APPENDIX R
AIR QUALITY IMPACT ASSESSMENT

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VALLEY OF THE WINDS AIR QUALITY IMPACT ASSESSMENT

Project name	**Valley of the Winds EIS**
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Approved by	**Jon Williamson**
Description	**Air quality impact assessment to determine potential impacts from the construction of the Valley of the Winds Windfarm project**

CONTENTS

1. Project Description

The Valley of the Winds wind farm ("the project") proposes construction and operational of 175 wind turbines and associated infrastructure near the town of Coolah in the Warrumbungle Shire, NSW. The undulating terrain in that area allows for the wind turbines to be sited on ridgelines within already cleared land that is currently being used for livestock grazing. Current farming practices such as livestock grazing would continue next to the wind turbines.

Wind turbine generators (WTG) are being proposed across three clusters named Mount Hope, Girragulang Road and Leadville. These clusters will be linked electrically, allowing for approximately 2,500,000 megawatt hours of renewable energy to be generated each year.

The wind turbines will have a maximum tip height of 250 metres with underground electricity cabling connecting each turbine to an electricity substation. Gravel access tracks will link the wind turbines and all ancillary infrastructure within private property. A high voltage transmission line will be required to connect the central substation to the National Electricity Market (NEM).

UPC Renewables Australia Pty Ltd (UPC) commissioned Ramboll Australia Pty Ltd (Ramboll) to prepare an air quality screening assessment to determine potential air quality impacts from the project on receptors surrounding the development. The intent of this modelling assessment is to provide a high-level, worst-case prediction of potential impacts.

2. Air Quality Approval Conditions

NSW EPA has issued Environmental Assessment Requirements (SEARS) relevant to this assessment, as copied below:

Air – Dust generation and management of potential impacts on adjacent rural residences during construction and operation phases of the project.

The development is a scheduled activity under the Protection of the Environment Operations Act (1997 (POEO Act) and will require an Environment Protection Licence.

The EIS must comply with the Protection of the Environment Operations Act 1997 and Protection of the Environment Operations (Clean Air) Regulation 2020 (the "Clean Air Regulation"). The air quality impact assessment (AQIA) must be carried out in accordance with the Approved Method for the Modelling and Assessment of Air Pollutants in NSW (the "Approved Methods"; 2016).

Further, the EIS must detail emissions control techniques and practices that will be employed at the site and identify how the proposed control techniques and practices will meet the requirements of the POEO Act, Clean Air Regulation and associated air quality limits or guidance criteria.

3. Potential Air Quality Impacts

The majority of potential impacts to air quality will occur during the construction phase of the project, when the key pollutant of concern will be dust particles.

Potential sources of air pollution during construction include:

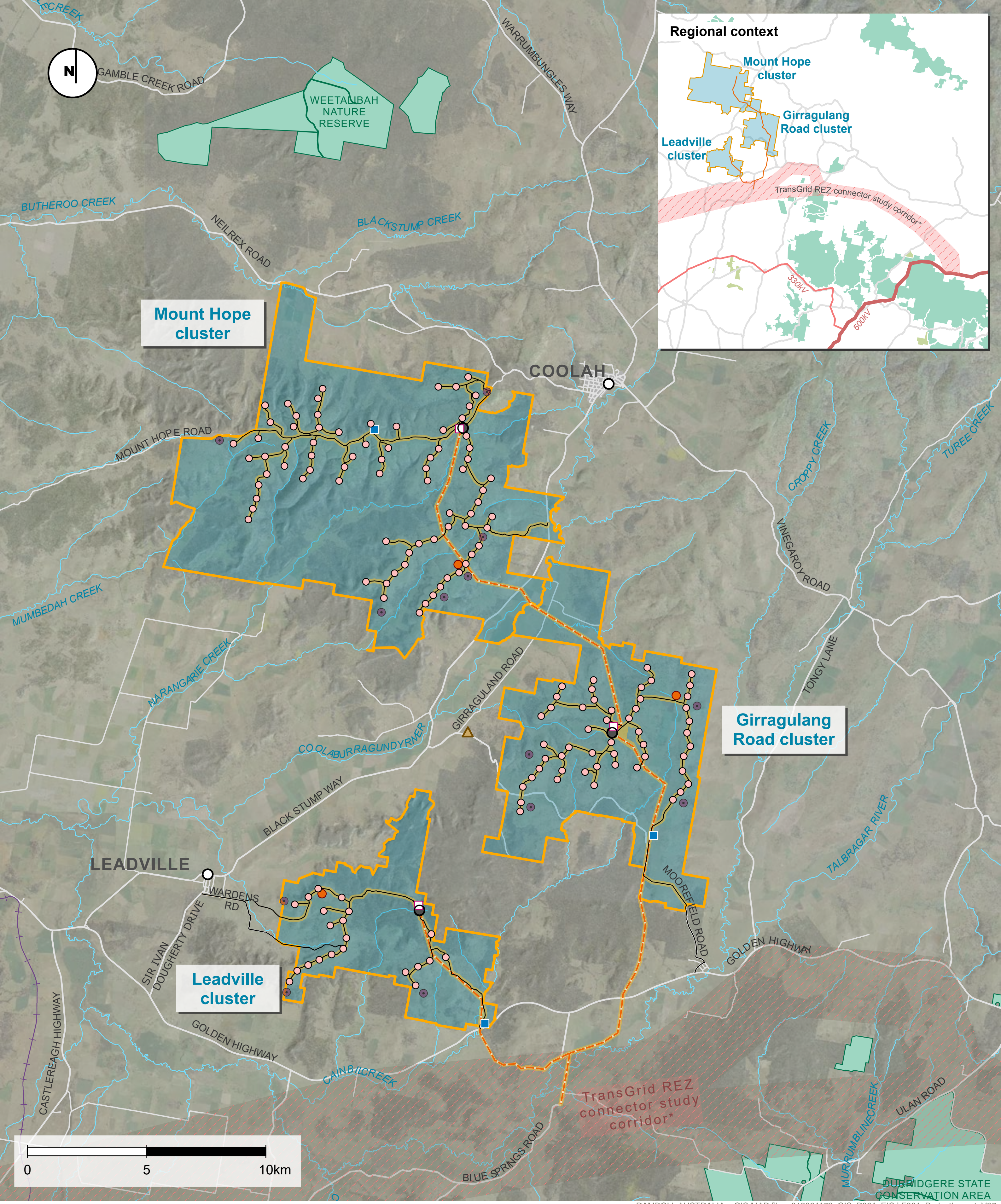
- Clearing of vegetation.
- Wind erosion of exposed areas and quarry locations.
- Excavation works for construction of infrastructure.
- Drilling and blasting material.
- Crushing and screening of material.
- Conveying material.
- Transferring material to stockpiles.
- Stockpiling material.
- Loading hoppers.
- Loading trucks with material.
- Unloading trucks at location.
- Use of front-end-loaders and other construction equipment.
- Hauling and vehicles on unsealed access tracks.

