Department of Planning,
Housing and Infrastructure

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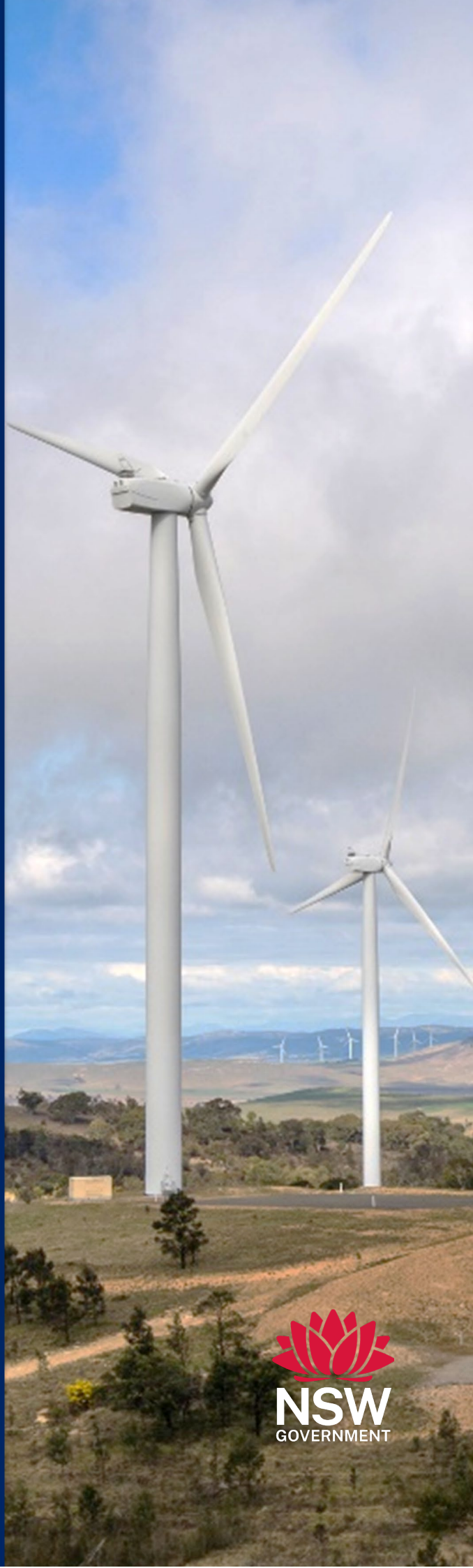
Wind Energy Guideline

Technical Supplement for Noise Assessment



November 2024

Acknowledgement of Country

The Department of Planning, Housing and Infrastructure acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land, and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Wind Energy – Technical Supplement for Noise Impact Assessment

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Glossary of terms

Term	Definition
Applicant	A person seeking consent for a development or modification application for a State significant development project under the *Environmental Planning and Assessment Act 1979,* or any person who seeks to carry out the development
Day–evening–night level (L_{den})	Day–evening–night–weighted sound pressure level as defined in section 3.6.4 of *ISO 1996 – 1:2016 Description, measurement and assessment of environmental noise*
Decibel (dB)	A unit of measure for sound level; the decibel is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage, intensity or other parameters. With sound pressure, it is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure squared to a reference sound pressure squared
Decibel A-weighted	A unit of measure for A-weighted sound pressure levels, expressed as dB(A); A-weighting is an adjustment to sound-level measurements to approximate the response of the human ear
Decibel C-weighted	A unit of measure for C-weighted sound pressure levels, expressed as dB(C); C-weighting is an adjustment to sound-level measurements that accounts for low-frequency components of noise within the audibility range of humans
Low-frequency noise	Noise with major components in the low-frequency range – 10 to 160 hertz (Hz) – of the frequency spectrum
National Park	An area of land that has been reserved for the protection and conservation of biodiversity, Australian native plants and animals, ecosystems, places of cultural significance and natural or geological features and protected by law under the *National Parks and Wildlife Act 1974*. It is separate to other types of protected areas such as Flora Reserves or State Conservation Areas

