BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

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| Application for a Certificate of Public Convenience and Necessity to Construct and Place in Service a Wind Turbine Electric Generation Facility Known as Glacier Hills Wind Park in Columbia County, Wisconsin | ) ) ) ) ) ) | Docket No. 6630-CE-302 |

**DIRECT TESTIMONY OF DR. GEOFF LEVENTHALL**
**ON BEHALF OF WISCONSIN ELECTRIC POWER COMPANY**

**Q. Please state you name, occupation, and business address.**

A. Dr. Geoff Leventhall. I am an acoustical consultant in sole practice at 150, Craddocks Avenue, Ashtead, Surrey, KT21 1NL, UK.

**Q. Please summarize your educational and professional background.**

A. I have a BSc in Physics and MSc and PhD in Acoustics. During the 1960s and 1970s I developed an Applied Acoustics Research Group at the University of London, dealing with noise problems and subjective acoustics. I personally supervised 30 students to completion of their PhD degrees, and a much larger number of MSc students were also seen to completion. One of the main interests of the Group was infrasound and low frequency noise, in which I am recognized internationally as an expert. During this time I also practiced part time as a consultant.

In the early 1980s I left London University to be Head of Acoustics at a large engineering consultancy (W S Atkins), becoming Technical Director.

In the late 1980s I was invited to apply for the post of Professor and Head of the, then, Institute of Environmental Engineering in London, where I stayed for about five years, also practicing part time as a consultant. Since that time I have been in practice full time as a consultant.

Much of my work has been in relation to low frequency noise problems. I have carried out work for the UK government department, DEFRA, on low frequency noise and there is an ongoing DEFRA project to help people cope with insoluble low frequency noise problems. I am also working with the US company Wyle Laboratories on a NASA project related to low frequency noise from a new concept heavy lift rotor, which may eventually replace short haul jets. Of course, there is also short-term problem-solving work in low frequency noise.

I first became involved with wind turbine noise in the mid 1980s, before there were any in the UK, looking at assessment methods for response to wind turbine noise. This work continued into the early 1990s, but for much of the remainder of the 1990s I spent more time on one of my other interests from my academic days, active control of noise, and had a consultancy with Digisonix, from Middleton near to Madison. This continued until 1997, about the time when Digisonix's parent company, Nelson Industries, was sold to a company that did not wish to continue with the active control work. I was then able to give more time to my other work, including wind turbine noise. I am regularly consulted in relation to the strange things which people say about infrasound and low frequency noise from wind turbines. In fact, for nearly 40 years I have been trying to educate the public and others in order to undo some of the harm which

was caused by media exaggerations in the 1970s and which have more recently developed on the Internet.

I am a former President of the UK Institute of Acoustics and have been awarded two medals by the Institute in recognition of my work.

I am, by invitation, a “Distinguished International Member” of the US Institute of Noise Control Engineering.

I was the founding editor of the Journal of Low Frequency Noise and Vibration, now in its 28th year and edited it for the first 18 years.

I have organized nine of the 13 international series of conferences on Low Frequency Noise and Vibration its Control, which have been held to date, and been advisor to the organisers of a further three. The 14th of these conferences will be held in 2010 in Denmark. Again, I am advisor to the organisers.
I was the originator of the International Conference Series on Wind Turbine Noise and organized the three which have been held so far. The fourth is currently being arranged for 2011.

Over the past few years I have been a member of two UK committees concerned with noise and health, both preparing reports on this topic, one of which has been published. I am currently a member of the AWEA committee of independent experts considering the effects of noise on health. This report is not yet completed. My Curriculum Vitae is submitted as Exhibit 17.

