Review:
Acoustic Study of the Lake Winds Energy Park
Mason County, Michigan

Prepared by request of Mr. Cary Shineldecker
Mason County Resident

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Robert W. Rand, Member INCE
Rand Acoustics
65 Mere Point Road
Brunswick, Maine 04011

1.0 Introduction

This review was prepared by request of Mr. Cary Shineldecker, a resident of Mason County, who expressed concerns regarding potential health effects from the operation of the Consumers Energy "Lake Winds Energy Park", a wind turbine facility with 56 Vestas V100-1.8MW wind turbines proposed for Mason County. Lands comprising the proposed special land use are as shown in Figure 1 (at back). This review presents analysis of two documents:

- Acoustic Study of the Lake Winds Energy Park Mason County, Michigan Report On Ambient Sound Monitoring, Tech Environmental, Inc., December 14, 2009; January 6, 2011 (1st revision); May 25, 2011 (2nd revision).
- Acoustic Study of the Lake Winds Energy Park Mason County, Michigan Report On Acoustic Modeling, Tech Environmental, Inc., January 7, 2011; June 9 (1st revision).

1.1 Summary

Community noise impact assessments were not found in the reports. Independent noise impact assessments by this reviewer show widespread adverse impacts summarized in Figures 2-A, 2-B and 2-C. Additional review detail is provided in Sections 2 through 7, with two appendices. Based on this review of the documents and experience, the proposed facility:

- will very likely exceed the existing regulatory noise limits at numerous locations on a regular basis due to omission of uncertainties in the prediction algorithm, omission of increases from night wind shear, and omission of facility design margin.
- will very likely generate adverse health and welfare impacts from sleep and activity interference and has potential for vestibular disturbance including nausea, dizziness, headache, inability to concentrate, anxiety and other adverse medical symptoms for the population within an area of over 22 square miles.
- does not appear to comply with the Mason County Zoning Ordinance.
- does not appear compatible with the Mason County Comprehensive Plan.

2. Summary detail

2.1 Figures

Figure 2-A, 2-B, and 2-C (at back of this document) provide striking visual summaries of the potential for strong, widespread adverse community noise impact. The figures were adapted by this reviewer from the Tech Environmental Figure 2 "Maximum Sound Levels" in the report, "Report On Acoustic Modeling, Tech Environmental, Inc., January 7, 2011; June 9 (1st revision), using three separate metrics:

Figure 2-A: Community Reaction, EPA Normalized Method, 1974
Figure 2-B: Annoyance, Pedersen et al 2004, and
Figure 2-C: Health Effects, WHO 2009.

It is worth noting that for all three figures, the illustrations probably understate the likely impact of the proposed facility, because the predictions by Tech Environmental (June 2011) omit model uncertainties and effects due to wind shear that would result in 5-10 dB higher sound levels than predicted.

Two areas are highlighted on the figures, the area bounded by 35 dBA, and the area bounded by 40 dBA. Statistics were derived and shown in Tables 1 and 2.

Table 1. Land area affected by predicted sound levels

35 dBA or higher:	22.6 square miles (~ 14500 acres)
40 dBA or higher:	14.0 square miles (~ 9000 acres)

Table 2. Population affected by predicted sound levels[1]

35 dBA or higher:	858
40 dBA or higher:	532

1 Estimated at 38 people per square mile, rural areas of Mason County, U.S. Census Bureau (Year 2000).

2.1.A Community Reaction

The USEPA made recommendations in the 1974 “Levels Document” [2], which presents a well-researched community reaction prediction methodology, sometimes referred to as the "Normalized Ldn" method for noise impact assessment. The EPA noise impact assessment method includes correction factors for background sound level, previous experience to the noise and sound character in terms of impulsive noise (Attachment 1). The community impact reaction can be predicted for wind turbines located in quiet areas with the EPA methodology.

Using the EPA's modeling corrections allow the reviewers to account for the features of wind turbine noise that distinguish it from other noise sources. Figure D-7 in Attachment 1 of this review shows the EPA normalized Ldn values with no corrections. The process used for this review analysis starts with converting the predicted Leq noise levels to EPA's Ldn. Leq is measured directly by sound meters and is predicted in noise models. To convert Leq to Ldn, a 6 dB adjustment factor is employed assuming steady operation during day and night, with the Ldn factoring a 10 dB weighting during the night hours, using Equation 1 shown below.

$$L_{dn} = 10 \log \frac{1}{24} \left[\left[15(10^{L_d/10}) + 9(10^{\frac{L+10}{10}}) \right] \right] \quad \text{(dB)} \qquad (1)$$

For example, an Leq of 45 dBA for a steady-state noise source approximately equals Ldn 51. Then, the following *normalizing* correction factors are applied:

0 dB	for year round operation,
10 dB	for being located in a quiet area,
5 dB	for no prior experience and,
5 dB	for tonal or impulsive character.

2 "Information On Levels Of Environmental Noise Requisite To Protect Public Health And Welfare With An Adequate Margin Of Safety", EPA 550/9-74-004, March 1974.

With the conversion to Leq (+6 dB) and the correction factors (+20 dB) applied, the predicted noise levels are evaluated as *normalized Ldn* and can be assessed directly with the EPA's case study data for community reactions. Figure 3 below shows the normalized Ldn noise level on the 'X-axis' and EPA case study community reactions on the 'Y-axis' with the project predicted levels circled.

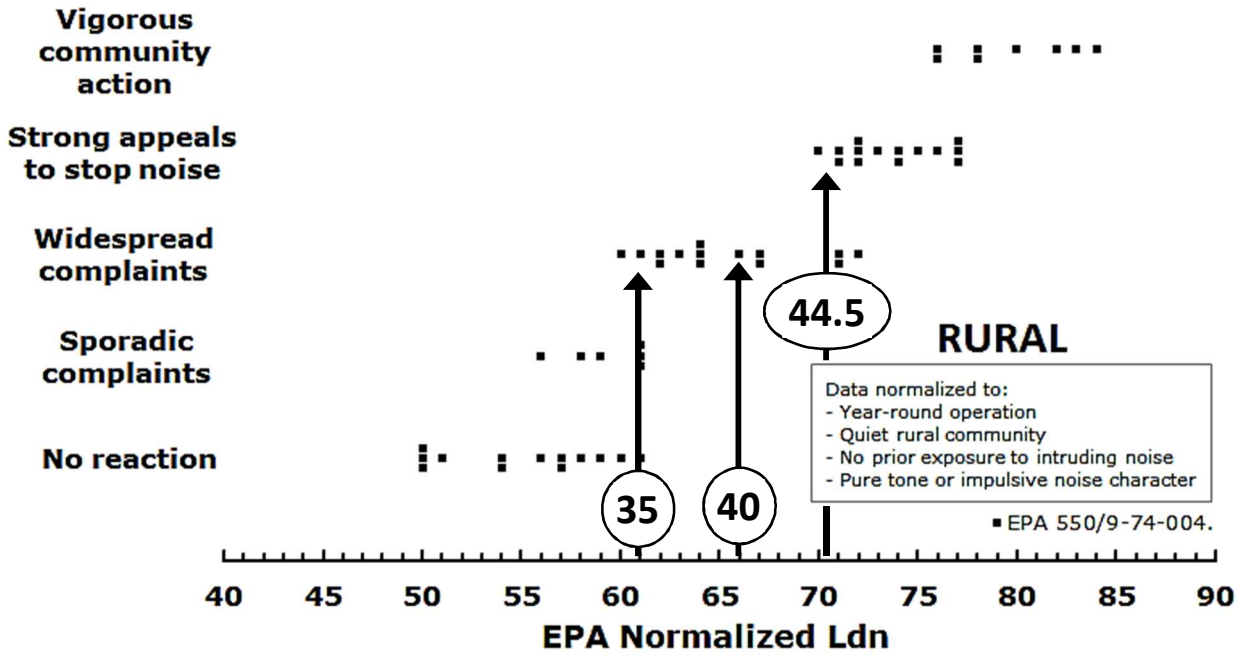

Figure 3. Community reaction to intrusive noise as a function of Normalized Ldn.

The community reaction to the proposed facility can be determined for example, by assessing the applicant's predicted wind turbine noise level of 35 and 40 dBA iso-contours (shown as circled numbers in Figure 3). The equivalent normalized Ldn values are 61 and 66 which are associated with the community reactions at "Widespread complaints." Noise levels of 44.5 dBA Leq at nearest neighbors normalize to Ldn 70.5 which is associated with "Strong appeals to stop noise."

The EPA suggested caution when applying the Normalized Ldn method to quiet areas with lower background sound levels than those evaluated during the EPA case studies. The reviewer made additional analyses that confirmed the usefulness of the EPA normalized method for wind turbine noise impacts in quiet areas (Mars Hill, Freedom, and Vinalhaven, Maine). These were provided to

Mason County Commissioners in previous transmittals.

It is worth noting that the results mimic the prevailing understanding of community reaction based on the change in noise level over the background, as listed in Figure 4 below.

Community Response

Increase in Noise	Estimated Community Response
5 dB	Sporadic Complaints
10 dB	Widespread Complaints
15 dB	Threats of Community Action
20 dB	Vigorous Community Action

Figure 4. Community response based on the increase in noise.

The Tech Environmental reports document background, L90 sound levels measured in the 21-32 dBA range. A 10-dB increase from 25 to 35 dBA is predicted to produce "Widespread complaints", the same as the Normalized Ldn method produced, with stronger response to increases over 35 dBA.

The Normalized Ldn method remains useful and valid today, and can be found for example referenced in a 2002 technical report [3] on roller coaster noise.

2.1.B Annoyance

Figure 2-B includes the results of independent wind turbine annoyance research by Pedersen & Waye in 2004 for non-participating residents [4]. Their data confirm that there can be an adverse community reaction, with associated activity interference, for wind turbine noise levels above 32 dBA in rural areas. It should be noted that Pedersen & Waye data included on Figure 1 were

3 C. Menge, *Residential impact criteria and abatement strategies for roller coaster noise,* Inter-Noise 2002.
4 Pedersen, E. and K. Pedersson Waye, *Perception and annoyance due to wind turbine noise: A dose–response relationship,* Journal of the Acoustical Society of America 116, 2004.

obtained around multiple wind turbine sites with sizes ranging from 150kw to 600kw, much smaller than the proposed wind turbines in the report under review. When the wind turbine noise level increases from 35 to 42 dBA, the Pedersen & Waye 2004 research found that the highly annoyed portion of the community increased from 6 to 45 percent, with the associated adverse health effects of "*psychological distress, stress, difficulties to fall asleep and sleep interruption*" as described in the conclusions in their 2008 report [5].