Term	Definition
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of running water sounds while talking in a busy kitchen
Receiver	The noise-sensitive location from which people can hear noise from a wind energy development
Residence	A lawful and permanent structure in a land use zone that permits residential use (or for which existing use rights under the *Environmental Planning and Assessment Act 1979* apply), where a person or people permanently reside and is not, nor associated with, a commercial undertaking, such as caretakers' quarters, hotel, motel, transient holiday accommodation or caravan park
Sector Management	Management (ie. shutting down) of certain turbines for certain wind conditions
Tonality	Noise with a prominent frequency and definite pitch
Passive recreation areas	Designated walking trails, picnic areas and scenic lookouts. For the purpose of this guideline, it does not include other parts of National Parks
SA Guidelines	Wind farms – environmental noise guidelines, South Australian Environmental Protection Authority (issued July 2009, updated November 2021)

1 Introduction

This document provides additional guidance for applicants, consent authorities, acoustic specialists and the community using the Wind Energy Guideline to understand the process and requirements for assessing noise impacts of wind energy development in NSW.

1.1 Purpose

This technical supplement provides a detailed description of the noise assessment process and includes practical guidance on how to measure and assess environmental noise impacts from wind energy projects. It ensures acceptable amenity for people living near proposed wind energy projects by establishing clear standards and noise limits.

This supplement aims to provide greater interpretation, clarity and rigour for assessing and regulating wind energy development noise, including low-frequency noise, tonality, and auditing and compliance issues. The objective is to ensure that the noise impacts of wind energy projects are appropriately identified, mitigated and managed.

This document should be read in conjunction with the more general assessment requirements in the *Wind Energy Guideline*. The Department of Planning, Housing and Infrastructure will review it over time to reflect any major changes in technology and contemporary assessment methods.

1.2 Characteristics of wind turbine noise

Wind energy projects require reliable wind resources, which typically exist in quiet, rural areas. For people living in these areas, the noise that wind energy development generates is often a concern.

To ensure acceptable noise levels for people, the NSW Government has adopted clear standards for conducting a noise impact assessment.

Assessing noise impacts from wind energy development is unique in three ways.

First, wind turbines operate under very different conditions from other industrial noise sources. Wind turbines function only when there is wind, and the noise level from each wind turbine rises as wind speed increases. The increase in wind speed also results in an equal or greater increase in the background noise level due to aerodynamic and foliage noise, which can mask turbine noise. The amount background noise increases with wind speed is generally site-specific and needs to be determined in the assessment process.

Second, the height of the noise source centre, the nacelle (which houses the machinery at the top of the wind turbine tower), is much higher than other noise sources, such as roads, railways, mines and

most industrial facilities. As a result, there is less opportunity to mitigate or shield the propagation of wind turbine noise.

Third, activities in rural areas, such as farming and agricultural practices, can generate significant noise from sources such as road traffic and farm machinery. Although noise from wind turbines is unlikely to be dominant, people may perceive the characteristics of wind turbine noise as different to these existing noise sources.

Given the unique characteristics of noise generated by wind turbines, specific guidance is warranted.

2 Assessment framework

The NSW Government has adopted the South Australia Environment Protection Authority's (EPA's) Wind farms environmental noise guidelines (the SA Guidelines [published in 2009; updated in 2021]) as the basis for assessing and managing noise from wind energy projects in NSW.

The SA Guidelines set out the methodology that applicants must follow when assessing the noise impacts of a proposed wind energy project, as well as the documentation requirements for a noise impact assessment.

However, the regional areas of NSW with high-quality wind resources are more populated than equivalent regions in South Australia. Therefore, variations specific to the NSW context that are outlined in detail throughout this document.

