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Human Health Hazard – The Shirley Wind Story

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Summary

In October 2014 the Brown County Board of Health declared the Shirley Wind project – located in Brown County, Wisconsin, U.S.A. – a Human Health Hazard, a finding that surprised many within the acoustics community. This paper tells the story of the Shirley Wind project, from the permitting phase, all the way through the current time. The paper will primarily rely on public documents, such as the Board of Health meeting minutes. Comparisons will be made between project characteristics and context, and factors that are known to contribute to human noise response.

1. Introduction

The Shirley Wind project ("Project") is a 20 MW, eight turbine wind power project, located in the Town of Glenmore, in Brown County, Wisconsin. The Town of Glenmore is a small town about 16 kilometers (10 miles) from the City of Green Bay, with a population of approximately 1,100 people [1]. A map of the project area, including turbine locations and surrounding residences, is shown in Figure 1. Constructed turbines are Nordex N100 2.5 MW units, with 80-meter hub heights. In many respects, including its size and locale, there is little unusual about the project.

Response to the project has been far from typical with at least 75 unique complainants and three families abandoning their homes [2]. This response resulted in the Brown County Board of Health passing a motion on October 14, 2014, declaring the Project a Human Health Hazard. This paper goes through the history of the project, with the hope that it will provide better understanding of some of the basis of the response.

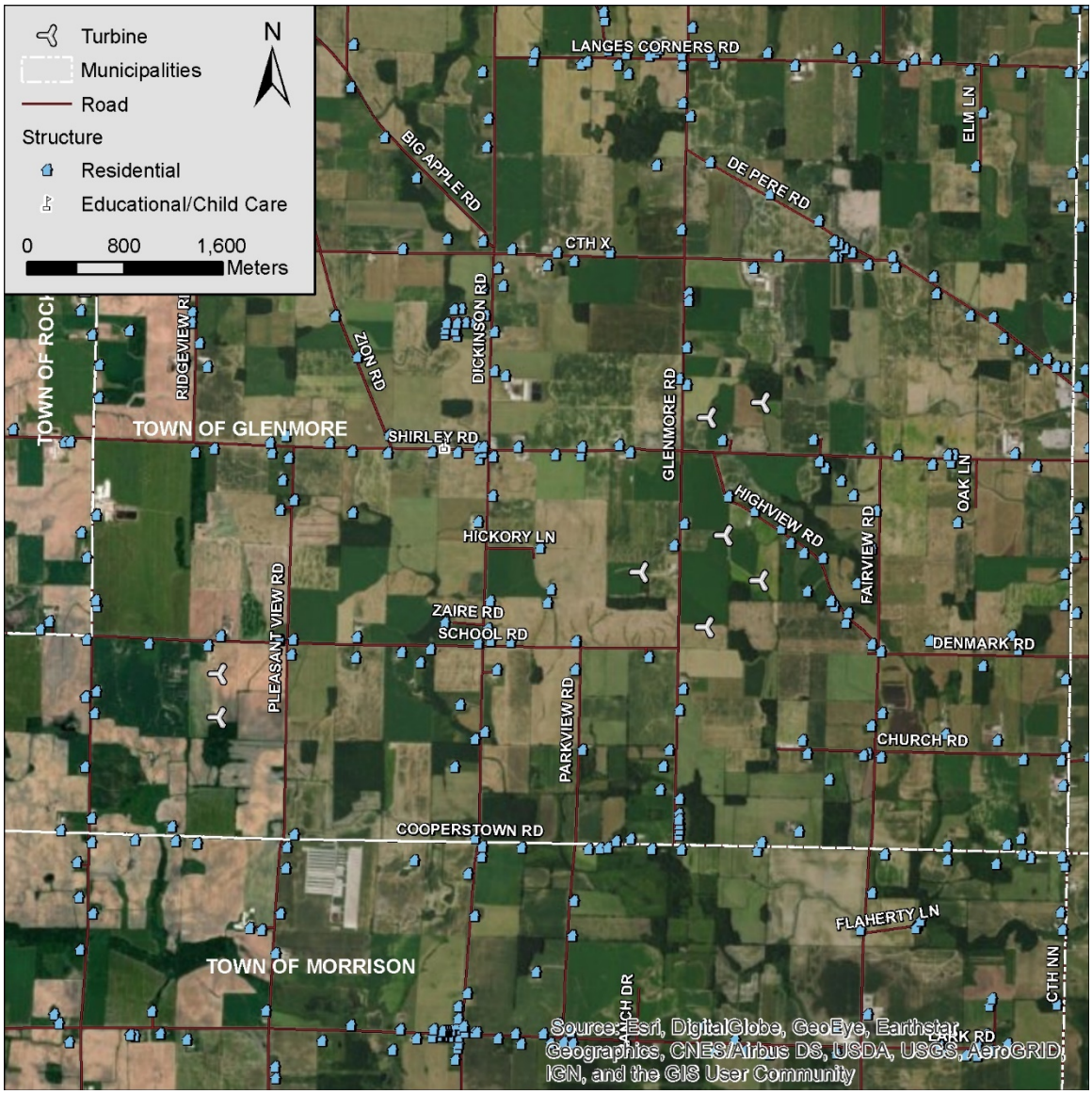

Figure 1: Area Surrounding the Shirley Wind Project

2. Project Permitting

The Shirley Wind Project permitting began around 2007 and was granted a Special Use Permit by the Town of Glenmore, Wisconsin the same year. The sound level limit from the special use permit was 50 dBA [2]. There was a provision in the permit, where a payment of $4,000 per megawatt ($80,000 total) is split between the Town of Glenmore, Brown County, and all landowners within a ½ mile radius of turbines on a yearly basis [3]. The project was initially permitted by a small developer, permitting their first project [4]. After completion the project was sold twice, the second time to Duke Energy [5] [4].

