This document has been prepared for **Air Liquide Australia Solutions Pty Ltd** 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

Proposed Carbon Dioxide Processing Plant, Bomaderry

Air Quality Impact Assessment

Addressee(s):	Air Liquide Australia Solutions Pty Ltd
Site Address:	Bolong Road, Bomaderry
Report Reference:	25.1094.FR1V4
Date:	2 April 2026
Status:	Final

air quality | environment | sustainability

Quality Control

Report	Reference	Status	Prepared by	Checked by	Authorised by
Proposed Carbon Dioxide Processing Plant, Bomaderry - Air Quality Impact Assessment	25.1094.FR1V4	Final	Northstar	GCG	MD

Report Status

Northstar References		Report Status	Report Reference	Version
Year	Job Number	(Draft: Final)	(R*x*)	(V*x*)
25	1094	Final	R1	V4
Based upon the above, the specific reference for this version of the report is:				25.1094.FR1V4

Final Authority

This report must by 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.

Martin Doyle **2 April 2026**

© Northstar Air Quality Pty Ltd 2026

Copyright in the drawings, information and data recorded in this document (the information) is the property of Northstar Air Quality Pty Ltd. This report has been prepared with the due care and attention of a suitably qualified consultant. Information is obtained from sources believed to be reliable, but is in no way guaranteed. No guarantee of any kind is implied or possible where predictions of future conditions are attempted. This report (including any enclosures and attachments) has been prepared for the exclusive use and benefit of the addressee(s) and solely for the purpose for which it is provided. Unless we provide express prior written consent, no part of this report should be reproduced, distributed or communicated to any third party. We do not accept any liability if this report is used for an alternative purpose from which it is intended, nor to any third party in respect of this report.

NON-TECHNICAL SUMMARY

Air Liquide Solutions Australia Pty Ltd has engaged Northstar Air Quality Pty Ltd to perform an air quality impact assessment for a proposed carbon dioxide processing plant to be located on Bolong Road, Bomaderry.

Emissions during the construction and operational phase of the Proposal have been considered. Given the minor scale of the proposed construction phase, emissions are likely to be minimal, and impacts negligible at the nearest sensitive receptor locations, and the implementation of air quality management measures as part of an over-arching construction environment management plan would be likely to be sufficient to manage any risk.

During the operational phase, emissions to air would be expected as a result of processing activities, haulage of product, and management of wastewater.

Emissions from processing activities have been assessed through a dispersion modelling exercise, using input data for three waste streams provided by Air Liquide Solutions Australia Pty Ltd. Model predictions indicate that all air quality criteria would be achieved at the relevant assessment locations. It is recommended that an emissions monitoring campaign is performed post-commissioning to confirm the assumptions adopted within this assessment.

Emissions associated with product haulage are anticipated to be minimal, as a result of the low traffic volumes, and hardstand nature of the Proposal site. Emissions could be further minimised through the implementation of a no-idling policy and adherence to speed limits at the Proposal site.

Any minor emissions associated with wastewater treatment would be managed at the waste water treatment plant operated by Manildra, which implements a range of odour management measures.

In conclusion, the impacts associated with the construction and operation of the Proposal are anticipated to be below criteria at all sensitive receptor locations. It is respectfully considered that the Proposal should not be rejected on the grounds of air quality.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

Air Liquide Solutions Australia Pty Ltd (the Applicant) has engaged Northstar Air Quality Pty Ltd (Northstar) to perform an air quality impact assessment (AQIA) for a proposed carbon dioxide (CO_2) processing plant (the Proposal) to be located on Bolong Road, Bomaderry (the Proposal site).

The AQIA identifies and examines potential air quality (including odour) impacts associated with the construction and operation of the Proposal, aligning with the NSW Planning Secretary's Environmental Assessment Requirements (SEARs), and outlines mitigation and monitoring requirements commensurate with those anticipated impacts to ensure that air quality criteria are achieved at surrounding sensitive receptor locations, or at locations where air quality criteria are required to be achieved.

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

- *Protection of the Environment Operations Act* 1997;
- Protection of the Environment Operations (Clean Air) Regulation 2022; and
- Approved Methods for the Modelling and Assessment of Air Pollutants in NSW.

This report has been prepared to address the requirements outlined in the SEARs which were issued for the Proposal (SSD 80824235) on 4 April 2025.

Table 1 details the SEARs coverage and indicates where requirements have been addressed within this AQIA.

Table 1 NSW Planning Secretary's Environment Assessment Requirements

Issue	Assessment requirements	Addressed
Air Quality	A quantitative assessment of the potential air quality, dust and odour impacts of the development (construction and operation) on surrounding landowners, businesses and sensitive receptors, in accordance with relevant Environment Protection Authority guidelines, including: • details of proposed mitigation, management and monitoring measures. • a cumulative assessment of the development and surrounding emissions sources.	Section 5 Section 6 Section 7

2. THE PROPOSAL

2.1. Environmental Setting

The Proposal site is located within the Shoalhaven City Council Local Government Area (LGA) and occupies land parcels along Bolong Road, Bomaderry between the Shoalhaven Starches facility and the former Australian Pulp and Paper Mill facility.

The Proposal will require underground piping to feed material from Shoalhaven Starches to the primary processing site and will occupy land legally described as:

- 220 Bolong Road, Bomaderry (Lot 143 DP1069758);
- 280 Bolong Road, Bomaderry (Lots 5 and 6 DP621040);
- 340 Bolong Road, Bomaderry (Lot A DP384559);
- Bolong Road, Bomaderry (Lot 1 DP544730);
- Hanigans Lane Bolong (Lot 4 DP 610696);
- 250 Bolong Road Bolong (Lot 1 DP 605942); and
- 250 Bolong Road Bolong (Lot 3 Sec 1 DP 3885).

The primary processing site is located at Lot A of DP 384559.

The location of the Proposal site is illustrated in Figure 1. Additionally, a layout of the Proposal with inclusion of the underground piping is provided in Figure 2, while a layout of the primary processing site is provided in Figure 3.

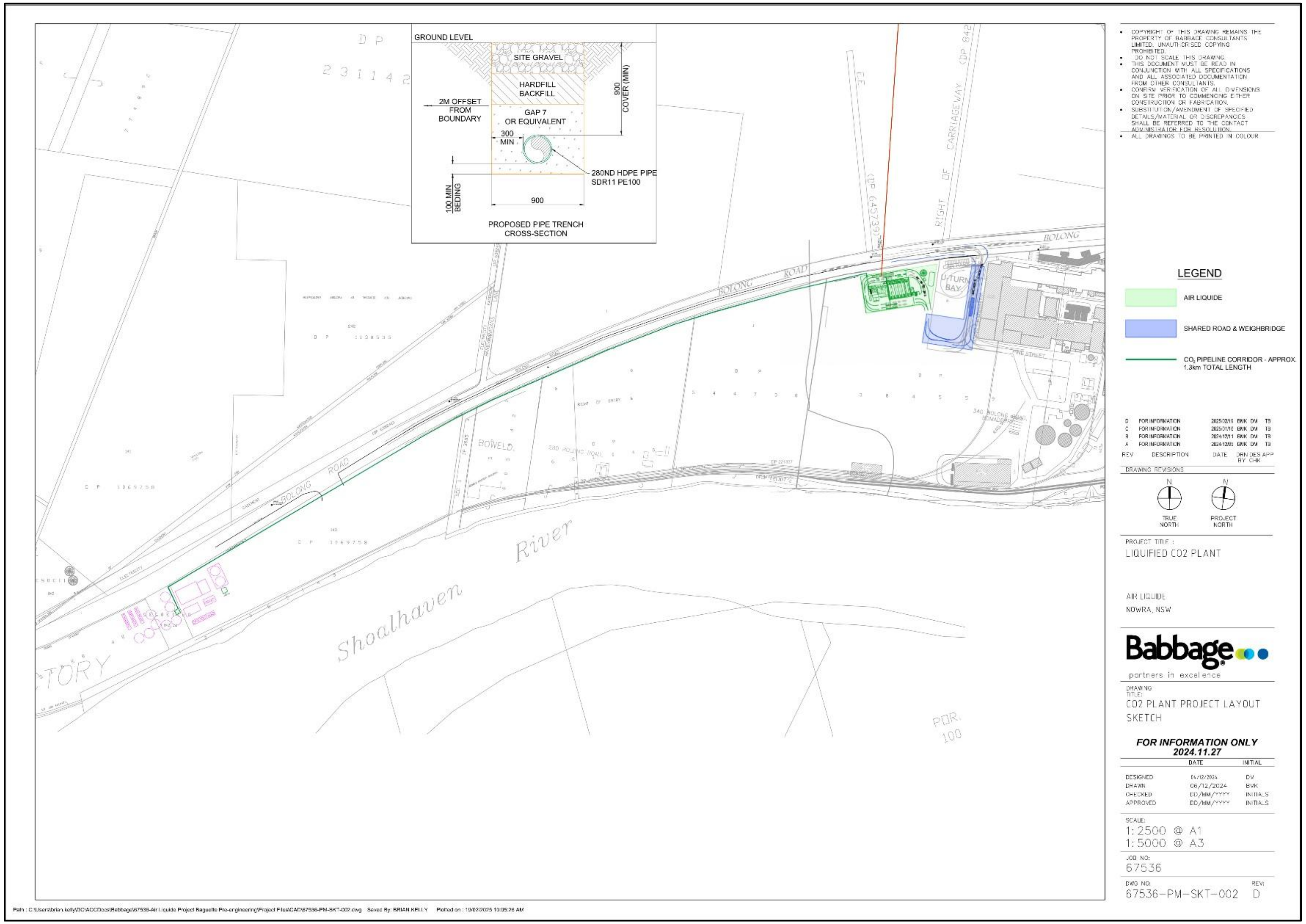
Land uses in the area immediately surrounding the Proposal site include industrial and agricultural land uses. The residential area of Bomaderry is located approximately 1.75 kilometres (km) to the west of the Proposal site.

It is noted that the Supagas CO_2 plant which also processes CO_2 generated from Shoalhaven Starches is located approximately 700 metres (m) to the west of the Proposal site, and the activities performed at the Supagas facility are similar to those expected to be performed at the Proposal site. An air quality assessment was performed for the Supagas facility (GHD, 2021a) as part of a proposed modification which has been referenced within this report.

Figure 1 Proposal site location

Source: Northstar

Figure 2 Proposal site layout – all components



Source: Babbage

Figure 3 Indicative Proposal site layout – processing site

Source: Northstar

2.2. Proposal Overview

The Applicant, in conjunction with Manildra Energy Australia Pty Ltd (Manildra), which operates the Shoalhaven Starches facility, is seeking consent to construct and operate a CO_2 processing plant at the Proposal site. The Proposal would capture and purify CO_2 generated at the Shoalhaven Starches facility into food and beverage grade liquid CO_2 through the deployment of a suite of heat recovery upgrades.

The Proposal will process up to 100 000 tonnes per year ($t{\cdot}yr^{-1}$) of CO_2 rich gas and would comprise of the following components:

- Feedstock gas rich in CO_2 would first enter a series of knock out pots located towards the eastern boundary of the Shoalhaven Starches facility to remove water condensate;
- After the water condensate is removed, the feedstock gas pressure would be increased to approximately 0.6 barA (absolute pressure) (equivalent to 60 kPa) via booster blower and transported to the main processing site via a pipeline within a 0.9 m corridor;
- At the processing site, the feedstock gas would enter a water scrubber / direct contact cooler decreasing its temperature from 40 °C to 10 °C. Once cooled, water and ethanol would be condensed and transported back to Shoalhaven Starches for further processing;
- The feedstock gas would then enter a compressor where it would be compressed to 20 barG (gauge pressure) (equivalent to 2 000 kPag);
- The feedstock gas would then pass through a series of filtration beds and carbon filters to remove hydrogen sulphide (H_2S), moisture, and particulate matter;
- Following the filtration process, the feedstock gas would be washed with pure liquid CO_2 in a scrubber, where trace hydrocarbons are collected in the liquid phase. These impurities would be collected and vented to atmosphere;
- The feedstock gas would then enter a distillation column where it would be liquified and non-condensable gases including oxygen, nitrogen and trace methane would be removed and vented to atmosphere. The distillation process would utilise a closed-loop ammonia refrigeration compressor to generate the temperature required to liquify the CO_2. The liquid CO_2 then passes through a liquid NO_X filter to remove any NO_X; and
- The liquid CO_2 would then be stored in insulated tanks at -25 °C and 20 barG (2 000kPag). The Proposal site would have 5 storage tanks each with capacity to store up to 360 t of CO_2, which equates to a total CO_2 storage capacity of 1 800 t). The final product would be tested and food and beverage-grade certified prior to dispatch.

