5. NOISE IMPACT AND HEALTH IMPLICATIONS

Director-General's Requirements

- the Environmental Assessment must:

1. include a comprehensive noise assessment of all phases and components of the project including turbine operation, construction and traffic noise. The assessment must identify noise sensitive locations (including approved but not yet developed dwellings or subdivisions with residential rights), baseline conditions based on monitoring results, the levels and character of noise (e.g. tonality, impulsiveness etc) generated by noise sources, noise criteria, modelling assumptions and worst case and representative noise impacts.

2. determine noise impacts under operating meteorological conditions (i.e. wind speeds from cut in to rated power), which may include impacts under meteorological conditions that exacerbate impacts. The probability of such occurrences must be quantified;

3. if any noise agreements with residents are proposed for areas where noise criteria cannot be met, provide sufficient information to enable a clear understanding of what has been agreed and what criteria have been used to frame any such agreements;

4. clearly outline the noise mitigation, monitoring and management measures that would be applied to the project. This must include an assessment of the feasibility, effectiveness and reliability of proposed measures and any residual impacts after these measures have been incorporated;

5. include contingency strategy that provides for additional noise attenuation should higher noise levels than those predicted result following commissioning and / or noise agreements with landowners not eventuate; and

6. include an assessment of vibration impacts associated with the project.

7. be undertaken consistent with the following guidelines (or as otherwise agreed with the DECCW):
   - Wind Turbines - the South Australian Environment Protection Authority's *Wind Farms - Environmental Noise Guidelines*, 2003;
   - Site Establishment and Construction - *Environmental Noise Control Manual* (NSW EPA, 2004);
   - Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW EPA, 1999);
   - Vibration – *Assessing Vibration: A Technical Guideline* (DECCW, 2006).

5.1 SUMMARY OF OBJECTIONS

Noise Impacts and Health Implications: Flyers Creek Wind Turbine Awareness Group (FCWTAG) objects to the Flyers Creek Wind Farm proposal:

5.1.1 Aurecon (Infigen's environmental consultant) has used the GE2.5xl-2.5 MW wind turbine to model noise impacts which significantly "under-represents" the eventual model that will be used, introducing significant sources of errors. **The Director General should refuse the FCWF proposal on these grounds alone.**

5.1.2 The measurement of background sound and the modelling of noise impact of the proposed FCWF is flawed and inaccurate.

5.1.3 There is no measurement of prediction of ***tonality*****.**

5.1.4 Monitoring of sound at Capitol Wind Farm by The Acoustic Group has found non-compliance of audible sound levels, and significant levels of infrasound also above allowable levels. This work casts into doubt the ability of wind turbines operated at Flyers Creek to be able to comply in any way with acceptable and regulated levels of noise. **The Director General should refuse the FCWF proposal on these grounds**.

5.1.5 The matter of noise guidelines and measurement, tonality and other issues are currently being examined by the South Australian courts and **no decision regarding the FCWF proposal should be contemplated until these matters are determined.**

5.1.6 Effective monitoring and compliance regimes must be imposed by the planning authority at the outset. None are proposed or contained in the Flyers Creek Environmental Assessment and it should not be approved on this basis.

5.2 NOISE – CRITIQUE OF MEASUREMENT AND MODELLING

The Flyers Creek Wind Turbine Awareness Group is indebted to the following for their critiques, analyses and additional information concerning the Environmental Assessment's noise studies and conclusions:

- The Acoustic Group (S. Cooper), Lilyfield, NSW
- L. Huson & Associates Pty Ltd, Consulting Scientists in Acoustics, Victoria
- Margaret Conn, Solicitor, Mudgee, NSW

5.2.1 Choice of representative wind turbine model

The choice of the GE 2.5xl 2.5MW wind turbine unit to "represent" the turbine that is to be installed at Flyers Creek, and upon which all sound studies are modelled, is flawed and casts into doubt all scenarios and conclusions described in the EA (both by Infigen and by ViPAC, the company employed to carry out the sound assessment).

The EA states that the wind turbine chosen will be between 2 to 3 MW generation capacity. Assuming this will be 3 MW this represents an increase of 20% over the representative GE turbine. If, as has been suggested by Infigen's Senior Development Manager at Infigen's Co-op Forum 13th October 2011 at Orange, the turbines will be "up to 3.3 MW", this will represent an increase of 32% generation capacity over and above the turbine model used for all calculation in this Environmental Assessment.

Moreover the GE turbine is 85 metres hub height, whereas the maximum height of 100 metres is alluded to in the EA. If, as seems certain, the turbines will be at the top end of the range of heights given – hub height 100 metres, total height 150 metres – then this will introduce another error of at least 17%.

Notwithstanding the detailed analysis of the flaws in the noise assessment following, the Flyers Creek Wind Turbine Awareness Group (FCWTAG) believes the Director-General should refuse to consider the Environmental Assessment on these grounds alone.

5.2.2 Time of Background Noise Monitoring

The Background noise monitoring was conducted between 13th November to 24th December 2009. The object was to obtain background noise from which to model the impact of the additional noise expected from the operation of wind turbines at the FCWF.

Generally the background noise is different in the Winter months compared with the Summer. For example, cicadas are active in the Summer and contribute to background noise. However they are inactive in the Winter months and make no contribution to background noise levels. Accordingly the measurements should be taken in the middle of Winter to record the lowest possible background noise levels in line with conservative and precautionary principles.

Therefore the results reported from the noise monitoring survey are not representative and thus unsuitable for use in modelling predicted noise levels, and accordingly the Environmental Assessment is invalid, misleading and rejected.

5.2.3 Noise Guidelines

1. The relevant noise guidelines for the Flyers Creek Wind Farm are the South Australian Environmental Protection Authority's ***Wind Farms - Environmental Noise Guidelines (2003).*** The Background Noise Monitoring Survey Report and the Noise Impact Assessment for the project were carried out for Aurecon Australia by the South Australian based **Vipac** Engineers and Scientists. It is acknowledged in the Appendices G1 and G2 that the 2009 Guidelines have been applied where practicable or as appropriate.

2. The issue of the extent of noise actually generated by wind turbines, together with the role of the South Australian Environmental Protection Authority's *Wind Farms – Environmental Noise Guidelines (2003)* in setting valid standards for noise limits, prediction and compliance, is currently under detailed scrutiny in the South Australian Courts in the "Quinn" litigation. The extent of scrutiny and specificity of the attacks on adequacy and validity of the Guidelines and associated compliance testing is that:

3. no project approval for the Flyers Creek Wind Farm should be contemplated until the matters under examination in South Australia have been determined.

4. The Director-General Requirements for Flyers Creek require a comprehensive noise assessment and determination of noise impacts. In light of the South Australian litigation, these matters have not been adequately addressed by the Vipac data or by the proponent. A comprehensive noise assessment and determination of noise impacts cannot be made for the project until the issues raised by the current South Australian litigation have been resolved.

5. On 7 November 2011, the Full Court of the Supreme Court of South Australia ([2011] SASCFC 126) allowed the appeal from the Environment, Resources and Development Court (the ERD Court) in the matter of Quinn & Ors v. Regional Council of Goyder & Anor [2010] SAERDC 63. At issue in the proceedings is the approval of the Hallett 3 wind farm in the North Mount Lofty Ranges. The approval given by the Goyder Council was initially confirmed by the ERD Court but the ERD Court decision has now been set aside by the Supreme Court and the matter will be re-heard in early 2012.

6. Although the case covers a variety of issues specific to the Hallett 3 Project and the relevant council Development Plan, the South Australian EPA Wind Farm Noise Guidelines were at the heart of the examination in relation to predicted wind farm noise levels, wind farm noise assessments and compliance testing and as such have direct relevance to the FCWF .