2.1.C Health Effects

Figure 2-C illustrates the potential for health effects and adverse health impacts from the proposed facility. The health effects descriptions are taken from the WHO 2009 report on health effects due to noise pollution [6]. WHO established in 2007 the target level of 30 dBA below which no health effects were observed [7]. In 2009 WHO established 40 dBA as a not-to-exceed, yearly average sound level. The following table summarizes the WHO peer-reviewed findings of health effects due to noise.

5 Project Wind Farm Perception, FP6-2005-Science-and-Society-20, Specific Support Action, Project no. 044628.
6 WHO, *Night Noise Guidelines For Europe*, 2009. ISBN 978 92 890 4173 7.
7 WHO, *Night Noise Guidelines For Europe*, Final implementation report, 2007, Grant Agreement 2003309.

Average night noise level over a year $L_{night,outside}$	Health effects observed in the population
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the NOEL for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40 dB is equivalent to the LOAEL for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

Table 1. Health effects observed in the population (WHO 2009).

They include a yearly average sound level of 30 dBA, night, outdoors as the level below, which there are no observed health effects, the "No Observed Effects Level" or NOEL. Above the 30 dBA NOEL, health effects including sleep disturbance were found, mild at lower levels for healthy individuals and more adverse with higher levels for "vulnerable groups"; children, the elderly, and people with disease or pre-existing health conditions. Above 40 dBA, the "No Observed Adverse Effects Level" (NOAEL), adverse health impacts are clearly evident and more severe for vulnerable groups.

While there has been debate among acousticians as to how to correlate WHO's 2009 yearly-averaged noise level guidelines to a wind turbine noise level and unique sound character that fluctuates minute to minute depending on wind speed, wind shear, and other factors, or what criteria best apply to the WHO

guidelines, there can be little question that adverse health impacts are certain for average noise levels above 40 dBA and health effects including sleep disturbance are possible with average noise levels above 30 dBA.

It doesn't take a year to decide if recurring sleep loss is a problem. Most people have experienced fatigue and other health effects from one poor night's sleep, or perhaps a few nights of interrupted sleep. Some living near wind turbines have to leave their homes and go to another location to get a good night's sleep, and are unable to sell their homes to move away (Mars Hill, Freedom, Vinalhaven, Maine).

For the proposed project, the associated health effects include the following.

Where levels exceed 35 dBA, annoyance affects a portion of the population. Associated health effects include awakening, sleep interference, vulnerable groups such as children, elderly and those with pre-existing conditions or disease are more susceptible to adverse impacts. The total area with predicted sound levels above 35 dBA is some 22.6 square miles (14,500 acres.) Some 858 residents are estimated would be exposed to health effects.

Where levels exceed 40 dBA, annoyance affects over a quarter of the population. Increasing adverse impacts are forecast for all individuals. The area affected is estimated at 14 square miles (9000 acres). Some 532 residents of the 858 residents inside the 35 dBA contour are estimated would be exposed to adverse impacts above 40 dBA.

It is worth noting from report review that these numbers are probably low due to the predicted levels being underestimated by 5 to 10 dB at night.

2.2 Mason County Zoning Ordinance

The reports prepared by Tech Environmental do not demonstrate to the reviewer that that the proposed wind turbine facility will meet the requirements of the Mason County Zoning Ordinance dated June 2, 2011 (Attachment 2). Sections of the ordinance are supplied below with comments in bold.

- Section 1.03 Statement of Purposes. 1. To promote the public health, safety, morals, and general welfare. (emphasis added.)

There is a strong potential for adverse noise impact on public health and welfare in a large region of Mason County from the proposed facility. The application reports do not assess for potential community impacts.

- Section 16.01 Statement of Purpose. 1. It is the purpose of this Article to specify the procedure and requirements for the review of special land uses, as specified in this Ordinance. Uses classified as special land uses are recognized as possessing unique characteristics (relative to location, design, size, public infrastructure needs, and other similar characteristics) which require individual review and approval standards in order to safeguard the general health, safety, and welfare of the County. (emphasis added.)

There is a strong potential for adverse noise impact on public health and welfare in a large region of Mason County from the proposed facility.

- Section 16.03 Data Required, Subsection 3.e & f.

The reports reviewed omit supporting statements, evidence, data, information, and exhibits that address criteria for assessing special land use applications; i.e. detailed noise impact assessments demonstrating the ability of the project to operate without adverse impacts on the health and welfare of the neighbors.

- Section 16.05 Standards for Approval.

The Planning Commission shall review the particular circumstances and facts applicable to each proposed special land use in terms of the following standards and requirements and shall make a determination as to whether the use proposed and subject site meet all of the following standards and requirements. If it is determined that the proposed use does meet all of the following standards and requirements, the use shall be allowed. If it is determined that the proposed use does not meet all of the following requirements, the use shall not be allowed.

1. Will be in accordance with the goals and objectives of the Mason County Comprehensive Plan. (emphasis added.)

2. Will be designed, constructed, operated, and maintained in harmony with the existing or intended character of the general vicinity and that such a use will not change the essential character of the area in which it is proposed. (emphasis added.)

3. Will not be hazardous or disturbing to existing or future permitted uses in the same general vicinity and in the community as a whole. (emphasis added.)

4. Will be served adequately by essential public facilities and services, such as highways, streets, police and fire protection, storm water drainage, refuse disposal, water and sewage facilities, and schools or persons or agencies responsible for the establishment of the proposed use shall be able to provide adequately for such services.

5. Will not create excessive additional requirements at public cost for facilities and services and will not be detrimental to the economic welfare of the community.

6. Will not involve uses, activities, processes, materials and equipment, or conditions of operation that will be detrimental to any person, property, or general welfare by reason of excessive production of traffic, noise, vibration, smoke, fumes, glare, or odors. (emphasis added.)

7. Will ensure that the environment shall be preserved in its natural state, insofar as practicable, by minimizing tree and soil removal, adequate setback from water courses, and by topographic modifications which result in maximum harmony with adjacent areas.

8. Will not impede the normal and orderly development and improvement of surrounding property for uses permitted within the Zoning District.

9. Will comply with the requirements of this Ordinance, including Article 21, Access Management and Highway Overlay District.

The reports raise serious questions for this reviewer as to the ability of the proposed project to comply *in any way* with the sections highlighted above.

2.3 Mason County Comprehensive Plan

The Mason County Comprehensive Plan (MCCP) [8] is the statement of policy by the County Planning Commission relative to the agreed upon and officially adopted guidelines for a desirable physical pattern for future community development. The plan consists of a series of maps, charts, and written material representing in summary form the soundest concept for community growth to occur in an orderly, attractive, economical, and efficient manner thereby creating the very best community living conditions, and includes any unit or part of such plan and any amendment of such plan or parts thereof.

The reports prepared by Tech Environmental do not demonstrate to the reviewer that the proposed wind turbine facility is compatible with the goals and vision of the MCCP. Sections of the ordinance are supplied below with comments.

- "*When asked about Mason County, residents use terms like "successful," "beautiful," "scenic," "clean," and "stimulating." Residents are also quick to say that Mason County is an outdoor recreation paradise and a great place to raise families or retire.*" (emphasis added.)

The predicted sound levels in the reports prepared by Tech Environmental are associated with high levels of annoyance, sleep interference and adverse health effects and would be incompatible with raising a family or retirement. **The proposed wind turbine facility appears to be incompatible with the MCCP.**

- "*Where the visual character, sounds, dust, smells, and level of activity of commercial and industrial development would not be compatible with residential neighborhoods and important scenic views, they are separated or buffered*." (emphasis added.)

The predicted sound levels in the reports prepared by Tech Environmental are

8 Mason County Comprehensive Plan Update, August 2006.

associated with high levels of annoyance, sleep interference and adverse health effects and would be incompatible with residential neighborhoods as reported from many locations worldwide. **The proposed wind turbine facility appears to be incompatible with the MCCP.**

- "*The rural landscape does more than simply provide scenery. The benefits of nature to residents' mental well-being and the attraction for tourists are important.*" (emphasis added.)

The predicted sound levels in the reports prepared by Tech Environmental are associated with high levels of annoyance, sleep interference and adverse health effects and would be incompatible with promoting mental well-being or attracting tourists or future residents wishing to live near scenic areas. **The proposed wind turbine facility appears to be incompatible with the MCCP.**

- IV. GOAL – UPDATE AGRICULTURAL ZONING TO BRING IN LINE WITH MODERN DAY FARMING METHODS. A. Objective – Minimize the incompatibility of non-farm rural residential areas and large farm production facilities. … 2. Strategy – *Encourage those farm practices that minimize odor, noise, and environmental risk.* (emphasis added.)

As it reads here, the goal of the MCCP is to minimize noise and environmental risk from farm practices, the principal use of the lands in the area. However, compared to existing quiet background (L90) sound levels, the reports prepared by Tech Environmental predict much higher noise levels day and night from the proposed wind turbine facility. It would not make sense to minimize incompatibility of large farm production facilities and rural residential areas yet allow significant noise increases and adverse health effects from the proposed special use. **The proposed wind turbine facility appears to be incompatible with the MCCP.**

3.0 Community Noise Impact Assessment: General Conclusions

Review of the proposed "Lake Winds Energy Park" wind turbine locations indicates the following. It should be noted that the conclusions drawn apply to most homes in the footprint of, or at similar distances to, the wind turbines in the proposed facility.

3.1. Probable sound levels: Based on direct experience with other wind turbine sites, continuous average sound levels at the residence could run from mid-30s to over 50 dBA, depending on wind speed and atmospheric conditions, with 1) low frequency components from turbines out to 1.5 miles or more from homes and 2) maximum sound levels several dB higher, experienced as whooshing and thumping at night. Higher sound levels and peaks could occur at night when atmospheric stability and layering sets in after the daytime thermal mixing dissipates (a normal occurrence in the temperate zone). It is worth noting that the predicted sound levels from the proposed facility appear to be low as they do not factor in 1) the +/- 3 dB uncertainty in the ISO 9613-2 standard underlying the model, 2) the potential for disastrous increases of an additional ***5 to 10 dB*** in night noise levels due to wind shear in stable air (van den Berg 2006), and 3) a lack of a facility design margin to ensure the proposed facility can meet noise limits *reliably*.