Processed liquid CO_2 would be transported from the Proposal site by semi-trailers (A-doubles, B-doubles and semi-trailers). It is expected that up to approximately 16 heavy vehicle movements per day would be required to dispatch liquid CO_2 from the Proposal site, and up to two trucks in a peak hour.

The Proposal is anticipated to operate 24 hours per day, 7 days a week.

Wastewater produced at the Proposal site would be piped to the Manildra wastewater treatment plant for treatment.

2.3. Identification of Potential Emissions to Atmosphere

Given the nature of the Proposal, emissions to air would be likely to be generated as described below.

2.3.1. Construction Phase

Construction of the Proposal would involve minor earthworks activities, installation of the underground pipeline and assembly of infrastructure at the main processing site. Specifically, the primary sources of emissions to air during the construction phase of the assessment would include:

- Excavation and filling of topsoil and overburden;
- Haulage of topsoil and overburden on access roads;
- Wind erosion of exposed surfaces and stockpiles; and
- Diesel fuel combustion from heavy vehicles, plant and equipment.

Each of the construction phase activities identified above would be expected to generate emissions of particulate matter as:

- Total suspended particles (TSP);
- Particulates with a mean aerodynamic diameter of 10 micrometres or less (PM_{10}); and
- Particulates with a mean aerodynamic diameter of 2.5 micrometres or less ($PM_{2.5}$).

As noted above, the main impacts associated with construction phase activities relates to 'construction dust', which generally impacts upon amenity rather than health and wellbeing. However, given the significantly limited scope of construction activities proposed, particulate matter emissions and associated air quality impacts during this phase are expected to be very minor. Correspondingly, construction phase emissions and have not been assessed further.

A range of industry standard construction dust management measures would be adopted during construction and outlined in a Construction Environment Management Plan (CEMP).

2.3.2. Operational Phase

Emissions of air pollutants during the operational phase would be limited to emissions associated with:

- the processing plant;

- vehicle movements (A-Doubles, B-Doubles, and semi-trailers) removing product liquid CO_2 from the Proposal site; and
- wastewater generated during liquid CO_2 production.

The following sections outline the potential for emissions to air from those sources in greater detail.

2.3.2.1. Processing

The Applicant has provided the anticipated composition of the three processing waste streams emitting to atmosphere, as presented in Table 2.

The emission rates of all pollutants in the waste streams have been calculated according to the equation below and are presented in Table 3.

$$Emission\ rate\ (g \cdot s^{-1}) = \left(\frac{X_p}{100}\right) \times Q_m \times MW_p$$

Where:

X_p = mole percent of pollutant (%)

Q_m = total molar flow of exhaust gas ($mol \cdot s^{-1}$)

MW_p = molecular weight of the pollutant ($g \cdot mol^{-1}$)

Those pollutants which have an emission rate greater than zero, and have an associated NSW Environment Protection Authority (EPA) impact assessment criterion (refer Section 3.3) are highlighted in green in Table 3.

Based on the cross-referencing of emissions and impact assessment criteria, the following pollutants are considered further in this AQIA (in no order):

- Methanol;
- Ethanol;
- *n*-propanol;
- 2-butanol;
- Acetaldehyde;
- Acetone;
- Ethyl acetate;
- Hydrogen sulphide (H_2S);
- Methyl mercaptan; and
- Nitrogen dioxide (NO_2).

In general, emissions are only relevant to emission point 224 (volatiles from wash), and no pollutants of concern in relation to ambient air quality are associated with emission points 130 and 149, with the exception of hydrogen sulphide (H_2S), which is emitted from all waste streams.

Table 2 Characteristics and composition of waste stream air emissions

Parameter	Emission Point 130	Emission Point 149	Emission Point 224
Name	Dehydration Purge	Non-condensable purge	Volatiles from wash
Operation	Periodic vent	Continuous	Continuous
Temperature (°C)	150	-30	150
Pressure (bar)	1.013	18.1	18.2
Molar flow ($kmol \cdot hr^{-1}$)	21.82	14.77	2.58
Molar flow ($mol \cdot s^{-1}$)	6.1	4.1	0.7
Actual volume ($m^3 \cdot hr^{-1}$)	757.56	13.89	4.79
Mol fraction (%)			
Carbon dioxide	22.209002	81.992632	90.219545
Water	2.155057	0	0.012397
Nitrogen	59.709811	14.068589	0.000868
Oxygen	15.904754	3.859853	0.000423
Hydrogen	0.011909	0.043964	0
Ethane	0.000009	0.000034	0.000053
Methane	0.009459	0.034922	0.000017
1-butene	0	0	0.010054
Methanol	0	0	0.002126
Ethanol	0	0	8.502931
n-propanol	0	0	0.004057
Isobutanol	0	0	0.004892
2-butanol	0	0	0.003799
Acetaldehyde	0	0	0.598002
Propionaldehyde	0	0	0.002975
Acetone	0	0	0.009913
Ethyl acetate	0	0	0.419353
Isoamyl alcohol	0	0	0.018359
Isopentyl acetate	0	0	0.099618
Hydrogen sulphide	0.000001	0.000003	0.000008
Carbonyl sulphide	0	0	0
Methyl mercaptan	0	0	0.002946
Dimethyl sulphide	0	0	0.007553
Nitrogen oxide	0	0	0.000003
Nitrogen dioxide	0	0	0.080104
Ammonia	0	0	0
1,2-propylene glycol	0	0	0
TOTAL	**100**	**100**	**100**

Table 3 Calculated air emission rates

Emission rate ($g{\cdot}s^{-1}$)	Emission Point 130	Emission Point 149	Emission Point 224
Carbon dioxide	5.92E+01	1.48E+02	2.85E+01
Water	2.35E+00	0.00E+00	1.60E-03
Nitrogen	1.01E+02	1.62E+01	1.74E-04
Oxygen	3.08E+01	5.07E+00	9.70E-05
Hydrogen	1.46E-03	3.64E-03	-
Ethane	1.64E-05	4.19E-05	1.14E-05
Methane	9.20E-03	2.30E-02	1.95E-06
1-butene	-	-	4.04E-03
Methanol	-	-	4.88E-04
Ethanol	-	-	2.81E+00
n-propanol	-	-	1.75E-03
Isobutanol	-	-	2.60E-03
2-butanol	-	-	2.02E-03
Acetaldehyde	-	-	1.89E-01
Propionaldehyde	-	-	1.24E-03
Acetone	-	-	4.13E-03
Ethyl acetate	-	-	2.65E-01
Isoamyl alcohol	-	-	1.16E-02
Isopentyl acetate	-	-	9.29E-02
Hydrogen sulphide	2.07E-06	4.19E-06	1.95E-06
Carbonyl sulphide	-	-	-
Methyl mercaptan	-	-	1.02E-03
Dimethyl sulphide	-	-	3.36E-03
Nitrogen oxide	-	-	6.45E-07
Nitrogen dioxide	-	-	2.64E-02
Ammonia	-	-	-
1,2-propylene glycol	-	-	-

Emissions associated with the processing activities have been assessed using a quantitative dispersion modelling approach as described in Section 5, with results presented in Section 6.

2.3.2.2. Haulage

It is anticipated that between six and 15 heavy vehicles movements would occur each day to remove product from the Proposal site over a 24-hour period. Given that the Proposal site would be constructed of hardstand and given the nature of the operations (i.e. no 'dusty' activities performed), the silt loading of that paved surface would be anticipated to be minimal.

Assuming a silt loading of 0.4 g·m^{-2} for the internal haulage route, consistent with a low trafficked road under normal conditions (table 13.2.1-2 of (USEPA, 2011)), over a road loop of approximately 750 m, results in estimated particulate matter emissions as presented in Table 4.

Table 4 Calculated particulate matter emissions from haulage at the Proposal site

Emission rate	TSP	PM_{10}	$PM_{2.5}$
kg·day^{-1}	0.73	0.14	0.03
g·s^{-1}	0.0085	0.0016	0.0004

A recent Transport Impact Assessment (TIA) for a proposed development at 53-57 Bolong Road, Bomaderry (TTPP, 2024) indicates that traffic counts obtained from Shoalhaven City Council along Bolong Road were 12 100 vehicles per day (annual average daily traffic [AADT], weekday) in February 2023, and 12 400 AADT (weekday) in May 2021.

Whilst the location for these traffic counts is further to the west along Bolong Road than the Proposal site, these values can be used as a conservative approximation of the potential traffic flows along Bolong Road near to the Proposal site. The proposed additional traffic flow of up to 15 heavy vehicles per day would constitute an increase in vehicle traffic of up to 0.12 %.

To evaluate the significance of the predicted changes in operational traffic flows, reference has been made to the Environmental Protection UK (EPUK) document "*Development Control: Planning for Air Quality (2010 Update)*" (EPUK, 2010) which has been referenced in lieu of any identified NSW or Australian guidance. The guidance provides threshold criteria for evaluating the significance of changes in traffic, as a traffic flow change of more than 5 % to 10 % on roads with AADT of >10 000 vehicles required to be assessed through quantitative methods (i.e. dispersion modelling).

The criteria outlined in EPUK (2010) provide a screening (i.e. qualitative) level of assessment which considers the potential for adverse air quality impacts based on traffic flows. As outlined above, the anticipated changes in traffic do not exceed that threshold and given the calculated minor emission rates of particulate matter from the Proposal site, it is not considered likely that the impacts associated with the Proposal would lead to adverse impacts during the operational phase. In accordance with the adopted guidance a quantitative assessment is not warranted.

2.3.2.3. Wastewater

Any wastewater generated through the operation of the Proposal would be piped across Bolong Road to the Manildra wastewater treatment plant (WWTP) for treatment. The volume of waste water treated at the

Manildra WWTP is approximately 4.5 million litres per day[1] and the quantity produced by the Proposal is likely to be insignificant in that context.

Odour control strategies are employed at the WWTP, including anaerobic and aerobic digesters, prior to water either being further treated through a reverse osmosis plant, and being reused within the Shoalhaven Starches facility, or used for irrigating nearby land.

Air quality and odour impacts associated with the operation of the WWTP are considered separately within approvals associated with the WWTP and are not considered within this AQIA.

[1] https://manildra.com.au/documents/environmental/Wastewater.pdf

3. LEGISLATION, REGULATION AND GUIDANCE

The following outlines the legislation and air quality criteria which are applicable to the activities being performed at the Proposal site.

3.1. Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act* 1997 (POEO Act) sets the statutory framework for managing air quality in NSW, including establishing the licensing scheme for major industrial premises (scheduled activities) and a range of air pollution offences and penalties.

Schedule 1, Part 1 of the POEO Act provides definitions for scheduled activities, and the associated threshold activity rates. For the Project, the thresholds associated with chemical production (clause 8) and chemical storage (clause 9) are most relevant, given that liquid CO_2 is listed as a dangerous good under the Transport of Dangerous Goods Code (NTC, 2022).

"8. Chemical Production

(1) This clause applies to the following activities—...

... dangerous goods production, meaning the commercial production, blending, recovering or using of, or research into, dangerous goods (other than toxic substances, explosives or radioactive substances)...

(2) Each activity referred to in Column 1 of the Table to this clause is declared to be a scheduled activity if it meets the criteria set out in Column 2 of that Table.

