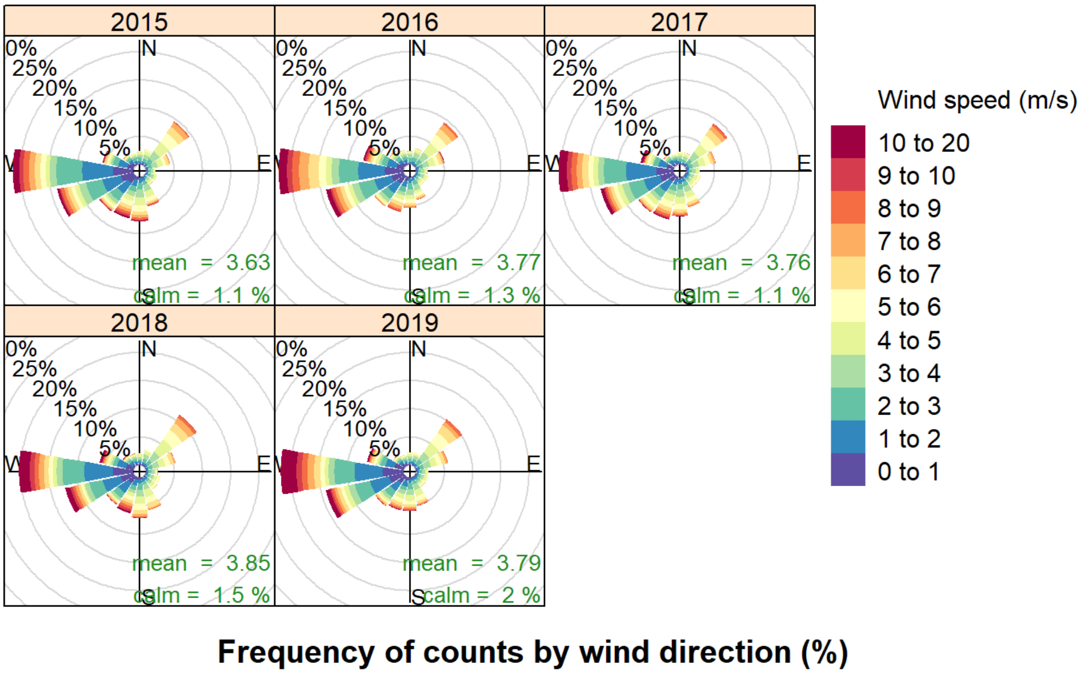


Figure A1 **Annual wind roses at BoM Albion Park from 2015-2019**

A1.3 Comparison of TAPM output with observational data

The model validation in the following sections compares observational meteorological data with data derived from running TAPM.

Table A1 presents statistical comparisons of TAPM output (wind speed and temperature) including assimilated observational data from Kembla Grove, Wollongong, and Albion Park meteorological stations to meteorological data recorded at the BoM automatic weather station located Albion Park. The TAPM output was extracted from the closest inner grid point to the location of the BoM Albion Park monitoring station.

The following statistical measures of model accuracy are presented in the tables.

The mean bias, which is the mean model prediction minus the mean observed value. Values of the mean bias close to zero show good prediction accuracy.

The root mean square error (RMSE), which is the standard deviation of the differences between predicted values and observed values. The RMSE is non-negative and values of the RMSE close to zero show good prediction accuracy. The RMSE is given by

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2}$$

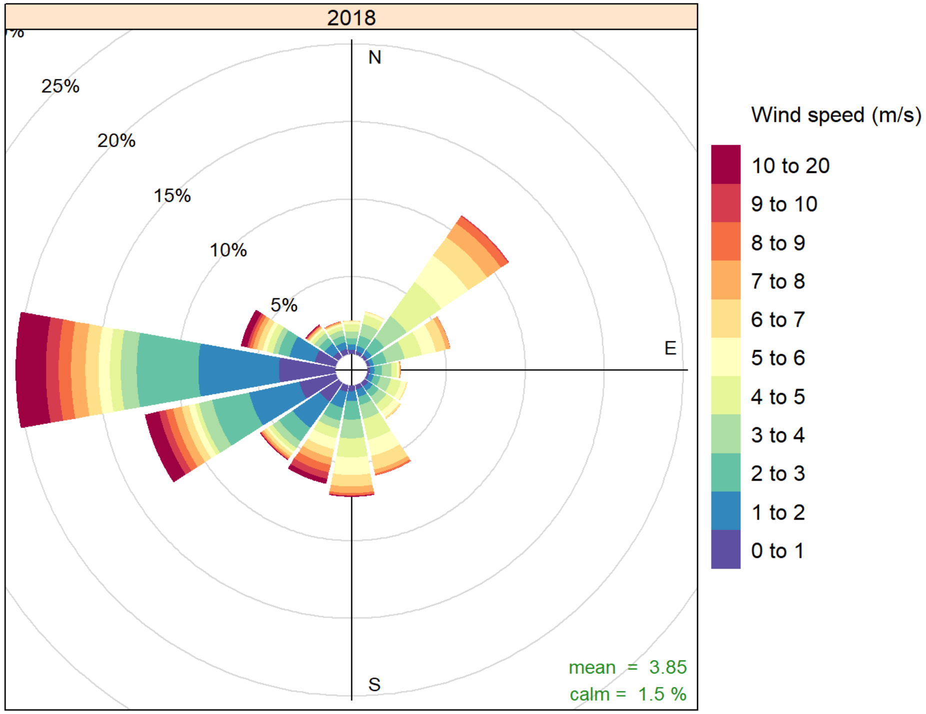
where N is the number of observations, P_i are the hourly model predictions and O_i are the hourly observations

