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Tumblong Landfill

Air Quality Impact Assessment

Addressee(s): Habitat Planning Pty Ltd

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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.



Gary Graham

14 November 2025

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NON-TECHNICAL SUMMARY

Northstar Air Quality Pty Ltd was engaged by Habitat Planning Pty Ltd on behalf of MH Earthmoving Pty Ltd (MHE) (the Applicant) to perform an air quality and odour impact assessment (AQIA), to support a Development Application (DA) modification for the proposed increase rate of waste disposal at the existing Tumblong Non-Putrescible Waste Disposal Facility (the Project). The proposal increase in waste disposal is from 60 000 tonnes per year to 99 000 tonnes per year.

The prediction of potential impacts associated with operational activities has been performed in general accordance with the requirements of the NSW Environment Protection Authority 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW' guidance document, using an approved and appropriate dispersion modelling technique. The estimation of emissions has been performed using referenced emission factors.

The findings of the air quality impact assessment predicts that with consideration of a range of worst-case assumptions and conservative input data, the operation of the Proposal is not predicted to result in any additional exceedances of relevant air quality or odour criteria at any off-site receptor location.

In addition to the management measures adopted as part of this assessment, it is considered that good site management practices would be sufficient to ensure that impacts are minimised during Proposal operation.

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1. INTRODUCTION

Habitat Planning Pty Ltd, acting on behalf of MH Earthmoving Pty Ltd (MHE) (the Applicant) has engaged Northstar Air Quality Pty Ltd (Northstar) to perform an air quality and odour impact assessment (AQIA), to support a Development Application (DA) modification, for the proposed increase in waste disposal at the existing Tumblong Non-Putrescible Waste Disposal Facility (the Project). The Project is located at Tumblong Reserve Road, Tumblong NSW (the Project site).

MHE operates the Tumblong Non-Putrescible Waste Disposal Facility under the development consent DA2019/143 and holds Environmental Protection Licence (EPL) No. 21440, issued by the NSW Environment Protection Authority (EPA) in 2020. It is currently licensed to accept up to 60 000 tonnes per year ($\text{t}\cdot\text{yr}^{-1}$) of general solid waste (non-putrescible) exclusively from the Visy Pulp and Paper Mill (Visy) in Tumut.

This AQIA will assess air quality and odour impacts associated with increasing the annual waste disposal allowance from 60 000 $\text{t}\cdot\text{yr}^{-1}$ to 99 000 $\text{t}\cdot\text{yr}^{-1}$. The proposed variations under this DA modification are further outlined in Section 2.2.

The AQIA identifies and examines potential air quality risks and impacts associated with the modified operation of the Project and identifies mitigation and monitoring requirements commensurate with those anticipated risks and impacts to ensure that air quality objectives are achieved at all surrounding sensitive receptor locations.

1.1. Purpose of the Report

The purpose of this AQIA is to assess the potential impact of air emissions resulting from the operation of the Project with the proposed modification. The AQIA adopts established methods for dispersion modelling and emissions estimation, considering source characteristics, emission rates, local meteorology, terrain, land use and sensitive receptor locations.

The AQIA has been performed with reference to the following relevant statutory legislative guidelines and assessment documents (in no order):

- *Protection of the Environment Operations Act 1997* (POEO Act);
- Protection of the Environment Operations (Clean Air) Regulation 2022 (POEO CAR);
- Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (NSW EPA, 2022a);
- Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (NSW EPA, 2022b);
- Technical Framework (NSW DEC, 2006a) and Technical Notes (NSW DEC, 2006b)– Assessment and Management of Odour from Stationary Sources in NSW; and
- Environmental Guidelines – Solid Waste Landfills (second edition) (NSW EPA, 2016).

Appendix A contains a glossary of abbreviations, acronyms, and commonly used units referenced in this AQIA.

1.2. Development Consent History

The Project has been operating since 2020 after receiving development consent DA2019/143 from the Cootamundra-Gundagai Council on 29 June 2020. It operates under EPL 21440, which authorises the landfill to accept up to 60 000 t·yr⁻¹ of general solid waste (non-putrescible) exclusively from the Visy Pulp and Paper Mill (Visy) in Tumut.

A modification application (DA2019/143.5) was recently determined on 27 June 2023 which permitted the construction of an additional temporary leachate storage pond and associated perimeter bunds on Lot 3 of Deposited Plan (DP) 702858. The temporary leachate storage pond is to be decommissioned five (5) years from the date of transfer from Cell 2.

Previously, the Project site was designated as a quarry reserve (Reserve 89508) in 1975.

2. THE PROJECT

The following provides a description of the context, location and scale of the Project, and a description of the processes and development activities on site. It also identifies the potential for emissions to air associated with the Project.

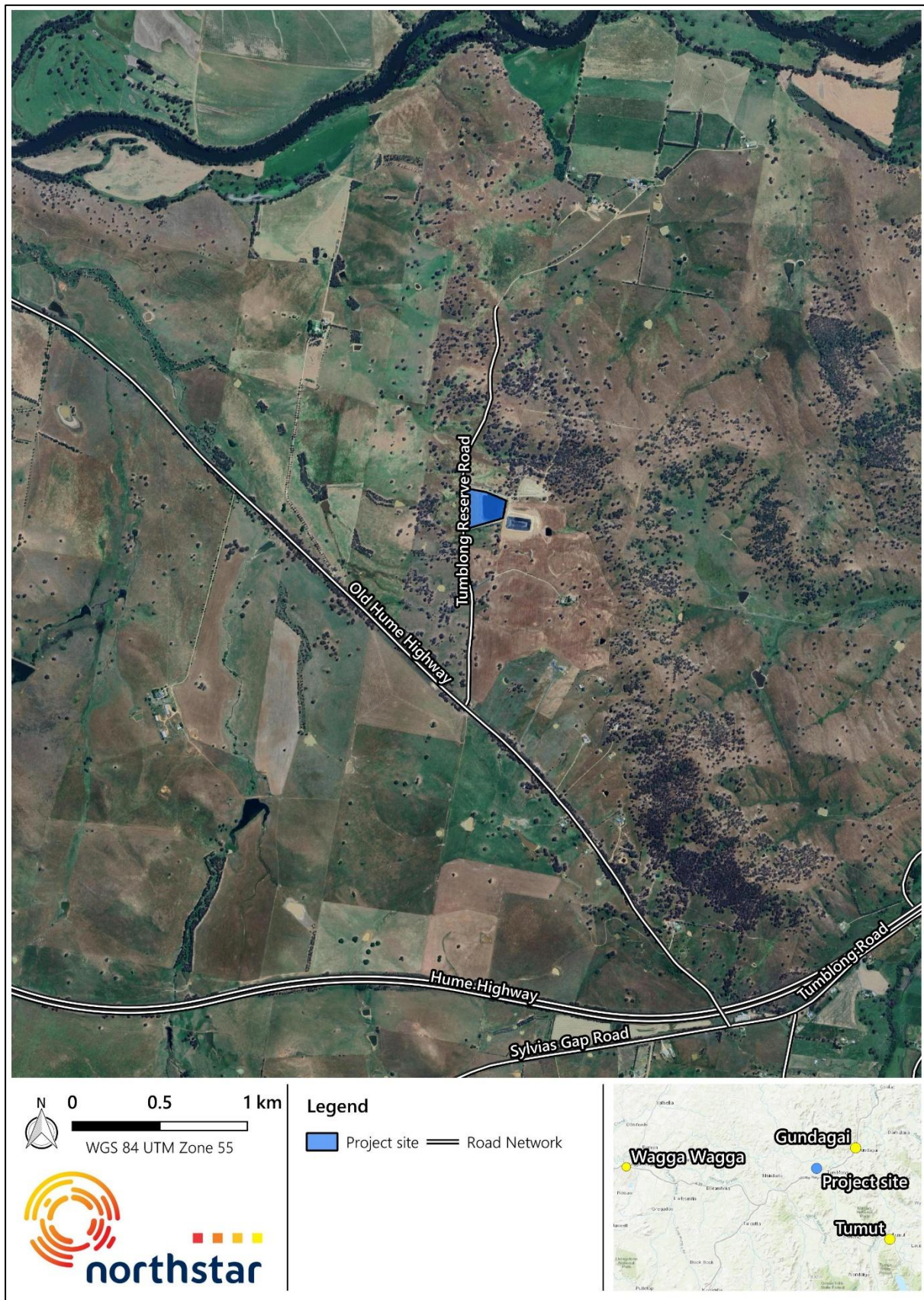
2.1. Environmental Setting

The Project site is located at Lot 7004 in Deposited Plan (DP) 1028797 & Lot 7300 DP 1149008 on Tumblong Reserve Road, Tumblong, NSW. The Project site is located within the Local Government Area (LGA) of Cootamundra-Gundagai Regional Council.

The Project site is situated in a predominantly rural area, which is zoned as RU1 (Primary Production). The nearest residential land use zone is over 11 kilometres (km) to the northeast of the Project site in the town of Gundagai.

A map illustrating the location of the Project site is presented in Figure 1.

Figure 1 Project site location



Source: Northstar Air Quality

2.2. Project Overview

As outlined in Section 1, the Applicant currently operates a non-putrescible waste disposal facility at the Project site. The existing approved operations under DA2019/143 allow the Applicant to accept up to 60 000 tonnes per year ($\text{t}\cdot\text{yr}^{-1}$) of general solid waste (non-putrescible) exclusively from the Visy Pulp and Paper Mill (Visy) in Tumut.

The proposed DA modification seeks consent for the following:

- **Increase in the annual waste disposal:** allowance at Tumblong Landfill from 60 000 tpa^{-1} to 99 000 tpa^{-1} . No changes to the total volume of waste disposed at the premises or operational lifespan is proposed – total capacity to remain as approved at 485 000 m^3 over 10 years from the date the first load of waste is received.
- **Provide increased surety to the Visy Pulp & Paper Mill:** The site is licensed to accept waste only from the Visy Pulp and Paper Mill (Visy) in Tumut. The increase in waste disposal tonnage will allow paper machine rejects from Visy to be disposed of locally, rather than to landfill further afield.
- **Enhance operational efficiency:** By increasing the allowable annual waste tonnage, the landfill can streamline operations, improve space utilisation and reduce the frequency of site closures due to capacity constraints.
- **Support local and regional development:** Increasing the annual waste intake allowance will provide a stable waste management solution that supports local and regional development without expanding the landfill's overall approved capacity.

All existing activities onsite including traffic generation and hours of operation (7 am to 5 pm) are expected to remain consistent and well within the site's capacity.

2.3. Landfill Design

2.3.1. Landfill Cells

Two landfill cells, repurposed from former quarrying activities, have been established at the Premises. Landfill cell 1 has been temporarily capped with interim cover, while landfill cell 2 is currently operational.

Each cell is lined with a geosynthetic clay liner (GCL) and topped with a 2-millimetre (mm) thick high-density polyethylene (HDPE) geomembrane, underlain by a minimum 200 mm compacted clay sub-base for effective containment. Additionally, both cells utilise protection (cushion) and separation (filter) geotextiles.

The active waste disposal area includes the waste unloading hopper and the associated working face. Once deposited into the hopper, waste is loaded by an excavator into a Moxy truck and delivered to the working

face of the operating landfill cell. The waste is then spread and compacted using a compactor. The working face refers to the area that has been stripped back from the previous day's operations, making space for the placement and compaction of the daily waste deliveries.

It is noted that Section 2.1.2 of the Contaminated Land Guidelines (NSW EPA, 2020) notes that:

"Building and demolition waste frequently contains plasterboard (gyprock) waste, which may generate hydrogen sulfide (H₂S) under anaerobic conditions. Hydrogen may be generated when acidic groundwater reacts with galvanised iron roofing, guttering and pipe waste. A wide range of trace gases may also be present."

To represent the landfill cells in dispersion modelling, two separate odour sources i.e. active landfill cell and intermediate cover cell have been modelled (see Section 5.2.2). Although it is noted that H₂S is likely to be generated, for the purpose of this assessment odour is assessed as a complex mixture of odorous air pollutants that includes H₂S (see Section 3.3.2.2 and Section 7.2).

2.3.2. Cover Materials

At the end of each working day, a layer of clayey virgin excavated natural material (VENM) soils is applied as a daily cover material across at a minimum depth of 150 mm, as stipulated in Condition O6.1 of EPL 21440.

A stockpile of daily cover material, comprised of clayey VENM, is located north east of both waste cells. This temporary stockpile provides materials for engineering, rehabilitation, and daily waste cover. The restoration and rehabilitation work at landfill cell 2 will use the clay material from the stockpile. Once these activities are finished, the remaining stockpile material will be reshaped, and the area will be rehabilitated.

The impact of cover materials on the potential odour emission rate is reflected in the adopted odour emission rates (see Section 5.2.2).

2.3.3. Leachate Management

Leachate management at the Premises involves two storage dams: one to the west of landfill Cell 1 ("Leachate Dam 1" being the permanent leachate dam) and a newly constructed dam ("Leachate Dam 2" being the temporary leachate dam) to the east south-east of landfill cell 2.

For specifications, reference should be made to the LMP (InSitu Advisory, July 2025).

2.3.3.1. Leachate Dam 1 (Permanent Dam)

The 2020 DA approval for the Premises included provision for a single permanent leachate storage dam on the western boundary of the site, designed to service both landfill cells 1 and 2. This dam is lined with compacted clay, GCL, and a 2 mm HDPE geomembrane, forming a composite barrier.

The leachate pumped from landfill cell 2 to Leachate Dam 1 is mechanically aerated and chemically oxidised to minimise the odour generation potential of leachate.

Mechanical aeration is provided by two (2) floating water pumps that draw leachate from deeper in the leachate column and spray the leachate via diffusers onto the dam surface. Diffusers reduce the sprayed droplet size which increases the aeration potential by increasing the diffused surface area, which is an effective odour control.

The stored leachate is also dosed with hydrogen peroxide (H_2O_2). H_2O_2 is an effective oxidation agent, minimising the emission of reduced sulphur compounds including hydrogen sulphide (H_2S) and carbon disulphide (CS_2).

The mechanical aeration and chemical oxidation controls are performed in accordance with EPL 21440 variation notice 1621459).

A fraction of the treated leachate is pumped from Leachate Dam 1 to Leachate Dam 2.

2.3.3.2. Leachate Dam 2 (Temporary Dam)

To provide adequate storage capacity for leachate generated in landfill cells 1 and 2, a temporary engineered leachate storage dam is also operational at the Premises. In accordance with the DA consent, '*the temporary leachate pond on Lot 3 DP 702858 is to be decommissioned five (5) years from the date of the transfer of leachate from Cell 2 to the temporary leachate pond*'. The decommissioning of the temporary leachate dam will be 12 December 2028.

Leachate Dam 2 is fitted with an engineered, surface-floating linear low-density polyethylene (LLDPE) cover to reduce rainfall ingress, and to provide odour control by way of containment of the leachate stored in the dam. The cover is fitted with two (2) air displacement outlets, each connected to activated carbon filters to minimise the rate of odour emission from the leachate stored under the cover, operated in accordance with advice provided in (TOU, November 2022).

