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Wind Farm Guidelines Consultation
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WIND FARMS

ENVIRONMENTAL NOISE GUIDELINES 2019

The issue of an updated noise guideline for wind farms in South Australia represents the third (public) attempt at the EPA to address wind turbine noise, and unfortunately still contains significant errors and omissions as to fundamental requirements with respect to the protection of the amenity of residents in proximity to wind farms.

Despite complaints from residents, and documentation in relation to such complaints, the EPA have not established appropriate criteria to protect the acoustic amenity of residents. Instead, there is a general response (for example with respect to the Waterloo wind farm) that noise monitoring found compliance with the EPA guidelines.

Matters of disturbance and impacts that residents experience as a result of the operation of wind farms have been presented to the Environment, Resources and Development (ERD) Court of South Australia, with the Court identifying that despite such matters being raised by residents the Court is required to abide by criteria issued by the South Australian EPA (*Tru Energy Renewable Developments Pty Ltd v Regional Council of Goyder & Ors*, [2014] SAERDC 48). And, notwithstanding claims of inadequacy of the guidelines the Court must consider such applications with respect to the guidelines as they represent the policy of the South Australian government.

There are fundamental issues that the EPA need to address in any revision of wind farm noise guidelines that to date have not been addressed.

As identified by the ERD Court, the EPA are the responsible authority charged to protect the acoustic amenity of residents in proximity to wind farms. Therefore, the failure to provide adequate guidelines to protect residents, and establish the basis of protection, lies with the South Australian EPA.

Acoustical consultants acting for wind farms in South Australia are quick to identify that the noise criteria have been determined by the EPA.

The introduction to the guideline identifies in the first paragraph that the guidelines are aiming to help assess environmental noise impacts from wind farms.

The second paragraph states:

The core objective of the guidelines is to balance the advantages of developing wind energy projects in South Australia with protecting the amenity of the surrounding community from adverse noise impacts. The Environment Protection Authority (EPA) has undertaken a minor technical review of the guidelines to reflect updates in international standards and multiple research works.

If one is to take the first two paragraphs of the guidelines as being accurate, then one would look to the wind farm guidelines:

- to ascertain what environmental noise impacts may occur from wind farms,
- to specify what is classified as an adverse noise impact, and
- to specify evidence based, corresponding noise levels, and quantification of noise characteristics (such as sound that is amplitude and frequency modulated), that will ensure adverse noise impacts or environmental noise impacts will not occur.

The shaded box in Section 2 identifies that wind turbines and wind farms have been operating in Denmark for over 35 years with base level set at 37 dB(A) and 39 dB(A) for noise sensitive land uses, and that limits are increase, for other land uses depending upon the windspeed.

The statement is technically correct, but has not been placed in the context of the size of the turbines (upon which the base levels were determined) nor the relevance of an increase in noise with increased capacity or size of wind turbines, or the matter of complaints that exist in relation to wind turbines even in Denmark.

The shaded box in Section 2 also refers to the New Zealand Standard setting a predicted base noise level of 40 dB(A) and also an alternative criterion based upon background +5 dB(A).



Again the text is correct with respect to the New Zealand Standard. However, the text is out of context with that Standard in that the New Zealand Standard uses background +5 dB(A) or a level of 40 dB(A), **whichever is greater**. It is also noted that the basis of the New Zealand Standard is to protect people against sleep disturbance (clause 4.4.1 in the 1998 version and clauses 5.1.2 and 5.1.3 in the 2010 version). The basis of the New Zealand Standard would appear to have been ignored by the SA EPA.

The New Zealand Standard has two versions. The first version of the Standard (1998) referred to *Community Noise – Archives of the Centre for Sensory Research Vol 2, Issue 1* prepared by Berglund and Lindvall (1995) for the World Health Organisation.

A qualification not identified in the NZ Standard is that the recommended level to protect against sleep disturbance was as a result of predominantly road traffic noise investigations. There is no information provided in the 1998 New Zealand Standard of any difference between wind turbine noise or road traffic noise. Nor is there identification in the 1998 New Zealand Standard that Berglund and Lindvall identify in section 10.6.3 that where a noise inside a dwelling contains low frequency noise then the noise criteria should be reduced. Section 7.9.6.4 of the Berglund and Lindvall report identifies that low frequency noise is common as background noise from air movement machinery including wind turbines, compressors an indoor ventilation and air conditioning units.

