



northstar



This document has been prepared for **MAAS Group Properties** by:

Northstar Air Quality Pty Ltd,

Head Office: Suite 1504, 275 Alfred Street, North Sydney, NSW 2060

Riverina Office: PO Box 483, Albury, NSW 2640

northstar-env.com | Tel: 1300 708 590

33 Magpie Hollow Road, South Bowenfels Residential Development

Sewage Pump Station - Odour Impact Assessment

Addressee(s): MAAS Group Properties

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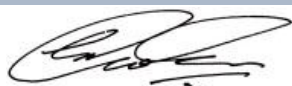
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Final Authority

This report must be regarded as draft until the above study components have been each marked as final, and the document has been signed and dated below. A draft report is a working document, is issued without prejudice and is subject to change.



G. Graham

20 November 2025

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NON-TECHNICAL SUMMARY

Northstar Air Quality Pty Ltd has been commissioned by MAAS Group Properties to perform an odour impact assessment to determine the potential impact from a proposed sewage pump station and an existing sewage pump station (to be upgraded in the future) required as part of a proposed residential development located at 33 Magpie Hollow Road, South Bowenfels NSW.

The assessment was undertaken in two stages:

- Stage 1: The proposed sewage pump station was modelled with the known sewage inflow rate to determine remaining 'headroom' between the initial modelled impact and the criterion.
- Stage 2: The future upgraded sewage pump station was 'back-modelled' to estimate the odour emission rate which should not be exceeded for the odour criterion to be achieved.

A conservative approach was adopted to assess odour impacts, assuming that all air displaced by the sewage flow was emitted to atmosphere via the ventilation stack. The results indicate that additional odour control at each sewage pump station is not considered to be required, with any odour and hydrogen sulphide impacts anticipated to be below the NSW Environment Protection Authority criteria across the Proposal site.

However, should odour control be required to be included for risk management, or contingency purposes, options such as installing an odour control unit or modifying vent stack design (e.g. increasing height or vertical velocity) could further reduce odour concentrations. Information derived from Sydney Water suggests that an odour control unit would ensure that odour concentrations remain well below the requirements, however installation and operational costs should be considered.

The assessment demonstrates compliance with the NSW Environment Protection Authority criteria without the need for additional management and control measures. Any further management or control measures would provide an extra layer of risk mitigation but are not required to ensure achievement of the relevant air quality criteria.

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1. INTRODUCTION

MAAS Group Properties (the Applicant) has engaged Northstar Air Quality Pty Ltd (Northstar) perform an odour assessment for a proposed multi-dwelling residential development (the Proposal) to be located at 33 Magpie Hollow Road, South Bowenfels NSW (the Proposal site). Specifically, the odour assessment considers the operation of two sewage pump stations (SPS) proximate to the proposed residential dwellings.

The purpose of this report is to undertake an assessment to understand the risks and potential impacts of odour (and odorous compounds) from the operation of the two SPS on the Proposal site.

To allow assessment of the level of risk associated with the SPS in relation to odour, this assessment has been performed in accordance with and with due reference to (in no order):

- *Protection of the Environment Operations Act 1997;*
- *Environmental Planning and Assessment Act 1979;*
- Protection of the Environment Operations (Clean Air) Regulation 2022;
- Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (NSW EPA, 2022); and
- Technical Framework and Notes - Assessment and Management of Odour from Stationary Sources in NSW (NSW DECC, 2006).

1.1. Approach to Assessment

This assessment seeks to provide information on whether odour emissions resulting from the operation of the two SPS (one existing and one proposed), specifically the emissions of odour through the ventilation stacks, will give rise to potential unacceptable amenity impacts at residential dwellings within the Proposal site.

It is noted that the existing SPS is expected to be upgraded in the future, however, the upgrade infrastructure is not yet designed and correspondingly details regarding the upgrade are currently unknown. Given this, the dispersion modelling assessment has adopted a staged approach as follows:

- Stage 1: The proposed SPS has been modelled with the known parameters to determine the remaining 'headroom' between the initial modelled impact and the criterion.
- Stage 2: The future upgraded SPS has been 'back modelled' to estimate the sewage inflow rate and odour emission rate which should not be exceeded for the odour criterion to be achieved.

In relation to SPS, impacts associated with odour are most likely to be correlated with impacts associated with hydrogen sulphide (H₂S). Within this assessment, impacts associated with odour and H₂S are identified, examined and assessed.

2. THE PROPOSAL

2.1. Environmental Setting

The Proposal site is located at 33 Magpie Hollow Road, South Bowenfels NSW in the Lithgow City Council Local Government Area (LGA). The Proposal site is legally described as Lot 2 Deposited Plan (DP) 1229039.

Land uses in the area surrounding the Proposal site are predominantly residential. Land use zoning surrounding the Proposal site under the Lithgow Local Environmental Plan (LEP) 2014 are discussed further in Section 4.1.1.