**Q. On whose behalf are you testifying?**

A. Wisconsin Electric.

**Q. Please briefly summarize your testimony.**

A. Based on my experience of infrasound and low frequency noise, it is my belief that the infrasound from wind turbines is of no consequence. Attempts to claim that illnesses result from inaudible wind turbine noise do not stand up to simple analyses of the very low forces and pressures produced by the sound from wind turbines. Additionally, the body is full of sound and vibration at infrasonic and low frequencies, originating in natural body processes. As an example, the beating heart is an obvious source of infrasound within the body. Other sources of background low frequency noise and vibration are blood flows, muscle vibrations, breathing, fluids in the gut and so on. The result is that any effect from wind turbine noise, or any other low level of noise, which might be produced within the body is “lost” in the existing background noise and vibration. This is considered in more detail in my Appraisal of Wind Turbine Syndrome, which is submitted as Exhibit 18.

More broadly, my testimony establishes that the claims of health effects from the low levels of infrasound and low frequency noise from wind turbines, as described in the Wind Turbine Syndrome and Vibroacoustic Disease hypotheses, fail. However, higher frequency noise from wind turbines, if it is audible, can cause disturbance to some residents, but this effect is no different from that of noise from another source.

My testimony also directly addresses Richard James's submissions to the PSC, which rely heavily on three hypotheses that do not withstand scrutiny: Wind Turbine Syndrome, Vibroacoustic Disease, and, novelly "mechanotensegrity," which, as its principal proponent explained to me, has no known applicability in this context. My testimony also briefly addresses James's criticism of the work done at Glacier Hills by George Hessler, and James's own suggested criteria for permitting wind developments. Finally, I also address James's misplaced reliance on my work.

**Q. What are your general reactions to the testimony submitted by Richard James?**

A. Part of James's testimony appears to be saying that it is impossible to model wind turbine noise. If James is correct in his approach, where are all the complaints from every wind farm? The problems which he says might occur do not normally do so, and especially not at the important locations nearest to the turbines.

He is incorrect to claim research showing a causal link between wind turbine low frequency sound levels and effects on health. Additionally, the effects of higher frequency wind turbine noise are no different from those of any other similar noise source. There is nothing special or mysterious about wind turbine noise.

## DISCUSSION OF VARIOUS CLAIMED HEALTH EFFECTS DUE TO INFRASOUND AND LOW FREQUENCY NOISE

**Q. Let's explore your criticisms of James's testimony in more detail. James claims in Exhibit 808 that new medical discoveries establish that low**

**frequency noise below the threshold of human hearing can have negative impacts on human health. What is your reaction to that claim?**

A. I do not agree. The new discoveries to which he is referring appear to be:

Wind turbine Syndrome – put forward by Pierpont

Vibroacoustic disease – put forward by the Portuguese

Tensegrity – put forward by Mulvihill

**Q. Please explain your view of Wind Turbine Syndrome.**

A. Pierpont's hypothesis about a Wind Turbine Syndrome, as resulting from disturbance to the vestibular systems by the low levels of infrasound from wind turbines, does not stand up to scrutiny.[1] I believe that this part of her work is now discredited and should be acknowledged as such. She has not made any new discoveries but, in the review section of her book (which I have reviewed in prepublication draft as its release date keeps being pushed back), has surveyed what is already known. The wide range of symptoms which she associates with Wind Turbine Syndrome are well known to others as the stress effects of audible noise, to which a small number of persons are susceptible. Also, my medical colleagues tell me that it is unusual to associate such a wide range of symptoms with a single named syndrome, as this makes the syndrome too easy to find.

**Q. Please continue.**

A. Pierpont has a very poor understanding of acoustics, which continually lets her down. Her work depends on two hypotheses, neither of which she is able to

[1] For a discussion of sound levels produced by wind turbines and perception thresholds, see pages 19-20 of my testimony.

support. Her first hypothesis relied, until recently, heavily on work by Todd et al.[2] However, it was clear to me on reading Todd's paper that she has both misunderstood and misrepresented it. She has incorrectly sought to insert noise issues into a paper which is entirely about vibration through the skull. I asked Todd about this some time ago but, at that time, he did not wish to become involved with the "politics" of wind turbines. However, there was publicity on Pierpont's work on 2nd August 2009 in a UK newspaper. As this article referred to his work, Todd finally came out and repudiated Pierpont, and her use of his research. In a letter to the newspaper (Exhibit 19), he said