The 2010 version of the New Zealand Standard refers to the 1999 WHO *Guidelines for community noise* by Berglund, Lindvall and Schwela. There is no reference to wind turbines in the WHO document.

The above references re sleep disturbance are relevant in that Section 2.3 of the draft guideline identifies that even for persons having an agreement with wind farm developers (on taking out the double negatives) that there will be unreasonable interference if the likely impact of exposure results in adverse health impacts (e.g. the level results in sleep disturbance and provides insufficient amenity outdoors).

The guidelines do not identify what level of noise, or what noise characteristics, will result in sleep disturbance.

Assuming that most people will sleep indoors, then Section 2.3 identifies that sleep disturbance is likely to be considered inside as an unreasonable interference, that in turn could create an adverse health impact. Section 2.3 is silent on what is a sufficient outdoor amenity to not create an adverse health impact.

For a person who is obtaining a financial income or has an agreement with the wind farm developer the guideline does not identify what constitutes sufficient amenity outdoors.



The draft guideline (as the previous versions of the guideline) does not identify what noise levels would be applicable to residents who do not have an agreement with wind farm developers (i.e. residents who not receive an income from the wind farm developer/operator) to protect against adverse health impacts, noting that Section 2.3 gives examples of health impacts as sleep disturbance and not having sufficient amenity outdoors.

Other than the reference to the WHO 1999 guideline in the grey box in Section 2.3 or the discussion of disturbance to host, I am unable to find any other reference in the guideline that refers to sleep or sleep disturbance.

Therefore, from the above it can be seen there is a **fundamental problem** with the core objective in the second paragraph of the introduction in terms of what sound levels protect the surrounding community from adverse noise impacts.

The fundamental problem becomes more of a concern when one examines the Disclaimer to the guideline that states:

This publication is a guide only and does not necessarily provide adequate information in relation to every situation. This publication seeks to explain your possible obligations in a helpful an accessible way. In doing so, however, some detail may not be captured. It is important, therefore, that you seek information from the EPA itself regarding your possible obligations and, where appropriate, that you seek your own legal advice.

From the above discussion the disclaimer is incorrect. Or is the Disclaimer meant to negate the content of the guideline?

The guideline does not provide adequate information for any situation (other than locations more than 30 km from a wind farm) and based on the inadequate technical material as found by residents the EPA does not assist residents in relation to wind turbine noise. From a resident's perspective the question that arises from the Disclaimer is the necessity for the EPA to identify their obligation to rural communities.

There is no information to identify what wind turbine noise levels and characteristics create and adverse impact for hosts or non-hosts. Because the draft guideline notes for persons who have an agreement with the wind farm that an adverse impact is sleep disturbance (assumed inside the dwelling) or not sufficient amenity outdoors, then it becomes obvious that the guideline should provide criteria for inside dwellings separately to outside dwellings, with the qualification of what is a satisfactory or sufficient amenity outdoors and what levels of turbine noise, and noise characteristics, give rise to sleep disturbance.



Without this material provided in the noise guidelines then there is absolutely no way that any environmental assessment can be undertaken for a wind farm and identify that there will be no adverse noise impact.

In December 2016, the very issue of what constitutes sleep disturbance and adverse impacts was raised by the author (in writing) to the Wind Farm Commissioner to which there has been no response 2 ½ years later, despite requests by the author and others for answers to a series of questions.

It is appropriate with respect to these draft noise guidelines that the South Australian EPA (who are responsible for creating or permitting adverse environmental impacts to occur from wind turbines) provide a response to the following questions and incorporate the relevant data into the noise guidelines so that the community can then consider as part of draft consultation how the core objectives of the guidelines can be achieved.