A layer of liquid above the cover assists the effective operation of the cover by minimising wind uplift of the cover from the leachate surface and also provides some UV resistance to the cover materials.

A fraction of the leachate that has been chemically treated and mechanically aerated in Leachate Dam 1 is pumped to Leachate Dam 2. The leachate may be stored beneath the floating cover or a smaller volume stored above the floating cover to fulfil the functions described above, and to facilitate evaporation.

Given that the leachate stored above the floating cover is chemically treated and mechanically aerated prior to pumping to Leachate Dam 2, the leachate should not pose a significant odour risk unless (a) the treatment in Leachate Dam 1 is insufficient to deal with the leachate loading rates, or (b) the leachate stored becomes stagnant / anoxic, or (c) the precipitated solids are allowed to build up which may cause an anaerobic layer which may become an odour source if disturbed.

Nevertheless, for completeness odour from leachate dams is considered as a separate source in this AQIA (see Section 5.2.2.3).

2.3.3.3. Odour Control Units

The odour generated and captured under the floating cover on the temporary leachate storage dam is drawn to two (2) odour control units (OCU) before the treated odour is released to the atmosphere, as illustrated in Figure 2.

Figure 2 McBerns Odour Control Unit



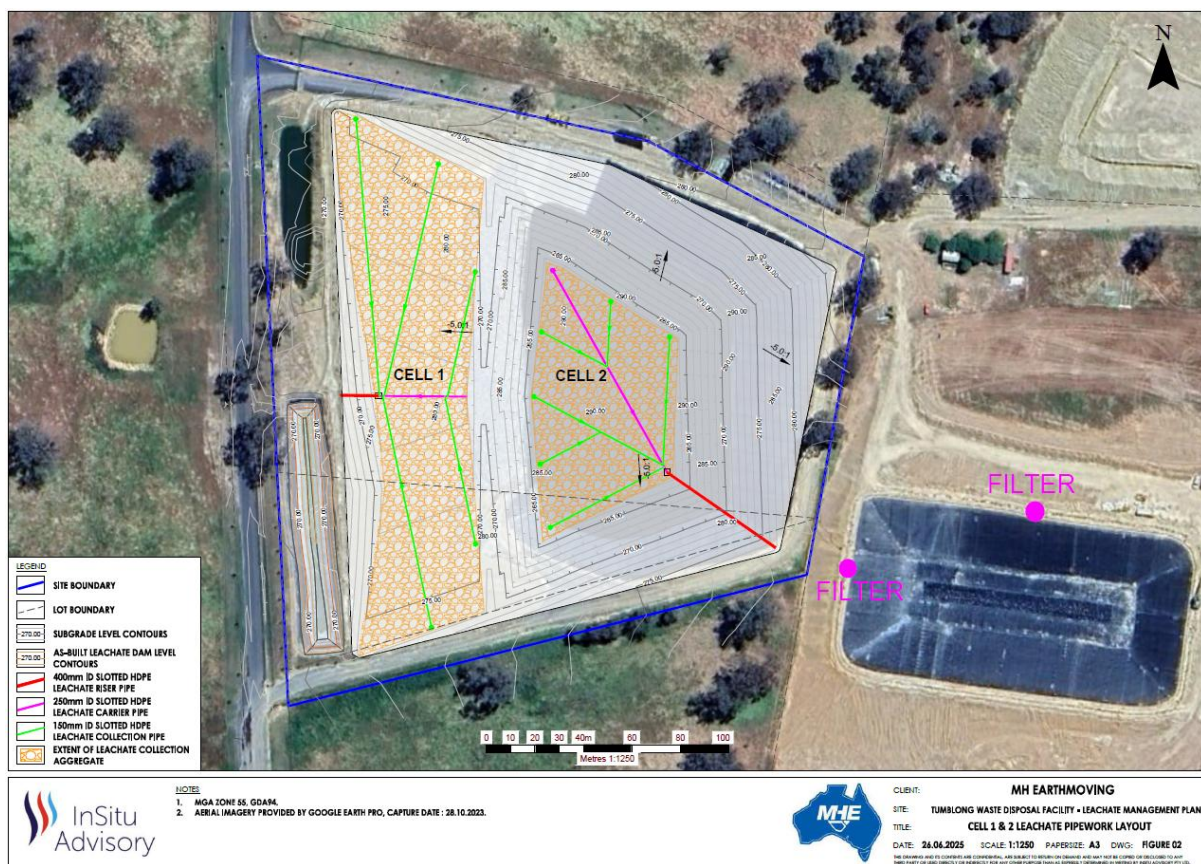
Source: McBerns Innovative Solutions 2025

The OCU is designed to treat wastewater odour emissions entering the unit through three stages comprising of the initial treatment by the potassium hydroxide (KOH) impregnated activated carbon, secondary treatment by McBerns Proprietary Bulk Combined Media, and tertiary treatment by McBerns Proprietary Combined Media Cartridges, which is then emitted to atmosphere. The OCU is expected to achieve 99.9 % reduction in odorous gases (McBerns 2025).

The impact of aeration and H_2O_2 dosing on the potential odour emission rate is reflected in the adopted odour emission rates (see Section 5.2.2).

The locations of the two OCUs is shown in Figure 3.

Figure 3 Locations of the two OCUs



Source: InSitu 2025

2.4. Identification of Potential Emissions to Air

The processes which may result in emission of pollutants to air during operations include:

- Movement of vehicles in and around the Project site on paved and unpaved road surfaces;
- Placement of waste;
- Placement of cover material;

- Active tip face;
- Intermediate waste cover; and
- Leachate

The specific pollutants of interest associated with those activities are:

- Total suspended particulates (TSP);
- Particulate matter with a mean aerodynamic diameter of 10 micrometres (μm) or less (PM_{10});
- Particulate matter with a mean aerodynamic diameter of 2.5 μm or less ($\text{PM}_{2.5}$); and
- Odour (as complex mixtures of odorous gases including H_2S).

During the performance of the proposed operational activities, a number of air quality management measures are to be employed to minimise the generation and off-site transport of pollutants. A discussion of these measures is presented in Section 5.3.

Assessment of the potential impacts upon local air quality resulting from the activities outlined above is presented in Section 6.

Exhaust emissions of oxides of nitrogen (NO_x), carbon monoxide (CO) and sulphur dioxide (SO_2) related to diesel consumption in plant and non-road mobile machinery (comprising of front-end loader (FEL), excavators and materials handling equipment) would also be experienced (in addition to particulates considered above). Given the quantity of equipment operating on site at any one time, it is not anticipated that emissions associated with diesel combustion (other than particulate matter which have been assessed) would be a significant contributor to total site emissions.

As outlined above, operational activities have the potential to generate both particulate matter and odour emissions from the various activities. Odour is of particular concern and interest as a regulatory and community issue because of its ability to have direct sensory effects on people who become exposed to those emissions over time. Depending on the frequency, intensity, and duration of odour exposure, this may lead to nuisance and complaints if not adequately controlled. Correspondingly, both particulate matter and odour emissions have been assessed in this AQIA and are presented in Section 6.

3. LEGISLATION, REGULATION AND GUIDANCE

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

3.1. Protection of the Environment Operations Act 1997

The *Protection of the Environment (Operations) Act 1997* (POEO) is applicable to scheduled activities in NSW. Chapter 5, Part 5.4, Section 128 relates to the control of air emissions (emphasis added).

- 128 *Standards of air impurities not to be exceeded*
- (1) *The occupier of any premises must not carry on any activity, or operate any plant, in or on the premises in such a manner as to cause or permit the emission at any point specified in or determined in accordance with the regulations of air impurities in excess of—*
 - (a) *the standard of concentration and the rate, or*
 - (b) *the standard of concentration or the rate,**prescribed by the regulations in respect of any such activity or any such plant.*
 - (1A) *Subsection (1) applies only to emissions (point source emissions) released from a chimney, stack, pipe, vent or other similar kind of opening or release point.*
 - (2) *The occupier of any premises must carry on any activity, or operate any plant, in or on the premises by such practicable means as may be necessary to prevent or minimise air pollution if—*
 - (a) *in the case of point source emissions—neither a standard of concentration nor a rate has been prescribed for the emissions for the purposes of subsection (1), or*
 - (b) *the emissions are not point source emissions...*

Section 129 of the POEO Act provides the requirements for the control of emissions of odour from licenced activities.

- 129 *Emission of odours from premises licensed for scheduled activities*
- (1) *The occupier of any premises at which scheduled activities are carried on under the authority conferred by a licence must not cause or permit the emission of any offensive odour from the premises to which the licence applies...*

It is noted that the Project involves activities defined as a scheduled activity under the POEO Act ie s39 Waste disposal (application to land) of Schedule 1 (Scheduled Activities).

3.2. Protection of the Environment Operations (Clean Air) Regulation 2022

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

3.3. NSW EPA Impact Assessment Criteria

3.3.1. Criteria Air Pollutants

State air quality guidelines adopted by the NSW EPA are published in the 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW' (the Approved Methods (NSW EPA, 2022a)) which has been consulted during the preparation of this AQIA.

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 of the Approved Methods clearly outlines the impact assessment criteria for the Project.

The criteria listed in the Approved Methods are derived from a range of sources (including NHMRC, NEPC, WHO and ANZECC). Where relevant to this AQIA (coincident with the potential emissions identified in Section 2.4), the criteria have been adopted as set out in Section 7.1 of the Approved Methods which are presented in Table 1.

Table 1 NSW EPA impact assessment criteria

Pollutant	Averaging period	Units	Criterion	Notes
Particulates (as PM ₁₀)	24 hours	µg·m ⁻³ ^(A)	50	Numerically equivalent to the AAQ NEPM ^(B) standards and goals.
	1 year	µg·m ⁻³	25	
Particulates (as PM _{2.5})	24 hours	µg·m ⁻³	25	
	1 year	µg·m ⁻³	8	
Particulates (as TSP)	1 year	µg·m ⁻³	90	
Particulates (as dust deposition)	1 year ^(C)	g·m ⁻² ·month ⁻¹	2	Assessed as insoluble solids as defined by AS 3580.10.1
	1 year ^(D)	g·m ⁻² ·month ⁻¹	4	

Notes: (A): micrograms per cubic metre of air
 (B): National Environment Protection (Ambient Air Quality) Measure
 (C): Maximum increase in deposited dust level
 (D): Maximum total deposited dust level

3.3.2. Odour

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.

3.3.2.1. 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.

3.3.2.2. 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). The ‘Technical framework: Assessment and management of odour from stationary sources in NSW’ (NSW DEC, 2006a) 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 DEC, 2006a) by setting a population dependant 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 Odour Technical Framework (NSW DEC, 2006a) is shown in Table 2. This table shows that in situations where the population of the affected community lies between 10 and 30 people for example, an odour assessment criterion of 6 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.

Table 2 NSW EPA Technical Framework odour criteria

Population of affected community	Impacted assessment criteria for complex mixture of odours (OU)
Urban area ($\geq 2\ 000$)	2.0
500 – 2 000	3.0
125 – 500	4.0
30 – 125	5.0
10 – 30	6.0
Single residence (≤ 2)	7.0

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

The area surrounding the Project site is largely rural in nature although as outlined in Section 4.1, ten residences have been identified within a radius of approximately 3 km of the Project site boundary. The average household size in the Cootamundra-Gundagai LGA as reported in the 2021 census was 2.4 persons (see also Section 4.2). A population total within 3 km of the Project site is therefore calculated to be approximately 24 persons. The relevant odour criterion for a population of this size is 6 OU, applicable for a population between 10 and 30 residents, as shown in Table 2.

As noted in Section 2.3.1, H₂S is likely to be generated at the Project site. It is noted that the Approved Methods for Modelling (NSW EPA, 2022a) stipulates separate assessment criteria for individual and complex

mixtures of odorous air pollutants. For the purpose of this assessment, the criteria for complex mixtures of odorous air pollutants (encompassing H_2S) is adopted.

4. EXISTING CONDITIONS

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

4.1. Surrounding Land Sensitivity

The Project site and immediate surrounds are currently zoned as RU1 (Primary Production) under the Gundagai Local Environmental Plan (2011). The nearest residential land use zone is over 11 km to the northeast of the Project site in the town of Gundagai.

4.2. 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. 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.

The Approved Methods (NSW EPA, 2022a) 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 noted that the assessment criteria applied to particulates (refer Table 1) are for a 24-hour averaging period, and as such the predicted impacts need to be interpreted at commercial and industrial receptor locations with care. It is considered to be atypical for a person to be at those locations for a complete 24-hour period and as such, the exposure risks associated with those pollutants at those locations would be over-estimated by adoption of those locations in the modelling assessment.

The selected receptor locations are a representative, but not exhaustive selection of all sensitive receptors in the study area. They reflect broader surroundings and may reasonably represent nearby areas. Where multiple receptors exist in close proximity (e.g. a school near a medical centre), the closest to emission sources is typically chosen to assess risks to surrounding sensitive land use.

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 Approved Methods, several receptors have been identified, as shown in Table 3 and illustrated in Figure 4

Table 3 is not a definitive list of sensitive land uses but a representative cross-section of locations used to characterise broader areas or highlight more sensitive sites where people may be more susceptible to air pollution.

To ensure that the discrete receptors selected for the AQIA reflect populated areas, data from the 2021 Australian Bureau of Statistics (ABS) census (ABS, 2022) covering mainland Australia in a 1 square kilometre (km²) grid has been used. Using a Geographical Information System (GIS), the locations of sensitive receptor locations have been confirmed with reference to their respective population densities (Figure 4).

For clarity, the ABS use the following categories to analyse population density (persons·km⁻²):

- No population Zero (0).
- Very low Up to 500.
- Low Between 500 and 2 000.
- Medium Between 2 000 and 5 000.
- High Between 5 000 and 8 000.
- Very high More than 8 000.