Potential sources of air pollution during operation include:

- Wind erosion of exposed areas.
- Use of project operational equipment.
- Vehicles on unsealed access tracks.
- Maintenance works on infrastructure including access tracks, hardstands and laydown areas.

4. Existing Environment

The project is made up of three distinct clusters of wind towers. The Mt Hope cluster is situated to the south-west of Coolah, the Leadville cluster is situated to the east of Leadville, and the Girragulang Road cluster is located at the approximate midpoint of the other clusters, between Tongy Road and Black Stump way. The project layout is shown in **Figure 4-1**.



RAMBOLL AUSTRALIA - GIS MAP file : 318001172_GIS_P001_EIS | F001_ProjectLayout_V07
Aerial photography from NSW Government Spatial Services

KEY

- Wind farm site
- Survey boundary
- Turbine location
- Access track
- Overhead transmission line
- Potential construction workforce accommodation
- Substation location
- Permanent operations and maintenance compound (also used during construction)
- Temporary construction compound
- Indicative quarry location
- Permanent meteorological mast location
- Railway
- National Parks and Reserves

*Approximate only

Figure 4-1 | Project overview

4.1 Terrain

The terrain of the project region is presented below in Figure 4-2, with the project boundary is shown in yellow. The terrain is mountainous, with the most significant terrain features being the mountain range in the Coolah tops National Park to the east and the Warrambungles to the north-west. There are a number of significant mountains and hills within the project bounds, as shown in Figure 4-4. The WTG's are proposed to be situated on or near to ridge lines, where winds are typically higher and most frequent.