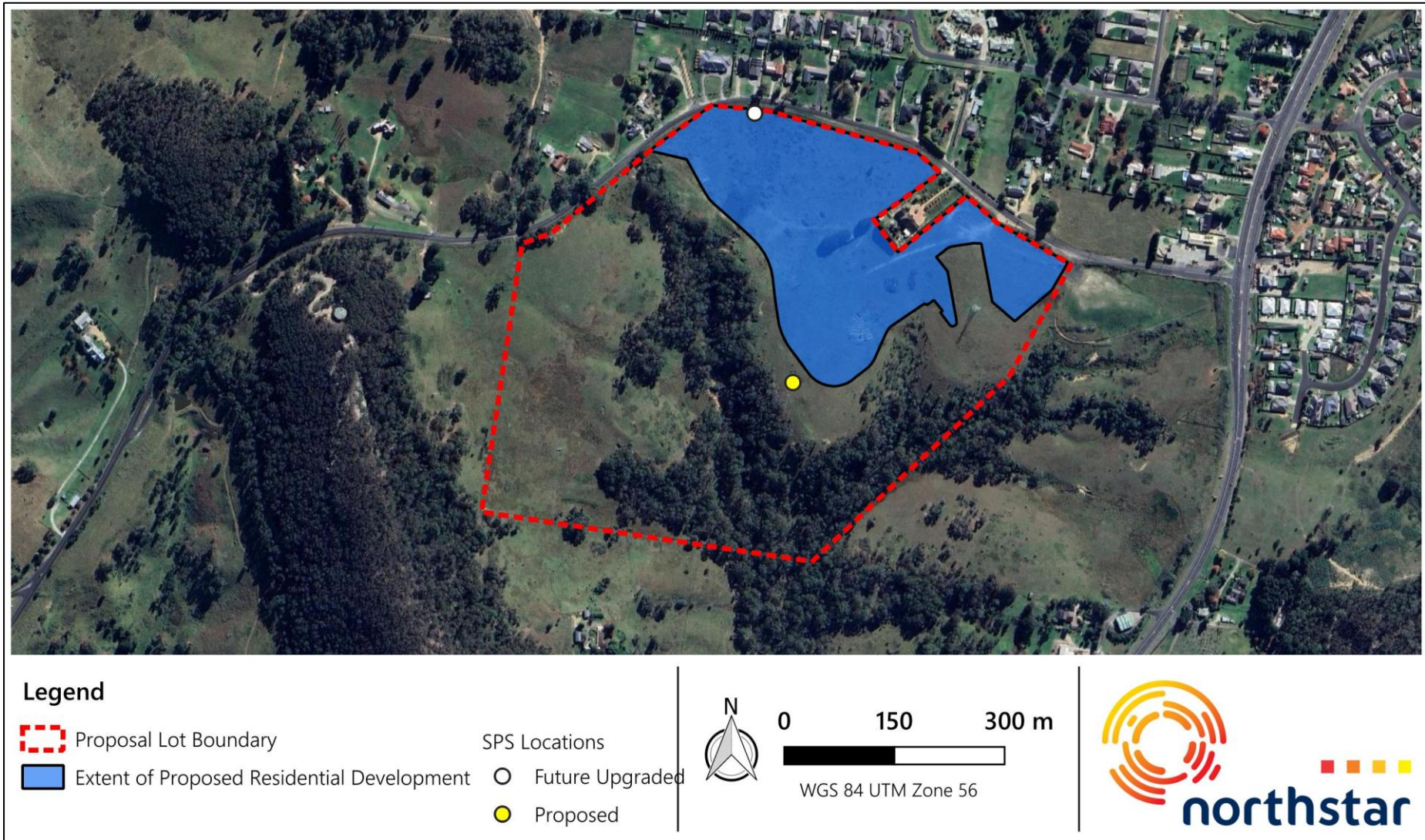
2.2. Overview

Consent is sought for a proposed residential development at the Proposal site which is expected to comprise 203 residential lots and an internal road network.

A private SPS will be required to service the Proposal and is anticipated to be located towards the south-western corner of the Proposal site. As outlined in Section 1.1 an existing SPS is located at the northern boundary of the Proposal site, which is anticipated to be upgraded.

The location and surrounding area of the Proposal site, including the location of the two SPS is illustrated in Figure 1, while the Proposal site layout is presented in Figure 2.

Figure 1 Proposal site location



Source: Northstar



3. LEGISLATION, REGULATION & GUIDANCE

Impacts from odorous air contaminants are often nuisance-related rather than health-related. Odour performance goals guide decisions on odour management and are generally not intended to achieve “no odour”, but manage odour impacts to an acceptable level.

3.1. Definitions of Odour

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the odour detection threshold (ODT) and defines one odour unit (OU). An odour goal of less than 1 OU would (by definition) result in no odour impact being detectable in laboratory conditions. In practice, the character of an odour can only be judged by the receiver’s reaction to it, and preferably only compared to another odour under similar social and regional conditions.

Based on the literature available, the level at which an odour is perceived to be a nuisance can range from 2 OU to 10 OU depending on a combination of the following factors:

- **Odour quality:** whether an odour results from a pure compound or from a mixture of compounds. Pure compounds tend to have a higher threshold (lower offensiveness) than a mixture of compounds.
- **Population sensitivity:** any given population contains individuals with a range of sensitivities to odour. The larger a population, the greater the number of sensitive individuals it contains.
- **Background level:** whether a given odour source, because of its location, is likely to contribute to a cumulative odour impact. In areas with more closely located sources it may be necessary to apply a lower threshold to prevent offensive odour.
- **Public expectation:** whether a given community is tolerant of a particular type of odour and does not find it offensive, even at relatively high concentrations. For example, background agricultural odours may not be considered offensive until a higher threshold is reached than for odours from a landfill facility.
- **Source characteristics:** whether the odour is emitted from a stack (point source) or from an area (diffuse source). Generally, the components of point source emissions can be identified and treated more easily using control equipment than diffuse sources. Point sources tend to be located in urban areas, while diffuse sources are more prevalent in rural locations.
- **Health effects:** whether a particular odour is likely to be associated with adverse health effects. In general, odours from agricultural activities are less likely to present a health risk than emissions from industrial facilities.

3.2. Odour Assessment Criteria in NSW

Experience gained through odour assessments from proposed and existing facilities in NSW indicates that an odour performance goal of 7 OU is likely to represent the level below which “offensive” odours should not occur (for an individual with a ‘standard sensitivity’ to odours). Therefore, the *Technical framework: Assessment and management of odour from stationary sources in NSW* (Technical Framework) (NSW DECC, 2006) recommends that, as a design goal, no individual be exposed to ambient odour levels of greater than 7 OU. In modelling and assessment terms, this is expressed as the 99th percentile value, as a nose response time average (approximately one second).

Odour assessment criteria need to consider the range in sensitivities to odours within the community to provide additional protection for individuals with a heightened response to odours. This is addressed in the Technical Framework (NSW DECC, 2006) by setting a population dependent odour assessment criterion, and in this way, the odour assessment criterion allows for population size, cumulative impacts, anticipated odour levels during adverse meteorological conditions, and community expectations of amenity. A summary of odour performance goals for various population densities, as referenced in the Technical Framework (NSW DECC, 2006) is shown in Table 1. This table shows that in situations where the population of the affected community lies between 125 and 500 people for example, an odour assessment criterion of 4 OU at the nearest residence (existing or any likely future residences) is to be used. For isolated residences, an odour assessment criterion of 7 OU is appropriate.