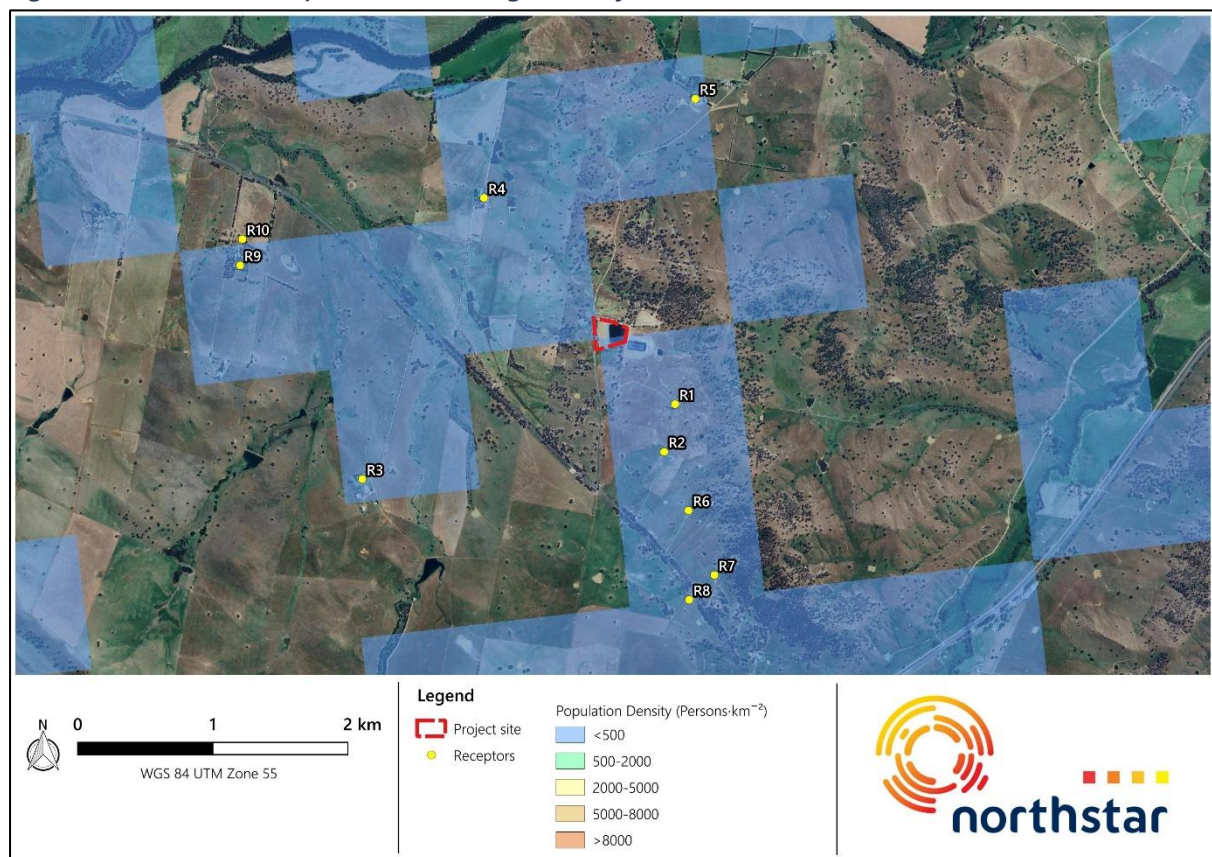
Using the ABS data in a GIS, the population density around the Project site and its immediate vicinity is categorised as very low (i.e. up than 500 persons·km⁻²), indicating a predominantly rural area.

Table 3 Discrete sensitive receptor locations

Receptor ID	Location	Land use	Coordinates (UTM)	
			mE	mS
R1	68 Tumblong Reserve Road, Tumblong	Residential	589 581	6 112 920
R2	108 Old Hume Highway, Tumblong	Residential	589 499	6 112 568
R3	419 Old Hume Highway, Tumblong	Residential	587 265	6 112 366
R4	346 Old Hume Highway, Tumblong	Residential	588 165	6 114 446
R5	335 Tumblong Reserve Road, Tumblong	Residential	589 731	6 115 179
R6	4 Old Hume Highway, Tumblong	Residential	589 680	6 112 134
R7	Old Hume Highway, Tumblong	Residential	589 871	6 111 656
R8	119 Old Hume Highway, Tumblong	Residential	589 685	6 111 473
R9	555 Old Hume Highway, Tumblong	Residential	586 360	6 113 947
R10	555 Old Hume Highway, Tumblong	Residential	586 378	6 114 140

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 Project site



Note: Areas with no colour represents a 1 km² grid cell with zero population

4.3. Meteorology

In accordance with the Approved Methods, the AQIA is required to address 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 Project site have been characterised using data collected by the Australian Government Bureau of Meteorology (BoM) at surrounding automatic weather stations (AWS).

Two meteorological stations operated by BoM were identified proximate to the Project site. A summary of the relevant AWS is provided in Table 4 below (listed by proximity).

Table 4 AWS proximate to the Project site

Site name	Station #	Source	Approximate location		Approximate distance (km)
			mE	mS	
Gundagai (Nangus Rd)	073141	BoM	600 173	6 119 308	12.4
Wagga Wagga AMO	072150	BoM	541 667	6 109 306	47.6

Note: Climate statistics available at <http://www.bom.gov.au/climate/data/index.shtml>

Data from Wagga Wagga AMO AWS (Wagga AWS) for the period between 2020 and 2024 have been analysed for use in this study. It is noted that there is no publicly available data between 2020 to 2024 at Gundagai (Nangus Road) AWS and, correspondingly this AWS was not analysed. The wind roses presented in Appendix B indicate that from 2020 to 2024, winds at Wagga AWS show generally similar wind distribution patterns across the years assessed, with predominant north-easterly wind directions.

The majority of wind speeds experienced at the Wagga AWS between 2020 and 2024 are generally in the range 1.5 metres per second ($\text{m}\cdot\text{s}^{-1}$) to $5.5 \text{ m}\cdot\text{s}^{-1}$ with the highest wind speeds (greater than $8 \text{ m}\cdot\text{s}^{-1}$) occurring from north-easterly and south-westerly directions. Winds of this speed are rare and occur during 2.8 % of the observed hours during the years while calm winds (less than $0.5 \text{ m}\cdot\text{s}^{-1}$) are more common and occur during 6.3 % of hours on average across the years between 2020 and 2024.

An analysis of the correlation coefficients between each year for wind speed, wind direction and particulate matter data distribution was performed to select a representative year for the meteorological modelling (refer Appendix B). Following this analysis, the year 2021 was selected as the representative year for further assessment.

To provide a characterisation of the meteorology which would be expected at the Project 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 B.

4.4. 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. These 'background' (sometimes called 'baseline') air quality conditions will vary depending on the pollutants to be assessed and can often be characterised by using representative air quality monitoring data.

Two air quality monitoring stations (AQMS) have been identified proximate to the Project site, operated by NSW Department of Climate Change, Environment, Energy and Water (NSW DCCEEW). These locations (listed by proximity) are briefly summarised in Table 5.

Table 5 AQMS proximate to the Project site

AQMS location	Distance to Project site	2021 data	Pollutants		
			PM ₁₀	PM _{2.5}	TSP
Junee	53.6	✓	✗	✗	✓
Wagga Wagga North	56.3	✓	✓	✓	✗

The closest representative AQMS with particulate matter data available for the year 2021 (the selected representative year consistent with the meteorological modelling) is noted to be located at Wagga Wagga North. Correspondingly, PM data from Wagga Wagga North for the year 2021 have been adopted for use in this assessment.

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

It is noted that Wagga Wagga North AQMS does not measure concentrations of TSP. This pollutant is of relevance to the expected emissions from the Project. Other sources of data have been adopted to allow representation of the TSP environment in the area surrounding the Project site, and a full discussion is provided in Appendix C.

The impact assessment criteria used for deposited dust (see Table 1) are presented as (i) a cumulative deposition rate of 4 g·m⁻²·month⁻¹ and (ii) a discrete deposition rate of 2 g·m⁻²·month⁻¹. In lieu of a background deposition rate to derive a cumulative rate, the incremental impact assessment criterion (2 g·m⁻²·month⁻¹) has been adopted. This is a commonly adopted approach when background deposition rates are not available.

The Project site is not located in close proximity to any other waste management facilities, or any facilities which may result in odour emissions of a similar nature. Correspondingly, the odour environment of the area would be expected to be dominated by emissions from the Project and therefore the background odour environment (i.e. without activities at the Project site) would be anticipated to be negligible.

A summary of the air quality monitoring data and assumptions used to produce this AQIA are presented in Table 6.

Table 6 Summary of background air quality used in the AQIA

Pollutant	Average period	Units	Monitored value	Notes
Particles (as TSP) (derived from PM ₁₀)	Annual	µg·m ⁻³	39.4	Estimated on a TSP:PM ₁₀ ratio of 2.222: 1
Particles (as PM ₁₀)	24-hour	µg·m ⁻³	Daily varying	The 24-hour maximum PM ₁₀ concentration in 2021 was 69.1 µg·m ⁻³
	Annual	µg·m ⁻³	17.7	
Particles (as PM _{2.5})	24-hour	µg·m ⁻³	Daily varying	The 24-hour maximum PM _{2.5} concentration in 2021 was 25.4 µg·m ⁻³
	Annual	µg·m ⁻³	6.3	
Dust deposition	Annual	g·m ⁻² ·month ⁻¹	2.0	Difference in NSW EPA max allowable and incremental impact criterion
Odour	Nose response time	OU	-	Assumed to be negligible

Note: Reference should be made to Appendix C

It is noted that in 2021 Wagga Wagga North AQMS recorded seven exceedances of the 24-hour average PM₁₀ criterion and one exceedance of the 24-hour PM_{2.5} criterion due to regional dust and agricultural burning from January to April (NSW DPE, 2023).

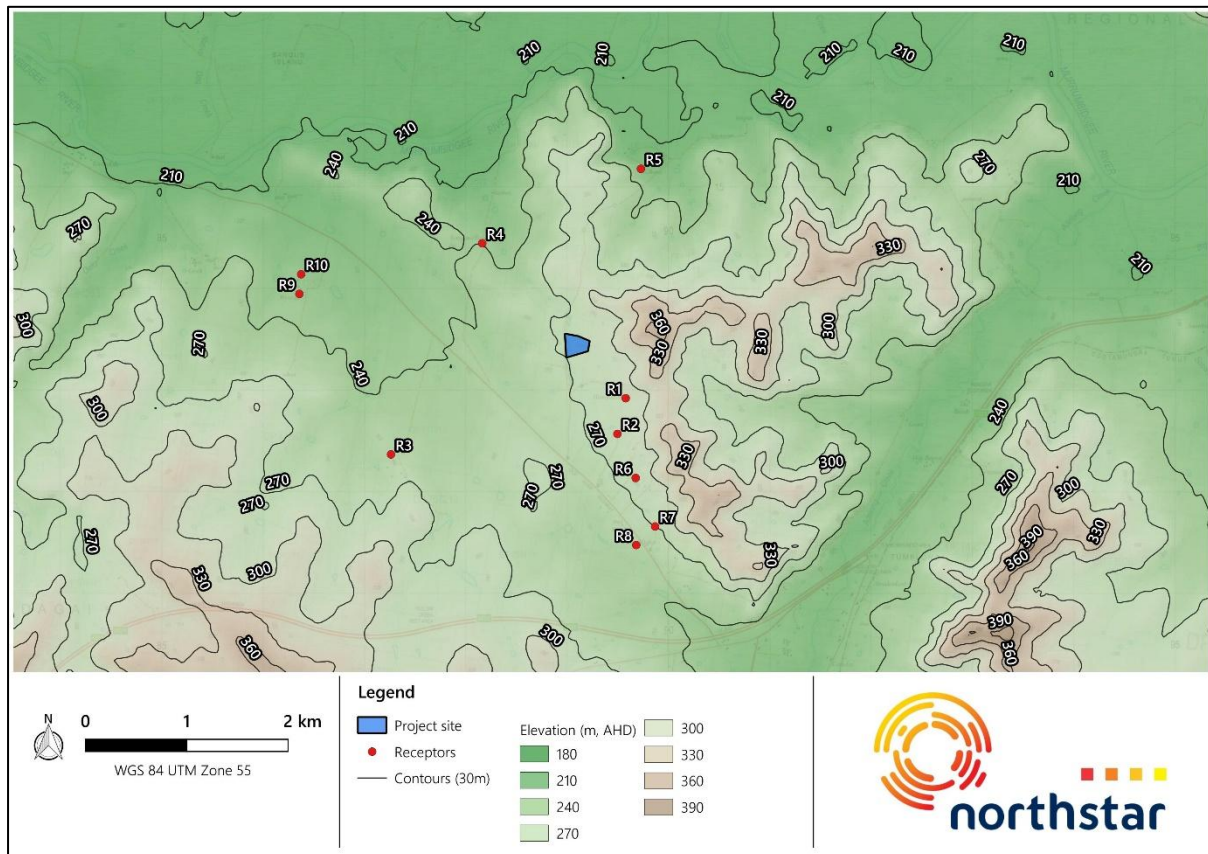
4.5. Topography

The elevation of the Project site is approximately 280 m Australian Height Datum (AHD). To the east of the Project site is a ridge line running from the northwest to the southeast rising to approximately 360 m AHD within 600 m of the Project site.

The topography between the Project site and the nearest identified sensitive receptor locations is relatively consistent with elevation variances across the Project. Nonetheless, the influence of topography has been included in the dispersion modelling assessment as described in Section 5.1.

The topography surrounding the Project site is presented in Figure 5.

Figure 5 Topography surrounding the Project site



Source: Northstar

4.6. Potential Cumulative Air Quality Impacts

The background air quality dataset, as described in Section 4.4 is likely to include the impact of regional sources of air pollutants (e.g. bushfires, dust storms), and sources which are local to the AQMS (e.g. commercial / industrial operations, and transport emissions). Given the separation distance between that AQMS and the Project site (approximately 56.3 km), that data may not adequately include the impacts of sources of air pollutants which are in closer proximity to the Project site. These sources may include existing, approved (but not yet operational), and proposed developments that could contribute to cumulative impacts at identified sensitive receptors.

A desktop survey has been conducted to identify nearby sources with similar emissions profiles that could contribute to cumulative impacts at sensitive receptors. The survey included a review of the National Pollutant Inventory (NPI), NSW EPL, and NSW Government Major Projects registers to identify existing, recently approved, and proposed developments in proximity to the Project site.

The desktop review identified no facilities proximate to the Project site that may result in cumulative impacts with the Project and the inclusion of background air quality data as described in Section 4.4 would appropriately account for any potential cumulative impacts associated with surrounding land uses.

5. APPROACH TO ASSESSMENT

The AQIA adopts a quantitative approach to assessment, intended to be consistent with that presented in (NSW EPA, 2022a) to evaluate the potential air quality impacts during operations.

5.1. Dispersion Modelling

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 meteorological dataset has been developed using The Air Pollution Model (TAPM, v 4.0.5) and CALMET (refer to Appendix B for further information).

An assessment of the impacts of the operation of activities at the Project has been performed which characterises the likely day-to-day operation of the Project, approximating average operational characteristics which are appropriate to assess against longer term (annual average) criteria for particulate matter. The likely peak activities at the Project have also been characterised to allow comparison of potential impacts against shorter term (24-hour) criteria for particulate matter.

The modelling scenario provides an indication of the air quality impacts of the operation of activities at the Project site. Added to these impacts are background air quality concentrations (where available and discussed in Section 4.4 and Appendix C) which represent the air quality which may be expected within the area surrounding the Project site, without the impacts of the Project itself.

The following provides a description of the determination of appropriate emissions of air pollutants resulting from the operation of the Project.