Table

Column 1	*Column 2*
Activity	*Criteria*
dangerous goods production	*capacity to produce, blend, recover or use more than 1,000 tonnes of dangerous goods per year*

and

"9. Chemical Storage

(1) This clause applies to the following activities—

general chemicals storage, meaning the storage or packaging in containers, bulk storage facilities or stockpiles of any chemical substance classified as a dangerous good in the Transport of Dangerous Goods Code...

(2) Each activity referred to in Column 1 of the Table to this clause is declared to be a scheduled activity if it meets the criteria set out in Column 2 of that Table.

Table

Column 1	*Column 2*
Activity	*Criteria*
general chemicals storage	*capacity to store more than 20 tonnes (pressurised gases), 200 tonnes (liquefied gases) or 2,000 tonnes (chemicals in any other form)*

Information provided by the Applicant indicates that the Proposal is anticipated to exceed the criteria outlined under Schedule 1 of the POEO Act for chemical production and chemical storage. Correspondingly, the Proposal would be considered a 'Scheduled Activity' and would require an Environment Protection Licence (EPL).

3.2. Protection of the Environment Operations (Clean Air) Regulation

The Protection of the Environment Operations (POEO) (Clean Air) Regulation 2022 (POEO CAR) sets requirements and standards of concentration relevant to the Proposal.

The Proposal would be operated, and equipment maintained in an appropriate manner, to ensure that general standards of concentration, and requirements associated with emissions from motor vehicles are achieved.

The activities to be performed at the Proposal site are not outlined in Schedule 2, Part 2, Division 1 or Division 2 of the POEO CAR, and therefore, the general standards of concentration outlined in Schedule 2, Division 3 of the POEO CAR are relevant and are presented in Table 5.

Table 5 General standards of concentration applicable to the Proposal

Air impurity	Plant	Group	Standard of concentration
Nitrogen dioxide (NO_2) or nitric oxide (NO) or both NO_2 and NO and NO_2 equivalent	An activity or plant, except boilers, gas turbines and stationary reciprocating internal combustion engines	6	350 $mg{\cdot}m^{-3}$
Hydrogen sulphide	An activity or plant	6	5 $mg{\cdot}m^{-3}$

Note: at 101.3 kPa, Dry, 273.15K

These standards are discussed further in Section 6.

3.3. NSW EPA Approved Methods

State air quality guidelines adopted by the NSW EPA are published in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (the Approved Methods (NSW EPA, 2022)).

The Approved Methods lists the statutory methods that are to be used to model and assess emissions of criteria air pollutants from stationary sources in NSW. Section 7.1 and Section 7.2 of the Approved Methods clearly outlines the impact assessment criteria for key pollutants of interest and both individual, principal toxic, and odorous air pollutants.

The criteria listed in the Approved Methods are derived from a range of sources (including National Health and Medical Research Council [NHMRC], National Environment Protection Council [NEPC], and World Health Organisation [WHO]).

The criteria specified in the Approved Methods are the defining ambient air quality criteria for NSW. As outlined in Section 2.3.2, the Proposal is expected to generate emissions of the following species:

- Particulate matter (from vehicle movements);
- Methanol;
- Ethanol;
- *n*-propanol;
- 2-butanol;
- Acetaldehyde;
- Acetone;
- Ethyl acetate;
- Hydrogen sulphide (H_2S);
- Methyl mercaptan; and
- Nitrogen dioxide (NO_2).

The assessment requirements outlined in the Approved Methods varies for each type of pollutant, with requirements outlined for the assessment of:

- incremental (Proposal related) impacts;
- cumulative (Proposal plus background) impacts;
- impacts over varying averaging periods;
- dispersion model outputs at varying percentiles; and
- impacts at different locations (either at sensitive receptors, or at and beyond the boundary of the facility).

The impact assessment criteria adopted to protect members of the community from health impacts in NSW for relevant criteria air pollutants (specifically for this Proposal, NO_2) are presented in Table 6.

As outlined in section 7.1.2 of the Approved Methods, these pollutants are required to be assessed at the nearest existing or future sensitive receptor locations, as an incremental concentration (Proposal related), and as a cumulative impact including existing background conditions (refer Section 4.3).

Table 6 NSW EPA impact assessment criteria - criteria air pollutants

Pollutant	Averaging period	Units[a]	Criterion[b]	Notes
Nitrogen dioxide (NO_2)	1-hour	$\mu g \cdot m^{-3}$	164	Numerically equivalent to the AAQ NEPM[c] standards and goals.
	Annual	$\mu g \cdot m^{-3}$	31	

Notes: (a): Micrograms per cubic metre of air

(b) Gas volumes are expressed at 25 °C (298 K) and at an absolute pressure of 1 atmosphere (101.325 kPa)

(c): National Environment Protection (Ambient Air Quality) Measure

The criteria associated with the remaining pollutants associated with the Proposal are presented in Table 7. These are a mixture of individual odorous, or toxic air pollutants.

As outlined in section 7.4.2 of the Approved Methods, the odorous air pollutants are required to be assessed at the nearest existing or future sensitive receptor locations, as an incremental concentration (Proposal related), as the 99.9th percentile of dispersion model outputs.

In relation to H_2S, impacts are also required to be assessed at the nearest existing or future sensitive receptor, but as the 99th percentile of dispersion model outputs, adjusted to reflect peak concentrations (refer Section 5.3).

In relation to acetone, the only individual toxic air pollutant emitted from the Proposal, this is required to be assessed '*at and beyond the boundary of the facility*', as an incremental concentration, and as the 99.9th percentile of dispersion model outputs as per section 7.2.2 of the Approved Methods.

Table 7 NSW EPA impact assessment criteria – individual odorous and toxic air pollutants

Pollutant	Basis for criterion	Criterion ($mg \cdot m^{-3}$)	Averaging period	Model output assessed	Criterion applicable
Methanol	Odour (Table 16, (NSW EPA, 2022))	3.0	1-hour	99.9th percentile	Receptors
Ethanol	Odour (Table 16, (NSW EPA, 2022))	2.1	1-hour	99.9th percentile	Receptors
n-propanol	Odour (Table 16, (NSW EPA, 2022))	0.041	1-hour	99.9th percentile	Receptors
n-butanol	Odour (Table 16, (NSW EPA, 2022))	0.5	1-hour	99.9th percentile	Receptors
Acetaldehyde	Odour (Table 16, (NSW EPA, 2022))	0.042	1-hour	99.9th percentile	Receptors
Acetone	Individual toxic (Table 13, (NSW EPA, 2022)	22	1-hour	99.9th percentile	At and beyond boundary
Ethyl acetate	Odour (Table 16, (NSW EPA, 2022))	12.1	1-hour	99.9th percentile	Receptors
Hydrogen sulphide	Odour (Table 17, (NSW EPA, 2022))	1.38 $\mu g \cdot m^{-3}$ (A)	1-hour	99th percentile	Receptors
Methyl mercaptan	Odour (Table 16, (NSW EPA, 2022))	0.00046	1-hour	99.9th percentile	Receptors

Note: As a nose-response time average (refer Section 5.3)

4. EXISTING CONDITIONS

The following information provides context around the location of sensitive receptor locations surrounding the Proposal site, the prevailing meteorology and air quality of the surrounding area and identifies other sources of air pollutants which have the potential to impact cumulatively with the Proposal.

4.1. Sensitive Receptor Locations

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. 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.

The Approved Methods defines a sensitive receptor location to be:

> *'A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area'.*

It is important to note that the selection of discrete receptor locations is not intended to represent a fully inclusive selection of all sensitive receptors across the study area. The location selected should be considered to be representative of its broader location and may be reasonably assumed to be representative of the immediate environs. In some instances, several viable receptor locations may be identified in a small area, for example a school neighbouring a medical centre. In this instance the receptor closest to the potential sources to be modelled would generally be selected and would be used to assess the risk to other sensitive land uses in the area.

In addition to the identified 'discrete' receptor locations, the entire modelling area is gridded with 'uniform' receptor locations that are used to plot out the predicted impacts, and as such the accidental non-inclusion of a location that is sensitive to changes in air quality does not render the AQIA invalid, or otherwise incapable of assessing those potential risks.

In accordance with the requirements of the Approved Methods, several receptors have been identified and the receptors adopted for use within this AQIA are presented in Table 8 and illustrated in Figure 4.

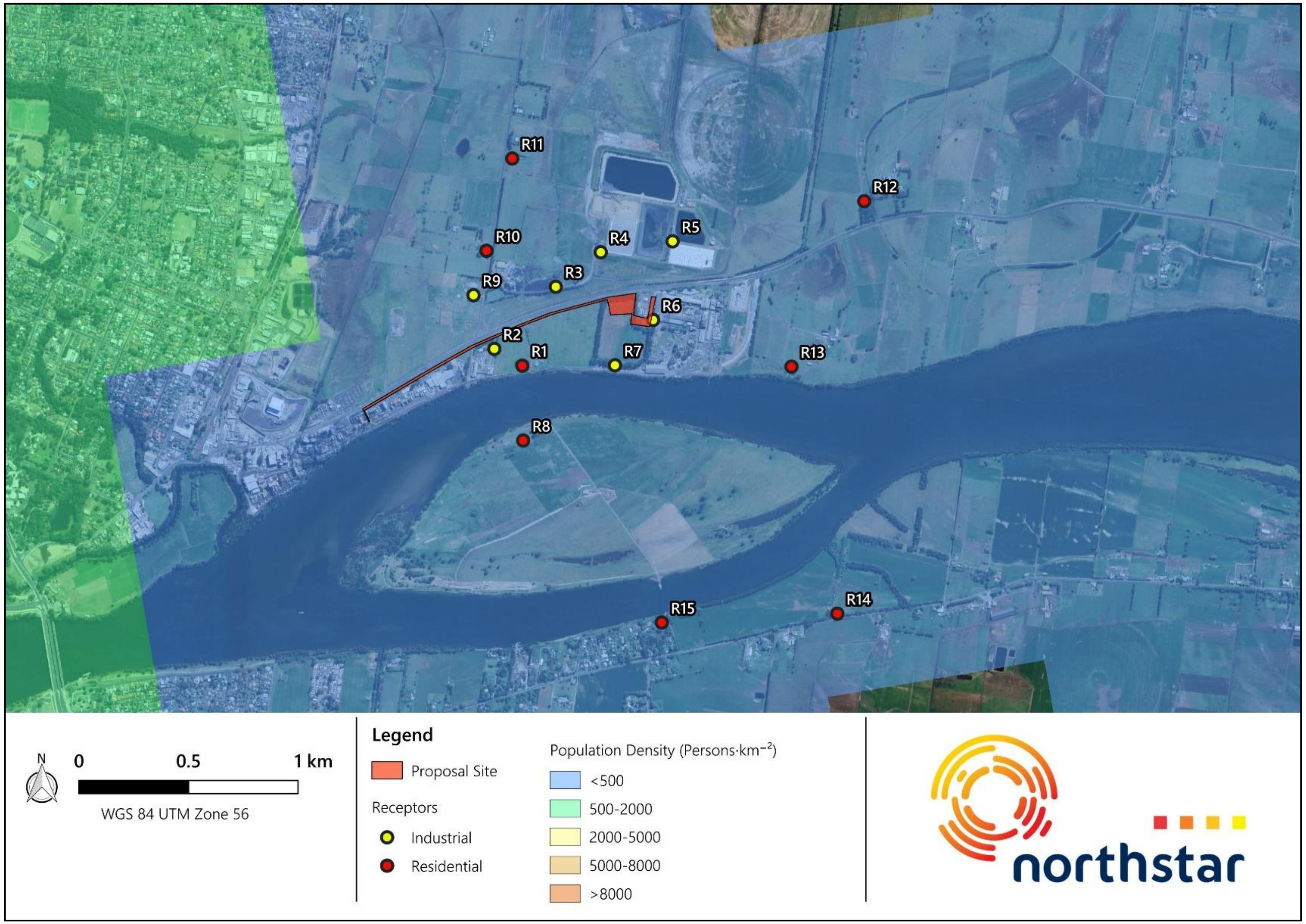
Table 8 is not intended to represent a definitive list of sensitive land uses, but a cross section of available locations that are used to characterise larger areas, or selected as they represent more sensitive locations, which may represent people who are more susceptible to changes in air pollution.