> *Our research is being cited to support the case that "wind turbine syndrome" is related to a disturbance of vestibular apparatus produced by low-frequency components of the acoustic radiations from wind turbines. Our work does not provide the direct evidence suggested. We described a sensitivity of the vestibular system to low-frequency vibration of the head, at about 100Hz, and not air-conducted sound.*
>
> *At present I do not believe that there is any direct evidence to show that any of the above acoustico-physiological mechanisms are activated by the radiations from wind turbines. Even if the vestibular system were activated in a controlled acoustic environment, it is not necessarily the case that it would produce pathological effects. Until such evidence is available I have an open mind on "wind turbine syndrome".*

[2] Todd, N., Rosengren, S. M., and Colebatch, J. G. (2008): Tuning and sensitivity of the human vestibular system to low frequency vibration. *Neuroscience Letters* **444**, 36 - 41.

The response from Dr. Todd was published on 9th August and shortly after this all references to him disappeared from Pierpont's web page (www.windturbinesyndrome.com).

Throughout Pierpont's work there is no clear indication of the excitation levels which she believes might cause a problem. While she must be aware of safe and unsafe doses of medication, she continues to close her mind to the concept of safe doses of sound, although "safe sound" is our everyday experience. Thus, Pierpont's first hypothesis fails.

**Q. What is Pierpont's second hypothesis, and does it fare any better in your estimation?**

A. Pierpont's second hypothesis is equally unfounded. She says that infrasound at 4 – 8Hz enters the lungs and vibrates the diaphragm and its attached liver, so passing confusing messages on to the visceral graviceptors. She gives no evidence to support this, but instead uses references to whole body vibration, applied to the feet or seat, which is a completely different excitation to that from sound. A simple order of magnitude calculation, using basic physics of the level which will be known to a 16-year-old school pupil, shows that the movement of the diaphragm under the forces which might result from wind turbine noise is less than 10 micron. That is less than one hundredth of a millimetre or about one tenth of the average thickness of human hair. During normal breathing, the

diaphragm moves several centimetres. Wind turbine effects will not be passed by the diaphragm on to the visceral gravicaptors, as hypothesized by Pierpont. There is no scientific merit in Pierpont's second hypothesis. In fact, in strictly scientific terms I find little to distinguish this hypothesis from the following equally fanciful Internet posting, which explains why the crew abandoned the Marie Celeste:

> *The mystery was unsolved for decades, until it became clear that infrasound was the explanation of the phenomenon. As it turned out, infrasound of seven hertz emitted by ocean waves under some definite conditions was the reason of it. But infrasound of seven hertz is terrible for people: they may go mad and throw themselves overboard to save their lives.* http://ghosts.monstrous.com/infrasound.htm

Another part of Pierpont's second hypothesis states that infrasound from wind turbines, at a frequency of 1 – 2Hz, vibrates the chest, so adding to the confusing signals which upset the balance system. However, there is already a strong source of infrasound inside the body, beating at 1 –2 Hz, giving far greater magnitudes than might be produced by infrasound from wind turbines at these frequencies: the human heart. The beating heart vibrates the surface of the body at a high enough level to be picked up by a stethoscope, or even the ear. The sound produced by wind turbines does not.