7. A series of detailed flaws in the operation of the Guidelines has been outlined to the Court by Professor Colin Hansen of Adelaide University. Professor Hansen's qualifications are unimpeachable. He is a Professor at the University's School of Mechanical Engineering with a First Class Honours degree in Mechanical Engineering and a PhD in acoustics. He is a Chartered Professional Engineer and a Fellow of Engineers Australia, the Australian Acoustical Society and the International Institute of Acoustics and Vibration. He has worked internationally and within Australia on acoustic and vibration projects. He has authored or co-authored ten books, edited 2 books and authored 8 chapters in other books, all on acoustics or vibration. He has published over 250 refereed journal papers and conference proceeding papers on acoustics and vibration. He has served as President of the International Institute of Acoustics and vibration. He was awarded the 2009 Rayleigh Medal by the British Institute of Acoustics for outstanding contribution to acoustics. He has taught, researched and consulted in acoustics at the University of Adelaide for the past 25 years.

5.2.4 Noise Assessment and Background Noise Monitoring at Flyers Creek

The matters raised, in detail, by Professor Hansen, are directly relevant to the Flyers Creek Wind Farm, to the Noise Assessment and Background Noise Monitoring carried out by Vipac, are as follows:

1. **The EPA Guidelines specify base levels in terms of the LAeq descriptor and then in the compliance checking procedure, the Guidelines use the LA90,10 descriptor.** The 2003 Guidelines set a predicted equivalent noise level which should not exceed 35dB(A). However the compliance checking procedure for this level refers to the loudest A-weighted noise level that occurs in the quietest 10% of the time and it ignores the noisiest 90% of each measurement period. The two descriptors do not measure the same thing. It is well established that LA90 underestimates the actual LAeq generated by a significant margin. As Professor Hansen says: "It is well known that LA90,10 noise levels are always less than LAeq,10 levels by between 2 and 4 dB(A) (as stated on page 56 of "The Assessment and Rating of Noise by Wind Farms" - ETSU-R-97), so this method of compliance checking significantly underestimates the actual LA eq,10 noise levels due to the wind farm.

2. **The effect of amplitude modulation with wind turbine noise is such that the difference between the measured LA90,10 level and the LAeq,10 level will be even more exaggerated.** LA90 may well be 5 dB less than the LAeq.

3. In relation to the background noise level specification, the EPA Guidelines state that the allowed noise level is 5 dB(A) above the LA90 background noise without the wind turbines. The background noise should be as determined by the data collection

and regression analysis procedure recommended under the Guidelines. **This procedure is flawed as the use of a regression line through a large number of LA90 levels to define the background noise level ignores the fact that there are many 10 minute intervals when the actual background noise is well below this artificial level and many times, this difference exceeds 20 dB(A).**

4. There are flaws in the wind speed range and its relationship to sound power which formula forms the basis of predicted noise levels. In the 2009 Guidelines, the EPA acknowledges that turbine noise increases with wind speed with the Guidelines stating that noise levels should increase between .5 and 1.5 dBb(A) for each 1 m/s wind speed. The Guidelines however suggest that, despite this, any increase in wind speed will be masked by the increase in background noise levels due to stronger wind. **This assumption is in error as background noise levels at the receiver do not necessarily increase with wind speed at turbine locations.** In some weather conditions, there will be strong hill top wind at turbine location but hardly any wind at receiver location on the valley floor. The assertion that background noise increases as wind speed at the turbine nacelle increases is often not true and there will be many occasions when wind turbine noise far exceeds the background levels at the receiver location. Ignoring the 2009 Guidelines, the manufacturer's assumptions that maximum sound power is produced at a speed slightly less than rated power are flawed and calculations automatically are likewise flawed.

5. For noise measurements, the most relevant wind speed is at the turbine nacelle. The formula provided in IEC 61400-11 is for determining wind speed at a height of 10 metres. This formula was applied by Vipac in the project appendices. The accuracy of these estimates depends on the assumed wind shear value which can vary dramatically with location and weather conditions such that **the accuracy of the measure is flawed!**

6. The relevant predictive noise models for wind farms depend on **sound power calculations** as set out in the Vipac data at Appendix G2. The method of predicting noise from a wind farm under the Guidelines requires taking the sound power level produced by each turbine and applying a noise propagation model to predict the noise level. The sound power radiated by a wind turbine is a measure of the total sound energy generated by the turbine and is only a function of the turbine **itself**. To measure sound properly around a turbine would require at least 20 sound pressure measurements on a spherical surface at a distance of about 200 metres. An approximate method is detailed in the standard IEC 61400-11. This method involves the unjustified assumption that measuring the sound pressure level at a **single point** on the ground at a distance from the turbine equal to the nacelle height plus one blade length is representative of the **average** sound pressure. Another unjustified assumption is that sound radiates uniformly.

7. Because the noise radiation from the blades will actually be **highly directional**, the measurement of the sound power on the ground according to the standard will be an **underestimate** of the true sound power. Directivity is affected by wind which refracts waves, the amount of diffraction being dependent on wind gradient which is in turn dependent on wind speed at 10 m altitude and ground roughness. Simply, **the method specified in the standard and used by manufacturers to measure turbine sound power levels will underestimate actual sound power levels particularly at distances.**

8. It is well documented that **substation noise** is dominated by **transformer noise** and that transformer noise is characterized by very pronounced ***tonality***. **Predicted transformer noise levels should be increased by 5 dbA before being combined with the wind turbine noise levels.**

9. There is no proper account taken of the ***aerodynamic modulation*** of wind turbine noise. **The noise monitoring recommended in ETSU-R-97 is totally ineffective in protecting residents from aerodynamic modulation noise because the specified noise descriptor (LA90,10) ignores the noisiest 90% of each measurement period and gives a result based on the loudest noise in the quietest 10% period.** Aerodynamic modulation noise can be heard at considerable distances from the turbines and can be difficult to detect closer to them. It is significantly affected by **atmospheric** conditions.

10. **CONCLUSION:** As a result of emerging noise data from the Hallett wind farms, the issues raised by Professor Hansen will now be re-argued and reviewed by the South Australian Courts. At the time of hearing, there was little data available from the Hallett projects to verify Professor Hansen's assertions. If these assertions are found to be accurate, the **noise model predictions for the Flyers Creek Wind Farm will not be accurate** and will be **conservative**. Aurecon has stated that "An accurate predictive noise model was used to assess the resultant noise levels at residences surrounding the wind farm." (12.8.2) The Hallett litigation directly challenges this assumption. **16 of the 34 turbines** of Hallett 2 are now **turned off at night** pending compliance data. **They will not be turned on until the above matters are resolved and project approval of Flyers Creek also needs to wait until this occurs and is resolved.**

5.2.5 Problems with FCWF noise data

There are **other noise issues** highlighted by "in progress" South Australian litigation which have particular relevance to the Flyers Creek noise data. **They demonstrate problems with the noise data such that the Director-General's Requirements in this area cannot be said to have been met.**

1. ***Tonality***

The Noise Impact Assessment affected by Vipac was based on the GE 2.5x1 generator. At the time of modelling, the actual turbine had not been settled. This is usual for projects of this type as the actual purchase of turbines is not made until after project approval. Nevertheless, Vipac will have relied on advice from the proponents and it is reasonable to assume that the preferred turbine is the specified and nominated turbine. Aurecon state "For the purposes of the noise assessment the noise characteristics of the GE 2.5x1 2.5MW turbine have been used. This turbine was selected for the noise assessment as being the turbine with the noise levels **typical** of the turbines that are under consideration for this project." (12.3 at p.12-2 in the EA)

In relation to the critical issue of ***tonality*** and the GE 2.5 turbine, Vipac (Appendix 2, p.9) state "There was **limited published data from the manufacturers outlining any detectable tones or any other significant characteristics such as impulsiveness, modulation or low frequency components in the sound power spectrum.**" So there is an acknowledged lack of precise data in relation to these characteristics. However, what data there is, suggests **tonality is present**: "We note that a preliminary report for the GE turbines show that tone at 7m/s wind speed ... Additionally, we are aware that GE are actively working on **eliminating any measurable tonality** in their 2.5MW turbine, and at the time of installation, tonality **may not** be present in the near field of the WTG." (writer's emphasis).

