8. Noise Assessment

MARSHALL DAY
Acoustics

WIMMERA PLAINS ENERGY FACILITY
OPERATIONAL NOISE ASSESSMENT

Report No. 002 20190083 | 4 March 2020

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EXECUTIVE SUMMARY

This report presents the results of an assessment of operational noise associated with the Wimmera Plains Energy Facility, that is proposed to be developed by BayWa r.e. Wind Pty Ltd (BayWa).

The assessment has been carried out on the basis of the proposed wind farm layout comprising fifty-four (54) multi-megawatt turbines

The planning application for the wind farm seeks permission to develop turbines with a maximum tip height of 247 m. The actual turbine which would be used at the site would be determined at a later stage in the project. The final selection would be made on account of a range of design requirements including achieving compliance with the planning permit noise limits at surrounding noise sensitive receiver locations. The assessment has therefore been based on a candidate turbine model that is representative of the size and type of turbine which could be used at the site. For the purpose of this assessment, the Vestas V162-5.6MW turbine has been nominated by BayWa as the candidate turbine with a tip height of 247 m (hub height of 166 m and a rotor diameter of 162 m).

Operational noise associated with the proposed turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010), as required by the Victorian Government's *Policy And Planning Guidelines for Development of Wind Energy Facilities In Victoria,* dated March 2019.

Operational noise limits for the development have been determined in accordance with NZS 6808:2010, accounting for the land zoning in the vicinity of the project.

Manufacturer specifications provided by BayWa for the candidate turbine have been used as the basis for the assessment. This document provides noise emission data, determined in accordance with the international standard[1] referenced in NZS 6808:2010. The data is consistent with the range of values expected for comparable types of multi megawatt wind turbines that are being considered for the site.

The noise emission data has been used to predict the level of noise expected occur at neighbouring sensitive receiver locations in accordance with the international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). The ISO 9613-2 standard has been applied on the basis of well-established input choices and adjustments, based on research and international guidance, that are specific to wind farm noise assessment.

The results of the noise modelling for the Wimmera Plains Energy Facility demonstrate that the predicted noise levels for the proposed wind farm layout and candidate turbine model achieve the base noise limits determinised in accordance with NZS 6808:2010 at all neighbouring noise sensitive receiver locations.

The noise assessment therefore demonstrates that the proposed Wimmera Plains Energy Facility is able to be designed and developed to achieve the Victorian policy requirements.

The noise limits determined in accordance with NZS 6808:2010, apply to the total combined operational wind farm noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore also considered two (2) other wind farm projects (operational or approved) in the broader surrounding area.

An assessment of the predicted noise levels for each wind farm has demonstrated that cumulative wind farms noise levels do not affect the compliance outcomes for any of the assessed projects.

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[1] IEC 61400-11:2012 *Wind turbines - Part 11: Acoustic noise measurement techniques*

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1.0 INTRODUCTION

BayWa r.e. Wind Pty Ltd (BayWa) is proposing to develop a wind farm known as the Wimmera Plains Energy Facility in the Victorian Local Government Area of Horsham.

The Wimmera Plains Energy Facility is proposed to comprise fifty-four (54) wind turbines.

This report presents the results of an assessment of operational noise for the proposed Wimmera Plains Energy Facility.

The assessment of operational noise associated with the turbines has been undertaken in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) as required by the required by the Victorian Government's *Policy And Planning Guidelines for Development of Wind Energy Facilities In Victoria* dated March 2019 (the Victorian Wind Energy Guidelines).

In advance of background noise monitoring results being available (survey currently underway), this assessment refers to the minimum operational wind farm noise limits (base noise limits) determined in accordance with NZS 6808:2010, accounting for the land zoning of the area surrounding the project.

The noise assessment presented in this report is based on:

- Operational noise limits determined in accordance with NZS 6808:2010, accounting for local land zoning in the vicinity of the site;
- Predicted noise levels for the proposed Wimmera Plains Energy Facility based on the proposed site layout and a candidate turbine model that is representative of the size and type of turbine that the planning application seeks consent for;
- A comparison of the predicted noise levels with the noise limits derived in accordance with NZS 6808:2010; and
- An assessment of cumulative effects for the proposed Wimmera Plains Energy Facility and two (2) other wind farm projects in the broader surrounding area.

Acoustic terminology used in this report is presented in Appendix A.

2.0 PROJECT DESCRIPTION

2.1 Overview

The Wimmera Plains Energy Facility is proposed to comprise fifty-four (54) wind turbines, which extend over an area spanning approximately 8 km from north to south and 11 km from west to east, approximately 12 km north east of Horsham.

The coordinates of the proposed wind farm are tabulated in Appendix B.

A total of thirty-four (34) noise sensitive receivers within 3 km of the Wimmera Plains Energy Facility have been considered in this noise assessment. This includes twelve (12) receivers where a noise agreement is in place between the land owners and BayWa, which are referred to as stakeholder receivers herein.

The coordinates of the receivers are tabulated in Appendix C.

A site layout plan illustrating the turbine layout and receiver locations is provided in Appendix D.

2.2 Candidate wind turbine model

The final wind turbine model for the site would be selected after a tender process to procure the supply of turbines. The final selection would be made on account of a range of design requirements including achieving compliance with relevant noise limits at surrounding noise sensitive receiver locations.

Accordingly, to assess the proposed development at this stage in the project, it is necessary to consider a representative candidate turbine model for the size and type of turbines being considered. The purpose of the candidate turbine is to assess the viability of achieving compliance with the applicable noise limits, based on noise emission levels that are typical of the size of turbines being considered for the development.

The candidate wind turbine selected by BayWa for this assessment is the Vestas V162-5.6MW. It is a variable speed wind turbine, with the speed of rotation and the amount of power generated by the turbines being regulated by control systems which vary the pitch of the turbine blades (the angular orientation of the blade relative to its axis). Two different types of blade design are available for Vestas V162-5.6MW turbine; a standard non-serrated version and a serrated version which reduces the total noise emissions of the turbine. This assessment has been based on the serrated variant of the turbine.

Details of the candidate wind turbine model are provided in Table 1.

Table 1: Candidate wind turbine model details - Vestas V162-5.6MW

Detail	Description
Rotor diameter	162 m
Rated power	5.6 MW
Hub height	166 m
Blade orientation	Upwind
Blade type	Serrated trailing edges (for noise control)
Turbine regulation method	Variable blade pitch

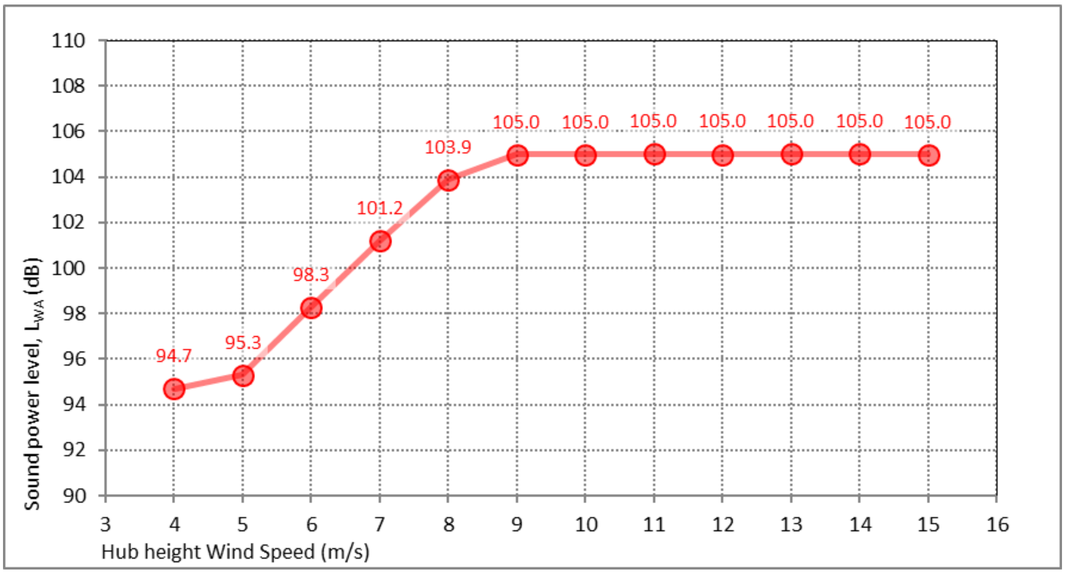
2.3 Wind turbine noise emissions

The noise emissions of wind turbines are described in terms of the sound power level for different wind speeds at the hub height. The sound *power* level is a measure of the total sound energy produced by each turbine and is distinct from the sound *pressure* level which depends on a range of factors such as the distance from the turbine.

Sound power level data for the candidate turbine model were sourced from the Vestas document No. 0079-5298_01 *V162-5.6MW Third octave noise emission* dated 23 January 2019 (the Vestas Document). The sound power data provided in the document has been adjusted by the addition of +1.0 dB at each wind speed to provide a margin for typical values of test uncertainty.

The sound power levels referenced in this assessment, including the +1.0 dB adjustment, are illustrated in Figure 1. The overall level represents the total noise emission of the turbines, including the secondary contribution of ancillary plant associated with the turbines (e.g. cooling fans and internal transformer).

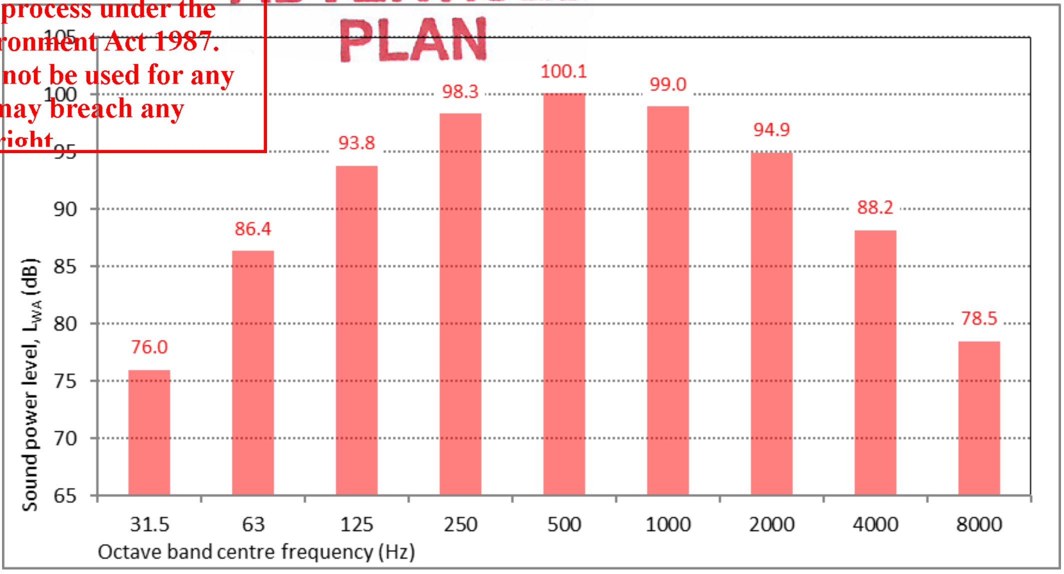
Figure 1: V162-5.6MW assessment sound power levels, dB L_{WA}



The sound power levels in Figure 1 are considered typical of the range of noise emissions associated with comparable multi-megawatt wind turbines. The data is therefore considered appropriate to reference in this assessment as a representation of the apparent sound power levels of the turbines when tested and rated in accordance with International Electrotechnical Commission publication IEC 61400-11:2012 *Wind turbines - Part 11: Acoustic noise measurement techniques* (IEC 61400-11), consistent with the recommendation of NZS 6808:2010.