2.1 Scoping and preliminary assessment

Wind energy project applicants must consider the potential noise impacts of a wind energy project at all stages of the project, including during site selection and the project design phase.

As part of project scoping, applicants should conduct an indicative noise impact assessment of expected noise levels at all receivers. The scoping report and request for the Planning Secretary's environmental assessment requirements must include this indicative noise assessment.

Although the project design may change during preparation of an environmental impact statement and in the development application stage, it is important to provide early indicative noise predictions using simple modelling techniques and conservative assumptions. For example, the predictions could be made using the maximum sound power level of the likely turbines and calculated under worst-case noise propagation conditions. Applicants should compare these indicative predictions with the base criteria of 35 dB(A), unless detailed studies support more elevated criteria based on prevailing background noise levels.

2.2 Environmental impact statement

Applicants must prepare a report detailing the noise assessment and include it in the environmental impact statement they submit to the Department of Planning, Housing and Infrastructure with the state-significant development application. The report should be prepared by a competent person as defined in section 2.2 off the NSW EPA's *Approved methods for* the *measurement and analysis of environmental noise* in NSW (2022 or latest version). By this stage, applicants will need to have undertaken monitoring to determine background noise levels and modelling of the predicted noise levels of the proposed turbines.

The environmental impact statement should clearly identify the expected noise levels at all non-associated receiver locations to ensure that affected people appropriately informed about the development proposal. At a minimum, the noise impact assessment must include:

- the model used to predict the wind energy project noise levels and input assumptions and the factors used in the model, noting that noise-management mode or sector management (i.e. stopping individual turbines or combinations, or operating in low noise mode, during identified meteorological conditions) should not be used in the primary modelling or predicting of noise levels. Any modelling and predictions that incorporate noise-management mode or sector management must be reported separately
- background noise measurement locations, including the time and duration of the background noise monitoring program
- wind speed monitoring locations within the project area, heights above ground and a graphical plot of hub height wind speed versus background noise level
- a summary of the project's environmental noise criteria at each integer wind speed
- likely performance specifications of the wind turbines and their locations
- predicted noise levels at the closest non-associated residences to the wind energy project at each integer wind speed that are likely to exceed the 35 dB(A) base objective
- a comparison of the predicted noise levels against the criterion at each integer wind speed for the most affected non-associated residences to the wind energy project that are likely to experience noise levels higher than the 35 dB(A) base limit
- modifications or operating strategy that would address unforeseen non-compliances, considering the error margins of the noise model.

The Department of Planning, Housing and Infrastructure and the EPA will evaluate the noise impact assessment to determine whether it meets the requirements of the SA Guidelines and this technical supplement and whether the predicted noise levels comply with the applicable criteria (see section 3.1).

2.3 Determination and post-approval regulation

Following assessment of a wind energy State significant development application, the consent authority will determine whether the project should be approved. The consent authority will consider the noise impacts of the project alongside other environmental, social and economic considerations, including the public interest. If the consent authority grants consent, the project will be subject to conditions that include noise limits (see section 3) and a requirement to monitor the noise from the operation of wind turbines to ensure it does not exceed the relevant criteria. The conditions of

consent will also require applicants to prepare a specific compliance assessment method and conduct noise compliance monitoring.

If noise compliance monitoring indicates that noise from turbines exceeds approved noise limits, applicants must identify feasible and reasonable noise mitigation and management measures to achieve compliance, including a timetable for implementation. These measures will depend on the nature of the issue and be implemented on a case-by-case basis.

If the consent authority grants consent, applicants will also need to get an environment protection licence from the EPA before starting construction. The licence typically includes noise performance requirements.

3 Noise limits

Setting noise level objectives for wind turbines aims to retain noise levels that are compatible with surrounding land uses and ensure that noise levels do not significantly affect the lifestyle of people living in the area.

The consent authority will set noise limit conditions to ensure they are enforced over time.