In the circumstances outlined above, **the only appropriate course is to add the required 5dbA penalty for tonality to all noise modelling for the project. It is completely unacceptable and inappropriate to provide noise modelling based on a turbine which has acknowledged tonality and not to include a tonality penalty in the modelling.** It is notable that Professor Hansen states that the 5dbA penalty for tonality in the Guidelines is itself likely to be **conservative**.

The Vipac "Noise Model" report goes on to state in relation to tonality: "**Additionally, this tone (measured in the near field) is likely to attenuate, and be masked by background noise effects at the nearest residential receiver (and therefore not audible, and penalty should not be set**)." This is **wrong.** There is no factual or scientific basis for this statement. In many cases, masking noise could well be other noise generated by the turbine being measured. However mid and high frequency turbine noise attenuates more rapidly with distance from turbine such that low frequency tonal noise is likely to be **more** noticeable at greater distances from the source. The masking noise itself is likely to reduce over distances such that the noise effect of the ***tonality*** **will be especially significant at distance** and worse when there is a relatively high speed at turbine height and little wind at receptor.

The **established failure** of the turbines at Hallett 2 to comply with noise Guidelines has been detected as a result of ***tonality***. **The tests carried out by Vipac at Hallett 2 did not detect tonality and residents have endured some 2 years of significant adverse impacts.**

Professor Hansen commented to the Supreme Court of South Australia: "The VIPAC data also shows peaks in the acoustic frequency spectrum that would indicate the possibility of tonal noise at frequencies of 223 HZ and 1110HZ, in addition to that at 125HZ. However their tonality analysis, carried out according to the standard IEC 61400-11, indicated that the noise did not have an audible tonal characteristic..........the fact that VIPAC was unable to detect an audible tonal characteristic in the noise generated by the Hallett 2 wind farm may be the consequence of a **data analysis error** as the analysis is complicated and errors are possible."

2. ***Substations***

There is no 5dbA penalty for the ***tonality*** present in substation noise. It is well established that substation noise is dominated by transformer noise and transformer noise is marked by very pronounced tones at 100HZ, 200HZ, 300HZ and 400HZ. The predicted transformer levels should be **increased by 5 dbA** before being combined with wind turbine noise levels.

The stated assumption that maximum loading and noise generation from the substation will occur during periods of strong winds and associated high background noise levels of over 40dB(A) **cannot be sustained**.

The stated assumption that "Due to distance between the substation and the receivers the 100Hz frequency component of transformer noise is not expected to be significant at the receiver locations" is **wrong**.

3. ***Background Testing***

The proponent states (12.6.1): "In setting noise amenity criteria pertinent to wind farm projects, it is recognized that, whilst background sound level can be relatively low at low wind speeds, the wind turbines do not operate at these speeds." This flies in the face of long established evidence relating the **difference in wind speeds at receptor location and turbine location.** The proponent continues "Also, as wind speed increases the background sound levels tend to increase." **Another unjustified assumption.**

The flaws in the regression analysis for background noise testing have been highlighted by and are under scrutiny in the **Quinn litigation**. The necessity of taking background measurements specifically when wind speeds are low has also been highlighted given wind farm noise predictions for ridges and valleys when winds are higher at turbine than in the valleys.

This is not addressed in the Vipac data for Flyers Creek. The importance of proper microphone siting is also highlighted by the Hallett litigation and there is insufficient information in the Vipac data to determine the adequacy or otherwise of placement issues.

There are 70 non-host residences affected by the project and a school within 3 km of the turbines. Out to 5 km the non-host residences rise to approximately 150 according to the mapping supplied by Aurecon (additional residences have not been marked so the figure is **inaccurate**). The Villages of Carcoar (population 218 – 2006 census) and Mandurama (population 150) are both 5 km from the proposed wind farm and these would add significantly to the non-host resident numbers. Despite such a high level of surrounding population, there have been background tests carried out at only 5 residential locations. The extrapolation to "non-logged residences" has been effected by "a background noise survey" which is **not produced** in the Annexure G2. Sites have then been allocated to a "similar ambient acoustic environment" which is precisely what the purpose of background testing is supposed to determine. As the Vipac report also admits: "**it is not possible to be definitive on all of these items as these factors vary over time."**

4. ***Limitation of Testing - Exclusion of Higher Wind Speeds***

It is argued in the Quinn/Hallett litigation that there are flaws in the wind speed range which forms the basis of predicted noise levels. The assumption underlying the limited range seems to be that the wind turbine manufacturers state that their wind turbines produce a maximum sound power at a wind speed slightly below that corresponding to the rated power and at higher wind speeds, the sound power will be slightly less than this maximum. There is an assumption by the EPA that at higher wind speeds, there will be a masking effect of the increased turbine noise by increased wind noise. **A determination of these issues is expected by the South Australian litigation and is critical to Flyers Creek noise modelling as the modelling appears to be based on a maximum wind speed of 12ms.**

5. *Compliance Testing and "Good Faith" Issues*

The projected noise impacts for Flyers Creek are significant on any analysis – turbines which have an existing ***tonality*** problem but no tonality is assumed in projected figures, non-compliance with noise standards even on existing data such that it is projected that a number of turbines will have to work in "noise reduction mode", and a school and 70 residences in the surrounding areas which, on established evidence, **will be impacted**.

Aurecon has **no proposed noise compliance assessment protocol**. They have not stated what will occur in the event of non-compliance. In the event of complaints from "more distant relevant receivers," these complaints "will be investigated." Ultimately, "necessary measures to achieve compliance" will be implemented. Aurecon states that it must be mindful that "If a large number of wind turbines were operated in noise reduction mode, the decrease in electricity generation would be significant."(12.7.1)

Vipac's position in relation to potential impacts for which compliance and monitoring may be required is clearly out of touch with reality and scientific fact - "The psycho-acoustic response or annoyance level to a new noise source is subjective ....but is unlikely to be significant with wind farm noise ..."

Aurecon express a similar attitude –

The current South Australian litigation highlights the fallacy of accepting that wind farm proprietors will be reliably compliant and self-monitoring. It was asserted and accepted for all noise predictions that there would be and was, no tonality with the Hallett turbines. But ***tonality*** was present and evidence in the hands of AGL established tonality **prior to wind farm construction**. The residents of Hallett 2 suffered enormous disturbance to their lives and well being for two years while complaints were ignored.

