STATE OF MINNESOTA

OFFICE OF ADMINISTRATIVE HEARINGS

FOR THE

PUBLIC UTILITIES COMMISSION

In the Matter of the Application of Goodhue Wind, LLC For a Certificate of Need for a 78 MW Wind Project (Goodhue Wind Project) and Associated Facilities in Goodhue County, Minnesota	Dockets: IP-6701/WS-08-1233 IP-6701/CN-09-1186

GOODHUE WIND TRUTH

TESTIMONY OF RICHARD JAMES, INCE

EXHIBIT RJ-01

I. INTRODUCTION

Q: **Would you please summarize the testimony you are presenting?**

A: Yes. My name is Richard R. James, and I have been asked to prepare comments on the setbacks under consideration by the PUC on behalf of Goodhue Wind Truth.

For the past three years I have been working with local communities and citizens groups around the Midwest to address questions of how to integrate industrial wind turbines into rural communities. I would like to share with you my concerns about siting criteria for modern industrial scale wind turbines.

Over the past two years I have visited sites throughout the Midwest from western Iowa to the coast of Maine and Ontario to West Virginia with wind turbines. I have also reviewed the noise criteria and setbacks proposed by States, Provinces and local government bodies for wind farms. I find three sections have a particular importance for my testimony.

In my testimony, I focus on several points:

First, setbacks, from property lines to the nearest turbine of 1500 feet are clearly inadequate. Wind turbine noise is distinctively annoying. The Environmental Report does not correctly or adequately describe the impact of the proposed project on the host community and the residents whose homes and properties are close to or within the footprint of the project. People living at distances up to 1 mile or further from wind turbines are experiencing adverse health effects from sleep disturbance at night and from other aspects of wind turbine sound emissions that are currently believed to be caused by vestibular disturbances from infra and low frequency sound.

Second, background sound levels submitted on behalf of background sound levels which include a ‘wind noise’ component result in a biased assessment of background sound levels. Further, the original Background Sound studies do not adequately define the background sound levels and characteristics of wind turbine noise for purposes of making decisions on location with respect to homes and properties.

Third, computer model estimates of operational sound levels from the proposed projects understate the impact of the turbines on the community.

Fourth, information provided by AWA Goodhue Wind in their application and as Comments, Appendices, and Figures, and references to studies and opinion papers on topics of health risks, infra and low frequency noise, noise limits and setbacks, background sounds in rural communitiesand computer modeling studies by Dr. Geoff Leventhal and others is misleading. Their assertions that there is no research supporting a causal link between wind turbine sound emissions at receiving properties and homes and health effects do not reflect current understanding of thresholds of perception and mechanisms whereby such perception can occur by experts who are not working for the wind industry.

The combination of the above negative factors related to wind turbine noise emissions will result in sleep disturbance for a significant fraction of those who live within a mile away and chronic sleep disturbance results in serious health effects.

The result of these technical flaws along with an outdated understanding of how the human body responds to acoustical energy previously considered to be below the threshold of perception leads to a conclusion that if the AWA Goodhue project, as proposed, is approved, it will, with a high degree of certainty, have negative noise impacts that are "significant."

I have reviewed the application of AWA Goodhue Wind and the Draft Permit proposed by the Office of Energy Security. I have also given cursory review to the Applicant’s prefiled

Comments, Appendices and Figures filed Friday, July 16, 2010, in particular the HDR report, and will have additional comments specific to those documents at the hearing. My experience with industrial wind projects leads me to conclude that siting criteria more lenient than those recommended by WHO's 40 dBA limit for avoiding health risks, such as the 45 to 55 dBA typically suggested by Applicants, and those used by the Minnesota Public Utilities Commission, will result in a high level of community complaints of both noise pollution and nuisance. In addition, there is mounting evidence that for the more sensitive members of your community, especially children under six, people with pre-existing medical conditions, particularly diseases of the vestibular system, the organs of balance, and seniors will be likely to experience serious health risks. The Minnesota Public Utilities Commission reviews Large Wind Energy Conversion Systems on a case by case basis and often attach conditions to permits. I will propose conditions in modification of the Draft Permit that would help alleviate these problems.

II. BACKGROUND AND C.V.

Q: **What is your professional background and training?**

A: I am a noise control consultant and an acoustical consultant, and I have been since 1971. I have a background in mechanical engineering. My Degree is from General Motors Institute, which is an accredited engineering college. As background, when I was going to college, that was at the ime when the EPA and a lot of the other noise issues were coming to a head. General Motors wanted to educate a limited number of engineers in the necessary issues, and that was the curriculum that I took. There were about ten of us. I graduated in 1971, with a Bachelor's in Mechanical Engineering with a focus on noise control engineering. Please see my C.V. attached.

Since 1973. after about six (6) years working for Chevrolet as Noise Control Engineer, I left GM to form my own company, Total Environmental Systems. Later, my partner in the first firm and I changed the name to James, Anderson and Associates, Inc. Currently, I'm working as an independent consultant under the name E-coustic Solutions.

Q: Do you have any teaching experience?

A: For the last 20 years or so, I have been teaching both at Michigan State University in their Speech and Communicative Disorders Department on the issues of noise and how it relates to speech Sciences. I've also taught at General Motors University. There, Itaught noise control and safety and health issues to almost all of my clients' Health and Safety Engineers. Noise control relating both to community noise issues and in-plant noise issues. Also have been an instructor for the American Industrial Hygiene Association, Michigan Department of Public Health, and a number of other groups on the issues of noise.

Q: **You use the abbreviation "INCE" after your name. What does that mean?**

A: Institute of Noise Control Engineer

Q. **On how many occasions have you testified as an expert in administrative hearings concerning noise?**

A. I have testified in over 15 administrative hearings as an expert in acoustical engineering on behalf of such companies as General Motors, Ford, and Chrysler held by the Occupational Safety and Health Administration. The purpose of my testimony in these cases was directed towards the limits of feasibility of engineering controls and to establish that my clients were taking the necessary administrative and medical/safety precautions to protect their employees from the adverse health effects of occupational noise exposure. I have also testified in approximately 10 to 12 administrative hearings considering applications by wind power companies to install wind powered electrical generating utilities. The subject matter of my testimony in these cases was to review and comment upon the noise studies conducted on behalf of the wind developer by its acoustical consultants, to present my research and recommendations for whether the wind project would result in nighttime sleep disturbance and other adverse health effects from the turbine's noise emissions, and to state my recommendations for criteria that would limit wind turbine noise to a level that would not be likely to cause adverse health effects.

Q: **Are you a medical doctor?**

A: I am not a medical doctor. Acoustical engineers must understand enough to read and use medical research related to noise and health, but that does not make us medical doctors. That is why I review these issues with other Doctors, such as Doctors Nina Pierpont, Robert McMurtry, Michael Nissenbaum, Jerry Punch, and Alec Salt, to determine what a medical doctor would understand about the health impacts of noise issues related to wind turbines. Because I am not a medical doctor, I rely on the international standards and other international documents from groups such as the World Health Organization. This is common in my profession, for example, Dr.Geoff Leventhall, who is often quoted on health issues related to wind turbines on behalf of the wind industry, has no more medical training than do I!

Q: **What work experience do you have with noise-related issues?**

A: I have focused on noise and health since 1971. As President of James, Anderson & Assoc., we were the tier one supplier of noise control engineer services for General Motors, John Deere, Navistar….. almost all of the large companies. We did all of their noise work, including all their community noise work for the period from about 1976 forward to the present. I have been involved in a lot of issues, siting of new plants, doing the studies to identify whether communities are compatible, and I also started out with a very strong interest in computer modeling, which has been applied to my clients' project. During some peak periods, we had a staff of 45 working on only noise related issues for our client's facilities not only in the U.S. but also in Canada and Mexico.

Q: **Please tell us about your computer noise-modeling experience?**

A: When I was a young engineer, computers were not yet one of the tools that we used for applied engineering. They were research tools, but I saw their use in modeling as an opportunity to apply them to practical problems. My graduation thesis was on the formulas and methods that are used for computer modeling for industrial facilities. At that time there were no standards, so we really had to rely on some very preliminary work. Models I developed were used in federal hearings on engineering feasibility of noise controls in 1976, in OSHA and EPA cases, and in the design of many manufacturing facilities. I have continued my interests on uses for computers for in-plant modeling and community noise modeling throughout my career.

Q: **Have you ever been retained to evaluate and testify regarding noise and health related issues associated with wind turbines?**

A: Since 2005, I have worked almost exclusively on wind turbines. In addition to working for community groups such as Goodhue Wind Truth, I've also worked with the Herron Zoning Board, Calumet Zoning Board, and a number of other communities around the country for setting up guidelines for the wind turbines. I'm also involved in about five cases in litigation at this point as the expert for the community.

Q: **Have you written any articles regarding wind related noise issues?**

A: Yes, I have written and co-written a number of articles. One in particular stands out – an article that I have written was co-written with one of my partners, George W. Kamperman. George Kamperman is the father of the Illinois EPA noise criteria. He was the person who helped establish those criterion, and he has monitored them over the years. He has been practicing since 1952. At this time he's in semi-retirement.

Some time ago, he and I were talking about the confusion in the industry and the fact that almost all the articles that we saw were coming from only one side of the argument. At that time, we decided that we should present an overview and conclusions of the field, and to do that, we would do a review of all of the literature and data that we could get our hands on, everything, basically, on noise studies, before and after studies, what's good, what's bad about turbines, health issues, and so forth. Then, based upon our combined almost 80 years of experience, we planned to sort that out into a set of guidelines the communities could use that would allow them to site wind turbines without having the problems we see in the different parts of the United States at this time. Exhibit RJ-02, The "how to" guide to siting wind turbines to prevent health risks from sound, George W. Kamperman, P.E., and Richard R. James, INCE, October, 2008.

This paper was first presented in Detroit at a meeting and has since been published. We have essentially completed a review of primary scientific studies and anecdotal information, categorized and analyzed it and drawn our conclusions as to what it really means.

Q: In your professional work, have you had an opportunity to discuss certain health related issues with Dr. Nina Pierpont?

A: Yes, I have.

Q: Why is Dr. Pierpont's work important to you?

A: In our work, we found it important to get right to the sources of a lot of the information, so, yes, I've carried on a number of discussions with Dr. Pierpont, and she has shared some of her insights with us. Her work coincides and overlaps with ours and what her study is finding is that we do have a valid concern about health related to improperly sited wind turbines -- and please note, we are referring to <u>improperly sited</u> wind turbines. I relied on her work, in part, for my testimony today.

One of the things that Dr. Pierpont noted is that all of her studies are for the newer models of wind turbines. A lot of the questions raised are asking why aren't we having problems in the other countries; and the answer is that other countries are using smaller wind turbines in many cases. But where they have put in the larger wind turbines, those problems are cropping up there, overseas, as well.

Q: Did you rely on Dr. Pierpont's studies and information in forming your conclusions with respect to the paper that you have recently authored?

A Yes, in part. Her studies and information were helpful in confirming aspects of our work and conclusions, and we put in a cautionary statement that that is still preliminary. There is plenty of scientific and health evidence already from the World Health Organization, and other studies not specific to wind turbines but specific to noise sources, that they can cause disturbances with sleep, that they do have an impact on health, not just a psychological impact, it's physiological changes as a result of long-term sleep deprivation.

Those symptoms and impacts of noise are well-recognized within the field whether it be railroad yards, airports, just about any type of noise sources. If the noise is such that it can wake people up, it does have a physiological effect. The bulk of the study put the weight on that because it is peer reviewed and is well established and is used by people all around the world in making the decision for land use planning with regard to noise sources.

Q: Have you published anything else recently?

A: Yes, recently I co-authored an article for Audiology today with Jerry Punch, Ph.D. Aud. Of MSU’s Department of Communicative Science and Disorders. See attached Exhibit RJ-03.

I participated in writing the Society for Wind Vigilance issued in January. Exhibit RJ-04, Wind Energy Industry Acknowledgement of Adverse Health Effects, Part I & Part 2 (detailed analysis), January 2010.

Q: Are there any additional studies that you have relied on in drafting this testimony?

