THE ACOUSTIC GROUP PTY LTD
CONSULTING ACOUSTICAL & VIBRATION ENGINEERS

PEER REVIEW OF ENVIRONMENTAL NOISE ASSESSMENT

CHERRY TREE WIND FARM

42.5005.R1:ZSC

Prepared for: *Trawool Valley-Whiteheads Creek Landscape Guardians*
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Date: 12th September*, 2012*

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APPENDICES

1.0 INTRODUCTION

An application has been submitted to the Mitchell Shire Council (in Victoria) for the proposed Cherry Tree Wind Farm approximately 80 km north-east of Melbourne and 15km south-east of Seymour in, in central Victoria.

Accompanying the application is a report from Sonus: *Cherry Tree Wind Farm, Environmental Noise Assessment* dated 18th April 2012 (report ref S3768C3). This report has been posted on the Council's website.

The community has raised concerns in relation to approval of the proposed wind farm, one of the concerns being noise disturbance. The Trawool Valley-Whiteheads Creek Landscape Guardians have cited impacts from existing wind farms in Australia as evidence of potential impacts arising from the proposed wind farm and have requested a peer review of the noise report.

The Sonus document identifies the assessment is in accordance with New Zealand Standard NZS 6808:2010 "Acoustics – Wind Farm Noise".

2.0 QUALIFICATIONS OF REVIEWER

The nature of actual or perceived noise impacts associated with wind farms is the subject of wide debate throughout communities in proximity to wind farms.

To date there are conflicting arguments or claims as to noise and resultant health impacts due to wind farm operations.

In conducting a peer review it is appropriate to identify the reviewer's technical expertise to undertake such an exercise and to identify any potential conflicts.

I Steven Edwin Cooper am the principal of The Acoustic Group Pty Ltd, Consulting Acoustical and Vibration Engineers.

I have been in practice as an Acoustical Consulting Engineer for 34 years. I hold a Bachelor of Science (Engineering) degree from the University of New South Wales and a Master of Science (Architecture) being a research degree in Acoustics from the University of Sydney and am a Chartered Professional Engineer. I am a Fellow of the Institution of Engineers Australia, a Member of the Australian Acoustical Society and a Member of the Institute of Noise Control Engineering (USA).

In the course of my acoustical consulting practice I have been involved in numerous projects for private, commercial and government organisations requiring expertise in acoustics, noise and vibration issues.

Furthermore as a practising Acoustical Consulting Engineer I am or have been a member of the Standards Association of Australia Committees AV4, AV/10, AV/10/4 and EV/11 dealing with Architectural Acoustics, Whole-Body Vibration, Rail Traffic Noise, and Aircraft Noise respectively. I was a member of the Australian Acoustical Society NSW Membership Grading Committee from 1979 to 1997 and was a member of the Australian Acoustical Society Federal Grading Committee in 1998. My Curriculum Vitae is set out in Appendix A.

It is noted that in the course of my professional career I have been involved in projects where I have appeared for Applicants, Objectors, Councils, Government Departments (State and Federal) and as a Court Appointed Expert. I am not a member of any political party and have not been retained or approached by any wind farm proponents to undertake an assessment of wind farm noise.

I have extensive experience in the measurement and assessment of large industrial premises where there is a requirement to maintain compliance with specified noise limits under all weather scenarios. I have also conducted research into various acoustic issues concerning the propagation of aircraft noise and sound dispersion in enclosed spaces that has questioned the status quo of various Standards or acoustic texts leading to modification/amendments to Australian Standards and International guidelines.

Whilst I have not been engaged by any wind farm applicant to undertake an acoustic assessment or compliance testing of planned or operational wind farms, I was requested late last year by a community group opposing a proposed wind farm at Flyers Creek (in NSW) to review an application.

I prepared a desk top review of the acoustic assessment that had been prepared for the Flyers Creek Wind Farm. The acoustic assessment of the Flyers Creek Wind Farm was based upon guidelines issued by the South Australian EPA.

My desk top audit was contained in a submission from the Flyers Creek Wind Turbine Awareness Group ("FCWTAG") in relation to the proposed Flyers Creek Wind Farm. The desk top review raised issues as to the ambient background levels, the predicted noise emission levels and the absence of an assessment of the noise impact of the proposed wind farm.

The desk top review was supplemented by preliminary noise testing in proximity to the Capital Wind Farm (in NSW) to experience first-hand wind farm operations and conduct sound level measurements. The preliminary testing highlighted a number of issues with respect to the assessment and evaluation of wind farm noise where currently the predominant acoustic descriptor is the dB(A) level.

I found at times there to be no audible noise inside or outside residential dwellings, whilst on other occasions I was able to detect wind farm noise both outside and inside dwellings.

My testing identified the possibility that noise originating from the wind farm could affect individuals and that further testing/investigations were required as set out in my review of the Flyers Creek Wind Farm application (available on the NSW Department of Planning website).

The NSW Department of Planning issued in late 2011 a draft set of wind farm guidelines for public comment ("the NSW Guidelines). The NSW guidelines are more stringent than the SA wind farm noise guidelines.

As part of my review of the draft NSW guidelines I undertook further measurements and analysis of wind farm noise (Capital, Cullerin and Woodlawn wind farms) to research wind farm noise and assess the practicality of compliance testing as set out in the draft NSW Guidelines.

I prepared a technical submission on the draft NSW Guidelines. I was not engaged by any party to prepare my submission, but as it relied upon previous material prepared for the Flyers Creek submission, my review of the draft NSW Guidelines was added to the Flyers Creek community submissions (available on the NSW Department of Planning website).

As part of my on-going investigations into wind farm noise I have attended residential properties and public roads in proximity to Waterloo and Hallett wind farms (in South Australia) and Cape Bridgewater, Glenthompson and Waubra wind farms (in Victoria) in order to place in context claims of excessive noise/impacts from those wind farms.

As experienced for the NSW wind farms I have attended, at some sites in South Australia and Victoria there was clearly audible noise from the wind farm, at other sites some noise was audible, whilst at other sites there was no audible noise.

In the reporting of wind farm noise, there are claims and counter claims as to bias in the presentation of data which is a fundamental issue to be addressed prior to this peer review.

As a Member of the Australian Acoustical Society (the "AAS") and a Fellow of the Institution of Engineers Australia I am required to abide by the Code of Ethics for those two organisations.

Appendix B provides a copy of the Code of Ethics of the Australian Acoustical Society.

If there is potential for an industry to jeopardise the welfare, health or safety of the public, or affect the well-being of the community I am duty bound to identify those issues under the Code of Ethics of the Australian Acoustical Society.

The AAS Code of Ethics requires that the acoustical assessment in relation to a wind farm is accurate and contains all the relevant material. This is the obligation placed on the acoustician. The acoustician has a heavy professional obligation and should be neither pro nor anti wind farm in approach.

In light of matters raised the community concerning acoustic assessments that have accompanied wind farm applications and "acoustic compliance tests" of wind farms I have prepared a technical discussion paper "*Wind Farm Noise – An ethical dilemma for the Australian Acoustical Society?*" that was published in the August issue of the society's journal "Acoustics Australia" – see Appendix C.

I approach all my work in accordance with my professional Code of Ethics. Contrary to misleading statement made by some wind industry representatives I make the specific statement in conducting this peer review that **I am not anti-wind farm**.

Any project, be it an industrial application or a wind farm, should operate without giving rise to disturbance, health effects or adverse impacts on the community. If it can do so then, from a noise point of view, it may be permitted.

In relation to the Sonus report that I am peer reviewing there is no indication of the author(s). I am aware of some of the Sonus staff and their professional qualifications who are Members of the Australian Acoustical Society. If however the author(s) of the report are not members of the Australian Acoustical Society then the report is required to accord with the Code of Conduct from the Association of Australian Acoustical Consultants of which Sonus Pty Ltd is identified as a member firm.

3.0 THE SONUS ASSESSMENT

3.1 Outline

The Introduction of the document indicates the assessment was undertaken in accordance with the 2010 version of the New Zealand Standard "Acoustics – Wind Farm Noise" where the base level for noise assessment had been set at 40 dB(A).

Reference is made to a lower base limit of 35 dB(A) for residences situated in high amenity areas. Sonus consider the wind farm being located with a "Farming Zone" does not constitute a high amenity area. I am advised residents of Trawool Valley take exception to the Sonus view the area is not of high amenity in that they have particularly noted the quiet nature of the area that is considered by the residents to be a high amenity.

With respect to land owners with commercial agreements upon which Turbines are located (normally identified as a "host") the Sonus report nominates noise criteria based on WHO guidelines for an indoor level of 30 dB(A) to protect against sleep disturbance.