5.2. Emissions Estimation

5.2.1. Particulate Matter

The estimation of emissions from a process is typically performed using direct measurement or through the application of factors which appropriately represent the processes under assessment. This assessment has adopted emission factors for materials handling process, movement of trucks on paved and unpaved site roads and wind erosion contained within the US EPA AP-42 emission factor compendium (US EPA, 1995 and updates) to represent the emission of particulate matter resulting from the operations occurring at the Project site as described in Section 2.2. These factors are appropriate for adoption in Australia and are routinely adopted in the assessment of operations of this nature.

A detailed emission inventory is shown in Appendix D.

5.2.2. Odour

It is noted that odour emissions from the non-putrescible waste material being deposited at the Project site are not likely to be significant. Measurement of odour generated by waste materials can often be limited to more odorous materials and therefore, emission factors adopted to support this AQIA present putrescible waste sources, which would significantly over-estimate the predicted odour impacts. The predicted odour impacts associated with waste materials being deposited as part of the Project should be viewed in terms of compliance, rather than seeking to represent the likely odour environment surrounding the Project site.

5.2.2.1. Odour Emission Factors

Emission factors adopted within this AQIA have been adopted from site specific source sampling performed to support the Melbourne Regional Landfill (MRL) Air Quality Assessment (PEL, 2016). As previously discussed, the odour emission rates adopted are associated with putrescible waste operations and therefore represent a relatively conservative approximation of likely odour emissions resulting from Proposal operation.

Measured odour emission rates at the MRL active tip face were $3.3 \text{ OU}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ with odour on interim covered waste at the MRL measured to be $0.16 \text{ OU}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$.

Odour resulting from storage of leachate has been calculated using odour emission rates measured at the leachate dam within the Woodlawn Bioreactor facility at Tarago, NSW. The odour concentration and specific odour emission rate associated with leachate storage at that facility was 724 OU and $0.459 \text{ OU}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ respectively (TOU, 2012)). Once again, the leachate generated at the Woodlawn site is associated with putrescible waste, and the leachate collected as part of the Proposal is likely to be significantly less odorous.

5.2.2.2. Calculation of Peak Concentrations

The Approved Methods (NSW EPA, 2022a) states that peak-to-mean ratios should be incorporated when conducting atmospheric dispersion modelling of odour. 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 concentrations, this assessment has adopted factors presented in Table 6.1 of the Approved Methods.

Specifically:

- to establish a conservatively high estimate of peak odour concentrations from an area source, the peak to mean ratio (P/M60) of 2.5 has been adopted in stability classes A to F (i.e. all stability classes).
- to establish a conservatively high estimate of peak odour concentrations from a point source (ie OCUs), the peak to mean ratio (P/M60) of 12 (stability classes A, B, C) and 25 stability classes D, E, F) has been adopted (for surface wake-free point sources).

5.2.2.3. Odour Activity Data

The area of the landfill assumed to be present as active tip face would be a maximum area of 600 m². The remainder of both Cell 1 and Cell 2 is assumed to be under interim cover (35 300 m² – 600 m² = 34 700 m²). The area of a full leachate storage area is assumed to be 2 436 m², in addition to a temporary leachate storage area of approximately 9,100 m². These areas represent the landfill operating at maximum capacity.

Based on the odour emission rates adopted and the areas of each odour source, Table 7 presents the odour emissions for area sources adopted to represent the placement and storage of waste at the Project site.

Table 7 Odour emissions for area sources

Source name	Area (m ²)	Specific odour emission rate (OU·m ⁻² ·s ⁻¹)	Peak to mean factor	Modelled odour emission rate (OU·s ⁻¹)
Active tip face	600	3.3	2.5	4 950
Interim cover	34 700	0.16		13 880
Leachate storage	2 436	0.459		2 795
Temporary Leachate Storage	9 100	0.459		9 869

In addition, the odour emission rates and the source parameters for the two OCUs are shown in Table 8.

Table 8 Odour emissions for point sources (OCU)

Parameter	Value	Units
Height	1.23 ¹	m
Flowrate	0.12 ¹	m ³ /s
Diameter	0.15 ¹	m
Exit velocity	6.8 ^{1,2}	m/s
Exit temperature	298	K
Odour concentration	724 ³	OU
Treatment efficiency	99.9 ¹	%
Odour emission rate	0.087	OU.m ³ /s

¹ Source: McBerns 2025

² Note: As the exhaust point on the OCU has a rain cap installed, the Vertical Momentum Flux is switched on in the dispersion model setup.

³ Source: (TOU, 2012)

5.3. Emissions Controls

A number of emissions controls would be adopted during the Project operations, to mitigate emissions of particulate matter and odour.

5.3.1. Particulate Matter

Emissions of particulate matter would be controlled during operations through:

- The road between the Project site and Old Hume Highway being paved, with the emission reduction calculated through the emission factor adopted (refer Appendix D);
- Minimisation of drop heights when placing waste and daily cover resulting in emissions reductions of 30 %;
- Pit retention with emission reduction calculated depending on pollutant (refer Appendix D); and
- Level 1 watering on unpaved roads onsite resulting in emission reductions of 50 %.

5.3.2. Odour

As previously described, odour emissions resulting from the placement and storage of non-putrescible waste materials are likely to be minor. Emissions will be managed through the adoption of industry best practice as outlined in the NSW Landfill Guidelines (NSW EPA, 2016), including (in no order):

- Restriction of the active tip face to 600 m²;
- Placement of daily cover on the active tip face at a depth of 150 mm at the close of business each day;
- The use of intermediate cover on areas awaiting final capping.
- Aeration and H₂O₂ dosing for the permanent leachate storage dam. Based on a technical study published in the Water Science & Technology journal (Charron, et al., 2004), H₂O₂ dosing by wet scrubbing is capable of a H₂S reduction of 98 %. It is acknowledged that the H₂O₂ dosing process at the Project Site is less efficient than scrubbing and will not achieve that control efficiency alone. On site, the H₂O₂-dosed leachate is also subjected to mechanical aeration. In the absence of site-specific data, H₂O₂ dosing and mechanical aeration is assumed to achieve 98 % odour control efficiency which is considered to be reasonable.
- Treatment of odour emissions collected from temporary leachate storage dam by two OCUs. As mentioned in Section 2.3.3.3, based on manufacturer's specification, the OCU is likely to achieve 99.9 % reduction in odorous gases (McBerns 2025).

To be conservative, the odour emissions are represented by continuously emitting sources (i.e. 24/7) in the dispersion modelling setup.

6. AIR QUALITY IMPACT ASSESSMENT

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

- **Incremental impact** – relates to the concentrations predicted due to the operation of the Project in isolation; and
- **Cumulative impact** – relates to the incremental concentrations predicted due to the operation of the Project PLUS background air quality concentrations discussed in Section 4.4.

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

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
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6.1. Particulate Matter

6.1.1. Annual Average TSP, PM₁₀ and PM_{2.5}

The predicted annual average particulate matter concentrations (as TSP, PM₁₀ and PM_{2.5}) resulting from the operations at the Project are presented in Table 9.

The results show that compliance with the relevant annual average TSP, PM₁₀ and PM_{2.5} criteria is achieved at all sensitive receptor locations.

Table 9 Predicted annual average TSP, PM₁₀ and PM_{2.5} concentrations

Receptor	Annual average concentration (µg·m ⁻³)								
	TSP			PM ₁₀			PM _{2.5}		
	Incr.	Bkg.	Cumul.	Incr.	Bkg.	Cumul.	Incr.	Bkg.	Cumul.
Criterion	90			25			8		
Max. % of criterion	0.6	43.7	44.3	1.1	70.8	71.9	0.0	78.8	79.4
R1	0.6	39.3	39.9	0.3	17.7	18.0	<0.1	6.3	6.4
R2	0.5	39.3	39.8	0.2	17.7	17.9	<0.1	6.3	6.4
R3	<0.1	39.3	39.4	<0.1	17.7	17.8	<0.1	6.3	6.4
R4	<0.1	39.3	39.4	<0.1	17.7	17.8	<0.1	6.3	6.4
R5	<0.1	39.3	39.4	<0.1	17.7	17.8	<0.1	6.3	6.4
R6	0.2	39.3	39.5	0.1	17.7	17.8	<0.1	6.3	6.4
R7	<0.1	39.3	39.4	<0.1	17.7	17.8	<0.1	6.3	6.4

Receptor	Annual average concentration ($\mu\text{g}\cdot\text{m}^{-3}$)								
	TSP			PM ₁₀			PM _{2.5}		
	Incr.	Bkg.	Cumul.	Incr.	Bkg.	Cumul.	Incr.	Bkg.	Cumul.
R8	<0.1	39.3	39.4	<0.1	17.7	17.8	<0.1	6.3	6.4
R9	<0.1	39.3	39.4	<0.1	17.7	17.8	<0.1	6.3	6.4
R10	<0.1	39.3	39.4	<0.1	17.7	17.8	<0.1	6.3	6.4

Note: Incr = Incremental impact, Bkg = Background, Cumul = Cumulative Impact

6.1.2. Annual Average Dust Deposition Rates

The predicted annual average dust deposition rates resulting from the operations at the Project are presented in Table 10.

The results show that compliance with the relevant annual average dust deposition criteria is achieved at all sensitive receptor locations.

Table 10 Predicted annual average dust deposition rates

Receptor	Annual average dust deposition ($\text{g}\cdot\text{m}^{-2}\cdot\text{month}^{-1}$)		
	Incremental impact	Background	Cumulative impact
Criterion	2.0	-	4.0
Max. % of criterion	<5%	-	<2.5%
R1	<0.1	2.0	<2.1
R2	<0.1	2.0	<2.1
R3	<0.1	2.0	<2.1
R4	<0.1	2.0	<2.1
R5	<0.1	2.0	<2.1
R6	<0.1	2.0	<2.1
R7	<0.1	2.0	<2.1
R8	<0.1	2.0	<2.1
R9	<0.1	2.0	<2.1
R10	<0.1	2.0	<2.1

6.1.3. Maximum 24-hour Average PM₁₀ and PM_{2.5}

Table 11 presents the maximum 24-hour average PM₁₀ and PM_{2.5} concentrations predicted to occur at the nearest sensitive receptors as a result of the operations at the Project. No background concentrations are included within this table.

It is noted that the concentrations summarised in Table 11 are demonstration to be minor, with the highest incremental 24-hour PM₁₀ and PM_{2.5} impacts predicted at receptor R1.

Table 11 Predicted maximum incremental 24-hour PM₁₀ and PM_{2.5} concentrations

Receptor	Maximum 24-hour average concentration (µg·m ⁻³)	
	PM ₁₀	PM _{2.5}
Criterion	50	25
Max. % of criterion	3.6	1.6
R1	1.8	0.4
R2	1.6	0.4
R3	0.6	0.1
R4	0.5	0.1
R5	0.3	<0.1
R6	1.1	0.3
R7	0.6	0.1
R8	0.6	0.1
R9	0.3	<0.1
R10	0.3	<0.1

A contemporaneous analysis of the 24-hour PM₁₀ and PM_{2.5} data has been performed where each predicted incremental concentration is added to the corresponding measured background concentration, in accordance with Section 11.2.3(b) of the Approved Methods (NSW EPA, 2022a)

Table 12 and Table 13 present the predicted maximum 24-hour average PM₁₀ and PM_{2.5} concentrations resulting from the operation of the Project, with the corresponding background included for each day.

Results are presented for the receptor at which the highest incremental PM₁₀ and PM_{2.5} impacts have been predicted, and for the receptors at which the highest cumulative impacts (incremental plus background) have been predicted. These may be different receptors than those at which the highest incremental impacts are predicted.

The left-hand side of Table 12 and Table 13 indicates that the predicted concentration on days with the highest cumulative impact (typically driven by the highest background concentrations), and the right side of the respective tables shows the total predicted concentration on days with the highest predicted incremental concentrations with the contemporaneous background values to derive the respective cumulative predictions.

For PM₁₀, the maximum cumulative impact (left-hand side of Table 12) and the maximum incremental impact (the right-hand side of Table 12) is predicted at receptor R1.

For PM_{2.5}, the maximum cumulative impact (the left-hand side of Table 13) and the maximum incremental impact (the right-hand side of Table 13) is predicted at receptor R1. Predicted impacts are lower at all other locations.

Table 12 and Table 13 show that exceedances associated with the highest cumulative impacts are driven by already elevated background air quality concentrations rather than incremental impacts from the Project. It

is noted that these exceedances occurred on days associated with hazard reduction burning activities, noted to be exceptional events (refer Section 4.4). A contour plot of the maximum incremental 24-hour average PM₁₀ and PM_{2.5} concentrations resulting from the operation of the Project is presented in Figure 6 and Figure 7 respectively.

Table 12 Summary of contemporaneous impact and background – PM₁₀ concentrations

Date	24-hour average PM ₁₀ concentration ($\mu\text{g}\cdot\text{m}^{-3}$) – Receptor R1			Date	24-hour average PM ₁₀ concentration ($\mu\text{g}\cdot\text{m}^{-3}$) – Receptor R1		
	Incr.	Bkg.	Cumul.		Incr.	Bkg.	Cumul.
30/04/2022	<0.1	69.1	69.2	3/07/2022	1.8	6.9	8.7
18/04/2022	0.3	62.9	63.2	14/06/2022	1.7	14.1	15.8
29/04/2022	0.3	62.6	62.9	31/05/2022	1.5	20.6	22.1
27/04/2022	0.3	59.3	59.6	4/07/2022	1.4	6.3	7.7
28/04/2022	0.2	59.3	59.5	10/05/2022	1.3	22.6	23.9
24/01/2022	0.2	53.6	53.8	11/05/2022	1.2	7.3	8.5
23/01/2022	0.2	51.0	51.2	20/06/2022	1.2	14.4	15.6
15/01/2022	0.1	49.4	49.5	29/05/2022	1.1	25.3	26.4
1/05/2022	<0.1	49.4	49.5	11/06/2022	1.1	7.6	8.7
8/03/2022	0.3	47.6	47.9	8/06/2022	1.1	8.2	9.3
These data represent the highest Cumulative Impact 24-hour PM ₁₀ predictions (outlined in red) as a result of the operation of the Project				These data represent the highest Incremental Impact 24-hour PM ₁₀ predictions (outlined in blue) as a result of the operation of the Project.			