The sound frequency characteristics of the turbines were also sourced from the Vestas Document. The reference spectrum used as the basis for this assessment is illustrated Figure 2 and corresponds to the highest overall sound power level illustrated in Figure 1.

Figure 2: V162-5.6MW assessment sound power level spectrum, dB L_{WA}



The manufacturer specification for the candidate turbine model does not provide information about tonality.

The occurrence of tonality in the noise of contemporary multi-megawatt turbine designs is generally limited. This is supported by evidence of operational wind farms in Australia which indicates that the occurrence of tonality at receiver locations is atypical. On this basis, adjustments for tonality have not been applied to the predicted noise levels presented in this preliminary assessment. Notwithstanding this, the subject of tonality would need to be addressed in subsequent assessment stages for the project.

3.0 VICTORIAN POLICY & GUIDELINES

The following publications are relevant to the assessment of operational noise from proposed wind farm developments in Victoria:

- Victorian Department of Environment, Land Planning and Water publication *Policy And Planning Guidelines for Development of Wind Energy Facilities In Victoria* dated November 2017 (the *Victorian Wind Energy Guidelines*); and
- New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010).

Details of the guidance and noise requirements provided by these publications are provided below.

3.1 Victorian Wind Energy Guidelines

The Victorian Wind Energy Guidelines provide advice to responsible authorities, proponents and the community about suitable sites to locate wind energy facilities and to inform planning decisions about a wind energy facility proposal.

The stated purpose of the Victorian Wind Energy Guidelines is to set out:

- *a framework to provide a consistent and balanced approach to the assessment of wind energy projects across the state*
- *a set of consistent operational performance standards to inform the assessment and operation of a wind energy facility project*
- *guidance as to how planning permit application requirements might be met.*

Section 5 of the Victorian Wind Energy Guidelines outlines the key criteria for evaluating the planning merits of a wind energy facility. Section 5.1.2(a) details information relating to the amenity of areas surrounding a wind farm development, including information relating to noise levels. In particular, it provides the following guidance for the assessment of noise levels for proposed new wind farm developments:

> *The Standard specifies a general 40 decibel limit (40 dB LA90(10min)) for wind energy facility sound levels outdoors at noise sensitive locations, or that the sound level should not exceed the background sound level by more than five decibels (referred to as 'background sound level +5 dB'), whichever is the greater.*
>
> *[...]*
>
> *Under Section 5.3 of the Standard, a 'high amenity noise limit' of 35 decibels may be justified in special circumstances. All wind energy facility applications must be assessed using Section 5.3 of the Standard to determine whether a high amenity noise limit is justified for specific locations, following procedures outlined in 5.3.1 of the Standard. Guidance can be found on this issue in the VCAT determination for the Cherry Tree Wind Farm*

Based on the Victorian Wind Energy Guidelines, the environmental noise of proposed new wind farm developments must be assessed in accordance with NZS 6808:2010. Consideration must also be given to whether a high amenity noise limit is warranted to reflect special circumstances at specific locations.

3.2 NZS 6808:2010

The New Zealand Standard NZS 6808:2010 provides methods for the prediction, measurement, and assessment of sound from wind turbines. The following sections provide an overview of the objectives of NZS 6808 2010 and the key elements of the standard's assessment procedures.

3.2.1 Objectives

The foreword of NZS 6808:2010 provides guidance about the objectives of the noise criteria outlined within the standard:

> *Wind farm sound may be audible at times at noise sensitive locations, and this Standard does not set limits that provide absolute protection for residents from audible wind farm sound. Guidance is provided on noise limits that are considered reasonable for protecting sleep and amenity from wind farm sound received at noise sensitive locations.*

The *Outcome Statement* of NZS 6808:2010 then goes on to provide information about the objective of the standard in a planning context:

> *This Standard provides suitable methods for the prediction, measurement, and assessment of sound from wind turbines. In the context of the* [New Zealand] *Resource Management Act, application of this Standard will provide reasonable protection of health and amenity at noise sensitive locations.*

Section C1.1 of the standard provides further information about the intent of the standard, which is:

> [...] *to avoid adverse noise effects on people caused by the operation of wind farms while enabling sustainable management of natural wind resources.*

Based on the objectives outlined above, NZS 6808:2010 addresses health and amenity consideration at noise sensitive locations by specifying noise criteria which are to be used to assess wind farm noise.

3.2.2 Noise sensitive locations

The provisions of NZS 6808:2010 are intended to protect noise sensitive locations that existed before the development of a wind farm. Noise sensitive locations are defined by the Standard as:

> *The location of a noise sensitive activity, associated with a habitable space or education space in a building not on the wind farm site. Noise sensitive locations include:*
>
> *(a) Any part of land zoned predominantly for residential use in a district plan;*
>
> *(b) Any point within the notional boundary of buildings containing spaces defined in (c) to (f);*
>
> *(c) Any habitable space in a residential building including rest homes or groups of buildings for the elderly or people with disabilities …*
>
> *(d) Teaching areas and sleeping rooms in educational institutions …*
>
> *(e) Teaching areas and sleeping rooms in buildings for licensed kindergartens, childcare, and day-care centres; and*
>
> *(f) Temporary accommodation including in hotels, motels, hostels, halls of residence, boarding houses, and guest houses.*
>
> *In some instances holiday cabins and camping grounds might be considered as noise sensitive locations. Matters to be considered include whether it is an established activity with existing rights.*

For the purposes of an assessment according to the Standard, the notional boundary is defined as:

> *A line 20 metres from any side of a dwelling or other building used for a noise sensitive activity or the legal boundary where this is closer to such a building.*

NZS 6808:2010 was prepared to provide methods of assessment in the statutory context of New Zealand. Specifically, the Standard notes that in the context of the New Zealand Resource Management Act, application of the standard will provide reasonable protection of health and amenity at noise sensitive locations. This is an important point of context, as the New Zealand Resource Act states:

> *(3)(a)(ii): A consent authority must not, when considering an application, have regard to any effect on a person who has given written approval to the application.*

Based on the above definitions and statutory context, noise predictions are normally prepared for stakeholder receivers irrespective of whether they are inside or outside of the boundary. However, the noise limits specified in the Standard are not applied to these locations on account of their participation with the project. Separate consideration is given to alternative guidance values for these locations, having regard to participating land owners both within and outside the site boundary, and participating neighbours outside the site boundary. In addition to consistency with NSZ 6808:2010 and its statutory context, this approach is also consistent with the policy and guidance applied in other Australian states.

3.2.3 Noise limit

Section 5.2 *Noise limit* of NZS 6808:2010 defines acceptable noise limits as follows:

> *As a guide to the limits of acceptability at a noise sensitive location, at any wind speed wind farm sound levels ($L_{A90(10\ min)}$) should not exceed the background sound level by more than 5 dB, or a level of 40 dB $L_{A90(10\ min)}$, whichever is the greater.*

This arrangement of limits requires the noise associated with a wind farm to be restricted to a permissible margin above background noise, except in instances when both the background and source noise levels are low. In this respect, the criteria indicate that it is not necessary to continue to adhere to a margin above background when the background noise levels are below the range of 30-35 dB.

The criteria specified in NZS 6808:2010 apply to the combined noise level of all wind farms influencing the environment at a receiver. Specifically, section 5.6.1 states:

> *The noise limits* [...] *should apply to the cumulative sound level of all wind farms affecting any noise sensitive location.*

3.2.4 High amenity areas

Section 5.3.1 of NZS 6808:2010 states that the baseline noise limit of 40dB L_{A90} detailed in Section 3.2.3 above is "*appropriate for protection of sleep, health, and amenity of residents at most noise sensitive locations*." It goes on to note that high amenity areas may require additional consideration:

> [...] *In special circumstances at some noise sensitive locations a more stringent noise limit may be justified to afford a greater degree of protection of amenity during evening and night-time. A high amenity noise limit should be considered where a plan promotes a higher degree of protection of amenity related to the sound environment of a particular area, for example where evening and night-time noise limits in the plan for general sound sources are more stringent than 40 dB $L_{Aeq(15\ min)}$ or 40 dBA L_{10}. A high amenity noise limit should not be applied in any location where background sound levels, assessed in accordance with section 7, are already affected by other specific sources, such as road traffic sound.*

The definition of a high amenity area provided in NZS 6808:2010 is specific to New Zealand planning legislation and guidelines. A degree of interpretation is therefore required when determining how to apply the concept of high amenity in Victoria.

Section 5.3 of NZS 6808:2010 provides details of high amenity noise limits, requiring that where a residential property is deemed to be located within a high amenity area as defined in Sections 5.3.1 and 5.3.2 of NZS 6808:2010, wind farm noise levels (L_{A90}) during evening and nigh-time periods should not exceed the background noise level (L_{A90}) by more than 5 dB or 35 dB L_{A90}, whichever is the greater. The standard recommends that this reduced noise limit typically apply for wind speeds below 6 m/s at hub height. High amenity noise limits are not applicable during the daytime period.

3.2.5 Special audible characteristics

Section 5.4.2 of NZS 6808:2010 requires the following:

> *Wind turbine sound levels with special audible characteristics (such as tonality, impulsiveness and amplitude modulation) shall be adjusted by arithmetically adding up to +6dB to the measured level at the noise sensitive location.*

Notwithstanding this, the standard requires that wind farms be designed with no special audible characteristics at nearby residential properties while concurrently noting in Section 5.4.1 that:

> […] *as special audible characteristics cannot always be predicted, consideration shall be given to whether there are any special audible characteristics of the wind farm sound when comparing measured levels with noise limits.*

NZS 6808:2010 emphasises assessment of special audible characteristics during the post-construction measurement phase of a project. However, an indication of the potential for tonality to be a characteristic of the noise emission from the assessed turbine model can be determined based on the results of tonality audibility assessment commonly provided by manufacturers with their IEC 61400-11 sound power level specifications.