The relevance of the WHO guidelines for determining noise impact of a wind farm in a rural environment is questioned in that in the WHO guidelines relate to noise disturbance in suburban areas as a result of traffic.

The assessment has been based on sixteen 16 Vestas V112-3MW wind turbines with hub heights up to 100 m.

The *Environmental Assessment Volume 1/Main Report* (the Main Report) prepared by Aurecon identifies on page 1-2 that the wind farm will have a maximum installed capacity of up to 56 MW of electrical power from the combined output of 16 wind turbines generators, each with a rated generation capacity of up to 3.5 MW.

There is a note on the bottom of page 1-2 that the rated capacity of up to 3.5 MW should not be excluded if turbines become available with a greater capacity.

The Sonus report makes no mention of turbines of 3.5 MW capacity or greater would seem to rely upon a motherhood statement that if an alternative turbine is selected it would be rated on the basis of sound power (noise) levels equal to or less than the V112 turbines (3MW) that were assessed.

The Main Report identifies in Section 6.3 that under the Mitchell Planning Scheme the proposed Cherry Tree Wind Farm is subject to relevant policies from the State Planning Policy Framework.

Page 6-19 of the Main Report refers to state Planning Policy Framework Clause 13.04-1 to noise abatement to ensure that the "community amenity is not reduced by noise emissions".

The response in the Main Report to clause 13.04 (that is not identified in the Sonus report) is that the "proposed Cherry Tree Wind Farm will not result in any significant loss of amenity as a result of acoustic impact".

The Sonus report indicates that ambient background noise monitoring was conducted in November & December 2011 with measurements being conducted in accordance with the New Zealand Standard. The documentation indicates the measurements were conducted using Rion NL21 Type 2 sound level meters claiming that the noise floor of the meters is less than 20 dB(A).

Page 4 refers to background levels in terms of $L_{A\ 90,\ 10\ min}$ which is the standard tie period of measurement for wind farm assessments.

Table 3 provides background noise levels at 3 monitoring locations referenced to the wind speed at a height of 80.4 metres above ground level at the wind farm site. The text below Table 3 indicates that with respect to residential dwellings that were not the subject of ambient monitoring the approach has been to utilise the lowest measured background level that any of the 3 locations.

Examination of Table 3 indicates that for wind speeds at a nominal turbine hub height of 80 metres would utilise the results from location R75 for wind speeds less than 7 metres per second, and the results from location R42 for wind speeds equal to or greater than 7 metres per second.

The assessment of the sub-station noise is undertaken in accordance with the *Noise from Industry in Regional Victoria* guidelines issued by Victorian EPA which looks to impose a noise criterion of 36 dB(A) Leq for night time operations. This therefore indicates that the noise limit applied to the sub-station is lower than that applied to the wind farm, i.e. industrial noise is set at a level lower than that for wind turbines.

The Sonus report indicates that the noise source level used for the turbines has been supplied by the manufacturer and that the turbines used in the assessment have not been assumed to contain tonal components. The report recommends that a guarantee is sought that the Manufacturers achieve a “tonal audibility” ($\Delta L_{a,k}$) of 0 dB(A) when assessed in accordance with International Standard IEC 61400/11.

The sound power levels shown in Table 10 provide the octave band data in A-weighted format, not linear (un-weighted) levels.

The assessment identifies the noise modelling was conducted using ISO 9613 being based on *meteorology conditions favourable to propagation identifying conditions for downwind propagation …. or, equivalently, propagation under well developed moderate ground based temperature inversion.*

The Sonus report identifies that the propagation parameters were based upon an article provided in the (UK) Institute of Acoustics Vol. 34 No. 2 March/April 2009 being inputs agreed by wind farm advocates for the purpose of assessing the A-weighted noise level.

The results of the computer analysis is provided in Appendix E and compared with the criteria derived by Sonus for the subject application. A graphical presentation of the predicted noise contours is set out in Appendix F.

Examination of Appendix E indicates that for the majority of the residential locations that have been assessed the predicted noise levels from the operation of wind farm are generally less than 30 dB(A) and it is only at higher wind speeds in the order of 10 metres per second that there are levels above 30 dB(A), except for residential locations R37, R70 & R71 that would appear by reason of the criteria being set at 45 dB(A) would be deemed to be hosts.

The predicted levels are less than the derived criteria – leading to a claim of compliance with the guidelines.

The sound power level for the transformers in the substation is not related to any specific transformer but would appear to be a generic level derived from Australian/New Zealand Standard AS60076.10:2009.

The assessment of the substation noise emission claims the substation noise is 14 dB(A) at residence R70 and as such will not adversely impact on the amenity of residences in the locality of the wind farm.

Substations emit low frequency noise and tonal noise that enhances the audibility of the noise and requires a correction to the measured level. Residents in proximity to wind farms complain about noise from the substation that interferes with their rest and repose.

Page 12 indicates that the actual location of the sub-station has not been finalised and that flexibility in the location is desired. The report indicates that based upon the predicted noise level then the location can vary anywhere within a 1 kilometre radius of the nominated location whilst maintaining compliance with the NIRV and the New Zealand Standard for residences. However, the relocation of the sub-station will result in different noise levels than that have been predicted and may or may not include an increase or decrease in attenuation due to shielding that could alter the noise emission level.

In industrial applications in NSW, if an environmental assessment nominates a noise emission level from the industrial source then the appropriate conditions of consent reflect that noise level or marginally above that noise level as a noise target so as to maintain the claims of noise impact set out in the Environment Assessment.

The report acknowledges that Infrasound is generated by turbines and refers to an audibility threshold of 85 dB(G) with reference to a draft guideline issued by the Queensland Department of Environment and Resources Management.

The Sonus report states:

> "*… measurements from a large range of measurements from modern upwind turbines indicates that as distances of 200 metres, infrasound is in the order of 25 dB below the recognised perception threshold of 85 dB(G). A 25 dB difference is significant and represents at least a 100 fold difference in energy content.*"

There are issues with the relevance of the above claim, particularly as there is a difference between an energy difference and a loudness difference. The above statement is of no assistance to residents in comprehending the acoustic impact of the proposed wind farm.

An energy difference is normally related to a power output, not loudness. In acoustic terms a 25 dB difference is related to an energy difference of 316 not 100. The change in energy does not relate to the same change in loudness.

As the quote is referencing a difference in perception (i.e. loudness) then presenting information in terms of energy content is meaningless and suggests the Sonus quote is misleading.

In the audible range a 10 dB difference is considered to be a subjective difference in loudness of 50% (as a reduction) or twice as loud (as an increase). A 25 dB difference in subjective loudness approximates a sound less than 20% or about 5.5 times as loud as the original sound. 25 dB is definitely not a 100 fold difference in loudness.

When dealing with infrasound the change in dB level is not the same linear relationship described above when compared to the audible frequencies. There is no material to relate to loudness levels (perceived or otherwise) for infrasound.

Furthermore there is a technical issue as to the suitability of 1/3 octave band FAST response measurements for the infrasound region in view of the time constants associated with such filters versus the timing response of the human ear. When dealing with the maximum level in the infrasound region the resultant levels are much higher than the levels obtained using rms FAST response (ref Dr M Swinbanks).

The claim as to natural sources of infrasound including wind and breaking waves has been questioned as a result of various measurements, particularly as discussed later in the report the difference between the use of 1/3 octave in narrowed band analysis that identifies a unique signature or pattern associated with turbine noise. The natural sources of infrasound that occur in the natural environment do not contain specific signatures or periodic patterns and as such infrasound from natural sources results in a different impact to that from wind farms.

A separate issue in relation to infrasound is not the matter of what constitutes an audible noise but whether the presence of the infrasound creates an impact on residents that they may feel rather than fear.

3.2 Analysis

The Sonus report is similar to that provided by that organisation for other wind farms and would appear to fall into a generic type of report. There are a number of issues arising from this generic approach.

One issue of concern in relation to the generic type of noise assessment prepared for the subject wind farm is that there is a conflict between the title of the report and the contents of the report.

The report is titled "Cherry Tree Wind Farm Environmental Noise Assessment" yet the report has not actually identified the noise impact that will be generated by the proposed wind farm. This would appear to be a fundamental failure in the obligations of the author(s) of the acoustic assessment i.e. a failure of the obligation to provide a meaningful document in relation to actual noise impacts that the community can understand.

The acoustic assessment has not explained to the community the impact that the proposed wind farm will have upon the existing acoustic environment of the area nor whether the operation of the wind farm will affect their daily activities or their night time sleeping patterns. Complaints from residents in proximity to other wind farms frequently refer to sleep disturbance.