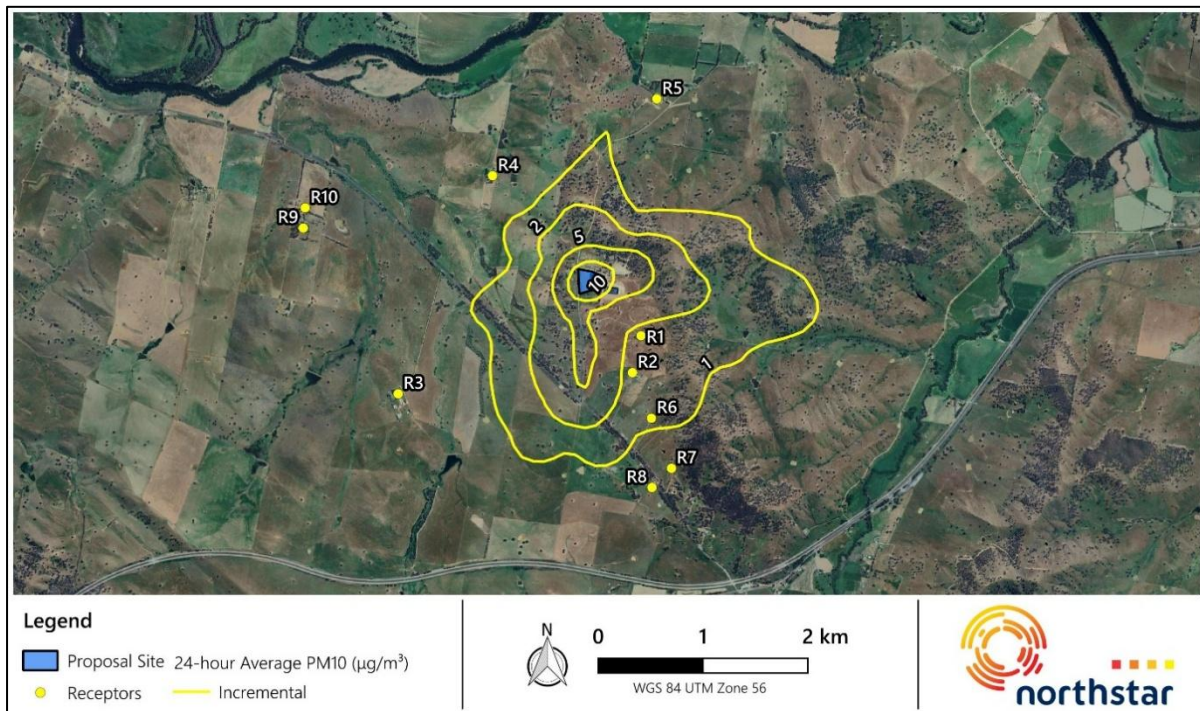
Note: Incr = Incremental impact, Bkg = Background, Cumul = Cumulative Impact

Table 13 Summary of contemporaneous impact and background – PM_{2.5} concentrations

Date	24-hour average PM _{2.5} concentration ($\mu\text{g}\cdot\text{m}^{-3}$) – Receptor R1			Date	24-hour average PM _{2.5} concentration ($\mu\text{g}\cdot\text{m}^{-3}$) – Receptor R1		
	Incr.	Bkg.	Cumul.		Incr.	Bkg.	Cumul.
21/05/2022	<0.1	25.4	25.5	14/06/2022	0.4	13.4	13.8
23/05/2022	<0.1	22.8	22.9	3/07/2022	0.3	5.3	5.6
18/04/2022	<0.1	22.3	22.4	31/05/2022	0.3	16.1	16.4
29/05/2022	0.3	19.2	19.5	11/05/2022	0.3	4.0	4.3
19/04/2022	<0.1	19.1	19.2	20/06/2022	0.3	15.5	15.8
11/07/2022	<0.1	18.9	19.0	22/05/2022	0.3	16.5	16.8
20/05/2022	0.2	18.4	18.6	29/05/2022	0.3	19.2	19.5
10/07/2022	0.2	17.7	17.9	4/07/2022	0.3	4.0	4.3
30/05/2022	0.2	17.2	17.4	10/07/2022	0.2	17.7	17.9
19/05/2022	0.2	17.0	17.2	30/05/2022	0.2	17.2	17.4
These data represent the highest Cumulative Impact 24-hour PM _{2.5} predictions (outlined in red) as a result of the operation of the Project.				These data represent the highest Incremental Impact 24-hour PM _{2.5} predictions (outlined in blue) as a result of the operation of the Project.			

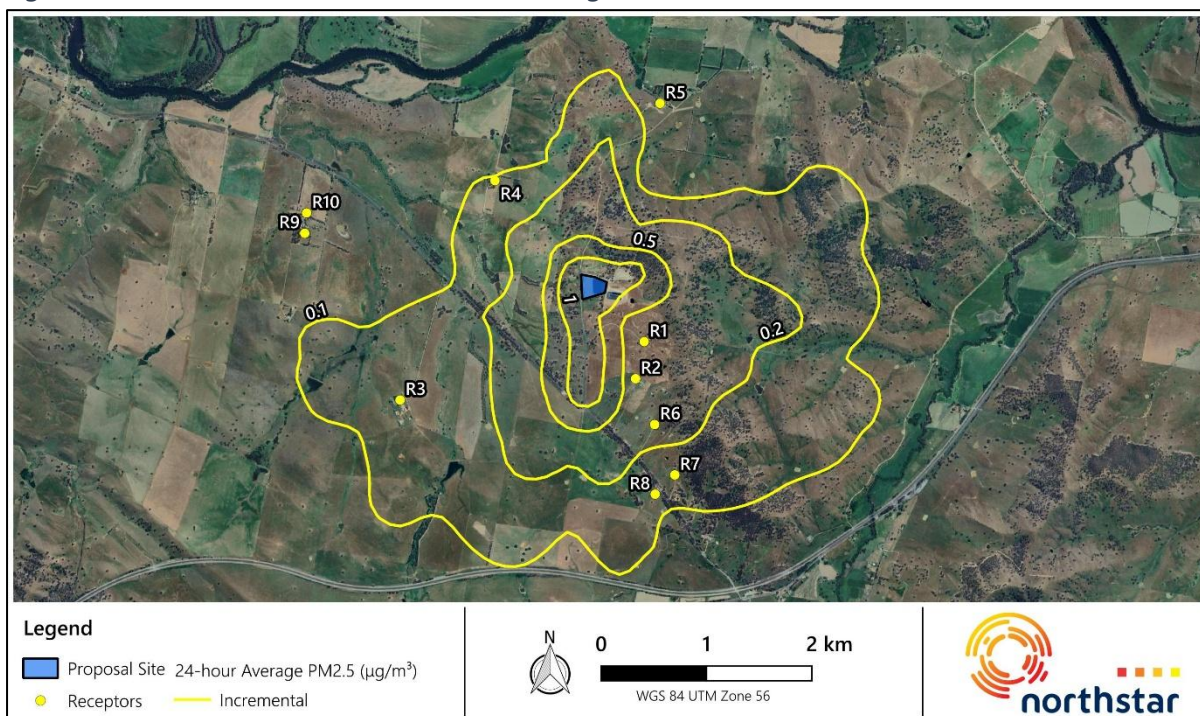
Note: Incr = Incremental impact, Bkg = Background, Cumul = Cumulative Impact

Figure 6 Maximum incremental 24-hour average PM₁₀ concentrations



Source: Northstar

Figure 7 Maximum incremental 24-hour average PM_{2.5} concentrations



Source: Northstar

6.2. Odour

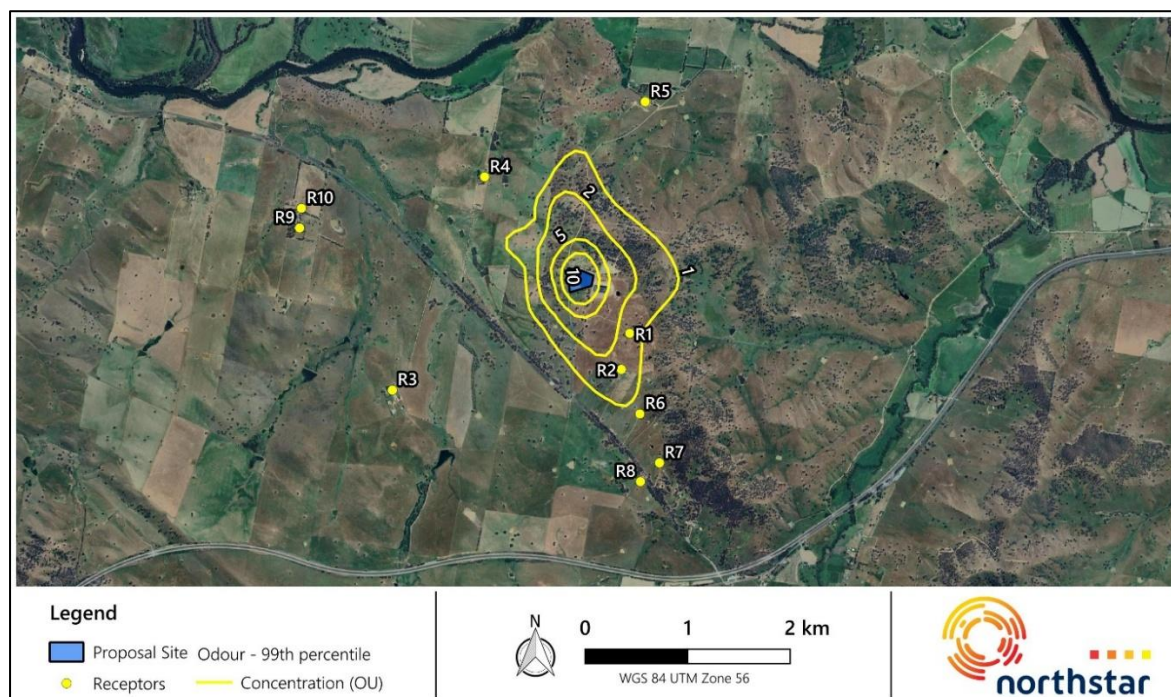
Presented in Table 14 are the maximum nose response time average odour concentrations predicted to occur at the nearest sensitive receptors as a result of the operation of Project. Odour concentrations at all receptor locations are predicted to be less than the odour criterion of 6 OU.

Figure 8 presents the spatial distribution of predicted odour impacts resulting from the operation of the Project.

Table 14 Predicted 99th percentile nose response time odour concentrations

Parameter	Predicted 99 th percentile 1-hour average (1-second nose response time) odour concentration (OU)
Criterion	6.0
R1	1.4
R2	1.5
R3	0.2
R4	0.3
R5	0.1
R6	0.9
R7	0.5
R8	0.3
R9	0.2
R10	0.2

Figure 8 Predicted 99th percentile odour concentration



Source: Northstar

7. DISCUSSION AND CONCLUSION

Northstar was engaged by Habitat Planning on behalf of MHE to perform an AQIA to support a DA modification, for the proposed increase in waste disposal.

The assessment quantifies the potential air quality impacts during the operational phase and identifies mitigation and monitoring requirements commensurate with those anticipated risks and impacts to ensure that air quality objectives are achieved at all surrounding sensitive receptor locations.

7.1. Assessment of H₂S Impacts

The odour monitoring data utilised in this AQIA include a contribution of H₂S, but will also include smaller volume fractions of other odorants, such as carbon disulphide (CS₂) and other reduced sulphur compounds. The assessment has been compared to the complex mixtures odour impact assessment criterion which is therefore more encompassing than H₂S as a discrete odorant.

As noted in Section 3.3.2, the Approved Methods stipulates separate criteria for individual and complex mixtures of odorous air pollutants. Although, the criterion for complex mixtures is adopted for this assessment, additional discussion is provided to provide context and relationship between monitored H₂S concentrations and the respective criterion (i.e. individual H₂S criterion).

The odour criterion adopted for this assessment is 6 OU, and the corresponding individual H₂S criterion is shown in Table 15.

Table 15 NSW EPA Technical Framework odour and H₂S criteria

Population of affected community	Complex Mixture (OU)	H ₂ S (µg·m ⁻³)	H ₂ S as percentage of complex mixtures
Urban area (≥2 000)	2.0	1.38	69%
500 – 2 000	3.0	2.07	69%
125 – 500	4.0	2.76	69%
30 – 125	5.0	3.45	69%
10 – 30	6.0	4.14	69%
Single residence (≤2)	7.0	4.83	69%

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

It is noted that the Project AQMP recommends onsite concurrent monitoring of odour and H₂S for the Project site. The Project is likely to comply with the individual H₂S criterion if the monitored concentration of H₂S is within 69% of monitored odour concentrations.

7.2. Summary of Predicted Air Quality Impacts

The results of the dispersion modelling assessment (refer Section 6) indicate that no additional exceedances of the relevant particulate matter and odour criteria are predicted to occur resulting from the operation of the Project at any identified sensitive receptor.

A range of conservative assumptions have been adopted in the calculation of air emissions, with the aim of providing a worst-case assessment. Even adopting those conservative assumptions, annual average TSP, PM₁₀ and PM_{2.5} concentrations are all predicted to be achieved at surrounding receptor locations, even with the addition of existing background concentrations. Annual average monthly dust deposition rates are predicted to be below the relevant criteria, both as an incremental and cumulative impact.

Incremental 24-hour maximum PM₁₀ and PM_{2.5} concentrations are predicted to be minor at all surrounding receptor locations, and cumulative 24-hour maximum PM₁₀ and PM_{2.5} concentrations only exceed on days with already exceeding background air quality concentrations associated with hazard reduction burns (refer Section 6.1.3).

Impacts associated with odour are predicted to be less than the most stringent odour criterion at the nearest sensitive receptors, even adopting worst case assumptions.

7.3. Recommended Air Quality and odour Management

7.3.1. Recommended Controls

The mitigation measures to be employed as part of the Project are outlined in Section 5.3.1 and reproduced below.

During operation, particulate matter emissions would be controlled by:

- Minimisation of drop heights when placing waste and daily cover; and,
- The limiting of vehicle speeds across the site, and on the paved road between the Old Hume Highway and the Project site.

Odour emissions resulting from the placement and storage of non-putrescible waste materials are likely to be minor. Emissions will be managed through the adoption of industry best practice as outlined in the NSW Landfill Guidelines (NSW EPA, 2016), including:

- Restriction of the active tip face to 600 m²;
- Placement of daily cover on the active tip face at a depth of 150 mm at the close of business each day; and,
- The use of intermediate cover on areas awaiting final capping.

- Aeration and H₂O₂ dosing for the permanent leachate storage dam.
- Treatment of odour emissions collected from temporary leachate storage dam by two OCUs.

The odour mitigation measures recommended here are consistent with those listed in the Leachate Management Plan prepared by InSitu (InSitu Advisory, July 2025).

It is demonstrated within this AQIA that the measures above will be sufficient to ensure that no exceedances of the adopted air quality and odour criteria would be experienced during the performance of activities at the Project site.

The implementation of the mitigation measures outlined above would be managed through an Air Quality Management Plan (AQMP). The AQMP would detail the management procedures to be employed at the Project site, and how these measures would be reviewed and audited.

7.3.2. Recommended Monitoring

Based on conditions in the EPL 21440 and the AQMP for the Project site, the following monitoring measures are recommended for the Project site:

- Odour monitoring using flux hood for the odour generating sources (ie leachate pond, active cell, intermediate covered cell and capped cell);
- H₂S monitoring using an appropriate hand-held H₂S monitor to establish the empirical relationship between H₂S and odour generation rates;
- Dust monitoring using dust deposition gauges at the specified locations within the EPL and AQMP.