A: There are many important studies, some referenced specifically within or at the end of this testimony, and others referenced here. Ones particularly important in my review of the AWA Goodhue wind project are Exhibits RJ-05 – RJ-16:

- Exhibit RJ-05 - Low frequency noise from large wind turbines, Henrik Moller & Christian Sejer Pederson, June 11, 2010 (+ original in Danish)
- Exhibit RJ-06 - Research Plans for Improving Understanding of Effects of Very Low-Frequency Noise of Heavy Lift Rotorcraft, Fidell, Horonjeff, Schmitz, NASA, February 2010.
- Exhibit RJ-07 - Wind Turbine Acoustics, Hubbard, Shepherd, NASA December 1990
- Exhibit RJ-08 - Application of Ray Theory to Propagation of Low Frequency Noise from Wind Turbines, NASA, July 1987
- Exhibit RJ-09 - Potential Health Impact of Wind Turbines, CMOH Report, May 2010
- Exhibit RJ-10 - Summary of Recent Research on Adverse Health Effects of Wind Turbines, Sterling with Krogh, October 2009
- Exhibit RJ-11 - Measurement and sound quality issues concerning low-frequency noise, Bray, October 2007
- Exhibit RJ-12 - Comments of Swinbanks on AWEA/CANWEA White Paper "Wind Turbine Sound & Health Effects" April 14, 2010
- Exhibit RJ-13 -Rebuttal of MJWagner's statement to Huron County Planning Commission, April 14, 2010
- Exhibit RJ-14 - Swinbanks Comments to MPSC on Setbacks & Noise, December 9, 2009 (for PSC-MI docket U-15899)
- Exhibit RJ-15 - CV of Dr. Swinbanks

- Exhibit RJ-16 - An Analysis of the Epidemiology and Related Evidence on the Health Effects of Wind Turbines on Local Residents, Carl Phillips, July 3, 2010 (for PSC-WI docket 1-AC-231)

Q: **Have you reviewed the application presented by AWA Goodhue Wind?**

A: Yes, I have reviewed the Amended Application, filed on October 19, 2009, and in particular, the noise section found on page 25-28. I have also reviewed their July 16, 2010 filings, in particular, the new map, and the HDR and Exponent reports.

Q: **Have you reviewed a site map?**

A: Yes, but I have not seen the most detailed version. The map filed was labeled "Trade Secret" and neither my clients nor myself have any idea what is presented on this map. Because of the substantive errors on the previous map filed, we need to review the "Trade Secret" map to be able to fairly comment on this project.

Q: **Are you familiar with the Minnesota Pollution Control Noise Standards?**

A: Yes, I have reviewed Minnesota's Noise Standards, Minn. R. Ch. 7030. [1]

Q **Would you please comment on these rules?**

A: The permitted sound levels for Class 1 property are not sufficiently restrictive to protect rural properties. These day and night limits are for urban and suburban communities where there is "urban hum" from distant manmade activities. The standards also focus only on dBA limits. This might work acceptably well for common urban and suburban community noise sources, but it does not work for wind turbines in rural communities. Minimally, the daytime limits should be an LA50 of 35dBA and at night an LA50 limit of 25 would more appropriately reflect and protect the extremely quiet nature of rural communities, especially at night. In no case should the average sound level be permitted to exceed 40dBA (Leq) at night since that is the threshold for adverse health effects set by WHO in their new 2007-2009 Nighttime Noise Guidelines.

[1] Online at www.revisor.mn.gov/rules/?id=7030

Exhibit RJ-17, WHO 2007/2009 Night Noise Guidelines, excerpt. Further, dBC limits are needed for wind turbines because they are predominantly emitters of infra and low frequency sound which is not measured when using A-Weighting. See Exhibit RJ-03, The “how to” guide to siting wind turbines to prevent health risks from sound, for our recommended nighttime dBC limits; see also Exhibit RJ-19, Proposed criteria in residential communities for low-frequency noise emissions from industrial sources, Hessler, 2004.(on criteria for gas turbine plants in rural areas). In our siting paper, we are more restrictive than Hessler, who works for the utilities so he may want more lenient standards, but even his lenient limits are better than no limits. Kamperman/James set the limits at this point to reflect the very quiet nature of rural areas. Note that George Hessler’s table of limits in his paper references L90 of 40dB. Since the rural nighttime noise levels in communities like Goodhue are 20 to 25 dB, we felt it was appropriate to use limits lower than Hessler.

Q: **Do these rules adequately address wind turbine noise?**

A: The limits set in the Minnesota Pollution Control Agency rules are questionable. As I noted above, they really apply more for a suburban environment. When the standards were written they were never intended to apply to very rural areas like Goodhue County and wind turbines were not an issue. The standards are what they are, but at this time there is a serious question as to whether they're really applicable for rural community wind turbine siting and whether they will protect that community in the way that the standard was intended to be protective. Based on my research, these rules require updating, because they do not address the different weighting scales necessary for measuring different types of noise, in particular, the types of noise made by wind turbines.

Q: **How are these standards used?**

A: One point, the standards were intended to be accessed by use of a sound level meter. However, they were not -- they were not designable standards, so-to-speak. Instead, they were standards used to propose tests for enforcement after a company has built a new facility. This might be a factory, or a wind turbine. And I think that leads to some very serious concerns about the report because what we see here is the use of computer modeling to replace measurement. Models may predict something is acceptable while measurements and/or community response to the project do not.

The result of these technical flaws along with an outdated understanding of how the human body responds to acoustical energy previously considered to be below the threshold of perception leads to a conclusion that if the AWA Goodhue project, as proposed, is approved, it will, with a high degree of certainty, have negative noise impacts that are "significant." In preparation for this testimony, the materials provided by the Applicant have been reviewed. This includes the background noise study and computer model estimates of operating sound levels prepared by HDR, submitted July 16, 2010, and other supplemental materials by others.

Q: Have you noticed similarities between AWA Goodhue's plan and others?

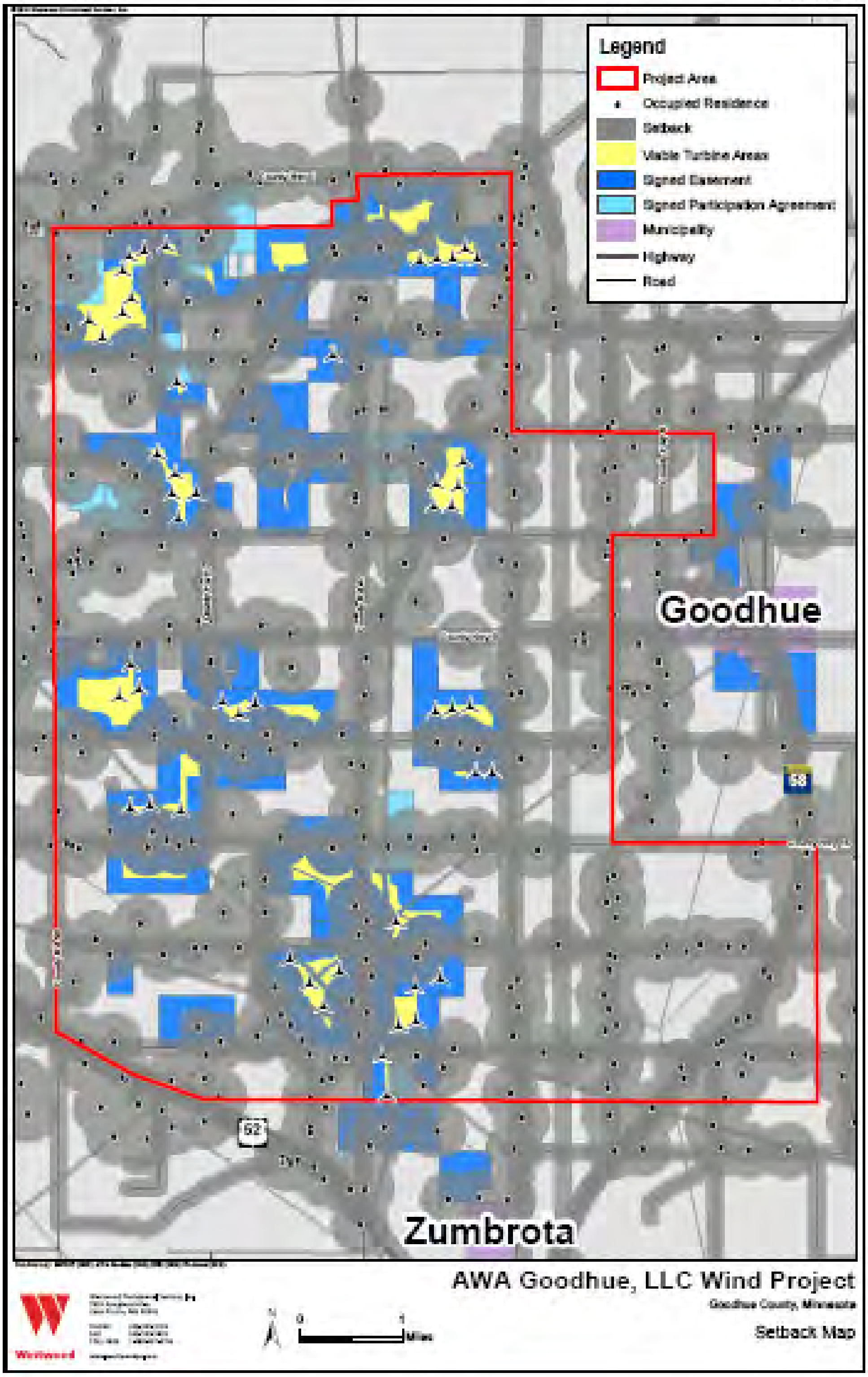
There is considerable similarity between AWA Goodhue's documents, and similar documents filed in other states on behalf of wind utility developers requesting permits for their projects. The arguments presented in these documents appear on the surface to be well-crafted technical statements regarding wind turbine noise, community and land-use compatibility, and public health risks. However, despite the similarities in presentation, methodologies, and conclusions between the various authors in these documents there are serious flaws in the arguments and information used to support those conclusions. These studies present one-sided information to support the development of wind utilities in locations where people will be expected to live within 1000 to 1500 feet of industrial scale wind turbines.

It is the goal and focus of my testimony to present an expert analysis and critical review, and to provide the Minnesota Public Utilities Commission with the references to foundational research, papers, and presentations needed to understand that what is <u>not disclosed</u> in the wind utility application reports and supporting documents is critical. Given the opportunity for the Public Utilities Commission to review the information provided in this report and its attached references, it is hoped that the Commission will understand why wind utility projects from Iowa to Maine, Ontario to West Virginia are now the locus of numerous complaints and lawsuits. These complaints and lawsuits detail the problems experienced with wind turbines causing sleep disturbance, adverse health effects, and other related problems. At the time of these problematic projects' permit applications, the developer for each of these projects assured the permitting agency that none of these problems would occur. This report is intended to provide information such that the Public Utilities Commission will not find itself permitting similar problematic situations.

Q: Have you reviewed the proposed project footprint and sound contours?