The ambient data reveals the existing acoustic environment of the area is significantly less than the base level of 40 dB(A). This automatically raises the question of "What is an acceptable noise impact from the proposed wind farm?" This is not an exercise that has been carried out in the subject assessment.

It would appear that the acoustic report considers that the description of the acoustic impact is satisfied by identifying compliance with a noise target set out in the NZ Standard. However, any experienced acoustic engineer would be aware that generating a noise which is significantly greater than the existing ambient background level of an area can create an impact which should be assessed.

The regression analysis curves reveal a significant degree of variation in background noise levels at individual wind speeds referenced to 80 metre above ground level at the proposed wind farm.

The regression analysis method set out in the report does not differentiate between the background levels that occur at night versus the background levels that occur in the day. One typically expects night time background levels to be lower than in the day.

Therefore if one was seeking to conduct an assessment of the impact of the wind farm on the community, it would be appropriate to differentiate between the acoustic environment that exists in the day versus that in the night.

The regression analysis does not continue below the cut-out speed to indicate the natural ambient background level of the environment. Nor do the graphs show the full extent of the ambient noise in the area.

Whilst the report claims the same instrumentation was used for background monitoring at various locations, the graphs for R42 and R70 to have a threshold limit around 20 dB(A), whilst house R20 that has a much higher ambient noise floor.

Examination of the graph for R42 would suggest that there should be two regression lines if one considered night versus day in that there is distinct difference in terms of the data that would suggest the night time background level from the cut in speed to say 12 metres per second is less than 25 dB(A). This leads one to examine the relationship of the loggers to the surrounding environment.

Examination of the logger photos on pages 18 & 19 of the report reveals location R20 is relative proximity to large trees that, dependent upon the prevailing wind direction could give rise to an enhancement of the ambient noise at that site. Location R42 would appear to be devoid of trees in proximity to the logger and therefore highlights the significant differences in ambient levels to R20.

R75 again shows a substantial range of background levels. The results show low background levels even with moderate wind at the wind farm location and a similar gap in data as for location R42 that could suggest lower night time background levels.

Photos provided by residents of the logger installation R75 from a different perspective to that shown in the Sonus report identify the location of a weather station to the right of the logger position and indicate the presence of substantial trees to either side of the logger location. The presence of a substantial row of trees to create a windbreak could therefore result in a significant range of apparent background levels so nominated in the Sonus report depended upon the wind direction.

As the assessment only utilised 3 logger locations to then apply the background noise levels at a multitude of residential receptors then the identification of the true ambient background level and the relevance of residential locations with or without trees in proximity to the those residences will automatically affect the identification of the true ambient background level.

The absence of wind data at the microphone (separately to, or supplementary to the 80m high wind data at the wind farm site) does not resolve the questionable data for loggers.

If, for example, the ambient background level used for the assessment of industrial noise looks to wind speeds less than 5 m/s at the microphone and selects the lowest 10 percentile of the background levels. The lowest 10 percentile of the background levels will obtain a lower value than the average line in the regression analysis used for the operational "background" level.

Accordingly, one has a "background" level for the area different to the "background" level for the assessment of the operation of a wind farm.

The graphs in Appendix D of the Sonus report reveal background levels below the regression line. A substantial number of data points are shown at the noise floor of the meter. This means that one can have background levels below the floor level of the meter.

If the regression lines are extrapolated to identify the background level (for the area) prior to the cut in speed then one would expect a lower background level to prevail. Similarly of the data was presented just for the night time measurements, which tend to be the critical time of concern to residents, then one would automatically expect a different regression curve.

For example at location R42 of the gap in the data would suggest the night time background level of 20 dB(A) for the turbine height wind speed of 5 m/s. If the true ambient background level is below that of the noise floor then the regression line either on the total data points or just the night time data points must also be lower.

If one assumes that the wind farm ambient background level of the area from the regression analysis is around 20 dB(A) at the cut-out speed, then it is an undeniable fact that wind farm noise at the nominal limit of 40 dB(A), would be clearly audible both inside and outside residential dwellings and would represent a significant impact in terms of the existing environment. Similarly even a contribution from the wind farm of 30 dB(A) would be clearly audible both outside and inside residential dwellings when one considers that the noise level detected by residents in proximity to wind farms is that of a low frequency noise which is not necessarily identified in the dB(A) value.

If one was to identify to the community there would be no impact/an impact /an adverse impact or severe impact from the proposed wind farm it would be appropriate for the report to discuss the relevance of the predicted noise levels versus the regression curve and/or the minimum background levels that relate to the various wind speeds.

Bearing in mind that the Sonus report does not discuss the actual acoustic impact of the proposed wind farm and has not identified the acoustic amenity that residents receive then it would appear the claim set out on page 6-20 of the Main Report that the wind farm will not result in any significant loss of amenity as a result of acoustic impact is one that must be attributed to Aurecon and not attributed to Sonus.

In addition to the above, in seeking to inform the community as to the noise impact of the proposed wind farm it would be appropriate to identify whether the assessment of noise is conservative and/or the extent of variation that may occur in such noise propagation.

The acoustic assessment purports at times to indicate that a conservative approach has been adopted in assessing the predicted noise emission levels but would not appear to identify the variation in noise levels that would occur as the result of weather conditions when compared to a worst-case scenario of propagation.

For example, one can have the turbines operating whilst at residential receivers there is absolutely no wind, which is not a situation identified in the acoustic assessment.

The Sonus report has not identified the relationship between the wind speed at the nominal hub height versus the wind speed at receiver locations. There is therefore no correlation with the predicted noise levels under the wind scenarios that have been assessed, nor identification of the difference in propagation for different wind directions. Nor is there identification of the frequency of the occurrence of adverse meteorological effects which could be identified in a generic term as temperature inversions, separately to the more detailed and complex analysis attributed to the van den Berg effect.

It is quite likely that such an analysis could show a range of noise levels and identify to the community that for a certain percentage of the time the wind farm would be inaudible/barely audible/clearly audible. Such an analysis would provide a clearer interpretation as to the acoustic impact of the proposed wind farm.

Whilst there is identification substation would not create an impact because its noise contribution is similar to or below the background level there is no such statement as to the impact of the wind farm.

For example the Sonus report could have identified that for some operating wind speeds in their opinion the audible characteristics of the wind farm would result in audibility or barely audible at residential properties. Whilst at other locations the wind farm would be clearly audible. Such a description would assist the community in comprehending the impact of the proposed wind farm.

In discussing the evaluation of high amenity areas in section 5.3 of the NZ Standard there is a suggestion to consider background sound levels in the evening or night time periods and for comparison of the predicted noise levels with those background levels to evaluate the use of a high amenity noise limit. That exercise is not been undertaken in the Sonus report by that organisation forming the view that the residence in the subject area to not consider there are acoustic amenity as being high.

It may very well be that if the Sonus report had considered the actual (real) background levels in the day, evening or night time periods then for some locations there could be no issue in the day, but an issue at night that could be resolved by not operating the turbines at night.

The predicted noise levels must have some degree of tolerance by reason of the noise source data and the variability in the assumptions made for propagation and local effects that could alter the predicted noise levels. Appendix C to the NZ Standard identifies it is good practice to state the uncertainty and confidence level four or sound levels determined in accordance with Standard. That does not appear to have happened in the Sonus report.

The assessment report has failed to identify the potential audibility of turbine noise outside or inside residential dwellings, which therefore is a significant failure of the report in providing appropriate advice to the community as to the likely acoustic impact. The community called understand the concept of hearing a noise versus not hearing a noise, whereas the NZ Standard specifically identifies that it is not dealing with audibility of the wind farm. Yet the position of the Standard that is being used by Sonus in relation to audibility has not been identified.

Section 4.3 of the Main Report refers to community engagement by way of two community information days held in December 2011. Photograph two identifies a sound system that may well have been used to "identify" to the community the noise from a wind farm.

After the community meeting held in Wellington by Bondangara Wind Turbine Awareness Group to provide information to the community in relation to a proposed wind farm, the applicant "Infigen" had set up on the opposite side of the road a "demonstration" for the community of wind turbine noise with markings on the footpath at various distances nominating dB(A) noise levels from the "wind farm". When one examined the basis of the "demonstration" the validity of the "demonstration" is questioned.

The "demonstration" failed to identify the nature of the existing background level at the time and therefore the relevance of the "demonstration".

If one acknowledges the ambient background levels in the town are higher than that in the rural area, particularly at night, then the existing ambient background levels provided a masking of the wind turbine noise in the demonstration.

The "demonstration" should have identified to the community the ambient levels at the time and therefore the limits of such testing. As rural residents know noises from various sources can be heard at significant distances from the source when in the "bush" the audibility test of the "wind farm noise" that disappeared only a short distance from the relatively small speakers was not a valid "demonstration".