3.2. Compliance with sound limits: Tech Environmental has designed the site right to the wire, conceptually within 0.5 dB of the maximum 10-minute noise limit in some locations, yet without any design margin and without factoring in the uncertainties and wind shear effects described above. The likelihood of the proposed facility exceeding the existing sound limits at multiple locations on a regular basis is beyond question for this reviewer. The turbines are simply located too close to residential properties.

3.3. Community reaction: These expected sound levels are 10 to 20 dB higher than the existing, quiet rural background (L90) sound levels measured by Tech Environmental. Increases such as these due to a new intrusive noise source are associated with "Widespread complaints" to "Vigorous community action."

With the broadly scattered wind turbine locations, these increases and reactions are expected at most of the homes in the vicinity of the proposed facility. The reports do not assess for community reaction.

3.4. Preventing complaints: The excessive predicted community reaction is indicative of insufficient facility design. To be a "good neighbor" means to design so the facility produces "No reaction" to no-more-than "Sporadic complaints." In the quiet rural area with background sound levels below 25 dBA, this equates to a maximum acceptable noise limit of no more than 33 dBA at night. The reports do not establish a dBA-criteria level below the regulatory limits to ensure no more than sporadic complaints.

3.5. Noise impacts: The Tech Environmental report grouped high ambient sound levels with low turbine operating states due to use of an inappropriately low wind shear value, and thereby *underestimated* the potential for full-output wind turbine sounds to exceed existing very low ambient background levels by a wide margin at night during high wind shear in stable atmosphere.

3.6. Soundscape: Typified now by quiet background levels, bird song, occasional high-altitude aircraft that come and go, and little noise from distant traffic or industry at night, the sound environment would be irrevocably *degraded* by the intrusive industrial noise from the wind turbines within 1.5 miles of each home. Wind turbine noise varies continuously, sounding at times like "a jet that never lands", or "sneakers in a dryer", and can contain tonal or screeching sounds from gear noise, blade defects and turning operations. Whistling sounds that rise and fall repeatedly with the blade rotation can arise from small dings in the blades; dings which the facility may not be able to locate or repair.

3.7. Potential adverse health effects: According to WHO, potential health effects from excessive noise could include increased and possibly unremitting sleep interference, associated stress conditions, and activity interference. According to WHO, children and elderly are particularly vulnerable, as would anyone with pre-existing medical conditions. When people suffering from health and stress

effects due to wind turbine acoustic emissions relocate away from the wind turbines, symptoms disappear and they feel better, only to relapse after returning. There is no physiological habituation to the noise. People never "get used to it."

3.8. In this reviewer's professional opinion and experience, it appears likely that there would be activity interference and loss of enjoyment at homes, including the outdoors around homes as well as acoustic intrusion into homes by low frequency and infrasonic sound, making it impossible to find a quiet place to rest. Those with a pre-existing vestibular condition or susceptible to motion sickness might find themselves experiencing adverse symptoms and might have to consider relocating to gain relief or possibly, abandoning the home.

3.9. In this reviewer's professional opinion and based on personal experience, large industrial wind turbines must be considered seriously as capable of creating an adverse health effect within a certain distance that varies with the individual. Only by incorporating sufficient distance can a facility owner be assured that they will not be adversely affecting the health and welfare of nearby residents (and risking for themselves the expense and damage of lawsuits). There is no fixed distance for this resolution. However, a distance of 1300 feet with predicted sound levels of close to 45 dBA must be considered completely insufficient to protect the public health and welfare for the proposed facility. Case medical study near a large wind turbine facility in Maine (Nissenbaum 2010) produced the conclusion that a minimum of 2200 meters (7200 feet) is required to alleviate the most adverse medical impacts. However in some locations worldwide, symptoms are appearing at farther distances.

4.0 Adverse medical symptoms: Confirmation by experience

In April 2011 (April 17-19, 2011) on a wind turbine noise survey with long-time colleague Stephen E. Ambrose, also a Member of INCE, this reviewer was unexpectedly overcome by the very symptoms described by folks unfortunate enough to live nearby where an industrial wind turbine facility has been built: Michigan, Maine (Mars Hill, Freedom, Vinalhaven), Massachusetts (Falmouth), in upper New York State, the UK, New Zealand, and elsewhere around the world where wind turbines have been sited too close to residential homes. Both investigators were severely affected and debilitated the first day and felt miserable until leaving the area. Symptoms included dizziness, loss of appetite, headache, nausea, vertigo, inability to concentrate, an overwhelming desire to get outside, and anxiety. It took more than a week to recover completely once away from the site. An eye examination was required and new prescription needed for full-time wear due to persistent eye strain post-survey when using the computer. Hyperacusis (extreme sensitivity to "normal" sounds) and nausea (when near low-frequency sounds) was experienced occasionally after the wind turbine noise exposure in April.

The distance was approximately 1700 feet from one 1.65MW industrial wind turbine. Relief was obtained, repeatedly, by going several miles away.

The complaints of adverse health effects from people living near large industrial wind turbines stem not from people simply being cranky or "anti-wind" as some wind industry proponents have asserted. Some might be tempted to think that this reviewer was "making up" the experience in April 2011 to gain notoriety or had fallen victim to the "fear-mongering" of the "anti-wind" rhetoric. Be assured that this is also incorrect thinking.

This reviewer can now confirm from personal experience that there is a potential for some people to suffer real, debilitating adverse health impacts from the acoustic emissions from wind turbines. Imagine sitting at your desk trying to work and feeling seasick, dizzy or with headache, and cloudy-headed all day long. This occurred during the survey and for a week or more afterward. Perhaps

the susceptibility may more pronounced for people who are prone to motion sickness (this reviewer is) or who have vestibular problems. According to the vestibular.org, 35 percent of people over age 40 have vestibular dysfunction.

It is vital to understand that the "A-weighted" sound level used in most regulations and noise ordinances is unable to capture or document the mechanism producing the adverse medical effects that were experienced. Symptoms surfaced and intensified indoors where the quiet background was about 18-20 dBA and outside when the A-weighted sound level was 42-44 dBA. These levels are below the usual regulatory noise limits in the US stemming from the EPA's work in the early 1970s. They are below the regulatory limit of 45 dBA set by Mason County for lots with occupied residences.

Extreme caution is suggested. Many reports of adverse medical symptoms have surfaced near wind turbine facilities, and as time goes by, detail is emerging of persisting physiological effects. Scientific certainty is emerging as to the relation between the symptoms experienced near wind turbines and infrasonic sensitivity in the inner ear [9].

The existing regulatory framework contains the means to control the degree of annoyance from intrusive noise through regulatory limits (in dBA). There is also a complete disconnection between the existing regulatory framework in dBA and the adverse medical impacts from wind turbines. However it appears that the dBA level may be used indirectly to develop a degree of protection from adverse medical impacts from wind turbine acoustic emissions. Agreement has been emerging among acoustic and medical professionals the last few years that an outdoor sound level not exceeding 30 to 33 dBA may represent an appropriate target for regulatory limits to protect public welfare from the adverse effects of wind turbine acoustic emissions. Alternately, a sufficient distance to achieve these low noise levels in dBA, reliably, may provide a measure of safety for the health and welfare of people living near wind turbine facilities.

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9 A. Salt, J. Kaltenbach, *Infrasound From Wind Turbines Could Affect Humans,* Bulletin of Science, Technology and Society, 2011.

5.0 INCE Membership and Responsibilities

This reviewer and the owner of Tech Environmental, Mr. Peter Guldberg, are Members of the Institute of Noise Control Engineering (INCE). Membership in INCE requires adherence to the INCE Canon of Ethics. The Canon reads as follows.

CANONS OF ETHICS for the
Institute of Noise Control Engineering of the USA

PREAMBLE

Noise control engineering is an important and learned profession crossing many branches of science and engineering. The members of the profession recognize that their work has a direct and vital impact on the quality of life for all people, and protects and preserves human hearing from the effects of excessive noise exposure. Accordingly, members of the Institute of Noise Control Engineering of the United States of America (INCE) must be honest, impartial, fair and equitable, and must be dedicated to the protection of the public health, safety, and welfare in the practice of their professional work. INCE members' practice and professional behavior must adhere to the highest principles of ethical conduct out of regard for the public, clients, employees, the profession at large, and the Institute of Noise Control Engineering itself.

I. FUNDAMENTAL CANONS
1. Hold paramount the safety, health and welfare of the public.
2. Provide services only in areas of their competence.
3. Issue public statements in an objective and truthful manner.
4. Act as faithful agents or trustees in all professional matters concerning their employers, clients, and the Institute.
5. Avoid improper solicitation of professional assignments, and deal with all professional colleagues, collaborators, and client personnel in a highly ethical manner under the rules of practice enumerated in these Canons.

II. RULES OF PRACTICE

1. INCE members shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties and shall:

a. Notify their client and such other authority as may be appropriate, if their professional judgment is overruled under circumstances where the public safety, health, property, or welfare is endangered.

b. Approve only noise control engineering studies, reports, or work which, to the best of their knowledge and belief, is safe for public health, property, and welfare and in conformance with accepted practice.

c. Not reveal facts, data or information obtained in a professional capacity without the proper consent of their client or their employer except as authorized or by law or by these Canons.

d. Not permit the illegal use of their name or their firm's name.

e. Not associate in business ventures with any person or firm which they have reason to believe is engaging in or intends to engage in fraudulent or dishonest business or professional practices.

f. Cooperate with proper authorities by furnishing requested information or assistance in inquiries into violations of these Canons. …"

The reports prepared by Tech Environmental may depart from the INCE Rules of Practice as, the predictions by Tech Environmental appear to present a strong potential for an adverse impact on the health and welfare of the residents of Mason County. Accordingly it may be appropriate that the reports be revised to incorporate community reaction assessments and conclusions about the potential for adverse community reactions and impacts on health, to hold paramount and take the necessary steps to safeguard the health and welfare of the residents of Mason County.

6.0 Report On Ambient Sound Monitoring

This section reviews the Ambient Sound Monitoring report.

3.0 Noise Regulations And Criteria

Tech Environmental presented the most recent Mason County regulatory noise limits (in dBA) for the project. However, there was no discussion of facility "criteria" as is generally understood and formulated in industrial acoustics. There was no assessment of community reaction to the project. These omissions render the reports insufficient relative to review for the Mason County Comprehensive Plan and Zoning Ordinance, which both require such assessments for a complete understanding of the project community noise impacts.