A: Yes. The Applicants Setback Map, Figure 3, on the next page, was filed July 16, 2010, and illustrates the extent to which the proposed footprint of the wind utility will encroach on residential homes:

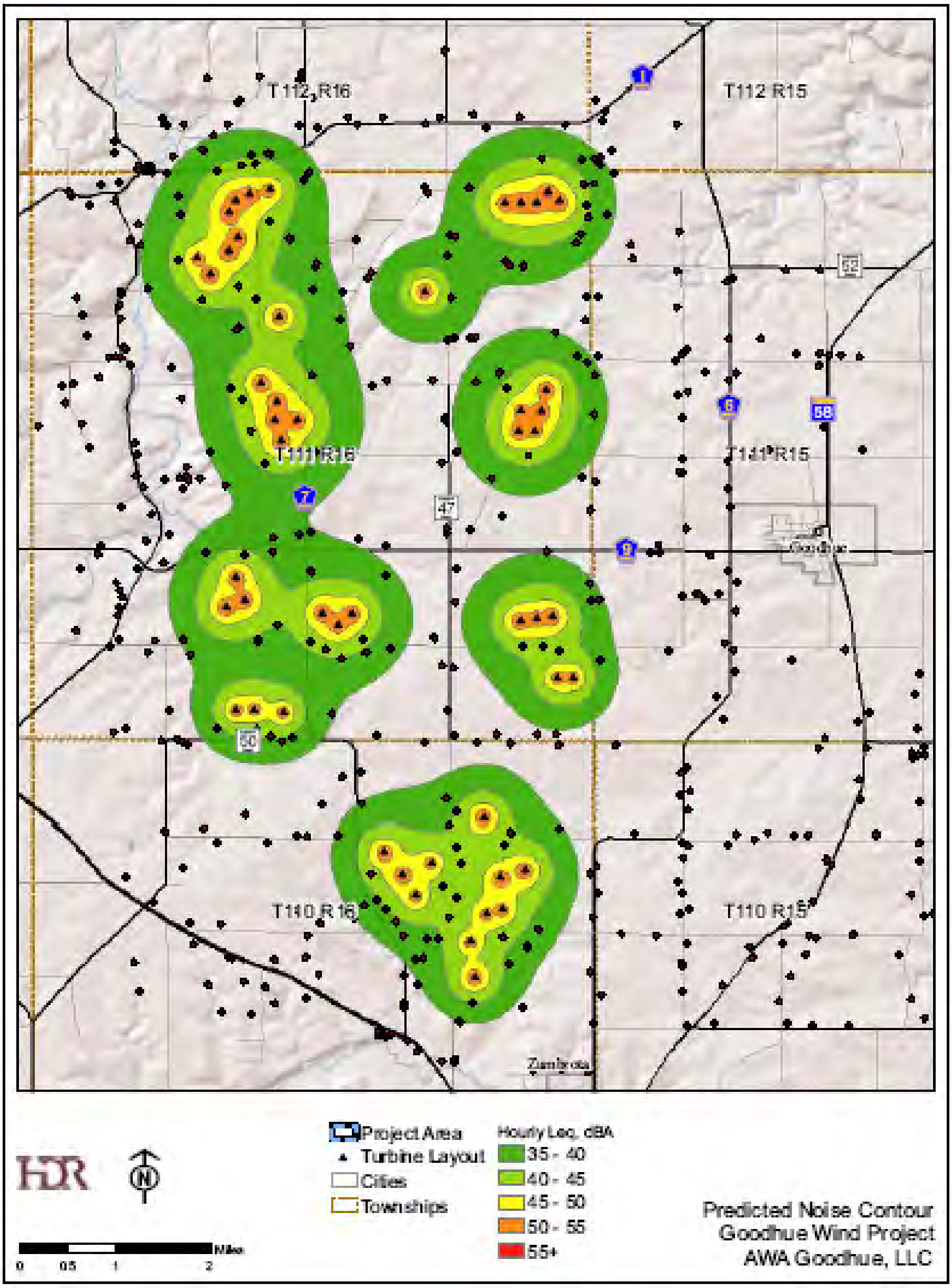
Figure 3

1 

Legend
Project Area
Occupied Residence
Setback
Viable Turbine Areas
Signed Easement
Signed Participation Agreement
Municipality
Highway
Road
Goodhue
Zumbrota
58
52
AWA Goodhue, LLC Wind Project
Goodhue County, Minnesota
Setback Map
Westwood
0
1
Miles

Q: Have you reviewed the Applicants Predicted Noise Contour, Figure 9, represents estimated noise?

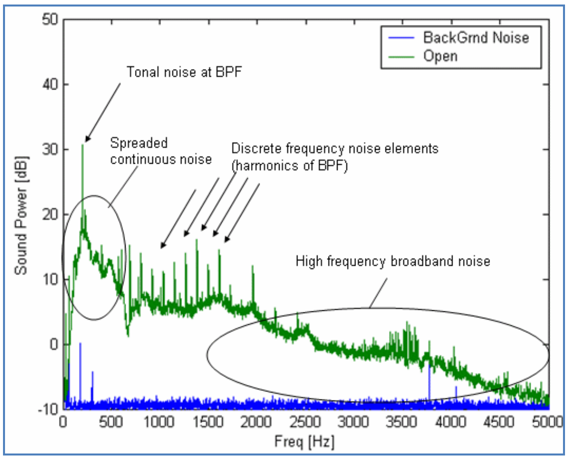
Figure 9

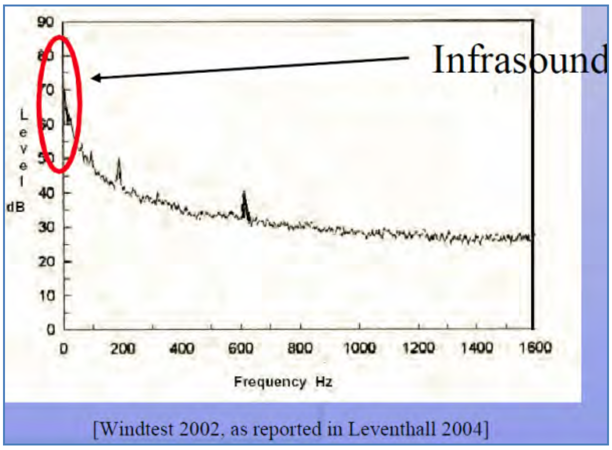


A: Yes, I have reviewed the Applicants Predicted Noise Contour Figure 9 – using 1,500 foot setbacks from homes.

Q: Are there particular ways of looking at turbine noise that are helpful to understand the cause of annoying noise?

A: Yes. It is common for people to look at wind turbines as a new type of noise source. However, some of the problems associated with them are easier to understand if we view wind turbines as a special case of large industrial fans. For example, if we take a look at the spectrum from a fan, as shown in Graph 2 below, there are certain characteristics that all fans have in common. There is maximum energy at the blade passage frequency, tones above the blade passage frequency, and broadband noise. The harmonics of that tone have somewhat lower energy content. The broadband spectrum starts above the range where the tones longer dominate. The energy is highest at the blade passage frequency and drops off as frequency increases.





Graph 2-Typical Fan Noise Spectrum

Graph 3-Vestas V-52 Spectrum (from NREL Presentation)

In Graph 3, the wind turbine spectrum for a Vestas V-52, shows some of the same spectral characteristics. For a wind turbine, the blade passage frequency is usually between 1 and 2 Hz and the primary harmonics occur usually below 10 Hz. Because this is a difficult range of frequencies to measure, especially in field test situations, most information about the spectral characteristics do not show the infrasound range (0-20Hz) sound pressure levels (SPL). This is further obscured by the practice of wind industry acoustical consultants to present data using only A-weighting (dBA). No specific dBC data was provided. The practice masks the spectrum shape by creating a visual impression of minimal low-frequency sound content. Even when octave band (1/1 or 1/3) Sound Pressure Levels (SPLs) are presented, the reports normally ignore frequencies below 31.5 or 63 Hz. The wind industry and its consultants often say that there is no infra or low frequency content. If that is true then the customary reporting practices are understandable. But, if those assumptions are not accurate, then these practices mask a potential source of significant problems.

The graphic to the right (Graph 4) shows a wind turbine's spectrum for the frequency range of 0-10 Hz. Note the tones and harmonics and the correlation of the frequency of the tones to rotational speed. This graph is from a study conducted by the Federal Institute for Geosciences and Natural Resources, Hannover, Germany, titled: "The Inaudible Noise of Wind Turbines" presented at the Infrasound work shop in 2005 (Tahiti).

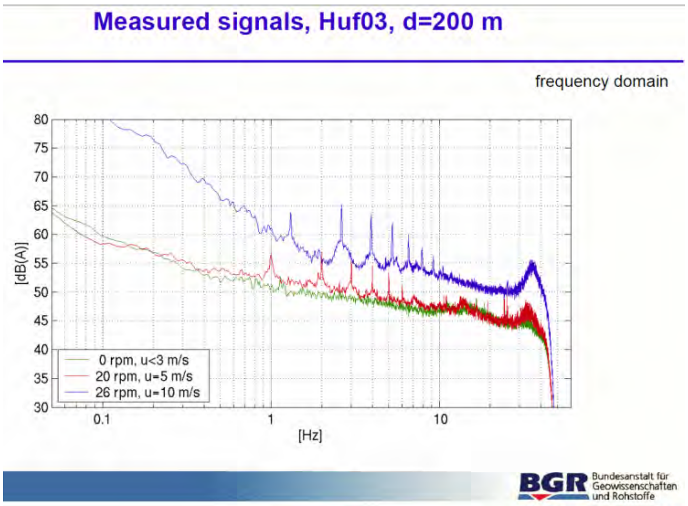
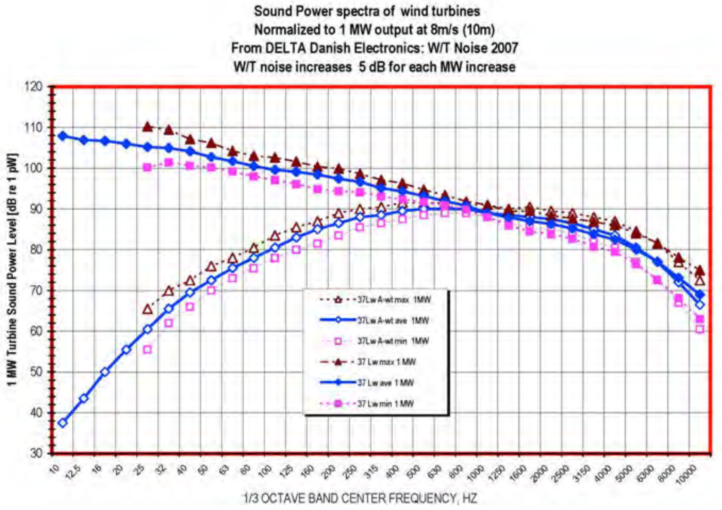


Figure 4-Wind Turbine Infrasound

Q: Are the sound emission characteristics similar or different for different models and makes of wind turbines?

A: Yes. Graph 5, below, shows the general spectrum shape of 37 modern upwind turbines of the type and sizes being located in the Midwest. This graph shows the sound power data after normalizing the data for each turbine to 1 MW of power output.[2] It is clear that there is little deviation in spectral shape between any of the various models that is not related to power produced. In fact, the study shows that for each increase of 1 MW in power output the graph there may be a shift upward by approximately 5 dB. Given that power to sound level relationship and the constant increase in the power rating of turbines being installed we could see the wind turbine sound levels increase another 25 dB by the time 5 MW turbines are commercially available.

Figure 5-Sound Power Level of 37 Turbines Normalized to 1MW



Q: Is wind turbine noise is distinctively annoying

A: Yes, wind turbine noise is distinctively annoying. There have been several studies, primarily conducted in European countries with a long history of wind turbines, showing that at the same sound pressure (decibel) level or less, wind turbine noise is experienced as more annoying than airport, truck traffic or railroad noise[345]. There are several reasons why people respond more negatively to wind turbine noise that are directly a result of the character of the noise more than the absolute level of the sounds received.

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2 DELTA, Danish Electronics, Light & Acoustics, "EFP-06 Project, Low Frequency Noise from Large Wind Turbines, Summary and Conclusions on Measurements and Methods," April 30, 2008

3 Pedersen, E., Waye, K. P., "Human response to wind turbine noise – annoyance and moderating factors", Proceedings of the First international Meeting on Wind Turbine Noise: Perspectives for Control, Berlin, October 17-18, 2005.

4 E. Pedersen and K. Persson Waye, "Perception and annoyance due to wind turbine noise: a dose–response relationship," J. Acoust. Soc. Am. 116, 3460–3470 (2004).
K. Persson Waye and E. Ohrstrom, "Psycho-acoustic characters of relevance for annoyance of wind turbine noise," Journal of Sound and Vibration 250(1), 65-73 (2002).
K. Persson Waye, E. Ohrstrom and M. Bjorkman, "Sounds from wind turbines – can they be made more pleasant?" In: N. Carter and R. F. S. Job (eds), 7th International congress on noise as a public health problem, pp 531-534 (22-26 Nov, Sydney, Australia 1998).
K. Persson Waye, A. Agge and M. Bjorkman, "Pleasant and unpleasant characteristics in wind turbine sounds," In: D. Cassereau (eds), Inter-Noise 2000, (August 27-30, Nice, France 2000).
K. Persson Waye and A. Agge, "Experimental quantification of annoyance unpleasant and pleasant wind turbine sounds," In: D. Cassereau (eds), Inter-Noise 2000, (August 27-30, Nice, France 2000).

5 Vandenberg, G., Pedersen, E., Bouma. J., Bakker, R. "WINDFARMperception Visual and acoustic impact of wind turbine farms on residents" Final Report, June 3, 2008.

Q: Explain what you mean by "character of the noise?