The audible sound from the ‘‘demonstration” did not appear to have any low frequency noise and the small sound system used for the “demonstration” could not generate the appropriate levels of infrasound or low frequency that are emitted from modern day turbines.

The Sonus report has failed to identify the potential audibility of turbine noise inside residential dwellings, or the spectral content of the wind farm sound at residential properties. The attenuation of building elements provides a greater degree of attenuation at high frequencies to that at low frequencies. Therefore the spectral balance of noise detected outside a dwelling is different to that inside a dwelling. Documents otherwise in the public domain establish that Sonus are aware of the significance of this issue for wind farms.

There would appear to be an assumption that the noise from the wind farm would not exhibit modulation or tonality at residential receivers thereby not requiring an adjustment to the predicted noise levels.

4.0 PLANNING POLICIES

Section 6 of the Main Report identifies legislation and planning policies applicable to the proposed wind farm.

The Main Report refers to a number of documents. With respect to noise it would appear that the only documents that are relevant are the *State Planning Policy Framework, the Local Planning Policy Framework (Mitchell Planning Scheme)* and the *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria*.

Section 6.3 refers to the State Planning Policy Framework. Clause 13.04-1 “Noise Abatement”.

> ***Objective***
> *To assist the control of noise effects on sensitive land uses.*
> ***Strategy***
> *Ensure that development is not prejudiced and community amenity is not reduced by noise emissions, using a range of building design, urban design and land use separation techniques as appropriate to the land use functions and character of the area.*

In response to the clause the Main Report states:

> ***Response***
> Pursuant to the Wind Energy Guidelines the correct standard to apply to any noise arising from the operation of the wind farm is the New Zealand Standard NZS 6808:2010 Acoustics – Wind Farm Noise (New Zealand Standard).
>
> Table 6-1 below provides a list of all dwellings within 3km of a wind turbine and their distance to the nearest wind turbine. The Table contains a total of 18 dwellings. This Table shows that the dwellings,
> 64, 131 and 133 are the closest dwellings that are located less than 2 km from the nearest turbine. This Table also shows that:
>
> - zero dwellings are within 1,000m of a turbine;
> - zero dwellings are located between 1,000m – 1,500m of a turbine;
> - a total of 3 dwellings are located between 1,500m – 2,000m of a turbine (64, 131 and 133); and
> - a total of 15 dwellings are located between 2,000m – 3,000m of a turbine (49, 110, 50, 142, 116,100, 36, 37, 111, 44, 151, 46, 186, 60 and 58).

Table 6-1 Dwellings within 3 km of a WTG at the proposed Cherry Tree Wind Farm

House ID	Distance to nearest WTG	WTG number	Associated with project (Y/N?)
64	1535	15	Yes
131	1592	2	Yes
133	1769	2	Yes
49	2050	16	No
110	2089	7	No
50	2098	16	No
142	2266	1	No
116	2589	7	No
100	2601	15	No
36	2662	16	Yes
37	2682	16	No
111	2779	15	No
44	2774	16	No
151	2816	1	No
46	2857	16	No
186	2763	7	No
60	2964	15	No
58	2974	15	No

> **Figure 1 in Volume III Figures & Photomontages** shows the location of each of these residences within 3 km of the proposed WTGs.
>
> An **Acoustic Assessment report** prepared by Sonus Pty Ltd is provided in **Volume II Specialist Assessments**. This report provides an acoustic assessment of the proposed Cherry Tree Wind Farm against the New Zealand Standard and finds the proposal is consistent with that standard. The Acoustic Impact Assessment report predicts that the wind farm will easily achieve the New Zealand Standard at all dwellings for the proposed layout with a Vestas V112-3 MW model turbine. Accordingly, any turbine with a sound power level and hub height that is equal to or less than that assessed for the V112 turbines, will also achieve the New Zealand Standard.

> Noise impacts from the proposed substation have been assessed against the provisions of the Noise from Industry in Regional Victoria Guidelines (NIRV), and conservatively included in the wind farm predictions. Based on the nominated location of the substation, the assessment has predicted that the substation will easily comply with the NIRV at all relevant dwellings.
>
> As such, the proposed Cherry Tree Wind Farm will not result in any significant loss of amenity as a result of acoustic impact.

Aurecon may consider the correct Standard to apply is the NZ Standard as that is the nominal criteria nominated by the Victorian government. However the community may beg to differ that it is the appropriate standard in light of the noise impact that has been reported around other wind farms in Victoria.

However as stated above the last paragraph of the above extract is not obtained from the Sonus report and there is no material in Sonus report to substantiate such a claim.

The Sonus report has not identified the existing acoustic amenity that the residents receive, and in any event they are somewhat limited by the use of only three monitoring locations.

If one utilises the predicted noise levels set out in Appendix E and compared it with the background levels nominated as being the lowest measured background level at any of the three locations (on page 5) then for example at house R42 for a wind speed of 10 m/s at the hub height the predicted level is 29 dB(A) whereas the range of background levels shown in Appendix D can vary between 22 and 44 dB(A).

The use of a generic regression curve without breaking up to day and night time background levels would suggest the mean background level at that wind speed is around 32 dB(A) which therefore shows the inappropriate use of an averaging technique and not a methodology to protect 90% of the people for 90% of the time.

As location R42 can experience background levels less than that predicted for the wind farm at a wind speed of 10 m/s at the hub height it must follow that the wind farm would be audible and cause an increase in the background level. The background level would increase and therefore there would be a loss of amenity.

At times the noise from the wind farm would exceed the general annoyance criterion of background + 5 dB(A). If the predicted dB(A) has a low frequency characteristic at the residence (not address by Sonus) then a penalty could be required to the predicted level.

From an acoustic perspective one may consider an adverse impact to occur at a noise level of greater than what may be considered a significant impact, which on A-weighted value may be assigned background + 5 dB(A) on the following basis. Under previous versions of Australian Standard AS 1055, noise level that exceeds the background may be considered to be annoying. Noise levels up to 5 dBA above the background were considered to be of marginal significance.

In NSW "offensive noise" is a noise that is harmful to a person or a noise that interferes with the rest and repose of a person. Noise from a wind farm that gives rise to sleep disturbance clearly interferes with the rest and repose of a person. There are a significant number of residents in proximity to wind farms who regularly complain of sleep disturbance, headaches and nausea when the wind farm is operating. In some cases people have had to abandon their homes due to ongoing sleep disturbance and adverse health effects, which have not be acknowledged in the Sonus report.

As such the application/acoustic assessment has not demonstrated or addressed Clause 13.04-1 of the State Planning Policy Framework.

Section 6.4 of the Main report refers to the Local Planning Policy Framework (Mitchell Planning Scheme) with subsection 6.4.15 referring to Clause 52.32 Wind energy facility. The response to Clause 52.32-3 commences in a table format on page 6-67 of the Main Report.

On page 6-70 there is reference to the NZ Standard and the requirement of an assessment of whether a high amenity noise limit is applicable under Section 5.3 of the Standard. The response refers to pages 2 & 13 of the Sonus report.

However page 2 of the Sonus report does not provide an assessment of whether a high amenity limit would apply. Sonus simply dismiss the application of a high amenity limit and have not referred to or carried out the analysis set out in Section 5.3 of the NZ Standard.

Page 13 of the Sonus report makes no mention of a high amenity limit.

Section 6.6 refers to Other Documents with section 6.6.1 covering the *Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria, August 2011.*

The Response to clause 5.1.2 Amenity of the surrounding area is a repeat of the general acoustic summary provided earlier in the Main report.

5.0 NZ STANDARD

The use of the New Zealand standard as the basis of the acoustic assessment for wind farms in Victoria does not provide any material that identifies a responsibility of the authority to protect the acoustic environment of residents who (if the development is approved) the exposed to unacceptable noise impacts.

The Foreword of the Standard identifies that the wind farm sound "may be audible at times of noise sensitive locations" and the Standard "does not set limits that provide absolute protection for residents from audible wind farm sound".

The Forward identifies that the Standard "provides a reasonable way of protecting health and amenity at nearby noise sensitive locations, without unreasonably restricting the development of wind farms".

The Standard identifies in Section 1.1 that the intent is "to avoid adverse noise effects on people caused by the operation of wind farms while enabling sustainable management of natural wind resources". The Standard does not identify what is an adverse noise effect that therefore presents some difficulty in the relevance of criteria contained in the Standard where a wind farm is located in a quiet rural area.

The Standard utilises the concept of a sliding scale of noise limits depended upon the background sound level generated by the wind and notes that this procedure is different to general measurement standards for acoustic assessment.