3.3. Ground Level Concentration Assessment Criteria in NSW

The primary purpose of a stack or control equipment, in relation to odour, is to control the discharge of a pollutant so that the odour is diluted and dispersed and subsequently reduced to an acceptable concentration by the time it has reached a location where it might be detected by people. An indication of whether this will be achieved can be determined by using ground level concentration (glc) criteria. In general, the criteria are set to protect the public against adverse health effects, aesthetic effects, offensiveness, and economic loss that might occur. Since the area of interest (the ‘breathing zone’) is close to the ground, the acceptable concentrations are referred to as ground-level concentrations (glcs) (NSW DECC, 2006). In the case of a multi-level development, the breathing zone may occur at multiple points (and heights) across the developments.

NSW EPA has adopted glc criteria for individual odorous and toxic compounds, set on the basis of either odour or health impacts, whichever is more stringent, for use in NSW.

The glc criteria are referred to in the Approved Methods (NSW EPA, 2022). To ensure that odour impacts are maintained within acceptable levels, odour emissions from an activity should be assessed against the glc criteria. Where several activities with similar odour character will result in a cumulative impact, the total of the odour (and odorous compounds) emissions from all contributing activities needs to be considered. When

carrying out an odour impact assessment, the concentration of pollutants should be predicted at and beyond the boundary of the premises. For point sources, dispersion modelling can be used to determine a stack emission limit that will ensure the glc criteria are not exceeded at these locations. This limit is prescribed to ensure that people living in the vicinity are unlikely to be impacted by 'offensive odour' (NSW DECC, 2006).

Odour concentration criteria and glc criteria for H₂S appropriate to this assessment are presented in Table 1, and are expressed on a scale relative to the size of the potentially exposed population.

Table 1 NSW EPA Technical Framework odour criteria

Population of affected community	Impact assessment criteria	
	Complex mixture of odours (OU)	Hydrogen sulphide (H ₂ S) (µg·m ⁻³)
Urban area (≥2 000)	2.0	1.38
500 – 2 000	3.0	2.07
125 – 500	4.0	2.76
30 – 125	5.0	3.45
10 – 30	6.0	4.14
Single residence (≤2)	7.0	4.83

Source: The Odour Technical Notes, (NSW DECC, 2006), (NSW EPA, 2022)

Given the residential nature of the Proposal and the area as a whole, an odour performance goal of 2 OU and 1.38 µg·m⁻³ of H₂S has been adopted for this assessment.

3.4. NSW Protection of Environment Operations Act

It is noted that the odour assessment criteria (see Section 3.2) are a design tool rather than a regulatory tool. The benchmark for operational facilities is not the odour assessment criteria outlined above but whether the emission of odour is 'offensive' or being prevented or minimised using best management practices.

The *Protection of the Environment (Operations) Act* 1997 (POEO Act) emphasises the importance of preventing 'offensive odour' and the principles contained within the POEO Act framework are applicable.

For reference, "offensive odour" is defined within the POEO Act as:

an odour:

- (a) *that, by reason of its strength, nature, duration, character or quality, or the time at which it is emitted, or any other circumstances:*
 - (i) *is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
 - (ii) *interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*

(b) that is of a strength, nature, duration, character or quality prescribed by the regulations or that is emitted at a time, or in other circumstances, prescribed by the regulations.

Further to the discussion of factors that determine whether an odorous mixture may be determined to lead to a nuisance in Section 3.1 and the impact assessment criterion determined in Section 3.2 and Section 3.3, numerous papers and articles identify the disconnect between that two drivers that help regulate odour (as referenced in (Graham, Lawrence, & Doyle, 2013)). The description provided in the POEO Act may be summarised as a function of five broad factors, called the FIDOL factors, namely:

- **Frequency:** indicates how often an odour is experienced. Exposure to relatively pleasant odours (such as a bakery, for example) may be perceived to be a nuisance (or 'offensive odour') if it is experienced too frequently, and conversely, a more unpleasant odour may be tolerated if it is experienced hardly ever.
- **Intensity:** indicates the relative strength of the odour;
- **Duration:** in parallel to frequency, duration is an important factor representing the length of time of which an odour exposure is observed;
- **Offensiveness:** indicates how pleasant / unpleasant an odour is to the population. Whilst individuals may express a personal opinion of acceptance to specific odours, it is generally accepted that some odours are more unpleasant than others due to their chemical composition and also a hazard identification function. The relative scale of typical pleasantness / unpleasantness is described as the odour's hedonic tone.
- **Location:** indicates the relationship between the odour experienced and the general perception of amenity that would be expected at that location. An odour that may be tolerated at an industrial site may be less tolerated at a healthcare centre, for example.

4. EXISTING CONDITIONS

4.1. Surrounding Land Sensitivity

4.1.1. Land Use Zoning

Land use zoning is a mechanism to provide planning and environmental control to achieve the objectives of the *Environmental Planning and Assessment Act 1979*.

The land occupied by the Proposal site is zoned as R2 – Low Density Residential under the Lithgow Local Environmental Plan (LEP) 2014. Other land zoning surrounding the Proposal site includes additional R2 land uses, C3 – Environmental Management, SP2 – Roads and Traffic Facility, and RU1 – Primary Production.

4.1.2. Sensitive Receptors

Air quality assessments typically use a desk-top mapping study to identify ‘discrete receptor locations’, which are intended to represent a selection of locations that may be susceptible to changes in air quality and odour. In broad terms, the identification of sensitive receptors refers to places at which humans may be present for a period representative of the averaging period for the pollutant being assessed. Typically, these locations are identified as residential properties although other sensitive land uses may include schools, medical centres, places of employment, recreational areas, or ecologically sensitive locations. In the case of this assessment, the sensitive receptors are defined as the Proposal site which includes (primarily) residential receptor locations.