The author of this paper requested the permitting documents from the Town of Glenmore, but, as of the writing of this paper (March 22, 2019), he has not yet received them. Further information will be added to this section if/when these documents are received.

3. Between Permitting and Commissioning

3.1 Wisconsin PSC Rulemaking

The State of Wisconsin began rulemaking to develop wind turbine siting standards in 2009 following 2009 Wisconsin Act 40 [6]. Act 40 also specifically appropriated power to the state for

regulating wind power projects, saying “A political subdivision that chooses to regulate shall enact an ordinance subject to sub. (6)(b), that is no more restrictive than the applicable standards established by the commission in rules promulgated under s.196.378 (4g).” The result of this rulemaking procedure was Wisconsin PSC 128 [7]. This set sound level limits of 45 dBA during nighttime hours and 50 dBA during daytime hours, along with an audible tone penalty. No specific metric is given for these limits and the duration it applies to is ambiguous.

3.1.1 Brown County Response to PSC 128

Acceptance to the rulemaking process in Brown County was decidedly negative. Residents commenting to the Brown County Board of Health (BCBOH) seemed to see it as an indication of the political power of wind developers. This sentiment was based on the makeup of the council that developed the legislation, which was viewed as slanted towards the wind power industry. The council also did not include “one member who is a University of Wisconsin System faculty member with expertise regarding the health impacts of wind energy systems,” as was required by Act 40 [6].

Three Towns in Brown County, Glenmore, Morrison, and Wrightstown (locations shown in Figure 2) submitted comments on June 23, 2010 regarding the draft of PSC 128 [8]. The comments were reportedly the product of much research and input from the public in seven town meetings, including two that were joint meetings of all three towns. The comments advocate setbacks of at least 0.5 miles (0.8 km) and sound level limit recommendations from various sources of below 40 dBA, though the metrics specified varied wildly. The comments also requested low frequency and infrasound specific limits. The most interesting aspect of this is the reduction in requested sound level limits from what is in the permit for Shirley wind (50 dBA). Also included is a request that towns should be able to require compliance for their existing ordinances.

3.1.2 Most Recent Glenmore Ordinance

The Town of Glenmore most recently modified its Wind Energy Facility ordinance in October 2010 [9], about three years after Shirley Wind received its permit. This ordinance sets sound level limits of 35 dBA for “any period of time” at inhabited structures, along with the permitting requirement of sound propagation modelling that includes low frequency sound and infrasound. Low Frequency Noise is defined in the ordinance as “an ongoing noise that impairs the health of a resident emitted during periods of turbulence as the blades are buffeted by changing winds that can cause structure vibration. Low frequency noise refers to sounds with energy in the lower frequency range of 20 to 200 Hz.”

3.2 Board of Health Involvement

The Board of Health’s involvement in wind turbine issues seems to begin with an email from the County Supervisor to the Health Department, dated March 30, 2010. The email states, “from what I understand there will be real health issues affecting the people in southern Brown County if the wind turbines are installed…. I will be looking for the BC health department to research this subject and disclose their findings and recommendations in a written report. I would request that either the Health Department, the Corporation Counsel, the Board Attorney or all three parties file an injunction to halt the process of construction until the health assessment by our local governing body is determined.” [10] This email resulted in a joint meeting of the Board of Health and Brown County Human Services Committee (BCHSC) on March 25, 2010. The purpose of the meeting was to provide information from Invenergy Wind (developer of the proposed Ledges Project, proposed for Brown County), the State of Wisconsin, and Brown County Citizens for Responsible Wind Energy (BCCRWE) [11]. The State of Wisconsin Department of Health Services representative indicated that there was little information available on the health and safety of wind turbines and that the state had not

formally taken a position on the subject. He went on to say that other organizations had not found an association between wind turbines and health impacts at typical setback distances. Individuals claiming health impacts should see their doctor. The Invenergy representative spoke, pointing to their health and safety record, largely regarding occupational health. Then he points to the economic and environmental benefits of projects including their proposed Ledge Wind Farm. Invenergy also submitted a newspaper article called “Winds of Change Inevitably Get the Hot Air Stirring.” BCCRWE has a presentation from several residents presenting a request for a moratorium on wind projects in Brown County pending completion of an epidemiological study. Other presentations included literature forwarding the view point that adverse health effects are inherent to wind turbine installations. Other residents presented interviews of those claiming health effects from other projects, claims of harm to livestock, reduced crop productivity, and concerns about groundwater. BCCRWE finally presented an 890-signature petition to the state to perform a health study in advance of more wind power project approvals.