It should be noted that the tonality assessment in accordance with IEC 61400-11 is undertaken in close proximity of a single tested turbine (generally within 150-250 m) whereas the assessment of potential characteristics is performed during post-construction noise monitoring at receiver locations.

4.0 ASSESSMENT METHODO

4.1 Overview

Based on the policies and guidelines outlined in Section 3.0, assessing the operational noise levels of a proposed wind farm involves:

- predicting the level of noise expected to occur as a result of the proposed wind farm;
- assessing background noise levels at noise sensitive locations around the project;
- assessing the land zoning of the project site and surrounding areas;
- establishing suitable noise criteria accounting for background noise levels and land zoning; and
- assessing whether the development can achieve the requirements of Victorian policy and guidelines by comparing the predicted noise levels to the noise criteria.

4.2 Noise predictions

Operational wind farm noise levels are predicted using:

- Noise emission data for the wind turbines;
- A 3D digital model of the site and the surrounding environment; and
- International standards used for the calculation of environmental sound propagation.

The method selected to predict noise levels is International Standard ISO 9613-2: 1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation* (ISO 9613-2). The prediction method is consistent with the guidance provided by NZS 6808:2010 and has been shown to provide a reliable method of predicting the typical upper levels of the noise expected to occur in practice from wind farm developments.

The ISO 9613-2 method is used in conjunction with a set of input choices and procedural modifications that are specific to wind farm noise assessment, based on international research on guidance.

The noise prediction method is summarised in Table 2. Further discussion of the method and the calculation choices is provided in Appendix G.

Table 2: Downwind prediction methodology

Detail	Description
Software	Proprietary noise modelling software SoundPLAN version 8.1
Method	International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2). Adjustments to the ISO 9613-2 method are applied on the basis of the guidance contained in the UK Institute of Acoustics publication *A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise* (the UK Institute of Acoustics guidance). The adjustments are applied within the SoundPLAN noise modelling software and relate to the influence of terrain screening and ground effects on sound propagation. Specific details of adjustments are noted below and are discussed in Appendix G.

Detail	Description
Source characterisation	Each wind turbine is modelled as a point source of sound. The total sound of the wind farm is then calculated on the basis of simultaneous operation of all wind turbines and summing the contribution of each. Calculations of turbine to receiver distances and average sound propagation heights are made on the basis of the point source being located at the position of the hub of the turbine. Calculations of terrain related screening are made on the basis of the point source being located at the maximum tip height of each turbine. Further discussion of terrain screening effects is provided below.
Terrain data	Elevation contours in 10 m resolution provided by BayWa
Terrain effects	Adjustments for the effect of terrain are determined and applied on the basis of the UK Institute of Acoustics guidance and research outlined in Appendix G. • Valley effects: +3 dB is applied to the calculated noise level of a wind turbine when a significant valley exists between the wind turbine and calculation point. A significant valley is determined to exist when the actual mean sound propagation height between the turbine and calculation point is 50 % greater than would occur if the ground was flat. • Terrain screening effects: only calculated if the terrain blocks line of sight between the maximum tip height of the turbine and the calculation point. The value of the screening effect is limited to a maximum value of 2 dB. The Wimmera Plains Energy Facility is located in an area that is relatively flat, and the turbines are located at similar ground elevations to that of the surrounding receivers. As such, the adjustments applied within the software for terrain effects are relatively small (typically of the order of 0.2 dB or less, based on comparison of predicted noise levels with and without terrain elevation data included). For reference purposes, the ground elevations at the turbine and receiver locations are tabled in Appendix B and Appendix C respectively. The topography of the site is depicted in the elevation map provided in Appendix E.
Ground conditions	Ground factor of G = 0.5 on the basis of the UK good practice guide and research outlined in Appendix G. The ground around the site corresponds to acoustically soft conditions (G = 1) according to ISO 9613-2. The adopted value of G = 0.5 assumes that 50 % of the ground cover is acoustically hard (G = 0) to account for variations in ground porosity and provide a cautious representation of ground effects.
Atmospheric conditions	Temperature 10 °C and relative humidity 70 % These represent conditions which result in relatively low levels of atmospheric sound absorption and are chosen on the basis of the UK Institute of Acoustics guidance and NZS 6808:2010. The calculations are based on sound speed profiles[2] which increase the propagation of sound from each turbine to each receiver location, whether as a result of thermal inversions or wind directed toward each calculation point.
Receiver heights	1.5 m above ground level

[2] The sound speed profile defines the rate of change in the speed of sound with increasing height above ground

4.3 Background noise levels

Background noise level information is used to assist in setting operational noise limits for a wind farm.

The procedures for assessing background noise levels are defined in NZS 6808:2010. The first step in assessing background noise levels involves determining whether background noise measurements are warranted. For this purpose, Section 7.1.4 of the standard provides the following guidance:

> *Background sound level measurements and subsequent analysis to define the relative noise limits should be carried out where wind farm sound levels of 35 dB $L_{A90(10\ min)}$ or higher are predicted for noise sensitive locations, when the wind turbines are at 95% rated power. If there are no noise sensitive locations within the 35 dB $L_{A90(10\ min)}$ predicted wind farm sound level contour then background sound level measurements are not required.*

The initial stage of an NZS 6808:2010 assessment therefore comprises:

- Preliminary wind farm noise predictions to identify all noise sensitive receiver locations where predicted noise levels are higher than 35 dB L_{A90}
- Identification of selected noise sensitive receiver locations where background noise monitoring should be undertaken prior to development of the wind farm, if required.

If required, the surveys involve measurements of background noise levels at receiver locations and simultaneous measurement of wind speeds at the site of the proposed wind farm. The survey typically extends over a period of several weeks to enable a range of wind speeds and directions to be measured.

The results of the survey are then analysed to determine the trend between the background noise levels and the site wind speeds at the proposed hub height of the turbines. This trend defines the value of the background noise for the different wind speeds in which the turbines will operate. At the wind speeds when the value of the background noise is above 35 dB L_{A90} (or 30 dB L_{A90} in special circumstances where high amenity limits apply), the background noise levels are used to set the noise limits for the wind farm.

5.0 EXISTING NOISE ENVIRONMENT

The results of noise modelling for the site, detailed in Section 6.2, indicates two (2) non-stakeholder receivers (5 and 19) where the wind farm noise levels were predicted above 35 dB L_{A90}.

A survey of background noise levels in accordance with the method detailed in NZS 6808:2010 is currently being carried out at these two (2) non-stakeholder receivers. The locations where background noise monitoring is being carried out are listed in Table 3.

Table 3: Background noise monitoring locations

Receiver	Location description
5	Non-stakeholder receiver approximately 1.2 km to the south of the proposed wind farm
19	Non-stakeholder receiver approximately 1.6 km to the north of the proposed wind farm

The background noise survey commenced on 4 February 2020 and will continue for a minimum period of four (4) weeks. Hub height wind speeds will be provided by BayWa based on wind data simultaneously measured at the site of the wind farm.

The results of the survey will be analysed in accordance with NZS 6808:2010 to determine the relationship between background noise levels and site wind speeds.

Full details of the survey, analysis methodology and measurement results will be documented in a separate report.

6.0 WIND TURBINE NOISE ASSESSMENT

6.1 Noise limits

6.1.1 High amenity areas

To assess high amenity area considerations in accordance with NZS 6808:2010, a review of the land zoning around the Wimmera Plains Energy Facility has been carried out.

In terms of the extent of areas that require consideration of high amenity limits, the standard states that there is no need to consider noise sensitive locations outside the predicted 35 dB L_{A90} wind farm sound level contour. This is consistent with the minimum noise limit for high amenity areas being set at a value of 35 dB.

Based on the predicted noise level contours presented subsequently in Section 6.2, and the zoning map for the area presented in Appendix F, all areas within the predicted 35 dB L_{A90} predicted contour are designated as Farming Zone.

Clause 35.07 of the Horsham Planning Scheme dated 11 February 2020 states the purpose of the Farming Zone as follows:

> *To implement the Municipal Planning Strategy and the Planning Policy Framework.*
>
> *To provide for the use of land for agriculture.*
>
> *To encourage the retention of productive agricultural land.*
>
> *To ensure that non-agricultural uses, including dwellings, do not adversely affect the use of land for agriculture.*
>
> *To encourage the retention of employment and population to support rural communities.*
>
> *To encourage use and development of land based on comprehensive and sustainable land management practices and infrastructure provision.*
>
> *To provide for the use and development of land for the specific purposes identified in a schedule to this zone.*

Based on the stated purpose detailed above, the Horsham Planning Scheme does not specify the Farming Zone as promoting a higher degree of protection of amenity related to the sound environment.

Following guidance from the VCAT determination for the Cherry Tree Wind Farm, as required by the Victorian Guidelines, the high amenity noise limit detailed in NZS 6808:2010 is therefore not deemed to be applicable to residential receivers in the vicinity of the Wimmera Plains Energy Facility.

6.1.2 Stakeholder receivers

The definition of noise sensitive locations in NZS 6808:2010 specifically excludes dwellings located within a wind farm site boundary. The discussion earlier in this report in Section 3.2.2, also provides details of the statutory context of NZS 6808:2010 and indicates the method is not intended to be applied to noise sensitive locations outside the site boundary where a noise agreement exists between the occupants and the proponent of the development.

This is consistent with model conditions in the Victorian Guidelines which state that the noise limits specified in NZS 6808:2010 would not apply if an agreement is in place between the proponents and the landowners.

Notwithstanding the above, a reference level of 45 dB has been applied as a base criterion for stakeholder dwellings in order to provide context to the predicted noise levels for these locations. This is consistent with the Victorian Wind Energy Guidelines which recommends a level of 45 dB for stakeholder dwellings. Comparisons between the predicted noise levels and the 45 dB reference level are provided for informative purposes only. Noise levels at these locations will ultimately need to be managed in accordance with the commercial agreements established between the Proponent and the land owners.

6.1.3 Applicable noise limits

Accounting for the conclusions of the assessment of high amenity areas and the increased base noise limits for stakeholder receivers, the noise criteria applicable to the Wimmera Plains Energy Facility are summarised in Table 4.

Table 4: Applicable noise criteria

Receivers	Noise criteria, dB L_{A90}
Non-stakeholder	40 dB or background L_{A90} + 5 dB, whichever is higher
Stakeholder	Noise limits do not apply Reference level of 45 dB or background L_{A90} + 5 dB, whichever is higher, are presented for informative purposes only

In advance of background noise monitoring results being available, a simplified and conservative approach has been adopted for this assessment by comparing the predicted noise levels with the base noise limits presented above. The background noise monitoring results would be used to derive background noise dependent noise limits.

6.2 Predicted noise levels

This section of the report presents the predicted noise levels of the Wimmera Plains Energy Facility at surrounding receiver locations, and an assessment of compliance with the applicable noise limits.