A grid of receptors has been included to cover the entire Proposal site. The results of the Stage 1 assessment (refer Section 1.1) are presented as the maximum predicted odour concentrations within the Proposal site for direct comparison with the relevant odour criterion.

4.2. Meteorology

The meteorology experienced within an area can govern the generation (in the case of wind-dependent emission sources), dispersion, transport and eventual fate of pollutants in the atmosphere. The meteorological conditions surrounding the Proposal site have been characterised using data collected by the Australian Government Bureau of Meteorology (BoM) at the Marrangaroo Automatic Weather Stations (AWS).

To provide a characterisation of the meteorology which would be expected at the Proposal site, a meteorological modelling exercise has also been performed. A summary of the inputs and outputs of the meteorological modelling assessment, including validation of those outputs is presented in Appendix A.

A summary of the Marrangaroo AWS operated by BoM is provided in Table 2 below.

Table 2 Details of meteorological monitoring surrounding the Proposal site

Site name	Approximate location (UTM 56)		Approximate distance
	mE	mS	km
Marrangaroo AWS – Station #063308	233 640	6 296 860	7.9

It is considered that Marrangaroo AWS is most likely to represent the conditions at the Proposal site, based upon its proximity. Given the wind distributions across the years examined (2020-2024), data for the year 2020 has been selected as being appropriate for further assessment, as it best represents the general trend across the 5-year period studied. Reference should be made to Appendix A for further details.

4.3. Topography

The elevation of the Proposal site ranges from approximately 930 m Australian Height Datum (AHD) to approximately 950 m AHD. No significant terrain features are evident at the Proposal site that may affect the transport of emissions from the SPS locations to the proposed residential dwellings.

4.4. Potential Cumulative Sources

A desktop survey has been performed to identify sources that would be expected to generate a similar odour character that may result in cumulative odour impacts experienced at proposed residential dwellings within the Proposal site. The survey did not identify any potential cumulative sources in the area surrounding the Proposal site.

It is noted that there may be potential for the two SPS assessed as part of this study to result in cumulative impacts. Generally, receptors that are located between two different sources would not experience cumulative impacts from the emissions of both sources given that wind directions would need to occur from opposing directions. However, short-term wind gusts may cause emissions to travel back and forth between the two SPS which may result in occasional cumulative impacts at the Proposal site which has been considered as part of the approach to this assessment (refer Section 1.1).

5. METHODOLOGY

5.1. Quantitative Odour Assessment

A dispersion modelling assessment has been performed using the NSW EPA approved CALPUFF atmospheric dispersion model. The modelling has been performed in CALPUFF 3-dimensional (3-D) mode. The 3-D meteorological dataset was derived using gridded prognostic data generated from The Air Pollution Model (TAPM, v 4.0.5) as developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), in conjunction with CALMET (refer Appendix A).

The Approved Methods requires that for a Level 2 assessment (this assessment), the 99th percentile of model predictions is presented for both H₂S and odour.

5.2. Stage 1 Assessment

As outlined in Section 1.1, the parameters associated with the future upgraded SPS are not yet known and correspondingly, the dispersion modelling has been performed in two stages. Initial modelling has been performed for the proposed SPS to determine the remaining 'headroom' between the initial modelled impact and the criterion as part of Stage 1. Results from the initial modelling were then used to identify the maximum allowable flow rate and emission rate associated with the future upgraded SPS as part of Stage 2 of the assessment.

5.2.1. Sewage Pump Station Vent Stack Parameters

The Stage 1 assessment has adopted a conservative approach to estimating the odour emission rate generated from the proposed SPS. Information provided by the Applicant indicates that the maximum flow rate of sewage associated with the proposed SPS would be 7 litres per second (L·s⁻¹) and this value has been adopted for the assessment, assuming that the maximum flow rate of sewage is equal to the volume of air displaced through the SPS ventilation stack. It is noted that the ventilation stack height and diameter associated with the proposed SPS are currently unknown. Correspondingly, for the purposes of this assessment, reasonable assumptions have been adopted for these parameters based on Northstar's previous experience in assessing odour from SPS infrastructure proximate to residential subdivisions.

The adopted ventilation stack diameter has additionally been used to estimate the air flow rate and velocity through the stack used for the assessment as presented in Table 3.

Table 3 Proposed SPS ventilation stack parameters

Parameter	Value	Units
Vent stack height	9	m AGL
Vent stack diameter (top)	0.15	m
Sewage inflow at SPS	7	L·s ⁻¹
Air displacement rate through the SPS vent stack	0.007	m ³ ·s ⁻¹
Discharge velocity from the vent stack	0.4	m·s ⁻¹

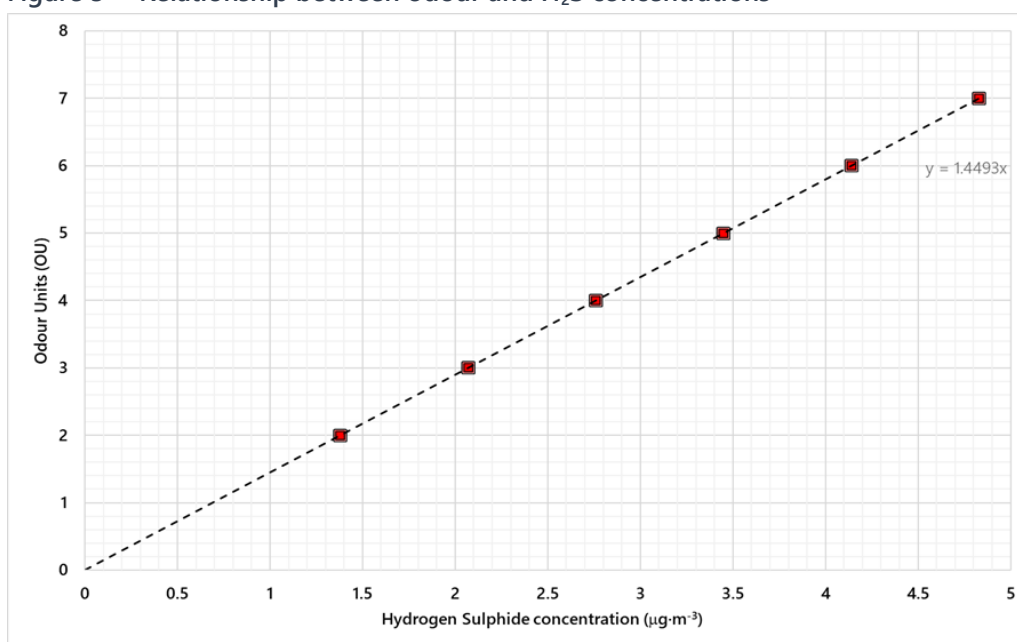
5.2.2. Sewage Pump Station Vent Emission Parameters