The Standard nominates a base criteria of 40 dB(A) or background + 5 dB(A) whichever use the greater to be applied at residential receivers.

The wind farm noise limit of 40 dB(A) is referenced in clause C5.1.2 and 5.1.3 as an external level for the protection of sleep and is appropriate for protecting the health and amenity of residents. In the context of sleep disturbance there is a reference to 3 authors (Berglund, Lindvall and Schwela) of which on page 5 of the Standard reveals the text to be the 1999 WHO Guidelines.

Reference to section 5.3 provides in certain situations consideration of a noise limit more stringent than 40 dB(A) of which that classification is related to high amenity areas. Where a high amenity noise limit is shown to be justified in accordance with the procedures set out in the Standard the limits and night time operations becomes 35 dB(A), although it may only apply to certain wind speeds.

The Standard requires corrections if necessary to special audible characteristics and consideration of the cumulative effects of multiple wind farms.

The Standard identifies in clause 6.1.4 that the predicted noise levels are to be determined in octave bands from at least 63 Hz to 4 k Hz and then A-weighting and energy adding these results to determine an overall predicted level at a given wind speed.

Therefore if the assessment has been carried out in accordance with the Standard octave band information should be available at residential receivers for individual turbines, although the Standard does not require the assessment of frequencies below 63 Hz and therefore does not cover the infrasound region.

The Standard refers to general procedures for computer calculation and as noted above requires identification of the uncertainty of the predicted levels. The concept of measuring wind at the nominal hub height is consistent with other standards/guidelines and so is the general concept of regression line curves with respect to the background levels.

Of relevance to the Sonus assessment for the Cherry Tree Wind Farm in terms of the application of the NZ Standard is a decision before the New Zealand Environment Court (Decision No [2012] NZEnvC 133) between Palmerston North City Council and New Zealand Windfarms issued on the 4 July 2012.

The case related to a wind farm called Te Rere Hau that is situated in the rural hinterland of Palmerston North pursuant to a consent issued by the Council in February 2005.

The turbines are relatively small turbines when compared with the subject application but the operation the wind farm gave rise to complaints with paragraph 29 of the decision identifying a number of acoustic reports that had been undertaken for the Applicant and the Council.

The original acoustic assessment was based on the 1998 version of the New Zealand Standard and was a somewhat more comprehensive report than the Sonus report for this application.

The decision identifies errors in the original source levels and errors in the computer modelling that was used, and more relevant for the subject application was that there were a significant number of complaints when by use of the criteria nominated in the Standard that there would be no loss of acoustic amenity.

Referring to paragraphs 115 and 116 of the decision cast doubt on the suitability of the NZ Standard to achieve the specific intent set out in C1.1 of the 2010 version of the Standard; namely "to avoid adverse noise effects on people caused by the operation of wind farms".

[115] NZWL accepted that it is … *apparent that the initial Noise AEE predictions contained inaccuracies in relation to both the sound power level and sound propagation.*[39] To the extent that NZWL might imply by use of the word *predictions*, that the statements in the AEE as to these matters were predictive only and were not intended to be binding, we disagree. The information as to these aspects of turbine performance was presented in the NIAR as statements of fact based on assessment of the Gebbies Pass turbine. In any event, we refer to our discussion on modelled predictions contained in paras [103]-[105] (above).

[116] The two conceded inaccuracies led to the following further inaccuracies in NZWL's description and evaluation of effects:

- Miscalculation of the wind farm noise contours;
- The conclusion that only three local residential locations were likely to be affected by sounds from the wind farm at levels of 30 dBA or more;
- The statement that there would be *nil noise effects* from TRH on residences further away than the three identified residences. (We accept NZWL's contention that the term *nil noise effects* was intended to indicate that other residential locations would not receive noise above 30 dBA, not that they would hear no noise from TRH at all);
- The conclusion that due to the restricted extent of noise effects there needed to be only one monitoring point for assessment of wind farm noise compliance.

We consider that all of these inaccuracies are relevant to consideration of Declaration 1.8.

If as in the New Zealand case that residents in proximity to the proposed wind farm have a relatively quiet amenity and background levels in the day and night can be around 20 – 25 dBA (or lower), then there would appear to be a conflict between the noise criteria set by the Standard and what residents who reside in such zones would consider is an acceptable acoustic amenity level.

There is a fundamental problem with the selection of the base criteria if they are meant to ensure there are no adverse noise impacts. What constitutes an acceptable acoustic amenity for residents in a rural area has not been established.

In the case of the South Australian wind farm guidelines there is no material in either the 2003 version (or the 2009 version) of the Guidelines identifying the basis of a base level of 40 dB(A) for a rural area. The bibliography towards the end of the Guidelines does not reference any reports or studies as to the acoustic amenity of rural areas in Australia (or in fact anywhere) nor any evaluation of acceptable amenity levels for rural areas.

The NZ Standard references World Health Organisation 1999 *Guidelines for Community Noise*.

However, examination of the WHO 1999 Guidelines reveals an indoor limit of 30 dBA is associated with urban areas impacted by road traffic. There is no mention of wind farms or criteria for sleep disturbance in rural areas in the WHO Guidelines. In some cases there is a suggestion the WHO 1999 Guideline limit of 30 dB(A) is appropriate for rural areas which clearly becomes inappropriate if ambient background level in rural dwellings is less than 20 dB(A).

Social surveys in Scandinavia (Sweden 2000, Sweden 2005 and Netherlands 2007) for turbines significantly smaller than proposed for the subject wind farm clearly demonstrated rural communities had a greater degree of annoyance when compared to the same noise level in suburban environments (Pederson and Waye). These surveys came after the WHO 1999 Guidelines.

As identifies above there is no definition of an adverse noise effect in the NZ Standard and is a similar situation in the SA Guidelines. However Section 2.3 of the SA Guidelines may assist in that is discusses ‘Agreements with wind farm developers” being stakeholders, i.e. residents who receive a financial interest from the wind farm. The last paragraph on page 3 states:

If it is shown that a development is having an 'adverse effect on an amenity value of an area that … unreasonably interferes with … the enjoyment of the area' then appropriate action can be taken under the Act.

As the SA Guidelines do not specifically define adverse effect in numerical terms, the Guidelines do identify sleep disturbance as an adverse impact. The Guidelines identify on page 4 that if stakeholders experience sleep disturbance then that must be an adverse health impact:

However, the existence of an agreement will affect the consideration of whether the interference is unreasonable in a given situation. It is unlikely that there will be unreasonable interference if:

- a formal agreement is documented between the parties,
- the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect upon the landowner's amenity, and
- the likely impact of exposure will not result in adverse health impacts (eg the level does not result in sleep disturbance).

If as identified in the SA Guidelines the stake holder dwelling is permitted a higher level of noise then does it not mean that for non-stake holders where the external limit for rural living is 35 dB(A), the corresponding internal limit should be 25 dB(A) so as to ensure there is no adverse health impact under an open windows situation or 15 dB(A) for a closed window situation?

The issue of sleep disturbance as an adverse health impact must lead to an examination of what noise causes sleep disturbance and to the use of dBA as the assessment parameter. Whilst identifying the sleep disturbance as an adverse health impact the SA Guidelines do not identify what level of noise from wind farms generates sleep disturbance. Noise generated from wind turbines covers the entire audio spectrum and includes infrasound. Where monitoring reveals compliance with the nominated dBA noise criteria residents still hear the wind farm noise and complain about sleep disturbance.

The A-weighted filter curve significantly attenuates low frequencies (see Appendix D) and cannot provide a true indication of potential low frequency noise issues, which is a common source of complaint concerning wind farms. Furthermore if one considers noise that is below the frequency range of human hearing (i.e. less than 20 Hz which is normally referred to as Infrasound) the A-weighted value for such frequencies is insignificant.