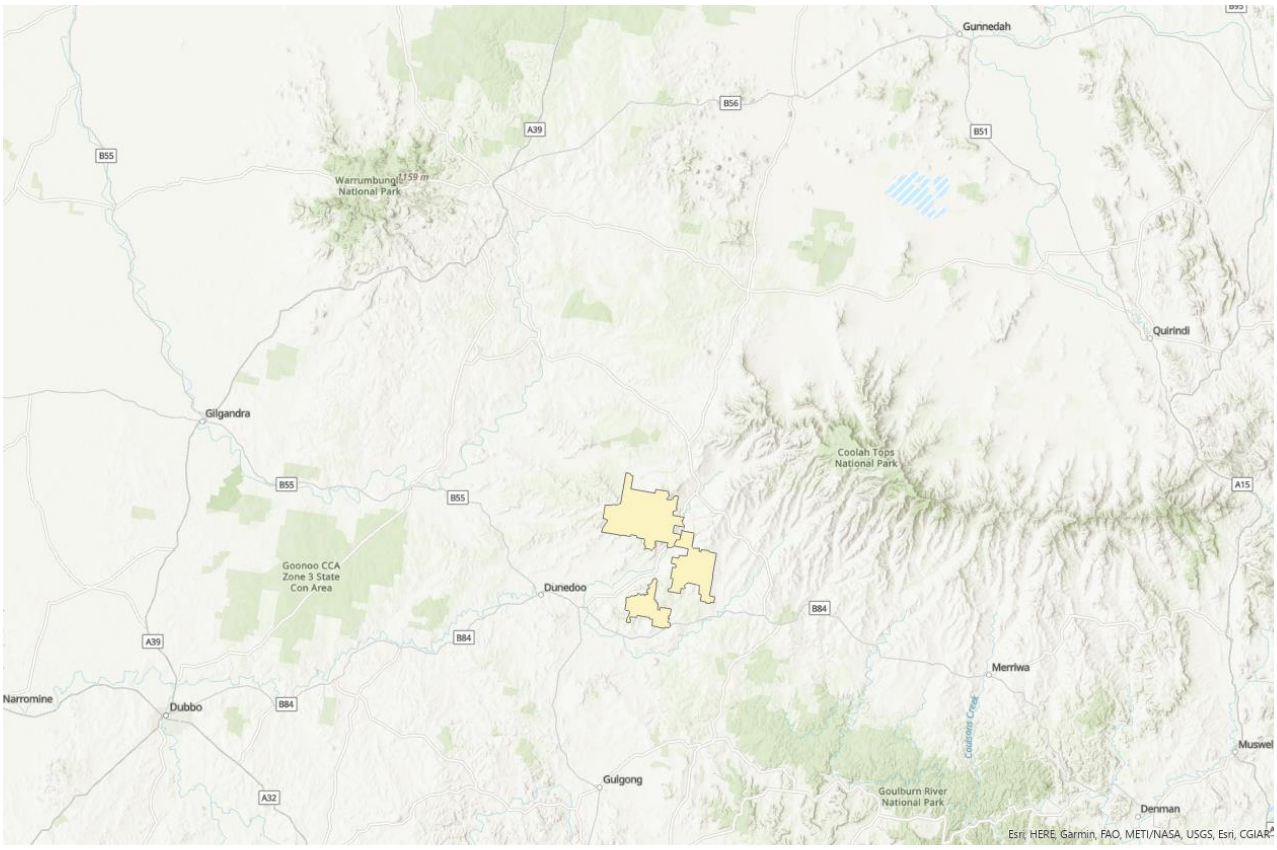
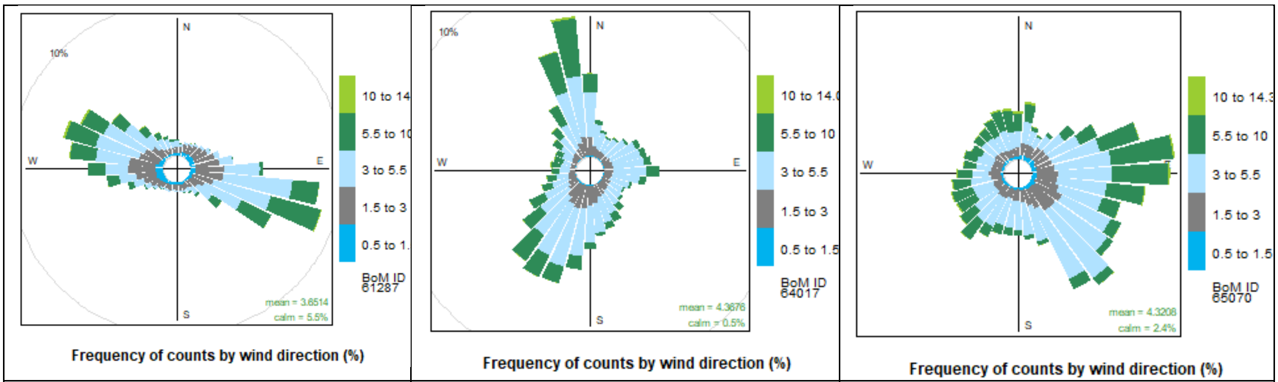


Figure 4-2 Terrain surrounding the project site

4.2 Meteorology

The Bureau of Meteorology (BoM) maintains automatic weather station's (AWS) in the region surrounding the project. From the approximate centre of the project, the Merriwa AWS (ID 061287) is located 55km to the south-east, the Coonabarabran AWS (ID 064017) is located 75km to the north-west, and the Dubbo AWS (ID 065070) is located 105km to the south-west. The AWS located in Dunedoo has not measured wind data since 2010, which is of importance for pollutant transport and dispersion of air pollutants, so has not been considered further.

Windroses for data measured at Merriwa, Coonabarabran and Dubbo from 2016 to 2020 are presented in Figure 4-3. The three locations show variable wind frequency patterns, which would be influenced by the terrain in the area. Merriwa is located south of the Coolah tops ridgeline, which runs east-west, influencing winds in the area to be predominantly along the east-west axis. Coonabarabran is located to the east of the Warrambungles, which would obstruct winds from the west, with the data showing prevailing winds from the north and south. Dubbo is located on relatively flat terrain, and shows winds from all directions, with a higher frequency of winds from the east.