Wind data in the hands of AGL was <u>not fully or properly discovered</u> to the complainants in the legal proceedings. The litigation may deal will this in due course but in the meantime, it demonstrates that **effective monitoring and compliance regimes must be imposed by the planning authority at the outset. <u>None</u> are proposed or contained in the Flyers Creek Environmental Assessment and it should <u>not</u> be approved on this basis.**

5.3 THE ACOUSTIC GROUP (STEVEN COOPER)

PEER REVIEW OF ACOUSTIC ASSESSMENT FLYERS CREEK WIND FARM

Steven Cooper of The Acoustic Group, Sydney, was commissioned by FCWTAG to provide an analysis of the acoustic measurements and modelling performed by Vipac and presented in the FCWF Environmental Assessment. The Acoustic Group's report is designated **Appendix 2.**

5.3.1 EXECUTIVE SUMMARY OF THE REPORT (For Full Report See Appendix 2)

The Acoustic Group has performed a desk-top review of the acoustic documents comprising the acoustic assessment for the Flyers Creek Wind Farm. Further, The Acoustic Group has conducted preliminary sound monitoring at an existing operational wind farm (the Capital Wind Farm) which was approved in New South Wales on the basis of similar analyses, guidelines and reports to that provided for the Flyers Creek Wind Farm. The conclusions of The Acoustic Group are set out below.

The Background Noise Monitoring Survey Report has been found to be flawed:

• Noise data that has been supplied does not truly reflect ambient background level;

• Logger positions with respect to residences and trees have not been adequately identified to enable assessment;

• One "residence" had two different logger positions;

• There are unexplained discrepancies in wind speed data;

• There is no evidence re essential wind speed correlations;

• There is no evidence that wind direction has been analysed for correlation to background levels nominated for residential receivers

The Noise Impact Assessment (Chapter 12, Environmental Assessment and Appendix G2 Noise Impact Assessment) has been found to be inadequate and likely to be inaccurate. It fails to properly examine:

• The lack of data for the type of turbine assumed;

• An appropriate sound power level for modelling purposes that reflects actual operating turbines;

- Modulation, interference patterns, low frequency noise and infrasound;
- The impact of meteorological conditions on sound propagation;
- Identify the actual noise impact of the wind farm;
- Substation noise, construction noise and transmission line noise.

There has been found to be a fundamental inadequacy in the acoustic assessments in that they do not attempt to discuss or examine the actual noise impact for the community. Such an analysis is required by the Director-General's Requirements and by the principles contained in the South Australian legislative framework.

The adequacy of the South Australian Guidelines in protecting the amenity of the community surrounding the wind farm has been examined. Fundamental inconsistencies and omissions in the South Australian legislative framework relating to wind farm noise have been identified.

There are fundamental inconsistencies and omissions in relation to Indicative Noise Levels and in relation to low frequency noise and infrasound. It has been found that the Guidelines establish criteria which conflict with their own objectives.

It has been found that application of the South Australian Guidelines cannot be reconciled with the New South Wales Protection of the Environment Operation Act (POEA) nor with the New South Wales Industrial Noise Policy. The proposed wind farm will result in the generation of offensive noise breaching the New South Wales legislative framework.

Initial results from preliminary testing at the Capital Wind Farm have been found to confirm concerns that the Flyers Creek Wind Farm will result in the generation of intrusive and offensive noise. Testing has demonstrated that the Capital Wind Farm is generating audible noise significantly above predicted levels and above levels prescribed by its consent at the residential site tested. These noise levels validate complaints of significant adverse impacts.

Preliminary testing at the Capital Wind Farm demonstrates low frequency noise and infrasound at levels and fluctuations likely to impact on residents.

On the basis of the above, The Acoustic Group has found that approval of the Flyers Creek Wind Farm proposal would expose the surrounding community to

intrusive and offensive noise and would leave the approval authority, land owners and the proponent open to litigation and complaint accordingly.

5.3.2 CONCLUSIONS FROM THE REPORT (See Appendix 2)

The Flyers Creek Wind Farm should not be approved.

The Background Noise Monitoring report is flawed. The noise data does not truly reflect ambient background levels. Logger positions with respect to residences entry have not been adequately identified to enable assessment. There are unexplained discrepancies in wind speed data and there is no evidence in relation to essential wind speed correlations. There is no evidence that wind direction has been analysed or correlated to background levels.

There is no analysis in relation to noise emitted from the wind farm taking into account various weather conditions, and in particular the presence of temperature inversions with and without downwind effects.

The Noise Impact Assessment fails to deal adequately with the lack of data for the type of turbines assumed.

The computer prediction provides tolerances greater than that nominated in the predicted levels, which therefore presents concerns in relation to the adequacy of the assessment.

There is no adequate, specific examination of substation noise, construction noise or transmission line noise.

There is no analysis of the noise impact of the wind farm as a whole. Such an analysis is required by the Director-General's Requirements and by the principles contained in the SA legislative framework. Insofar as the Assessment uses the WHO guidelines in relation to wind turbines and sleep, these guidelines are outdated and insufficient to deal with sleep disturbance from wind turbines in rural areas.

The South Australian Guidelines are inconsistent and contradictory within their own legislative framework and failed to meet their own objectives.

The SA guidelines permit noise from a wind farm that is intrusive. The NSW INP defines intrusive noise limit is background +5 dB(A). The base level from the SA Guidelines is 35 dB(A). Where one has a background level below 25 dB(A) and a limit of 35 dB(A) then noise at the "strict noise limit" must by definition be intrusive.

The Acoustic Assessment for the proposed Flyers Creek Wind Farm is very similar to that for the Capital Wind Farm proposal. Both proposals purport to indicate there will be no acoustic issues. Further measurements and testing are required at Capital Wind Farm to provide additional data to the preliminary testing. However the preliminary testing undertaken to obtain measurement data assessment suggests that the assessment and its predictions are incorrect. It suggests there is valid foundation for complaints in relation to the noise impact of that wind farm.

There is no doubt that the acoustic environment inside residential dwellings in rural areas is different to that outside. The use of an acoustic criterion expressed in terms of the A-weighted level is inadequate for assessment purposes when assessed external to the dwelling and totally inadequate for assessing the noise level obtained inside a dwelling.

The assumptions made as to outside inside attenuation for a typical suburban dwelling do not apply for rural dwellings subject to the impact of noise/energy generated by wind farms.

It is impossible to predict from available data what buffer zones would be required to give protection from noise impacts to the residents affected by the FCWF.

5.4 L. HUSON & ASSOCIATES PTY LTD REVIEW – NOISE IMPACT ASSESSMENT PREPARED FOR FLYERS CREEK WIND FARM

W. Les Huson of L . Huson & Associates Pty Ltd, was commissioned by FCWTAG to provide and analysis of the acoustic measurements and modelling performed by Vipac and presented in the FCWF Environmental Assessment. L. Huson & Associates' report is designated **Appendix 3**.

5.4.1 EXECUTIVE SUMMARY OF THE REPORT (See Appendix 3)

L Huson & Associates Pty Ltd has completed a preliminary review of the acoustic aspects of the Flyers Creek wind farm development proposal submitted by AURECON on behalf of Flyers Creek Wind Farm Pty Ltd in May 2011.

The review focuses on the sound emissions of the proposed wind turbines, the modelling used to predict sound levels in the community and the methods used to determine target noise compliance curves.

The documents detail **background survey data that we believe is inaccurate and non-compliant with the requirements of the South Australian Wind Farm Noise**

Guidelines and the directions of the NSW DECC. There is insufficient detail to show what data was deemed to be removed from the analyses and no detail on the effects caused by the reported equipment failures.

The noise modelling described is at best unintentionally confusing. **Incorrect parameters were input to the CONCAWE noise model and the results of this were used to justify the use of ISO9613 for the results presented to assess compliance.**

Contradictory noise model accuracies are presented and the lower used to feign an approach of conservatism. Despite the vagaries of the noise predictions the results show non-compliance in idealised conditions for the wind farm for a number of dwellings.