Sound levels in environmental assessment work are typically reported to the nearest integer to reflect the practical use of measurement and prediction data. However, in the case of wind farm layout design, significant layout modifications may only give rise to fractional changes in the predicted noise level. This is a result of the relatively large number of sources influencing the total predicted noise level, as well as the typical separating distances between the turbine locations and surrounding assessment positions. It is therefore necessary to consider the predicted noise levels at a finer resolution than can be perceived or measured in practice. It is for this reason that the levels presented in this section are reported to one decimal place.

The receiver locations where operational wind farm noise levels are predicted to be higher than 30 dB L_{A90} are listed in Table 5. The predicted noise levels are based on when the wind farm's noise emissions have reached their highest level (corresponding to hub height wind speeds of 9 m/s and above).

The value of 30 dB is referenced here for informative purposes. The minimum noise limit applicable to the wind farm at non-stakeholder receivers is however 40 dB L_{A90}.

The location of the predicted 35 dB and 40 dB L_{A90} noise contours is illustrated in Figure 3.

Predicted noise levels for each integer wind speed are tabulated in Appendix H for all considered receiver locations, including dwellings where the highest predicted noise level is below 30 dB L_{A90}.

Table 5: Predicted noise level at receivers on or within the 30 dB L_{A90} predicted noise contour

Receiver Location	Highest predicted noise level dB L_{A90}
1 (S)	36.1
2	34.8
3 (S)	36.8
4 (S)	40.6
5	38.0
6	34.0
7	32.9
8	33.3
10 (S)	32.4
11	32.8
12	32.7
14	34.4
18 (S)	37.1
19	35.3
22 (S)	30.9
39	31.8
58 (S)	33.3
61 (S)	34.8
62 (S)	30.8
63 (S)	33.5

(S) Stakeholder receiver

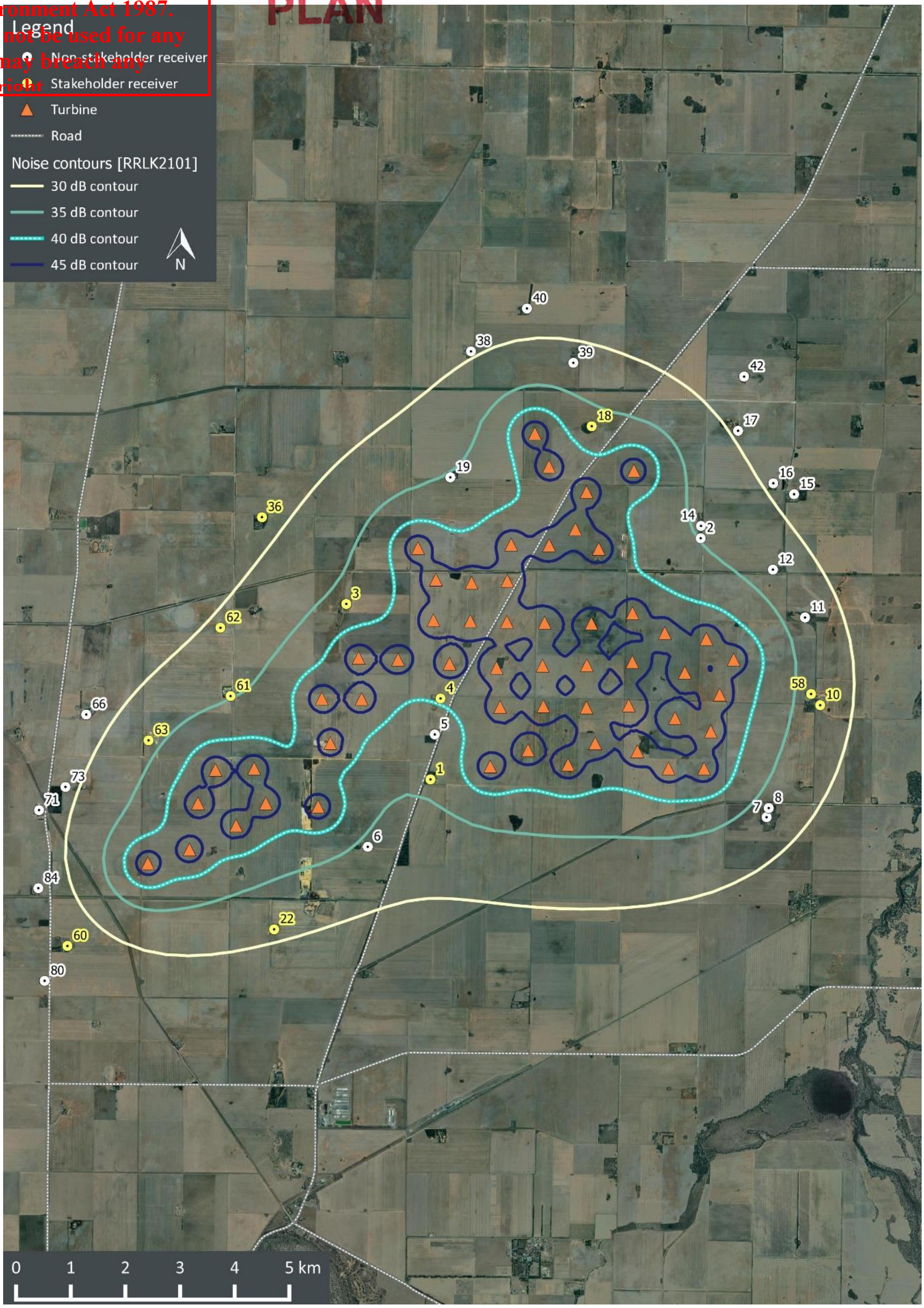
The results presented in Table 5 demonstrate that the predicted noise levels are:

- below the base noise limit of 40 dB at all assessed non-stakeholder receiver locations by at least 2.0 dB; and
- below the reference level of 45 dB at all assessed stakeholder receiver locations by at least 4.4 dB.

The predicted noise levels at all other receiver locations further from the development than those listed in Table 5 are less than 30 dB L_{A90}.

The results therefore demonstrate that the Wimmera Plains Energy Facility is predicted to comply with the operational noise requirements of NZS 6808:2010, as required by the Victorian Wind Energy Guidelines.

Figure 3: Wimmera Plains Energy Facility - highest predicted noise level contours (corresponding to hub-height wind speeds of 9 m/s or greater)



6.3 Cumulative wind farm noise levels

The noise limits determined in accordance with NZS 6808:2010 apply to the total combined operational wind farm noise level, including the contribution of any neighbouring wind farm developments. The assessment has therefore considered other approved and operational wind farm projects in the surrounding area.

Based on publicly available information[3], two (2) wind farms in the broader area around the proposed Wimmera Plains Energy Facility have been identified for the review of potential cumulative noise considerations. These wind farms are detailed in Table 6.

Table 6: Wind farm development in the broader area around the proposed Wimmera Plains Energy Facility

Wind farm name	Status	Approximate distance to nearest turbine
Jung	Approved	550 m within the north eastern section of the site
Murra Warra	Under construction	7.5 km to the north

A site plan showing the location of these projects is provided in Figure I1 of Appendix I.

The following sections provide a cumulative assessment for each of the surrounding wind farm development.

6.3.1 Jung Wind Farm

The Jung Wind Farm received planning approval for the construction of two (2) turbines on 8 October 2018.

The noise assessment report[4] submitted with the planning application provides the following information:

- Turbine model: Vestas V150-4.2MW with a hub height of 166 m (Section 2.2 of the MDA Jung Report)
- Applicable base noise limit for non-stakeholder receivers: 40 dB L_{A90} (Section 5.1.3 of the MDA Jung Report).

The sound power level data for the Vestas V150-4.2MW, without serrations, was sourced from Vestas' specification document No. 0067-4767 V05 *V150-4.0/4.2 MW Third octave noise emission* dated 15 March 2018[5] (supplied by BayWa).

Predicted noise levels from the Jung Wind Farm do not exceed 25 dB L_{A90} at any of the assessed receiver locations in the vicinity of the Wimmera Plains Energy Facility. The noise contribution from the Jung Wind Farm, being at least 15 dB below the base noise of 40 dB L_{A90} applicable to non-stakeholder receivers, is sufficiently low and therefore inconsequential to the noise assessment for the Wimmera Plains Energy Facility.

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3 https://www.energy.vic.gov.au/renewable-energy/wind-energy/wind-projects

4 MDA Report Rp 001 R02 20171391 *Jung Wind Farm - Environmental Noise Assessment*, dated 14 February 2018 (the MDA Jung Report)

5 This specification document is more recent than the one referenced in the MDA Jung Report, dated 13 November 2017

6.3.2 Murra Warra Wind Farm

The Murra Warra Wind Farm received planning approval in November 2016 for the construction of one hundred and sixteen (116) turbines[6]. The coordinates of the turbines were provided by BayWa.

It is our understanding that construction of Stage 1, southern section comprising thirty-four (34) turbines, is complete at the time of writing this report. The following information for Stage 1 was sourced from MDA Report Rp 004 20181019[7] (the MDA Murra Warra Report):

- Turbine model: Senvion 3.7M144 with a hub height of 149 m (Section 2.0 of the MDA Murra Warra Report)
- Sound power levels: Detailed in Table 12 of Appendix D of the MDA Murra Warra Report
- Applicable base noise limit for non-stakeholder receivers: 40 dB L_{A90} (Section 3.0 of the MDA Murra Warra Report).

The turbine model for Stage 2, northern section comprising fifty-five (55) turbines, is not currently known. For the purpose of this cumulative assessment, the Stage 2 turbines are assumed to be the same as for Stage 1.

To inform the assessment of potential cumulative noise considerations, reference is made to Clause 5.6.4 of NZS 6808:2010 which states:

> *For the purposes of 5.6.1, if the predicted wind farm sound levels for a new wind farm are at least 10 dB below any existing wind farm sound levels permitted by any resource consent or plan, then the cumulative effect shall not be taken into account.*

Additional contextual information is provided in the commentary to Clause 5.6.4 which notes:

> *If an existing wind farm sound level is say 40 dB and the predicted wind farm sound level for a new wind farm is say 30 dB then the combined level would be 40.4 dB. This increase of less than 0.5 dB cannot be reliably measured and would be undetectable to people, and will therefore not give rise to any adverse cumulative effect.*

Based on the above guidance and considering the relatively large separating distances between the Wimmera Plains Energy Facility and the Murra Warra Wind Farm, a simplified assessment of potential cumulative noise considerations can be made by comparing the predicted 30 dB L_{A90} contours from each project.

The predicted 30 dB L_{A90} contours associated with each wind farm operating in isolation are presented in Figure I2 of Appendix I. The predicted 30 dB L_{A90} contour is presented for the wind speeds which give rise to the highest noise emissions from each site respectively. It is also noted that the noise level contours are predicted on the basis of downwind propagation from each turbine; in most instances where cumulative noise is considered, a noise sensitive receiver cannot be simultaneously downwind of all wind turbines of adjoining projects. The predictions are therefore conservative for the purpose of considering cumulative noise levels.