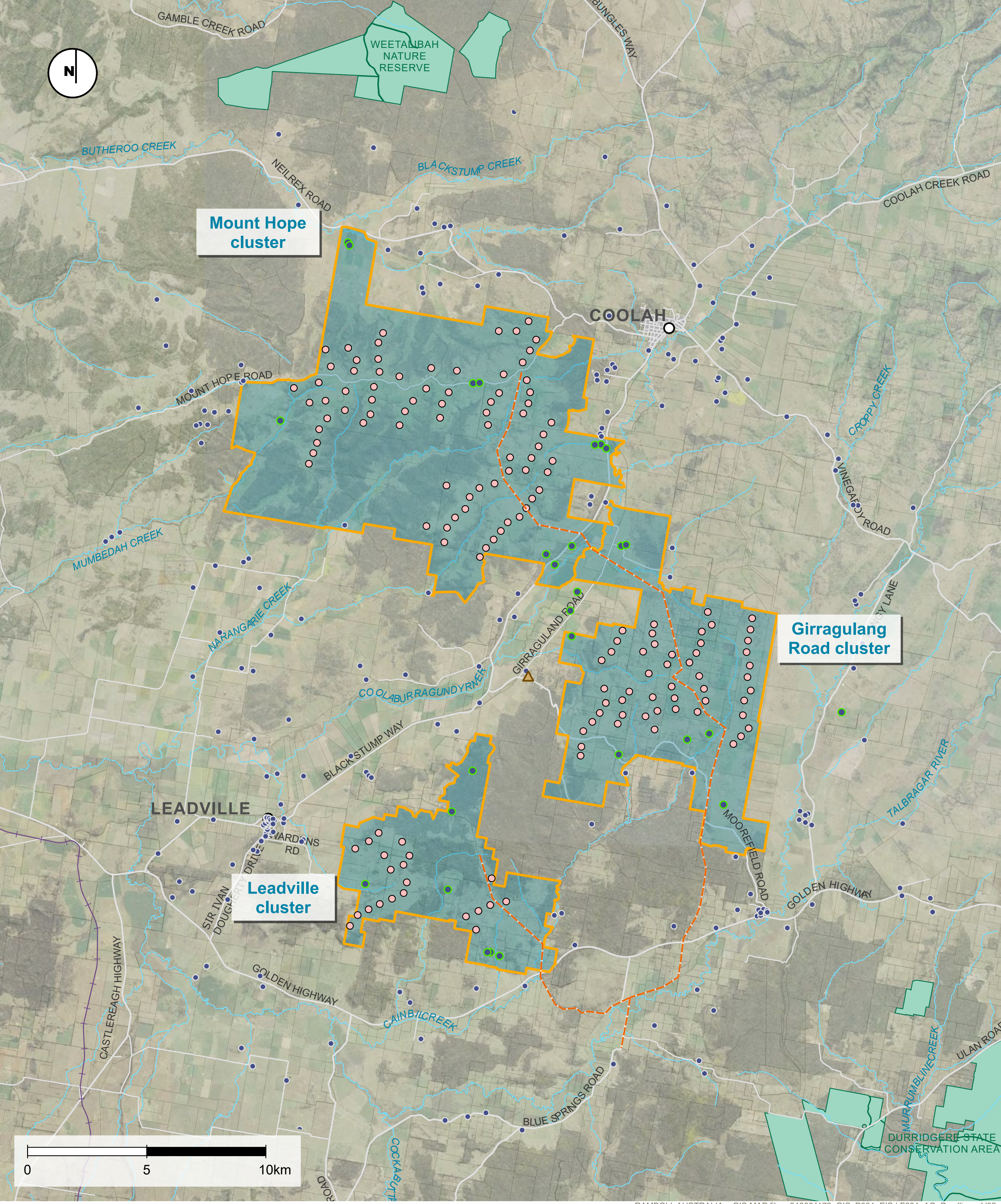
Merriwa	Coonabarabran	Dubbo

Figure 4-3: Wind roses: Merriwa, Coonabarabran and Dubbo

The mean minimum temperature measured at Dunedoo (Post Office, ID 064009) was 2.1 ºC and the mean maximum was 32.2 ºC (1946 to 2021; BoM, 2021). These measured values have been applied as model inputs for this assessment.

4.3 Sensitive receptors

The closest 361 sensitive receptors to the project are shown in Figure 4-4. The yellow shaded areas represent the cluster project boundaries, the blue dots represent the location of each individual WTG, and the brown houses represent the sensitive receptor locations. Note there are additional sensitive receptors located beyond the bounds of the map (mostly to the north), which are not presented for display purposes.