In addition, it is recommended that the operator performs daily, ad-hoc air quality and odour observational monitoring. In the event that visual dust plumes and/or odour is observed at or beyond the site boundary it is recommended that additional controls are promptly implemented to reduce emissions appropriately.

7.3.3. Recommended Complaint Management System

A complaints register would be maintained at the Project site to record any complaints relating to air quality (and odour). These records would be made available to NSW EPA and DPHI upon request.

7.4. Conclusions

This AQIA has been based on a range of worst-case assumptions and conservative input data. Even adopting those assumptions, potential air quality and odour impacts are predicted to meet all relevant criteria. Impacts during modified operation would be anticipated to be less than those predicted within this assessment, and it is respectfully suggested that approval for the modification should not be refused based on air quality issues.

8. REFERENCES

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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	Prefix	Symbol	Factor
T	tera-	10^{12}	p	pico-	10^{-12}
G	giga-	10^9	n	nano-	10^{-9}
M	mega-	10^6	μ	micro-	10^{-6}
k	kilo-	10^3	m	milli-	10^{-3}
h	hector-	10^2	c	centi-	10^{-2}
da	deca-	10^1	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 $50 \mu\text{g}\cdot\text{m}^{-3}$ and not $50 \mu\text{g}/\text{m}^3$; and,

0.2 kilograms per hectare per hour would be presented as $0.2 \text{ kg}\cdot\text{ha}^{-1}\cdot\text{hr}^{-1}$ and not 0.2 kg/ha/hr .

Commonly used SI-derived and non-SI units

$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	gram per square metre per second	rate of mass deposition per unit area
$\text{g}\cdot\text{s}^{-1}$	gram per second	rate of mass emission
$\text{kg}\cdot\text{ha}^{-1}\cdot\text{hr}^{-1}$	kilogram per hectare per hour	rate of mass deposition per unit area
$\text{kg}\cdot\text{m}^{-3}$	kilogram per cubic metre	density
$\text{L}\cdot\text{s}^{-1}$	litres per second	volumetric rate
m^2	square metre	area
m^3	cubic metre	volume
$\text{m}\cdot\text{s}^{-1}$	metre per second	speed and velocity
$\text{mg}\cdot\text{m}^{-3}$	milligram per cubic metre	mass concentration per unit volume
$\text{mg}\cdot\text{Nm}^{-3}$	milligram per normalised cubic metre (of air)	mass concentration per unit volume
$\mu\text{g}\cdot\text{m}^{-3}$	microgram per cubic metre	mass concentration per unit volume
$\text{mg}\cdot\text{m}^{-3}$	milligram per cubic metre	mass concentration per unit volume
Pa	pascal	pressure
ppb	parts per billion (1×10^{-9})	volumetric concentration
pphm	parts per hundred million (1×10^{-5})	volumetric concentration
ppm	parts per million (1×10^{-6})	volumetric concentration

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
CSIRO	Commonwealth Scientific and Industrial Research Organisation

Abbreviation	Term
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·m ³ ·s ⁻¹	odour units times metres cubed per second
OU·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
TAS	Tasmania

Abbreviation	Term
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

As discussed in Section 4.3, a meteorological modelling exercise has been performed to characterise the meteorology of the Project site in the absence of site-specific measurements. The meteorological monitoring has been based on measurements acquired from surrounding automatic weather stations (AWS) operated by the Australian Government Bureau of Meteorology (BoM).

A summary of the relevant monitoring sites is provided in Table B1.

Table B1 Details of the meteorological monitoring surrounding the Project site

Site name	Station #	Source	Approximate location		Approximate distance (km)
			mE	mS	
Gundagai (Nangus Rd)	073141	BoM	600 173	6 119 308	12.4
Wagga Wagga AMO	072150	BoM	541 667	6 109 306	47.6

As outlined in Section 4.3, meteorological conditions at Wagga Wagga AMO AWS (Wagga 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 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 B2. The correlation coefficients were ranked and aggregated to select the representative year for the meteorological modelling. The rankings are also presented in Table B2.

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

The majority of wind speeds experienced at the Wagga AWS between 2020 and 2024 are generally in the range 1.5 metres per second ($m \cdot s^{-1}$) to $5.5 m \cdot s^{-1}$ with the highest wind speeds (greater than $8 m \cdot s^{-1}$) occurring from north-easterly and south-westerly directions. Winds of this speed are rare and occur during 2.8 % of the observed hours during the years while calm winds (less than $0.5 m \cdot s^{-1}$) are more common and occur during 6.3 % of hours on average across the years between 2020 and 2024.

Figure B1 Annual wind roses –Wagga Wagga AMO AWS (2020 – 2024)

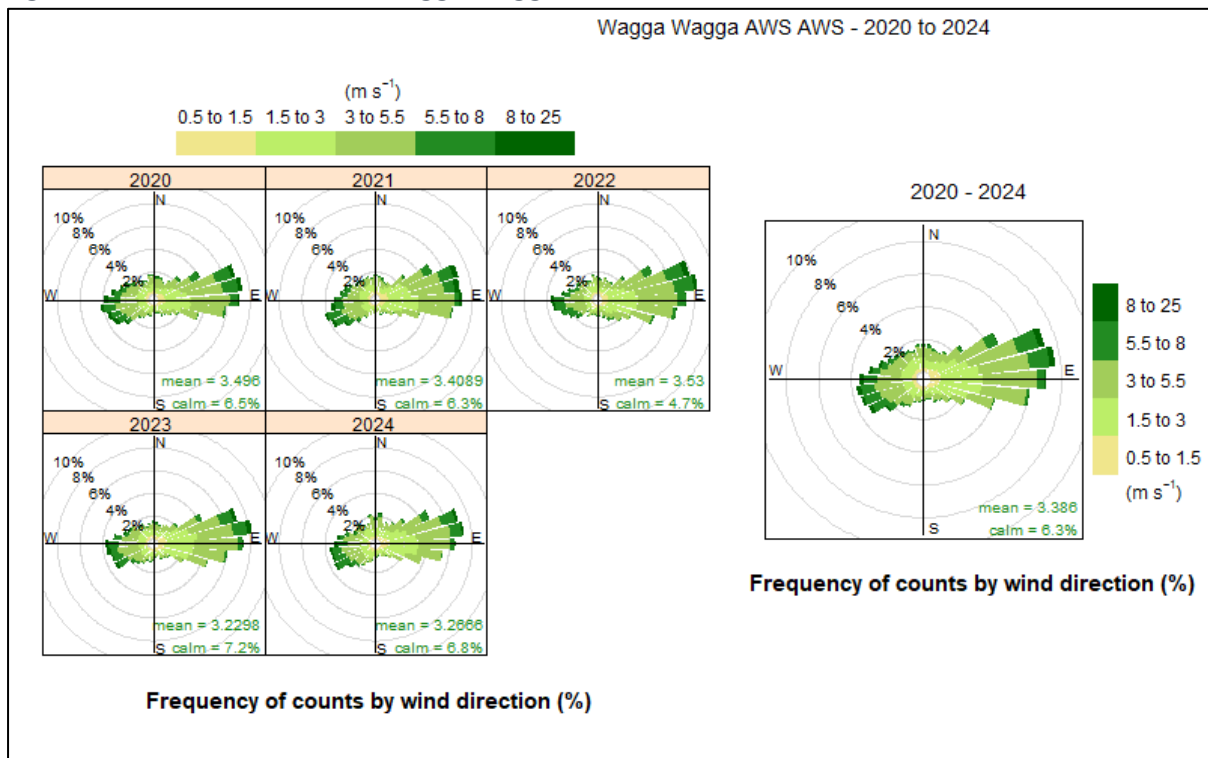


Figure B2 Annual wind speed and direction distributions – Wagga Wagga AMO AWS (2020 – 2024)

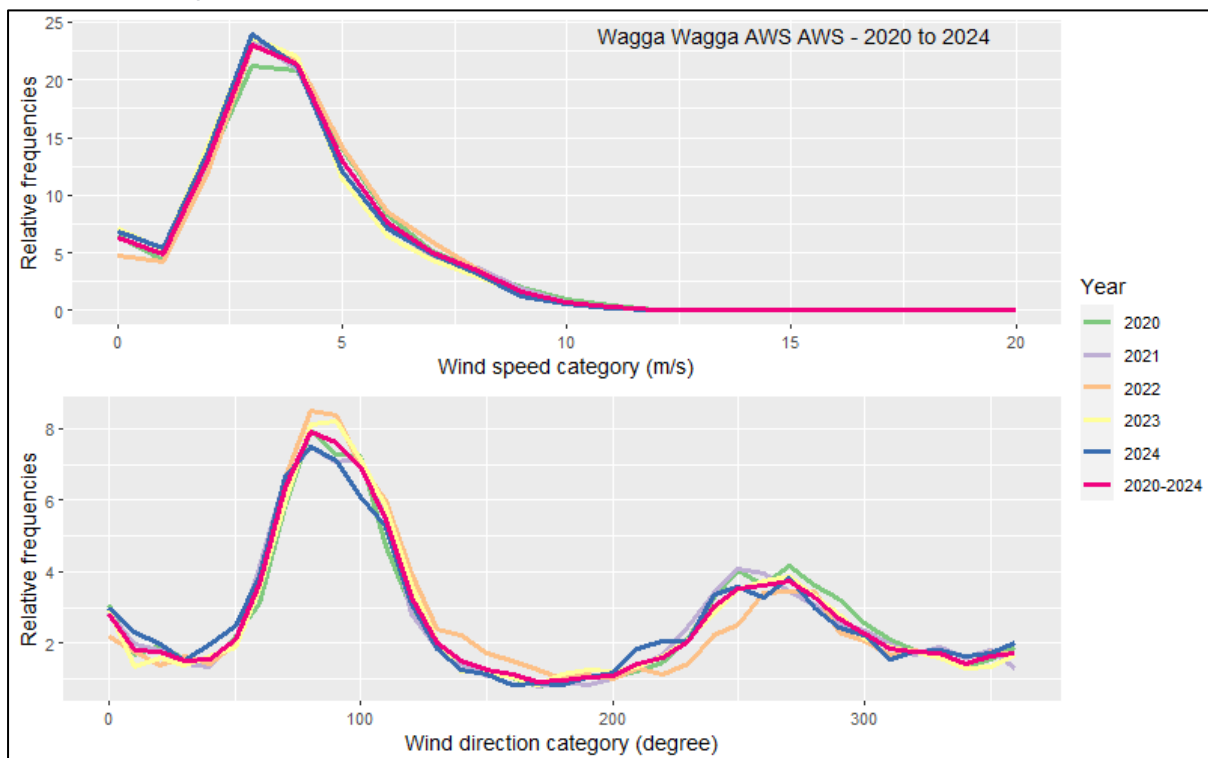


Table B2 Correlation coefficient analysis – Wagga Wagga AMO AWS and Wagga Wagga North AQMS (2020 –2024)

Parameter	Wind speed		Wind direction		PM ₁₀		PM _{2.5}		Aggregated rank
	Corr.	Rank	Corr.	Rank	Corr.	Rank	Corr.	Rank	
2020	0.9975	3	0.9890	3	0.9863	3	0.9927	2	3
2021	0.9996	1	0.9901	2	0.9921	1	0.9972	1	1
2022	0.9964	5	0.9807	5	0.9468	4	0.9578	4	5
2023	0.9968	4	0.9952	1	0.9914	2	0.9880	3	2
2024	0.9986	2	0.9886	4	0.9339	5	0.9572	5	4
2020-2024	1	-	1	-	1	-	1	-	-

Note: Corr. = correlation

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 2021 is the highest ranked for correlation against the wind speed over the five-year period.

Wind direction observations for each year are reasonably well correlated against the wind direction over the five-year period, with each year having a correlation coefficient greater than of 0.98. The year 2023 is the highest ranked for correlation against the wind direction over the five-year period.

PM concentrations for each year are also well correlated against PM concentrations over the five-year period. Each year resulted in having a correlation coefficient greater than 0.94. The year 2021 is the highest rank for PM₁₀ and for PM_{2.5}.

The correlation coefficient analysis indicates that 2021 is the most appropriate representative year for meteorological modelling. Correspondingly, 2021 has been adopted for use for meteorological modelling.

Meteorological Processing

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

In absence of any measured onsite meteorological data, site representative meteorological data for this Project was generated using the CALMET meteorological model in a format suitable for using in the CALPUFF dispersion model (refer Section 5.1).

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.

For this AQIA, 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). The TAPM model is cited in 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) as a suitable prognostic meteorological model for applications involving complex meteorological conditions.

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.

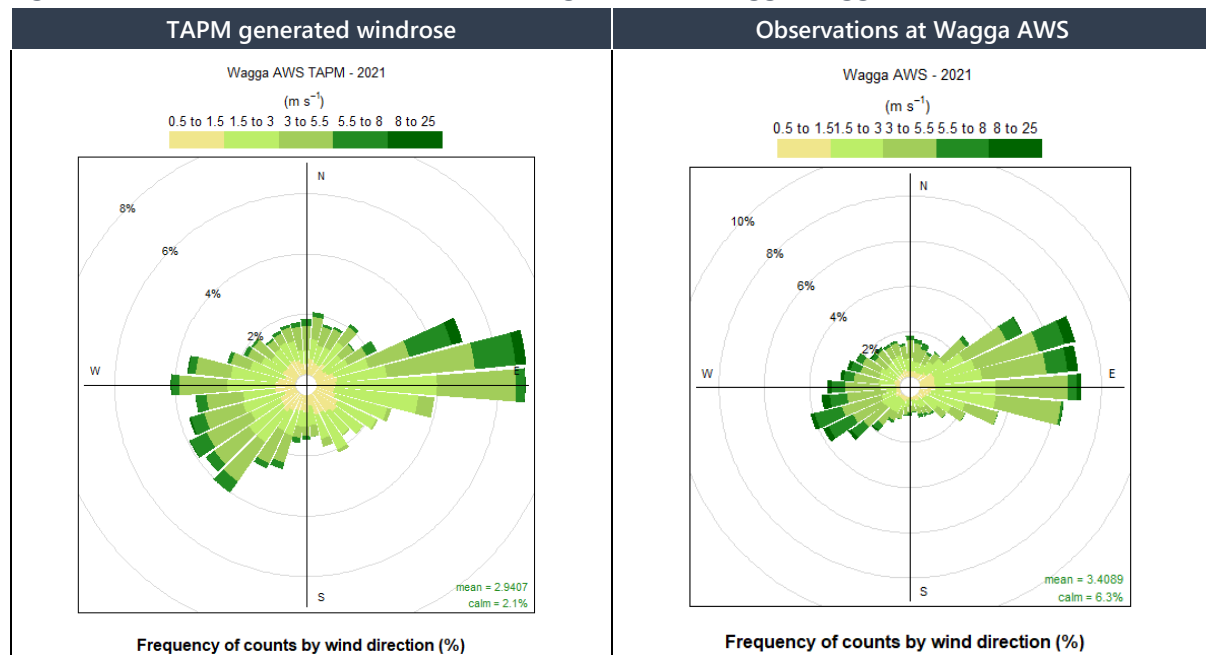
The parameters used in TAPM and CALMET modelling are presented in Table B3.