**Q. Please comment on James's continued reliance on the writings of Drs. Todd, Rosengren, and Colebatch.**

A. I am surprised, and saddened, to find that as late as 5th October, two months after Todd cleared the air by firmly repudiating Pierpont's use of his work, James is still relying on Todd in his "Comments on WEPCO's Glacier Hills Application and Supporting Documents regarding Wind Turbine Noise and Its Impact on the Community" (Exhibit 808). On pages 9 –10 he uses Todd as an example to "demonstrate that there is sufficient evidence to present a causal link between ILFN and adverse health effects." What Todd actually showed was that, for a vibration input through physical contact to the mastoid area at the back of the head, certain reflexes, indicative of a vestibular response, continue to about 15dB lower than the level at which the hearing mechanism of the inner ear ceases to respond to vibration in the skull. It takes only a little thinking to realise that all of the people who use bone conduction hearing aids are receiving vibration inputs to their vestibular system at levels well above the system's perception threshold. This does not affect them, as one might expect from Todd's penultimate sentence in his repudiation of Pierpont, where he is saying, in effect: So what – vestibular excitation is not necessarily a problem.

**Q. James relies on Dr. Eileen Mulvihill's writings. What have you found out about the source of these writings and what is your reaction to them?**

A. James did not give the details of the paper from which he took the quotation, which he reproduces on page 9 of his Exhibit 808. I searched for the paper and eventually found it on the web page of the New Mexico Citizens Alliance for Responsible Energy and Sustainability (http://www.newmexicocare.org/1pages/vad.html).

This Internet page includes the statement:

> *The presentation below is a summary in response to reports suggesting that identification of "Wind Turbine Syndrome" is unnecessarily alarming and misleading to the general public and that VAD, or Vibroacoustic Disease, is part of some conspiracy*.

This is then followed by reference to papers, amongst others, on

- Military, applications of infrasound as a non-lethal weapon;
- Work carried out in connection with the Apollo space program (i.e. levels equivalent to exposure of astronauts during blast off);
- Echocardiography of aerospace workers (i.e. those working around ground running aero engines); and
- Noise risks in military operations.

All the above relate to very, very high levels of infrasound and bear no connection to the sound produced by wind turbines.

Dr. Mulvihill also reviews papers on aircraft and traffic noises and summarizes papers on VAD, some of which describe experiments on rats, which have been given continuous long term exposure (up to seven months) at levels around 100dB, or more, in the frequency range 80Hz to 500Hz. Another paper describes effects on rats, which have been exposed for 3 months at levels of about 100dB between 50Hz and 100Hz. These exposures would deafen us. It is not surprising that the rats suffered adverse effects. However, the work is not relevant to wind turbine noise, which has levels falling from about 50dB to 35dB

over this range. That is from about 50 to 65dB lower than that imposed on the unfortunate rats.

It must be emphasized that, on a noise dose basis, which, as discussed below, the VAD group adheres to**,** the noise dose received from 1 year at 100dB will take 100,000 years to be received at 50dB.

And finally, at the end of this long web page of Dr. Mulvihill's, we find the paragraph quoted wholesale by James. (This webpage is also the source of pages 196 – 206 in James's supporting documents, submitted as Exhibit 809).

Let us be clear. This quotation is not from a refereed publication, but from a self-published Internet page. However, James's extract does give a reference to a paper by Prof. Ingber, which James has included in full at page 308 of his supporting documents.

**Q Did you investigate any relevance Prof. Ingber's research might have to the issue of adverse health effects attributable to low frequency sound or infrasound from wind turbines?**

A. Yes. Prof. Ingber says on page 320 of Exhibit 809:

> *All organs also use structural hierarchies to mediate the mechanotransduction response. Contraction and dilation of the heart, for example, results in deformation of its component ECMs [extra cellular matrix] which distort cells and their integrin adhesion as well as focal adhesions and the linked cytoskeletal and nuclear components. At every size scale and level of organisation, the level of tone or prestress in these*

*discrete structural networks, governs their overall response to stress, both mechanically and biomechanically. This is also true in sound sensation in the ear, responsiveness to air movements in the lung, hemodynamic stresses in blood vessels and the compression in bone and cartilage. Thus, tensegrity helps to guide force retransmission and orchestrate multimolecular responses to stress at all size of scale and in all organ systems*