3.1 Noise limits for residences

The SA Guidelines permit a higher base noise level in land use zones associated with high-intensity farming practices, and a lower base noise level in land use zones associated with residential uses. The guidelines allow this level to go higher than the base criterion if it does not exceed the ambient background noise level by 5 dB(A) or more.

The NSW Government recognises that rural land use zones in NSW are often more densely settled than those of South Australia and that there is a relatively high density of rural residential living in parts of regional NSW with reliable wind resources.

Therefore, NSW applies only the lower base noise criterion from the SA Guidelines. This criterion applies to all residential receivers and has the following definition.

Noise limits for residential receivers

The predicted equivalent noise level, ($L_{Aeq,\ 10}$),[1] adjusted for tonality and low-frequency noise, should not exceed 35 dB(A) or the background noise ($L_{A90,\ 10}$) by more than 5 dB(A), whichever is greater, at all relevant receivers for wind speed from cut-in to rated power of the wind turbine generator and each integer wind speed in between.

Although the noise criterion is based on a 24-hour period, noise readings are taken at 10-minute intervals.

Figure 1 shows the average distances at which compliance with different noise standards should occur, using other Australian and international standards as examples.

[1] Determined in accordance with section 4 of the SA Guidelines.

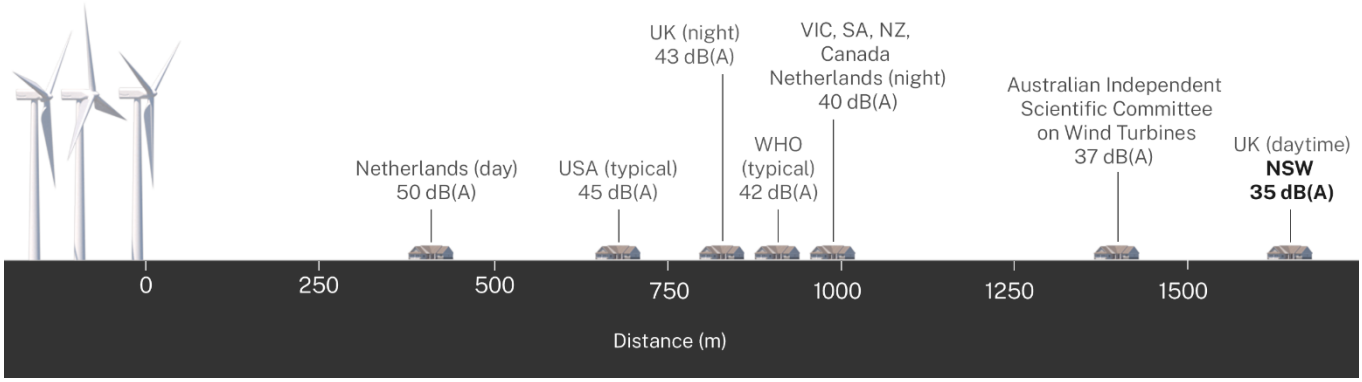

Figure 1. Distances at which compliance with different noise standards should occur[2]

3.2 Noise limits for other land uses

Wind energy projects can be in close proximity to national parks given the location of high-quality wind resources in NSW. This has the potential to impact the amenity of passive recreation areas, including designated walking trails, picnic areas and scenic lookouts. To manage noise amenity in these areas, the following criterion applies.

Noise limits for national parks

The predicted noise level, adjusted for tonality and low-frequency noise, should not exceed L_{eq} 50 dB(A) at designated passive recreation areas within national parks (when in use) for wind speed of 4 m/s or cut-in speed, whichever is greater. This criterion applies only to national parks and not to other types of protected areas, such as flora reserves or state conservation areas, as defined by a statutory source.

Projects typically meet this criterion at setback distances of 500 m.

It is rare that wind energy projects impact other non-residential receivers. In cases where projects do impact other sensitive receivers, Table 2.2 of the NSW EPA *Noise Policy for Industry* provides guidance on the acceptability of such noise to those receivers.