Table 8 Discrete sensitive receptor locations

Receptor ID	Land use	Coordinates (UTM)	
		mE	mS
R1	Residential	282 874	6 140 724
R2	Industrial	282 746	6 140 801
R3	Industrial	283 027	6 141 085
R4	Industrial	283 232	6 141 242
R5	Industrial	283 560	6 141 292
R6	Industrial	283 471	6 140 933
R7	Industrial	283 297	6 140 726
R8	Residential	282 878	6 140 383
R9	Industrial	282 651	6 141 046
R10	Residential	282 711	6 141 249
R11	Residential	282 828	6 141 670
R12	Residential	284 435	6 141 475
R13	Residential	284 103	6 140 720
R14	Residential	284 313	6 139 592
R15	Residential	283 511	6 139 551

Note: The requirements of this AQIA may vary from the specific requirements of other studies, and as such the selection and naming of receptor locations, may vary between technical reports. This does not affect or reduce the validity of those assumptions.

Figure 4 Sensitive receptors surrounding the Proposal site



Source: Northstar

4.2. Meteorology

In accordance with the requirements of the NSW EPA Approved Methods, the AQIA is required to describe and account for the influence of the prevailing meteorological conditions.

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 Nowra Royal Australian Navy (RAN) Air Station automatic weather stations (AWS) (Nowra AWS). This AWS is considered the most representative station for the area surrounding the Proposal site.

To provide a characterisation of the meteorology which would be expected at the Proposal site, a meteorological modelling exercise has been performed.

Data from the year 2021 have been selected for use in the AQIA to provide an approximation of 'representative' conditions surrounding the Proposal site. This year has been selected through an analysis of the correlation coefficients between each year for wind speed, wind direction and particulate matter for the five-year period 2020 to 2024 (refer Appendix B). Following this analysis, the year 2021 was selected as the most representative year for meteorological modelling.

A summary of the inputs and outputs of the meteorological modelling assessment, including model validation is presented in Appendix B. This analysis includes a discussion of data availability and variability.

4.3. Background Air Quality

The air quality experienced at any location will be a result of emissions generated by natural and anthropogenic sources on a variety of scales (local, regional and global). The relative contributions of sources at each of these scales to the air quality at a location will vary based on a wide number of factors including the type, location, proximity and strength of the emission source(s), prevailing meteorology, land uses and other factors affecting the emission, dispersion and fate of those pollutants.

When assessing the impact of any particular source of emissions on the potential air quality at a location, the impact of all other sources of an individual pollutant should also be assessed. This 'background' (sometimes called 'baseline') air quality will vary depending on the pollutants to be assessed and can often be characterised by using representative air quality monitoring data.

Air quality monitoring data from Albion Park AQMS has been adopted to provide a representative dataset for the area surrounding the Proposal site for the assessment year of 2021 (consistent with the selected meteorological modelling data [refer Appendix B]). As such, NO_2 data as monitored at Albion Park South

AQMS in 2021 have been used to approximate typical conditions around the Proposal site. For clarity, for all other pollutants subject to assessment, only incremental impacts are required to be assessed, and no existing background data is required.

Appendix C provides a detailed assessment of the background air quality monitoring data used in this AQIA.

A summary of the air quality monitoring data and assumptions used to produce this AQIA are presented in Table 9.

Table 9 Summary of background air quality used in the AQIA – Albion Park South AQMS 2021

Pollutant	Averaging period	Units	Measured value	Notes
Nitrogen dioxide (NO_2)	1-hour	$\mu g \cdot m^{-3}$	65.6	Hourly maximum 1-hr average in 2021
	24-hour	$\mu g \cdot m^{-3}$	4.7	Annual average 2021

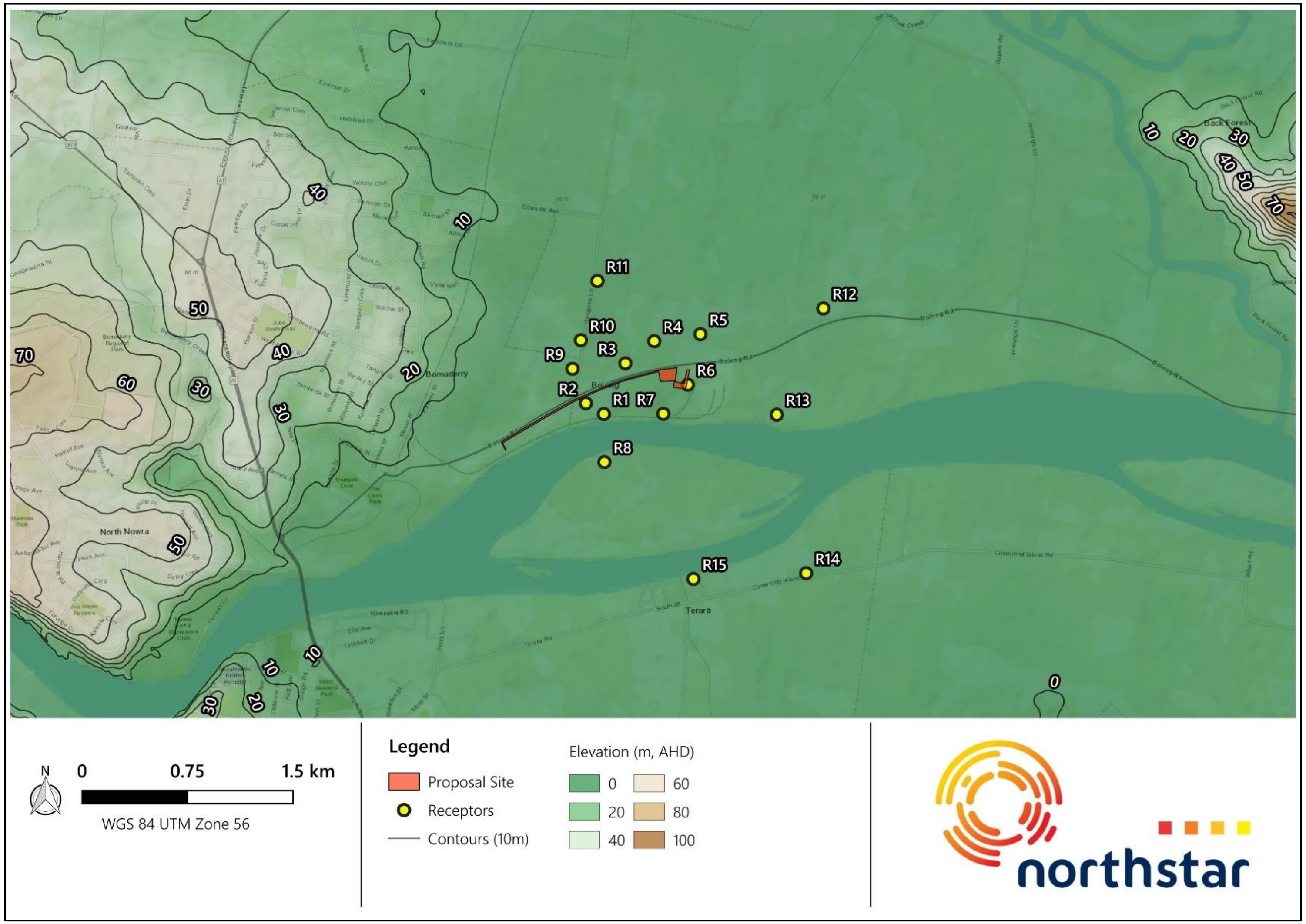
Note: Reference should be made to Appendix C

The AQIA has been performed to assess the contribution of the operations at the Proposal site to the air quality of the surrounding area. A full discussion of how the Proposal may impact upon air quality is presented in Section 6.

4.4. Topography

The elevation of the Proposal site ranges between approximately 3 m and 4 m Australian Height Datum (AHD). The topography between the Proposal site and nearest sensitive receptor locations is uncomplicated (from an AQIA perspective). A representation of the topography surrounding the Proposal site is presented in Figure 5.

Figure 5 Topography surrounding the Proposal site



Source: Northstar

4.5. Potential for Cumulative Impacts

As discussed in Section 2.1, the Shoalhaven Starches facility and the Supagas CO_2 processing plant are located to the southwest of the Proposal site. Given that the materials processed at the Proposal site are derived from the Shoalhaven Starches facility and processed at the Supagas facility in a similar (but not identical) manner, it is considered that potential emissions from the Proposal site may have the potential to result in cumulative impacts with those proximate developments.

4.5.1. Shoalhaven Starches

Shoalhaven Starches Pty Ltd operates a large facility approximately 1 km to 1.5 km to the southwest of the Proposal site. The Shoalhaven Starches facility processes flour and grains to produce ethanol, starch, gluten, glucose, and distiller's dried grain. The facility operates under Environment Protection Licence (EPL) 883.

A recent AQIA for the Shoalhaven Starches facility (GHD, 2021b) assessed the potential for particulate matter, NO_2, and odour impacts on surrounding land uses as a result of proposed modifications to the packing plant, plus all other emissions sources at the facility.

GHD (2021b) predicted that odour impacts near to the Proposal site associated with the Shoalhaven Starches facility and the WWTP were between 2 odour units (OU) and 5 OU (criterion of 6 OU). Incremental PM_{10} concentrations were likely to be less than 5 $\mu g{\cdot}m^{-3}$ as a maximum 24-hour average at the Proposal site (figure 8.4 of (GHD, 2021b)). Incremental NO_2 impacts associated with the Shoalhaven starches facility cannot be determined from the GHD (2021b) AQIA.

4.5.2. Supagas

The Supagas facility is operated adjacent to the former Dairy Farmers factory at 220 Bolong Road, Bomaderry, approximately 850 m to the southwest of the Proposal site. A modification to that facility was proposed and assessed within an AQIA (GHD, 2021a) which indicated that no significant emissions or associated air quality impacts were expected at land uses surrounding the facility. No dispersion modelling was performed for that assessment, and a qualitative assessment indicated that air quality and odour impacts associated with that operation would not be anticipated and there would be no expected increase to cumulative levels in the area. The Department of Planning Industry and Environment (now Department of Planning, Housing and Infrastructure) approved that modification in October 2021.

4.5.3. Potential for Cumulative Impacts with the Proposal

4.5.3.1. Particulate Matter

Emissions and impacts associated with particulate matter from the Proposal are likely to be minimal, and no cumulative impacts with surrounding facilities at sensitive receptor locations is anticipated to occur.

4.5.3.2. Odour

Odour emissions from the Shoalhaven Starches facility, and the associated WWTP are characteristic, and are not likely to be similar to those resulting from the operation of the Proposal. Cumulative impacts are therefore not likely to occur.

5. METHODOLOGY

5.1. Dispersion Modelling Approach

The air emissions assessment for the operational phase of the Proposal has utilised quantitative dispersion modelling techniques. This section outlines the approach taken in the AQIA for the operational phase of the Proposal.

5.1.1. Dispersion Model

A dispersion modelling assessment has been performed using the NSW EPA approved CALPUFF Atmospheric Dispersion Model. CALPUFF is a Lagrangian Gaussian (steady-state) plume dispersion model, recognised in the Approved Methods as a widely accepted model for regulatory applications in NSW. It is used to predict pollutant concentrations from various sources typically found at industrial facilities.

The CALPUFF model uses hourly meteorological data to define conditions for plume rise, transport, diffusion, and deposition. It estimates concentrations or deposition values for each source-receptor combination on an hourly basis and calculates user-selected short-term averages. CALPUFF also accounts for local terrain, making it well-suited for modelling complex terrains, including slope flows, valley flows, terrain blocking, and kinematic effects.

Since most air quality standards are based on averages or percentiles, CALPUFF enables further analysis of results for comparison. The CALPUFF-percent post-processing utility calculates the maximum concentration of a pollutant at a specific percentile over a given period, across all receptors. This percentile approach helps omit unusual short-term meteorological events that may cause elevated concentrations, providing a more accurate representation of likely average pollutant concentrations over the averaging period.