H. G. Leventhall published a paper in Noise & Health 6.23 (April 2004) "Low frequency noise and annoyance" where the abstract states:

> *Low frequency noise, the frequency range from about 10Hz to 200Hz, has been recognised as a special environmental noise problem, particularly to sensitive people in their homes. Conventional methods of assessing annoyance, typically based on A-weighted equivalent level, are inadequate for low frequency noise and lead to incorrect decisions by regulatory authorities. There have been a large number of laboratory measurements of annoyance by low frequency noise, each with different spectra and levels, making comparisons difficult, but the main conclusions are that annoyance of low frequencies increases rapidly with level. Additionally the A-weighted level underestimates the effects of low frequency noises. There is a possibility of learned aversion to low frequency noise, leading to annoyance and stress which may receive unsympathetic treatment from regulatory authorities. In particular, problems of the Hum often remain unresolved. An approximate estimate is that about 2.5% of the population may have a low frequency threshold which is at least 12dB more sensitive than the average threshold, corresponding to nearly 1,000,000 persons in the 50-59 year old age group in the EU-15 countries. This is the group which generates many complaints. Low frequency noise specific criteria have been introduced in some countries, but do not deal adequately with fluctuations. Validation of the criteria has been for a limited range of noises and subjects.*

In the paper Leventhall specifically cites the World Health Organization as recognising low frequency noise as an environmental problem. He references the WHO publication on Community Noise and provides the following in relation to rest, sleep and adverse effects:

"It should be noted that low frequency noise, for example, from ventilation systems can disturb rest and sleep even at low sound levels"

"When prominent low frequency components are present, noise measures based on A-weighting are inappropriate"

"Since A-weighting underestimates the sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting"

"It should be noted that a large proportion of low frequency components in a noise may increase considerably the adverse effects on health"

"The evidence on low frequency noise is sufficiently strong to warrant immediate concern"

"For noise with a large proportion of low frequency sounds a still lower guideline (than 30dBA) is recommended"

In 2009 Leventhall provided another paper in the Journal of Low Frequency Noise, Vibration and Active Control Low Frequency Noise, "What we know, what we do not know, and what we would like to know". He defines low frequency noise as in the range of 10 Hz to 100Hz, but could be extended an octave each end to give 5 Hz to 200Hz.

Whilst the 2009 paper contains the majority of the 2004 information he highlights significant issues concerning low frequency noise that cannot be detected using A-weighting.

Although we know a great deal about low frequency noise, there are aspects which we cannot yet explain. We know about how people hear low frequency noise and that some have a low tolerance to it. We believe that low frequency noise may, in general, be more annoying than higher frequency noise, but do not know why this is so. We do not know why some people complain of a low frequency noise which cannot be measured separately from the background noise.

It is also possible that there are subtle effects of low frequency noise on the body, which we do not yet understand.

Leventhall provides standardised threshold levels over a frequency range assigned for human hearing, including levels for part of the range described as Infrasound. He provides a series of questions that are clearly relevant to the proposed wind farm if it is shown that low frequency noise is likely to be produced:

SOME FINAL QUESTIONS

This review of low frequency noise and its effects leaves some unanswered questions, towards which future work might be directed.

- *Is the ear the most sensitive receptor to low frequency sound in the body?*
- *Alternatively, is there a receptor mechanism in the body which is more sensitive than the ear at low frequencies? If so, what is the mechanism?*
- *Are levels of infrasound below hearing threshold potentially harmful? If this is true, are there safe levels?*
- *When people complain about noise which cannot be measured, is it because they are disturbed by fluctuations in the background noise?*
- *Can fluctuations in the background noise level turn a noise, which has an average level below the hearing threshold of a listener, into a nuisance?*
- *If fluctuations are combined with the lowest sensitivity of the hearing threshold (e.g. three standard deviations below the median) can people hear noises which have a measured average value so far below the hearing threshold that we might consider them inaudible?*
- *Does the way in which we measure low frequency noise hide some of its disturbing characteristics?*
- *Considering the normal distribution of the hearing threshold, why are there not more complaints of low frequency noise?*

Barbara Griefahn (Institute of Occupational Physiology at the University of Dortmund, Germany) is a well-known researcher on sleep disturbance due to noise. In Noise & Health Vol 4, 15 (2002) the abstract to "Sleep disturbance related to environmental noise" identifies that the ear still hears even when asleep:

> *The permanently open auditory channel and the ability of the brain to process incoming acoustical stimuli even while asleep and to respond adequately is the essential precondition for noise-induced sleep disturbances which are regarded as the most deleterious effects of noise. In the past, research was mainly focused on the detection and description of the various effects of noise, on the influence of personal and environmental factors, on the determination of dose response relations and the definition of critical noise loads, above which noise becomes intolerable. These limits are, however, as yet only tentative or applicable for a very few situations and need to be verified or revised.*

This material was available prior to the 2010 NZ Standard and gives an explanation as to potential sleep disturbance impacts from wind farms that may operate continuously or intermittently at night.

The NZ Standard recommends computer prediction methods in accordance with ISO 9613-2. Computer models for acoustic purposes are designed to deal with general noise sources not wind farms with low frequency noise.

In a submission on the Draft NSW Wind Farm Guideline document issued for public comment last year, Vestas Australian Wind Technology Pty Ltd (available on NSW Department of Planning Website) states:

> Low frequency noise
>
> The Draft Guidelines state that "*Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise and is generally less than that of other industrial and environmental sources.*"

> It is therefore unnecessary to require the prediction and monitoring of low frequency noise emissions from wind turbines. This is especially so, given the absence of regulation or limits upon the low frequency noise from "other industrial and environmental sources" as mentioned in the above statement from the Draft Guidelines. This is a further example of the way in which the Draft Guidelines discriminate against wind farms.
>
> In addition, the existing and well validated industry standard models for acoustic propagation are not designed to deal with frequencies at the low end of the audible spectrum, specifically because noise emissions in this band are not considered to pose issues likely to affect the surrounding environment. Accordingly, Vestas suggests the removal of the requirement to measure low frequency noise from the Draft Guidelines.

The above comment on low frequency noise from a local subsidiary of Vestas Wind Systems A/S (identifying themselves as the world's largest manufacturer of wind turbines and being supplier of the turbines currently proposed) confirms the computer models (including the computational standard used by Sonus) are not designed to deal with the low frequencies.

Use of the A-weighting as an assessment criterion in the NZ Standard overcomes the inadequacy of the computer models (because it ignores low frequency) and does not deal with the presence and impact of low frequency noise received at dwellings from wind farms.

One result of considering the potential adverse impact of sleep disturbance is that as there is an assumption people sleep at night, the assessment should differentiate between day and night. This would enable consideration of whether approval conditions requiring that turbines not operate at night could satisfy the obligations imposed by Clause 13.04-1 of the State Planning Policy Framework.

In addition to low frequency noise, the operation of wind farms produces noise characteristics that do not get picked up in an average A-weighted measurement. For example there are modulations in the noise signature, tonal characteristics and infrasound.

Noise data in relation to wind farms in the Goyder region(of South Australia) are discussed in the following section and show amplitude modulation, tones and infrasound exist for wind farms in proximity to the proposed wind farm. These characteristics, when present, can also be said to be adverse noise impacts from which the surrounding community is required to be protected.

Finally, there are those matters (outlined in preceding sections) in relation to which clear identification of the range of expected higher noise levels and the frequency of occurrence of the same needs to be made.

The predicted noise levels for a wind farm will be expected to vary as a result of different weather conditions. When there is no wind in the area, the wind farm will not create an acoustic impact.

However different wind strengths (at the wind farm turbine height) will generate different noise levels. Similarly different wind direction will also change the level of noise.

Similarly temperature inversions can alter the propagation of noise that can significantly increase the noise levels.

The community will experience a range of noise levels over time depending upon the prevailing weather conditions. It would seem appropriate to clearly identify the range of noise levels and the frequency of occurrence of the higher noise levels

6.0 TESTING OF WINDFARM NOISE - WATERLOO AND HALLETT

Any appropriately qualified and experienced acoustic engineer will be aware that when there are vigorous complaints from residents as to noise disturbance then there is likely to be some form of noise impact occurring with respect to the relevant noise source. There may very well be a heightened sensitivity of residents who are continuously exposed to the subject noise and who can become "tuned into" the noise.

As part of my ongoing research into the actual or perceived impacts associated with wind farms, when the opportunity arises it is appropriate to undertake sound level measurements.

This section provides the results of measurements taken by the author near turbines in the region of the Waterloo Wind Farm to identify noise levels associated with the source and noise measurements at residential receivers. The results assist in placing the perceived noise impact in the existing environment and are relevant to the acceptability concept identified in the NZ Standard and SA Guidelines. This material provides context to the subject application with respect to the topography and acoustic environment of the area.

These measurements may also provide an opportunity for residential receivers potentially impacted by the proposed wind farms to attend various locations in proximity to the Waterloo Wind Farm, or the group of wind farms that generically go under the name of Hallett, and ascertain for themselves the external acoustic environment that they could receive as a result of the subject proposal.

By use of noise contour graphs that identify the A-weighted level to be emitted from the Wind Farm, residents can find locations that would approximate their residence with respect to the proposed development to gauge first-hand the impact. For example, such a practical method permits residents who may be subject to a major road upgrade to experience the predicted noise levels as a result of that upgrade and thereby ascertain the likely impact.

Some caution should be applied to this suggestion as noise levels will depend on weather conditions and the perceived noise will relate to external noise, and not the noise levels obtained inside a dwelling.