A: For example, wind turbines have a characteristic "Amplitude Modulation", also referred to as an "Audible Blade Swish." It is not clear whether it is:

1) the distinctive rhythmic, impulsive or modulating character of wind turbine noise, which are all synonyms for "thump" or "swoosh" or "beating" sounds);

2) its characteristic low frequency energy (both audible and inaudible, and also impulsive), health effects of chronic exposure to wind turbine noise (especially at night);

3) in-phase modulation among several turbines in a wind farm (this can triple the impulse sound level when impulses of three or more turbines become synchronized); or

4) some combination of all of these factors best explains the annoyance.

One or more of these characteristics are likely present depending on atmospheric and topographic conditions, (especially at night)[6] as is the individual susceptibility of each person to them.

Q: What is the relation between Amplitude Modulation, noise levels and annoyance or problems?

A: Reports based on surveys of those living near wind farms consistently find that, when compared to surveys of those living near other sources of industrial noise, annoyance is significantly higher for comparable sound levels among wind utility footprint residents. In most cases, where relationships between sound level and annoyance have been determined, annoyance starts at sound levels 10 dBA or more <u>below the sound level</u> that would cause equivalent

[6] G.P. Van den Berg, "The beat is getting stronger: The effect of atmospheric stability on low frequency modulated sound on wind turbines," Noise notes 4(4), 15-40 (2005) and "The sound of high winds: the effect of atmospheric stability on wind turbine sound and microphone noise" Thesis (2006)

annoyance from the other common community noise sources. Whereas one would expect that people would be annoyed by 45 dBA nighttime sound levels outside their homes in an urban area, rural residents are equally annoyed by wind turbines when the sound levels are 35 dBA independent of the time of day. Given that wind turbine utilities are often permitted to cause sound levels of 40 to 50 dBA at the outside of homes adjacent to or inside the footprint of wind utilities in the states east of the Mississippi the negative reactions to wind turbines from many of those people is understandable. Their reactions provide objective evidence in support of an expectation that a substantial number of people who live near the Glacier Hills Wind project will complain that the noise level they experience is both causing nighttime sleep disturbance and creating other problems once operation commences.[7] [8]

Q: What causes amplitude modulation?

A: Although there remain differences in opinions about what causes the amplitude modulation of audible wind turbine noise most of the explanations involve air turbulence around the turbine blades[9]. There are a number of explanations and more than one may apply at any specific wind farm site. For example, eddies in the wind, wind shear (different wind speeds at the higher reach of the blades compared to the lower reach), slightly different wind directions across the plane of the blades, and interaction among turbines, have each been identified as causes of modulating wind turbine noise from modern upwind turbines.[10]

Q: Is sound modeling a reasonable predictor of turbine noise for a given project?

A: I have noted that consultants for wind utility developers often claim that wind turbine sound emissions inside and adjacent to the project footprint estimated by the sound propagation

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[7] Pedersen (2007); Kamperman and James (2008); James (2009b); Minnesota Department of Health (2009), pp. 19-20.
[8] Bajdek, Christopher J. (2007). *Communicating the Noise Effects of Wind Farms to Stakeholders*, Proceedings of NOISE-CON (Reno, Nevada), available at http://www.hmmh.com/cmsdocuments/ Bajdek_NC07.pdf
[9] Van den Berg (2006, pp. 35-36); Bowdler (2008), Palmer (2009) and Oerlemans/Schepers (2009).
[10] Bowdler (2008)

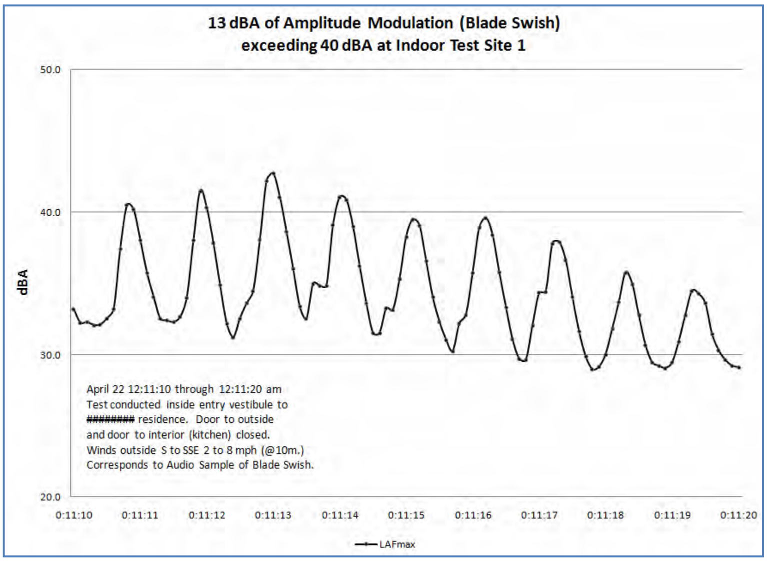
model's represent worst-case conditions. However, it is only true that the input data used for the turbine's acoustic energy represents the turbine's sound emissions at or above its nominal operating wind speeds under standardized weather and wind conditions. That is reasonable given that the purpose of these tests is to produce standardized data to permit a prospective buyer of turbines to compare the sound emissions from various makes and models. However, this needs to be understood as being similar to the US EPA's standardized gasoline mileage tests. You do not get the mileage posted on the vehicle sticker since your driving habits are different. The same is true for wind turbines and the environments in which they operate. The IEC test data does not account for the increased noise from turbulence or other weather conditions that cause higher sound emissions.

Q: Are guidelines for measurement helpful?

A: A review of the IEC 61400-11, Wind Turbine Systems-Part 11: Acoustic Noise Measurement Techniques' assumptions in the body and appendices (esp. Appendix A) show that the IEC test data reported to turbine manufacturers is not 'worst case' for real world operations. Independent of the effect of weather and wind on the turbine's noise emissions, ANSI standards for outdoor noise specifically caution that turbulence in the air can increase the downwind sound levels by 6-7 dB or more. 6-7dB represents about a doubling of loudness, – a significant increase. Any assertions by the acoustical modeler that the models represent worst case sound level estimates rely on careful phrasing and/or ignorance of the underlying standards and methods by the reviewers.

Q: Please explain "impulsive sound" and the advances made to reduce impulsive sound levels.

A: Impulsive sound was considered more problematic for older turbines that had rotors mounted downwind from the tower[11]. The sound was reduced by mounting the rotor upwind of the tower, common now on all modern turbines[12]. Initially, many presumed that the change from downwind to upwind turbine blades would also eliminate amplitude modulated sounds, the whooshes and thumps, being received on adjacent properties. However, in a landmark study by G. P. van den Berg, which is now referred to in all serious discussions of wind turbine noise[13], it was shown that the impulsive swishing sound increases with size because larger modern turbines have blades located at higher elevations where they are subject to higher levels of "wind shear" during times of ground level "atmospheric stability." This results in sound fluctuating 3-5 dBA between beats under moderate conditions and 10 dBA or more during periods of higher turbulence[14].



Graph 6-Audible Blade Swish inside home from New York Wind Utility

I have confirmed amplitude modulation (blade swish) at every wind project I've investigated. During periods of high turbulence I have measured levels of blade swish of 10-13 dBA. Graph 6, to the right shows the rise and fall of the A-weighted sound levels from blade swish measured inside a closed entry vestibule to a home. This test site is approximately 1500 feet from two (2) GE 1.5 MW turbines

[11] Rogers (2006, p. 10)
[12] *Id.*, pp. 13, 16; Van den Berg (2006), p. 36.
[13] Van den Berg (2006, p. 36)
[14] *Id.*,

with sound emission characteristics similar to the turbines proposed for the AWA Goodhue project. It should be noted that the sound levels exceed 40 dBA inside the home in the rooms facing the turbines with a window partly open.

Q: How is this "annoyance factor" addressed in modeling?

A: To compensate for the added annoyance of fluctuating or impulsive sound, the convention is to add a penalty of 5 dBA to computer model estimates of average sound levels to account for the increased annoyance from sort term fluctuations in sound levels.[15] In the Kamperman/James criteria, this penalty is already included in its recommendation for a maximum allowable sound level at the receiving property of 35 dBA.

Frequency of Conditions that Cause Blade Swish

Q: How common is "Blade Swish" in today's wind turbines?

A: Research shows that blade swish is linked to certain weather conditions that occur frequently. Winter is often a period with high levels of swish. The phenomenon of wind shear coupled with ground level atmospheric stability refers to the boundary between calm air at ground level and turbulent air at a higher altitude. "*A high wind shear at night is very common and must be regarded a standard feature of the night time atmosphere in the temperate zone and over land.*"[16] A recent paper presented at the 2009 Institute of Noise Control Engineers, Noise-Con 2009 conference in Ottawa, Canada on background noise assessment in New York's rural areas noted: "*Stable conditions occurred in 67% of nights and in 30% of those nights, wind velocities represented worst-case conditions where ground level winds were less than 2 m/s and hub-height winds were greater than wind turbine cut-in speed, 4 m/s.*"[17]

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[15] Van den Berg (2006), p. 106; Minnesota Department of Public Health (2009), p. 21. *See also* Pedersen (2007, p. 24) ("Amplitude-modulated sound has also been found to be more annoying than sound without modulations."
[16] Van den Berg (2006, p. 104). *See also* Cummings (2009)
[17] Schneider, C. "Measuring background noise with an attended, mobile survey during nights with stable atmospheric conditions" Noise-Con 2009

Based on a full year of measurements every half-hour at a wind farm in Germany, Van den Berg found:

> *the wind velocity at 10 m[eters] follows the popular notion that wind picks up after sunrise and abates after sundown. This is obviously a 'near-ground' notion as the reverse is true at altitudes above 80 m. . . . after sunrise low altitude winds are coupled to high altitude winds due to the vertical air movements caused by the developing thermal turbulence. As a result low altitude winds are accelerated by high altitude winds that in turn are slowed down. At sunset this process is reversed.*[18]

In other words, when ground-level wind speed calms after sunset, wind speed at typical hub height for large wind turbines, typically 80 meters, or 262 feet, commonly increases. As a result, turbines can be expected to operate, generating noise, while there is no masking effect from wind-related noise where people live. "*The contrast between wind turbine and ambient sound levels is therefore at night more pronounced*.[19]" As the turbine's blades sweep from top to bottom under such conditions the blade encounters slightly different wind velocities creating unexpected turbulence that results in rhythmic swishing noise[20]. Such calm or stable atmosphere at near-ground altitude accompanied by wind shear near turbine hub height occurred in the Van den Berg measurements 47% of the time over the course a year on average, and most often at night[21].

Infra and Low Frequency Sounds

Q: Please explain "infra" and "low" frequency sounds.

A: Sound measured as dBA is biased toward 1,000 Hz, the center of the most audible frequency range of sound pressure. Low frequency sound is in the range below 200 Hz and is

---

[18] (Van den Berg 2006, p. 90)
[19] *Id.*, p. 60
[20] *Id.*, p. 61. *Cf. also* Minnesota Department of Public Health (2009), pp. 12-13 and Fig. 5.
[21] Van den Berg 2006, p. 96

more appropriately measured as dBC, using a "C" weighted scale, using instrumentation that can provide 1/3 octave band resolution of the spectrum sound pressure levels. Sound below 20 Hz, termed **infrasound**, is generally presumed to not be audible to most people. *See* Leventhall (2003, pp. 31-37); Minnesota Department of Public Health (2009, p. 10); Kamperman and James (2008, pp. 23-24). For many years, it has been presumed, without inquiry or verification, that only infra and low frequency sounds that reached the threshold of audibility for people posed any health risks. Many acoustical engineers were taught that if you cannot hear a sound, it cannot harm you. The sensitivity and annoyance produced by a noise source increases substantially for increases in **low frequency sound,** once it is perceived, than the more readily audible mid-frequency sounds.

Recent research has shown that the human body is more sensitive to infra and low frequency noise (ILFN) than to higher frequencies, and that the vestibular organs of balance and cardio-vascular systems respond at levels of sound significantly lower than the thresholds of audibility. [22] Dr. Nina Pierpont has conducted a peer reviewed study of the effects of infra and low frequency sound on the organs of balance that establishes the causal link between wind turbine ILFN and medical pathologies. The new research is from fields different from those that have typically provided guidance for acoustical engineers when assessing compatibility of new noise sources and existing communities. This research is coming from the field of medical research into how our bodies respond to external energies at the cellular level. Numerous studies are now available showing how the body responds to extremely low levels of energy not just through the traditional organs of auditory and balance, but at the level of cell activity.