The model input configuration to assess the impact of processing emissions from the Proposal, has considered of the 'Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'' (Barclay & Scire, 2011).

(Barclay & Scire, 2011) recommend using CALMET No-Obs mode for regulatory screening when good-quality gridded prognostic meteorological data are available, which has been applied in the dispersion modelling process.

5.1.2. Meteorological Modelling

Section 4 of the Approved Methods requires one-year of site-specific meteorological data or site-representative meteorological data, in the absence of site-specific data, to be used for dispersion modelling.

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 D). Section 4.5 of the Approved Methods further identifies TAPM as a commonly used prognostic meteorological model in NSW.

TAPM 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.

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.

Further discussion on the meteorological model configuration and input parameters is provided in Appendix B.

5.1.3. Terrain Effects

The CALPUFF model incorporates terrain information with heights being applied to all receptors and sources. In order to account for the potential influence on pollution dispersion and varying receptor elevations across the modelling domain, a gap filled and filtered (vegetation and obstacles removed) topography file with 3 second resolution (approximately 90 m) derived from the Shuttle Radar Topography Mission (SRTM) data was obtained from Geoscience Australia and was processed for use in CALPUFF.

5.1.4. Building Downwash

For dispersion modelling assessments, the influence of surrounding buildings on emission transport is a material consideration. Nearby buildings can create turbulence and a building wake that affect pollutant dispersion, particularly through a phenomenon known as building downwash. The ratio of stack height to building height also impacts this effect; if the stack is significantly taller than the building, downwash is minimal.

Section 5.3 of the Approved Methods outlines the following requirements for determining which buildings to consider within a dispersion modelling assessment:

> *"The location and dimensions of buildings located within a distance of 5L (where L is the lesser of the height or width of the building) from each release point for buildings with a height greater than 0.4 times the stack height…"*

The Building Profile Input Program – Plume Rise Model Enhancements (BPIP-PRIME) uses building heights and corner locations near the stack to simulate effective dimensions. The BPIP-PRIME downwash algorithm computes these dimensions in ten-degree intervals, allowing CALPUFF to assess the impact on plume dispersion and ground-level concentrations. While simplified, this building geometry offers a reasonable estimate of how structures disrupt wind flow nearby.

Therefore, to analyse downwash effects from point sources mimicking air emissions, the buildings surrounding the Proposal site were incorporated into the CALPUFF model.

With reference to the requirements outlined in the Approved Methods, Figure 6 illustrates the locations of the buildings included in the BPIP-PRIME model for downwash calculations, which are subsequently incorporated into the CALPUFF dispersion modelling process. Also shown are the emission discharge points for the scenario modelled (refer Section 5.2).

Figure 6 Buildings and discharge points considered in dispersion modelling

Source: Northstar

5.2. Modelling Scenario

The following modelling scenario has been compiled to determine the potential impacts under the anticipated operational conditions of the Proposal.

Through initial dispersion modelling, elevated concentrations of certain pollutants were predicted at and beyond the site boundary, and at proximate receptor locations due to emissions from point 224, mainly due to the low volumetric flow and calculated stack exit velocity of that emission. Subsequent modelling has combined emissions from streams 224 and 149 which allows a greater exit velocity and increased dispersion of emissions.

Presented in Table 10 are the adopted emission parameters for the two emission streams.

Table 10 Adopted emission parameters

Parameter	Units	Emission Point 130	Emission Point 149 + 224
Stack location	m, UTM	283 332, 6 141 023	283 320, 6 141 019
Stack height	m	8	15
Stack diameter	m	0.6	0.025
Volumetric flow rate	$m^3 \cdot s^{-1}$	0.21	0.005
Exit velocity	$m \cdot s^{-1}$	0.74	10.24
Temperature	K	423	333
Emission rate	$g \cdot s^{-1}$	As per Table 3 H_2S only	As per Table 3 Combined emissions from 149 and 224

5.3. Odour Peak to Mean Ratio

Dispersion modelling is commonly employed to assess compliance with odour impact assessment criteria. However, this process is challenging as dispersion models are generally designed to predict concentrations averaged over periods of one hour or longer, whereas human perception of odour occurs over much shorter durations, typically on the order of one second.

Odour concentrations can vary considerably within short timeframes due to fluctuations in atmospheric turbulence and source characteristics. For instance, during a three-minute period, instantaneous odour levels may spike well above or fall below the hourly mean concentration predicted by a dispersion model.

To address the difference between short-term odour detection and modelled hourly averages, research was carried out to understand how peak odour concentrations relate to longer-term means. This led to the development of peak-to-mean ratios (P/M60), which allow hourly modelled concentrations to be adjusted to reflect short-term peaks more representative of how odours are actually perceived. The appropriate ratio depends on factors such as the type of source, atmospheric stability, distance from the source, and stack height (for point sources).

Under Level 2 odour impact assessments, predicted concentrations are compared against the NSW EPA's odour assessment criteria, which are expressed as 1-second peak concentrations at the 99th percentile. These criteria are designed to reflect the sensitivity of the human nose and ensure that the potential for odour nuisance at the nearest existing or future sensitive receptor is appropriately evaluated.

In the case of the Proposal, impacts of odour are considered through the application of the criteria outlined in Table 7, and the P/M60 must be applied to modelled 1-hour H_2S concentrations as per section 7.4.2 of the Approved Methods. For clarity, all other odorous compounds assessed within this AQIA do not need to be supplemented with a P/M60 as the criteria are 1-hour and not 1-second (nose response time average).

A summary of the peak-to-mean ratios are presented in Table 11. The Approved Methods incorporate these principles and form the basis for determining compliance with odour criteria that are grounded in human sensory response times. The factor for 'wake-affected point' has been applied within this AQIA.

Table 11 Factors for estimating peak-to-mean concentrations

Source type	Pasquill-Gifford stability class	Near-field P/M60*	Far-field P/M60*
Area	A-D	2.5	2.3
	E-F	2.3	1.9
Line	A-F	6	6
Surface wake-free point	A-C	12	5
	D-F	25	7
Tall wake-free point	A-C	17	9
	D-F	35	6
Wake-affected point	A-F	2.3	2.3
Volume	A-F	2.3	2.3

6. IMPACT ASSESSMENT

This section presents the results of the dispersion modelling assessment and uses the following terminology:

- **Incremental impact** – relates to the concentrations predicted as a result of the operation of the Proposal.
- **Cumulative impact** – relates to the incremental concentrations predicted as a result of the operation of the Proposal PLUS the background air quality (refer Section 4.3), where relevant.

The results are presented in this manner to allow examination of the likely impact of the facility in isolation and the contribution to air quality impacts in a broader sense, as required.

In the presentation of results, the tables included shaded cells which represent the following:

Model prediction	**Pollutant concentration / deposition rate less than the relevant criterion**	**Pollutant concentration / deposition rate equal to, or greater than the relevant criterion**

6.1. Impacts at Sensitive Receptor Locations

As discussed in Section 3.3, impacts associated with a number of pollutants are required to be assessed at nearby sensitive receptor locations. Results are presented in the following sections for those pollutants.

6.1.1. Nitrogen Dioxide

Results are presented in this section for the predictions of nitrogen dioxide (NO_2) which is emitted from emission point 224 only. The averaging periods associated with the criteria for NO_2 is 1-hour and an annual average, as outlined in Table 6.

The predicted maximum 1-hour and annual average NO_2 concentrations are presented in Table 12.

The assessment of cumulative impacts has been performed in accordance with Method 1, Level 1 as outlined in section 8.1.1 of the Approved Methods. This is the most conservative level of assessment and adopts the maximum 1-hour NO_2 background concentration measured.

The results indicate that predicted incremental and cumulative hourly and annual NO_2 concentrations are below the criteria at all surrounding receptor locations.

Table 12 Predicted 1-hour and annual average NO_2 concentrations

Receptor	Nitrogen dioxide (NO_2) concentration (µg·m^{-3})					
	1-hour average			Annual average		
	Incr.	Bkg.	Cumul.	Incr.	Bkg.	Cumul.
Criterion	164			31		
Max. % of criterion	2.6	40.0	42.6	0.8	63.5	63.6
R1	1.5	65.6	67.1	<0.1	4.7	4.7
R2	1.5	65.6	67.1	<0.1	5.7	5.7
R3	2.4	65.6	68.0	0.1	6.7	6.8
R4	3.3	65.6	68.9	0.1	7.7	7.8
R5	2.3	65.6	67.9	<0.1	8.7	8.7
R6	4.3	65.6	69.9	0.3	10.7	11.0
R7	2.5	65.6	68.1	<0.1	11.7	11.7
R8	1.1	65.6	66.7	<0.1	12.7	12.7
R9	1.3	65.6	66.9	<0.1	13.7	13.7
R10	1.4	65.6	67.0	<0.1	14.7	14.7
R11	1.0	65.6	66.6	<0.1	15.7	15.7
R12	0.8	65.6	66.4	<0.1	16.7	16.7
R13	1.3	65.6	66.9	0.1	17.7	17.8
R14	0.8	65.6	66.4	<0.1	18.7	18.7
R15	0.7	65.6	66.3	<0.1	19.7	19.7

Notes: Incr. – Incremental, Bkg. – Background, - Cumul. – Cumulative.

6.1.2. Other Pollutants

Impacts associated with pollutants with the potential cause odour impacts at nearby sensitive receptor locations are presented in Table 13. The results indicate that no exceedances of the relevant criteria are predicted at any surrounding receptor.

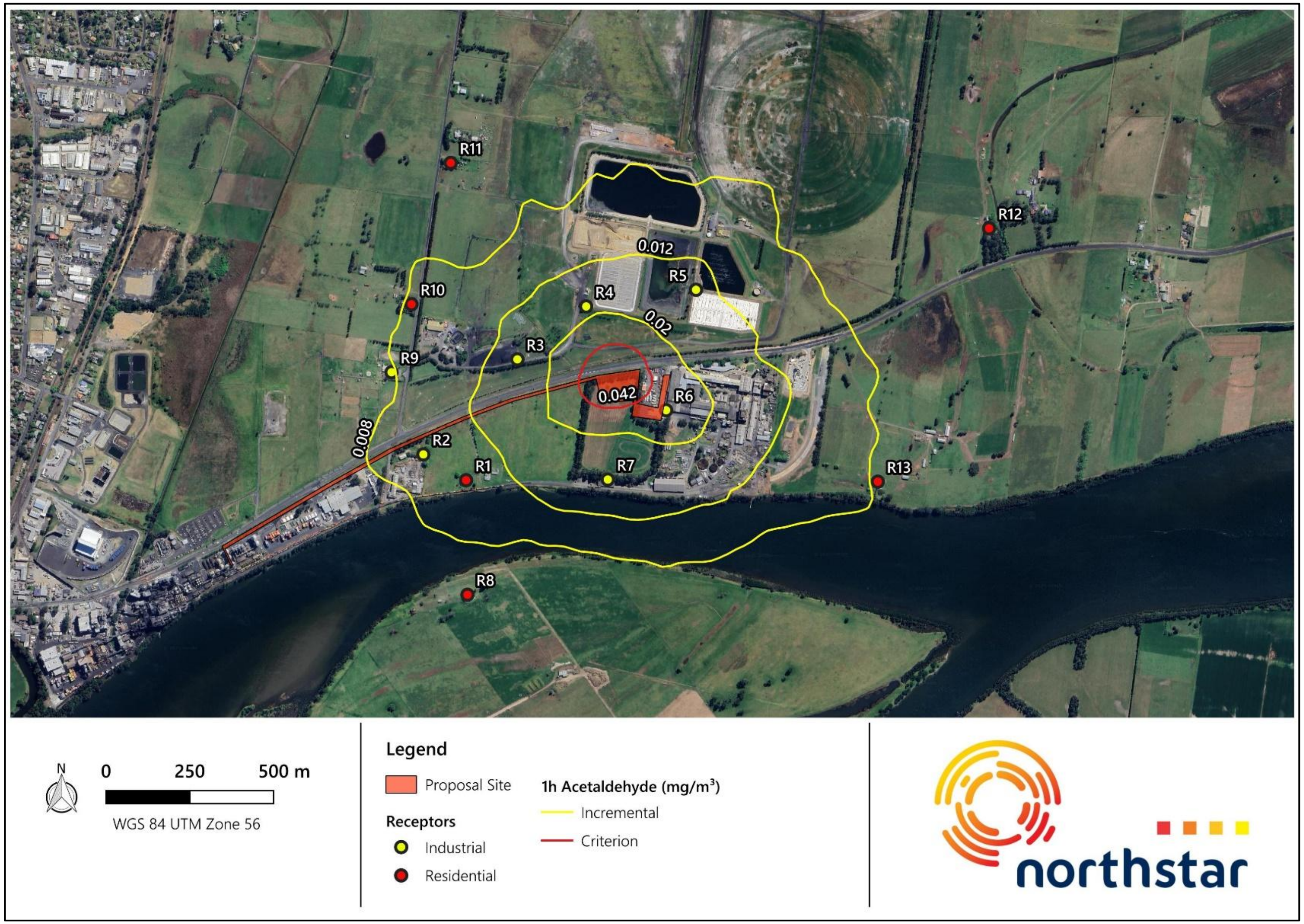
A contour plot showing the spatial distribution of predicted acetaldehyde concentrations surrounding the Proposal site is presented in Figure 7.