After this meeting, discussion on wind turbine issues became a common theme of Board of Health meetings. At the October 12, 2010 meeting, Dr. Jay Tibbetts (a member of the Brown County Board of Health) distributes the minority report for the Wind Siting Commission, and explained that he found their position well written and objective. Particular among their concerns, were a lack of low frequency noise consideration [12]. The minority report was a document that specified considerably more restrictive siting rules than what was eventually included in PSC 128 and was written by dissenting members of the commission.

At the January 11, 2011 Board of Health meeting, BCCRWE introduced a draft legislature bill was introduced that increased setbacks to 1,800 feet (549 meters).

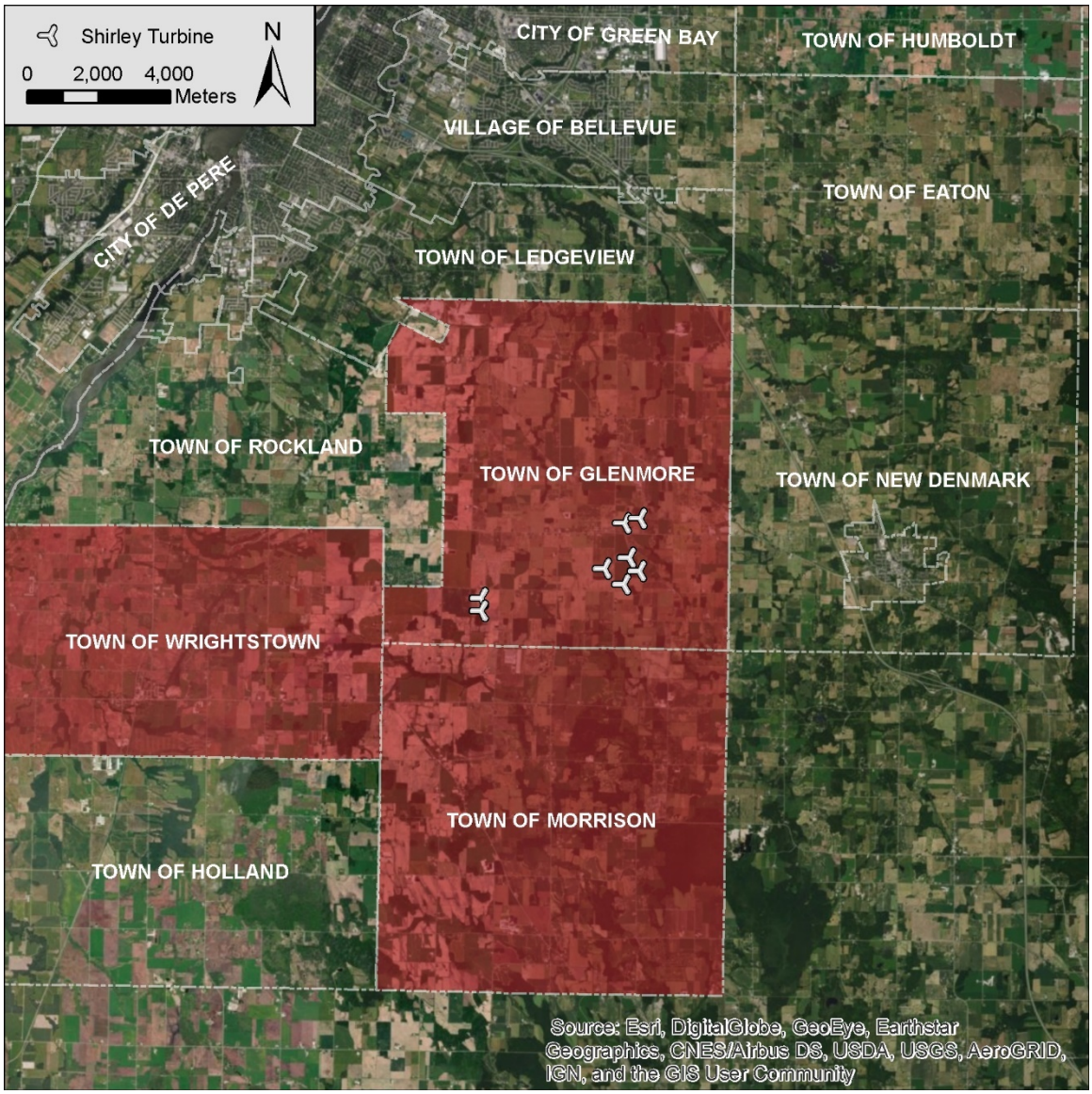

Figure 2: Brown County Area Showing Towns that Submitted Comments to the Wisconsin PSC

4. Post-commissioning

The Shirley Wind Project was commissioned in December 2010 [5].

4.1 Other Brown County Wind Power Projects

A second wind power project was proposed for the Town of Glenmore, by a developer called Prelude that would have included seven turbines. Most of the permits for the project had been obtained by the developer before 2010 [13]. A power purchase contract had also been signed, with the provision that all permits would need to be obtained before March 1, 2011. The developer learned around September 2010 that the project would require building permits for each of the seven turbines. After this, the developer submitted applications to the Town Board for these building permits, after which the Town Board requested further information. The developer provided this information by December 31, 2010 and informed the Board Chair of the impending deadline. At the January and February 2011 town meeting angry citizens opposed the plan and the Board Chair was receiving “threats to his physical safety should he approve the wind turbine project” [13]. The original developer (Prelude Energy) was purchased by CEnergy in a sale that closed in February 2011. The Town Board did not take up the permit issue at either the January or February meeting, citing need for the Town Attorney to review the newly-submitted information, though the developer later claimed it was due to threats the Board Chair was receiving [13]. The permits were finally approved on March 7, 2011, and the meeting

was closed, but the meeting was re-opened due to pressure from some of those in attendance, and the permits were rescinded [13]. One week later the board had a special meeting, reinstating the revoked permits. The permits were never actually issued due to completeness concerns from Glenmore's lawyer.