What Prof. Ingber is saying here is that his model of tensegrity, which shows how cells respond to deformations and then return to their original shapes, applies to all movement in the body. He gives the examples of hearing, breathing, stresses caused to blood vessels by the flow of blood, and compressions in stiff structures in the body. To these could be added movement and flow in any part of the body. Cells respond to the stresses in accordance with their function. As this contradicts the assumption that low frequency noise might be harmful, I made contact with Prof. Ingber. His reply contained the following

*I was not aware that my work has been cited to support the concept that low frequency noise will adversely influence cell activity, and there is no evidence that I am aware of to support this idea. Moreover, mechanical noise can sometimes have positive effects on cell activity and human physiology. For example, you should read the work of James Collins at Boston University and now at the Wyss Institute that I head (www.wyss.harvard.edu) who has pioneered the use of 'stochastic resonance', which involves applying a sub-threshold mechanical vibratory*

*signal and thereby increasing fidelity of control in elderly patients with gait control problems, diabetics with peripheral neuropathy, etc.*

Thus, Prof. Ingber's research has no bearing on the issues in this case.

**Q. Do you agree with James's assertion that Vibro Acoustic Disease can be caused by wind turbine sound?**

A. I do not agree. If this assertion was correct, every resident of Madison would be equally at risk, not to mention most of the USA and other first world countries. This is because the infrasonic and low frequency sound levels in urban areas, below about 50Hz, are similar to wind turbine sound levels in this range.

It also seems that Pierpont herself has doubts about VAD. On page 58 of the June 30th prepublication version of her book, she writes in reference to the aeronautical workers who are exposed to very high levels:

*High intensities of low-frequency noise over prolonged time periods may cause marked neurological damage as described by the Vibroacoustic Disease group in Portugal. This is a provocative body of research, full of interesting case descriptions and pathology studies, but compromised by absence of specified study group criteria, absence of control groups and lack of quantification.*

And this is in reference to the VAD group's main work at very high sound levels - 120dB. There is no merit in the assertions that the low levels of wind turbine sound will cause a problem. From a noise dose point of view, as stated elsewhere, it will take a 100,000 years to receive the same dose from a 50dB noise as that received in one year from a 100dB noise.

Submitted as Exhibit 20 is my full assessment of VAD, which I believe further demonstrates that whatever merit it may have at very high sound levels, it has no applicability at sound levels produced by wind turbines.

## JAMES'S VIEWS ON MODELING AND PERMITTING STANDARDS ARE BOTH UNREASONABLE, AND NOT SUPPORTED BY THE SCIENCE

**Q. Please explain your view of James's critique of modelling methods used to predict potential sound levels from wind turbines**.

A. Other experts have found that the widely-accepted modelling methods used by Mr. Hessler do work satisfactorily. For example, a paper given at the Wind Turbine Noise 2009 Conference, entitled "Wind farm noise predictions and comparison with measurements," showed a good agreement over the three sites investigated and at distances up to one kilometer. This paper is submitted as Exhibit 21. It will be noted that the sites used in that study were either flat or undulating, but an author of the paper tells me that:

> *Over a hilly area the approach should hold fine. You may get a couple of factors to take account of, one is barriers where line of sight to the tip of a turbine is blocked we assume a 2 dB(A) reduction. The other is if the ground falls away significantly between the source and receiver then you can get a +3 dB(A) addition to noise levels .*

In general, accuracy is greatest over shorter distances, so that the nearest residences, at about 300m, will be accurately predicted. These are the most important positions for any analysis.

**Q. Do you have reactions to James's paper entitled "The 'How To' Guide to Siting Wind Turbines to Prevent Health Risks from Sound?"**

A. I considered this paper in some detail in my earlier comments, which are submitted as Exhibit 22. It seems to me that the paper has two main problems. First, there is undue emphasis on infrasound and low frequency noise. There has been a great deal of irresponsible nonsense written about these, extending over the past 40 years, initially in newspapers and other media, but now on the Internet. Their paper gives me the impression that Kamperman and James may have come to the subject already preconditioned to believe that there was an infrasound problem from wind turbines, and determined to prove it.