1. Please provide studies upon which the wind turbine/farm noise criteria for have been developed?
2. Please identify the noise source(s) that have been used in the studies related to question 1?
3. Please provide the dose-response data related to wind turbine/farms on which the criteria are based on, and the corresponding level that represents 10% of the population that is highly affected?
4. The most common complaint from residents relates to sleep disturbance. Please provide the studies of wind farm noise that identifies the noise (in any relevant acoustic index) that gives rise to sleep disturbance?
5. Please provide studies of wind farm noise that identify the noise level (in any relevant acoustic index) that will not give rise to sleep disturbance.
6. Please provide studies of wind farm noise that identifies the noise level that would protect the acoustic amenity of residents in proximity to wind farms.
7. In light of the above please identify why the SA EPA would not be liable (in a damages claim) for the consequences of adverse impacts

It is noted that the matter of potential health impacts and the issue of sleep disturbance, was acknowledged by the Administrative Appeals Tribunal in the matter of Waubra Foundation and Commissioner of Australian Charities and Not-for-profits Commission (file 2015/4289 decision date 4 December 2017).



At paragraph 470 in the AAT decision is stated:

There are as yet no comprehensive studies which have combined objective health measurements with actual sound measurements in order to determine for a given population the relationships between the sound emissions of wind turbines, annoyance, and adverse health outcomes. Indeed there is as yet no study which has given rise to a soundly based understanding of the degree to which particular types or levels of wind turbine emissions give rise to annoyance, or what levels or types of emissions are associated with what level of annoyance in the population. Because it relied on calculated rather than actual sound measurements, and was limited to the A and C-weighted systems, the Health Canada study did not do this.

The above extract from the AAT decision is relevant in that there was no material presented to the AAT as to what constitutes an acceptable level or not create an adverse impact – which goes to the very heart of the lack of specificity in the objectives of the various versions of the SA EPA Guidelines.

There is no material to support the limits specified in the guidelines, and in light of no dose-response data for wind turbines, the matter of not identifying the precautionary principal in creating a noise guideline in relation to wind turbines is not acceptable.

In relation to fulfilling the ethical and moral obligations of acousticians to rural communities in proximity to wind farms, research has been conducted by multiple researchers including Professor Colin Hansen, Associate Professor Con Doolan, & Dr Kristy Hansen at Adelaide University & Flinders University, Dr B Thorne, Mr L Huson and the author into what constitutes the acoustic signature of wind turbines, and how it is impacting upon people. The Adelaide University researchers conducted almost all of their research at Waterloo Wind Farm in South Australia, and have published a text book as well as multiple peer reviewed published papers. There is no reference to any of that material in the bibliography to the draft guidelines that would be relevant in terms of addressing the core objectives of the subject guidelines.

In addition to the failure of the SA EPA to establish the acoustical basis of the core objectives and how the nominated levels will protect the community for adverse noise or health impacts there are technical issues in the guidelines that question the technical capability of the SA EPA to fulfil their obligations to protect the rural community from adverse noise impacts from wind turbine installations.



Environmental criteria

There is general agreement in acoustic Standards that there is a distinct different degree of sensitivity to noise by residential receivers during the night to that in the day.

There are many Acoustic Standards throughout the world in relation to industrial noise and transportation noise where there is a different weighting (for different acoustic descriptors) applied to noise events that occur in the night-time period when compared to the daytime period.

In some cases, the day may be further subdivided to cover the evening period and day, in that generally night is taken from 10 PM through to 7 AM the following morning (with some minor modifications in terms of starting and finishing times for some localities or different days).

The concept for wind turbines of using a generic criteria based upon 24-hour measurements would appear to be inconsistent with general environmental assessments, in that there is an expectation of lower background levels and therefore lower criteria for the night time periods.

Background levels at night are typically lower than in the day. Yet the draft guideline does not acknowledge this fact by providing different criteria.

Generally for a wind farm application, with respect to wind data monitoring of the wind for a proposed wind farm is undertaken over a number of years. Therefore, the concept of utilising two weeks of noise data for establishing criteria for a wind farm would appear to be inadequate and not appropriately considered by the EPA.

The difference in prevailing wind for a site or receiver location for the different seasons of the year may be significant in terms of both the assessment of the background level and the predicted noise levels. Such differences are not appropriately reflected in a regression averaging technique based upon hub height wind speeds without any identification of wind direction or seasons.

Regression Line

In the determination of noise criteria for other noise sources such as industry for transportation, the use of dose response curves determines criteria based around 10% of the population seriously or highly affected.

One concept presented in New South Wales by the EPA and Department of Planning is to establish criteria to protect 90% of the population 90% of the time and in that regard ambient background level is expressed in terms of the lowest 10 percentile of the background levels.



It is upon that lowest 10 percentile background level upon which in NSW the background +5 dB(A) limit as a general criterion is based.