Attendance at a number of residential dwellings found that residents related having experienced varying degrees of disturbance/impacts when the turbines are operating compared to the situation prior to the construction of the relevant wind farm. Measurements were conducted both external to various dwellings, and in some cases simultaneous measurements both external to an inside the dwelling were undertaken.

During the course of attending various residences where either complaints have been registered with the local Council, or compliance monitoring has been conducted by the wind farm operators, an opportunity was also presented to conduct measurements on public roads in proximity to turbines in situations where noise was not influenced by either vehicular activity (i.e. no vehicles) or activities associated with rural properties. On attending a number of residences noise from the wind farms varied ranging from barely audible, clearly audible or not audible outside the residence. Measurements inside residences found differing degrees of audibility.

Some residents near Mt Bryan advised of sleep disturbance, whilst for periods when the turbines were not operating at night, they experienced no disturbance.

Some residents did not want their property specifically identified and therefore have been excluded from the material contained in this peer review. Residences referred to in this peer review are identified by a house code (house 5 – 12 are in the vicinity of Hallett and Waterloo Wind Farms).

The SA Guidelines indicate that there is no issue in terms of low frequency noise and that infrasound is only generated in poorly maintained wind farms. However, testing has revealed otherwise.

Towards the northern end of the Waterloo Wind Farm there is one public road that passes through the Wind Farm (Quinns Gap Road) and another that runs along the northern side of the current Wind Farm (Mollers Gap Road). These public roads permit access to positions relatively close to the turbines from which measurements may be undertaken.

One set of measurements were conducted on the top of Quinns Gap Road where one microphone was located directly in front of the turbine at a position 142 m from the base, or 168 m slant distance to the hub. A second microphone was located at a similar distance but perpendicular to the side of the hub so as to be in line with the rotating plane of the turbine blades.

A second set of measurements were conducted on the top and eastern side of Mollers Gap Road where one microphone was located at to the side turbine at a position 152 m from the base or 172 m slant distance to the rear housing.

The response curves in Appendix D show the response of the ear is non-linear across the frequency bands. The general community assessment uses the A-weighted curve (the blue curve in the lower graph of Appendix D) and as identified previously attenuates the low frequency components.

Typically wind turbine noise spectra are also presented in A-weighting curves that show the maxima to be in the mid frequencies.

The upper graph in Appendix E presents the turbine power levels measured for a distance of 800 metres for Capital Wind Farm (NSW) and Waterloo Wind Farm (slant distances noted above) on the assumption of hemispherical radiation and 6 dB per doubling of distance. These results are Linear results (without the A-weighting filter).

The lower graph in Appendix E reproduces the Linear results and also the same results when presented as A-weighted levels. The difference in the identification of low frequency becomes obvious.

Appendix F present the 1/3 octave band results of the Quinns Gap Road measurements over the Guideline standard 10 minute sample. The results show the spectrum information on a statistical basis in a linear format (not A-weighted) and show the statistical variation in the noise level.

There were no other intrusive noises at the site, only turbine noise. The results clearly identify frequency peaks rather than a broadband noise.

The measurement results show different frequency characteristics for noise off the front of the turbines versus to the side.

The A-weighted level was not constant and exhibited a variation in level which as nominated in the Guideline is identified as modulation. The modulation occurs over the entire audio spectrum. Whilst not showing a significant variation in the statistical analyses in Appendix F the modulation is most obvious in the upper frequency bands as shown by comparison of the A-weighted level versus the 2500 Hz 1/3 octave band in Appendix G.

Appendix H presents a number of FFT analyses that show the sound spectrum in a linear format (rather than constant percentage bandwidth – 1/3 octave bands) to permit identification of narrowband tones. Appendix H1 shows the statistical variation in the frequency display with the remaining graphs being the energy average (Leq) of each 2 minute sample.

The FFT analyses progressively reduce the bandwidth of each analysis to permit identification of specific tones that occur in the frequency area nominated as covering low-frequency sound and infrasound. The bottom axes are frequencies in Hz (i.e. Appendix H1 and H2 show 0 – 1 kHz, Appendix H3 0 – 100 Hz and Appendix H4 0 – 12.5 Hz).

The frequency graphs clearly show that there are low frequency and infrasound components generated by the turbine.

The results set out in Appendices E – H for the measurements of the turbine reveal modulation, low frequency noise and infrasound components.

The Sonus report identifies ambient background levels below 40 dBA for residential receivers in proximity to the proposed Cherry Tree Wind Farm.

Appendix I provides measurements using a SVAN 957 Sound Level Meter at a location approximately 2km south of the proposed Hallett 3 in South Australia. The location is well removed from any main roads.

The background levels (shown in Appendix I) during the day are below 20 dB(A) – except for 40 minutes in the day whilst the evening and night time background level are below 15 dB(A). How much below 15 dB(A) cannot be ascertained as the background is less than the electrical noise floor of the sound level meter.

The daytime (7am – 6pm) Leq, is 31 whilst the Leq for the entire 23 hour period shown in Appendix I is 28 dB(A). The ambient noise in the rural environment as such is significantly lower than a nominated acceptable base level of 40 dB(A).

As to the background level as a result of the wind at the microphone, that becomes relevant in terms of independent compliance testing when the wind farm weather data is not provided, the regression graphs in Appendix I2 show the same instrumentation in open field one with grass and one with furrowed ground. There is no difference for low wind speeds at the microphone but above 10 metres per second the grassed field produce higher background levels.

As noted previously the Sonus report does not provide information to identify the wind at the microphone versus the wind farm weather monitoring station so as to clarify the relationship between the wind farm wind and the wind at residential receivers.

This matter becomes important in that residents in proximity to operational wind farms have been critical of noise audits conducted by the operator when turbines have been observed to be not operating and claims of restricting or controlling the pitch of the blades during testing have been made in Australia and in other countries.

Truly independent testing without the knowledge of the wind farm operator and subsequent supply of wind farm operating data (including turbine SCADA) can address these issues, as can obtaining wind corrections for wind induced aerodynamic noise on microphones as per the results in Appendix I2 and/or provision of supplementary wind screens (over the primary microphone wind screen).

Appendix J provides a series of measurements conducted at House 10 which is approximately 1300 metres from the northern end of the Waterloo Wind Farm. The measurements include simultaneous inside and outside measurements where the internal location was in the centre of the master bedroom and the external location was located at 15 metres in front of the dwelling towards the wind farm.

The measurements in Appendix J were recorded during the night time period. The turbines were audible both outside and inside the dwelling. The external background level was found to be 27 dB(A) and the background in the bedroom (windows closed) was 16 dB(A).

The modulation of the turbine noise external to the dwelling becomes obvious in the 2 minute sample of the A-weighted level over time. However the attenuation of the building eliminates the high frequency modulation inside the building, which becomes obvious in comparing the results.

Similarly the presence of both low-frequency sound and infrasound inside the dwelling and outside the dwelling is shown in the frequency spectra.

Moller (for Maastricht City Council) identifies the use of A-weighted measurements and in relation to audibility states:

> The level of the infrasound produced by modern wind turbines is so low that the sound cannot be perceived by humans even close to the turbines[6]. Much higher levels occur elsewhere in our daily environment, e.g. in transportation.
>
> Low-frequency wind turbine noise is usually described as humming or rumbling. It may have a more or less pronounced tonal character, e.g. in terms of tones that fluctuate and vary in level and/or pitch, or of tone-like pulses excited with regular or random intervals. The feeling of pressure at the eardrums is also reported. It is characteristic that the noise varies a lot in time and with wind and other atmospheric conditions.
>
> The rate of modulation of the low-frequency noise from wind turbines (and higher frequencies as well) is often in the infrasonic frequency range, e.g. the blade passage frequency, and the noise may thus be mistaken as infrasound, even when there is little or virtually no infrasound present.

The measurements in proximity to the Waterloo turbines identifies the blade pass frequency of the turbines and the harmonics of that frequency to be present and those frequencies are also present outside and inside houses. The turbine measurements reveal the presence of infrasound components. Use of narrow band analysis, rather than 1/3 octave bands, reveals the pattern of the noise emitted from turbines exhibits a distinct signature. The signature can shift in frequency for higher turbine speeds but still exhibits a pattern, which also appears at residential premises.

The measurement of infrasound inside houses is similar to that obtained in Falmouth by Rand and Ambrose.

It is noted that the difference from outside to inside with respect to the low frequency sound and infrasound components is relatively small, and in some cases there is a negative difference in that there are higher levels inside the dwelling than outside.

When one is dealing with low frequency or infrasound noise associated with gas fired power stations it has been found that the energy emitted from the power station can excite the building elements into resonant modes or physical vibration that leads to the internal surfaces of the room in question vibrating and radiating noise.