The reports suggest that the wind farm should be built and then managed to reduce any non-compliant noise emissions. The management options include facilities available to the example wind turbine used in the study, which it is stated is not the preferred choice for the development. **We believe that this approach is inappropriate and that for the project to be approved there should be a clear conservative margin of compliance in the assessment methodology and results.**

5.4.2 ADDITIONAL COMMENTS BY FCWTAG

1. L. Huson is critical about the choice of representative turbine. On page 6 of his report he states:

   "General Electric has advised that they are working on a solution to a **tone emitted from their 2.5xl wind turbine**. Accordingly, this model will not, after all, be considered for this project and another turbine is likely to be used. **Why did they not choose another representative turbine?** Part of the impact assessment states that compliance can only be achieved at some dwellings if lower noise emission operating modes of the wind turbine, that is a feature of this particular model, are implemented. We question if any of the other alternatives have **similar lower noise emission operating modes."**

2. The basis for the noise impact assessment should be the 2003 version of the SA Wind Farm guidelines **only** and that the DGRs were issued prior to the release of the 2009 SA Wind Farm guidelines. Vipac have used **both** guidelines.

3. Errors in the Background Noise Report (Appendix G1) include:

   - There were 5 background sites but only 2 rainfall detectors and 3 wind speed and direction weather stations. Measurements are therefore **<u>non compliant</u>**.

- Corrections for wind speed at the microphone are **not accurately described** and are **<u>incorrectly performed</u>**.

- Rainfall data from 2 sites have been extrapolated to the 3 sites without rainfall meters. This is **<u>inaccurate</u>** as rain can be localised.

- At least two sites experienced multiple equipment failure leading to significant amounts of data being removed. This has led to doubts about the **<u>quality</u>** of all data collected.

- "Background noise curves at 4 out of 5 background monitoring sites have been applied to other residences using an educated guess procedure." There ***are*** **better, more rigorous approaches**.

- The regression analysis curve for location # 89 is **suspicious**. Sound monitoring down to 20 dB(A) is suspect and **outside the approved measurement range for the instrument used** (operational range is a minimum of 30 dB(A)).

- There is an absence of wind date at location #89 between 16-25 November 2009 (a time of high wind). This makes the sound levels reported at the time **<u>suspect</u>**, yet data has been included in the trend analysis.

- Only one met mast was used to produce **all noise trend curves**. This is likely to have produced less accurate background sound levels. The employment of at least the second available met mast would allow for the calculation of more accurate background sound levels.

4. Errors in the Noise Predictions (Appendix G2 and Chapter 12 Main Report)

- No comment on the variations from a noise model, **as required** by the SA guidelines, has been provided in the Vipac reports.

- There are issues of non-compliance and accuracy with the estimation of predicted sound levels.

- L. Huson states that the assurance by the proponent that any exceedance of noise limits in the SA Wind Farm Guidelines will result in their taking action to ensure compliance. And remarks that this is a "leap of faith". This is surely not the premise on which to base the operation of a 44 wind turbine operation.

- The use of particular noise modelling, and conclusions therefore reached, are **questionable**. **Even using flawed noise modelling there are exceedances of target noise limits** that require special noise reduction operating modes for some turbines.

- In modelling noise no account has been made for the **turbulence effects from upwind turbines** that can increase noise emissions above those used for the modelling.

- The 'Noise sub plan' of the **OEMP is inadequate**. Compliance checking will be difficult and problematic due to the fact that the background surveys presented in the EA "leave one to suspect that the data collected …..makes **any test of compliance problematic** unless the surveys are repeated."

- L. Huson states on page 8 of his report: "An outdoor target noise level from the wind farm from the non-relevant receivers is proposed at 45 dB(A)" and suggests there will be no sleep disturbance at this level in accordance with WHO Community Noise Guidelines. However he draws on WHO considerations of vulnerable groups which experience less abilities and/or possibilities of being able to cope with the impacts of noise exposure (the aged, babies and young children, people in hospital or rehabilitations, those with hearing or visual impediments, people with certain medical conditions etc). These groups have **not** been considered in the FCWF EA.

- L. Huson discusses the levels of sound that can disturb sleep and states that measurable effects start from about 30 dB LAeq. The sensitive groups are mainly elderly persons, shift workers, and persons vulnerable due to physical and mental disorders. It is generally accepted, according to the WHO, that SPL should not exceed approximately 30 dB LAeq if the negative effects on sleep are to be avoided.

- At night it is noted by the WHO that sound outdoors should not exceed 45 dB LAeq and that indoors should not exceed 30 dB LAeq. This assumes an attenuation of 15 dB between outdoors and indoors. This may not be the case and the WHO states that attenuation may only be 5-7 dB. L. Huson has found, under Australian conditions, that the range is at the most equal to 5 dB(A) and more typically is around 3 dB(A) with open windows. To attain a maximum of 30 dB(A) indoors the outside sound limit would have to be no more than 33 dB(A).

- L. Huson concludes: "It is doubtful if the seven 'wind-farmers' or non-relevant receivers that are located within 1 km of the turbines know or understand what sound levels they will be exposed to at night in the summer months with windows open. **The internal sound levels predicted will not protect sleep** if the attenuation of sound from outdoors to a bedroom is only 3 dB(A) with windows open."

5.5 HEALTH AND AUDIBLE SOUND

5.5.1 The Environmental Assessment makes little comment on noise impacts on health other than to deny any impact at all. In Chapter 16 the EA states that the wind farm "can be designed and operated such that it will comply with the very strict noise amenity criteria utilised in NSW". Since those criteria are the SA EPA Noise Guidelines which are currently central to the "Quinn case" in South Australia and have been referred back to the ERD Court, this is not a commendation.

5.5.2 The EA quotes several sources as stating there are no adverse physiological effects from the noise emanating from wind turbines. But research and legal opinion has moved on. For instance, the EA makes reference to the National Health and Medical Research Council (NHMRC) which published a *"Wind Turbines and Health: A Rapid Review of the Evidence"* in July 2010 stating in part that there was no direct pathological effects from wind farms[36]. This has been convincingly rebutted by – see for instance, Dr. Carl Phillips in his submission (No.897) to the Australian Senate Enquiry into Rural Wind Farms.[5] Nevertheless the NHMRC also clearly says:

1. a precautionary approach should be taken
2. research outcomes should continue to be monitored;
3. wind turbine design standards should be complied with;
4. site evaluation should occur to minimise potential impacts; and
5. people who believe they are experiencing health problems should consult their doctor promptly.

By omitting the recommendations contained in this Public Statement and only noting that 'NHMRC has confirmed that there is no published scientific evidence to support adverse health effects of wind turbines on health' completely **distorts the Public Statement and by its omission is dishonest**.

5.5.3 Professor Warwick Anderson (CEO of the NHMRC) stated in his oral evidence to the Senate Enquiry: **"we do not consider there are no ill effects" from wind turbines[5]. He also noted that "an absence of evidence does not mean there is no problem".** The NHMRC advocates the application of the precautionary principle and recommends that more research should be performed.

5.5.4 This corroborated the Senate Enquiry's seven recommendations which include that adequately resourced epidemiological and laboratory studies should be initiated[5].

5.5.5 The "Quinn case" in South Australia has questioned the ability of the SA EPA noise guidelines to adequately protect the health of residents living near wind farms, and this has been dealt with in detail in this submission.

5.5.6 A recent Canadian Court judgement (18th July 2011) has found on the basis of expert evidence presented to the court that there are adverse health effects from large industrial wind turbines:

> *"This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree."* [19]

5.5.7 It is an indictment of the wind energy industry that it continues with health impacts denial when there is a rapidly growing body of more recent, independent material published by respected academic researchers and medical practitioners which strongly indicating the opposite view. These health impacts are more pronounced as wind turbines become taller and more powerful with large rotor diameters and hence sound propagation.