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[6] https://www.newswire.com/news/116-turbine-murra-warra-wind-farm-granted-planning-approval

[7] MDA Report Rp 004 20181019 - *Murra Warra Wind Farm Stage 1 - Post-construction noise assessment* dated 25 November 2019 (web link)

The results demonstrate that the predicted 30 dB L_{A90} contours for each project are separated and do not overlap. Based on this finding, the following can be concluded:

- At any receiver location where the predicted noise level of one of the wind farms is between 30 and 40 dB, the predicted noise level from an adjoining wind farm will be less than 30 dB, and significantly lower in most cases
- At any receiver location where the predicted noise level from one of the wind farms approaches the 40 dB base noise limit applicable to both sites, the predicted noise level associated with an adjoining wind farm will be more than 10 dB lower. Based on the guidance of NZS 6808:2010, the cumulative effect does not need to be taken in account for the nearest receivers to each wind farm development.

The predicted noise levels therefore demonstrate that cumulative wind farm noise considerations between the Wimmera Plains Energy Facility and the Murra Warra Wind Farm are not applicable. Specifically, the noise contribution of the Murra Warra Wind Farm is sufficiently low to be inconsequential to the noise assessment for the Wimmera Plains Energy Facility. Conversely, the predicted noise contribution of the Wimmera Plains Energy Facility at the receiver locations in the vicinity of the Murra Warra Wind Farm would not affect the compliance outcome for this project.

7.0 SUMMARY

An assessment of operational noise for the proposed Wimmera Plains Energy Facility has been carried out. The assessment has been carried out on the basis of the proposed wind turbine layout comprising fifty-four (54) multi-megawatt turbines.

Operational noise associated with the proposed wind turbines has been assessed in accordance with the New Zealand Standard 6808:2010 *Acoustics – Wind farm noise* (NZS 6808:2010) as required by the Victorian Government's *Policy And Planning Guidelines for Development of Wind Energy Facilities In Victoria* dated March 2019.

Noise modelling was carried out on the basis of the Vestas V162-5.6MW candidate turbine model which has been nominated by BayWa as being representative of the size and type of turbine which could be used at the site. The results of the modelling demonstrate that the Wimmera Plains Energy Facility is predicted to achieve compliance with the applicable base noise limits determined in accordance with NZS 6808:2010.

This assessment has also considered two (2) other wind farm projects in the surrounding area. Based on an assessment of predicted noise levels for each wind farm, it has been demonstrated that cumulative wind farm noise considerations are not applicable to the Wimmera Plains Energy Facility.

The noise assessment has therefore demonstrated that the proposed Wimmera Plains Energy Facility can be practically designed to achieve Victorian policy requirements for operational noise.

APPENDIX A GLOSSARY OF TERMINOLOGY

The basic quantities used within this document to describe noise adopt the conventions outlined in ISO 1996-1:2016 *Acoustics - Description measurement and assessment of environmental noise – Basic quantities and assessment procedures*.

Accordingly, all frequency weighted sound pressure levels are expressed as decibels (dB) in this report. For example, sound pressure levels measured using an "A" frequency weighting are expressed as L_A dB. Alternative ways of expressing A-weighted decibels such as dBA or dB(A) are therefore not used within this report.

Term	Definition	Abbreviation
Amplitude modulation	A cyclical and repetitive audible rise and fall in sound pressure levels.	-
A-weighting	A method of adjusting sound levels to reflect the human ear's varied sensitivity to different frequencies of sound.	See discussion above this table.
A-weighted 90^{th} centile	The A-weighted pressure level that is exceeded for 90 % of a defined measurement period. It is used to describe the underlying background sound level in the absence of a source of sound that is being investigated, as well as the sound level of steady, or semi steady, sound sources.	L_{A90}
Centile level	The sound pressure level that is exceeded for a set percentage of a defined measurement period. The percentage is denoted N and the time is denoted as t. For example, a centile level represents the sound pressure level that is exceeded for N % of a time period of duration t.	$L_{N,t}$
Decibel	The unit of sound level.	dB
Hertz	The unit for describing the frequency of a sound in terms of the number of cycles per second.	Hz
Impulsive sound	Transient sound having a peak level of short duration, typically less than 100 milliseconds.	
Octave Band	A range of frequencies. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.	-
Sound power level	A measure of the total sound energy emitted by a source, expressed in decibels.	L_W
Sound pressure level	A measure of the level of sound expressed in decibels.	L_p
Special Audible Characterises	A term used to define a set group of Sound characteristics that increase the likelihood of adverse reaction to the sound. The characteristics comprise tonality, impulsiveness and amplitude modulation.	SAC
Tonality	A characteristic to describe sounds which are composed of distinct and narrow groups of audible sound frequencies (e.g. whistling or humming sounds).	-

APPENDIX B TURBINE COORDINATES

The following table sets out the coordinates of the proposed turbine layout of the proposed Wimmera Plains Energy Facility (data supplied by BayWa on 3 March 2020).

Table 7: Wimmera Plains Energy Facility turbine coordinates – MGA 94 zone 54

Turbine	Easting (m)	Northing (m)	Terrain elevation (m)
T1	619,688	5,950,302	140
T2	619,038	5,950,302	140
T3	618,466	5,950,616	140
T4	617,696	5,950,763	140
T5	617,200	5,950,371	140
T6	616,467	5,950,635	140
T7	615,777	5,950,339	140
T8	615,957	5,951,427	140
T9	616,748	5,951,442	140
T10	617,536	5,951,419	140
T11	618,309	5,951,457	140
T12	619,157	5,951,224	140
T13	619,810	5,950,981	140
T14	619,974	5,951,652	140
T15	620,230	5,952,297	140
T16	619,337	5,952,057	140
T17	618,376	5,952,252	140
T18	617,543	5,952,192	140
T19	616,733	5,952,185	140
T20	615,893	5,952,147	140
T21	616,080	5,952,987	140
T22	616,771	5,952,972	140
T23	617,626	5,952,957	140
T24	618,379	5,953,147	140
T25	618,970	5,952,782	140
T26	619,730	5,952,674	140
T27	617,761	5,954,323	140
T28	616,853	5,954,390	140
T29	617,333	5,954,683	140
T30	618,404	5,955,757	140
T31	617,538	5,955,364	140
T32	616,852	5,955,834	140
T33	616,593	5,956,437	140
T34	616,159	5,954,401	140
T35	614,455	5,954,338	140
T36	614,782	5,953,760	140
T37	615,434	5,953,704	140
T38	616,088	5,953,738	140
T39	615,412	5,953,002	140
T40	614,737	5,953,017	140
T41	615,031	5,952,219	140
T42	614,090	5,952,296	140
T43	613,368	5,952,328	140
T44	613,423	5,951,573	140
T45	612,695	5,951,583	140
T46	612,850	5,950,765	140
T47	611,458	5,950,302	140
T48	610,749	5,950,278	140
T49	610,429	5,949,663	140
T50	611,671	5,949,664	140
T51	611,126	5,949,257	140
T52	610,273	5,948,818	140
T53	609,512	5,948,566	140
T54	612,628	5,949,604	140

APPENDIX C RECEIVER LOCATIONS

The following table sets out the thirty-four (34) noise sensitive receivers located within 3 km of the proposed site and considered in the environmental noise assessment, together with their respective distance to the nearest turbine.

Table 8: Receiver locations – MGA 94 zone 54

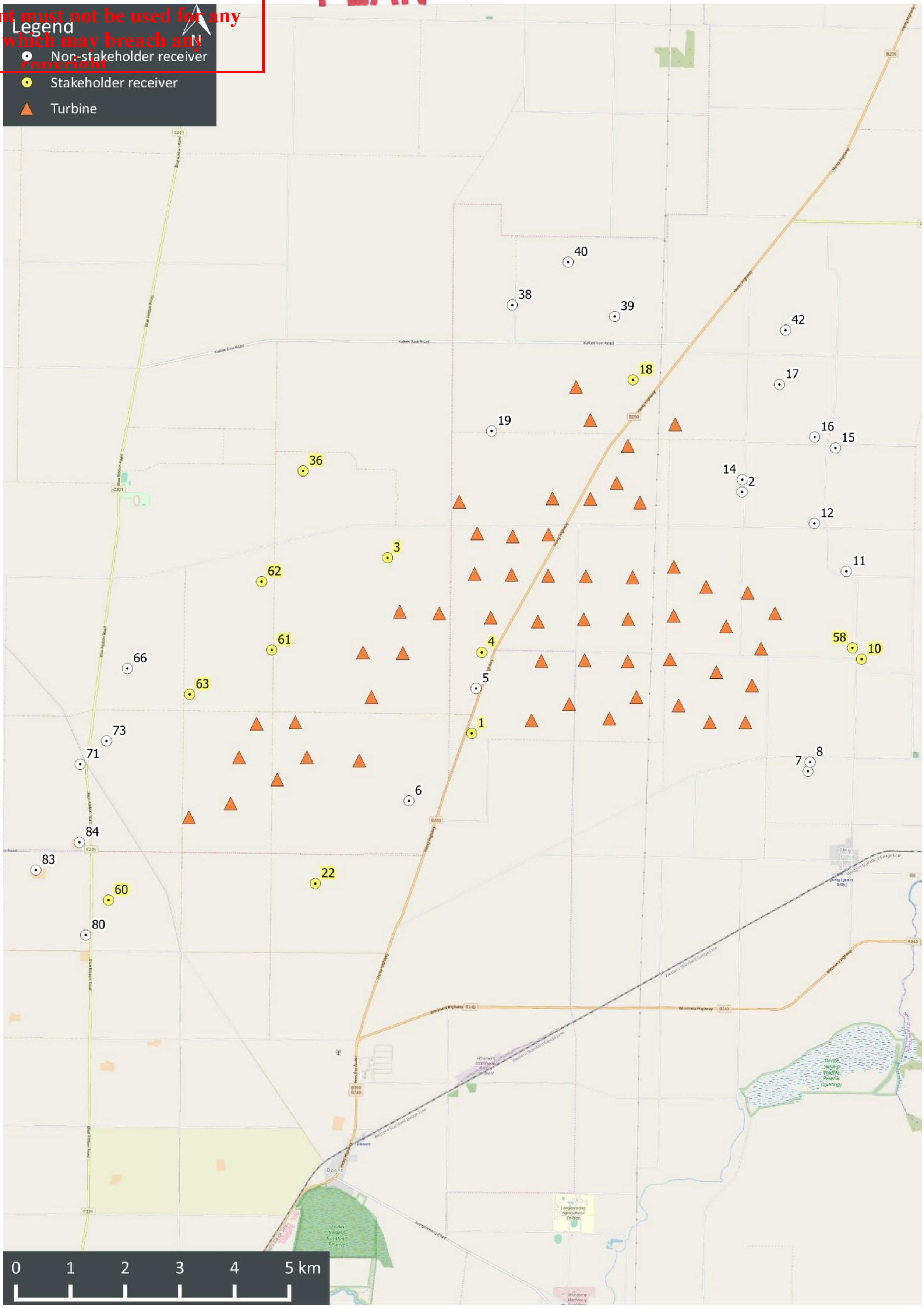
Receiver ID	Easting (m)	Northing (m)	Terrain elevation (m)	Distance to the nearest turbine (m)
1 (S)	614,683	5,950,101	140	1,132
2	619,626	5,954,517	140	1,749
3 (S)	613,143	5,953,314	140	1,024
4 (S)	614,867	5,951,583	140	677
5	614,762	5,950,924	140	1,183
6	613,536	5,948,867	140	1,181
7	620,832	5,949,409	140	1,461
8	620,871	5,949,576	140	1,398
10 (S)	621,813	5,951,460	140	1,799
11	621,535	5,953,066	140	1,524
12	620,948	5,953,943	140	1,767
14	619,632	5,954,743	140	1,601
15	621,335	5,955,324	140	2,968
16	620,955	5,955,524	140	2,567
17	620,310	5,956,485	140	2,047
18 (S)	617,633	5,956,569	140	1,061
19	615,046	5,955,633	140	1,433
22 (S)	611,823	5,947,355	140	2,032
36 (S)	611,600	5,954,903	139	2,915
38	615,424	5,957,939	140	1,911
39	617,297	5,957,730	140	1,482
40	616,448	5,958,725	140	2,299
42	620,421	5,957,478	140	2,657
58 (S)	621,646	5,951,665	140	1,560
60 (S)	608,041	5,947,051	140	2,118
61 (S)	611,026	5,951,627	140	1,387
62 (S)	610,840	5,952,878	140	2,268
63 (S)	609,525	5,950,816	140	1,348
66	608,385	5,951,289	140	2,577