In industrial acoustics, "criteria" are facility target noise limits crafted in consultation with the facility owners and sometimes with regulatory agencies, established from consideration of 1) the facility noise output, 2) the potential to exceed regulations, 3) the potential to create complaints or adversely affect public health and welfare, and 4) determination of a facility acoustic *design margin* to ensure, reliably, that the facility does not exceed regulations, create complaints, or adversely affect public health and welfare. A typical acoustic design margin may be 2 to 3 dB, or more, depending on the degree of confidence in the facility noise predictions versus distance, and may include specific or more-stringent acoustic design margins for certain problematic noise-producing equipment. There is no discussion in the Tech Environmental report of establishing a criterion for the project that protects public health and welfare.

It is insufficient to design the facility to just barely meet the regulatory limits of Mason County which are 45 to 50 dBA. As found in Netherlands studies from 2004 to 2009, the adverse health effects of wind turbine noise on people start below 35 dBA outside, and affect large portions of a population at levels of 35 to 45 dBA outside. Tech Environmental's omission of a facility criterion that considers the adverse noise impacts of wind turbine acoustic emissions exposes the population of Mason County to the potential of adverse health effects from excessive wind turbine noise.

4.1 Methodology

This section presents a grouping basis for ambient noise measurements by wind speed at hub height speeds. Tech Environmental apparently based their estimate of hub height wind speed (95m or 304 feet above ground) using the so-called "roughness length". Roughness length is defined as the height where the average wind speed is zero. Tech Environmental selected a roughness length of 0.05 m (2 inches) from *International Standard IEC 61400-11, Section 8.1, Table 1, Roughness Length for "Farmland with some vegetation"*.

It should be noted that a wind shear inferred from a roughness length selected from a table is not necessarily correlated to the actual wind shear at elevations where the wind turbines blades turn [10]. The wind speed data referenced by Tech Environmental came from two met-tower elevations, 47 and 57 meters. The project blade rotation heights range from 45 meters to 145 meters with a 95-meter hub height. Thus the wind-speed data used by Tech Environmental barely reach into the bottom portion of the atmosphere where the wind turbine blades rotate.

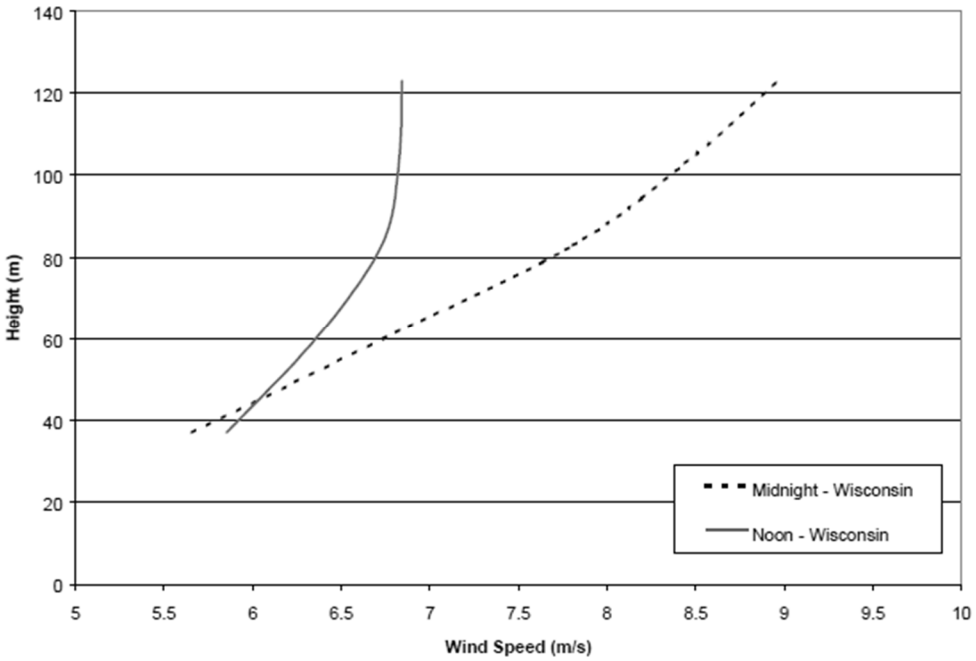
Large variations in wind speed and direction ("wind shear") can and do occur especially at night [11]. High winds shears do occur above the project met-tower monitoring elevations as documented in the Midwest by NREL [12]. From the NREL study, vastly higher than standard wind shears are found in the region near the proposed facility. A low wind shear exponent is linked to a higher ground-wind-speed estimate than actual under higher wind shear. As illustrated in the figure below, under low wind shear, a hub-height wind speed of about 6-3/4 m/s is linked to a ground level wind speed of 5 m/s. Under high wind shear, a hub-height wind speed of about 8-1/4 m/s is linked to a ground level wind speed of 3-1/2 m/s.

---

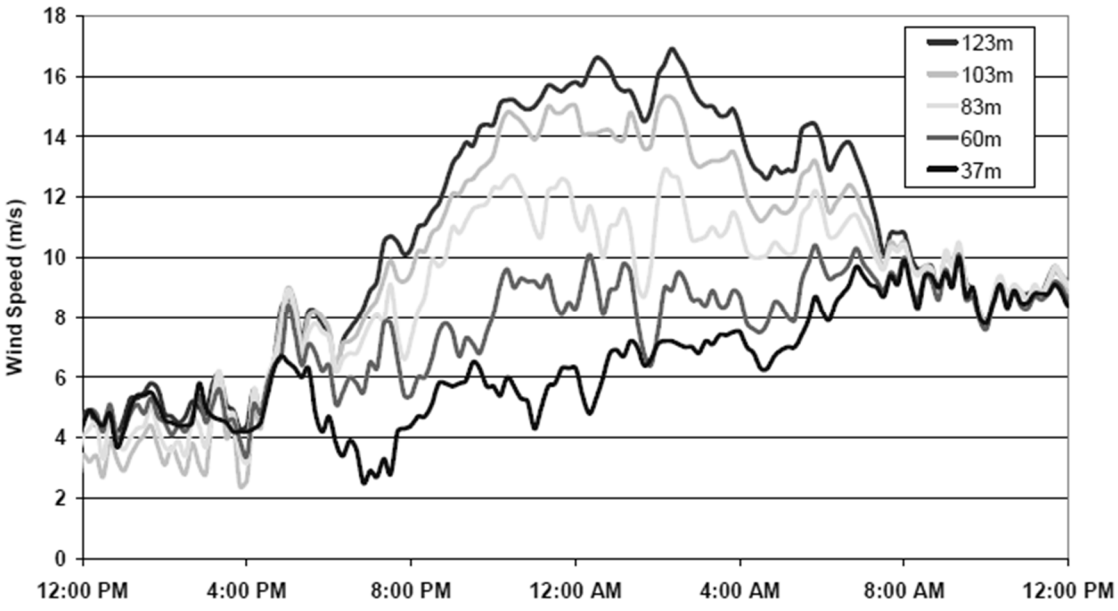
10 P. Gipe, Wind Power, Revised Edition: Renewable Energy for Home, Farm, and Business, 2004. The wind shear exponent varies with the time of day, season, terrain, and stability of the atmosphere. The equivalent wind shear for roughness length 0.05m following the 1/7 power law is 0.19, p.41.

11 G.P. van den Berg (2003) Effects of the wind profile at night on wind turbine sound. Journal of Sound and Vibration 277 (2004) 955–970.

12 K. Smith, G. Randall, and D. Malcolm, Global Energy Concepts, LLC, N. Kelley and B. Smith, NREL, *Evaluation of Wind Shear Patterns at Midwest Wind Energy Facilities*, NREL, 2002. During one 10-minute period just after midnight, the 37-m height wind speed dropped to 5 m/s while the 123-m height wind speed increased to approximately 16.7 m/s resulting in an average wind shear exponent of 1.0.



(*NREL Figure 9. Day and Night Wind Speed Profiles at the Wisconsin TYP Project*)



(*NREL Figure 8. Prolonged High Wind Shear Event at the Wisconsin TVP Project*)

From the NREL study, the figure above shows a typical high wind shear event that would not be detected by a two-stage met tower at 47 and 57 meters.

The contract between Consumers Energy and the equipment supplier, Vestas, formally specified the project's "average" wind shear at 0.27 [13]. This wind

13 Lake Winds Energy Park Turbine Purchase Agreement.

shear exponent is much higher than the equivalent wind shear inferred by Tech Environmental (approximately 0.19). Yet the project's "average" wind shear of 0.27 is far less than wind shears documented by NREL (as high as 1.0). It is worth noting that since wind shear occurs almost always at night, the "average" daily wind shear of 0.27 can be obtained with "average" night wind shear over 0.4 combined with "average" day wind shear of 0.19.

This indicates that the ambient-noise/wind-speed groupings, table and figures developed by Tech Environmental are biased. That is, Tech Environmental has apparently associated higher background sound levels than would be present for actual hub height wind speeds at the site at night. The Tech Environmental ambient sound categories could be revised based on the project wind shear exponent of 0.28 and further to account for the high night wind shears documented by NREL in the region (wind shear = 1.0). When this is done, it appears likely that the wind turbines would operate with strong winds aloft yet with ground-level winds absent and ambient sound levels below 25 dBA.

Tech Environmental makes reference to hub height wind speeds as if they were measured during the survey, which they were not (example, "*hub height winds were sufficient for low to medium power turbine operation*".) With the higher wind shear values found in the region and specified for the project, it could be inferred that hub-height wind speeds were sufficient for *full-power* operation.

4.2 Results and discussion

From the analysis of the previous section, the results in the report appear biased. The ambient noise levels noted in the report section 4.2 and in the table and supporting figures appear tied to the wrong hub-height wind speeds due to use of a low wind shear exponent.

In particular, exception is taken to Tech Environmental's assertion that masking can occur.