5.5.8 Significant research has been performed on the adverse health effects of wind turbine noise.[47,42,38,24,68,69,39,45,23,31,21] The issue of the extremely adverse wind turbine noise impact on children's mental and physical health is dealt with in some detail[10].

5.5.9 The impacts from wind turbine noise are well documented in the above cited references. Noise is sometimes described as "annoyance" but physiological effects are concerning and include: headaches, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia (rapid heart rate), hypertension, cardiovascular disease (including Tako Tsubo episodes with 3-6% mortality), irritability, confusion, reduced concentration and memory problems, panic episodes with severe depression and worsening control of pre-existing and previously stable medical conditions such as angina, diabetes.

5.5.10 Cappuccio et al (2011) summed up the health impacts from excessive noise[15]. One of the most significance consequences is that of sleep deprivation with physiological and psychological sequelae, including depression. Lack of sleep results in "detectable changes in metabolic, endocrine and immune pathways. Too little sleep …[is] associated with adverse health outcomes, including total mortality, type 2 diabetes, hypertension and respiratory disorders, obesity in both children and adults, and poor self-rated health. Both short and long duration sleep are predictors, or markers, of cardiovascular outcomes."

5.6 HEALTH AND INFRASOUND

5.6.1 Infrasound is also termed Non-Audible Sound and refers to that sound that cannot be heard, but can be felt, and is usually considered to be less than 20 Hertz frequency.

5.6.2 There are two critical issues to consider:

1. Do industrial wind turbines produce infrasound?
2. If they do, does infrasound from wind turbines have a health impact?

5.6.3 **Do Industrial Wind Turbines produce infrasound?**

Despite wind energy company denial there is now a considerable, and growing, body of work that has found that **wind turbines do produce infrasound**. Low frequency sound is likely produced by wind turbines with the displacement of air by the blades and the turbulence around the blade surface; and as the turbines grow larger the potential to produce infrasound increases.[54,55,26,27,76,69,7] In fact results confirm the hypothesis that the spectrum of wind turbine noise **moves down in frequency with increasing turbine size**[34]. Compared to medium and high frequencies, **low frequency levels decay slowly with distance**, are **less attenuated by conventionally designed structures (such as homes), cause certain building material to vibrate** and can sometimes **resonate with rooms**, thereby undergoing **amplification.**[60] Thus infrasound is more likely to be an **indoor problem rather than an outdoor**. Recent work in Europe has found that infrasound can be measured out to **8-11 kilometres.**[51,16] **This has significant implications for the determination of a *set back* distance of residences from wind turbines**.

5.6.4 **Does Infrasound from Wind Turbines have a Health Impact?**

Infrasound, like audible sound, will affect people in different ways, both as to susceptibility (about 15% of the population exhibit increased noise sensitivity) and symptoms (type and degree). The difference between audible sound and infrasound is that infrasound is felt rather than heard. It manifests as those health impacts associated with audible sound but additionally health effects can include sensations of fullness, pressure, vibration or tinnitus, tiredness and malaise.

Lower frequencies correspond to resonating frequencies of our body organs and in their presence encourage them to vibrate. Shepherd[60] notes that the head resonates at 20-30 Hertz and the abdomen at 4-8 Hertz. The following table illustrates the effects of chronic low frequency vibration and subsequent physiological consequences[60].

Table 5.1: Psychological and physiological sequelae resulting from low frequency vibration

Frequency of vibration	Symptoms
4 – 9 Hz	Feeling of discomfort
5 – 7 Hz	Chest pains
10 – 18 Hz	Urge to urinate
13 – 20 Hz	Head aches

There has been considerable research published in recent years confirming the health impacts of infrasound from wind turbines.[60,10,68,69,70,4,34]

5.6.5 Infrasound and the FCWF Environmental Assessment

The EA in Chapter 16 quotes the World Health Organization (unreferenced) that "there is no reliable evidence that sounds below the hearing threshold produce physiological or psychological effects."

Further the Vipac Report (Appendix G2) states: "The psycho-acoustic response or annoyance levels to a new noise source is subjective and will vary from person to person but is unlikely to be significant with wind farm noise and particularly so with increasing separation distance between the turbines and the residences. Current wind turbine designs are not a significant source of low frequency noise or infrasound – even nearby (less than 500m), any infrasound is well below the threshold of human perception and would not cause health effects." **There is no reference(s) quoted to confirm this statement**.

In contradiction to this the WHO has stated[8]:

"….a large proportion of low-frequency components in noise may increase the adverse effects on health…. It should be noted that the low frequency noise, for example, from ventilation systems, can disturb rest and sleep even at low sound pressure level…Special attention should be given to: noise sources in an environment with low background sound levels; combinations of noise and vibrations; and to noise sources with low-frequency components."

And further:
"The evidence on low frequency noise is sufficiently strong to warrant immediate concern…Health effects due to low frequency components in noise is estimated to be more severe than for community noises in general".

5.7 WIND TURBINES AND THE AUSTRALIAN HEALTH EXPERIENCE

5.7.1 Since the construction of wind turbines, and more latterly as the number of wind farms increase and the size of the wind turbines themselves grow larger, there have been an increasing number of complaints about the impact of the wind turbines on mental and physical health in Australia. The symptoms are consistently those that are described as Wind Turbine Syndrome and have been discussed above[47]. There are many reports of similar health experiences described in Europe, Canada, New Zealand and the United States[52,53,55,4,10,21,24,26,30,31].

5.7.2 The volume of reports cannot be ignored or dismissed as the rankings of jealous non host families. There are now reports of host families being affected and leaving their homes as a consequence (personal communication). Health effects are real and their cause can be found in both non compliant audible sound, and from infrasound which is consistently denied by the wind industry. As one example, the report published here from The Acoustics Group illustrates the lie of this claim by the wind industry. Infrasound and non-compliant audible sound have made the lives of a significant number of residents close to wind turbines intolerable and has put them at considerable health risk (mental and physiological).

5.7.3 The FCWTAG has made efforts to undertake a preliminary survey of affected people and has received histories from a number of people from geographical disparate areas of Australia. The overwhelming impression is that there are a growing number of people who are completely desperate, who feel they are not being taken seriously by the wind energy industry, the medical profession, Public Health officials, or appropriate Government departments (Federal, State or local).

5.7.4 Appendix 7 is a compendium of some emails and letters which we have received recently. A sample only is published here and some, who wish to remain anonymous because of intimate medical details, have had their names removed. We have also had responses from overseas as well. This is not only an Australian issue, but one that has ramifications throughout the world. These are indeed cries for help and bear attention from those who seek to make determinations about the siting of wind turbine installations and have any regard for the well-being of their fellow man as well as their duty of care.