Receiver ID	Easting (m)	Northing (m)	Terrain elevation (m)	Distance to the nearest turbine (m)
71	607,522	5,949,538	140	2,221
73	608,005	5,949,963	140	2,062
80	607,624	5,946,412	140	2,869
83	606,712	5,947,601	140	2,966
84	607,509	5,948,109	140	2,061

(S) Stakeholder receiver

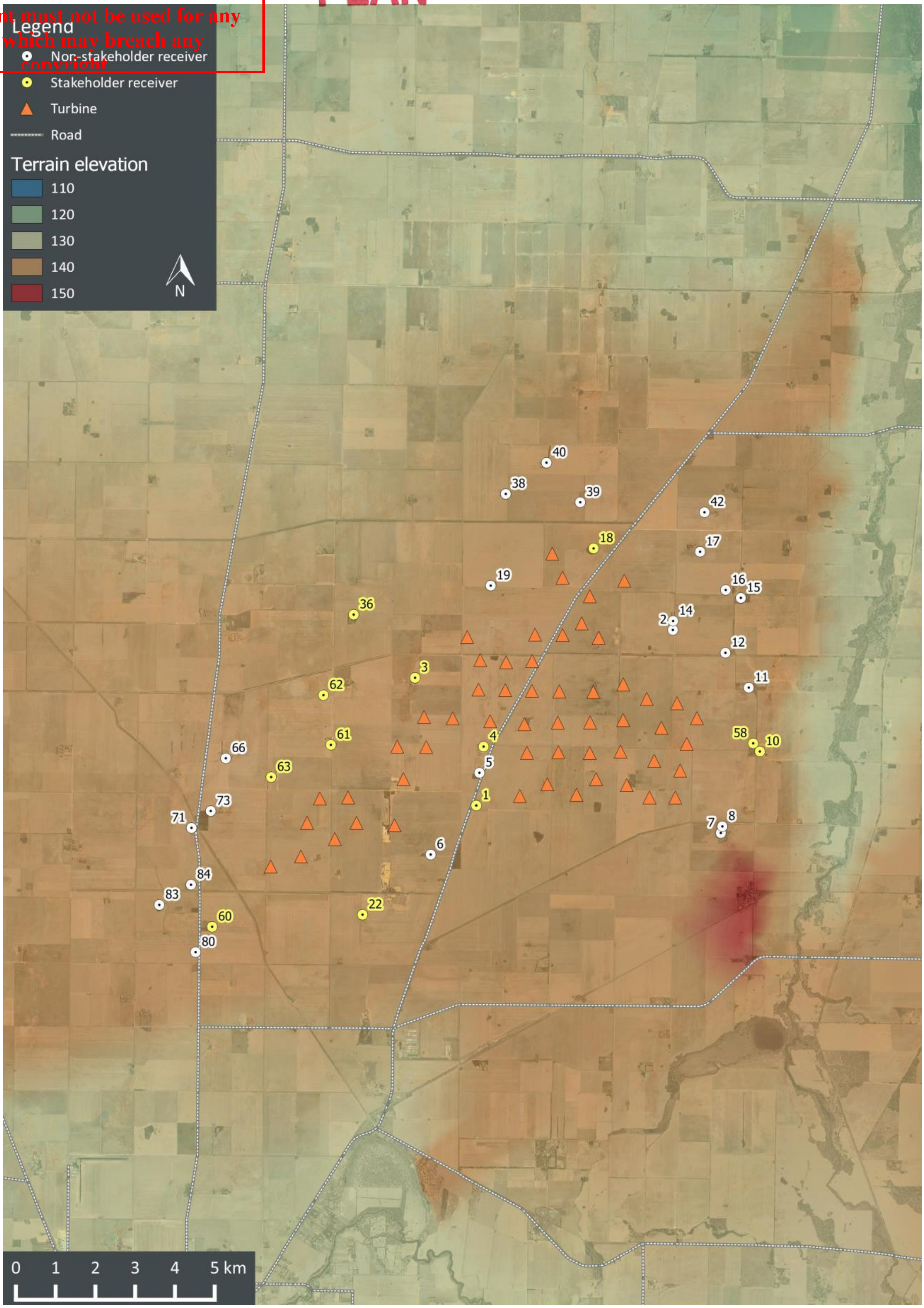
APPENDIX D SITE LAYOUT PLAN

Figure 4: Proposed turbine locations and sensitive receiver locations for the Wimmera Plains Energy Facility



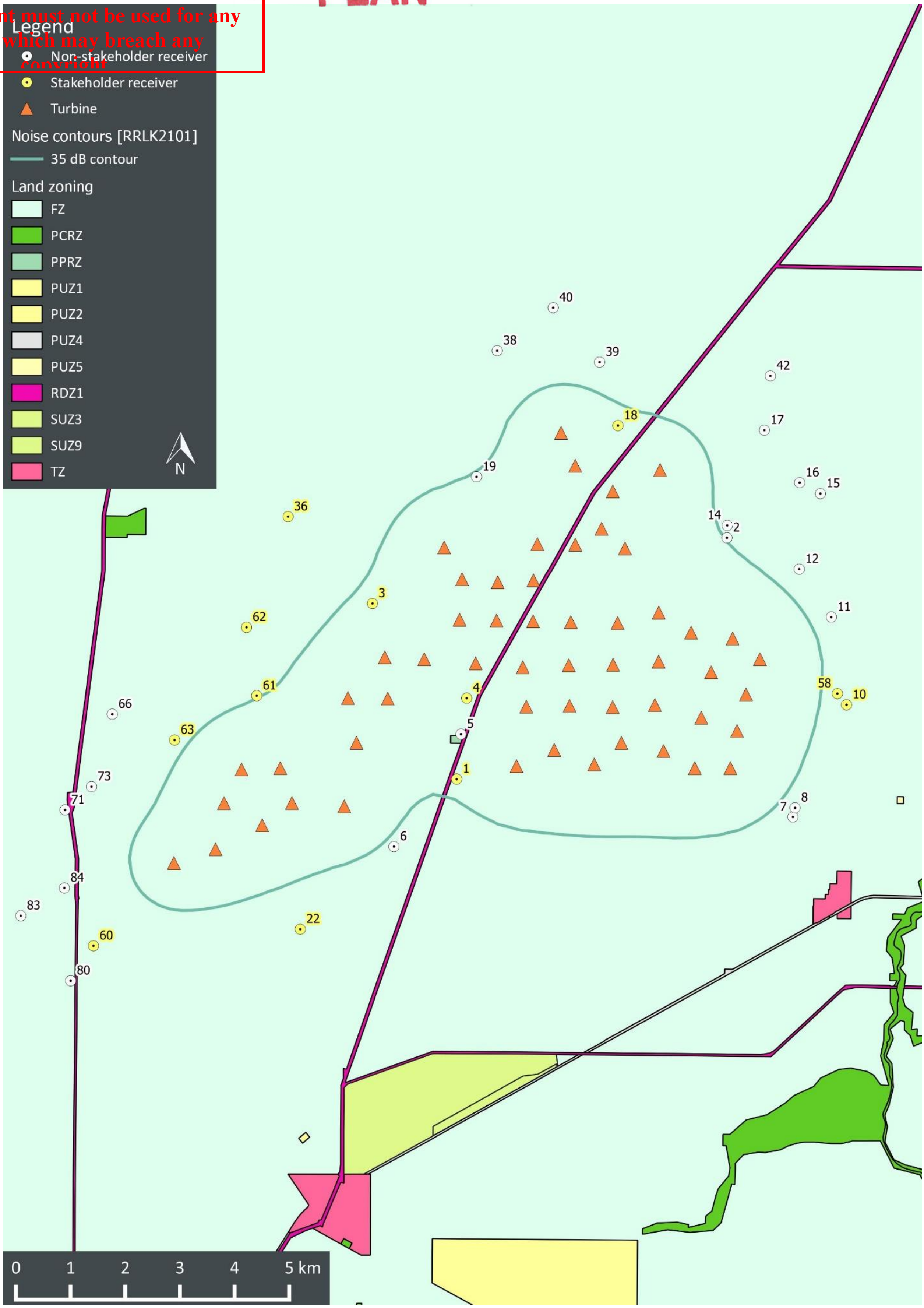
APPENDIX E SITE TOPOGRAPHY

Figure 5: Terrain elevation map for the Wimmera Plains Energy Facility and surrounding area



APPENDIX F LAND ZONING MAP

Figure 6: Land zoning map for the Wimmera Plains Energy Facility and surrounding area



APPENDIX G NOISE PREDICTION MODEL

Environmental noise levels associated with wind farms are predicted using engineering methods.

The international standard ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors - Part 2: General method of calculation* (ISO 9613-2) has been chosen as the most appropriate method to calculate the level of broadband A-weighted wind farm noise expected to occur at surrounding receptor locations. This method is considered to be the most robust and widely used international method for the prediction of wind farm noise.