> *"Existing sound levels will sometimes provide a degree of masking for wind turbine sound because during a high level of operation (maximum turbine sound power), existing average Leq sound levels are above 45 dBA more than 50% of the time and existing quietest-*

> *interval L90 sound levels are above 40 dBA more than 50% of the time, while LakeWinds sound at Unpooled parcel occupied structures will be below 45 dBA. … any masking of turbine sound by existing sound levels will be more prevalent during low power turbine operation than for medium and high power operation."*

Tech Environmental concludes that masking is possible and more likely at lower turbine operation. However, as documented by G.P. van den Berg, high shear at night during ***stable*** atmospheric conditions can result in strong winds aloft and no winds on the ground; turbines running at speed aloft with very low ambient sound levels, rendering the wind turbine noise highly audible and capable of producing adverse health impact:

> *"It is often assumed that there is a fixed relation between the wind velocity at hub height and at a reference height of 10 meter. This is the relation valid in a neutral or 'standard' atmosphere. No other relations are given in legislation or international guidelines for wind turbine sound that are valid in other conditions of the atmosphere, viz. the stable and unstable conditions.*
>
> *The atmosphere is unstable when in daytime the air near the ground is relatively warm from contact with the surface heated by solar insolation. In that case vertical air movements originate and the wind profile is not equal to the profile in a neutral atmosphere, though it does not differ strongly. A stable atmosphere however has a markedly different wind profile. The atmosphere is stable when the air close to the ground is relatively cold due to contact with the ground surface when this cools down at night by radiating heat. A stable atmosphere occurs especially in nights with a partial or no cloud cover and the wind is not too strong (close to the ground). In a stable atmosphere the turbulence has decreased substantially and as a result layers of air are less strongly coupled. The lower layer of air is thus less taken along with the wind that at higher altitudes keeps on blowing, giving rise to greater differences between wind velocities at different heights.*
>
> *When the wind profile after sunset changes while the atmosphere becomes more stable, the difference in wind velocity over the rotor*

> *increases. This causes a change in the level of the trailing edge sound. The differences in wind speed lead to variations in the sound radiated by the blade tips that reach their highest values when a tip passes the mast. With several turbines the fluctuations in sound can reinforce one another when they reach the ear of an observer simultaneously. With two turbines (at the same distance) this leads to an increase in level of 3 dB, with three turbines to an increase of 5 dB. Near the wind farm the variations were usually 5 dB, but they could rise to approximately 9 dB, as expected when the fluctuations of several turbines coincide. From other research and from descriptions of residents one can establish that the sound of a wind turbine or wind farm becomes more annoying because of 'swishing', 'sloshing', 'clapping', 'beating' or ' thumping'. All descriptions mention a periodic variation on top of a constant noisy sound. From psycho-acoustic research it has been shown earlier that human sensitivity to sound fluctuations is high at frequencies that occur in the night time sound of modern wind turbines. If this fluctuating sound is sufficiently loud in a bedroom it can cause sleep disturbance."*

And, as documented by Bolin [14], wind turbine noise *may* be mask-able when ambient sound levels are approximately ***10 dB above*** wind turbine noise. There is no plausible foundation provided by Tech Environmental that masking can occur at differentials less than this. Under high wind shear conditions, ambient noise levels measured in the low 20s dBA at ground observer level would be associated with sufficient hub-height wind speeds to turn the turbines up to and including full power. The conclusion that can be drawn is that there will be no masking of the wind turbine noise for the proposed facility especially at low wind speeds.

14 Bolin, K., "Wind Turbine Noise and Natural Sounds- Masking, Propagation and Modeling", Doctoral Thesis, Royal Institute of Technology, Stockholm, Sweden, 2009.

7.0 Report On Acoustic Modeling

This section reviews the Acoustic Modeling report. Several summary comments are made similar to those covering the Ambient Sound Monitoring report.

- There is no discussion in the Tech Environmental report of establishing a criterion for the project that protects public health and welfare. The Mason County ordinance specifically requires that the project be designed to protect public health and welfare, separate from and adjunct to meeting all regulatory noise limits.

- There was no assessment of community reaction to the project. As a general guideline, projects should be designed to provoke no more than "Sporadic Complaints". The predicted sound levels (Figure 2) indicate "Widespread Complaints" over an area of some 22 square miles, with stronger reactions possible within some 14 square miles.

- Tech Environmental asserts there will be "masking" of the wind turbine noise by ambient sound levels. This is refuted in the previous section of this review (wrong wind shear values re NREL and van den Berg 2006; Bolin 2009).

- Section 2 and Figure 1 of the report in review have a number of inconsistencies compared to standard acoustical understanding, and are not germane to the project modeling.

- The acoustic modeling did not incorporate the +/1 3 dB uncertainty stated in the ISO 9613-2 algorithm for distances out to 1000 meters and indicates the model may need revision. The modeling did not note that ISO 9613-2 has no estimate of certainty for distances beyond 1000 meters.

- The acoustic modeling appeared to specify a ground absorption value of 0.5 for "Winter frozen ground conditions". It is understood that the value for winter frozen ground conditions is 0.0 and indicates the model may need revision.

4.6 Infrasound and health effects

As may already be evident to the reader, there are assertions made by Tech Environmental in this section that simply do not stand up to fact. To be fair, if Tech Environmental principals have not yet experienced the adverse medical symptoms themselves, they may not truly understand that there is a real adverse health impact mechanism involving the acoustic emissions from wind turbines that is unrelated to the A-weighted sound level or even the C-weighted sound level, placing the ball squarely in the infrasonic court.

It is worth noting that averaged infrasonic dB readings produced by wind passing over the microphone do not relate directly to infrasonic acoustic/pressure pulsations emitted by wind turbines.

This reviewer can attest directly from the unexpected and debilitating impacts on survey in April 2011. Wind turbine acoustic emissions create adverse medical symptoms and infrasonic, inaudible acoustic or pressure pulsations appear to be involved.

Tech Environmental is correct that the infrasonic levels produced by and measured near wind turbines appear to be inaudible to most people at levels below about 90 dBG. What Tech Environmental fails to incorporate in their report is the fact that there is emerging medical science that has documented the sensitivity of portions of the inner ear to infrasonic energy, energy that the ear would not hear, at levels starting around 60 dBG, and that there are afferent pathways linking infrasonic response to the brain.

> "Our present understanding of inner ear physiology and of the nature of wind turbine sounds demonstrates that low-level infrasound produced by wind turbines is transduced by the OHC of the ear and this information is transmitted to the cochlear nucleus of the brain via Type II afferent fibers. We therefore conclude that dismissive statements such as “there is no significant infrasound from current designs of wind turbines” are undoubtedly false. The

> fact that infrasound dependent information, at levels that are not consciously heard, is present at the level of the brainstem provides a scientific basis for the possibility that such sounds can have influence on people. The possibility that low-frequency components of the sound could contribute both to high annoyance levels and possibly to other problems that people report as a result of exposure to wind turbine noise cannot therefore be dismissed out of hand." [15].

As an INCE member, it seems appropriate of Tech Environmental to rethink their absolute refusal to incorporate medical scientific peer-reviewed published findings and expand their consideration of the potential for adverse medical impacts on people living near wind turbines, especially given that a subset of populations in residential areas near wind turbines all over the world have raised complaints and described symptoms that point to influence of the vestibular system. With respect to consideration of the proposed facility, it appears vital to understand that Tech Environmental's assertions about infrasound not being a problem appear to be dismissive of people's real suffering and are not in step with the emerging medical science.

15 A. Salt, J. Kaltenbach, *Infrasound From Wind Turbines Could Affect Humans*, Bulletin of Science, Technology and Society, 2011.

ATTACHMENT 1

COMMUNITY REACTION TO ENVIRONMENTAL NOISE

Excerpt From: Information On Levels Of Environmental Noise Requisite To Protect Public Health And Welfare With An Adequate Margin Of Safety, 550/9-74-004, March 1974.

There are two methods of indirectly assessing the cumulative effects of environmental noise on people. These are examining the reactions of individuals or groups of individuals to specific intruding noises, either (a) with respect to actions taken (complaints, suits, etc.), or (b) in terms of responses made to social survey questionnaires. The first category, involving overt action by individuals or groups, is summarized in this section, and key data regarding the second category, involving responses indicating annoyance, is summarized in the next section.

In the last 25 years, many new types of noise sources have been introduced into suburban and urban residential communities. These sources, such a jet aircraft, urban freeways, new industrial plants, and homeowner equipment, have created numerous community problems with environmental noise. These problems have provided significant data and insight relating to community reaction and annoyance and stimulated the development of several indices for measurement of the magnitude of intruding noises.

Various U.S. Governmental agencies began to investigate the relationships between aircraft noise and its effect on people in communities in the early 1950's. This early research resulted in the proposal of a model by Bolt, Rosenblith and Stevens for relating aircraft noise intrusion and the probable community reaction. This model, first published by the Air Force, accounted for the following seven factors:

1. Magnitude of the noise with a frequency weighting relating to human response.
2. Duration of the intruding noise.
3. Time of year (windows open or closed).
4. Time of day noise occurs.
5. Outdoor noise level in community when the intruding noise is not present.
6. History of prior exposure to the noise source and attitude toward its owner.
7. Existence of pure-tone or impulsive character in the noise.

Correction for these factors were initially made in 5 dB intervals since the magnitudes of many of the corrections were based solely on the intuition of the authors, and it was considered difficult to assess the response to any greater degree of accuracy. This model was incorporated in the first Air Force Land Use Planning Guide in 1957 and was later simplified for ease of application by the Air Force and the Federal Aviation Administration.

Recently the day-night sound level has been derived for a series of 55 community noise problems to relate the normalized measured Ldn with the observed community reaction. The normalization procedure followed the Bolt, Rosenblith and Stevens method with a few minor modifications. The correction factors which were added to the measured Ldn to obtain the normalized Ldn are given in Table D-7. The distribution of the cases among the various noise sources having impact on the community are listed in Table D-8. The results are summarized in Figure D-7.

The "no reaction" response in Figure D-7 corresponds to a normalized outdoor day-night sound level which ranges between 50 and 61 dB with a mean of 55 dB. This mean value is 5 dB below the value that was utilized for categorizing the day-night sound level for a "residential urban community," which is the baseline category for the data in the figure. Consequently, from these results, it appears that no community reaction to an intruding noise is expected, on the average, when the normalized day-night sound level of an identifiable intruding noise is approximately 5 dB less than the day-night sound level that exists in the absence of the identifiable intruding noise. This conclusion is not surprising; it simply suggests that people tend to judge the magnitude of an intrusion with reference to the noise environment that exists without the presence of the intruding noise source.

The data in Figure D-7 indicate that widespread complaints may be expected when the normalized value of the outdoor day-night sound level of the intruding noise exceeds that existing without the intruding noise by approximately 5 dB, and vigorous community reaction may be expected when the excess approaches 20 dB. The standard deviation of these data is 3.3 dB about their means and an envelope of +5 dB encloses approximately 90 percent of the cases. Hence, this relationship between the normalized outdoor day-night sound level and community reaction appears to be a reasonably accurate and useful tool in assessing the probable reaction of a community to an intruding noise and in obtaining one type of measure of the impact of an intruding noise on a community.