5.7.5 In addition to the histories presented in Appendix 7 it is noteworthy to assess other venues where medical complaints and histories are presented. These include:

A significant number of submissions (greater than 30) to the Federal Senate Enquiry into *The Social and Economic Impacts of Rural Wind Farms* (2011);

http://www.aph.gov.au/senate/committee/clac_ctte/impact_rural_wind_farms/report/index.htm

Eleven signed affidavits of health impacts at the AGL Hallett 2 wind farm in South Australia – submitted by the Coopers Gap Landscape Guardians as an inclusion in their reply to the AGL Initial Assessment Report, Qld, 2011;

Evidence given at the Quinn –v- AGL Hallett 2 legal proceedings in both the ERD and Supreme Courts of SA;

Any one following this issue will find a plethora of material detailing the health impacts and consequences (social, financial, medical and cultural) of wind turbine installation in the media (TV, radio, newsprint, websites and blogs etc.) Websites include:
www.wind-watch.org
www.waubrafoundation.com.au
www.windvigilance.com
www.windperformance.info
www.atkinsonrapley.co.nz
www.windturbinesyndrome.com

5.8 EXPLANATORY NOTES

5.8.1 Industrial Wind Turbines, Sound Measurement and Human Sound Perception

1. **Industrial Wind Turbines** (IWTs) are significant structures of human engineering. Current models consist of a tower at the top of which are three rotor blades attached by a hub to gears and a generator. These sit in a box (nacelle) at the top of the tower. The tower is anchored to a steel reinforced concrete foundation. A motor turns the nacelle to face into the wind. The blades spin upwind of the tower and blade angles are adjustable. When the rotor spins, it turns a shaft. The shaft spins magnets inside copper coils. This induces a current in the coils. The frequency and voltage of the electricity so generated is modified by circuitry and the current is sent off to the relevant Grid.

2. There has been a significant increase in the height and size of turbines since original construction. Initial tower heights were about 15 metres in the 1980's with a power output of about 50 kw. By 1990, towers were up to 40 metres, doubling to 80 metres by 2000. Power output had increased to 2000 kw. The turbines presently proposed in most developments in NSW are approximately 162 metres in overall height with tower heights of up to 100 metres and blade lengths

of over 60 metres. Prototype turbines are now 193 metres in height. As the wind industry has developed with government renewable energy targets and subsidies, the variety of terrains into which the turbines have been located has extended.

3. The **human body** however, is a vastly more complex piece of engineering than an IWT. The capacity of the human organism to function depends on its capacity to react to its external and internal environment. We possess refined sensory receptors – our skin, our ears, our eyes, our motion and balance senses amongst others – which allow us to do this. These receptors transmit detailed information via our neural pathways to our brains which in turn process this information and co-ordinate our bodies' responses to it. As would be expected for survival, many of these responses occur automatically, without conscious control. Each night, we sleep and the cognitive processes of the brain are consolidated. It is not surprising, indeed it is completely predictable, that if our sensory input or our sleep is disturbed in a prolonged manner, we may, and will, become sick. Our capacity to hear persists even during sleep as opposed to other sensory modalities. This forms the basis for the effectiveness of smoke alarms to wake us compared to other sensory input.

5.8.2 Sound, Sound Measurement and Sensory Perception of Sound

1. Operating IWTs emit sound energy which is transmitted as waves. The science of sound and its associated physics is far from simple but an understanding of the physical principles of sound and its effect on human health arising from IWT projects is central to this document.

2. The spectrum of sound waves is continuous but is commonly divided into the classifications of **infrasound**, **low frequency sound**, **mid-frequency sound** and **high frequency sound**. Although variable classifications exist the one used here is after Dr Robert Thorne and consists of:

Infrasound	20 Hz and below
Low Frequencies	20 Hz to 250 Hz
Mid frequencies	250 Hz to 2000 Hz
High frequencies	2000 Hz to 20,000 Hz[71]

3. The Hertz measurement refers to the cycles per second at which the wave is travelling. Lower frequencies have **longer** wave lengths than higher frequencies. The **force** of the wave (referred to as pressure) is measured in **decibels (dB).**

4. There are a number of scales available to measure sound energy. Some of these scales weight (i.e. give preference to) particular frequencies in their measurements. The sounds of all frequencies are not heard equally well by humans. The **A scale** was developed to deal with **human hearing**. Most studies of community noise have accordingly used the A weighted scale. This scale weights the contributions of sound waves in the 1,000 Hz to 6,000 Hz range. It progressively reduces contributions from about 500 Hz down and 7,500 Hz up[68,62]. Pierpont states that the effect of the weighting is to reduce sound measured by about 30 dB at 100 Hz, and about 40 dB at 31 Hz. So the A weighted scale does not give, or purport to give, a pure measure of frequencies outside the range of hearing of the human ear and *increasingly* distorts the contribution of lower frequencies as it moves down the spectrum[67].

5. The **C scale** captures sound equally (i.e. without weighting) over most of the audible range down to 31 Hz. After this, it has a decreasing response. The **Z scale** is an unweighted scale (sometimes called **"Lin"** or **"Flat"**) which gives an equal response to sounds between 10 Hz and 20,000 Hz in acoustical standards. The **G weighted scale** measures infrasound frequencies. Some researchers prefer the G scale for infrasound measurement although Dr Thorne uses the **Z scale** in conjunction with the C weighted scale.

6. The relationship between our perception of sound and the measurement of sound is an interesting one. If we can hear sound, we do not necessarily hear in accordance with what is measured. Firstly, it is usual for sound measurements to be *averaged* over time. If the time period over which sound is measured is short, unique noise events will be captured. But over a longer period, unique events are averaged away[49]. As it is often said, the human organism does not perceive averages.

7. Secondly, sound is perceived against a background of other sounds. The relevance of background noise in determining the perception of noise is well recognized[43]. Sound may, in some circumstances, be masked by other sounds and we do not perceive it notwithstanding its presence. Conversely, it is widely accepted that sound is likely to be perceived more loudly if it is heard against a quieter background. A difference of **10 dB** is perceived by human hearing as **twice** as loud.

8. Sounds are not constant. Just as we may perceive a contrasting sound as louder than measured, we perceive increases in sound from a single sound source as greater than the actual change in decibels[70]. Again a 10 dB increase from a single sound source is likely to be perceived as twice as loud as the original sound.

9. Leaving aside audibility, sound waves in the **low frequency** and **infrasound frequency** ranges share characteristics which differ from sound in the **mid to higher frequencies** and which are pertinent to the IWT/adverse health debate. In particular, infrasound and low frequency sound waves **attenuate** at slower rates. They **travel further** and **fall away less quickly**. At distance, when sound emanates from a broadband source, the lower frequency components will **dominate**. Lower frequencies are less easily masked by noise in the mid to high frequency ranges[75,76]. Low frequency waves, with their longer wavelengths, are **not effectively filtered by buildings[75,76].** Nor is hearing protection effective[67].

10. In relation to the human perception of lower frequencies, low frequency sound may be audible. Older people's hearing is proportionally more acute at low frequency ranges than mid to higher frequencies[67]. Infrasound is generally regarded as **inaudible** but research has established that there is in fact a **threshold for audibility**. The World Health Organization states that noise with low frequency components requires **lower guideline values** in view of health effects being **more severe** than for community noises in general[63].

11. Audible or not, the ear is **not insensitive to infrasound**. Recent American studies have confirmed that the ear of higher mammals responds to infrasound waves below audible levels[52,53,54,55,56]. The research suggests that this may occur in a number of ways – by stimulation of the Outer Hair Cells of the Cochlea (the Inner Hair Cells respond to sound which we hear), by affecting the ear's response to higher frequency sounds, by stimulation of the vestibular hair cells or by influencing the volume of the fluid in the inner ear (the endolymph). This research highlights that the ear is both the organ of **hearing** and the organ of **balance**. Any effect on the vestibular system will impact on the body's balance and equilibrium.

12. Note also, that sound waves are **energy waves**. In addition to allowing humans to hear when they impact on the ear, they may cause vibrations in other organs as well as in external structures. Just as low frequency noise can cause vibrations of walls or windows, the bones, organs and tissues of the body are capable of vibration and resonance also.