Second, their reliance on the difference between the levels of the C-A weighting as a criterion for a low frequency noise problems is not convincing. The development of C – A as an *indicator* of low frequency noise was for tonal noise at low frequencies, not for broadband wind turbine noise. Most low frequency environmental noise problems have been tonal problems in which the A-weighting does not give a proper assessment of the low frequency tone. Consequently, their use of the C-A difference as a criterion is not safe.

Their attempt to carry this through to a criterion fails on a technical level for the following reasons:

The C-A limit is not substantiated.

The comparison of an A-weighted level before installation with a C-weighted level after installation takes no account of existing C-weighted noise prior to installation.

Where, on page 17 of Exhibit 808,James writes his condition as

$$L_{Ceq(immission)} \text{ minus } (L_{A90(background)} + 5) < 20dB$$

And states that

$$L_{Ceq(immission)} = L_{C90\ (background)}) + 5dB$$

These can be combined to give

$$L_{C90\ (background)} \text{ minus } L_{A90(background)} < 20dB$$

Where the $L_{C90}$ is with turbines operating and the $L_{A90}$ is before installation. In the EIS, Table 5.8.4, measurements are given at existing wind farms for both $L_{C90}$ and $L_{A90}$ levels for turbines on and off. The $L_{A90}$, turbines off, can be associated with the preconstruction levels. Inspection of the Table shows that the difference between $L_{Ceq}$ (turbines on) and $L_{A90}$ (turbines off) is around 20dB, but the difference between $L_{C90}$ (turbines on) and $L_{C90}$ (turbines off) is only a few decibels. The proposed criterion is not only faulty in its proposed limit, but also unfair in that it suppresses existing low frequency noise. An enlarged part of Table 5.8-3 is included as Exhibit 23, illustrating this point.

**Q. James writes that the Glacier Hills Wind Park will "expose the public to unsafe conditions 24 hours a day and 365 days a year." Do you agree?**

A. I do not agree. Some opponents of wind turbine developments have, in the past, said that wind turbines are of little benefit because they operate for only about 25% of the time. Nobody, except James, believes that they operate 24/365. The correct figure is probably between 25% and 100%. However some of their operational time is at low speed in low wind conditions, when their noise levels are low. Further, as demonstrated in this testimony, there is simply no support

for the assertion that inaudible infrasound or low frequency sound from wind turbines is harmful to human health.

**Q. James also states that sound from wind turbines is inherently more annoying than sound from other industrial sources. What do you think?**

A. A fluctuating noise is normally more annoying than a steady sound of the same average level. If the higher frequency wind turbine sound is fluctuating in level, there will be this modulation effect. However, this does not occur all the time or at every installation. Studies in the UK have shown that only four out of about 130 wind farms had a problem of fluctuation (amplitude modulation).[3] The response of the British Government to this work was to decide that amplitude modulation was, in reality, not a significant enough problem to merit further work on it. [4]

Other work in Denmark looked at a wide range of sounds evaluated by the Danish method of assessing low frequency noise, which covers the range 10Hz to 160Hz. Wind turbine noise, as heard indoors, was assessed for a 3.6MW turbine at 600m and shown to be lower than all other sources except for a refrigerator.[5]

**Q. What is your reaction to James's estimate of the amount of time that wind turbine sound may be amplitude modulated?**

[3] Moorhouse, A., Hayes, M., von Hunerbein, S., Piper, B., and Adams, M. (2007): Research into aerodynamic modulation of wind turbine noise. BERR Report URN 07/1235. *http://www.berr.gov.uk/files/file40570.pdf*.

[4] *www.berr.gov.uk/files/file40571.pdf*

[5] Pedersen, T. H. (2008): Low frequency noise from large wind turbines. *DELTA Report EFP - 06*.