The permit approval ended up being too late, since the power purchase agreement was cancelled on March 4, 2011. The developer ended up suing the Town of Glenmore citing that it was deprived of property without due process, requesting a judgment that would have cost each resident of Glenmore $6,000.

The appeal for the suit was decided against the developer on August 7, 2014.

The Ledge Wind farm was a 150 MW wind farm proposed by Invenergy for southern Brown County. This project was cancelled in March 2011, citing "regulatory uncertainty" at the state level [14].

4.2 Board of Health Proceedings

The first mention of Shirley Wind to the Board of Health after commissioning comes in the May 10, 2011 minutes, where residents from two households report having health issues that they blamed on the Project [15]. One mentions low-frequency noise and describes it as a "sound you can feel" and report that others within the town have had the same issues. Another reports that they did some internet research and attributes the issues to infrasound. One Board of Health member recommends they see a doctor, which is met with the response that they found it unlikely the doctor would find anything since symptoms are only present near the turbines. Another Board of Health member remarks, it's similar to what Nina Pierpont reported in her book and some of the stories told at the May 25, 2010 joint meeting. Dr. Tibbetts considers state health officials to be unsympathetic and wants a study of the issue. The following meeting on July 26, 2011 included a response from the State of Wisconsin indicating that it was unlikely that the State would be performing a study on wind turbine noise.

The next time the Shirley project was mentioned in the health board minutes is for November 15, 2011, where the board considers whether or not to support a bill that would require submittal of a study on wind turbine health effects by the State health board, before the new siting guidelines take effect [15]. Members of the Board of Health also went on a site visit to a farm where 13 of the 87 cows had died without apparent cause since operation of the wind farm. On the site visit, one of the residents who had abandoned their residence due to health effects they attributed to the turbines, invited the board members over to his house. One board member reported having pressure in their ears. Another board member reports that the Shirley project had been bought and sold three times since the turbines were installed (other sources indicate twice [4]).

The January 10, 2012 meeting brought a presentation by BCCRWE on stray voltage [16], which is what was blamed for the cow deaths mentioned in the November 15, 2011 minutes. After this presentation, the Board of Health passes a resolution to ask the state for financial aid for those that relocated due to the wind project. The board votes to support the "Wisconsin Citizens Safe Siting Guidelines." These guidelines were endorsed by the Towns of Glenmore, Holland, and Morrison, and drafted by a handful of Wisconsin Citizen groups. Dr. Tibbetts indicates that Richard James (an acoustician and Principal of E-coustic Solutions) had been hired to measure infrasound in the Shirley Project area, since he considered that to be the primary concern.

At the March 13, 2012 meeting, there is a report of several more complaints due to the Project. The Board of Health tasks the Health Department with measuring sound levels at a

complainant's residence [17]. There is more discussion about having Mr. James revise the county ordinance and do a noise study of the area. At the next meeting on May 8, 2012, results from the noise complaint test are reported, which indicated an exceedance of the county noise ordinance [18]. The report was presented to Duke, which responded that the Town of Glenmore special use permit possessed by the Project superseded the County's jurisdiction, a conclusion which the counsel for the county agreed with. Effectively the County does not have the jurisdiction to regulate wind farms, since the Special Use Permit was granted by the Town of Glenmore and current legislation has moved regulation to the State of Wisconsin. Dr. Tibbetts puts forward the idea that the noise issues can be dealt with when Shirley's permit is brought up for a review, which would occur at a five-year interval. The next meeting in July 2012 indicates that there had been several other complaints about noise the Project [19]. Apparently, a study was performed by Mr. James indicating an "issue" with low frequency noise, though no further details are given. This study was distributed to Board of Health Members.

There is talk among the BCBOH of having Mr. James draft a low frequency noise ordinance during this period [19] [20] [21]. The final conclusions seem to be that the ordinance would not be enforceable for wind farms due to PSC rules. BCCRWE encourages the ordinance anyways, to send a message [20]. The board approves hiring Mr. James to write the ordinance in January 2013 and funding was obtained [22].

At the September 2012 meeting, a study regarding infrasound from wind turbines was distributed by Dr. Tibbetts, though no further information was provided in the minutes. Another Board member reports that three families have now abandoned their homes due to infrasound. Interestingly enough, one of these families specifically referenced audible sound in their complaint [23]. Further discussion about the low frequency noise ordinance leads to the conclusion that it might not be enforceable due to the restrictions on local regulations. The Board of Health also approves of Dr. Tibbetts sending a letter to municipalities to consider health effects of wind turbine noise that included the infrasound study mentioned above, as well as information about the three families that abandoned their homes. At the November 2012 meeting, there is extensive discussion about how the PSC took away local control of permitting. BCCRWE says that they are looking for the Board to facilitate low frequency sound studies but with the PSC's funding. The Board doubted that they would have sufficient expertise or the ability to pick anyone other than the lowest bidder, since there were concerns about picking an expert that might be "biased." They agree to send a letter by registered email to the PSC along with letters of those that claimed they were experiencing health effects caused by wind turbines, which were provided by BCCRWE.