The methodology applied to arrive at the correlation between normalized Ldn and community complaint behavior illustrated in Figure D-7 is probably the best available at present to predict the most likely community reaction in the U.S. Unfortunately, readiness to complain and to take action is not necessarily an early indicator of interference with activities and annoyance that the noise creates. The fact that correction for the normal background noise level without intruding noise results in better correlation of the data points might be interpreted to mean that urban communities have adapted to somewhat higher residual noise levels that are not perceived as interfering or annoying. On the other hand, it is more likely that the higher threshold for complaining is caused by the feeling that higher residual noise is unavoidable in an urban community and that complaining about "normal" noise would be useless.

Table D-7

CORRECTIONS TO BE ADDED TO THE MEASURED DAY-NIGHT SOUND LEVEL (Ldn) OF INTRUDING NOISE TO OBTAIN NORMALIZED Ldn[1]

Type of Correction	Description	Amount of Correction to be Added to Measured L_{dn} in dB
Seasonal Correction	Summer (or year-round operation)	0
	Winter only (or windows always closed)	-5
Correction for Outdoor Noise Level Measured in Absence of Intruding Noise	Quiet suburban or rural community (remote from large cities and from industrial activity and trucking)	+10
	Normal suburban community (not located near industrial activity)	+5
	Urban residential community (not immediately adjacent to heavily traveled roads and industrial areas)	0
	Noisy urban residential community (near relatively busy roads or industrial areas)	-5
	Very noisy urban residential community	-10
Correction for Previous Exposure & Community Attitudes	No prior experience with the intruding noise	+5
	Community has had some previous exposure to intruding noise but little effort is being made to control the noise. This correction may also be applied in a situation where the community has not been exposed to the noise previously, but the people are aware that bona fide efforts are being made to control the noise.	0
	Community has had considerable previous exposure to the intruding noise and the noise maker's relations with the community are good	-5
	Community aware that operation causing noise is very necessary and it will not continue indefinitely. This correction can be applied for an operation of limited duration and under emergency circumstances.	-10
Pure Tone or Impulse	No pure tone or impulsive character	0
	Pure tone or impulsive character present	+5

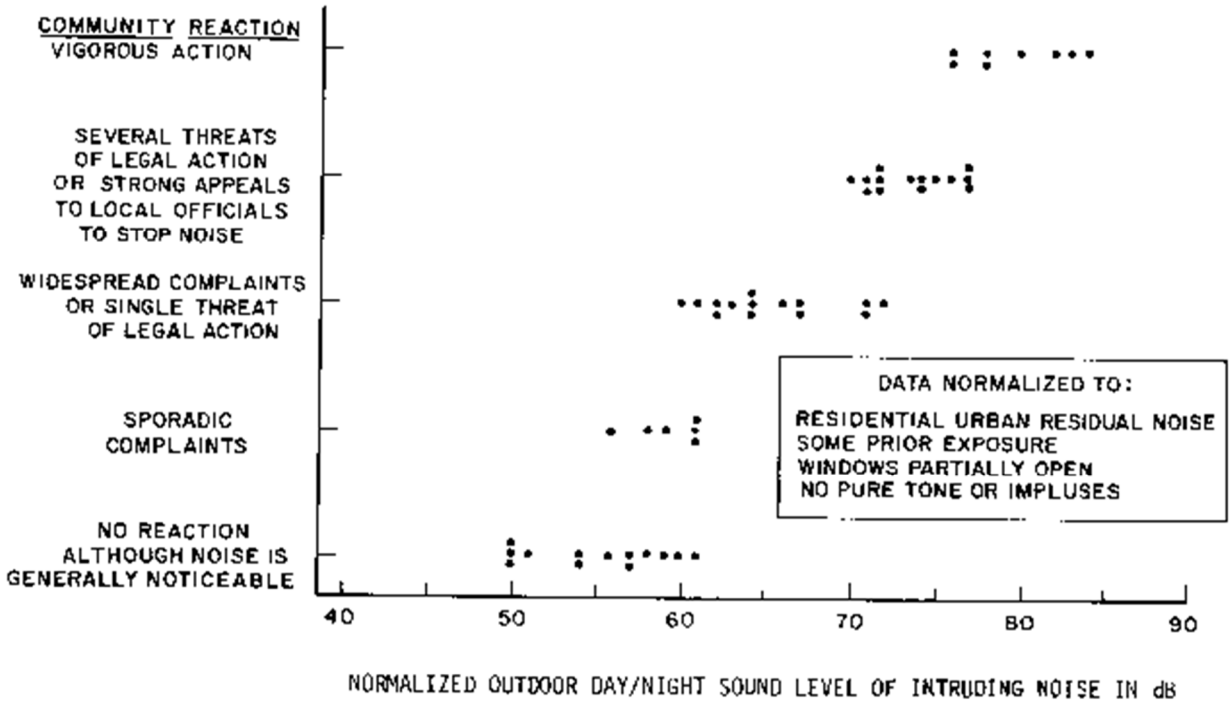
Table D-8

NUMBER OF COMMUNITY NOISE REACTION CASES AS A FUNCTION OF NOISE SOURCE TYPE AND REACTION CATEGORY

Type of Source	Community Reaction Categories			Total Cases
	Vigorous Threats of Legal Action	Wide Spread Complaints	No Reaction or Sporadic Complaints	
Transportation vehicles, including:				
Aircraft operations	6	2		12
Local traffic			4	3
Freeway	1		3	1
Rail		1		1
Auto race track	2			2
Total Transportation	9	3	7	19
Other single-event or intermittent operations, including circuit breaker testing, target shooting, rocket testing and body shop	5			
Steady state neighborhood sources, including transformer substations, residential air conditioning	1	4	2	7
Steady state industrial operations, including blowers, general manufacturing, chemical, oil refineries, et cetera	7	7	10	24
Total Cases	22	14	19	55

Figure D-7

Community Reaction to Intensive Noises of Many Types as a Function of the Normalized Outdoor Day Night Sound Level of the Intruding Noise[1]



1. Eldred, K. M., "Community Noise", Environmental Protection Agency NTID 300.3, December 1971.

Attachment 2. Mason County Noise Regulations

This section details the Mason County regulatory noise limits on industrial wind turbines (dated June 2, 2011). Emphasis is added where regulatory requirements related to public health and welfare were found.

ARTICLE I

TITLE, PURPOSES, AND LEGAL CLAUSES

Section 1.01 Short Title.

This Ordinance shall be known and may be cited as the Mason County Zoning Ordinance.

Section 1.02 Repeal of Ordinance.

The Mason County Zoning Ordinance, effective March 3, 1972 and all amendments thereto, are hereby repealed effective coincident with the effective date of this Ordinance being June 30, 2010.

Section 1.03 Statement of Purposes.

1. To promote the public health, safety, morals, and general welfare.

2. To encourage the use of lands in accordance with their character and capabilities and to limit the improper use of land.

3. To avoid overcrowding of population.

4. To lessen congestion on the public roads and streets.

5. To reduce hazards to life and property.

6. To reasonably consider the character of each district, its peculiar suitability for particular uses, the conservation of property values and natural resources, and the general and appropriate trend and character of land, building, and population development.

ARTICLE XVI

SPECIAL LAND USE CONDITIONS, REVIEW, AND APPROVAL

Section 16.01 Statement of Purpose.

1. It is the purpose of this Article to specify the procedure and requirements for the review of special land uses, as specified in this Ordinance. Uses classified as special land uses are recognized as possessing unique characteristics (relative to location, design, size, public infrastructure needs, and other similar characteristics) which require individual review and approval standards in order to **safeguard the general health, safety, and welfare of the County**.

2. The following use permit review procedures are instituted to provide an opportunity to use a lot or parcel for an activity which, under certain circumstances, might be

detrimental to other permitted land uses and should not be permitted within the same district, but which use can be permitted under circumstances unique to the proposed location and subject to conditions acceptable to the community and providing protection to adjacent land uses. The procedures apply to those Special Land Uses which are specifically designated as such in the Zoning Ordinance.

Section 16.02 Review and Approval Authority.

The Planning Commission shall have the authority to approve special land use permits, subject to such conditions of design, operation, and appropriate and reasonable safeguards as the Commission may require for any special land use included in the various provisions of this Zoning Ordinance.

Section 16.03 Data Required.

1. Applications for Special Approval Land Uses authorized in this Ordinance shall be submitted to the Zoning Administrator. Applications shall include the appropriate number of copies of the site plan and the fees as established by the County Board of Commissioners. Applications will be processed according to the procedures adopted by the County.

2. The Zoning Administrator shall review the proposed application to determine if all required information has been supplied, and forward completed applications and supporting data in accordance with the provisions of this ordinance. If all required information is not supplied, the Zoning Administrator shall return the application to the applicant with a list of information needed.

3. An application for a special land use permit shall include the following:

a. Applicant's name, address, and telephone number.

b. Address and property tax identification number of the proposed site.

c. A signed statement that the applicant is the owner of the proposed site, or is acting as the owner's representative.

d. A complete site plan containing all the applicable data required by Article XVIII.

e. **Supporting statements, evidence, data, information, and exhibits that address criteria for assessing special land use applications**.

f. **Any additional information deemed necessary for the Planning Commission to determine the impact of the proposed special land use on the adjacent properties, public infrastructure, and community as a whole. Such information may take the form of, but is not limited to**, traffic impact analyses, **environmental impact assessments,** market studies (to determine demand, use saturation), fiscal impact analyses or reports and/or testimony by officials representing state, county or local departments of public safety (police and fire), **health,** highways or roads, and/or environment.

Section 16.04 Review Process

1. Upon receipt of a complete application for a special use permit, the Planning Commission shall hold a public hearing in accordance with the notification requirements of the State law and Section A complete application under this Section shall be one that addresses the items set forth in Section 16.03.

2. The Planning Commission shall review the proposal and base its decision upon review of the individual standards for that Special Approval Land Use and the general standards of this Article.

The Planning Commission shall grant approval of the application with any conditions it may find necessary or it may disapprove the application. The decision on a Special Land Use shall be incorporated in a statement of conclusions relative to the Special Land Use under consideration.

The decision shall specify the basis for the decision and conditions imposed.

a. Approval. If the Planning Commission determines that the particular Special Approval Land Use(s) shall be allowed, it shall clearly set forth in writing the particular use(s) which have been allowed.