Table B3 TAPM and CALMET meteorological parameters

TAPM v 4.0.5	
Modelling period	1 January 2021 to 31 December 2021
Centre of analysis	565 300 mE, 6 112 860 mS (UTM Coordinates)
Number of grid points	60 × 60 × 25
Number of grids (spacing)	4 (25 km, 10 km, 3 km, 1 km)
Terrain	AUSLIG 9 second DEM
Data assimilation	N/A
CALMET	
Modelling period	1 January 2021 to 31 December 2021
Southwest corner of analysis	584 000 mE, 6 108 500 mS (UTM Coordinates)
Meteorological grid domain (resolution)	50 km × 50 km (0.2 km)
Vertical resolution (cell heights)	10 (0 m, 20 m, 40 m, 80 m, 160 m, 320 m, 640 m, 1 200 m, 2 000 m, 3 000 m, 4 000 m)
Data assimilation	No-obs approach using TAPM – 3D.DAT file

A comparison of the TAPM generated meteorological data, and that observed at Wagga AWS, are presented in Figure B3. These data generally compare well which provides confidence that the data being input to CALMET for further modelling are appropriate. Comparison of the CALMET modelled data and the observations at Wagga AWS is not possible due to the large separation distances between the Project site and that AWS.

Figure B3 Modelled and observed meteorological data – Wagga Wagga AMO AWS



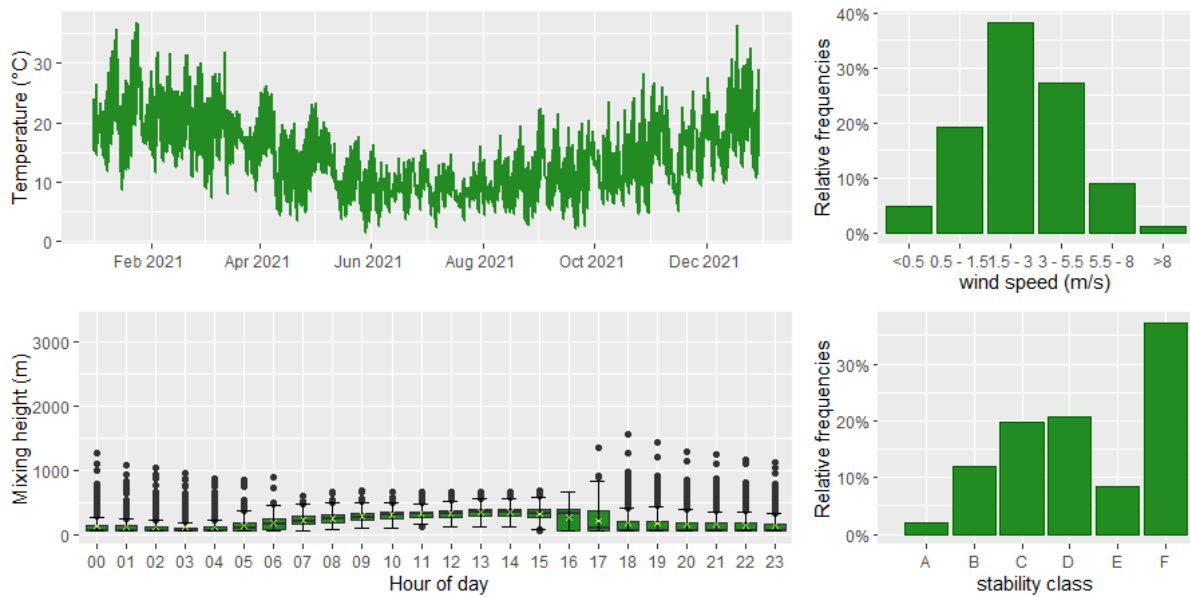
Source: Northstar

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 Project site, detailed discussion of the humidity, evaporation, cloud cover, katabatic air drainage and air recirculation potential of the Project site has not been provided. Details of the predictions of wind speed and direction, mixing height and temperature at the Project site are provided below.

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Project site during 2021 period 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.

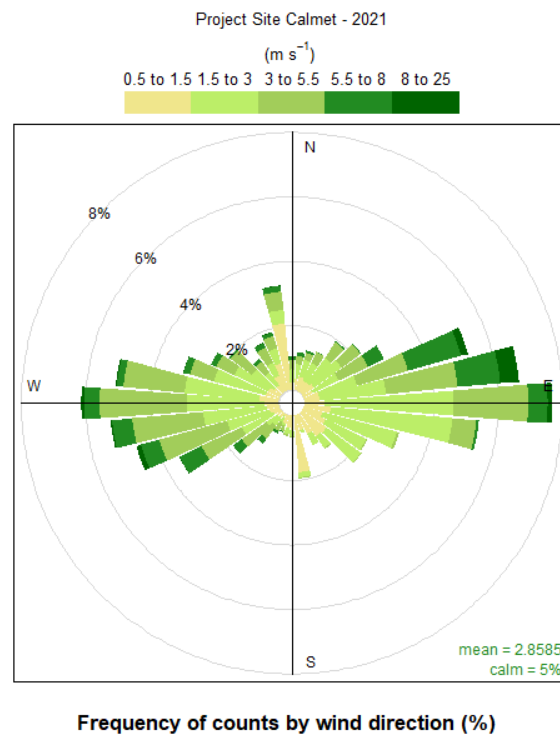
Figure B4 Predicted mixing height, wind speed and stability class frequency at the Project site (2021)



Source: Northstar

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

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



Source: Northstar

APPENDIX C

Air Quality

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

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

Air quality monitoring is performed by the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) at air quality monitoring stations (AQMS) surrounding the Project site. Details of the monitoring performed at these AQMS is presented in Table C1.

Table C1 NSW DCCEEW AQMS surrounding the Project site

AQMS location	Distance to Project site	2021 data	Pollutants		
			PM ₁₀	PM _{2.5}	TSP
June	53.6	✓	✗	✗	✓
Wagga Wagga North	56.3	✓	✓	✓	✗

The closest representative AQMS with particulate matter data available for the year 2021 (the selected representative year consistent with the meteorological modelling) is noted to be located at Wagga Wagga North and correspondingly data from Wagga Wagga North AQMS has been adopted for use in this assessment. Particulate matter data for the period 2020 to 2024 has been analysed. The annual frequency distribution for the five-year period is presented in Figure C1.

The results of the correlation coefficient analysis provided in Appendix B indicates that meteorological and PM data measured in 2021 is the most appropriate dataset for use within this study.

Concentrations of TSP are not measured at Wagga Wagga North AQMS. An analysis of co-located measurements of TSP and PM₁₀ in the Lower Hunter (1999 to 2011), Illawarra (2002 to 2004), and Sydney Metropolitan (1999 to 2004) regions is presented in Figure C2. The analysis concludes that, on the basis of the measurements collected in all regions between 1999 to 2011, the derivation of a broad TSP:PM₁₀ ratio of 2.222 :1 (i.e. PM₁₀ represents ~45 % of TSP) from the Illawarra region is appropriate. In the absence of any more specific information, this ratio has been adopted within this AQIA, resulting in a background annual average TSP concentration of 39.4 µg·m⁻³ being adopted.

Summary statistics for the selected data are presented in Table C2.

Figure C1 Annual distribution at Wagga Wagga North AQMS for PM₁₀ (2020 – 2024)



Figure C2 Co-located TSP and PM₁₀ measurements – Lower Hunter, Sydney Metro and Illawarra

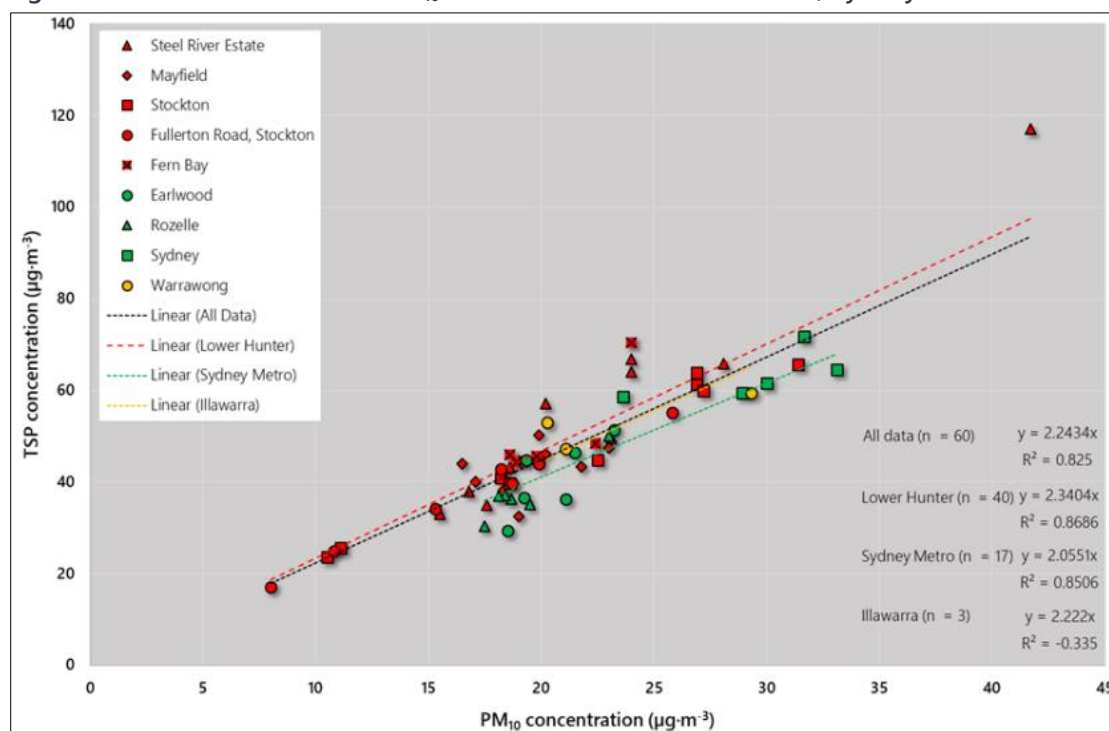


Table C2 Background air quality statistics –Wagga Wagga North AQMS (2021)

Pollutant	TSP ($\mu\text{g}\cdot\text{m}^{-3}$)	PM ₁₀ ($\mu\text{g}\cdot\text{m}^{-3}$)	PM _{2.5} ($\mu\text{g}\cdot\text{m}^{-3}$)
Averaging period	Annual	24-Hour	24-Hour
Statistics			
Data Points (number)	359	359	349
Mean	39.4	17.7	6.3
Standard deviation	-	11.2	3.9
Skew ¹	-	1.6	1.7
Kurtosis ²	-	3.0	3.9
Minimum	-	3.5	0.5
Percentiles			
25 th	-	9.6	3.8
50 th	-	14.5	5.6
75 th	-	23.2	7.7
90 th	-	32.5	10.9
95 th	-	37.5	14.0
97 th	-	44.3	16.3
98 th	-	49.4	17.7
99 th	-	59.3	19.2
Maximum	-	69.1	25.4
Data Capture (%)	98.4	98.4	95.6

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 skew represents a more peaked distribution, and negative skew represents a distribution more flattened than a normal distribution. Kurtosis is dimensionless.

Graphs presenting the daily varying PM₁₀ and PM_{2.5} data recorded at Bringelly AQMS in 2021 are presented in Figure C3 and Figure C4 respectively.

Figure C3 PM₁₀ concentrations –Wagga Wagga North AQMS (2021)