No monitoring data for either odour or H₂S is generally publicly available for specific SPS vent locations. For the purposes of this assessment, data as outlined in (Shammy, 2017) is referenced which indicates that the median H₂S concentration in Australian sewers is 1 880 µg·m⁻³.

To provide an estimation of the likely odour emission rate from the proposed SPS vents, the relationship between the H₂S and odour criteria (refer to Table 1) has been examined. Based on the comparison between those criteria, the association between H₂S concentration and odour is defined by the relationship $OU = 1.4493 \times H_2S$ (µg·m⁻³) as presented in Figure 3.

Concentrations of H₂S of 1 880 µg·m⁻³ can therefore be calculated to represent odour concentrations of 2 725 OU.

Figure 3 Relationship between odour and H₂S concentrations



Source: Northstar, based on data from (NSW EPA, 2022) and (NSW DECC, 2006)

Based on the relationship derived above, the specific odour emission rate can be calculated for the proposed SPS ventilation stack, based on the volumetric flow rate of air, as presented in Table 3. The resulting odour emission rate (OER) through the vent stack is presented in Table 4.

The Approved Methods (NSW EPA, 2022) states that peak-to-mean ratios should be incorporated when conducting atmospheric dispersion modelling of odour and H₂S. The peak to mean ratio (P/M60) is defined as the ratio of peak 1-second average concentrations to mean 1-hour average concentrations. To estimate peak odour emission rates, table 6.1 of the Approved Methods outlines the P/M60 ratio to be used.

Specifically, to establish a conservatively high estimate of peak odour or H₂S concentrations from wake-affected point sources (the sewer educt vents), the peak to mean ratio (P/M60) of 2.3 is required to be adopted in all stability classes (A to F), and correspondingly the specific odour emission rate (SOER) used in the modelling for the proposed SPS is presented in Table 4.

Table 4 Proposed SPS ventilation stack – odour emissions

Parameter	Value
Odour emission rate (OER)	19.1 OU·m ³ ·s ⁻¹ (2 725 OU × 0.007 m ³ ·s ⁻¹)
Specific odour emission rate (SOER)	43.87 OU·m ³ ·s ⁻¹ (19.1 OU·m ³ ·s ⁻¹ × 2.3)

5.3. Stage 2 Assessment

The sewage inflow rate and emission rate of odour which would be required not to be exceeded from the upgraded SPS has been calculated through 'back modelling' (i.e. the determination of an emission rate which results in the achievement of a criterion at a point). The modelling methodology remains consistent with the requirements of the Approved Methods (NSW EPA, 2022). However, for the purposes of this assessment the ventilation stack height, diameter and discharge velocity adopted for the proposed SPS have been applied to the upgraded SPS as part of the modelling assessment.

It is noted that a nominal emission rate of 1 OU·m³·s⁻¹ has been used as an initial rate, with outputs factored to determine the required sewage inflow and emission rates not to be exceeded. It is noted that the outcome of this study does not depend on the nominal value used, it is just required to quantify the numerical relationship between odour emission rate and odour impacts.

6. ODOUR IMPACT ASSESSMENT

The results of the dispersion modelling assessment are presented in Table 5.

Table 5 Modelling assessment result summary

SPS	Parameter	Associated with location	Value
Proposed SPS	Predicted 99 th percentile 1 second average odour concentration	Most impacted proposed residence	0.03 OU
	Predicted 99 th percentile H2S concentration		0.02 µg·m ⁻³
The above were modelled to allow determination of the remaining ‘headroom’ between the modelled impact and the criterion. This then informed the maximum sewage inflow rate and odour emission rate allowable from the existing / future SPS:			
Future upgraded SPS	Maximum allowable sewage inflow rate to meet the odour criterion	SPS infrastructure	2 362 L·s ⁻¹
	Maximum allowable emission rate to meet the odour criterion	At point of discharge	14 801 OU·s ⁻¹

Table 5 indicates that the proposed SPS is predicted to result in an odour impact of 0.03 OU at the most impacted residential dwelling within the Proposal site. Given the headroom between the modelled proposed SPS impact and the odour criterion of 2 OU, it is estimated that the future upgraded SPS may allow a sewage inflow rate of 2 362 L·s⁻¹ and a maximum odour emission rate of 14 801 OU·s⁻¹. Based on the assumptions adopted for the proposed SPS, this is anticipated to be easily achievable.

Additionally, the higher sewage inflow rates would result in a greater exit velocity from the SPS stack than that adopted (0.4 m·s⁻¹), which would also increase odour dispersion. The 'allowable' odour emission rate from the existing SPS upgrade is therefore likely to be greater than that calculated.

Given that the results and calculated parameters presented in Table 5 indicate that no exceedances of the relevant criteria are predicted, no additional odour control is considered to be required. Additionally, given the very minor odour and H₂S concentrations predicted at the Proposal site from the proposed SPS, no contour plots have been presented.

7. CONCLUSION

MAAS Group Properties has engaged Northstar to perform an odour impact assessment to determine the potential impact from a proposed SPS and an existing SPS (to be upgraded in the future) required as part of a proposed residential development located at 33 Magpie Hollow Road, South Bowenfels NSW.