The January 2013 minutes include a review of the Cooperative Measurement Program (described in Section 4.3) [21]. The next available set of minutes, is March 11, 2014, though wind power is not discussed. At the May 13, 2014 [24] meeting a letter was read that was sent to the medical community to "increase their index of suspicion." It was written by Dr. Tibbetts with assistance from two of the residents that abandoned their homes (one is a BCCRWE member), and Mr. James. This seems to be the meeting where the idea of declaring the Project a human health hazard is first put forward. There is a discussion about whether it more fit the definition of a "Public Nuisance," "Human Health Hazard," or "Immediate Human Health Hazard." There is also discussion of surveys from those near the Shirley and Fond Du Lac wind farms being sent to Carmen Krogh (a pharmacist) and an expected noise study from Mr. James. It's implied that Mr. James is assembling much of the literature collected by the Board.

A series of binders are passed out to the BCBOH members, assembled by Mr. James. These binders appear to include his report conclusions, along with a letter containing his request for the Human Health Hazard declaration [25]. A special meeting was scheduled for September 9, 2014 to discuss the information distributed. Minutes are not available for this meeting. Dr.

Tibbett's letter was also sent to area newspapers and BCCRWE distributed the information as flyers to about 400 people in the Glenmore area.

4.3 Cooperative Measurement Program

As part of the permitting process for the Highland Wind project, also located in Wisconsin, a measurement study at the Shirley Wind Project was performed by five acoustical consultants (George Hessler, David Hessler, Robert Rand, Bruce Walker, and Paul Schomer) [26]. The study entailed detailed sound level measurements, particularly in the low frequency and infrasonic range at three homes that had been abandoned by the residents. Measurements showed clearly visible blade passage frequency harmonics at two of the three monitored locations. Audible sound levels at the closest residence (1,100 feet or 335 meters) were as high as 50 dBA. The report included four individual reports by each consultant, as well as combined conclusions, including the statement:

> "The four investigating firms are of the opinion that enough evidence and hypotheses have been given herein to classify LFN and infrasound as a serious issue, possibly affecting the future of the industry. It should be addressed beyond the present practice of showing that wind turbine levels are magnitudes below the threshold of hearing at low frequencies."

This report has since been extensively cited, both for its measurement results and for the above-referenced conclusion. One of the difficulties of the study was that the project owner did not cooperate with the study, by providing data or by performing organized turbine shutdowns to allow for background sound level measurements. The Health Board reviewed this report, focussing on the above statement. Discussion of the report lead to discussion of developing a low frequency noise and infrasound ordinance for the county.

Paul Schomer formalized his hypothesis as was first elucidated in the cooperative report in a journal paper [27]. Bruce Walker later published a listening test pilot study, using measurements from the cooperative study at the 2015 Wind Turbine Noise conference [28]. Four of the five acousticians involved in the cooperative study (excluding Robert Rand) published a follow-up paper [1] in 2017. This paper had the following conclusions:

> "Our analysis illustrates that a wind turbine is not a classic LFN source; that is, one with excessive low-frequency spectral content. But a wind turbine is a unique power-generating source with spectral content down to the 1-Hz octave band, emitting measurable IS in addition to LFN. Infrasound (IS, 0-20 Hz) from wind turbines can almost be ruled out as a potential mechanism for stimulating motion sickness symptoms. But to be thorough and complete, we recommend that one or two relatively simple and relatively inexpensive studies be conducted to be sure no infrasound pathways to the brain exist other than through the cochlea. Pending the results of these studies, we feel that no other IS or LFN criteria are required beyond an acceptable A-weighted level."

While this does not fully rebut the statement from the cooperative report, it is much more sceptical of the idea that sub-audible infrasound is the cause of health effects near wind turbine installations.

4.4 Other Sound Studies

E-coustic Solutions (written by Rick James) was hired by one of Shirley Wind's neighbors to do a noise study. The study included microbarometer measurements in and around the project, up to a distance of about 10 kilometers (6 miles) [29] to measure infrasound. Most of the measurements were performed by two project complainants who had abandoned their homes [30]. The E-coustic summary report measured wind-turbine caused infrasound at each of these locations. Conclusions were:

> "Based on the above, it is reasonable to conclude that the adverse health effects reported by member of the Shirley community are linked to the operation of the Shirley Wind project wind turbines. While there may still be debate about the precise mechanism that causes these sound to induce the symptoms; it is clear from this study, and others conducted in different parts of the world by other acousticians, that acoustic energy emitted by the operation of the modern utility scale wind turbines is at the root of the adverse health effects."

This conclusion was followed by a recommendation that either landowners near (within about 4 miles) the project should be bought out, or that turbine operations should be halted.

5. Board of Health Decision

The Board of Health Declaration was made on October 14, 2014. At this meeting, only four of six Board members were present [2]. The second item of the meeting was regarding additional information about wind turbine sound and included the request letter from Mr. James which reads.