A. On page 6 of his report (Exhibit 808) James says, “The author has confirmed amplitude modulation (blade swish) at every project he has visited.” This is possible, as he probably only visits installations where there have been complaints, but some numbers would be useful. However, on page 7 of his Exhibit 808, he quotes an assessment for New York rural areas. “Stable conditions occurred for 67% of the time and that for 30% of those nights, wind velocities represented worst case conditions where ground level winds were less than 2m/s and hub height winds were greater than wind turbine cut in speeds, 4m/s”. 30% of 67% is 20%.

He also quotes van den Berg’s estimate of 47% of the time over a year for the Rhede Wind Farm on the border between Germany and The Netherlands. However, this is a very extensive flat area, such as is most prone to these effects.

**Q. Please describe the levels of infrasound and low frequency noise emitted by wind turbines similar to those proposed for the Glacier Hills Wind Park.**

A. I am willing to accept the spectrum given by Kamperman and James in their “How to Site” paper, which can be found at both the beginning and the end of their Exhibit 809, on Fig. 1, page 7 of their paper. This shows the level external to a residence from a 2.5MW turbine at 305m (1000ft). From the graph given, one can extract the low frequency levels in tabulated form as follows:

| Freq | 10 | 12.5 | 16 | 20 | 25 | 31.5 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level | 63 | 62 | 61 | 59 | 57 | 55 | 53 | 50 | 48 | 46 | 44 | 42 | 42 | 39 | 38 | 37 |

**Q. Please describe the average levels at which infrasound and low frequency sound are audible.**

A. The best work on the audibility of infrasound and low frequency noise has been by Watanabe and Moller in Denmark.[6] Auditory threshold levels are

| Freq Hz | 4 | 8 | 10 | 12.5 | 16 | 20 | 25 | 31.5 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Level dB | 107 | 100 | 97 | 92 | 88 | 79 | 69 | 60 | 51 | 44 | 38 | 32 | 27 | 22 | 18 | 14 |

This shows that the levels in the infrasound region start at 107dB at 4Hz and gradually reduce into the audible region.

When one compares these two tables with each other one arrives at the following in the low frequency region:

| **Freq Hz** | **10** | **12.5** | **16** | **20** | **25** | **31.5** | **40** | **50** | **63** | **80** | **100** | **125** | **160** | **200** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Threshold | 97 | 92 | 88 | 79 | 69 | 60 | 51 | 44 | 38 | 32 | 27 | 22 | 18 | 14 |
| WT sound | 63 | 62 | 61 | 59 | 57 | 55 | 53 | 50 | 48 | 46 | 44 | 42 | 42 | 39 |
| Difference | 34 | 30 | 27 | 20 | 12 | 5 | -2 | -6 | -10 | -6 | -17 | -20 | -24 | -25 |

[6] Watanabe, T., and Møller, H. (1990a): Hearing thresholds and equal loudness contours in free field at frequencies below 1kHz. *Jnl Low Freq Noise Vibn* **9**, 135-148.

In this comparison table, where the difference is positive, that is up to about 31.5 – 40Hz, the wind turbine sound is not audible to the average person. The low infrasound frequencies are well below the hearing threshold.

This shows that while some low frequency noise produced by wind turbines may be above the hearing threshold, it does not reach harmful levels, because the sound pressure level is low.

**JAMES'S RELIANCE ON MY PRIOR ACADEMIC WORK IS MISPLACED.**

**Q. James relies on a paper you wrote entitled "Low Frequency Noise and Annoyance." What is your reaction to that?**

A. I was invited to write a paper on Low Frequency Noise and Annoyance for a special Low Frequency Noise Issue of the Journal of Noise and Health. The paper contains general material on annoyance by noise, and is angled towards low frequency noise. Much of what is in the paper is applicable to any audible noise, including the coping methods referred to by James at the bottom of page 13 of his report, Exhibit 808. They are not specific to low frequency noise. In fact, similar methods are used to help people with high frequency tinnitus. There is nothing mysterious about these methods. They involve learning to desensitize oneself to the noise and its effects. In this, one's attitude toward the noise is very important. [7] [8] The constant propaganda that wind turbines are dangerous to health has caused fear and concern amongst the public. It is well known that if

[7] Jonsson, E., and Sorensen, S. (1970): Relation between annoyance reactions and attitude to source of annoyance. *Public Health Reports* **85**, 1070 - 1074.