RAMBOLL AUSTRALIA - GIS MAP file : 318001172_GIS_P001_EIS | F031_AQ_Dwellings_V02
Aerial photography from NSW Government Spatial Services

KEY

- Wind farm site
- Turbine location
- Overhead transmission line
- Potential construction workforce accommodation
- Associated dwelling
- Non-associated dwelling
- National Parks and Reserves

Figure 4-4 | Sensitive receptor locations

4.4 Background air quality

Air quality monitoring stations maintained by the Department of Planning, Industry and Environment (DPIE) in Merriwa were reviewed for particulate matter of less than 2.5 microns aerodynamic diameter ($PM_{2.5}$) and less than 10 microns diameter (PM_{10}). Data was assessed for the period of 1 January to 16 December 2021 to determine average background concentrations of $PM_{2.5}$ and PM_{10}. The average concentration from the measured data is presented below in Table 4-1. These values are applied to determine the potential cumulative impact of the project with other background sources in the region.

Table 4-1: Background particulate matter concentrations, Merriwa 2021

Pollutant	Average concentration (µg/m^3)
$PM_{2.5}$	3.1
PM_{10}	15.5

No background air quality monitoring data was available for total suspended particulates (TSP).

5. Assessment Methodology

5.1 Relevant air quality criteria

The Approved Methods specify particulate concentration assessment criteria, by particle size and averaging period. The air quality criteria applicable to this assessment are presented below in Table 5-1.

Table 5-1: Impact assessment criteria for particulates $PM_{2.5}$, PM_{10} and TSP

Pollutant	Unit	24-hour Average	Annual Average
$PM_{2.5}$	µg/m^3	25	8
PM_{10}	µg/m^3	50	25
TSP	µg/m^3	N/A	90

The above criteria are compared against the 100th percentile prediction. Background air quality should also be considered for a cumulative assessment of impacts.

5.2 Level 1 screening dispersion modelling assessment

The Approved Methods specify two levels of impact assessment:

- Level 1 – screening-level dispersion modelling technique using worst-case input data.
- Level 2 – refined dispersion modelling technique using site-specific data.

This air quality impact assessment applies a Level 1 assessment approach.

The screening model AERSCREEN was used to quantify particulate impacts from the construction of the project. AERSCREEN is the US EPA recommended screening-level air quality model based on the AERMOD model. AERSCREEN also interfaces with AERMAP, the terrain pre-processor, considered of importance for this project owing to the complex terrain of the region. The model produces a site-specific matrix of meteorological conditions and predicts concentrations at the plume centreline, regardless of source-receptor-wind direction orientation thereby estimating worst-case impacts (US EPA, 2021).

5.3 Receptor distances

The AERSCREEN model outputs an estimate of pollutant concentration by distance from the source. The distances between the WTG's and the sensitive receptors were determined using GIS data prepared for the project. A summary of the distances assessed to show the range of impacts predicted by the model are presented in Table 5-2.

Table 5-2: Assessment distances

Statistic	Distance (m)
Minimum	861
Maximum	61,726
Median	18,811
Average	19,820

5.4 Model inputs

The model inputs summarised in Table 5-3 have been applied to AERSCREEN to complete this assessment.

Table 5-3: AERSCREEN model inputs

Parameter	Input
Domain size (km)	40 km x 40 km
Volume source configuration	1 in the approximate centre of the clusters Easting: 751,322 m Northing: 6468,808 m
Release height (m)	1 m AGL
Initial Vertical Dimension	0.5
Length of side	5,714 m (equivalent area as project footprint)
Minimum temperature (º C)	2.1
Maximum temperature (º C)	32.2
Minimum wind speed (m/s)	0.5
Landuse type	Cultivated Land
Albedo	AERMET seasonal tables
Bowen Ratio	AERMET seasonal tables
Surface Roughness (m)	AERMET seasonal tables
Terrain Effects	Y (SRTM1/SRTM3)
Adjust Surface Friction Velocity (ADJ_U*)	Y

To convert the mean hourly concentration predicted by the dispersion model to a 24-hour average, AERSCREEN provides factors presented in Table 5-4, which have been applied to this assessment.

Table 5-4: Factors for converting 1-hour average results to other averaging periods

Desired Averaging Period	Factor
24-hour	0.60
Annual	0.10

5.5 Source locations

A map of the source location from AERSCREEN is provided below in Figure 5-1. The source was placed at a lower elevation on a ridgeline to reduce the distance between the source and the ground level in the valleys which would reduce dispersion distance and generate a conservative result.