[2] Comparing interjurisdictional wind energy noise criteria is complex. Setback distances are indicative only and do not account for site-specific conditions that may increase or decrease the noise level, such as topography. Modelled using the ISO 9613.2 algorithm for 3 typical 6 MW turbines (with a hub height of 170 m) directly upwind of receivers.

3.3 Special noise characteristics

Although the main noise assessment criterion for wind energy projects is the base noise level, applicants need to consider alternative special noise characteristics as part of the noise assessment of any wind energy project.

Tonality

In addition to sound pressure level (measured in decibels [dB]), pitch or frequency (measured in hertz [Hz]) partially determine the way humans perceive sound. Human hearing covers frequencies from 20 Hz to 20,000 Hz and is less sensitive at low and high frequencies. Sounds that have unusually high energy levels in a relatively narrow band of frequencies may be referred to as being tonal.

Audible tonal sounds from wind turbines generally relate to rotational equipment in the turbine nacelle and can have a specific pitch depending on the rotation speed. This can cause noise to be more noticeable. These tonal characteristics (see below) typically do not occur in well-designed and well-maintained wind turbines.[3]

The SA Guidelines suggest that the tonality assessment in the International Standard IEC 61400–11 is appropriate for measurement near a turbine or that it can be modified for assessing wind farm associated tones at distant receivers. However, the NSW EPA assesses tonality with reference to the International Organization for Standardization (ISO) 1996.2 standard.

For consistency in NSW, applicants should conduct assessment, prediction and compliance of tonality objectives in accordance with ISO 1996-2:2017, *Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels*, using measured or similar representative data. The survey method in the standard's Annex K (comparison of one-third octave levels) assessed at integer wind speeds provides an acceptable screening test. It defines tonality as when the level of a one-third octave band exceeds the level of the adjacent bands on both sides by:

- 5 dB or more if the centre frequency of the band containing the tone is in the range 500 Hz to 10,000 Hz
- 8 dB or more if the centre frequency of the band containing the tone is in the range 160 Hz to 400 Hz
- 15 dB or more if the centre frequency of the band containing the tone is in the range 25 Hz to 125 Hz.

[3] Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3), EPA, Ireland (2011).

If tonality is found to be a repeated characteristic of the wind turbine noise, 5 dB(A) must be added to measured noise levels from the wind energy project. The tonal characteristic penalty applies only if the tone from the wind turbine is audible at the relevant receiver. Absence of tone in noise emissions measured at an intermediate location is sufficient proof that the wind energy project noise is not tonal at a receiver location. The assessment for tonality should only be made for frequencies of concern from 25 Hz to 10,000 Hz and for sound pressure levels above the threshold of hearing (as defined in ISO 389.7:2019, *Acoustics — Reference zero for the calibration of audiometric equipment — Part 7: Reference threshold of hearing under free-field and diffuse-field listening conditions*).

The consent or regulatory authority may require narrow band analysis using the engineering method in ISO1996-2:2017, Annex J where it appears that a tone is not being adequately identified – for example, where it appears that the tonal energy is at or close to the one-third octave band limits of contiguous bands.

Low-frequency noise

Low-frequency noise is present in all types of environmental noise and is particularly difficult to measure in the presence of wind due to the increased level of background noise. Analysis of wind turbine spectra shows that low-frequency noise is typically not a significant feature of modern wind turbine noise when it complies with the A-weighted criteria in section 3.1.

In the unlikely event that excessive low-frequency noise is a repeated characteristic – that is, noise from the wind project would repeatedly be greater than 60 dB(C) – of the wind turbine noise, dB(A) must be added to the predicted or measured noise level from the wind energy project.

Applicants need to take appropriate care when measuring C-weighted and low-frequency noise levels, as wind at microphone height can influence measured levels. Consider the performance of the selected microphone and windscreen combination, so that measurements can exclude data potentially affected by wind-induced noise across the microphone.