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[22] Alves-Pereira, Marianna and Nuno A. A. Branco (2007a). *Vibroacoustic disease: Biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling,* 93 PROGRESS IN BIOPHYSICS AND MOLECULAR BIOLOGY 256–279, available at http://www.ncbi.nlm.nih.gov/ pubmed/17014895><
and, Alves-Pereira, Marianna and Nuno A. A. Branco (2007b). *Public health and noise exposure: the importance of low frequency noise*, Institute of Acoustics, Proceedings of INTER-NOISE 2007,

Q: Would you explain the World Health Organization's guidelines for noise?

A: While on the topic of nighttime sound levels and the impacts of noise, it should be noted that the World Health Organization (WHO) revised its guidelines for nighttime noise in 2007, noting the following effects of sleep disturbance:

> The review of available evidence leads to the following conclusions.
>
> • Sleep is a biological necessity, and disturbed sleep is associated with a number of adverse impacts on health.
>
> • There is sufficient evidence for biological effects of noise during sleep: increase in heart rate, arousals, sleep stage changes, hormone level changes and awakening.
>
> • There is sufficient evidence that night noise exposure causes self-reported sleep disturbance, increase in medicine use, increase in body movements and (environmental) insomnia.
>
> • While noise-induced sleep disturbance is viewed as a health problem in itself (environmental insomnia) it also leads to further consequences for health and well-being.
>
> • There is limited evidence that disturbed sleep causes fatigue, accidents and reduced performance.
>
> • There is limited evidence that noise at night causes clinical conditions such as cardiovascular illness, depression and other mental illness. It should be stressed that a plausible biological model is available with sufficient evidence for the elements of the causal chain

Van den Berg (2006), p. 106; Minnesota Department of Public Health (2009), p. 21. *See also* Pedersen (2007, p. 24).

Amplitude-modulated sound has also been found to be more annoying than sound without modulations." The revised guidelines supersede the guidelines commonly referenced from 1999 and before.[23] These guidelines provide the definition of what is required for a causal link to be established between a exterior forcing agent like noise and health. They state:

> ***Sufficient evidence:*** *A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could reasonably be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.*
>
> ***Limited evidence:*** *A relation between the noise and the health effect has not been observed directly, but there is available evidence of good quality supporting the causal association. Indirect evidence is often abundant, linking noise exposure to an intermediate effect of physiological changes which lead to the adverse health effects.*

In Table 3 of the 2007 Guidelines, WHO presents the maximum sound levels that should be permitted outside the walls of a home to prevent adverse health effects:

Table 3. Summary of the relation between night noise and health effects in the population

$L_{night,outside}$ **up to 30 dB**	Although individual sensitivities and circumstances differ, it appears that up to this level no substantial biological effects are observed.
$L_{night,outside}$ of **30 to 40 dB**	A number of effects are observed to increase: body movements, awakening, self-reported sleep disturbance, arousals. With the intensity of the effect depending on the nature of the source and on the number of events, even in the worst cases the effects seem modest. It cannot be ruled out that vulnerable groups (for example children, the chronically ill and the elderly) are affected to some degree.
$L_{night,outside}$ of **40 to 55 dB**	There is a sharp increase in adverse health effects, and many of the exposed population are now affected and have to adapt their lives to cope with the noise. Vulnerable groups are now severely affected.
$L_{night,outside}$ of **above 55 dB**	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a high percentage of the population is highly annoyed and there is some limited evidence that the cardiovascular system is coming under stress.

End of WHO 2007 Guideline Excerpts

[23] WHO Night Noise Guidelines (2007)

The new criteria are based on recent research into nighttime noise and health that was not available when the 1999 guidelines were published. The outdoor criteria ($L_{night-outside}$) represent the long term conditions, not a single night's exposure. Table 3 shows that nighttime sound levels of 30 dBA and under pose no health risks. However, nighttime sound levels of 40 to 50 dBA as projected for homes in the footprint of AWA Goodhue wind would result in "a sharp increase in adverse health effects, and many of the exposed population are now affected and have to adapt their lives to cope with the noise."

Q: Does this provide a different understanding of impacts of sound?

A: Yes. Essentially, our understanding is outdated, and until recently, viewed with blinders because of our failure to utilize cross-disciplinary inquiry. To get a idea of just how outdated our understanding is of the way our bodies interact with the energies and forces around us, I would like to share a short piece that was sent to me by Eileen Mulvihill, a genetic biologist who received her Ph.D. in Molecular Biology from the Université Louis Pasteur, Strasbourg, France. She holds six patents for discoveries she made during her career.

Dr. Mulvihill's point is to demonstrate how our body's cells and molecules function as sensory receptors that augment the sensory organs, like our auditory and vestibular organs. Most of us learned that we have primary sensory organs and they perform all the needed functions for sensing the world around us, especially those who have not remained current with research in the field of molecular and cellular biology. It is this now outdated view-point that leads some of the wind industry acoustical experts to still claim that 'If you can't hear it, it can't hurt you." In other words, they believe that because the average person's auditory function, the outer, middle, and inner ear, is not as sensitive to infra and low frequency sounds, such as rumble, as it is to mid and high frequency sounds, such as those where speech occurs; and, that the infra and low frequency sounds from wind turbines are not loud enough to be <u>heard</u> by <u>most</u> people, there is no potential for adverse health effects. Dr. Mulvihill recently provided a good example of research that shows how our body can sense external forces. In other words, she describes other ways we sense acoustic energy, like low frequency sounds, through cellular level mechanisms not related to dedicated sensory organs. Dr. Mulvihill offered the following example using a paper by Dr. D. Ingber:

> Anyone who is skilled in the art of physical therapy knows that the mechanical properties, behavior and movement of our bodies are as important for human health as chemicals and genes. However, only recently have scientists and physicians begun to appreciate the key role which mechanical forces play in biological control at the molecular and cellular levels.
>
> An article by Dr. D. Ingber, who first described the model of tensegrity, describes what his team has learned over the past 30 years as a result of their research focused on the molecular mechanisms by which cells sense mechanical forces and convert them into changes in intracellular biochemistry and gene expression-a process called "mechanotransduction".
>
> Ingbers work has revealed that molecules, cells, tissues, organs, and our entire bodies use "tensegrity" architecture to mechanically stabilize their shape, and to seamlessly integrate structure and function at all size scales. Through the use of this tension-dependent building system, mechanical forces applied at the macroscale produce changes in biochemistry and gene expression within individual living cells.
>
> **This structure-based system provides a mechanistic basis to explain how application of physical impacts, such as low frequency sound, influences cell and tissue physiology.** (Emphasis added)

<u>Prog Biophys Mol Biol. 2008 Jun-Jul;97(2-3):163-79. Epub 2008 Feb 13</u>

What Dr. Mulvihill describes is the process by which low levels of energy can affect hormone production which by their actions result in adverse health effects. There are many more and smaller receptors for sensory input that than just our dedicated organs. Because these receptors are so small they may be far more sensitive to low amplitude, low frequency sound than the studies conducted focusing on the auditory and vestibular organs only would reveal.

Also, remember that low frequency sound penetrates into our body with little attenuation in the same way that it passes through the walls and roofs of our homes.

Q: What other significant research has been published regarding sensitivity to and impacts of noise?

A: We are also finding that new research tools not available to the researchers who are frequently quoted by wind developers in their defense are showing that our auditory and vestibular organs themselves are more sensitive than previously known. In Dr. Pierpont's study, Wind Turbine Syndrome, she cites the research of Drs. Todd, Rosengrenm, and Colebatch in their paper "Tuning and sensitivity of the human vestibular system to low-frequency vibration" published in Neuroscience Letters 444 (2008) 36–41. In this paper they present the findings of a study in the abstract as:

> Mechanoreceptive hair-cells of the vertebrate inner ear have a remarkable sensitivity to displacement, whether excited by sound, whole-body acceleration or substrate-borne vibration. In response to seismic or substrate-borne vibration, thresholds for vestibular afferent fibre activation have been reported in anamniotes (fish and frogs) in the range −120 to −90 dB re 1 g. In this article, we demonstrate for the first time that **the human vestibular system is also extremely sensitive to low-frequency and infrasound vibrations** by making use of a new technique for measuring vestibular activation, via the vestibulo-ocular reflex (VOR). We found a highly tuned response to whole-head vibration in the transmastoid plane with a best frequency of about 100 Hz. At the best frequency we obtained VOR responses at intensities of less than −70 dB re 1 g, which was **15 dB lower than the threshold of hearing** for bone-conducted sound in humans at this frequency. Given the likely synaptic attenuation of the VOR pathway, human receptor sensitivity is probably an order of magnitude lower, thus approaching the seismic sensitivity of the frog ear. These results extend our knowledge of vibration-sensitivity of vestibular afferents but also are remarkable as they indicate that the **seismic sensitivity of the human vestibular system exceeds that of the cochlea for low-frequencies.**" (Emphasis added)

These examples are provided to demonstrate that there is significant evidence to support a hypothesis of a causal link between ILFN and adverse health effects. The typical acoustician has not caught up on these biophysiological understandings of how our bodies respond to infra and low frequency sound levels -- these levels were only a few years ago considered too low to cause any physical response. Once we understand that what you cannot hear, can hurt you; we will be in a better position to develop the procedures and criteria to use wind turbines as a renewable energy resource but until the time when the necessary studies have been completed it is appropriate to follow the precautionary principle and not expose the public to a potential health risk.

Q: Please explain "low frequency" in relation to typical wind turbine noise.

A: Wind turbine noise includes a significant low-frequency component, including inaudible infrasound as shown in Figures 3 through 5. For example, according to the manufacturer, under ideal test conditions at a distance of 200 meters (656 feet), a single 2.5 MW Nordex N80 wind turbine generates 95 decibels at 10 Hz[24]. This is at the threshold of human hearing for the average person and above the threshold for the most sensitive individuals.[25] The Nordex study also showed that sound pressure levels were highest at the blade passage frequency (between 1 and 2 Hz) and dropped off with increasing frequency. Thus, we can expect that below 10Hz sound pressure levels were higher than 95 dB. What does this say about infrasound during "non-ideal" conditions which increase infra sound emissions?

Although low frequency sound is in the less-audible or inaudible range, it is often felt rather than heard. Unlike the mid and higher frequency A-weighted components, the low-frequency components of wind turbine noise "*can penetrate the home's walls and roof with very little low frequency noise reduction.*[26]" Acoustic modeling for low frequency sound emissions of ten 2.5 MW turbines indicated "*that the one mile low frequency results are only 6.3 dB below the*

[24] Nordex (2004, p. 4).
[25] Rogers et al. (2006, p. 9, table 5)
[26] Kamperman and James (2008), p. 3.

1,000 foot one turbine example.[27]" This makes the infra and low frequency sound emissions from wind turbines a potential problem over an even larger area than the audible sounds, such as, blade swish and other wind turbine noises in the mid to high frequency range.

Background Sound Levels

Q: How are background sound levels measured and considered, and why is this important?

A**:** Apart from the distinctive characteristics of wind turbine noise, including its low frequency component, the quiet soundscapes found in rural and semi-wilderness areas accentuate the perceived annoyance and potential for sleep disturbance. The Minnesota Public Utilities Commission has procedures for how to assess the pre-operational background sound levels that were designed for the types of communities in which the more traditional power generating utilities are located. Whether these are adequate for wind utilities located in quiet communities remains to be determined. It is not in the scope of this report to anticipate any needed changes, but the discussion above relative to the potential issues related to infra and low frequency sound does imply that some method of assessing and controlling the lower frequency sounds is warranted.[28]

Q: What sound information has been presented in the AWA Goodhue Application?

A: The sound information presented in the AWA Goodhue application was sparse, consisting of just three pages in the October, 2009 application[29] and ExhibitA-7, Noise Footprint GE 1.5 MW sle/xle Turbine. This section states:

> GE provided the sound power level at the turbine hub for the GE 1.5 MW xle turbine is 104 dBA. The term "sound power level" means a logarithmic measure of the sound power in comparison to a specified reference level. The sound power level of a source is

[27] *Id.*, p. 12
[28] Hessler,/gas turbine paper
[29] AWA Goodhue Application, p. 25-29.

expressed in decibels (dB) and is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to a reference sound power. The reference sound power in air is normally taken to be 10^{-12} watt.

Application, p.26.

This paragraph is missing critical information, specifically

1) octave band level of detail for sound emissions at various wind speeds for frequencies from 6 Hz through 10,000 Hz;
2) Explanation that test results do not consider weather/wind condition producing highest levels of blade swish.
3) Information of all average sound levels while wind turbine sounds vary by as much as 15 dB above the steady sound emissions.