The index of agreement (IOA), which takes a value between 0 and 1, with 1 indicating perfect agreement between predictions and observations. The IOA is calculated following a method described in Willmott (1982), using the equation

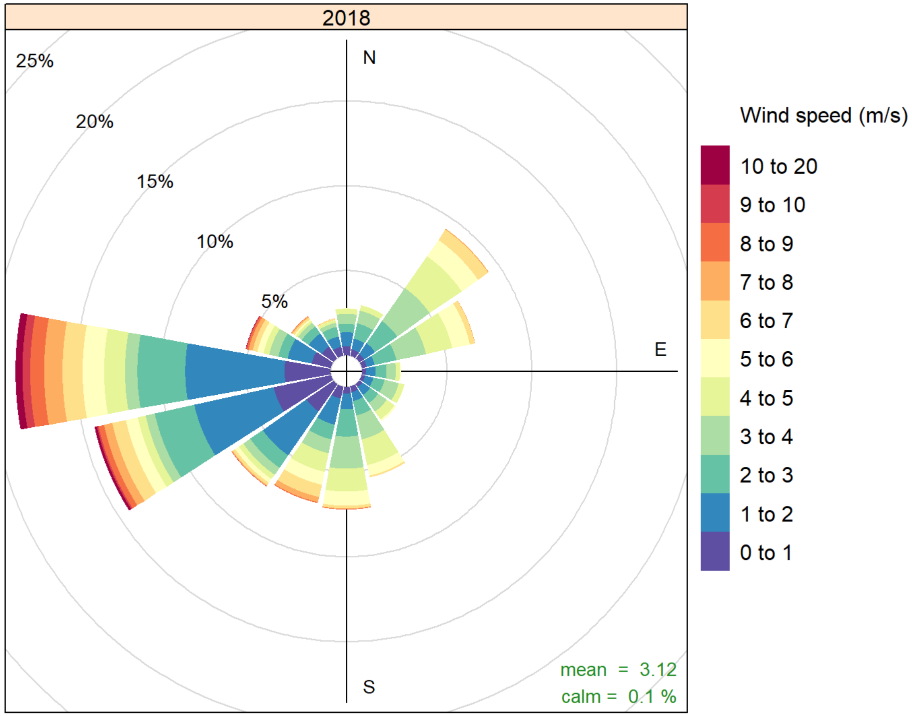
$$\mathrm{IOA} = 1 - \frac{\sum_{i=1}^{N}(P_i - O_i)^2}{\sum_{i=1}^{N}(|P_i - O_{mean}| + |O_i - O_{mean}|)^2}$$

where N is the number of observations, P_i are the hourly model predictions, O_i are the hourly observations and O_{mean} is the observed observation mean.

Whilst the bias and RMSE values are slightly outside the benchmark ranges, the IOA for wind speed and temperature are both greater than the minimum benchmark value, and the probability distribution functions illustrate the assimilated data TAPM runs show good distribution of wind speeds and wind directions compared with observations at BoM Albion Park (Figure A3). Wind roses of annual wind speed and direction distributions for observational data and the TAPM output are depicted in Figure A2.



Frequency of counts by wind direction (%)

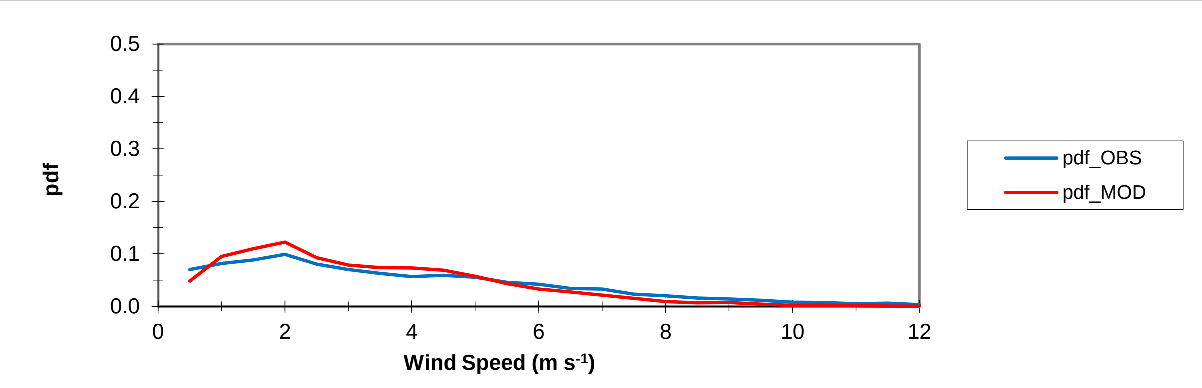


Frequency of counts by wind direction (%)