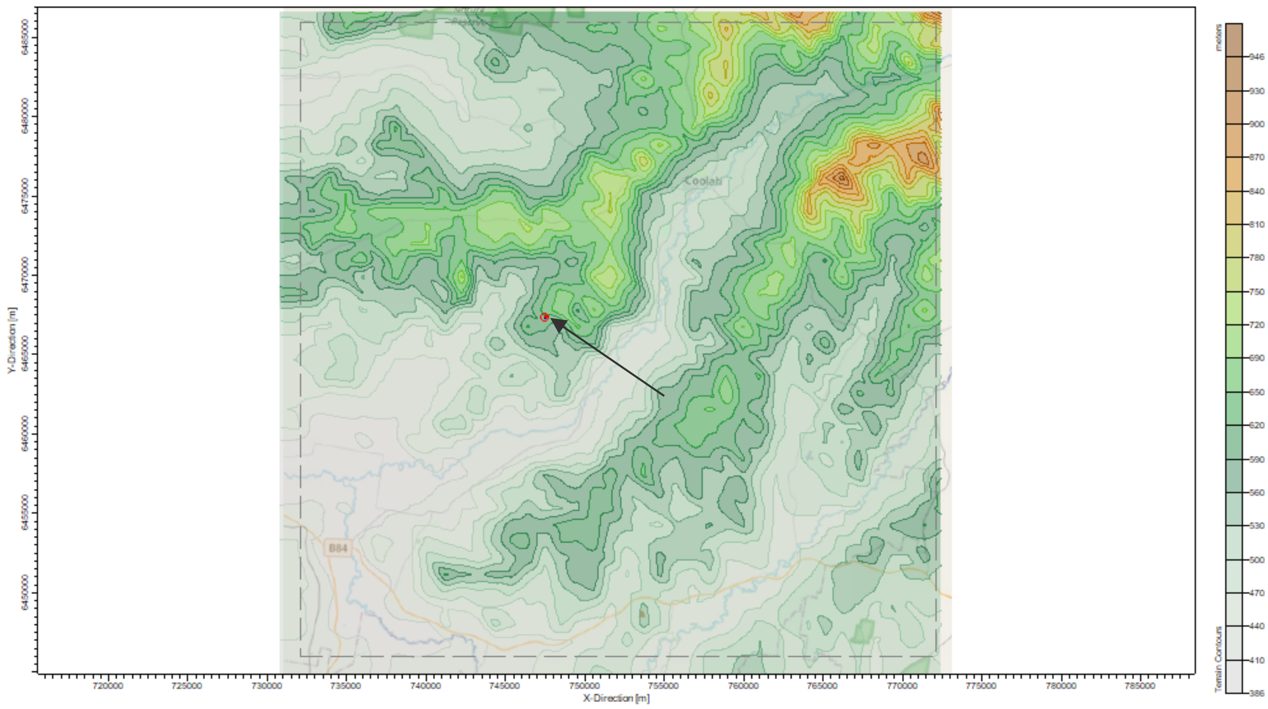


Figure 5-1: Modelled source location in AERSCREEN

6. Construction Assessment

6.1 Emissions inventory

The emission source details used to determine emission factors for TSP and PM_{10} are provided in Table 6-1. Civil estimates of quantities (e.g. aggregate, concrete, sand etc) in combination with NPI emission estimation technique manuals[1] were used to estimate emissions for activities proposed for the project. Note that not all TSP and PM_{10} emissions factors were available for all activities, therefore PM_{10}:TSP ratios were calculated for some activities based on emission rates of other activities of similar nature. $PM_{2.5}$ emissions factors were not available in the NPI emission estimation technique manuals and therefore a PM_{10}:$PM_{2.5}$ ratio was assumed based on research by Cowherd *et al.* (2010).

[1] Emission estimation technique manual for Mining and Processing of non-metallic minerals, version 2.1

Table 6-1: Emissions inventory summary

Activity	Emission Factor			Control Applied (%)	Justification	Emission Factor Controlled			Qty	Unit	Emission Mass		
	TSP	PM_{10}	Unit			TSP	PM_{10}	Unit			TSP	PM_{10}	Unit
Quarrying													
Drilling	0.000081	0.00004	kg/hole	0	controlled ER: wet drilling	0.000081	0.000040	kg/hole	1,028	holes	0.083	0.041	kg
Blasting	0.015	0.0080	kg/blast	0	17m2 per blast	0.015	0.0080	kg/blast	1,028	blasts	16	8.2	kg
Processing													
Primary Crushing	0.00035	0.00017	kg/t	50%	water sprays	0.00018	0.000087	kg/t	815,340	t	143	71	kg
Secondary Crushing	0.00048	0.00022	kg/t	50%	water sprays	0.00024	0.00011	kg/t	815,340	t	194	90	kg
Tertiary Crushing	0.00060	0.00027	kg/t	50%	water sprays	0.00030	0.00014	kg/t	815,340	t	245	110	kg
Primary Screening	0.0018	0.0011	kg/t	0	controlled ER: water spray	0.0018	0.0011	kg/t	815,340	t	1,468	897	kg
Secondary Screening	0.0018	0.0011	kg/t	0	controlled ER: water spray	0.0018	0.0011	kg/t	815,340	t	1,468	897	kg
Tertiary Screening	0.0018	0.0011	kg/t	0	controlled ER: water spray	0.0018	0.0011	kg/t	815,340	t	1,468	897	kg
Transfer to stockpiles	0.000070	0.000023	kg/t	0	controlled ER: water spray	0.000070	0.000023	kg/t	815,340	t	57	19	kg
Truck Load	0.00010	0.000050	kg/t	0	controlled ER: water spray	0.00010	0.000050	kg/t	815,340	t	82	41	kg
Truck Unload to location or CPB	0.000016	0.0000080	kg/t	0	controlled ER: water spray	0.000016	0.0000080	kg/t	815,340	t	13	6.5	kg
FEL to hardstand	0.000016	0.0000080	kg/t	0	controlled ER: water spray	0.000016	0.0000080	kg/t	647,464	t	10	5.2	kg
Cement Batching													
Total process emissions	0.101	0.050	kg/t	0	N/A	0.10	0.050	kg/t	386075	t	38,922	19,304	kg
Cable Trenching													
Sand dump to trench	0.028	0.014	kg/t	50%	water spray	0.01	0.0070	kg/t	65240	t	1,842	913	kg
Wind (project duration 2 years)													
Wind - quarry & stockpiles	7.9	3.9	kg/ha/day	50%	water spray	3.9	2.0	kg/ha/day	730 & 30	Day & ha	86,107	42,705	kg
Wind - area disturbed at any one time	0.4	0.2	kg/ha/hr	70%	30% for walled bunker	0.28	0.14	kg/ha/hr	17520 & 3	Hr & ha	14,717	7,358	kg