Providing a few more specifics, the application goes on to note:

> Goodhue Wind analyzed the noise footprint of the Project from the proposed GE 1.5 MW xle wind turbine model using the WindPRO version 2.6.1.252 module Decibel for Noise Impact Calculation (see **Exhibit A-7**). According to the manufacturer's noise data, the sound power level of the GE 1.5 MW xle wind turbine at a 10 meter height for an 80 meter hub height ranges from less than 96 dB (at 3 m/s wind speed) to less than or equal to 104.0 dB (at 9 m/s wind speed to the cut out speed). Using the highest sound power level of 104.0 dB, the distance to the 50 dBA noise setback distance from a single GE 1.5 MW xle wind turbine averages 531 feet (162 meters). As shown in **Exhibit A-7**, no residences are located within the 50 dBA setback area.

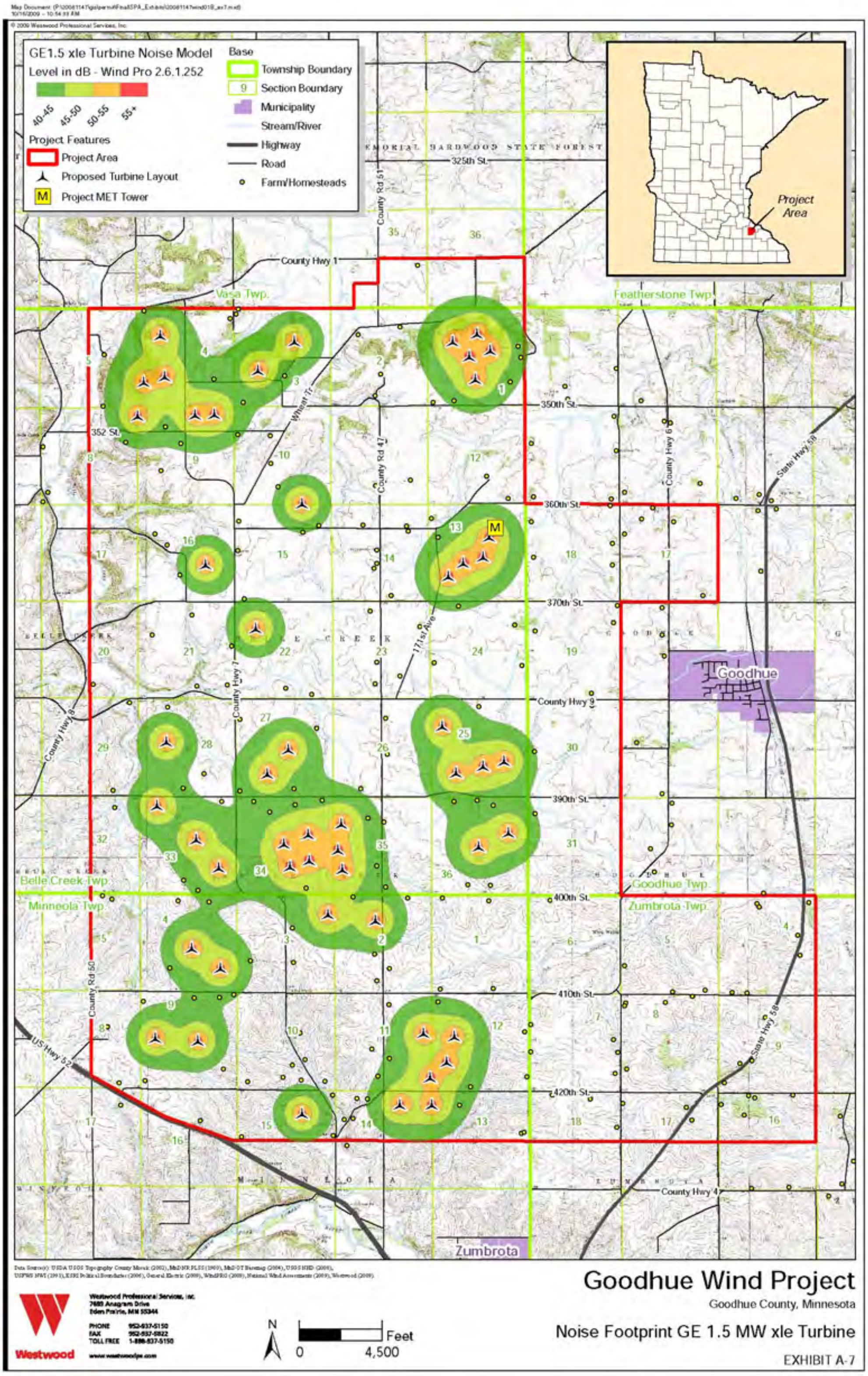
Id.

This methodology is flawed for several reasons.

1) No details of the input data was provided, only the results of modeling as an energy averaged dBA Leq;
2) No details showing the sound energy in each frequency band at homes and properties;
3) Assumed ground was 70% absorptive which is only possible during early summer with heavy ground cover and loose soil. Winter and when ground is hard-packed and has 0% absorption.

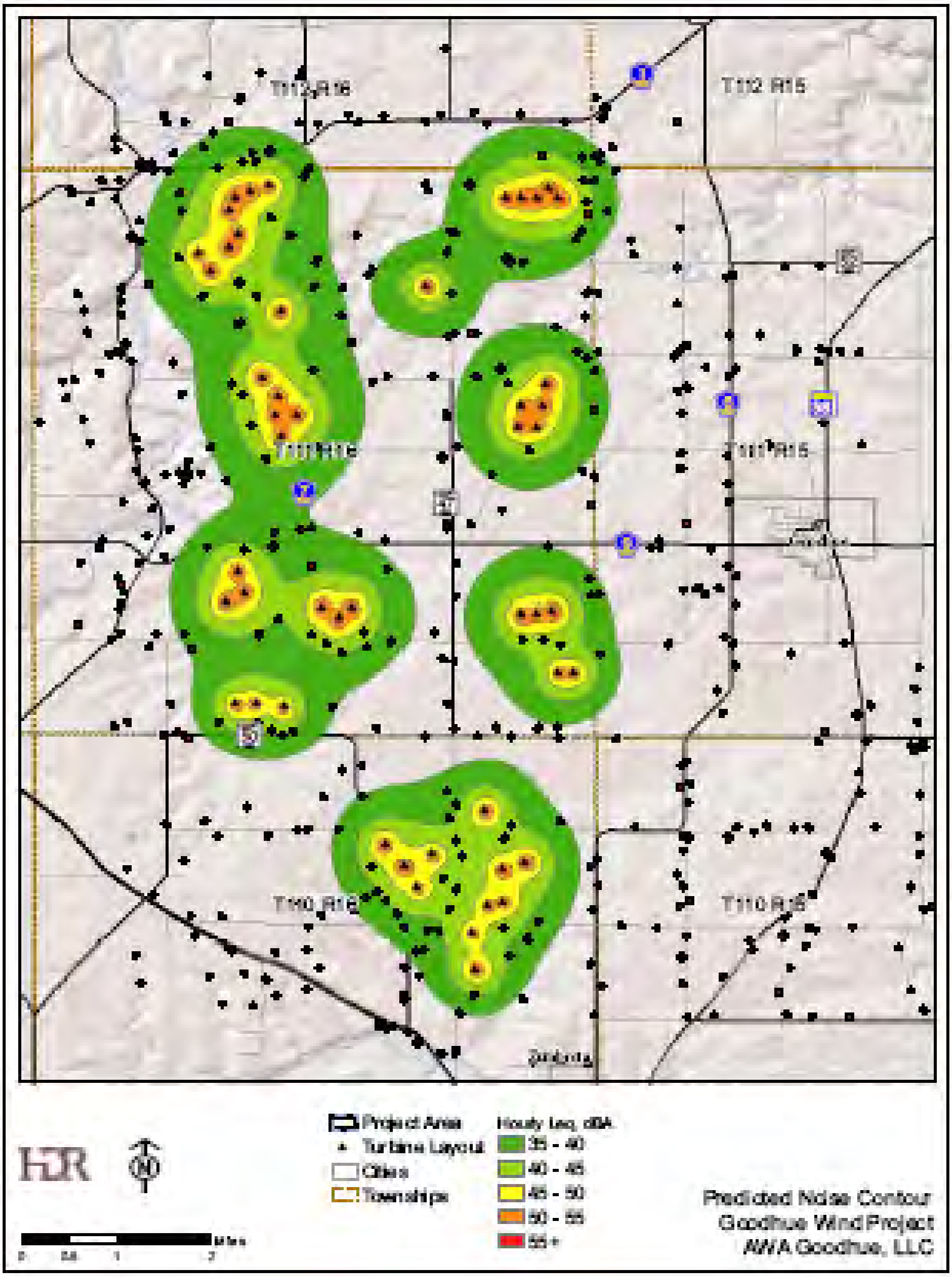
4) Assumes low frequency sound propagates at a similar rate to mid and high frequency sound. However, Infra and low frequency sound spreads at one-half or less the rate of mid and high frequency sound. Where a high frequency sound might decay at the rate of 6 dB per doubling of distance (point source) the lower frequencies will decay at rates more like 3 dB per doubling of distance. Thus, the rumble and roar are heard at much greater distances that the higher frequency sounds. Yet, use of dBA criteria would ignore that component of the wind turbine noise emissions.
5) No accommodation for blade swish and other noises normally associated with complaints. Averages can hide the dynamic sound swings. We need to know the maximum sound levels that will occur from any operation mode in all weather situations. We also need to know how much atmospheric conditions can lead to focusing sounds down to the ground that might otherwise have escaped into the atmosphere. These variables are not trivial. They can add as much as 15 dB to the average level the models predict.

This methodology resulted the graphic representation in Exhibit A-7, Noise Footprint GE 1.5 M sle/xle Turbine, and is the methodology upon which the Environmental Report and the Environmental Impact Statement are based – the Environmental Impact Scoping Decision was issued May 28, 2010:


GE1.5 xle Turbine Noise Model
Level in dB - Wind Pro 2.6.1.252
40-45
45-50
50-55
55+
Project Features
Project Area
Proposed Turbine Layout
Project MET Tower
Base
Township Boundary
Section Boundary
Municipality
Stream/River
Highway
Road
Farm/Homesteads
Project Area
County Hwy 1
Vasa Twp.
Featherstone Twp.
325th St.
350th St.
352 St.
360th St.
370th St.
County Hwy 9
390th St.
400th St.
410th St.
420th St.
County Hwy 4
County Rd 51
County Rd 47
County Rd 50
County Hwy 7
County Hwy 8
County Hwy 6
State Hwy 58
US Hwy 52
171st Ave
Wheat Tr.
Goodhue
Goodhue Twp.
Belle Creek Twp.
Minneola Twp.
Zumbrota Twp.
Zumbrota
Goodhue Wind Project
Goodhue County, Minnesota
Noise Footprint GE 1.5 MW xle Turbine
EXHIBIT A-7
Westwood
N
Feet
0
4,500

The recent prefiled Figure 9 shows a much changed footprint and distribution:

Figure 9



The prefiled Appendices include Appendix D, a Memo from HDR, a noise analysis and modeling and "24-hour noise measurements at five locations that are representative of the rural portions of the project area." I have reviewed this Memo and note the following problems, reiterating those listed above:

1) Octave band level of detail for sound emissions at various wind speeds for frequencies from 6 Hz through 10,000 Hz;

2) Explanation that test results do not consider weather/wind condition producing highest levels of blade swish.

3) Information of all average sound levels while wind turbine sounds vary by as much as 15 dB above the steady sound emissions.

4) No details of the input data was provided, only the results of modeling as an average dBA log;

5) No details showing the sound energy in each frequency band at homes and properties;

6) Assumed ground was 70% absorptive which is only possible during early summer with heavy ground cover and loose soil. Winter and when ground is hard-packed has 0% absorbtion.

7) Assumes low frequency sound propagates at a similar rule to mid and high frequency sound. Infra and low frequency sound spreads at one-half or less the rate of mid and high frequency sound.

8) No accommodation for blade swish and other noises normally associated with complaints.

9) Misconception about how wind may or may not mask wind turbine sounds.

10) No tolerances for known errors in algorithms. These tolerances should add4dBto predicted model results.

Computer Model Predictions

Q: Is the computer modeling by HDR reliable?