[8] Hatfield, J., Job, R., Carter, N., Peploe, P., Taylor, R., and Morrell, S. (2001): The influence of psychological factors on self-reported physiological effects of noise. *Noise and Health* **3**, 1-13.

there is fear of a noise source, or an antagonism to its creators, then the responses are more negative than they would otherwise have been. This also applies to wind turbines.[9]

I disagree with James's assertion in this section that I have been having an "ongoing debate" with Pierpont. Some five years ago, when she was the leading NIMBY in her locality, I criticised some of her statements about noise. The response of her and her husband was to attempt to discredit me, instead of replying to the points raised. We have never debated. Exhibit 24 shows the response of Pierpont to my submission in this proceeding on Wind Turbine Syndrome. Finally, as it has been shown that the claims of health effects through direct physiological action by low levels of infrasound and low frequency noise are untenable, James's final sentence on page 13 is not relevant.

**Q. James also relies on a paper you wrote entitled "Effects on Performance and Work Quality Due to Low Frequency Ventilation Noise." What is your reaction to that?**

A. The spectrum which was used for the low frequency element of the noise in that study was vastly different from that of wind turbine noise in several respects. It mirrored more closely the spectrum which is produced by tonal low frequency noises in the environment. The low frequency component of the noise was an amplitude modulated tone of around 35Hz, fluctuating in level about twice per second to produce a rapid throbbing sound. The maximum tone level was about

[9] Pedersen, E., van den Berg, F., Bakker, R., and Bouma, J. (2009): Response to noise from modern wind farms in The Netherlands. *J Acoust. Soc. Am* **126**, 634-643.

40dB above the surrounding noise levels and clearly audible. The spectrum is submitted as Exhibit 25. Of course, this additional noise was noted by the participants as a disturbing factor. Nevertheless, differences between performance in this low frequency noise and in medium frequency noise were small. Social orientation changed by about 7% and pleasantness by about 10%. The change in annoyance was not statistically significant.

This work cannot be compared with the effects claimed to be attributable to wind turbines. James is incorrect when, on page 18 of his Exhibit 808, he compares the experimental levels of this work with those of wind turbines in homes. In our work the level was about 75dB in the 31.5 Hz 1/3 octave band. The levels outside residences given by Kamperman and James at 31.5Hz are 55dB, and will be even lower inside.

**Q. In addition to relying on your work, James submitted several hundred pages of supporting materials in Exhibit 809. Could you comment on those materials?**

A. I found this to be a rather confusing collection of material, with only part of it relevant to his testimony. I have addressed some of it in my testimony, but, like James, I have not referred directly to most of it.

## APPLICATION OF THE PRECAUTIONARY PRINCIPLE IS UNWARRANTED IN THIS CONTEXT

**Q. James advocates application of the precautionary principle with regard to wind turbine noise. Do you agree?**

A. This is related to the different approaches of Clinicians and Legislators. Clinicians deal with individuals – their patients -- and are concerned for the well-being of each one as a unique person. A legislator, or planner, considers people as a group and develops criteria for protection of the majority. For noise sources, this has normally been achieved by a social survey, which relates number annoyed to a physical characteristic of the noise, such as dBA or $L_{dn}$. A decision is then made on where to set the limiting level for a protection criterion. Criteria do not, and never have been, designed to protect the most sensitive, although the special problems of the sensitive may influence the criteria.

A difficult decision has to be made, balancing national needs against individual needs. The approaches of both Clinicians and Legislators are valid within their own spheres. However, problems may arise when one impinges on the field of the other.

**Q. Does this conclude your testimony?**

A. Yes.