Table 6-2: Emission factors used in the assessment

Emission detail	TSP	PM_{10}	$PM_{2.5}$[A]	Unit
Total emission mass	146,750	73,322	10,998	kg
Emission rate per day	201	100	15	kg/day
Emission rate per hour	8.4	4.2	0.63	kg/hr
Emission rate per second	2.3	1.2	0.17	g/s

A - $PM_{2.5}$:PM_{10} ratio used was 0.15 (aggregate handling and storage, open area wind erosion)

6.2 Project-only and cumulative assessment results

The model outputs a gradient of pollutant concentrations at an increasing distance from the source, beginning at the point of highest concentration, refer Figure 6-1. As terrain was included in this assessment, the concentration gradient accounts for the undulating terrain. The results represent the highest 1-hour concentrations over an annual period, during worst-case meteorological conditions for all seasons. The averaging period factors detailed in Table 5-4 are applied to the 1-hour average results for comparison to applicable 24-hour and annual average criteria. Where the maximum ground level concentration was predicted at a greater distance than the nearest sensitive receptor, the maximum result was applied to the nearest sensitive receptor.

The results of the assessment are presented below in Table 6-3 for project only contribution and Table 6-4 for a cumulative assessment. When considering project-only contribution there are no exceedances of the criteria for TSP, PM_{10} or $PM_{2.5}$ for both 24-hour and annual averaging periods. When considering the cumulative impacts, there are also no exceedances of the criteria for TSP, PM_{10} or $PM_{2.5}$ for both 24-hour and annual averaging periods. It is noted there was no TSP background monitoring data available and therefore TSP was not assessed cumulatively, however, generally, where PM_{10} and $PM_{2.5}$ criteria are satisfied, there would be expected to be no exceedances for TSP. A screening model approach is intended to be conservative. A more refined modelling approach has the potential to minimise the predicted impact, but the extent to which the results will change is dependent on the various input parameters revised.

Table 6-3: Project only results by distance to sensitive receptors

Statistic	Distance	1-hour			24-hour			Annual		
		TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Minimum	861	54.5	28.4	4.3	32.7	17.1	2.6	5.5	2.8	0.4
Maximum	61,726	25.5	13.3	2.0	15.3	8.0	1.2	2.5	1.3	0.2
Median	18,811	27.5	14.3	2.1	16.5	8.6	1.3	2.7	1.4	0.2
Average	19,820	25.5	13.3	2.0	15.3	8.0	1.2	2.5	1.3	0.2

Table 6-4: Cumulative results by distance to sensitive receptors

Statistic	Distance (m)	24-hour		Annual	
		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Minimum	861	32.6	5.7	18.3	3.5
Maximum	61,726	23.5	4.3	16.8	3.3
Median	18,811	24.1	4.4	16.9	3.3
Average	19,820	23.5	4.3	16.8	3.3