The regression line analysis in the draft guideline basically provides for average background levels for approximately 50% of the time and therefore presents a different method of assessment to general industrial noise.

One can, with an appropriate dataset, determine the L90 of the ambient background level measurements by taking the results in the individual wind bins and determining the L90 of the individual bins, from which a line of best fit can be produced for the lowest 10 percentile. If one is to be consistent with protecting 90% of the people then in terms of the regression line methodology set out in the SA EPA guideline the background +5 dB(A) limit would be reduced.

It has been found for a number of wind farm compliance tests that a regression line determined at post-installation can lead to a lower background noise level than pre-installation measurements.

This is not to say that the construction of a wind farm sucks the noise out of the area, but is simply a matter of highlighting the problems with not taking account seasonal variations and/or the impact of prevailing winds when data is obtained for regression analysis.

It could also be considered inappropriate to undertake ambient background levels in summer months for rural environments where the ambient noise levels are affected by cicadas that sing on a relatively consistent basis and significantly elevate the background level.

An extended ambient monitoring over a number of months would provide sufficient data to determine regression lines for different prevailing winds and could be subdivided into both day and night assessment criteria.

Under the recurrent regression analysis method set out in the guidelines there is no identification of prevailing winds with respect to a receiver location. It is considered that identification of the occurrence of prevailing wind throughout the year and/or different seasons would therefore identify a variation in noise levels that would occur at residential receivers and may very well highlight a limited situation in terms of enhanced potential impact, or sleep disturbance where one could adopt the approach of the New South Wales EPA by consideration of prevailing winds or temperature inversion effects during winter during night time periods. When the occurrence of such meteorological conditions that can enhance sound happens for more than 30% of the nights then the assessment must take consideration of those enhancements.



The presence of wind at residential receivers gives rise to a marginal increase in ambient background level as result of wind on the microphone, but can give rise to a significant increase in ambient background level as result of wind impacting foliage (trees and bushes) in proximity to the receiver location.

If a dwelling has trees as wind breaks around the property then there may be a significant variation in the ambient noise level depending upon the proximity of those trees and the wind direction.

This presents an issue where monitoring for the wind farm developer has placed noise loggers in bushes, or has utilised a location to be representative of other locations in an area without quantifying the surrounding topography and proximity to bushes and trees for that representative location or other locations that that data is to be applied.

There is potential for trees and bushes in proximity to a dwelling to increase in height between pre-installation and post-installation, and also the possibility for trees and bushes to be removed between pre-installation and post-installation that therefore could affect the results and need to be taken into consideration.

Annoying Characteristics

Section 4.7 (Annoying characteristics) repeats the previous errors (in the current and original version of the guideline) in relation to infrasound and clearly an inadequate literature research that indicates that is not a problem.

The suggestion in Section 4.7 that amplitude modulation or low frequency noise is not expected to impact on receivers during a substantial fraction of the year is incorrect.

Annoying characteristics can enhance the concept of sleep disturbance, On -going sleep disturbance, which is identified in the WHO European night-time guidelines (2009), can result in adverse health impacts. It is not an appropriate concept of utilising a substantial percentage of the year to those residents that are impacted and unable to sleep.

There are a number of issues in relation to annoying characteristics presented in the guideline that indicates an incorrect understanding of wind turbine noise, particularly if one was seeking to satisfy the core objectives set out in Section 1 of the guidelines.

Amplitude modulation by definition is the variation in the level of a carrier frequency where the variation in the level of that carrier frequency (described as modulation) occurs due to a much lower frequency.



In the situation of wind turbines, it is the author's experience that there is amplitude modulation, for a limited portion of the audible spectrum.

For a wind turbine when one is utilising the correct terminology, amplitude modulation can be related to the output shaft speed of the gearbox (where that tone is the carrier, as a clear and distinct tone) that is modulated at the rate of the blade pass frequency. Depending upon the turbine model the carrier frequency may be at for example, 25.5 Hz, 26 Hz or 31.5 Hz. A narrowband frequency analysis of the signature reveals side bands (to the gearbox output shaft frequency) that clearly satisfy the definition of amplitude modulation ("A simplified method of determination of "amplitude modulation" of audible and inaudible wind turbine noise", 23rd International Congress on Acoustics, Aachen Germany, September 2019 available at <https://www.wind-watch.org/documents/simplified-method-for-determination-of-amplitude-modulation-of-audible-and-inaudible-wind-turbine-noise/>)

However, the audible noise associated with the "swish" or "thumping" noise is not amplitude modulation (by definition) but is a "modulation of the sound" as identified in the New Zealand Standard as a special audible characteristic. One would have expected the SA EPA to have understood the difference between amplitude modulation and modulation of the sound.