Table 13 Predicted 1-hour concentrations – odorous pollutants

Receptor	99.9th percentile 1-hour concentration ($mg \cdot m^{-3}$)							99th percentile 1-hour concentration ($\mu g \cdot m^{-3}$)
	Methanol	Ethanol	*n*-propanol	2-butanol	Acetaldehyde	Ethyl acetate	Methyl mercaptan	Hydrogen sulphide(A)
Criterion	3.0	2.1	0.041	0.5	0.042	12.1	0.00046	1.38
Max. % of criterion	<0.1	17.6	0.6	0.1	59.0	0.3	29.0	0.1
R1	<0.1	0.1	<0.001	<0.01	0.009	<0.1	0.00005	<0.1
R2	<0.1	0.1	<0.001	<0.01	0.009	<0.1	0.00005	<0.1
R3	<0.1	0.2	<0.001	<0.01	0.015	<0.1	0.00008	<0.1
R4	<0.1	0.2	<0.001	<0.01	0.016	<0.1	0.00009	<0.1
R5	<0.1	0.2	<0.001	<0.01	0.013	<0.1	0.00007	<0.1
R6	<0.1	0.4	<0.001	<0.01	0.025	<0.1	0.00013	<0.1
R7	<0.1	0.2	<0.001	<0.01	0.015	<0.1	0.00008	<0.1
R8	<0.1	0.1	<0.001	<0.01	0.007	<0.1	0.00004	<0.1
R9	<0.1	0.1	<0.001	<0.01	0.008	<0.1	0.00004	<0.1
R10	<0.1	0.1	<0.001	<0.01	0.008	<0.1	0.00004	<0.1
R11	<0.1	0.1	<0.001	<0.01	0.006	<0.1	0.00003	<0.1
R12	<0.1	0.1	<0.001	<0.01	0.005	<0.1	0.00003	<0.1
R13	<0.1	0.1	<0.001	<0.01	0.008	<0.1	0.00004	<0.1
R14	<0.1	0.1	<0.001	<0.01	0.004	<0.1	0.00002	<0.1
R15	<0.1	0.1	<0.001	<0.01	0.004	<0.1	0.00002	<0.1

Note: (A) includes P/M60 ratio (refer Section 5.3)

Figure 7 Predicted incremental 99.9th percentile acetaldehyde concentrations



Source: Northstar

Note: Criterion – 0.0042 mg·m^{-3}

6.2. Impacts at and Beyond the Boundary

As outlined in Section 3.3, one individual toxic air pollutant (acetone) is required to be assessed at all locations 'at and beyond the boundary' of the Proposal site. The 99.9th percentile 1-hour dispersion model prediction at the location of maximum impact is presented in Table 14.

The criterion for acetone is predicted to be easily achieved at all locations at and beyond the boundary of the Proposal site.

Table 14 Predicted 1-hour concentrations – toxic pollutants

Receptor	99.9th percentile 1-hour concentration ($mg \cdot m^{-3}$)
Criterion	22.0
Max. % of criterion	<0.1
Maximum impact, at and beyond the boundary	<0.1

6.3. Comparison with POEO (Clean Air) Regulation 2022

The general standards of concentration applicable to the Proposal, as outlined within the POEO (CAR) are presented in Section 3.2. After conversion, taking into account the emission stream water content, pressure, and temperature, the emission concentrations are presented in Table 15.

Table 15 Assessment of compliance with POEO (CAR) general standards of concentration

Air impurity	Standard of concentration	Emission concentration (actual)	Conditions at discharge	Emission concentration (standard)
NO_2	350 $mg \cdot m^{-3}$	(149+224) 5 091.51 $mg \cdot m^{-3}$	0.012397 mol% H_2O 18.2 bar 333.15 K	345.7 $mg \cdot Nm^{-3}$
H_2S	5 $mg \cdot m^{-3}$	(130) 0.01 $mg \cdot m^{-3}$	2.155057 mol% H_2O 1.013 bar 423.15 K	0.02 $mg \cdot Nm^{-3}$
		(149+224) 1.19 $mg \cdot m^{-3}$	0.012397 mol% H_2O 18.2 bar 333.15 K	0.08 $mg \cdot Nm^{-3}$

Note: 'standard' = 273.15K, 101.3 kPa, dry

All emission concentrations comply with the requirements of the POEO (CAR).

7. MITIGATION, MANAGEMENT, AND MONITORING

The following sections outline the potential mitigation, management, and monitoring measures which would be employed as part of the Proposal.

7.1. Construction

Prior to construction, a Construction Environment Management Plan (CEMP) would be prepared which would include a range of air quality management measures. Whilst air quality impacts during the construction phase are anticipated to be minimal and short-term in nature, a range of industry standard management measures would be detailed to manage any minor risks.

7.2. Operation

The dispersion modelling results presented within this AQIA indicate that impacts are anticipated to be below the relevant criteria at the appropriate assessment locations. However, it is recommended that following commissioning, an emissions monitoring campaign is performed to confirm the assumptions adopted within this assessment.

With regard to potential air quality impacts associated with heavy vehicle movements, as outlined in Section 2.2, up to 16 heavy vehicle movements are expected to be required to dispatch product from the Proposal site each day, and up to two movements in a peak hour. Whilst no significant impacts would be anticipated as a result of that low traffic flow, the implementation of the following mitigation methods at the Proposal site would further reduce the risk of air quality impacts resulting from vehicle movements:

- A no-idling policy for dispatch vehicles;
- Speed limits of 15 $km \cdot hr^{-1}$ on the internal roadway; and,
- Good housekeeping measures including keeping the internal roadway clear of debris.

8. CONCLUSION

The Applicant has engaged Northstar to perform an AQIA for a proposed CO_2 processing plant to be located on Bolong Road, Bomaderry.

Emissions during the construction and operational phase of the Proposal have been considered. Given the minor scale of the proposed construction phase, emissions are likely to be minimal, and impacts negligible at the nearest sensitive receptor locations, and the implementation of air quality management measures as part of an over-arching construction environment management plan would be likely to be sufficient to manage any risk.

During the operational phase, emissions to air would be expected as a result of processing activities, haulage of product, and management of wastewater.

Emissions from processing activities have been assessed through a dispersion modelling exercise, using input data for three waste streams provided by the Applicant. Model predictions indicate that all air quality criteria would be achieved at the relevant assessment locations. It is recommended that an emissions monitoring campaign is performed post-commissioning to confirm the assumptions adopted within this assessment.

Emissions associated with product haulage are anticipated to be minimal, as a result of the low traffic volumes, and hardstand nature of the Proposal site. Emissions could be further minimised through the implementation of a no-idling policy and adherence to speed limits at the Proposal site.

Any minor emissions associated with wastewater treatment would be managed at the WWTP located within the Manildra WWTP, which implements a range of odour management measures.

In conclusion, the impacts associated with the construction and operation of the Proposal are anticipated to be below criteria at all sensitive receptor locations. It is respectfully considered that the Proposal should not be rejected on the grounds of air quality.

9. REFERENCES

Barclay, J., & Scire, J. (2011). *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Asssessment of Air Pollutants in NSW, Australia'.*

EPUK. (2010). *Development Control: Planning for Air Quality (2010 Update), Environmental Protection UK.*

GHD. (2021a). *Proposed modification to CO2 Plant (Supagas): Air Quality Assessment.*

GHD. (2021b). *Shoalhaven Starches Modification 21 - Proposed Modification to Packing Plant and Other Works: Air Quality Assessments.*

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

NTC. (2022). *Australian Code for the Transport of Dangerous Goods by Road & Rail, Edition 7.8.*

TTPP. (2024). *53 & 57 Bolong Road and 4 Beinda Street, Bomaderry, Transport Impact Assessment, 18 April 2024.*

USEPA. (2011). *AP42 Compliation of Air Pollutant Emission Factors, Chapter 13.2.1, Paved Roads, January 2011.*

APPENDIX A

Commonly used units and abbreviations

Units Used in the Report

Units presented in the report follow the International System of Units (SI) conventions, unless derived from references using non-SI units.

Commonly used SI units

The following units are commonly used in Northstar reports.

Symbol	Name	Quantity
SI base units		
K	Kelvin	thermodynamic temperature
kg	kilogram	mass
m	metre	length
mol	mole	amount of substance
s	seconds	time
Non-SI units mentioned in the SI or accepted for use		
°	degree	plane angle
d	day	time
h	hour	time
ha	hectare	area
J	joule	energy
L	litre	volume
min	minute	time
N	newton	force or weight
t	tonne	mass
V	volt	electrical potential
W	watt	power

Multiples of SI and non-SI units

The following prefixes are added to unit names to produce multiples and sub-multiples of units:

Prefix	Symbol	Factor
T	tera-	10^{12}
G	giga-	10^{9}
M	mega-	10^{6}
k	kilo-	10^{3}
h	hector-	10^{2}
da	deca-	10^{1}

Prefix	Symbol	Factor
p	pico-	10^{-12}
n	nano-	10^{-9}
µ	micro-	10^{-6}
m	milli-	10^{-3}
c	centi-	10^{-2}
d	deci-	10^{-1}

In this report, units formed by the division of SI and non-SI units are expressed as a negative exponent, and do not use the solidus (/) symbol. For example:

- 50 micrograms per cubic metre would be presented as 50 $\mu g{\cdot}m^{-3}$ and not 50 $\mu g/m^3$; and,
- 0.2 kilograms per hectare per hour would be presented as 0.2 $kg{\cdot}ha^{-1}{\cdot}hr^{-1}$ and not 0.2 kg/ha/hr.