The use of this standard is supported by international research publications, measurement studies conducted by Marshall Day Acoustics and direct reference to the standard in NZS 6808:2010 *Acoustics – Wind farm noise,* the South Australian EPA 2009 wind farm noise guidelines, and AS 4959:2010 *Acoustics – Measurement, prediction and assessment of noise from wind turbine generators.*

The standard specifies an engineering method for calculating noise at a known distance from a variety of sources under meteorological conditions favourable to sound propagation. The standard defines favourable conditions as downwind propagation where the source blows from the source to the receiver within an angle of ±45 degrees from a line connecting the source to the receiver, at wind speeds between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground. Equivalently, the method accounts for average propagation under a well-developed moderate ground based thermal inversion. In this respect, it is noted that at the wind speeds relevant to noise emissions from wind turbines, atmospheric conditions do not favour the development of thermal inversions throughout the propagation path from the source to the receiver.

To calculate far-field noise levels according to the ISO 9613-2, the noise emissions of each turbine are firstly characterised in the form of octave band frequency levels. A series of octave band attenuation factors are then calculated for a range of effects including:

- Geometric divergence
- Air absorption
- Reflecting obstacles
- Screening
- Vegetation
- Ground reflections.

The octave band attenuation factors are then applied to the noise emission data to determine the corresponding octave band and total calculated noise level at receiver locations.

Calculating the attenuation factors for each effect requires a relevant description of the environment into which the sound propagation such as the physical dimensions of the environment, atmospheric conditions and the characteristics of the ground between the source and the receiver.

Wind farm noise propagation has been the subject of considerable research in recent years. These studies have provided support for the reliability of engineering methods such as ISO 9613-2 when a certain set of input parameters are chosen in combination. Specifically, the studies to date tend to support that the assignment of a ground absorption factor of G = 0.5 for the source, middle and receiver ground regions between a wind farm and a calculation point tends to provide a reliable representation of the upper noise levels expected in practice, when modelled in combination with other key assumptions; specifically all turbines operating at identical wind speeds, emitting sound levels equal to the test measured levels plus a margin for uncertainty (or guaranteed values), at a temperature of 10 °C and relative humidity of 70 % to 80 %, with specific adjustments for screening and ground effects as a result of the ground terrain profile.

In support of the use of ISO 9613-2 and the choice of G = 0.5 as an appropriate ground characterisation, the following references are noted:

- A factor of G = 0.5 is frequently applied in Australia for general environmental noise modelling purposes as a way of accounting for the potential mix of ground porosity which may occur in regions of dry/compacted soils or in regions where persistent damp conditions may be relevant
- NZS 6808:2010 refers to ISO 9613-2 as an appropriate prediction methodology for wind farm noise, and notes that soft ground conditions should be characterised by a ground factor of G = 0.5
- In 1998, a comprehensive study (commonly cited as the Joule Report), part funded by the European Commission found that the ISO 9613-2 model provided a robust representation of upper noise levels which may occur in practice, and provided a closer agreement between predicted and measured noise levels than alternative standards such as CONCAWE and ENM. Specifically, the report indicated the ISO 9613 method generally tends to marginally over predict noise levels expected in practice
- The UK Institute of Acoustics journal dated March/April 2009 published a joint agreement between practitioners in the field of wind farm noise assessment (the UK IOA 2009 joint agreement), including consultants routinely employed on behalf of both developers and community opposition groups, and indicated the ISO 9613-2 method as the appropriate standard and specifically designated G = 0.5 as the appropriate ground characterisation. This agreement was subsequently reflected in the recommendations detailed in the UK Institute of Acoustics publication A good practice guide to the application of ETSU-R-97 for the assessment and rating of wind turbine noise (UK IOA good practice guide). It is noted that these publications refer to predictions made at receiver heights of 4 m. Predictions in Australia are generally based on a lower prediction height of 1.5 m which tends to result in higher ground attenuation for a given ground factor, however conversely, predictions in Australia do not generally incorporate a -2 dB factor (as applied in the UK) to represent the relationship between L_{Aeq} and L_{A90} noise levels. The result is that these differences tend to balance out to a comparable approach and thus supports the use of G = 0.5 in the context of Australian prediction methodologies.

A range of measurement and prediction studies[8, 9, 10] for wind farms in which Marshall Day Acoustics' staff have been involved in have provided further support for the use of ISO 9613-2 and G = 0.5 as an appropriate representation of typical upper noise levels expected to occur in practice.

The findings of these studies demonstrate the suitability of the ISO 9613 method to predict the propagation of wind turbine noise for:

- the types of noise source heights associated with a modern wind farm, extending the scope of application of the method beyond the 30 m maximum source heights considered in the original ISO 9613-2;
- the types of environments in which wind farms are typically developed, and the range of atmospheric conditions and wind speeds typically observed around wind farm sites. Importantly, this supports the extended scope of application to wind speeds in excess of 5 m/s.

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8 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions: The Risks of Conservatism*; Presented at the Second International Meeting on Wind Turbine Noise in Lyon, France September 2007.

9 Bullmore, Adcock, Jiggins & Cand – *Wind Farm Noise Predictions and Comparisons with Measurements*; Presented at the Third International Meeting on Wind Turbine Noise in Aalborg, Denmark June 2009.

10 Delaire, Griffin, & Walsh – *Comparison of predicted wind farm noise emission and measured post-construction noise levels at the Portland Wind Energy Project in Victoria, Australia*; Presented at the Fourth International Meeting on Wind Turbine Noise in Rome, April 2011.

In addition to the choice of ground factor referred to above, adjustments to the ISO 9613-2 standard for screening and valleys effects are applied on the basis of recommendations of the Joule Report, UK IOA 2009 joint agreement and the UK IOA Good Practice Guide. The following adjustments are applied to the calculations:

- screening effects as a result of terrain are limited to 2 dB
- screening effects are assessed on the basis of each turbine being represented by a single noise source located at the maximum tip height of the turbine rotor
- an adjustment of 3 dB is added to the predicted noise contribution of a turbine if the terrain between the turbine and receiver in question is characterised by a significant valley. A significant valley is defined as a situation where the mean sound propagation height is at least 50 % greater than it would be otherwise over flat ground.

The adjustments detailed above are implemented in the wind turbine calculation procedure of the SoundPLAN 8.1 software used to conduct the noise modelling. The software uses these definitions in conjunction with the digital terrain model of the site to evaluate the path between each turbine and receiver pairing, and then subsequently applies the adjustments to each turbine's predicted noise contribution where appropriate.

APPENDIX H TABULATED PREDICTED NOISE LEVEL DATA

Table 9: Predicted Noise Levels, dB L_{A90}

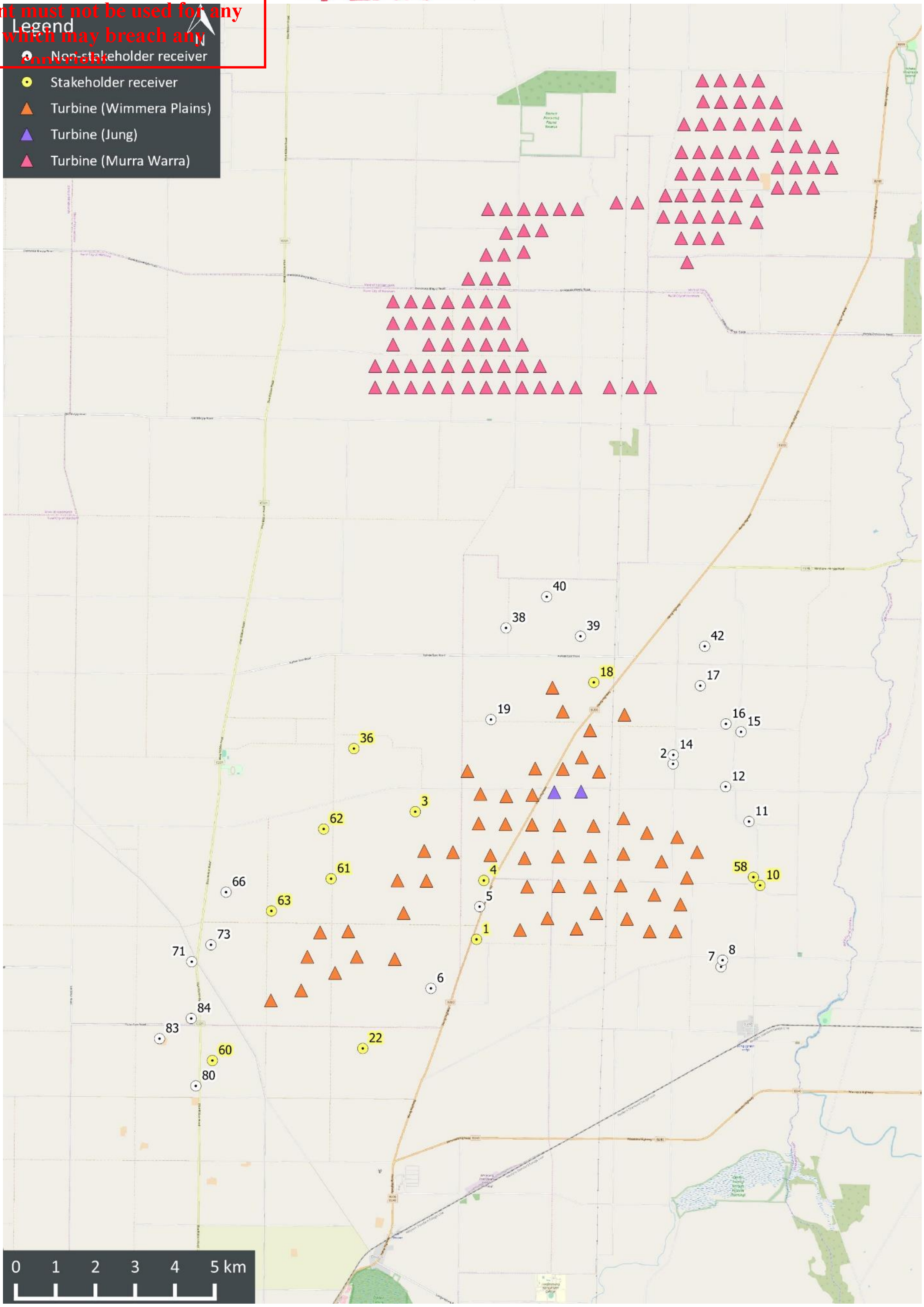
Receiver	Hub-height wind speed (m/s)						
	4	5	6	7	8	9	≥10
1 (S)	25.8	26.4	29.4	32.3	35.0	36.1	36.1
2	24.5	25.1	28.1	31.0	33.7	34.8	34.8
3 (S)	26.5	27.1	30.1	33.0	35.7	36.8	36.8
4 (S)	30.3	30.9	33.9	36.8	39.5	40.6	40.6
5	27.7	28.3	31.3	34.2	36.9	38.0	38.0
6	23.7	24.3	27.3	30.2	32.9	34.0	34.0
7	22.6	23.2	26.2	29.1	31.8	32.9	32.9
8	23.0	23.6	26.6	29.5	32.2	33.3	33.3
10 (S)	22.1	22.7	25.7	28.6	31.3	32.4	32.4
11	22.5	23.1	26.1	29.0	31.7	32.8	32.8
12	22.4	23.0	26.0	28.9	31.6	32.7	32.7
14	24.1	24.7	27.7	30.6	33.3	34.4	34.4
15	18.6	19.2	22.2	25.1	27.8	28.9	28.9
16	19.1	19.7	22.7	25.6	28.3	29.4	29.4
17	19.2	19.8	22.8	25.7	28.4	29.5	29.5
18 (S)	26.8	27.4	30.4	33.3	36.0	37.1	37.1
19	25.0	25.6	28.6	31.5	34.2	35.3	35.3
22 (S)	20.6	21.2	24.2	27.1	29.8	30.9	30.9
36 (S)	18.5	19.1	22.1	25.0	27.7	28.8	28.8
38	19.2	19.8	22.8	25.7	28.4	29.5	29.5
39	21.5	22.1	25.1	28.0	30.7	31.8	31.8
40	17.6	18.2	21.2	24.1	26.8	27.9	27.9
42	17.0	17.6	20.6	23.5	26.2	27.3	27.3
58 (S)	23.0	23.6	26.6	29.5	32.2	33.3	33.3
60 (S)	16.6	17.2	20.2	23.1	25.8	26.9	26.9
61 (S)	24.5	25.1	28.1	31.0	33.7	34.8	34.8
62 (S)	20.5	21.1	24.1	27.0	29.7	30.8	30.8
63 (S)	23.2	23.8	26.8	29.7	32.4	33.5	33.5
66	17.9	18.5	21.5	24.4	27.1	28.2	28.2
71	17.2	17.8	20.8	23.7	26.4	27.5	27.5