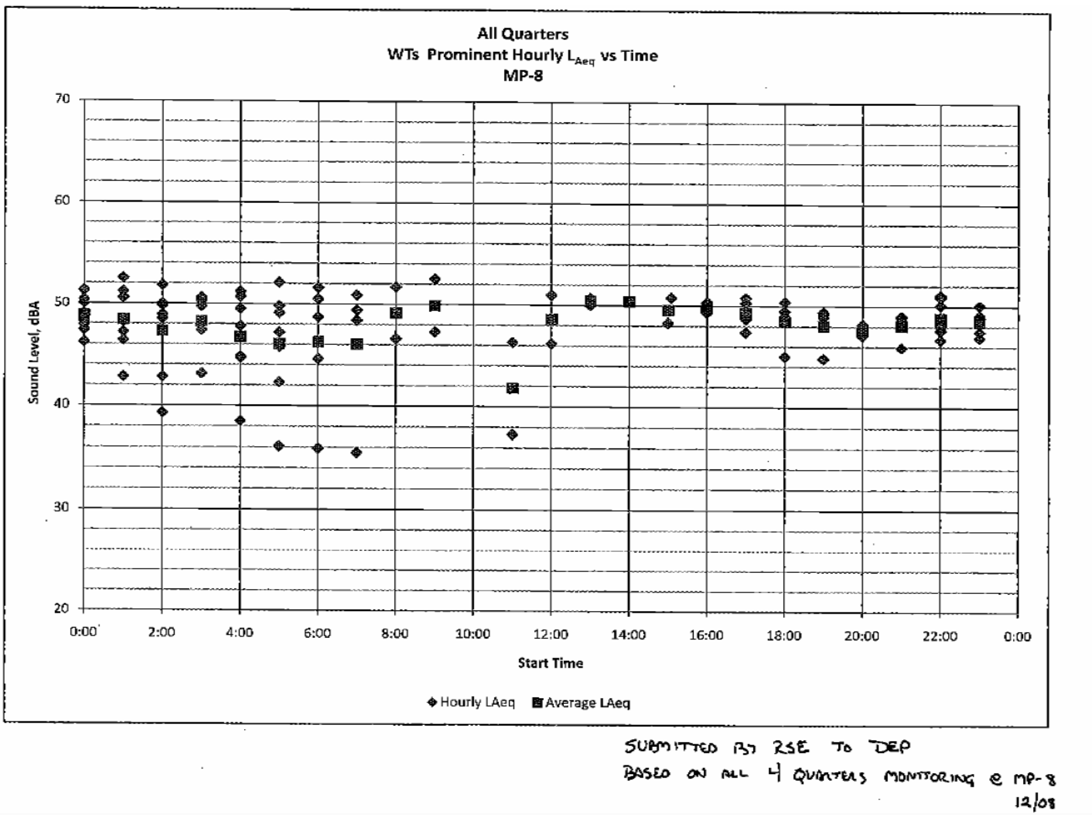
A: Computer modeling is always based on assumptions, and so the assumptions used in the base case determine the outcome. Studies on behalf of AWA Goodhue presenting computer simulations that purportedly estimate the "worst-case" sound levels that will be received in the community should be viewed with serious skepticism. Models are representations and simplifications of complex interactions between noise emitters, and their surrounding environment. Models are not precise instruments, and are not any better than Ihe input data used to represent the noise source and accuracy of the algorithms used to represe situations of modeling wind turbines in complex terrain, such as ridges and valleys, acoustical models are seriously challenged. The ability of the model to accurately replicate how the sound decays with increasing distance from the location of each source. For specific are blocked by terrain or reflected by terrain is especially weak. Errors in models of wind turbine noise propagation located on flat terrain have been shown to have errors of 5 to 10 dB or more when studied by independent acoustical engineers. It would be expected that errors of this magnitude or higher would be found in models of more complex terrain such as is found in the community near AWA Goodhue's footprint.

Q: Why is there such a broad range of levels?

A: This range of levels is understandable, given the discussion earlier in this report about the assumptions in the modeling process and also in the input data used to replicate the more important interactions as the wind turbine's sound propagates into the community. First, the model estimates a single number at a receiving site. This is an average value, representing for the input data and assumptions a yearly estimate of the sound emissions at the receiving site. It also does not reflect all of the conditions that can lead to higher sound emissions from blade swish and other weather induced effects on the turbine's noise.[30] Sometimes it is easier to understand this variability visually.

[30] Ebbing, C. E. Some Limitations and Errors in Current Turbine Noise Models, Report for Appeal of Record Hill Wind decision in Maine.

The chart in Graph 7, below, was presented to the citizens of Mars Hill, Maine in December of 2008 by the Director of the Maine Bureau of Land and Water Quality which includes the Dept. of Environmental Protection.



Maine's MDEP commissioned a four quarter study of the sound levels under various operating conditions and seasonal variations. This chart shows the 'best' of the data that was hand selected to represent only sound levels when wind turbines were operating and clearly audible. The test site is over 2000 feet from the nearest wind turbine, a 1.5MW upwind model. Note that the sound levels range from a low of about 35 dBA to a high of just over 52 dBA. All of these represent wind turbine sounds and not wind or other artifacts. The initial model estimated that the sound levels at this site would be 47.5 dBA. Sound levels higher than 52 dBA were observed but ground level winds above 5m/sec prevented accurate measurement.

Q: Why are these assumptions problematic, producing an inaccurate result?

A: Assuming that wind and other factors can result in a 17 dB range of sound levels for this operating wind utility, and that measurements during the highest noise conditions were precluded by wind speeds at the microphone exceeding the limits of the wind screen, how can any study of a operating wind utility claim that the levels estimated by the model adequately characterize the impact on the community. If the model reflects 'worst-case' wind speeds for the turbine, why are there so many complaints from people near turbines? The truth of the matter is that when the person who constructs the model is permitted to assess its accuracy the results should be viewed with suspicion. It is in that light that we must view the results of the HDR model presented. Goodhue Wind Truth asks that the Minnesota Public Utilities Commission view the estimates of sound propagation in the same way. It is at best a guide to estimate how the sound will affect the community, but to imply that the results have a high degree of accuracy is to stretch the credulity of the reviewer.

Q: Is there information about assumptions and models that is missing?

A: Yes. Studies that use models normally disclose the strengths and weaknesses of the models and also disclose the input data and other important assumptions. They give appropriate cautions and disclose error tolerances for all possible known conditions that the model does not consider. This is not done in the HDR modeling for AWA Goodhue. The model is poorly documented and missing important data if the study is to be critically reviewed by others competent to do so. Much could be said again about the flaws in computer modeling of sound in complex situations but that evidence has been previously submitted. The arguments are academic and not something that most non-engineers would not care to review. However, the use and accuracy of CADNA and similar models are debated every year atnoise conferences with only wind turbine consultants claiming high levels of accuracy.

Q: How can we establish the validity of the assumptions and modeling?

A: The easiest way to establish that wind turbine models underestimate sounds at properties adjacent wind utilities is to look at existing wind projects. Since most, if not all, follow-up sound studies on various wind projects are conducted by acoustical consultants with strong ties to the wind utility developers, it is reasonable to look at other studies for projects. This review has conducted studies of operating wind utilities in many different states, and in Ontario. In all cases the projects were granted permits based on sound studies claiming the community had high background sound levels, came with discussions of how wind noise masks turbine noise, and presented wind turbine sound models estimating levels in the low to mid 40 dBA range at the nearest properties.

Other studies of background sound levels in rural communities confirm the results of the Kamperman-James study. For example, similarly low background sound levels were also reported in the study by Mr. Clifford Schneider[31]. Schneider reported that the median L_{A90} sound level for approximately 20 test locations in northern New York was 25.5 to 26.7 dBA. This reviewer has also found that in rural areas background sound levels are typically less than 30 L_{A90}. When sampling is conducted during the evening hours when community activities are at a minimum the L_{Aeq} and the L_{A90} are usually within 5 dB of each other. It is during this time that the sounds from the wind turbines will be most apparent and it is against those low background sound levels that land-use compatibility should be assessed.

[31] Schneider, C. "Measuring background noise with an attended, mobile survey during nights with stable atmospheric conditions" Noise-Con 2009

The background sound study Hessler and Associates conducted for a wind developer in the upper New York area near Cape Vincent was questioned by members of that community. The complete Cape Vincent study by the wind developer's consultant Hessler & Associates is attached as Exhibit RJ-20. They commissioned an independent study by Dr. Paul Schomer, who is the Chair of the Acoustical Society of America's Standards Committee and is highly respected for impeccable work by his peers.[32] Dr. Schomer concluded that:

> Hessler's BP study for the Cape Vincent Wind Power Facility appears to have selected the noisiest sites, the noisiest time of year, and the noisiest positions at each measurement site. Collectively, these choices resulted in a substantial overestimate of the a-weighted ambient sound level, 45-50 dB according to Hessler.

Rebuttal by Dr. Paul Schomer, attached as Exhibit RJ-21, Background sound measurements and analysis in the vicinity of Cape Vincent, New York, Schomer, May 2009; Exhibit RJ-22, Background sound measurements and analysis in the vicinity of Cape Vincent, New York, Schomer, May 2009; and Exhibit RJ-23, Letter to Supervisor Hirschey, Town of Cape Vincent, Schomer, April 23, 2010.

The review by Dr. Schomer should be reviewed by the Public Utilities Commission to determine whether the AWA Goodhue sound study was free from similar bias. Given that HDR is a Canadian firm accustomed to Ontario's rules which follow the Hessler approach, there is reason for caution.

Q: Why should we look at past noise studies and modeling in relation to the current noise information provided in this docket?

A: Historically, there is a pattern of overly optimistic and inaccurate modeling results based on inadequate refinement of base case assumptions.

[32] Schomer, P., PE, INCE Bd. Cert., "Cape Vincent Background Noise Study," May 11, 2009

Note the similarities in these studies to what AWA Goodhue has presented for the AWA Goodhue wind project under consideration. And consider what has happened at those locations that the Public Service Commission should take into consideration. The project developers made promises based on their submitted studies and modeling:

- The promises of compatibility with existing community sound levels;
- Promises of no potential for nighttime sleep disturbance or low frequency 'vibrations'

These promises have been followed by numerous complaints from the public, affected nearby residents, about noise and health, complaints to the local Boards and state Commissions that issued the site permits. In some cases this has escalated to threats of litigation and lawsuits.

Given that track record, it is a safe assumption to consider the AWA Goodhue models to be estimates of turbine noise under optimum operating conditions and nothing more.

Q: Have you reviewed the Exponent report provided by AWA Goodhue?

A: Yes, The prefiled Appendices also includes Appendix E, by Exponent, entitled "Evaluation of the Scientific Literature on the Health Effects Associated with Wind Turbines and Low Frequency Sound." I have reviewed this literature survey and note that there are substantive errors and omissions. Recent studies link low frequency noise impacts to impairment of the vestibular system or other organs.[33] This new link between health and noise should be considered along with studies showing that wind utility noise from turbines operating at distances of up to one mile is a cause of sleep disturbance for a vulnerable minority, and chronic sleeplessness results in adverse health effects.

[33] See Alves-Pereira and Branco, 2007; (linking the low-frequency component of wind turbine noise to abnormal growth of collagen and elastin in the blood vessels, cardiac structures, trachea, lungs, and kidneys of humans and animals exposed to infrasound (0–20 Hz) and low-frequency noise (20–500 Hz), in the absence of an inflammatory process). See also Pierpont "Wind Turbine Syndrome" study (2009) and Minnesota Department of Public Health (2009), pp. 7-8.

An article in Noise and Health by Dr. Leventhall addresses these coping mechanisms for people exposed to noise.[34] It deserves careful reading by the Minnesota Public Utilities Commission. This study describes the coping mechanisms and other adaptations to life style that people adopt when exposed to infra low frequency noise (ILFN) over long periods of time. It is interesting to note that many of the coping mechanisms in that article are used by people who are now living in the footprint of wind utilities like the one proposed for Goodhue Wind. Indeed, there has been an ongoing debate between Dr. Leventhall and Dr. Pierpont about the risks of exposure to wind turbine sounds that seem to be contradicted by the statements of Dr. Leventhall in this article. If it can be assumed that the causal link between wind turbine noise exposure and the ILFN from wind turbines is established by the new medical research referenced earlier, and the levels of ILFN required to initiate a response from our bodies is lower than previously thought, then the disagreement between them appears to resolve in favor of Dr. Pierpont's research.