A staged approach was undertaken to perform the assessment as follows:

- Stage 1: The proposed SPS was modelled with the known sewage inflow rate to determine the remaining 'headroom' between the initial modelled impact and the criterion.
- Stage 2: The future upgraded SPS was 'back modelled' to estimate the odour emission rate which should not be exceeded for the odour criterion to be achieved.

The assessment has adopted a conservative approach with assessing odour impacts, assuming that all air displaced by the sewage flow was emitted to atmosphere from the stack. The predicted results indicate that additional odour control at each SPS is not considered to be required, however, should odour control be required to be included for risk management, or contingency purposes, the following is provided.

Sydney Water outline the requirements of an Odour Control Unit (OCU) and ventilation parameters in a standard specification document (Sydney Water, 2011). In terms of the performance of the OCU, the requirements are outlined in Table 6.

Table 6 OCU minimum requirements

Item	Criteria
Outlet concentration as measured at the exit of the vent stack	Hydrogen sulphide (H ₂ S) ≤ 0.1 ppm
	Mercaptans (Thiols) ≤ 0.02 ppm
	Odour concentration ≤ 500 OU
	Or otherwise, at a level that is demonstrated to achieve no odour nuisance at the nearest residence or public space
Flow rate	Minimum of 6 × airspace/headspace volume per hour
Discharge vent stack	The discharge vent stack height shall generally comply with Sewerage Code of Australia for vent stacks (14 m above ground level) unless otherwise agreed by the Principal. Typically the vent stack shall be designed to maximise the air velocity out of the top of the stack to obtain maximum dilution with the surrounding air

Source: (Sydney Water, 2011)

Essentially, the above information derived from Sydney Water (Sydney Water, 2011) indicates that the installation of an OCU would ensure that odour concentrations would be below the requirements outlined above (i.e. ≤2 725 OU assumed within this assessment [≤500 OU achievable through installation of OCU]).

It is recognised that not insignificant costs may be associated with the installation and ongoing operation of an OCU. Alternative methods which might be appropriate may include an increase in vertical velocity through the vent stack (by decreasing the diameter of the vent stack) or increasing the height of the ventilation stack.

In conclusion, the results of this assessment indicate that any odour and H₂S impacts are anticipated to be below NSW EPA criteria across the Proposal site. Any further management and / or control measures would act to reduce concentrations further, offering a level of contingency and risk management. For clarity, additional management and control measures are not required to ensure the achievement of the relevant air quality criteria.

8. REFERENCES

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APPENDIX A

Meteorology

As discussed in Section 4.2 a meteorological modelling exercise has been performed to characterise the meteorology of the Proposal site in the absence of site-specific measurements. The meteorological monitoring has been based on measurements taken at the Marrangaroo automatic weather stations (AWS) operated by the Bureau of Meteorology (BoM).

A summary of the Marrangaroo Airport AWS is provided in Table A1.

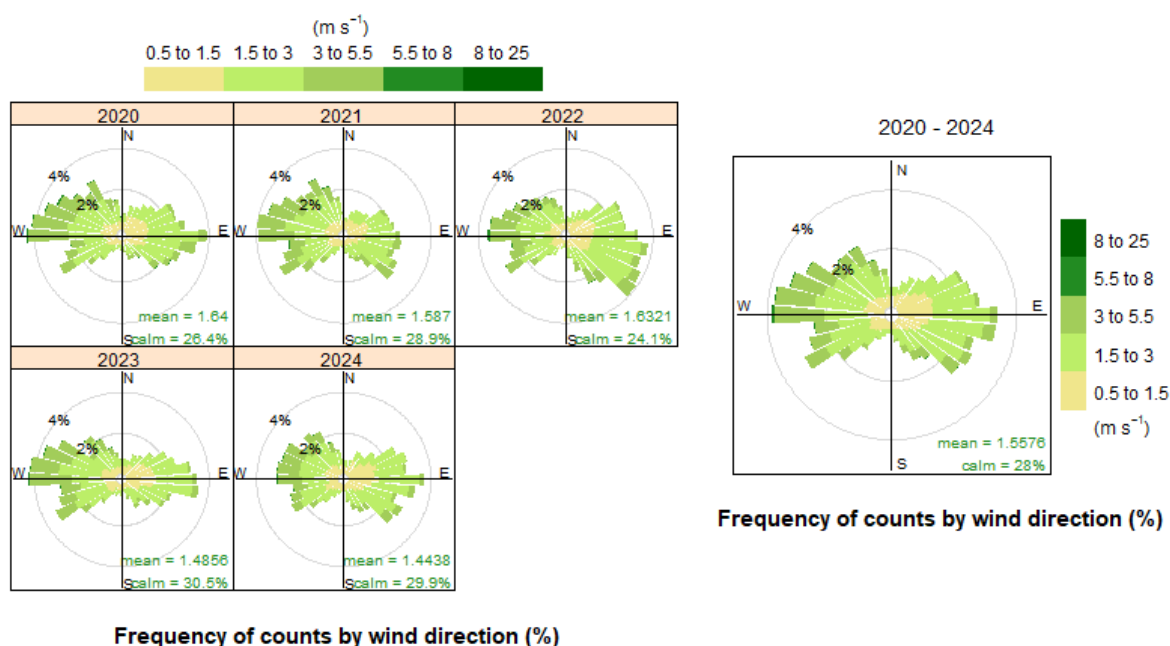
Table A1 Details of the Marrangaroo Airport AWS

Site name	Approximate location (UTM zone 56)		Approximate distance
	mE	mS	km
Marrangaroo AWS – Station #63303	233 640	6 296 860	7.9

Meteorological conditions at the Marrangaroo AWS have been examined to determine a ‘typical’ or representative dataset for use in dispersion modelling. Annual wind roses for the most recent years of data (2020 to 2024) are presented in Figure A1. The annual wind speed frequency distribution for the five-year period is presented in Figure A2. The correlation coefficient between each year and the five-year period for wind speed and wind direction distribution are summarised in Table A2. The correlation coefficients were ranked and aggregated to select the representative year for the meteorological modelling. The rankings are also presented in Table A2.