Thereafter, the Zoning Administrator may issue a zoning permit in conformity with the particular Special Approval Land Use so approved. In all cases where a particular Special Land Use has been granted as provided herein, application shall be made to obtain a zoning permit in the County not later than one year thereafter, or such approval shall automatically be revoked. The Planning Commission may grant an extension thereof for good cause after receiving written request from the applicant.

b. Denial. **If the Planning Commission shall determine that the particular Special Approval Land Use(s) requested does not meet the standards of this Ordinance or otherwise will tend to be injurious to the public health, safety, welfare, or orderly development of the County, it shall deny the application in writing and clearly set for the reasons for such denial.**

3. The Planning Commission may impose such conditions or limitations in granting approval as may be permitted by State law and this Ordinance which it deems necessary to fulfill the spirit and purpose of this Ordinance. The conditions may include:

a. Assurance that public services and facilities affected by a proposed land use or activity will be capable of accommodating increased service and facility loads caused by the land use or activity;

b. Protection of natural resources and conservation of energy;

c. Assurance of compatibility with adjacent uses of land;

d. Promotion of the beneficial use of land in a socially and economically desirable manner.

4. Special conditions imposed shall meet each of the following:

a. Be designed to protect natural resources, the health, safety, and welfare, as well as the social and economic well-being of those who will use the land use or activity under consideration, residents and landowners immediately adjacent to the proposed land use or activity, and the community as a whole.

b. Be related to the valid exercise of the police power and purposes, which are affected by the proposed use or activity.

c. Be necessary to meet the intent and purpose of the zoning regulations; be related to the standards established in this Ordinance for the land use or activity under consideration; and be necessary to ensure compliance with those standards.

The conditions imposed with respect to the approval of a land use or activity shall be recorded in the record of the approval action and shall remain unchanged except through an amendment process following the same procedure as the initial approval. The County Clerk shall maintain a record of changes granted in conditions.

5. Postpone: If the special land use application does not meet the requirements of the Zoning Ordinance, the Planning Commission may postpone action on the site plan to allow time for additional study and/or site plan revisions.

6. Appeals: Within twenty (20) days following the date of a decision on any Special Use Permit, an applicant or any aggrieved party, including any governmental body or agency, may appeal the decision of the County Planning Commission to the Board of Appeals. Upon the filing of an appeal, the application, all relevant documents and testimony, and the findings and decision of the County Planning Commission shall be transmitted to the Board of Appeals.

Section 16.05 Standards for Approval.

The Planning Commission shall review the particular circumstances and facts applicable to each proposed special land use in terms of the following standards and requirements and shall make a determination as to whether the use proposed and subject site meet all of the following standards and requirements. If it is determined that the proposed use does meet all of the following standards and requirements, the use shall be allowed. If it is determined that the proposed use does not meet all of the following requirements, the use shall not be allowed.

1. Will be in accordance with the goals and objectives of the Mason County Comprehensive Plan.

2. **Will be designed, constructed, operated, and maintained in harmony with the existing or intended character of the general vicinity and that such a use will not change the essential character of the area in which it is proposed.**

3. Will not be hazardous or disturbing to existing or future permitted uses in the same general vicinity and in the community as a whole.

4. Will be served adequately by essential public facilities and services, such as highways, streets, police and fire protection, storm water drainage, refuse disposal, water and sewage facilities, and schools or persons or agencies responsible for the establishment of the proposed use shall be able to provide adequately for such services.

5. Will not create excessive additional requirements at public cost for facilities and services and will not be detrimental to the economic welfare of the community.

6. Will not involve uses, activities, processes, materials and equipment, or conditions of operation that will be detrimental to any person, property, or general welfare by reason of excessive production of traffic, **noise,** vibration, smoke, fumes, glare, or odors.

7. Will ensure that the environment shall be preserved in its natural state, insofar as practicable, by minimizing tree and soil removal, adequate setback from water courses, and by topographic modifications which result in maximum harmony with adjacent areas.

8. Will not impede the normal and orderly development and improvement of surrounding property for uses permitted within the Zoning District.

9. Will comply with the requirements of this Ordinance, including Article 21, Access Management and Highway Overlay District.

Section 16.06 Issuance of a Zoning Permit.

A zoning permit may be issued by the Zoning Administrator upon approval of the special land use by the Planning Commission. The zoning permit shall list all the conditions of approval stipulated by the Planning Commission.

Section 16.07 Reapplication.

No special land use application which has been denied wholly or in part by the Planning Commission shall be resubmitted until the expiration of twelve (12) months or more from the date of such denial, except on the grounds of newly discovered evidence or proof of changed conditions. A reapplication shall be processed in the same manner as the original application.

Section 16.08 Site Plan Amendments in Conjunction with a Special Land Use.

Any approved site plan shall become part of the record of special land use approval. Subsequent improvements relative to the authorized use shall be consistent with the approved site plan, unless a change conforming to this Ordinance receives the mutual agreement of the landowner and the Planning Commission. A site plan amendment shall be reviewed and considered in the same manner as the original site plan application, except as otherwise provided in this Ordinance.

Section 16.09 Validity and Revocation of Special Land Use Permits.

1. Validity of Permit: Once the special land use is established and the conditions of the permit fulfilled, the special land use permit shall be valid until such time that there is a

change of conditions or use related to the permit as permitted by the Planning Commission. The Planning Commission reserves the right to review, with the applicant and the County Zoning Administrator, the status of Special Use Permits on an annual basis.

2. Permit Revocation: The Planning Commission shall have the authority to revoke special land use approval following a hearing, if construction of the approved improvements does not proceed in conformance with the approved site plan. Upon discovery of a violation, the Zoning Administrator shall issue a stop work order and a notice to appear for a hearing before the Planning Commission.

Notice of the hearing date shall be provided to the applicant no less than ten (10) days prior to the date of the hearing.

Section 16.10 Amending a Special Land Use

Amendments to a special land use permit shall be handled in the same manner as the initial special land use permit request. Minor non-substantive changes to a site plan in accordance with Section 18.06 may be made to a special land use permit with the approval of the Zoning Administrator.

ARTICLE XVII. SPECIAL LAND USE REQUIREMENTS

Section 17.70 Utility Grid Wind Energy Systems

17. Noise levels.

a. Sound Level Limits.

1. The A-weighted equivalent sound level (LAeq) measured at the property line of an unpooled (single) parcel (as defined in subsection 19 hereof) upon which there is an occupied building or dwelling shall not exceed 45 dBA. If the unpooled parcel does not have an occupied principal building or dwelling on it, then the 45 dBA sound limit may be exceeded at the property line; provided that when an occupied principal building or dwelling is built on such unpooled parcel after the special land use permit has been issued, the sound level shall not exceed 45 dBA measured at the nearest wall of the occupied building or dwelling located on the unpooled parcel and in compliance with the minimum required front, side and rear yard setbacks then in effect within the zoning district in which the occupied building or dwelling is located.

2. On a pooled parcel, the ten-minute LAeq sound level measured at the wall of an occupied building nearest to the wind turbine or turbines shall not exceed 55 dBA.

3. These sound level limits are to be evaluated using the A-weighted equivalent sound level (LAeq) descriptor. The LAeq should be measured using a ten-minute time interval.

4. The sound level limits listed above apply to the contribution from the wind energy system only and do not include contributions from background ambient sounds.

b. Studies Required.

1) Preconstruction Noise Background Survey. The applicant shall provide a noise background study at the time of application which indicates Leq, L10, and L90 ten-minute sound levels using A-weighting. For applications submitted after the effective date of this ordinance, the applicant shall submit proposed measurement locations to the Planning Commission in advance of the survey for review and approval. Measurement procedures should generally follow the most recent versions of ANSI S12.18, and ANSI S12.9, Part 3 (with or without an observer present) guidelines. The selected test locations shall be described with GPS coordinates or some other level of detail such that the location can be used by others to repeat or verify sound measurements. Measurements shall be taken using an ANSI or IEC Type 1 Precision Integrating Sound Level Meter. The noise background study shall report for the period of monitoring topography, temperature, weather patterns, sources of ambient sound, and prevailing wind direction. The study shall include a map showing proposed wind turbine locations, pooled and unpooled parcels, and all occupied buildings.

2) Sound Modeling Study. A predictive sound study of turbine noise shall accompany an application for a wind energy system to verify that ordinance requirements can be met for dBA sound levels. The applicant shall present the maximum Sound Power Level of the proposed turbine on both the dBA and dBC scales, and will calculate the difference [dBC - dBA] in decibels and compare it to the 20 decibel threshold in IEC 61400-11, Annex A, as an indicator of whether the turbine is likely to produce low-frequency noise that could create annoyance. For assessing potential low frequency or vibration problems, refer to Section 17.70 17.d. The sound modeling must follow the most recent version of International Standard, ISO 9613-2 “Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation.” The sound modeling study shall use wind turbine sound power levels determined according to the most recent version of IEC 61400 – Part 11. The sound study shall include a map with sound contour lines for both dBA sound emitted from the proposed wind energy system. The study shall include a map showing sound contours at 5 dBA intervals, proposed wind turbine locations, pooled and unpooled parcels, and all occupied buildings. The predicted values must include sound levels created by all proposed turbines from the applicant’s project. The sound study shall extend out to the 30 dBA sound contour line or 1 mile from a wind turbine generator, whichever is closer to the nearest wind turbine.