However, at their discretion, applicants can carry out a more detailed assessment to demonstrate that low-frequency noise is not a repeated characteristic. They must conduct this assessment using Fact Sheet C of the *Noise Policy for Industry* (NSW EPA, 2017). However, wind energy projects require minor modifications to this approach:

- the assessment must cover a 24-hour period, rather than the day, evening, and night approach of the Noise Policy for Industry,

- where the project exceeds any of the one-third octave noise levels in Table 1 (reproduced below from Table C2 from the Noise Policy for Industry) by as much as and including 5 dB and cannot be mitigated, a 2-dB(A) positive adjustment to the measured or predicted A-weighted levels applies,
- where the project exceeds any of the one-third octave noise levels in Table 1 by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to the measured or predicted A-weighted levels applies.

Table 1. One-third octave low-frequency noise thresholds (reproduced from Table C2 from the *Noise Policy for Industry*)

Unit	One-third octave $L_{Zeq,15minute}$ threshold level												
Frequency (Hz)	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Decibel Z-weighted, expressed as dB(Z)	92	89	86	77	69	61	54	50	50	48	48	46	44

Penalties for special noise characteristics

A special noise characteristic is a repeated and excessive feature if it occurs for more than 10% of an assessment period; this would be for more than 144 minutes in a 24-hour period.

The SA Guidelines add 5 dB(A) to the measured noise level only where there is tonality. In NSW, assessments must adjust the wind energy project noise level where they identify excessive levels of tonality, low-frequency noise, or a combination of both, in accordance with this technical supplement to a maximum adjustment of 5 dB(A). The noise monitoring report should report the results of these calculations.

Typically, monitoring campaigns that aim to identify special noise characteristics would be no longer than one week.

3.4 Noise from ancillary sources

Applicants must assess noise from ancillary operation sources, such as electrical substations and battery energy storage facilities, against the NSW *Noise Policy for Industry*.

4

Management and mitigation

4.1 Noise management and sector management

Noise management mode and sector management are operating strategies that applicants may use to meet noise criteria and optimise turbine performance. If applicants intend to use these strategies, they must provide the department, the EPA and any potentially impacted residents with the parameters and meteorological conditions that trigger their use as well as an auditable process by which these groups can independently confirm compliance.

4.2 Private agreements

Applicants commonly negotiate agreements with private landholders to manage impacts where projects may not achieve noise limits. This means that landholders may enter into an agreement with applicants to accept noise levels above the prescribed noise limits. Where such an agreement is in place, these receivers do not require an assessment of noise impacts. Where known, these receivers should be identified in the scoping report and environmental impact statement, including on any relevant maps.

If applicants enter into a private agreement after submitting an environmental impact statement but before a project's determination, they should provide this information to the consent authority at the earliest opportunity.

The *Private Agreement Guideline* provides additional guidance on private agreements.

5 Noise monitoring

5.1 Use of alternative or intermediate noise-monitoring locations

Once the wind energy project is operational, measuring its operational noise will be a condition of consent. During typical operating conditions, wind or other extraneous noises may partially or fully mask or substantially contaminate wind turbine noise. Measuring wind turbine noise in these conditions is often difficult and, in some cases, impossible. To conduct compliance measurements under these circumstances, NSW regulators may accept alternative techniques, which they will assess individually and on their merits.

Techniques may include using alternative or intermediate locations between the wind energy project and the relevant receiver, where the signal-to-noise ratio is much higher and for which there are well-established theoretical and empirical relationships to the relevant receivers. Applicants may use data from such sites to supplement and support conclusions from the receiver locations. In most cases, intermediate locations are chosen from predicted noise contour maps. Intermediate locations that would return L_{eq} levels of approximately 45–50 dB(A) under downwind conditions would likely be approximately 400 m from the nearest turbines. At such levels, the signal-to-noise ratio should be high enough to allow the collection of valid data under a wide range of meteorological conditions and extraneous background noises.