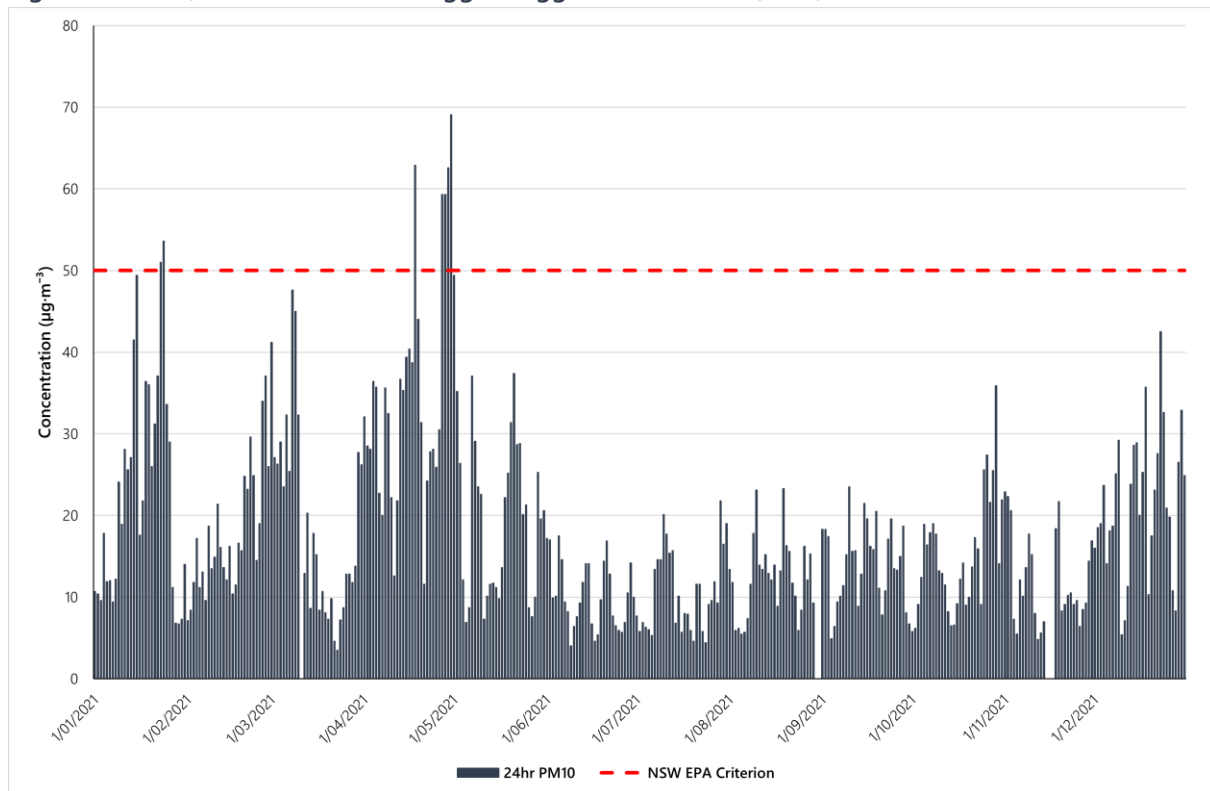
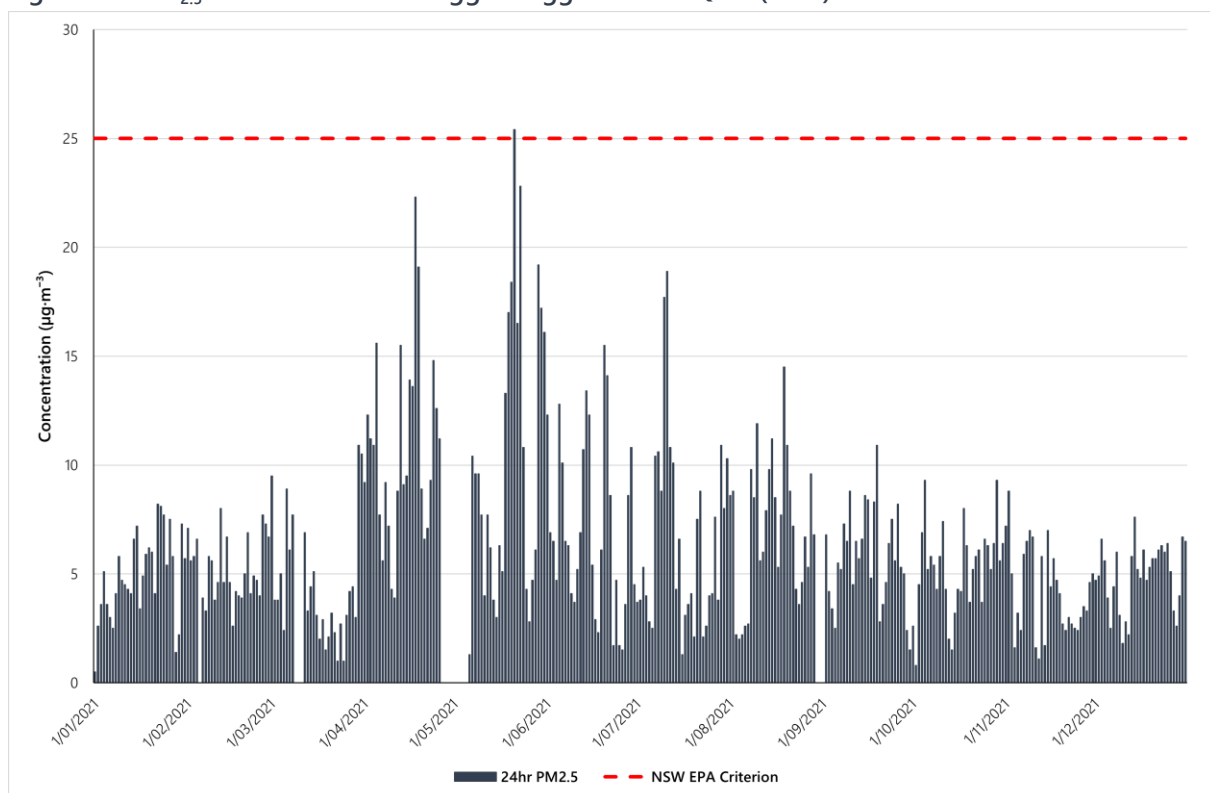


Figure C4 PM_{2.5} concentrations –Wagga Wagga North AQMS (2021)



APPENDIX D

Emissions Estimation

Emission Factors

As outlined in Section 2.4, multiple operations integral to the Project have the potential to result in particulate matter emissions. To assess these, the AQIA has relied upon emission factors sourced from the US EPA AP-42 emissions factor compendium (US EPA, various).

This appendix provides an overview of the adopted emission estimation techniques utilised to derive total emissions from the identified sources.

Paved Roads

Emissions of particulate matter resulting from the movement of vehicles on paved roads have been estimated using the emission factors presented in Section 13.2.1 (Paved Roads) of AP-42 (US EPA, 2011).

The emission factor in Section 13.2.1.3 of (US EPA, 2011) has been adopted for the operations of vehicles on paved roads:

$$EF_{(kg.VKT^{-1})} = k \times \left(\frac{s}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5}$$

where:

$EF_{(kg.VKT^{-1})}$ = emission factor (kg per vehicle kilometre travelled) multiplied by 0.2819 to convert from lb per vehicle mile travelled.

k = particle size multiplier (dimensionless).

s = surface material silt content (%).

W = mean vehicle weight (tons) multiplied by 0.907185 to convert from metric tonnes.

The particle size multipliers for TSP, PM_{10} and $PM_{2.5}$ (k) are provided in (US EPA, 2011).

The quality rating for this application is rated B for TSP, B for PM_{10} and B for $PM_{2.5}$.

The silt content on the paved roads has been assumed to be $7.4 \text{ g}\cdot\text{m}^{-2}$, which is generally representative of haul roads at a municipal solid waste landfill (Table 13.2.2-1 of (US EPA, 2006a)). The mean vehicle weight is based on the average weight of truck fleet (30 t).

Unpaved Roads

Emissions of particulate matter resulting from the movement of materials on unpaved haul routes have been estimated using the emission factors presented in Section 13.2.2 (Unpaved Roads) of AP-42 (US EPA, 2006a).

The emission factor in section 13.2.2 of (US EPA, 2006a) has been adopted for the operations of vehicles on unpaved roads:

$$EF_{(kg.VKT^{-1})} = 0.2819 \times k \times \left(\frac{s}{12}\right)^a \times \left(\frac{W \times 0.907185}{3}\right)^b$$

where:

$EF_{(kg.VKT^{-1})}$ = emission factor (kg per vehicle kilometre travelled) multiplied by 0.2819 to convert from lb per vehicle mile travelled

k = particle size multiplier (dimensionless)

s = surface material silt content (%)

W = mean vehicle weight (tons) multiplied by 0.907185 to convert from metric tonnes

The particle size multipliers for TSP, PM_{10} and $PM_{2.5}$ (k) are provided in (US EPA, 2006a) as 4.9, 1.5 and 0.15, respectively.

The quality rating for this application is rated B for TSP, B for PM_{10} and B for $PM_{2.5}$.

The silt content of unpaved haul roads at the Project has been taken to be 7.1 % which is consistent with haul roads at a sand and gravel processing material storage area (Table 13.2.2-1 of (US EPA, 2006a). The mean vehicle weight is based on a CAT950 FEL (24.5 t).

Materials Handling

Emissions for material handling, loading and unloading operations have been characterised using the factors given in Section 13.2.4.3 of AP-42 for batch drop processes (US EPA, 2006b). This equation is consistent with that associated with the use of excavators, shovels and FEL, as outlined in the NPI EETM for Mining (NPI, 2012):

The equation is:

$$EF (kg \cdot tonne^{-1}) = k(0.0016) \frac{\left(\frac{U (m \cdot s^{-1})}{2.2}\right)^{1.3}}{\left(\frac{M (\%)}{2}\right)^{1.4}}$$

where:

$EF_{TSP} (kg \cdot tonne^{-1})$ = emission factor for total suspended particles

$EF_{PM_{10}} (kg \cdot tonne^{-1})$ = emission factor for total suspended particles

k_{TSP} = 0.74 for particles less than 30 micrometres aerodynamic diameter

$k_{PM_{10}}$ = 0.35 for particles less than 10 micrometres aerodynamic diameter

$k_{PM_{2.5}}$ = 0.053 for particles less than 2.5 micrometres aerodynamic diameter

U = mean wind speed ($m \cdot s^{-1}$) (modelled at $2.1 m \cdot s^{-1}$)

M = material moisture content (% by weight) (assumed 1 %)

The quality rating for this application is rated A.

Wind Erosion (Exposed Areas)

Emissions of particulate matter resulting from the wind erosion of exposed areas have been estimated using the emission factors presented in Section 11.9-4 of AP-42 (Western Surface Coal Mining) (US EPA, 1998). The emission factors in Table 11.9-4 apply to the operations outlined above. The emission factor is:

$$EF_{TSP} (tonne \cdot (hectare \cdot year)^{-1}) = 0.85$$

where:

$EF_{TSP} (tonne \cdot (hectare \cdot year)^{-1})$ = emission factor for total suspended particulate matter

PM_{10} and $PM_{2.5}$ emission factors are not available in AP-42 although have been taken to be 50 % of TSP for PM_{10} and, 7.5 % of TSP for $PM_{2.5}$ as per Section 13.2.5 of AP-42 for industrial wind erosion (US EPA, 2006c).

The quality rating for the emission factor is C.

Emissions Estimates

Table E1 to Table E3 outline emissions calculated for volume sources in the Project, while Table E4 to Table E6 detail emissions concerning wheel-generated dust. Additionally, Table E7 to Table E9 present emissions related to wind erosion areas. These tables cover both peak 24-hour and annual emissions, which were included in the AQIA using dispersion modelling.

Table E1 Emission estimates – volume sources – peak daily and annual activity rates

Source ID	Description	Emission factor	Activity rate	
			t·day ⁻¹	t·yr ⁻¹
VOL1	Unloading of waste material	AP-42 - Batch drop - Section 13.2.4.3	495	99 000
VOL2	FEL on waste material	AP-42 - Batch drop - Section 13.2.4.3	495	99 000
VOL3	Daily cover pickup (FEL)	AP-42 - Batch drop - Section 13.2.4.3	324	64 800
VOL4	Daily cover placement	AP-42 - Batch drop - Section 13.2.4.3	324	64 800

Table E2 Emission estimates – volume sources – peak daily emissions rates

Source ID	Emission factor				Emissions controls	Controlled emissions (kg·day ⁻¹)		
	TSP	PM ₁₀	PM _{2.5}	Units		TSP	PM ₁₀	PM _{2.5}
VOL1	0.0017	0.0008	0.0001	kg·t ⁻¹	Pit Retention (50% TSP, 5% PM ₁₀ , PM _{2.5}), Minimise drop height (30%)	0.29	0.26	0.04
VOL2	0.0017	0.0008	0.0001	kg·t ⁻¹	Pit Retention (50% TSP, 5% PM ₁₀ , PM _{2.5})	0.41	0.37	0.06
VOL3	0.0017	0.0008	0.0001	kg·t ⁻¹		0.54	0.25	0.04
VOL4	0.0017	0.0008	0.0001	kg·t ⁻¹	Pit Retention (50% TSP, 5% PM ₁₀ , PM _{2.5}), Minimise drop height (30%)	0.19	0.17	0.03

Table E3 Emission estimates – volume sources – annual emission rates

Source ID	Emission factor				Emissions controls	Controlled emissions (kg·yr ⁻¹)		
	TSP	PM ₁₀	PM _{2.5}	Units		TSP	PM ₁₀	PM _{2.5}
VOL1	0.0017	0.0008	0.0001	kg·t ⁻¹	Pit Retention (50% TSP, 5% PM ₁₀ , PM _{2.5}), Minimise drop height (30%)	57.4	51.6	7.8
VOL2	0.0017	0.0008	0.0001	kg·t ⁻¹	Pit Retention (50% TSP, 5% PM ₁₀ , PM _{2.5})	82.1	73.7	11.2
VOL3	0.0017	0.0008	0.0001	kg·t ⁻¹		107.4	50.8	7.7
VOL4	0.0017	0.0008	0.0001	kg·t ⁻¹	Pit Retention (50% TSP, 5% PM ₁₀ , PM _{2.5}), Minimise drop height (30%)	37.6	33.8	5.1

Table E4 Emission estimates – wheel generated dust – peak daily and annual activity rates

Source ID	Description	Emission factor	Activity rate	
			VKT·day ⁻¹	VKT·yr ⁻¹
ROAD1	Transfer of waste to site	AP-42 Paved roads - Section 13.2.1	43	8 580
ROAD2	Transfer of overburden to site	AP-42 Paved roads - Section 13.2.1	28	5 616
ROAD3	FEL travel on site	AP-42 Unpaved roads - Section 13.2.2	13	2 645

Table E5 Emission estimates – wheel generated dust – peak daily emission rates

Source ID	Emission factor				Emissions controls	Controlled emissions (kg·day ⁻¹)		
	TSP	PM ₁₀	PM _{2.5}	Units		TSP	PM ₁₀	PM _{2.5}
ROAD1	0.641	0.123	0.030	kg·VKT ⁻¹		27.5	5.3	1.3
ROAD2	0.641	0.123	0.030	kg·VKT ⁻¹		18.0	3.5	0.8
ROAD3	2.572	0.709	0.071	kg·VKT ⁻¹	Level 1 watering (2 L/m ² /hr) (50%)	17.0	4.7	0.5

Table E6 Emission estimates – wheel generated dust – annual emission rates

Source ID	Emission factor				Emissions controls	Controlled emissions (kg·yr ⁻¹)		
	TSP	PM ₁₀	PM _{2.5}	Units		TSP	PM ₁₀	PM _{2.5}
ROAD1	0.641	0.123	0.030	kg·VKT ⁻¹		5,499.9	1,055.7	255.4
ROAD2	0.641	0.123	0.030	kg·VKT ⁻¹		3,599.9	691.0	167.2
ROAD3	2.572	0.709	0.071	kg·VKT ⁻¹	Level 1 watering (2 L/m ² /hr) (50%)	3,400.8	937.3	93.7

Table E1 Emission estimates – open area wind erosion sources – peak activity rates

Source ID	Description	Emission factor	Peak activity rate	
			Area (ha)	hr·day ⁻¹
WE1	Wind erosion of excavated cell	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	2.30	24
WE2	Wind erosion of stockpiled material	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	1.50	24
WE3	Wind erosion of daily cover / active cell	AP-42 - Wind erosion of exposed areas - annual - Table 11.9-4	0.06	24

Table E2 Emission estimates – open area wind erosion sources – peak daily emission rates

Source ID	Emission factor				Emissions controls	Controlled emissions (kg·day ⁻¹)		
	TSP	PM ₁₀	PM _{2.5}	Units		TSP	PM ₁₀	PM _{2.5}
WE1	850.0	425.0	63.8	kg·ha ⁻¹ ·yr ⁻¹		5.4	2.7	0.4
WE2	850.0	425.0	63.8	kg·ha ⁻¹ ·yr ⁻¹		3.5	1.7	0.3
WE3	850.0	425.0	63.8	kg·ha ⁻¹ ·yr ⁻¹		0.1	0.1	0.0

Table E3 Emission estimates - open area wind erosion sources – annual emission rates

Source ID	Emission factor				Emissions controls	Controlled emissions (kg·yr ⁻¹)		
	TSP	PM ₁₀	PM _{2.5}	Units		TSP	PM ₁₀	PM _{2.5}
WE1	850.0	425.0	63.8	kg·ha ⁻¹ ·yr ⁻¹		1,957.6	978.8	146.8
WE2	850.0	425.0	63.8	kg·ha ⁻¹ ·yr ⁻¹		1,275.0	637.5	95.6
WE3	850.0	425.0	63.8	kg·ha ⁻¹ ·yr ⁻¹		51.0	25.5	3.8

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