5.8.3 Industrial Wind Turbines Operating Characteristics

1. What happens to sound waves and vibrations when IWTs are anchored into place in varying numbers in different locations and are "turned on". The immediate answer is "we don't know" with any real specificity or accuracy. The adequacy of wind industry modelling and pre-construction predictions has been criticized in peer reviewed literature. Wind farm compliance measures are carried out by the

wind industry to the **minimum extent necessary to comply** with development conditions. This means the extent of comprehensive and detailed independent studies is usually limited.

2. When turbine blades rotate, they produce soundwaves through the broadband spectrum ranging from infrasound, through the lower frequencies and the mid and high frequencies. As the blades rotate through the air, the pressure (amplitude) of the waves so created fluctuates or changes. This is referred to as **amplitude modulation**. With audible waves we hear the modulation often described as louder/softer, louder/softer or swish/swish/swish. Some evidence indicates that this variation is heard when the blades pass from the horizontal position going down. When the blade comes up, it is passing through varying degrees of air turbulence and the change in frequency is audible as a thump or a beat[52,53,54,55,56]. The fluctuations in the sound waves are occurring across all frequencies but it is common for people living near wind farms to describe an audible "swish/thump", "swish/ thump" with variations in the "thump."

3. In relation to frequencies that are audible, **amplitude modulated** noise is more **easily perceived and more annoying** than a constant level of noise[70]. Swedish researchers have shown that audible noise from IWTs is more annoying than other kinds of industrial/transportation noise levels for this very reason[8]. Residents have been shown to be highly annoyed by wind turbine noise at 38 dBA while aircraft noise has to reach 57 dBA, and road traffic noise, 70 dBA. Audible wind turbine sound waves vary in amplitude within relatively short spaces of time, and without cessation, even at night. They are likely to be far more intrusive to the central nervous system than a pure amplitude measurement would suggest.

4. When multiple turbines are placed together and are operating, what is occurring to the energy waves? Dr Robert Thorne suggests that with two or more turbines in phase together and a light breeze, there can be a variation (i.e. an increase) of 6 – 7 dBA arising from the synchronicity of the blades. Recalling that a 10 dBA change in a sound source is likely to be perceived as twice as loud. Alternatively, if the blades are not operating in synchronicity or there is turbulence with different wind velocities and directions (presumably a common occurrence with ridgeline wind turbines), the "thump" produced by the upward blade movement is exacerbated. The blades cannot be continuously and sufficiently adjusted to cope with the turbulence.

5. Further, Dr Thorne and others have shown that downwind from a cluster of turbines, vortices interact and sound is enhanced. Thorne describes these areas where sound is amplified as **Heightened Noise Zones (HNZ)**. There can be

significant variations in residences reasonably close to each other if one falls within a Heightened Noise Zone, receiving higher amplitude of waves temporarily, and the other does not. As wind directions change, so do the Heightened Noise Zones. The same residence may be in a HNZ at some times and not at others.

6. The audible amplitude can also be markedly affected by terrain. The most productive land based wind sources can be along ridge lines with houses nestled in adjacent valleys. It is along ridgelines that **noise enhancement** also occurs. Partly, this can be as simple as the fact that a house is built in an area protected from the usual wind in the area. The masking effect which the wind might otherwise have on the audible turbine noise is absent. Remember that noise perceived depends partially on background and masking noise. More importantly, wind turbine noise is enhanced by the atmospheric conditions which frequently occur in ridges and valleys[64]. Warm air rises. At night, the air stabilizes. With a light wind blowing at turbine height, sound levels at homes 800 to 3.2 kilometres away in the valley have been measured at 5 – 15 dBA higher than the models would otherwise suggest[26]. These conditions are likely to occur at night when families are asleep and can be prolonged with foggy, still weather.

7. All of these factors suggest that audible noise produced by IWTs can and will be **far greater** than manufacturer's specifications suggest and **compliance monitoring detects**. This fact is well known. Dr M Swinbanks, an applied mathematician with extensive experience in the theory and practice of aerodynamic sound generation, states that this was well known to NASA by 1990[26]. NASA and their subcontractors calculated sound levels generated by ideal turbine blades operating in clean airflow and identified how, inevitably, turbulence resulted in unsteady blade loadings, thus increasing sound levels. They then extended the work to consider the effect of wind gradient (i.e. wind velocity varying with height across the face of a turbine). This generated substantially higher noise levels. Finally, they subjected people to impulsive wind turbine noise under laboratory conditions and showed that the hearing threshold could be almost 20 dB lower than the conventionally accepted noise threshold. Swinbanks has stated:

> "During this period [i.e.1980-1990], NASA and NASA sub-contractors identified almost all of the specific issues relating to wind-turbine noise, that now are being re-learned the hard way, by bitter experience" [67]

8. It seems probable that the wind industry itself is aware of this issue. In his presentation in May 2010, Erik Sloth stated "Current modelling techniques were

developed when turbine projects consisted of one or two turbines." 17 He went on to comment that in relation to new projects requiring detailed noise study including **wind speed**, **wind direction** and **directional transmission paths**, "No modelling tools are at present available to do this kind of modelling, but tools are probably on the way."[79]

9. The Finnish acoustics engineer, Denis Siponen has suggested that as turbines get larger, so will the complexities of amplitude modulation[62]. Because the blade length of modern wind turbines can be more than 60 metres, the difference in wind speed at different blade positions can be several metres per second. Growing the size of the turbines and the diameter of the blades is likely to yield increasing problems with **amplitude modulation**: "As wind turbines are still getting larger and their rated power higher, the number of complaints of wind turbine noise is also quite likely to be increased." [62]

10. Concerning infrasound and low frequency sound, the picture is even more interesting. Because infrasound and low frequency sound waves attenuate at slower rates than higher frequencies, it is predictable that they will predominate in the sound waves produced by IWTs at distance – for example at 2-3 kilometres c.f. 500 metres. It is predictable that residences located at distances from operating IWTs are being exposed to low frequency sound and infrasound. We know that these waves can travel through buildings and cause walls, windows and people to vibrate. Resonations can be set up. What then are the levels of infrasound and low frequency waves actually generated by operational IWTs? **We do not know**. The wind industry measures on the A weighted scale only. This is consistent with current development requirements which are now totally inadequate.

11. Available recent studies strongly indicate that low frequency and infrasound generated by IWTs are greater than previously acknowledged and likely to be greater still with increases in the height and size of turbines. Robert Thorne[70,71] uses the C weighted scale in conjunction with the Z scale.; Pedersen and colleagues[42,43] use the G scale. These studies show that the lower frequency sound waves generated by IWTs indeed predominate at distance. They are modulated and are present at very significant levels. By way of example, measurements taken inside a residence at Waubra, Victoria by Dr Thorne reveal that there are infrasound waves occurring in Australian residences near wind farms in the 50 to 70 dB(Z) range. There are also high levels of amplitude modulated low frequency waves which may be audible to some individuals.

12. In his presentation to the 4th International Meeting on Wind Turbine Noise at Rome in April this year, Dr Swinbanks presented evidence indicating that

conventional techniques of assessing low frequency and infrasound waves have underestimated their impact and that typical wind turbine infrasonic and low frequency noise can be "readily audible at very much lower levels that has hitherto been acknowledged."[67] He again points out that these results are consistent with the extensive work carried out by NASA in the decade between 1980 and 1990. NASA identified and reported increases in low frequency impulsive sound patterns from modern upwind rotor configuration turbines in 1989. NASA attributed the increase to wind-gradients and shadowing effects. At the same meeting, Denis Siponen noted that the increase in the low frequency noise component with large turbines is higher than the increase in the A weighted sound levels[62]. Larger wind turbines emit higher noise levels at low frequencies and this would seem where the future of industrial wind turbines lies.