Where a project proposes using an intermediate assessment location, a robust transfer function between the intermediate noise monitoring point and the sensitive receivers it represents needs to be established. The site or project-specific compliance assessment method required by the consent conditions should identify any intermediate noise monitoring locations along with details of the transfer function. Where possible, intermediate noise monitoring points should be at an easy-to-access public location. Such intermediate assessment locations benefit regulators, as they can make their own indicative short-term measurements in response to complaints or queries.

5.2 Duration of monitoring

The SA Guidelines' noise compliance checking procedure requires the collection of 2,000 data points, including a minimum of 500 from the worst-case wind direction for operational wind energy projects. Experience shows that for some NSW locations, the worst-case wind direction rarely occurs. Therefore, it may be impractical to collect 500 valid data points under worst-case conditions. Consequently, data collection should continue for up to six weeks, and the valid data collected during this time will be acceptable for worst-case wind direction. However, applicants should obtain 2,000 valid data points in all cases as part of the noise assessment procedure to

demonstrate that the operating wind energy project complies with applicable noise criteria and consent conditions.

As with all statistical methods that graphically represent the relationship between a dependent variable and independent variables, the wind speed bin analysis method[4] can also produce unexpected results when there is a low number of data points within an individual wind speed bin.

Although the SA Guidelines do not nominate a minimum number of data points, International Standard IEC 61400-11 requires a minimum of 10 data points in a wind speed bin to form a valid assessment. NSW also adopts this requirement unless otherwise justified.

[4] The wind speed bin analysis method is a way of assessing wind speed that involves grouping data points into speed intervals (bins) before undertaking further calculations. This approach is consistent with the methods as discussed in *International Standard IEC 61400–11*.

6 Health effects

The scientific findings of the National Health and Medical Research Council and the advice of NSW Health continue to inform the NSW Government's position on potential health impacts of wind energy projects. The government does not require applicants to conduct a health impact assessment in relation to wind energy development and very low frequency sound known as infrasound. This is based on the findings of the National Health and Medical Research Council in 2015 that concluded that there is no direct evidence that exposure to wind farm noise affects physical or mental health, and there is currently no consistent evidence supporting a link between wind energy projects and adverse health outcomes in humans. More specifically, the council concluded that although exposure to environmental noise is associated with health effects, these effects occur at much higher levels of noise than people living in close proximity to wind farms in Australia are likely to experience.

The Australian Energy Infrastructure Commissioner (formerly the National Wind Farm Commissioner) and the Independent Scientific Committee on Wind Turbines, which the federal government established in 2015, have also produced several reports providing advice on the potential impacts of wind turbine sound on health and the environment, including *Wind turbine sound limits: Current status and recommendations based on mitigating noise annoyance (2018)*.

This report indicates that $L_{A90,10}$ (equal to 37 dB) is an appropriate maximum noise level limit to mitigate annoyance for residents. However, as section 4 of this technical supplement notes, this does not preclude a landholder from accepting higher noise levels in a private agreement with an applicant.

In 2018, the World Health Organization (WHO) released its *Environmental noise guidelines for the European Region*. This document offers recommendations including reducing noise levels from wind turbines to below 45 dB day–evening–night levels (L_{den}), as wind turbine noise above this level is associated with adverse health effects. The World Health Organization's recommended level of L_{den} 45 dB(A) is a minimum of 3.5 dB higher than the base NSW criterion and would typically be expected to equate to a level measured in NSW of approximately L_{eq} 42–50 dB(A).

The criterion in this guideline is significantly lower than the World Health Organization's recommended level and slightly below the levels that the Independent Scientific Committee on Wind Turbines recommends.

The NSW Government will continue to monitor contemporary scientific research outcomes to ensure its position reflects robust evidence on any health effects.