> "The purpose of this letter is to inform you that residents living in and near the Town of Glenmore, citizens of Brown County, Wisconsin, are being negatively impacted by sources that began after the construction of the Shirley Wind Project. This letter is an appeal and urgent request to the Brown County Board of Health and the Director of the Health Department to declare the Shirley Wind Project a Human Health Hazard in order to protect the health and well-being of the residents who are in extreme peril."

The statute read to support the request included the following definition of Health Hazard.

> "Human Health Hazard means a substance, activity or condition that is known to have the potential to cause acute or chronic illness or death if exposure to the substance, activity or condition is not abated."

After this was read, a BCBOH member read the timeline of their involvement with wind turbine noise issues, beginning with the March 30, 2010 letter from the BCHSC through to 2014, including the cooperative study and concluding with the E-coustic study. This is followed by several testimonies by residents about their experience near the project, typically urging the BCBOH to declare Shirley wind a Human Health Hazard and recounting of stories worldwide about adverse effects on humans and animals attributed to wind turbines. Mr. James describes more of his studies in a recorded presentation. Patrick Evans (the author of the March 2010 letter to the BCBOH from the BCHSC) several times reminds the Board that it's the Health Board's mission to protect the public. Declaring Shirley Wind a "Human Health Hazard" is then brought to a vote and the motion is passed, though the vote count is not recorded in the minutes. At a later meeting, Dr. Tibbetts says the vote was unanimous [30].

6. Post-decision

At the first few meetings after the declaration there is considerable discussion by BCBOH about next steps to compel Shirley Wind to somehow address the issue. Most of these discussions occurred in closed sessions with legal counsel, so the details are not part of the minutes [31] [32] [33] [34] [35] [36] [36].

Shirley Wind's first interaction with the BCBOH seems to occur only after the decision, with a letter sent on October 31, 2014 requesting due process [32]. At the November 11, 2014 meeting, a lawyer representing Duke objects to the declaration on legal grounds. The Board

then approves Duke presenting to the Board at the January 20, 2015. At this presentation, a lawyer presents Duke's version of events, a legal analysis indicating that the BCBOH does not have jurisdiction over Shirley Wind, and requests that the Board rescind the declaration [32].

BCBOH seems to conclude that they cannot compel Shirley Wind to do something, but the Health Director can, since one of their responsibilities is enforcement [37]. At the May 12, 2015 meeting, they hand all information on the subject that had been collected during previous BCBOH meetings to the Health Director, named Chua Xiong. Ms. Xiong indicates that she will review the collected information, including that sent by Duke, conduct meetings with interested parties, and do additional research before making a decision [38]. The deadline for document submission was set at September 30, 2015 [36]. This additional research ended up being a full literature review of available sources, with the assistance of a local graduate student [36]. At the October 13, 2015 meeting, Ms. Xiong presented the procedures she was using for the literature review with no objections from Board members or the public mentioned in the minutes [39].

BCCRWE takes increased interest in the BCBOH during this period, with multiple members present at each meeting, presenting new information and challenging the validity of information presented by others and/or the presenter's credibility [32] [34] [38] [40]. They asked to invite speakers to present to the Board, particularly Carmen Krogh, though this is challenged by a couple of Board members and citizens due to Krogh's lack of credentials and perceived bias [38].

There also seems to be more scepticism of the idea of infrasound causing health effects from some of those attending the meetings including criticisms directed at the Board that they were getting a single sided story [38] [40] [36].

6.1 Health Director Determination

The Health Director's determination was given on December 15, 2015 and is one of two sets of minutes that is presented verbatim instead of in a summarized format [37]. The meeting starts with public comments, mostly those praising the BCBOH's declaration or specifying health issues attributed to Shirley Wind. One interesting comment is from a resident near the proposed Highland Wind farm that indicates residents near that project received a postcard from Brown County warning them of the effects of wind turbines.

The Health Director then presents her findings, indicating that:

> "Presently, there is insufficient scientific evidence based research to support the relationship between wind turbine and health concerns. However, I will continue to keep an open mind and review any new scientific evidence based literature on an annual basis. As the Brown County Health Officer, I will accept and review any new, current, scientific evidence based literature and provide updates on an annual basis regarding significant findings."

In the short period between the Health Director's report and the end of the meeting, reaction from the public seems stunned, but upset. Most of the Board members seem to have accepted Ms. Xiong's decisions, though Dr. Tibbetts says,

> "Ah, I know that when we, when we, passed this, ah, October 14th, ah, it was unanimous, ah, and I for one stand by that. I'm afraid Chua and at least I, as a member, are at odds with, ah, declaring this, ah, human health hazard. Ah, I understand why she wouldn't want to because that demands action and I for one am very disappointed with the, ah, with the response of Chua."

7. Board Activity After Health Director Decision

The next meeting on January 12, 2016 is also a verbatim transcript [41]. The meeting opens with more public comments. Most of the comments are either expressing disappointment about the decision, or reporting more health effects. A member of BCCRWE went through the list of "experts" that they provided to Ms. Xiong that she did not contact. They take this as evidence that she did not do her due diligence in making the decision. Another BCCRWE member said, "You are now part of the problem and will guarantee more people, more families, more children, more parents will be harmed." One resident says, "Are you a leader or not? If you are not a leader step aside." Other comments accuse Ms. Xiong of being derelict of her duties. Dr. Tibbetts says he considers the literature review she performed to be a waste of time.