Commonly used SI-derived and non-SI units

Units	Value	Description
bar	atmospheric pressure (1 bar = 100 kPa)	pressure
$g \cdot m^{-2} \cdot s^{-1}$	gram per square metre per second	rate of mass deposition per unit area
$g \cdot s^{-1}$	gram per second	rate of mass emission
$kg \cdot ha^{-1} \cdot hr^{-1}$	kilogram per hectare per hour	rate of mass deposition per unit area
$kg \cdot m^{-3}$	kilogram per cubic metre	density
$L \cdot s^{-1}$	litres per second	volumetric rate
m^2	square metre	area
m^3	cubic metre	volume
$m \cdot s^{-1}$	metre per second	speed and velocity
$mg \cdot m^{-3}$	milligram per cubic metre	mass concentration per unit volume
$mg \cdot Nm^{-3}$	milligram per normalised cubic metre (of air)	mass concentration per unit volume
$\mu g \cdot m^{-3}$	microgram per cubic metre	mass concentration per unit volume
$mg \cdot m^{-3}$	milligram per cubic metre	mass concentration per unit volume
Pa	pascal	pressure
ppb	parts per billion ($1x10^{-9}$)	volumetric concentration
pphm	parts per hundred million (1×10^{-5})	volumetric concentration
ppm	parts per million ($1x10^{-6}$)	volumetric concentration
%mol	mol fraction (expressed as percent)	amount of a substance

Commonly used abbreviations

Abbreviation	Term
ABS	Australian Bureau of Statistics
ACT	Australian Commonwealth Territory
AGL	above ground level
AHD	Australian height datum
APC	air pollution control
AQI	air quality index
AQIA	air quality impact assessment
AQMS	air quality monitoring station
AQRA	air quality risk assessment
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS/NZS	Australian Standard / New Zealand Standard
AWS	automatic weather station
BCA	Building Code of Australia
BGL	below ground level
BOM	Bureau of Meteorology
CEMP	construction environment management plan
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide

Abbreviation	Term
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	digital elevation model
EETM	emission estimation technique manual
EPA VIC	Environmental Protection Authority Victoria
EPBC	Environment Protection and Biodiversity Conservation Act
FIBC	flexible intermediate bulk container
GIS	geographical information system
IAQM	UK Institute of Air Quality Management
IBC	intermediate bulk container
ID	internal diameter
LLV	low level waste
LoM	life of mine
MSDS	Material Safety Data Sheet
NCAA	National Clean Air Agreement
NEPM	National Environment Protection Measure
NH_3	ammonia
NO	nitric oxide
NO_X	oxides of nitrogen
NO_2	nitrogen dioxide
NORM	naturally occurring radioactive material
NSW	New South Wales
NSW DCCEEW	New South Wales Department of Climate Change, Energy, the Environment and Water
NSW EPA	New South Wales Environment Protection Authority
NT	Northern Territory
OEMP	operational environmental management plan
O_3	ozone
OU	odour unit
$OU \cdot m^3 \cdot s^{-1}$	odour units times metres cubed per second
$OU \cdot s^{-1}$	odour units per second
Pb	lead
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 µm or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 µm or less
ROM	run of mine
SA	South Australia
SEPP	State Environmental Protection Policy
SO_X	oxides of sulphur
SO_2	sulphur dioxide
SRTM3	Shuttle Radar Topography Mission
SVOC	semi-volatile organic compound
TAPM	The Air Pollution Model

Abbreviation	Term
TAS	Tasmania
TEU	twenty-foot equivalent unit
TSP	total suspended particulates
TVOC	total volatile organic compounds
TWA	time weighted average
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VIC	Victoria
VLLW	very low level waste
VOC	volatile organic compound

APPENDIX B

Meteorology

Meteorological Stations

As discussed in Section 4.2, a meteorological modelling exercise has been performed to characterise the meteorology of the Proposal site. The meteorological monitoring has been based on measurements acquired from Nowra Royal Australian Navy (RAN) Air Station automatic weather stations (AWS) (Nowra AWS) operated by the Australian Government Bureau of Meteorology (BoM).

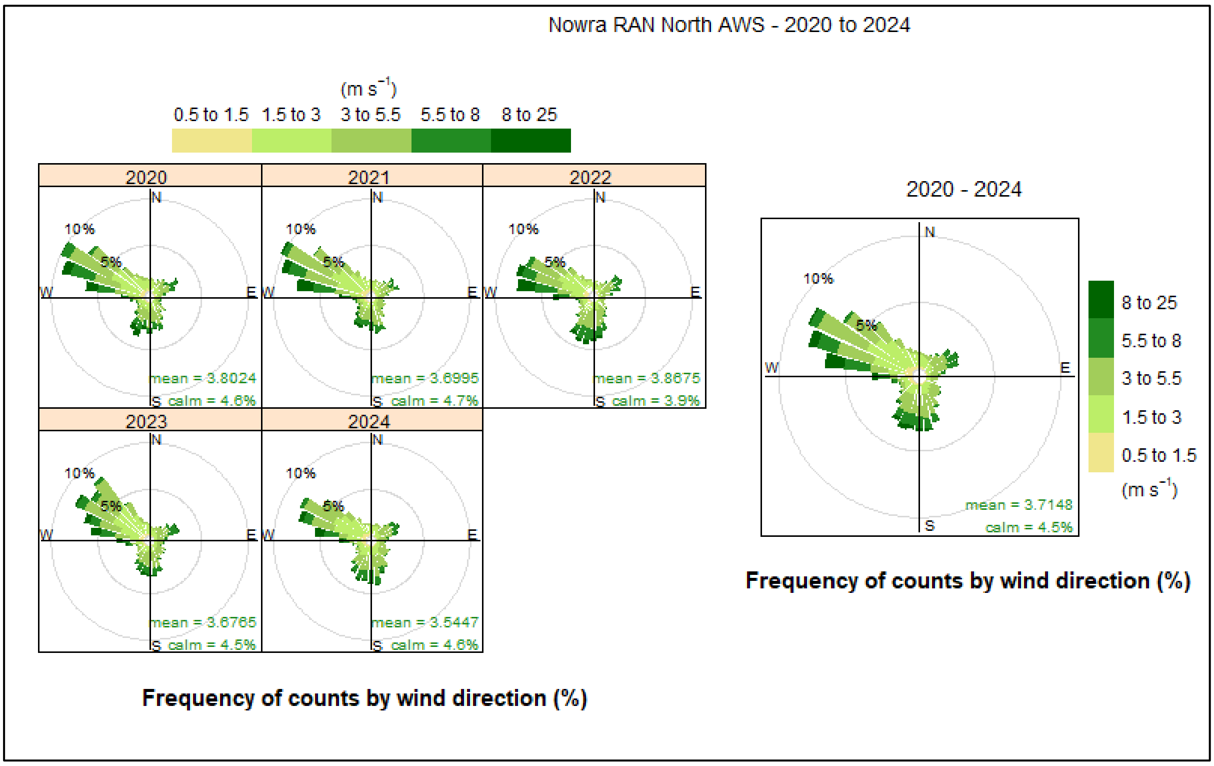
Meteorological conditions at Nowra AWS have been examined to determine a 'typical' or representative dataset for use in dispersion modelling. Annual wind roses for the most recent years of data (2020 to 2024) are presented in Figure B1. The annual wind speed frequency distribution for the five-year period is presented in Figure B2.

The wind roses indicate that from 2020 to 2024, winds at Nowra AWS show generally similar wind distribution patterns across the years assessed, with predominant north-westerly wind directions evident.

The majority of wind speeds experienced at the Nowra AWS between 2020 and 2024 are generally in the range 1.5 meters per second ($m \cdot s^{-1}$) to 8 $m \cdot s^{-1}$ with the highest wind speeds (greater than 8 $m \cdot s^{-1}$) occurring mostly from north-westerly directions. Winds of this speed occur during 4.8 % of the observed hours during the years while calm winds (less than 0.5 $m \cdot s^{-1}$) occur during 4.5 % of hours on average across the years 2020 to 2024.

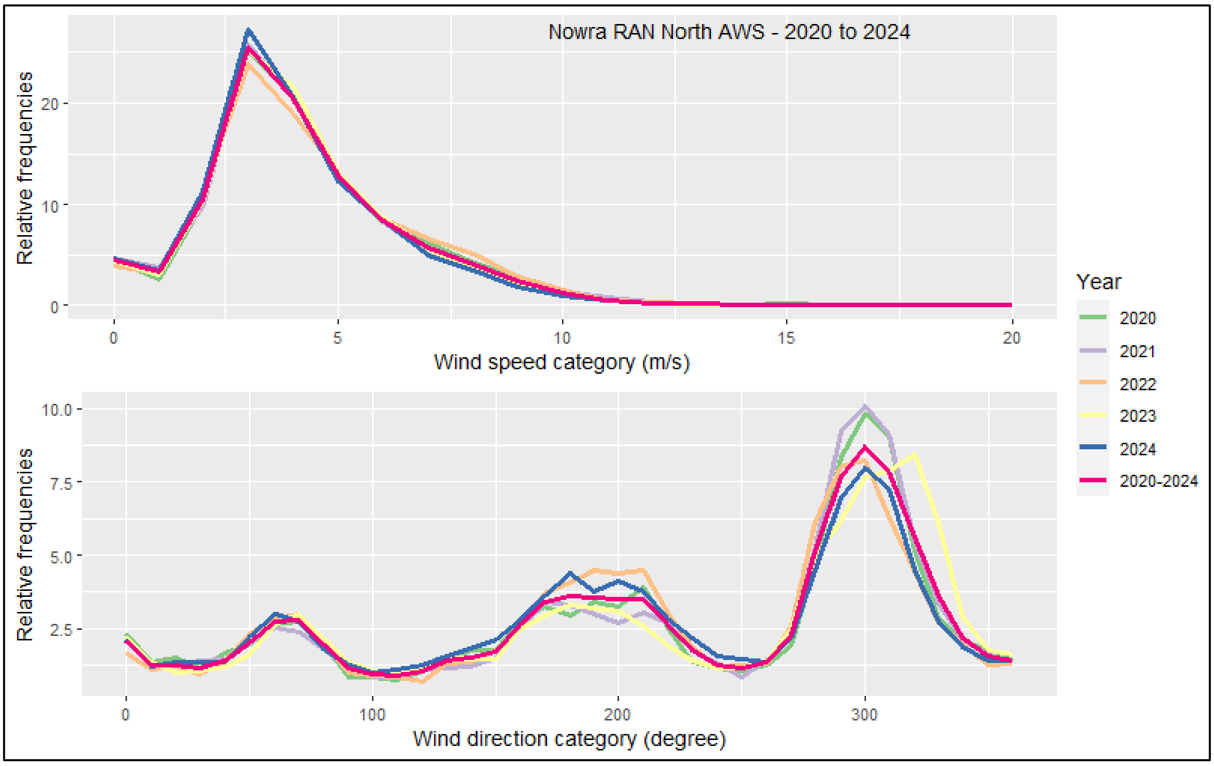
The correlation coefficient between each year and the five-year period for the distribution of wind speed, wind direction, PM_{10} and $PM_{2.5}$ are summarised in Table B1. The correlation coefficients were ranked and aggregated to select the representative year for the meteorological modelling. The rankings are also presented in Table B1.

Figure B1 Annual wind roses – Nowra AWS (2020 to 2024)



Source: Northstar

Figure B2 Wind direction and speed distributions Nowra AWS (2020 to 2024)



Source: Northstar

Table B1 Correlation coefficient analysis – Nowra AWS & Albion Park South AQMS (2020 to 2024)

Parameter	Wind speed		Wind direction		PM_{10}		$PM_{2.5}$		Aggregated rank
	Corr.	Rank	Corr.	Rank	Corr.	Rank	Corr.	Rank	
2020	0.9994	1	0.9864	2	0.9904	3	0.9934	3	2
2021	0.9993	2	0.9870	1	0.9986	1	0.9994	1	1
2022	0.9974	5	0.9655	4	0.9506	5	0.9600	5	5
2023	0.9993	3	0.9297	5	0.9911	2	0.9966	2	3
2024	0.9983	4	0.9829	3	0.9692	4	0.9630	4	4
2020-2024	1	-	1	-	1	-	1	-	-

Wind speed observations for each year correlated well against the wind speed over the five-year period, with each year having a correlation coefficient greater than 0.99. 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 greater than of 0.92. The year 2021 is the highest ranked for correlation against the wind direction over the five-year period.

Particulate matter concentrations for each year are well correlated against particulate matter concentrations over the five-year period. Each year resulted in having a correlation coefficient greater than 0.95. The year 2021 is the highest rank for both PM_{10} and $PM_{2.5}$.

The correlation coefficient analysis indicates that 2021 is the most representative year for meteorological modelling.

Meteorological Processing

To generate a meteorological dataset appropriate to use within the dispersion modelling assessment, a meteorological modelling exercise has also been performed using the CALMET meteorological model in a format suitable for using in the CALPUFF dispersion model (refer Section 5).

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.

It is noted that the initial TAPM modelling run provided wind roses which did validate well against observations at Nowra AWS, and correspondingly this has been considered sufficient to represent meteorological parameters at the Proposal site for use in CALMET.