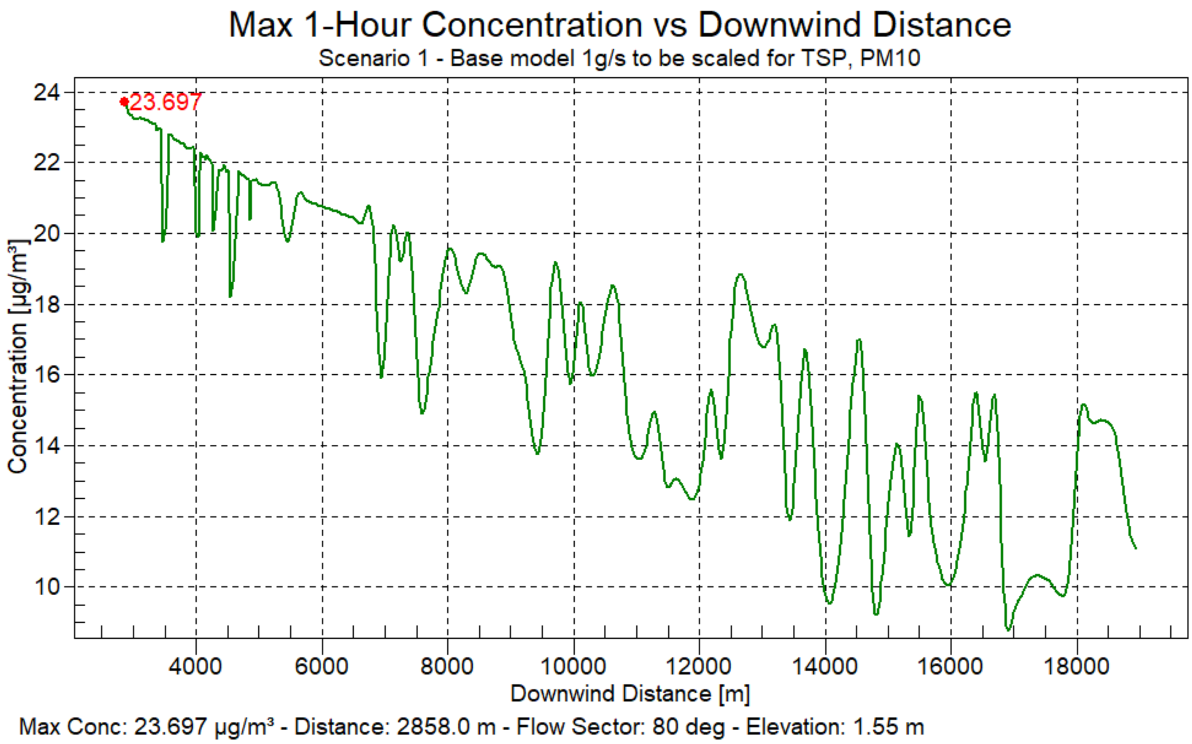


Figure 6-1: Predicted concentration profile by distance from the source

7. Operational Impacts

The operational air quality impacts from the project are likely to consist of wind erosion from exposed areas, use of operational equipment, vehicles travelling on unsealed surfaces and maintenance works. These impacts are considered minor, so no modelling has been conducted. The project will be managed to ensure risks to air quality are avoided or minimised. Mitigation and management measures for air quality will be outlined in the Air Quality Management Plan (AQMP).

8. Mitigation and Management Measures

An AQMP will be prepared for construction of the project. The AQMP will outline the management measures to control and minimise dust generation from the project.

Mitigation and management measures during construction may include:

- Apply water and/or dust suppressants to exposed areas, stockpiles and unsealed roads using a water cart.
- Cover all loads when transporting material off-site.
- Implement speed restrictions for equipment operating on unsealed access tracks and disturbed areas.
- Water injection during drilling.
- Water sprays activated during material crushing.
- Wind breaks constructed around conveyors.
- Enclosing all hoppers.
- Minimise the surface area of disturbed surfaces during construction.

- Stabilise and progressively rehabilitated exposed areas through vegetation planting as soon as practicable after construction to minimise dust from wind erosion.
- Limit construction activities during unfavourable, high dust-generating conditions.
- Regularly inspect construction activities to ensure appropriate air quality controls and implemented to minimise dust emissions.

Mitigation and management measures during operation may include:

- Minimise dust emissions from exposed areas and access tracks through application of water and/or dust suppressants.
- Implement speed restrictions for equipment operating on unsealed access tracks and disturbed areas.
- Limit operational activities during unfavourable, high dust-generating conditions.
- Regularly inspect construction activities to ensure appropriate air quality controls and implemented to minimise dust emissions.

9. Conclusion

A Level 1 screening air quality impact assessment was prepared for the Valley of The Winds wind farm project. The assessment was completed in accordance with the NSW EPA's *Approved Methods for the modelling and assessment of air pollutants in NSW*.

Emissions of $PM_{2.5}$, PM_{10} and TSP were estimated based on proposed civil works quantifies and methods using emission factors from NPI emissions estimation technique manuals.

The assessment predicted 100 percentile worst-case 1-hour averages over an annual period, using worst-case meteorological conditions. Averaging period factors were applied to the 1-hour model results to adjust for 24-hour and annual averaging periods to compare to NSW EPA air quality impact assessment criteria.

The screening modelling predicted a gradient of decreasing particulate concentrations at increasing distance from the source. There were no predicted exceedances of the air quality criteria when considered all particulate size fractions assessed, all relevant averaging periods and project-only and cumulative scenarios.

A screening modelling approach is intended as a conservative worst-case prediction of impacts. It is likely that a refined level 2 dispersion modelling process would lower the predicted impacts at the sensitive receptors, and each receptor could be assessed individually.

10. References

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