Ms. Xiong is not present at the next meeting on March 8, 2016 [3] and resigns on March 18, 2016 [42]. BCBOH receives criticism from other parts of the county government, calling their conduct towards Ms. Xiong unprofessional [3].

In following meetings there are considerable criticisms of Ms. Xiong's decisions by the public, BCCRWE, and even an acoustician, Robert Rand, who writes a letter condemning the decision. BCCRWE issues a formal rebuttal of some of the references cited by Ms. Xiong and asks for the decision to be reversed [42].

In March 2016, another Board member was added, who ended up being more critical of BCBOH's declaration and submits information to the Board to support criticism of the declaration, though these submissions are criticized by BCCRWE [42]. A motion was later brought to rescind the declaration which failed in two votes to four [43].

Duke offers a presentation on health effects due to wind turbine noise, presented by Dr. Robert McCunney in September 12, 2017 [44]. Dr. McCunney is a medical doctor who has contributed to and authored several papers on wind turbine noise. Best known is his 2014 literature review.

As of the writing of this paper, the declaration has not been rescinded, but there has not been a health director decision affirming the declaration. There has not been any action against the project by the State of Wisconsin.

8. Comparison with Human Response Factors

While sound exposure is correlated with human response, it often only explains 20 percent or less of the variation [45]. Several authors have looked at other factors that influence response both for wind turbine noise and other noise sources. Table 1 shows some of these factors along with an assessment of whether they were present for Shirley Wind.

For some of these factors, such as Noise Sensitivity, it would be difficult to impossible to assess the relevance for Shirley Wind, due to the types of evidence reviewed for this paper. In other cases, these factors may have been influential for some residents, but not for others (such as Project Audibility, Visual Annoyance, and Place Attachment). Consequently, a "yes" in the second column indicates that there is some kind of evidence that this was a factor for at least some residents, but it may not have been factor for all.

Table 1: Comparison of Human Response Factors with Context of the Shirley Wind Project.

Factor	Presence at Shirley	Source(s)	Notes
Noise Sensitivity	Maybe	[46] [47]	Not possible to determine from analysed information

Factor	Presence at Shirley	Source(s)	Notes
Perceived Stress	Y	[46]	
Concern for Physical Safety	Y	[46] [48] [49]	Concerns about infrasound and stray voltage.
Property Ownership	Y	[46]	All three of the cases where homes are abandoned were owned by the residents.
Self-reported Sleep Disturbance	Y	[46]	Several complaints mention sleep disturbance.
Visual Annoyance to Wind Turbines or annoyance to other non-acoustic characteristics	Y	[46] [49]	Shadow flicker is mentioned as an issue in some cases. Concern about stray voltage. Located in a flat area, so turbines are visible within a radius of several kilometres.
Audible Wind Turbine Noise	Y	[46] [47]	Some complaints in the minutes specified that the noise was audible. In other cases it was specified as inaudible.
Complaint About Wind Turbines	Y	[46]	Over 75 complaints
Attitude Towards the Noise Source	Y	[47] [49]	Developer/owner lack of response and mis-steps. It's not clear if those in the project area viewed the turbines as necessary.
Belief noise can be prevented	Y	[49]	
Place attachment	Y	[47]	Not possible to tell from the minutes for many cases. However, rural areas adjacent to larger populated areas often have a large number of people who moved there for the rural environment.
Trust/Distrust of Authorities	Y	[48]	Change of jurisdiction and lack of response

Factor	Presence at Shirley	Source(s)	Notes
			from the State or developers
Expectations	Y	[48] [50]	Consistent presentation of literature showing relationship between infrasound and health effects
Noise Exposure History (Character of area)	Y	[48] [49]	No previous multi-turbine projects