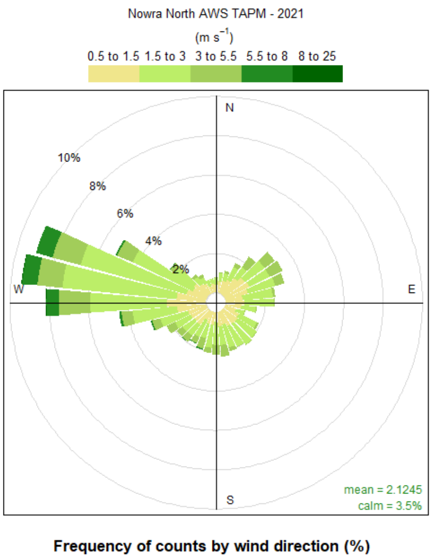
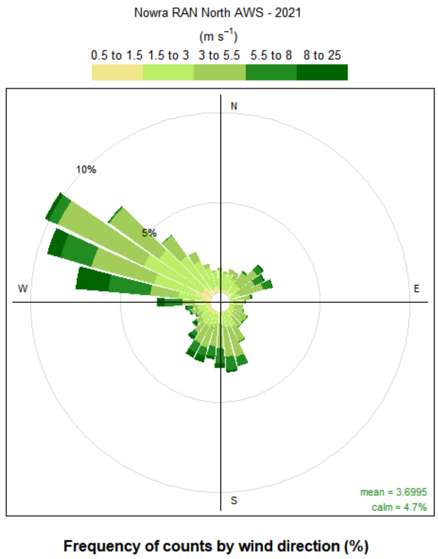
A comparison of the TAPM generated meteorological data, and that observed at Nowra AWS, are presented in Figure B3. These data generally compare well which provides confidence that the meteorological conditions modelled as part of this assessment are appropriate.

The parameters used in TAPM and CALMET modelling are presented in Table B2.

Table B2 Meteorological parameters used for this study

TAPM v 4.0.5	
Modelling period	1 January 2021 to 1 January 2022
Centre of analysis	281 381 mE, 6 139 134 mS (UTM Coordinates)
Number of grid points	25 × 25 × 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 2021 to 1 January 2022
South-West corner of analysis	280 209 mS, 6 137 905 mS (UTM Coordinates)
Meteorological grid domain (resolution)	4.5 km x 4.5 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

Figure B3 Modelled and observed meteorological data – Nowra AWS (2021)

TAPM generated data	Observed data
	

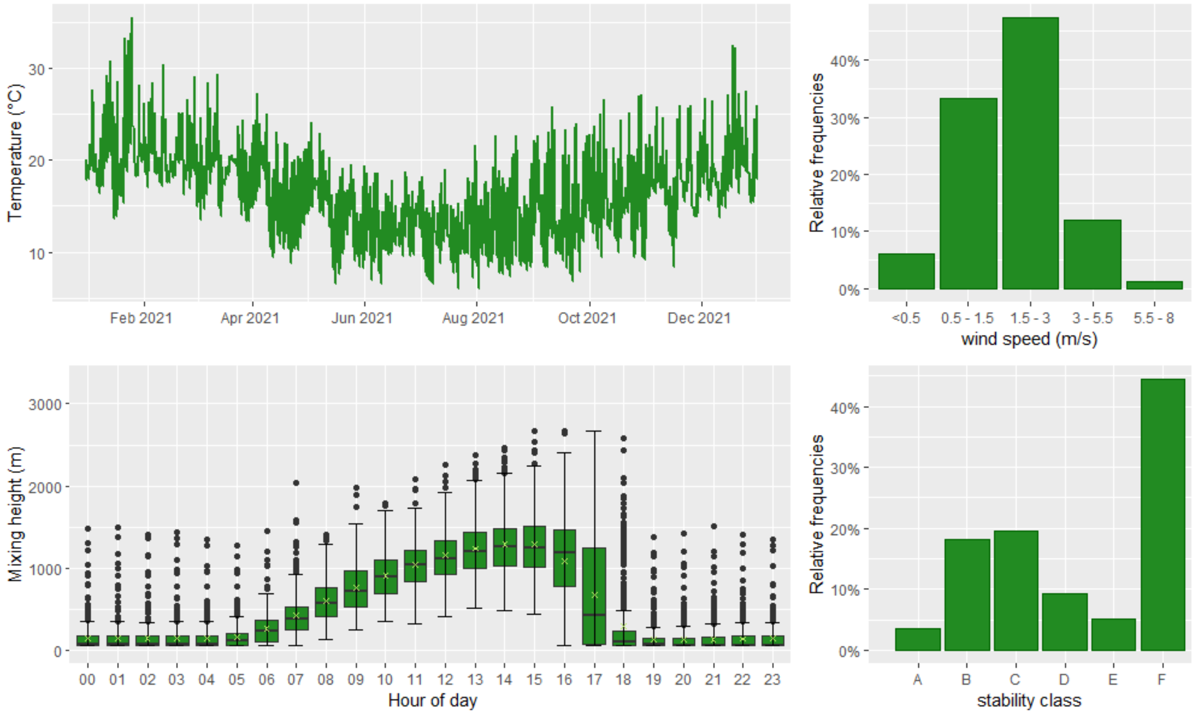
Source: Northstar

As generally required by 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 2021 are illustrated in Figure B4.

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.

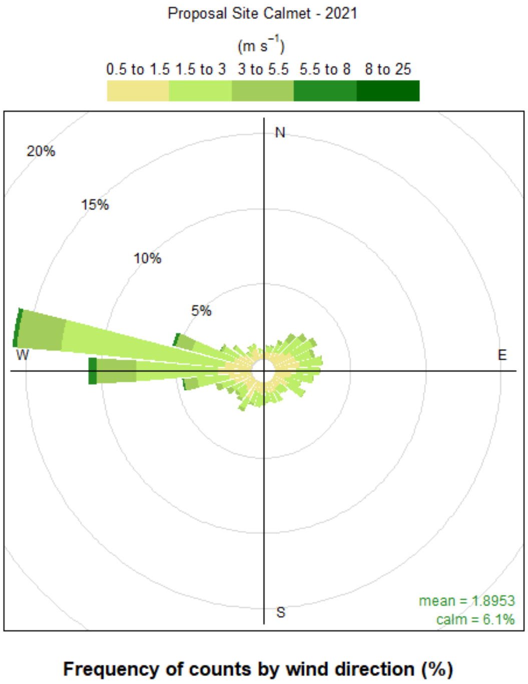
Figure B4 Predicted temperature, mixing height, stability class and wind characteristics – Proposal site (2021)



Source: Northstar

The modelled wind speed and direction at the Proposal site during 2021 are presented in Figure B5.

Figure B5 Predicted wind direction and speed – Proposal site (2021)



Source: Northstar

APPENDIX C

Background Air Quality

Background Air Quality

Air quality is not monitored at the Proposal site and therefore air quality monitoring data measured at a representative location has been adopted for the purposes of this assessment. Determination of data to be used as a location representative of the Proposal site and during a representative year can be complicated by factors which include:

- The sources of air pollutant emissions around the Proposal site and representative AQMS; and
- The variability of particulate matter concentrations (often impacted by natural climate variability).

The closest active air quality monitoring station (AQMS) operated by the NSW Department of Climate Change, Energy, Environment and Water (NSW DCCEEW) that records NO_2 data is noted to be located at Albion Park South AQMS and is considered to be the most reflective of the conditions at the Proposal site.

The results of the correlation coefficient analysis provided in Appendix B indicates that meteorological measured in 2021 is an appropriate dataset for use within this study. Reference should be made to Appendix B for justification.

Summary statistics for the selected data monitored at Albion Park South AQMS are presented in Table C2.

Graphs presenting the hourly varying NO_2 data recorded at Albion Park South AQMS in 2021 are presented in Figure C1.

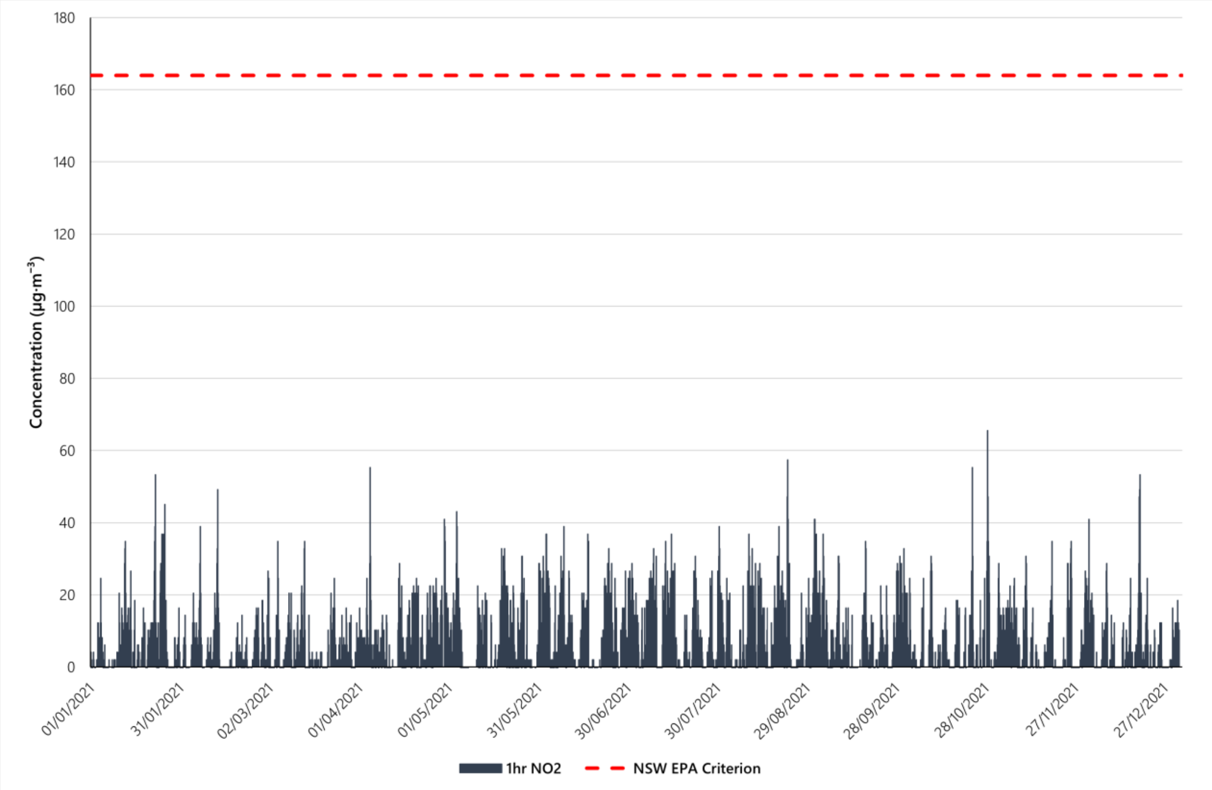
Table C3 Background air quality statistics for Albion Park South AQMS (2021)

Pollutant	NO_2
Averaging period	1-hour
Units	$\mu g \cdot m^{-3}$
Data points (number)	8122
Mean	4.7
Standard deviation	8.0
Skew [1]	*1.9*
Kurtosis [2]	*4.9*
Minimum	-4.1
Percentiles	
25th	0.0
50th	2.1
75th	8.2
90th	16.4
95th	20.5
97th	24.6
98th	28.7
99th	32.8
Maximum	**65.6**
Data Capture (%)	**92.7**

Notes: 1: Skew represents an expression of the distribution of measured values around the derived mean. Positive skew represents a distribution tending towards values higher than the mean, and negative skew represents a distribution tending towards values lower than the mean. Skew is dimensionless.

2: Kurtosis represents an expression of the value of measured values in relation to a normal distribution. Positive kurtosis represents a more peaked distribution, and negative kurtosis represents a distribution more flattened than a normal distribution. Kurtosis is dimensionless.

Figure C1 Hourly varying NO_2 concentrations – Albion Park South AQMS (2021)



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

northstar

supporting carbon neutral
Turn Emissions into Trees®

Tel: 1300 708 590 | admin@northstar-env.com | northstar-env.com