Figure A1 Annual wind roses 2020 to 2024, Marrangaroo AWS

Marrangaroo AWS - 2020 to 2024



The wind roses indicate that from 2020 to 2024, winds at the Marrangaroo AWS show predominant eastern directions.

The majority of wind speeds experienced at the Marrangaroo AWS between 2020 and 2024 are generally in the range 1.5 metres per second ($\text{m}\cdot\text{s}^{-1}$) to $5 \text{ m}\cdot\text{s}^{-1}$ with the highest wind speeds (greater than $8 \text{ m}\cdot\text{s}^{-1}$) occurring from a westerly direction. Winds of this speed occur during less than 0.01 % of the observed hours over the 5-year period while calm winds occur 28.0 % of observed hours.

Figure A2 Annual wind speed and wind direction distributions Marrangaroo AWS, 2020-2024

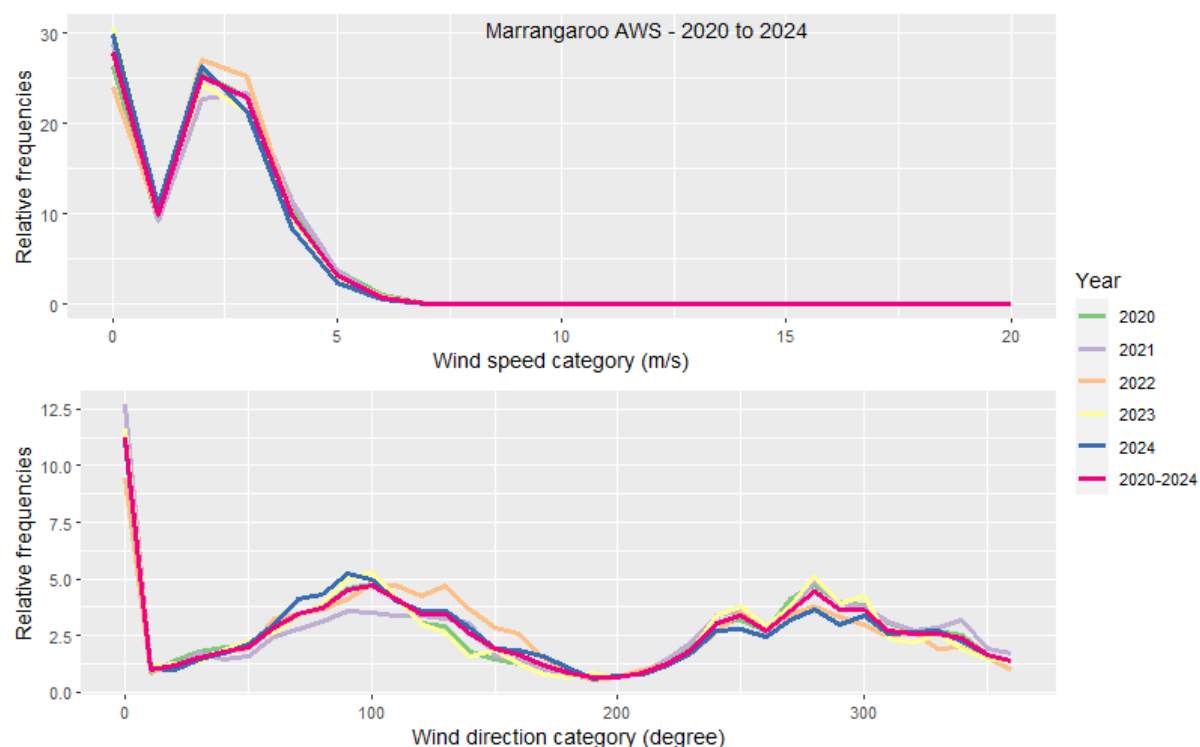


Table A2 Wind speed and wind direction distribution correlation coefficient Marangaroo Airport AWS 2019-2023

Parameter	Wind speed		Wind direction		Aggregated rank
	Correlation	Rank	Correlation	Rank	
2020	0.9989	1	0.9904	1	1
2021	0.9970	4	0.9724	4	4
2022	0.9929	5	0.9543	5	5
2023	0.9973	2	0.9851	2	2
2024	0.9971	3	0.9850	3	3
2020-2024	1	-	1	-	-

Wind speed observations for each year are well correlated against the wind speed over the five-year period, with each year having a correlation coefficient of 0.99 or greater. The year 2020 is the highest ranked for correlation against the wind speed over the five-year period.

Wind direction observations for each year are also well correlated against the wind direction over the five-year period, with each year having a correlation coefficient of 0.95 or greater. The year 2020 is the highest ranked for correlation against the wind direction over the five-year period.

The combined rank as presented in Table A2 indicates that 2020 is the most suitable year of data for meteorological modelling, as it best represents the general trend across the 5-year period studied.

Meteorological Modelling

The BoM data adequately covers the issues of data quality assurance, however it is limited by its location compared to the Proposal site. To address these uncertainties, a multi-phased assessment of the meteorological data has been performed.

In absence of any measured onsite meteorological data, site representative meteorological data for the Proposal site was generated using the CALMET meteorological model in a format suitable for using in the CALPUFF dispersion model (refer Section 4.2).

CALMET is a meteorological model that develops wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics, and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field and thus the final wind field reflects the influences of local topography and current land uses.

In this study, CALMET has been run in no-observations (no-obs) mode using gridded prognostic data generated by The Air Pollution Model (TAPM, v 4.0.5), developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

TAPM is a prognostic model which predicts wind speed and direction, temperature, pressure, water vapour, cloud, rainwater and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

The parameters used in TAPM and CALMET modelling are presented in Table A3.