The fact that there are discrete frequencies detected inside the dwelling that fall into the frequencies typically associated with different levels of sleep states is a matter that should be noted. The assessment of sleep disturbance is outside my field of expertise but the material provided in Appendix I is informative.

It is noted that in viewing the frequency graphs contained in this report, the measurement results are those obtained directly from the Bruel & Kjaer Pulse system with a low pass filter of 7 Hz (rather than the standard 22 Hz) and utilising Bruel & Kjaer Type 4189 microphones that have a frequency response that falls off below 10Hz.

If one is looking to accurately define the sound levels occurring in the infrasound region then one needs to adjust the measurement results appended to this review which will result in higher sound pressure levels for frequencies below 7 Hz.

Similarly, in view of the low ambient noise levels recorded both inside and outside the dwellings the measurement results are approaching the electrical noise floor of the microphones. More detailed investigations require specialised microphones to accurately record such levels.

During the course of monitoring at house H10, the occupants related that on the night upon which the measurement results appended to this review were obtained, they experienced disturbed sleep.

Residents at houses 10 and 12 advised the author that testing has been conducted by independent consultants to reveal that both of these properties comply with the SA Guidelines (and therefore the NZ Standard). Yet the occupants of both of these properties experience sleep disturbance and at times complained of excessive noise intrusion. I was advised that at house H10 monitoring conducted by one set of independent consultants placed the microphone approximately 1.5 m from the bedroom window of that residence.

Attendance at House H12 also suggested that monitoring which had been conducted by independent consultants was not in accordance with the SA Guidelines. The occupant identified that the monitoring position was to the side of the residence in relatively close proximity to large trees, rather than the complying with the requirement to be between the residence and the wind farm which would have placed the monitor in an open paddock.

Residents indicated that there are significant differences in noise received at their property dependent upon the weather conditions and cited both light and strong winds giving rise to different noise effects. Cloud cover was also cited as altering the noise propagation.

For the purposes of this peer review, the attached Appendices are sufficiently detailed to reveal that even when wind farms in the Goyder area are apparently able to comply with the SA Guidelines (being lower than the NZ Standard limit), they are still generating adverse impacts at residential properties. These impacts can be detected and measured when one looks to the use of non-A-weighted measurement results. The measurement data appended to this review identifies that there are both low frequency and infrasound components generated by the turbines that are currently located in the region.

A recent Application for the Stony Gap Wind Farm that came before the Goyder Development Assessment Panel on 1st August 2012. The panel heard testimony from people at Waterloo (3MW Vestas V90 wind turbines on the next range over from the proposed Stony Gap wind development) who live out to 8 – 10km away from wind turbines who claimed their lives have been significantly affected by the wind farm. The Applicant was requested by DAP to give a guarantee there would be no adverse health impacts. The Applicant was unable to confirm the proposed wind farm would not give rise to noise or health impacts.

The grounds of refusal were:

> It is considered that the nature of the proposed wind farm development will adversely and unreasonable impact on the health and amenity of the locality through noise and vibration caused by the operation and hours of operation of the proposed wind farm development.
>
> The proposed wind farm development is at odds with the following Regional Council of Goyder Development Plan Objectives and Principles of Development Control:
>
> **2.1. Council Wide – Interface Between Land Uses**
>
> Objective 1
>
> Development located and designed to prevent adverse impact and conflict between land uses
>
> Objective 2
>
> Protect Community health and amenity and support the operation of all desired land uses
>
> **Principles of Development Control**

1. Development should not detrimentally affect the amenity of the locality or cause unreasonable interference through any of the following:

   (b) noise

   (c) vibration

   (g) hours of operation

2. Development should be designed and sited to minimise negative impact on existing and potential future land uses considered appropriate in the locality.

6. Sensitive uses likely to conflict with the continuation of lawfully existing developments and land uses considered appropriate for the zone should not be developed or should be designed to minimize negative impacts.

7. Developments should be designed, constructed and sited to minimize negative impacts of noise and to avoid unreasonable interference.

2.2 Council Wide – Orderly Sustainable Development

Objective 1. Orderly and economical development that creates a safe, convenient and pleasant environment in which to live.

It is relevant to note that the proposed Stony Gap Wind Farm was predicted to comply with a 35 dB(A) or background + 5 dB(A) limit – being similar to the noise limits for Waterloo and Hallett wind farms that were experienced by the residents.

Residents around the Waterloo Wind Farm have been the subject of two community surveys.

The first survey was conducted by an Adelaide University last a student in 2011 and the second by community member Mary Morris.

The university student Frank Wang's, original survey showed that of the study participants, who all live within 5 km of the Waterloo Wind Farm, 50% of them, were moderately to severely impacted by the noise.

The survey conducted by Mary Morris set out 230 surveys to every household within 10 km of the turbines and received a 40% response rate. 49% of the respondents were negatively affected by some or all of: noise, shallow flicker, sleep deprivation, interference. Another 17 respondents indicated they notice the above affects and/or that the effects varied with whether but they were not affected.
The remaining respondents said they were not affected.

The extent of the population around the Waterloo Wind Farm that is affected by the operation of the wind farm when taken out to 10 km indicates a significantly higher proportion of the population than the nominal concept in socio-acoustic surveys of setting benchmark criteria for 10% of the person seriously affected.

The results of the two surveys question the appropriateness of the NZ Standard base noise limit or high amenity noise limit in terms of the intent of the Standard to avoid adverse noise effects on people caused by the operation of wind farms.

7.0 CONCLUSIONS

Sonus has relied solely upon the NZ Standard and has ignored the acoustic characteristics that residents will actually receive as a result of the Cherry Tree Farm. They have not addressed the actual acoustic impact of the wind farm on the community.

The Sonus acoustic assessment provides a set of predicted noise levels in terms of the A-weighted values set out in the Standard and concludes that there are no tonal or modulation characteristics requiring modification to the predicted noise levels.

In relation to background levels, the Sonus measurement results confirm (as expected) that ambient background levels outside rural properties are significantly lower than 30 dB(A). As such, the noise generated by the wind farm is likely to be significantly greater than background +5dB(A) and therefore to have an impact significantly greater than for an “annoyance.”

The issue of low frequency noise and infrasound has been raised and discussed above. Documentation from the world's leading supplier of turbines has identified that computer models are inadequate for low-frequency noise propagation. As high frequencies are rapidly attenuated over distance (when compared to low frequencies) audible characteristics of the turbines may be reduced to a low frequency hum and can also include frequencies below the normal range of human hearing.

The NZ Standard ignores infrasound and low frequency noise.

The SA EPA Guidelines identify that infrasound is not generated on a well maintained wind farm yet the measurement results obtained for the purposes of this report prove otherwise. The measurement data appended to this review identifies that there are both low frequency and infrasound components generated by the turbines that are currently located in the region.

A proper assessment of community impact cannot ignore low frequency noise and "infrasound." To the extent that it does, when these have been issues of specific complaint with other wind farms, the Sonus report falls short of its responsibility to the community as required by the Code of Ethics of the Australian Acoustical Society and the Code of Conduct of the AAAC.

The SA Guidelines identify that for host stakeholders, sleep disturbance is an adverse health effect. The NZ Standard seeks to avoid adverse noise effects but does not define what constitutes an adverse noise effect.

It is not unreasonable for Council and the community to assume that if sleep disturbance gives rise to an adverse health effect for persons in South Australia who are obtaining a financial gain from hosting turbines, then sleep disturbance that impacts upon the general community (i.e. non-host stakeholders) must also give rise to an adverse health effect. It is not unreasonable to expect people in Victoria to experience similar impacts as those in South Australia, This peer-review has identified two eminent acousticians who, in 2002/2004, identified that there are issues with low frequency and infrasound and that the ear still continues to work and receive signals even when people are asleep. The mechanism causing sleep disturbance (for example, whether individuals are able to detect the infrasound components) is an issue outside my expertise.

But it is clear that use of the A-weighted value for assessment or compliance purposes does not address all of the noise impact issues associated with wind farms.

The current application has not satisfactorily addressed all of the matters to determine the current acoustic amenity, and has not actually assessed the noise or the impact of the subject development.

Inadequacies of the NZ Standard in meeting the fundamental intent has been raised.

As a result of the various matters raised and outlined above, there can be no confidence that the community will not be adversely impacted by the proposed Cherry Tree Wind Farm. It is recommended that Trawool Valley-Whiteheads Creek Landscape Guardians should request further particulars from the Applicant to address the individual matters raised above with a view to identifying the actual noise impact that will be generated by the proposed wind farm.

Yours faithfully,

THE ACOUSTIC GROUP PTY LTD

STEVEN E. COOPER

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