The use of the dB(A) level cannot, by definition be considered as a single frequency because it is a result of multiple frequencies. The dB(A) level can be seen to be modulated at the rate of the blade pass frequency. Therefore, the modulation (variation) of the dB(A) level cannot be called amplitude modulation. The periodic variation on the amplitude of the dB(A) is a modulation of the dB(A) level, where the modulation occurs at an infrasound rate.

Furthermore, using dB(A) and FAST response to track such signals involves a dampened time trace because of the time response of the A-weighted filter and a damping of the peak levels by use of the FAST response.

Additionally, it must be noted that determining "compliance" by use of a L90 average level would not account for the modulation of the acoustic signal.

The time signature of a wind turbine identifies a series of pulses which occur at the blade pass frequency. The blade pass frequency is in the order of 0.86 Hz for a three bladed turbine operating at 17 rpm. The 0.86 Hz "signal" is not a constant signal and does not generate a sine wave that one typically encounters in the audio world with respect to the operation of fans.



The pulsing represents transient signals. Therefore the analysis of a transient pulse will show a fundamental at the frequency of the transient pulse and harmonics of that pulse. However, in terms of the duration of the pulse the time period is less than that required by the formula of $BT=1$ where B is the bandwidth of the frequency analysis and T is the time of the analysis.

Therefore, there are questions as to whether infrasound as a concept of sound itself is generated by wind turbines (“Wind Farm Infrasound – Are we measuring what is actually there or something else?” Acoustical Society of America Meeting, Jacksonville November 2015, ASA POMA vol **25/1/10/1121/2.00001777** and “The use of synthesized or actual wind turbine noise for subjective evaluation purposes”, 23rd International Congress on Acoustics, Aachen Germany, September 2019 available at <https://www.wind-watch.org/documents/use-of-synthesised-or-actual-wind-turbine-noise-for-subjective-evaluation-purposes/>).

As such the concept of audibility or effects from infrasound as suggested in the guideline may not be appropriate. The threshold of audibility for a tone is different to that of a pulse, especially in the infrasound region.

Research work and investigations undertaken by the author (by testing conducted in a chamber that could produce infrasound pure tones down to 1 Hz) identified that there is a difference in terms of the perception of infrasound for pure infrasound tones on a constant basis versus pulsations. There is also a hysteresis effect in the thresholds (for both sensitivity and hearing) when increasing the level of infrasound versus decreasing the level (presented to the Wind Turbine Noise Working Group of the Acoustical Society of America and published in the ASA’s POMA following peer review as “Threshold of hearing v threshold of sensation for low frequency and infrasound”, Acoustical Society of America Meeting, Salt Lake City, May 2016, ASA POMA vol 26/10.1121/2.0000432.).

Additional work undertaken by the author has identified the provision of signals recorded in houses in proximity to wind farms and specifically using filters to prohibit any sound below 40 Hz into the speakers, to find that digital frequency analysis of the signal will show the presence of a signature in the infrasound region by way of the incorrect analysis of the pulsations, when in fact there is no infrasound present (Subjective perception of wind turbine noise – The stereo approach”, Acoustical Society of America Meeting, New Orleans, December 2017, ASA POMA Vol **31/10.1121/2.0000653**). The errors in the analysis have been verified by Bruel & Kjaer in Denmark, in the presence of the author.

The presence of modulating sound that has the modulation rate being less than 10 Hz is defined by Zwicker and Fastl in *Psychoacoustics: facts and models* as “fluctuation”, where there is identification that individuals do not hear the fluctuations but actually sense the fluctuations.



The suggestion in Section 4.7 of the draft guideline that annoying characteristics are not fundamental to a typical well-maintained wind farm is incorrect.

In the UK there have been efforts to define “excessive amplitude modulation” in light of the increase in annoyance that identifies the above SA EPA claim of annoying characteristics is incorrect.