Table A3 Parameters adopted for meteorological modelling

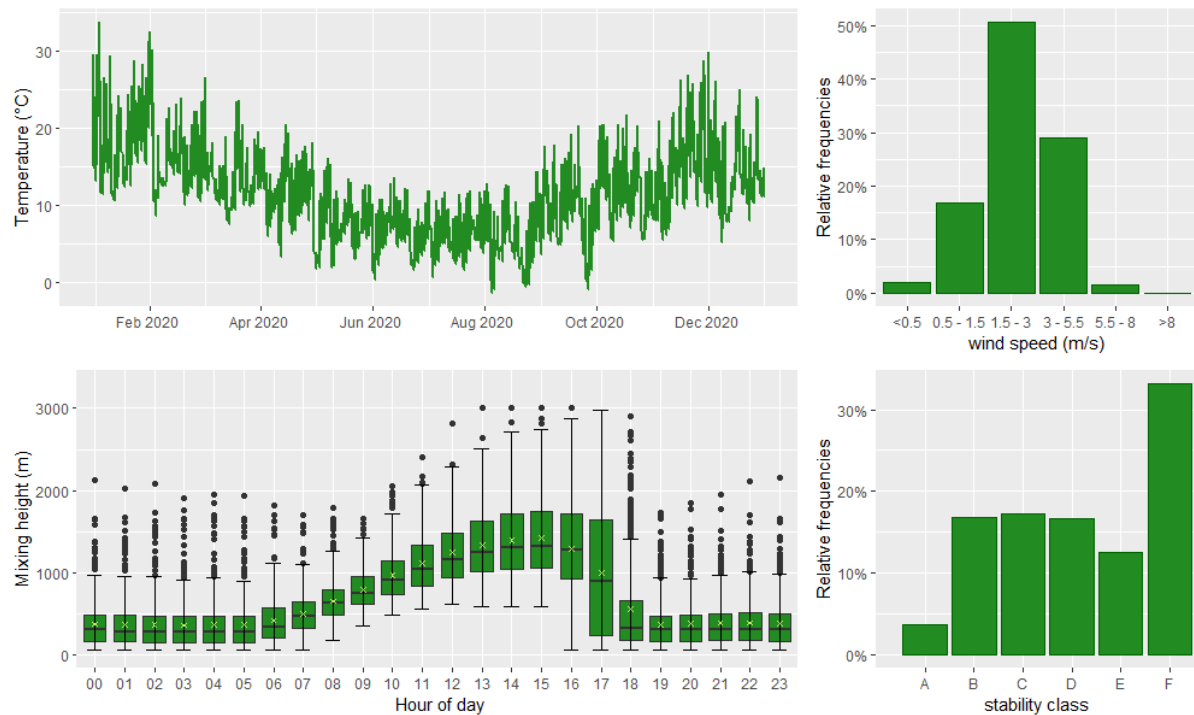
TAPM v 4.0.5	
Modelling period	1 January 2020 to 31 December 2020
Centre of analysis	232 162 mE, 6 288 634 mS (UTM Coordinates)
Number of grid points	25 x 25 x 25
Number of grids (spacing)	5 (30 km, 10 km, 3 km, 1 km, 0.3 km)
Terrain	AUSLIG 9 second DEM
Data assimilation	No data assimilation
CALMET	
Modelling period	1 January 2020 to 31 December 2020
South-West corner of analysis	230 331 mS, 6 286 936 mS (UTM Coordinates)
Meteorological grid domain (resolution)	4 km x 4 km (0.1 km)
Vertical resolution (cell heights)	10 (0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1200 m, 2000 m, 3000 m, 4000 m)
Data assimilation	No-obs approach using TAPM – 3D.DAT file

As generally required by the NSW EPA the following provides a summary of the modelled meteorological dataset. Given the nature of the pollutant emission sources at the Proposal site, detailed discussion of the humidity, evaporation, cloud cover, katabatic air drainage and air recirculation potential of the Proposal site has not been provided. Details of the predictions of wind speed and direction, mixing height and temperature at the Proposal site are provided below.

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Proposal site during 2020 period are illustrated in Figure A3.

As expected, an increase in mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground-based temperature inversions and growth of the convective mixing layer.

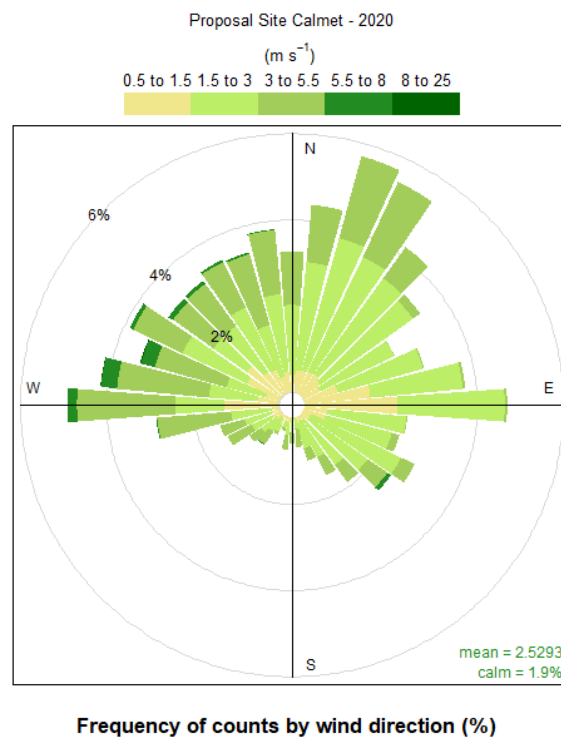
Figure A3 Predicted mixing height, wind speed and stability class frequency at the Proposal site (2020)



Source: Northstar

The modelled wind speed and direction at the Proposal site during 2020 are presented in Figure A4.

Figure A4 Predicted wind direction and speed - Proposal site (2020)



Source: Northstar

air quality | environment | sustainability

air quality	Northstar specialises in all aspects of air quality, dust, and odour management, covering monitoring, modelling and assessment, due diligence and process specification, licencing and regulatory advice, peer review and expert witness.
environment	Our team has extensive experience in environmental management, covering environmental policy and management plans, licencing, compliance reporting, auditing, data, and spatial analysis.
sustainability	We look beyond compliance to add value and identify opportunities. Our services range from sustainability strategies, ecologically sustainable development reporting and assessment, to bespoke greenhouse gas and energy estimation and reporting.

Head Office

Suite 1504, 275 Alfred Street,
North Sydney NSW 2060

Riverina Office

PO Box 483
Albury NSW 2640



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