The supplemental reports provided by AWA Goodhue written by Dr. Leventhal and others take issue with this position. Leventhal's critique of the Kamperman/James paper shows there are two primary issues that he felt requires a response.

1) Kamperman/James are too focused on ILFN, and
2) The proposed criteria using the difference in a-weighted sound levels and c-weighted sound levels should not apply.

Information provided earlier in this testimony demonstrated that wind turbines do produce ILFN, including one chart showing infra sound from an early study of turbines by Leventhal, and that new research, not well known by acoustical engineers, show that the levels of acoustical energy are in the range of perception, above 90dB, for at least a small segment of the exposed

[34] Leventhall, H. G. "Low Frequency Noise and Annoyance," Noise and Health, Vol. 6, Issue 23, Page 59-72 (2004)

population. One chart in this shows infra and is referenced from an early study of turbines by Leventhal. With respect to whether wind turbines emit ILFN, consider that if one totals the acoustic energy of a wind turbine across the entire frequency spectrum from 16Hz up to the speech frequencies, the difference in the sum of the energy below 200 Hz is often 10-15 dB higher than the sum of the energy at 200 Hz and above. It is clear that wind turbines are primarily producers of noise in the ILFN range. Use of dBA criteria for this type of noise is non-sensical.

Any critique of the Kamperman/James emphasis on ILFN must consider that the recommendations be seen as precautionary. At the time the manuscript was prepared there was less information about the nature of the sound emission in operating wind utilities. Based on information culled from studies of some of the first wind projects in the US and other countries, it was decided that there was a need for a limit to ILFN as a precaution. We did not know, at that time, if all wind turbines produced the same spectrums as those we saw in the sound tests conducted for many of the participants in Dr. Pierpont's study. But, based on the initial indications, and our experience with other large fans, and related problems in work areas subject to 'rumble' it was decided to include criteria that would severely limit any increases in the existing long term ILFN to which people in rural areas are typically exposed. Dr. Leventhal's critique misses this important point. The focus by Kamperman/James on ILFN was initially precautionary. Subsequent to the development of those criteria additional information has been accumulated that supports the need for that precaution.

Even if only 5-10% of the people living in the footprint of an operating wind utility are susceptible, that is still a large number and given the fast rate at which wind utilities are being constructed this number will continue to increase. The Kamperman/James manuscript is written to apply the Precautionary Principle to what we do and do not know about the causal links and the short and long term health effects of wind turbine noise emissions. The criteria developed in that manuscript, which I encourage the Public Utilities Commission to consider as a replacement for the current 50 dBA criteria, are based on that principle. When solving one problem, the need for clean energy, it is not appropriate to expose people to a second problem, a potential health risk. The discussion about the causal links between ILFN and adverse health effects can help the debate between those that are concerned about health effects and those who continue to deny need for such caution can now progress beyond the 'if you can't hear it, it can't hurt you' stage of argument. When, new information of the type disclosed by Dr. Pierpont and others is made available, wind turbine manufacturers and reasonable experts will try to understand these new concepts before rejecting them in favor of the former beliefs.

Dr. Leventhal's critique of Kamperman/James's use of C-A demonstrates that he did not conduct a careful review of the manuscript. If he had done so, he would have noticed that the subscripts for the C-A criteria are: $LCeq_{(immission)}$ minus $(LA90_{(background)} +5) \leq 20$ dB. This formulation is again an application of the precautionary principle. Given that we do not know how much increase in ILFN is needed to trigger an adverse health effect, the criteria was established to limit the additional ILFN from the operating turbines to no more than a small increase over the pre-operational background sound levels. In addition, the Kamperman/James paper suggests that the L_{Ceq} when the turbines are operating be limited to LCeq (emmision)= L_{C90}(background) +5 dB and not exceed 55dBC LCeq. In both cases, the justification is precaution. Until the extent of the links between nighttime sleep disturbance from audible sounds; and vestibular and cardio pathologies from audible sound or ILFN are known, it is best to error on the side of safety and health.

Dr. Nina Pierpont's work

Q: Please address the work of Dr. Nina Pierpont.

A: The symptoms reported by Dr. Pierpont for people exposed to dynamically modulated ILFN from wind turbines are not that different from the symptoms reported by Kirsten Persson Waye in collaboration with Dr. Leventhal in their 1997 paper "*Effects On Performance And Work Quality Due To Low Frequency Ventilation Noise,*"[35] This study compared the performance and other factors for a work group that was exposed to dynamically modulated low frequency sound to that of a work group exposed to more normal HVAC system sound spectrum with lower levels of LFN and no modulation. This study reported that the group exposed to LFN reported:

1. Subjective estimations of noise interference with performance were higher for the low frequency noise (exposed group)

2. The exposure to low frequency noise resulted in lower social well-being ('96 words) "more disagreeable, less co-operative, helpful and a tendency to lower pleasantness "more bothered, less contented as compared to the mid frequency noise (exposed group)

3. Data may indicate that the response time during the last part of the test was longer in the low frequency noise exposure e.g. cognitive demands were less well coped with under the low freq. noise condition.

4. The effects seemed to appear over time

5. The hypothesis that cognitive demands are less well coped with under the low frequency noise condition needs to be further studied.

They also reported that a "few previous studies indicate that low frequency noise may reduce performance at levels that can occur in such occupational environments. Some of the symptoms that are related to exposure to low frequency noise such as

1. Mental tiredness,

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[35] *Journal of Sound and Vibration (*1997), 205(4), 467-474

2. Lack of concentration and

3. Headache related symptoms.

could be associated with a reduced performance and work satisfaction."

> The reported symptoms and effects on mood were apart from tiredness in accordance with earlier findings on effects after exposure low-frequency noise. The subjects reported a feeling of pressure on the head rather than headache and lower social orientation and pleasantness after low-frequency noise exposure

Persson-Waye 1995.

Given that this study identified adverse health effects from dynamically modulated LFN that is similar in level to what is experienced inside the homes of people living near turbines, one might think that Dr. Leventhal would embrace the new medical studies and Dr. Pierpont's research as a possible answer to the HVAC study's findings. The symptoms listed in Dr. Pierpont's report are very similar to those reported in the HVAC study.

Q: Would you please summarize position of the World Health Organization?

A: Certainly. The World Health Organization (WHO) has a long established position that considers sleep disturbance to be an adverse health effect and to lead to secondary adverse health effects[36]. Dr. Leventhal did not seem to think this was important enough to include in his critique of Kamperman/James or of Dr. Pierpont. Nothing about these guidelines was mentioned in either of Mr. Hessler's reports. Chronic sleeplessness, in turn, causes a variety of health effects, including:

> *[P]rimary physiological effects . . . induced by noise during sleep, including increased blood pressure; increased heart rate; increased finger pulse amplitude; vasoconstriction; changes in respiration; cardiac arrhythmia; and an increase in body movements.*[37]"
> "*Exposure to night-time noise also induces secondary effects, or so-called after effects . . . including reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance.*[38]

[36] WHO (1999), pp. 44-46
[37] Id., p. 44.
[38] Id., pp. 44-45

Waking up in response to nighttime noise decreases as people get habituated to the noise; however, "*habituation has been shown for awakenings, but not for heart rate and after effects such as perceived sleep quality, mood and performance*."[39]

WHO issued the 2007 Night Time Noise Guidelines (NNGL) as a replacement for the 1999 Guidelines. These guidelines are intended to replace all earlier guidelines with respect to sleep and noise. They supersede the prior guidelines that recommended that sleeping rooms be protected from outside sound that raises sound levels inside to above 30 dBA. Because the earlier guidelines provided a limit in terms of interior sound levels and also included special conditions when low frequency sounds were present outside the home WHO explains that it was decided there was too much room for interpretation of their research findings. Thus, in 2007, following several years of research by respected experts in health and noise and three major meetings to present their findings WHO issued the new guidelines. This time, they elected to establish the guidelines for the outside façade of the home and not the sleeping area. This avoided issues such as whether windows are open and if so how much and also issues of various types of building construction that affect how low frequency sounds penetrate into the home. The focus was to establish science based guidelines that would promote healthful sleep.
The table excerpted from WHO's 2007 guideline clearly states that to avoid adverse health effects during sleeping hours that the sound levels at the outside wall of a home should not exceed 30 dBA at night. It also states that when sound levels outside a home are over 40 dBA there is a sharp increase in adverse health effects; that people would be attempting to adapt to cope with the high outdoor noises, and that the more vulnerable members of the exposed population would be severely affected. These are the same sound levels that AWA Goodhue has claimed are compatible with the community and safe for the people living under and adjacent to

[39] Id., p. 45.

the turbines. WHO's descriptions of the health effects on the exposed populations closely parallel the experiences of people in other communities where wind utilities are currently operating.

Q: Hast the World Health Organization's position triggered further regional and local analysis of the impacts of wind turbines?

A: Yes. The new guidelines from WHO and other recent medical research have led several health organizations to call for serious research before more wind turbines are located near people's homes. Recently, Health Canada, which functions much as the US Center for Disease Control does in the US, issued a position statement calling for reconsideration of a wind utility project in Nova Scotia that would result in sound levels at homes similar to those projected for the AWA Goodhue project. The basis for their statement includes the new medical research, Guidelines such as WHO's, and the existence of other projects in Nova Scotia where the studies submitted for permitting showed no potential for health risks or complaints but operation of the utilities resulted in them anyway. The Maine Medical Association, which has been evaluating new health research on residents of Maine's first wind utility at Mars Hill, issued a Resolution stating:

> *WHEREAS, there is a need for modification of the State's regulatory process for siting wind energy developments to reduce the potential for controversy regarding siting of grid-scale wind energy development and* ***to address health controversy with regulatory changes...*** (emphasis added)

Minnesota's medical community, outside the Public Health Inquiry Regarding Health Impacts of Wind Turbines (PUC Docket 09-845), has yet to address the health controversy with a call for regulatory changes, but the situation in Minnesota is similar to that in Maine and elsewhere. Public officials with a duty to protect the public health and welfare should seriously consider whether it is a wise decision to grant permits to a utility operator that, by its own admission, will expose the public to unsafe conditions 24 hours a day and 365 days a year.

Those who wish to be fair and impartial in making decisions that affect the public and its health should note that many of the complaints this author has been asked to evaluate for residents and local governments including wind utilities operating or proposed in New York and other states, Canada, the U.K., and, places as remote as New Zealand are all directly related to noise resulting from operation of turbines during conditions excluded from the IEC test results and the sound propagation models.

Q: Do you have any words of conclusion regarding this project?

A: Many questions have been raised. Has AWA Goodhue, in its reports, presentations, studies and recommendations to the Public Utilities Commission, discussed these negatives and uncertainties in an open manner or have they focused on defending themselves when these issues have arisen through public questions? Have they disclosed that there are operating wind utilities, possibly even some of their own, where complaints or lawsuits have been lodged?

Finally, this caution is offered. If the data submitted by AWA Goodhue has created the impression with the Public Utilities Commission that there will be no future problems from noise they should consider that these same assertions were made to other government officials tasked with deciding on whether or not to issue permits. The local government officials of areas affected by AWA Goodhue’s plans for a wind utility will be in the same place as the officials of other communities where anger, complaints, and litigation are common. Those other officials, or their successors, are now facing complaints and threats of litigation from the people living in their wind utility’s footprint.

Background sound levels obtained by an independent acoustical consultant (Kamperman) shows that existing conditions at the Glacier Hills project in Wisconsin are often below 30 dBA. My own findings regarding the Goodhue site, just completed, are similar. Operation of wind turbines will increase sound levels on a routine basis to 40-45 dBA for many local residents and above that for conditions not accounted for in the models. For AWA Goodhue to meet WHO's guidelines the limits for sound at affected properties would need to be set at 35 dBA or lower. The studies and representations by AWA Goodhue show that estimated sound levels at properties adjacent to and inside the footprint of the proposed utility will exceed the nighttime sound levels WHO has identified as a health risk even without applying 5dB for tolerances and 10-15 dB for blade swish. Experience with other wind utilities with operating turbines having similar sound emission characteristics shows that wind turbine noise levels at distances of 1500 feet can exceed 50 dBA and that sound levels inside homes can easily exceed 30 dBA. Based on the above, the AWA Goodhue project, as proposed, will, with a high degree of certainty, have noise and health impacts that are "significant."

Q: Does this conclude your testimony?

A: Yes, it does.

Citations to references relied upon but not provided as Exhibits:

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