Often residents complain that they hear (generally inside the dwelling but also external to the dwelling) on a continuous basis a low frequency noise when the turbines are operating, with the description typically expressed as a plane that never lands.

If an adverse impact identified for hosts involves sleep disturbance, then it is difficult to comprehend how the annoying characteristics claims in Section 4.7 of the guidelines can be justified, particularly when the guidelines do not present any criteria for sleep disturbance either as an external noise or an internal noise.

Conclusion

The development of wind farms in South Australia has resulted in the creation of a new industrial noise source that gives rise to disturbance to rural residents.

With the benefit of hindsight, it is apparent that the guidelines introduced by the South Australian EPA were not based upon actual wind turbine noise but on criteria for other noise sources without identifying the differences between those established noise source sources and wind turbine noise.

Over the ensuing period the size of wind turbines has increased and so has the impact. Therefore one questions the relevance of original work on wind turbine noise carried out in Europe on turbines with significantly lower capacity.

From the outset, the South Australian wind farm guidelines had failed to provide material that identifies how the objectives of the guidelines are satisfied, by not identifying what acoustic impacts occur or adverse health impacts that occur as a result of the operation of wind turbines.

On a statistical basis, the number of complaints from communities in proximity to wind turbines is well above the norm and as such cannot be ignored by any regulatory authority if acting to protect the amenity of residents.



The principal issue that the author has experienced in attending residential properties with respect to wind farms is that residents report sleep disturbance. There appears to be a deterioration over time for some people that are impacted. It is noted that not all people are impacted by wind turbines which is compatible with an analogy for seasickness.

The ERD Court of South Australia has identified on a number of occasions to the author that the responsibility in terms of wind turbine noise impacts that residents experience lies with the South Australian EPA.

The current guidelines and the proposed amended draft guidelines have still not addressed the fundamental issue with the core objectives by failing to provide identification of impacts noise or health impacts, as a result of wind turbines and what noise levels will not give rise to adverse impacts.

When one considers the lack of material to determine the core objectives and then views the Disclaimer to the guidelines, it is clear the SA EPA have failed to protect rural residents for adverse noise impacts as a result of approving wind turbines in terms of the criteria nominated in the guidelines.

There is a common mantra that “what you hear cannot hurt you”, which is clearly incorrect in terms of the complaints from residents and the fact that a number of residents have simply abandoned their homes and left the area, which they claim that as a result of the move their health improves.

There is often an excuse provided that there are no studies to show that wind farms create health impacts, which can also be said in the reverse case that there are no studies to show there are no health impacts. Because there is a lack of studies.

Work undertaken by the author has identified that in a laboratory situation persons who have become sensitised to wind turbines can detect the presence of a wind turbine signal even though it is inaudible (“Subjective perception of wind turbine noise – The stereo approach”, Acoustical Society of America Meeting, New Orleans, December 2017, ASA POMA Vol **31**/10.1121/2.0000653).

I am advised by persons who have been adversely affected by wind turbines to the point of having to relocate from their properties (permanently or regularly) and who have recently participated in testing undertaken by Flinders University that in terms of the sleep study they have experienced disturbed sleep.



Further work by the author in relation to the investigation of fluctuations (that is not just restricted to wind turbine noise) reveals that the presence of excessive modulation, which occurs on a regular basis from wind turbines, gives rise to a greater level of annoyance which should be added to the A-weighted levels with respect to wind turbine noise (“A simplified method of determination of “amplitude modulation” of audible and inaudible wind turbine noise”, 23rd International Congress on Acoustics, Aachen Germany, September 2019 available at <https://www.wind-watch.org/documents/simplified-method-for-determination-of-amplitude-modulation-of-audible-and-inaudible-wind-turbine-noise/>).

There is a side issue not identified in terms of the guidelines (that has been a common complaint by residents) is the concept of permitting persons involved in the acoustic assessment of wind turbine applications to undertake compliance testing. The Wind Farm Commissioner has recommended that that not be permitted and should be reflected in the guidelines.

The South Australian EPA, are responsible for the provision of inadequate wind farm noise guidelines that have failed to protect the amenity of residents. The draft guidelines need further amendments and must provide the appropriate material so as to ensure the SA EPA fulfil their statutory obligations to protect communities from adverse noise and environmental impacts as a result of the operation of wind farms.

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