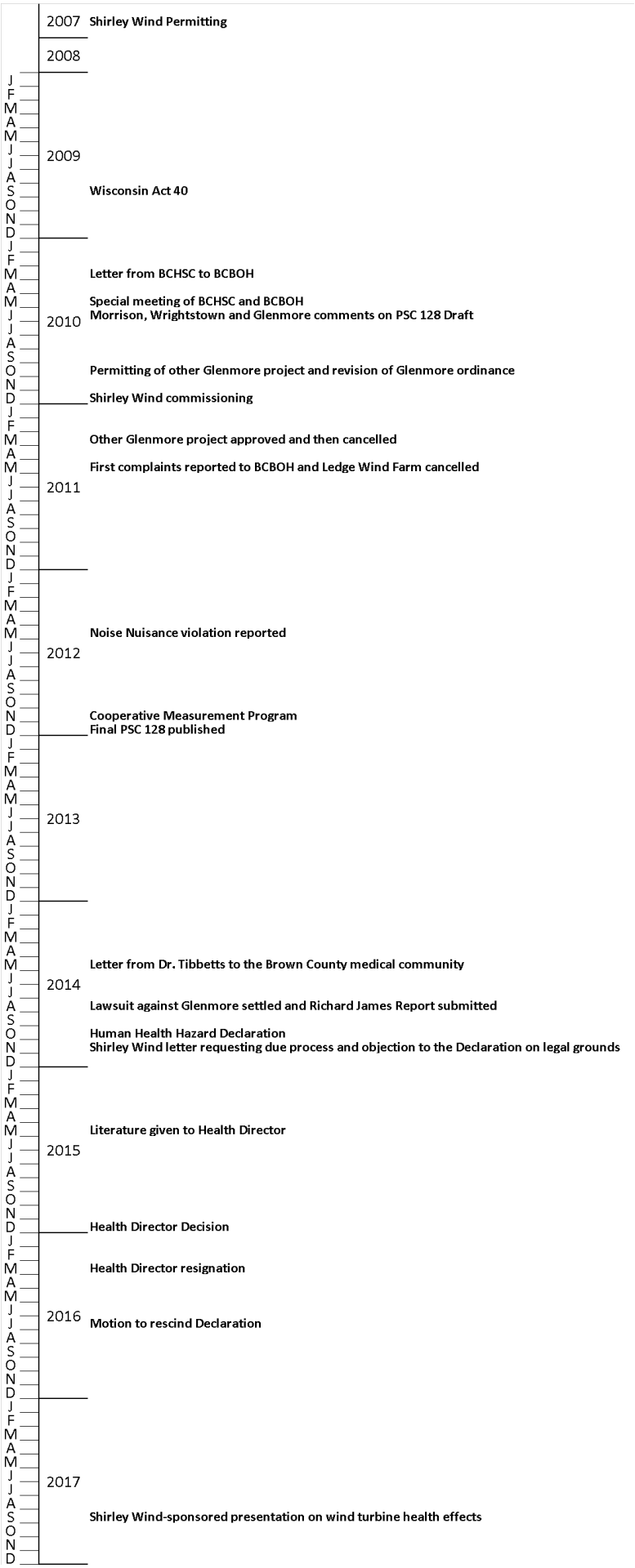

Figure 3: Shirley Wind Event Timeline

9. Discussion

Response to the Shirley Wind project has been extraordinary, particularly considering the relative size of the project (other projects in Wisconsin are larger). Although relatively high sound emissions (compared to WHO guidelines, for example) are a potential cause, sound level limits in excess of 50 dBA are not uncommon for the region. Similarly, the hypothesis that infrasound could be the cause of such a response is also unlikely, since one would expect a similar response from similar projects, with similar turbines installed, and similar setbacks. While there are other projects that have had strong adverse response, this is not a typical response. Furthermore, recent laboratory studies have shown a lack of response to wind turbine-produced infrasound at magnitudes typical near wind power projects in blinded tests [28] [50].

Other factors that can influence response to environmental noise sources have long been studied in acoustics. Particularly striking is the extent to which some cultural and situational factors were present, particularly negative expectations and events that are likely to have degraded trust in state authorities and the developer/owner of the Project. The presence of two of these factors are summarized below:

- Several events seem to result in a strong distrust of authorities, whether it was the state government or specific developers:
    - Wisconsin Act 40 removing permitting and regulator authority for local municipalities and inability of local authorities to address noise complaints.
    - A lack of response from the State of Wisconsin to requests that the State study the issue.
    - The lawsuit between a developer and the Town of Glenmore.
    - Lack of response by Shirley Wind to resident concerns, other than legal analyses. Similar is the 2010 presentation which contained information about economic benefits and an article which seemed to minimize any concerns.
    - Multiple sales of the project.
- Although the origin of the concerns about health effects from infrasound and other characteristics of wind turbines has not been determined in this paper, expectation was established and propagated:
    - Proliferation of information by BCCRWE in the community and elsewhere.
    - Dissemination of information by the BCBOH.
    - Use of those who claimed health effects due to the turbines as infrasound testers and the report provided by Mr. James.

Although some of the factors that may have eroded trust were not directly related to Shirley Wind, it may be that people of Brown County mentally grouped all wind power developers/owners as an external “they.” Distrust of authorities may have also sped acceptance by some residents to accept the idea that characteristics of wind turbines (including infrasound) were harmful. It was several years between the first concern about wind turbine health effects and a strong response by either the state of Wisconsin or any developers presenting alternative health-based information. By the time there was any response, most BCBOH members seemed to have firmly taken a position and any alternative explanation was met with firm resistance, as can be seen through the response to the Health Director’s decision. The two Board members that ended up questioning the declaration were only added after the declaration was made.

The root of the specific health effects indicated by some of the residents is an interesting topic, considering the factors listed in Section 8 are related to noise annoyance and not the specific symptoms (nausea, tinnitus, headaches, etc.) mentioned by the residents. It’s beyond the

scope of this paper to fully address this, except to mention some authors who have looked at the influence of high level annoyance to some of these effects [51] [52].

10. Conclusions

The Shirley Wind project (Project) has been noteworthy for the strong response of residents in the project area, resulting in the Brown County Board of Health (BCBOH) declaring the Project a "Human Health Hazard." This paper has looked through the history of the Project, using public information to assess which factors, that are known to result in adverse response to noise sources, were present in the project context. The paper shows that:

- Several events from project permitting through the Human Health Hazard declaration, likely resulted in a degradation of trust in local authorities and wind power project developers/owners.
- Extensive proliferation of information by several parties associating several characteristics of wind turbines with various health effects. Distrust of authorities likely helped speed acceptance of this information and reduced acceptance of other information that pointed to a different conclusion, once it became known.

Given the sheer density of information proliferated, the number of events that could have eroded trust of authorities, and relatively high noise exposure to some residents, the adverse response to the Shirley Wind project is understandable.

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