Receiver	Hub-height wind speed (m/s)						
	4	5	6	7	8	9	≥10
73	18.7	19.3	22.3	25.2	27.9	29.0	29.0
80	14.1	14.7	17.7	20.6	23.3	24.4	24.4
83	13.8	14.4	17.4	20.3	23.0	24.1	24.1
84	16.9	17.5	20.5	23.4	26.1	27.2	27.2

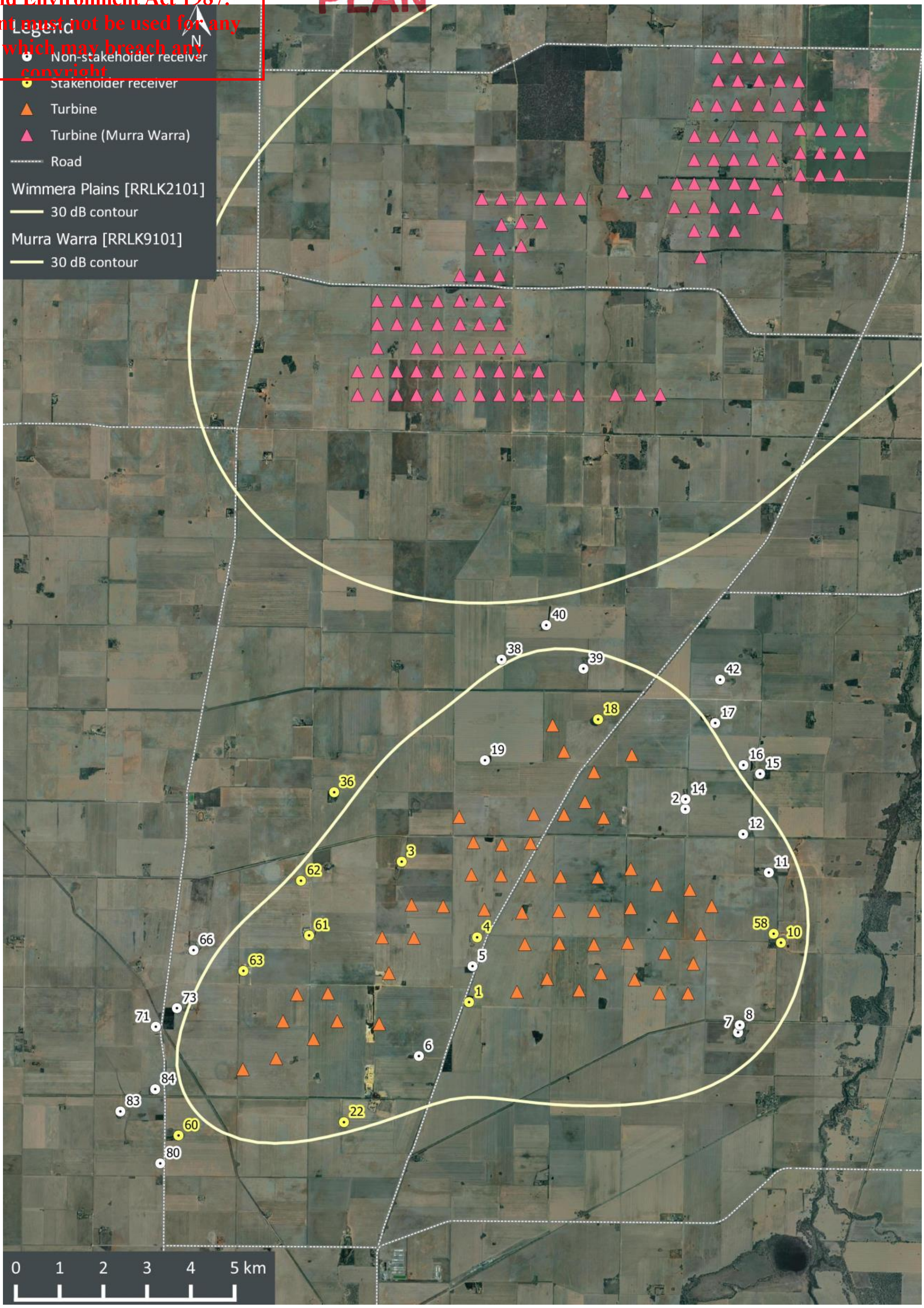
(S) Stakeholder receiver

APPENDIX I CUMULATIVE ASSESSMENT

I1 Map of wind farms in the surrounding area



12 Predicted 30 dB L_{A90} contours for the Murra Warra Wind Farm and Wimmera Plains Energy Facility



3 Predicted cumulative noise levels

Table 10: Predicted cumulative noise levels, dB L_{A90}

Receiver	Wimmera Plains only	Murra Warra only	Jung only	Cumulative	Increase over highest noise contribution
1 (S)	36.1	18.5	17.9	36.2	+0.1
2	34.8	22.7	24.8	35.5	+0.7
3 (S)	36.8	21.8	19.9	37.0	+0.2
4 (S)	40.6	20.2	23.0	40.7	+0.1
5	38.0	19.5	20.5	38.1	+0.1
6	34.0	16.9	13.5	34.1	+0.1
7	32.9	17.6	13.9	33.1	+0.2
8	33.3	17.7	14.1	33.5	+0.2
10 (S)	32.4	19.6	15.0	32.7	+0.3
11	32.8	21.0	17.2	33.2	+0.4
12	32.7	21.9	19.4	33.2	+0.5
14	34.4	23.0	24.4	35.1	+0.7
15	28.9	23.0	17.2	30.1	+1.2
16	29.4	23.3	18.2	30.6	+1.2
17	29.5	24.5	18.3	30.9	+1.4
18 (S)	37.1	25.5	23.9	37.6	+0.5
19	35.3	24.6	25.0	36.0	+0.7
22 (S)	30.9	15.0	<10	31.0	+0.1
36 (S)	28.8	23.1	14.8	30.0	+1.2
38	29.5	27.8	17.7	31.9	+2.4
39	31.8	27.1	19.3	33.2	+1.4
40	27.9	28.9	16.1	31.6	+2.7
42	27.3	25.6	15.9	29.7	+2.4
58 (S)	33.3	19.8	15.7	33.6	+0.3
60 (S)	26.9	13.6	<10	27.1	+0.2
61 (S)	34.8	19.3	12.9	34.9	+0.1
62 (S)	30.8	20.6	13.2	31.3	+0.5
63 (S)	33.5	17.8	<10	33.6	+0.1
66	28.2	17.8	<10	28.6	+0.4
71	27.5	15.9	<10	27.8	+0.3
73	29.0	16.5	<10	29.3	+0.3

Receiver	Wimmera Plains only	Murra Warra only	Jung only	Cumulative	Increase over highest noise contribution
80	24.4	11.3	<10	24.7	+0.3
83	24.1	13.6	<10	24.5	+0.4
84	27.2	14.6	<10	27.5	+0.3

(S) Stakeholder receiver

APPENDIX J DOCUMENTATION

(a) Map of the site showing topography, turbines and residential properties: See Appendix D

(b) Noise sensitive locations: See Section 2.1 and Appendix C

(c) Wind turbine sound power levels, L_{WA} dB (also refer to Section 2.3)

Sound power levels (manufacturer specification + 1dB margin for uncertainty)

	Hub height wind speed (m/s)						
	4	**5**	**6**	**7**	**8**	**9**	**10**
L_{WA} (dB)	94.7	95.3	98.3	101.2	103.9	105.0	105.0

Reference octave band spectrum adjusted to 105.0 dB L_{WA}

	Octave Band Centre Frequency (Hz)								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
L_{WA} (dB)*	76.0	86.4	93.8	98.3	100.1	99.0	94.9	88.2	78.5

* Based on octave band spectral information at 9 m/s

(d) Wind turbine model: Vestas V162-5.6MW, details provided in Table 1 of Section 2.2

(e) Turbine hub height: 166 m

(f) Distance of noise sensitive locations from the wind turbines: See Appendix Table 8 in Appendix C

(g) Calculation procedure used: ISO 9613-2:1996 prediction algorithm as implemented in SoundPLAN v8.1 (See Section 4.2 and Appendix G)

(h) Meteorological conditions assumed:

- Temperature: 10 °C
- Relative humidity: 70 %
- Atmospheric pressure: 101.325 kPa

(i) Air absorption parameters:

	Octave band mid frequency (Hz)							
Description	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Atmospheric attenuation (dB/km)	0.12	0.41	1.04	1.93	3.66	9.66	32.8	116.9

(j) Topography/screening: 10 m elevation contours provided by the proponent

(k) Predicted far-field wind farm sound levels: See Table 5 of Section 6.2 and Table 9 of Appendix H.