Figure A2 **Annual distribution of winds recorded by the Albion Park AWS (left) and generated by TAPM at the nearest grid point to the Albion Park AWS (right)**

Table A1 **A comparison of the observed meteorological data with TAPM with data assimilation output**

Statistic	"Good" value	Wind speed			Temperature		
		Benchmark	Observational data	TAPM	Benchmark	Observational data	TAPM
Mean	-	-	3.76	3.17	-	17.00	18.4
Standard deviation	-	-	2.84	2.09	-	5.86	5.04
Minimum	-	-	0.00	0.00	-	-0.44	6.00
Maximum	-	-	16.85	12.60	-	40.72	38.60
Bias	0	<±0.5 m/s	-0.59		<±0.5 °C	1.40	
Root mean square error (RMSE)	Close to 0	<2 m/s	1.25		-	2.12	
Index of agreement	Close to 1	>0.6	0.94		≥0.8	0.90	



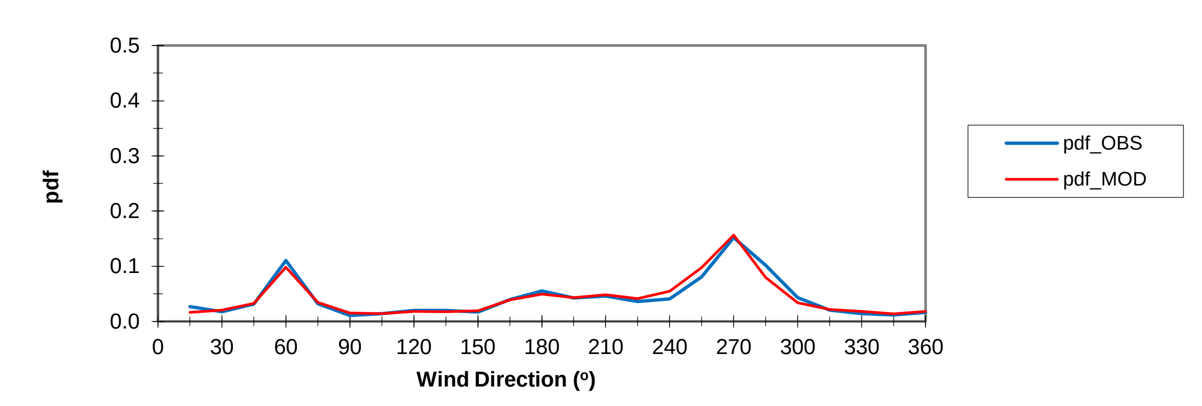


Figure A3 **PDF plots of wind speed and wind direction comparing observational data from BoM Albion Park against the TAPM with assimilated obs output.**

A2 DISPERION MODELLING

A2.1 TAPM

The general TAPM input parameters and settings were as follows:

- Mother domain of 30 km resolution with 3 nested daughter grids of 10 km, 3 km and 1 km resolutions
- 36 x 36 grid points for all domains resulting in a 36 x 36 km grid at 1 km resolution
- 25 vertical levels; from the surface up to an altitude of 8000 metres above ground level
- All domains were centred at a location close to the Tallawarra B Power Station location, with the centre having latitude 34°30' and longitude 150°48.5'.
- Default TAPM terrain data
- The default TAPM land use data was edited based on aerial photography to match current land use in the region
- Default databases for synoptic analyses and sea surface temperature were used
- Default options selected for advanced meteorological inputs
- TAPM was run for one year beginning on 1 January 2018.

TAPM pollution modelling settings were as follows:

- Pollution modelling grid based off the 36 x 36 grid point 1 km resolution domain, centred at latitude 34°30' and longitude 150°48.5' for all scenarios.
- Resolution increased to 101 x 101 grid points with 250 m spacing.
- Two Tracer species were included in .pse files, one for NOx and one for PM_{10}.
- All emission sources initialised in LPM
- 900 second particle travel time before converting to EGM
- All other settings were left as default.

A2.2 Method for assessing angular release

The installation of PDD outlets to the Tallawarra B power station exhaust stacks results in angular release of stack emissions. To account for this angular release the angle of release and exhaust velocity were used to approximate the vertical component of the exit velocity with the following equation:

$$Vertical\ exit\ velocity\ component = \sin^{1}(90° - PDD\ release\ angle\ °) \times exhaust\ velocity\ (ms^{-1})$$