3) Post Construction Sound Survey. Documentation of sound pressure level measurements shall be provided to the Zoning Administrator by a third-party qualified professional selected by the Planning Commission and at the expense of the wind energy system owner within 12 months of the commencement of the operation of the project. The post construction study shall be performed at the same locations as the pre-construction study unless additional locations are required by the Planning Commission. The study should generally follow the procedures in the most recent versions of ANSI S12.9 Part 3 (with or without and observer present) and ANSI S12.18. All sound pressure levels shall be measured with instruments that meet ANSI

or IEC Type 1 Precision integrating sound level meter performance specifications. In addition to measuring A-weighted sound levels, at least one monitoring location shall collect one-third octave band data down to 6.3 Hertz. As part of the study, octave band data must be measured as addressed in Section 17.70. 17.d. The post construction test shall verify that equivalent sound level limits in dBA are in compliance with the standards of this ordinance. The compliance test procedure will use an alternating series of turbine-on and turbine-off 10-minute Leq measurements when wind speeds are fairly constant. Measured levels (turbine-on and turbine-off) for similar hub height wind speeds will be compared to determine the sound level from only the wind turbines. The firm conducting the study shall collect LA90 and LA10 data. The study shall address noise complaints on file with the County (as indicated in Section 17.70 (24)) and may require additional study locations as deemed necessary by the Planning Commission. The firm conducting the post-construction sound survey shall consult with the Planning Commission, or their representative, prior to conducting the study to agree on the compliance testing locations. The study shall delineate pooled and unpooled parcels as well as occupied buildings. Should the sound study indicate a non-compliant measurement, the owner of the wind energy system will be required to obtain compliance through mitigation or other measures.

c. Wind Rose Chart. The applicant shall submit a Wind Rose Chart at the time of the application. This is a chart or graph that describes 12 months (or more) of wind data collected from the proposed project area. This graph or chart will demonstrate direction, duration, and intensity of the wind (pooled or not). These data will be for each height of wind sensor mounted on the meteorological tower.

d. Low Frequency Sound and/or Vibration. The applicant shall provide acoustic modeling at the time of application to assess potential low frequency or vibration problems. The modeling study of low frequency sound and vibration shall demonstrate meeting: (1) ANSI S12.9/Part 4 Annex D threshold for minimal annoyance and beginning of rattles from outdoor low frequency noise as summarized in Section 2.2 2 of the March-April, 2011 Noise Control Eng. article by O'Neal, et al. and (2) the ANSI S12.2 sound level limits for moderately perceptible vibration and rattles within homes as modified to equivalent outdoor sound limits in Table 2 of the March-April, 2011 Noise Control Eng. Journal article by O'Neal, et al.. The ANSI S12.2 interior sound level limits for low frequency sound and perceptible vibration within homes, as modified to equivalent outdoor sound limits in Table 2 of the March-April, 2011 Noise Control Eng. Journal article by O'Neal, et al. shall be utilized to determine if outdoor sound levels will create perceptible vibration or low frequency problems indoors. If the post-construction sound survey outdoor octave band sound level measurements reveal that low frequency sound from wind turbines at the exterior of an unpooled, occupied or non-occupied building may create a vibration or low frequency noise problem, then further studies should be conducted to assess the problem. The further studies shall use the above referenced standards (ANSI S12.2 and ANSI S12.9/Part 4 Annex D). If the further study indicates that the low frequency sound/vibration exceeds acceptable levels, mitigation may be required by the Planning Commission.

Mitigation may include operational changes to the turbine, modifications to the subject building or buildings, or other measures as determined by the Planning Commission.

19. Pooling of Parcels.

a. If two or more parcels of land are included in the special land use, they shall be pooled into a single unit (the “pooled unit”) for purposes of the special land use, in accordance with this paragraph 19.

Note: "Pooled" parcels are taken to mean the aggregated single unit or units of land comprised of parcels owned by leasee, participating land owners.

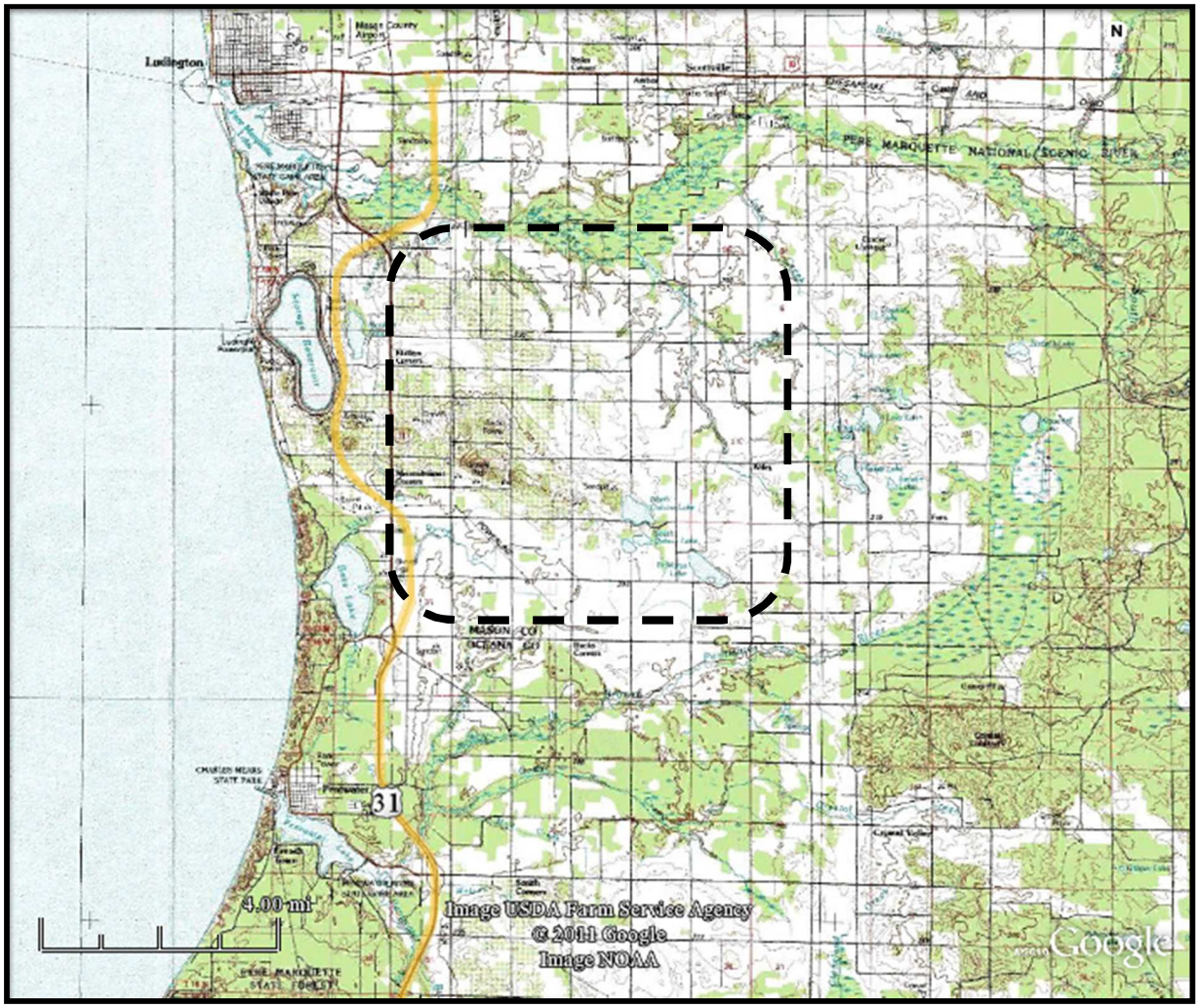


Figure 1. Site location, Mason County, Michigan.

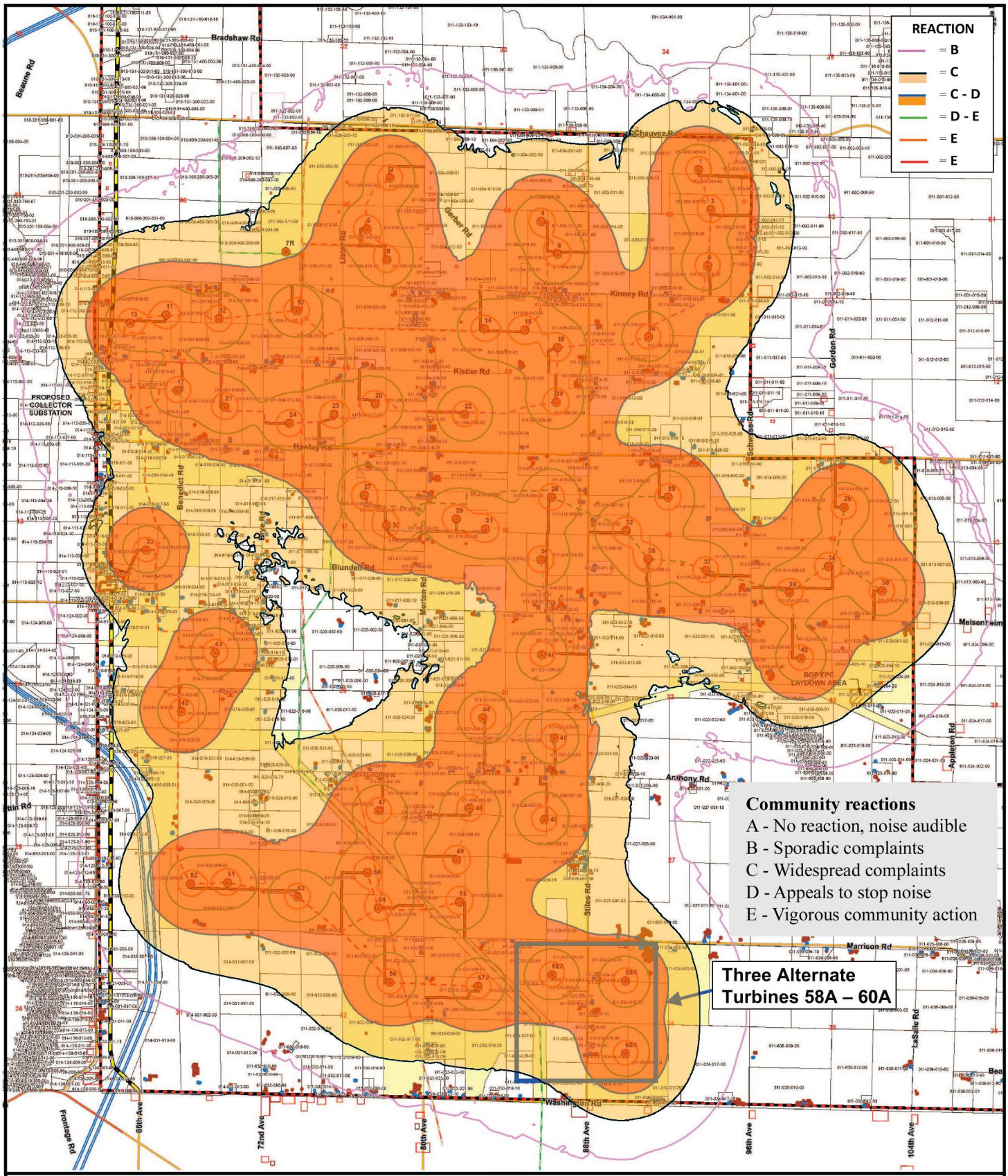


Figure 2-*A. Community reaction (EPA 1974).*

Maximum Sound Levels (dBA) for the Consumers Energy Co. Lake Winds™ Energy Park 56 V100 Turbine Layout + 3 Alternate Locations, Design Wind Speed Conditions

Widespread complaints, to Appeals, to Vigorous action.

Widespread complaints.

TECH environmental
FOCUSED KNOWLEDGE. REAL SOLUTIONS.

Source: Report on Acoustic Modeling, LakeWinds Energy Park, Tech Environmental, June 2011.
Review and overlays: Rand Acoustics, 6-23-2011.

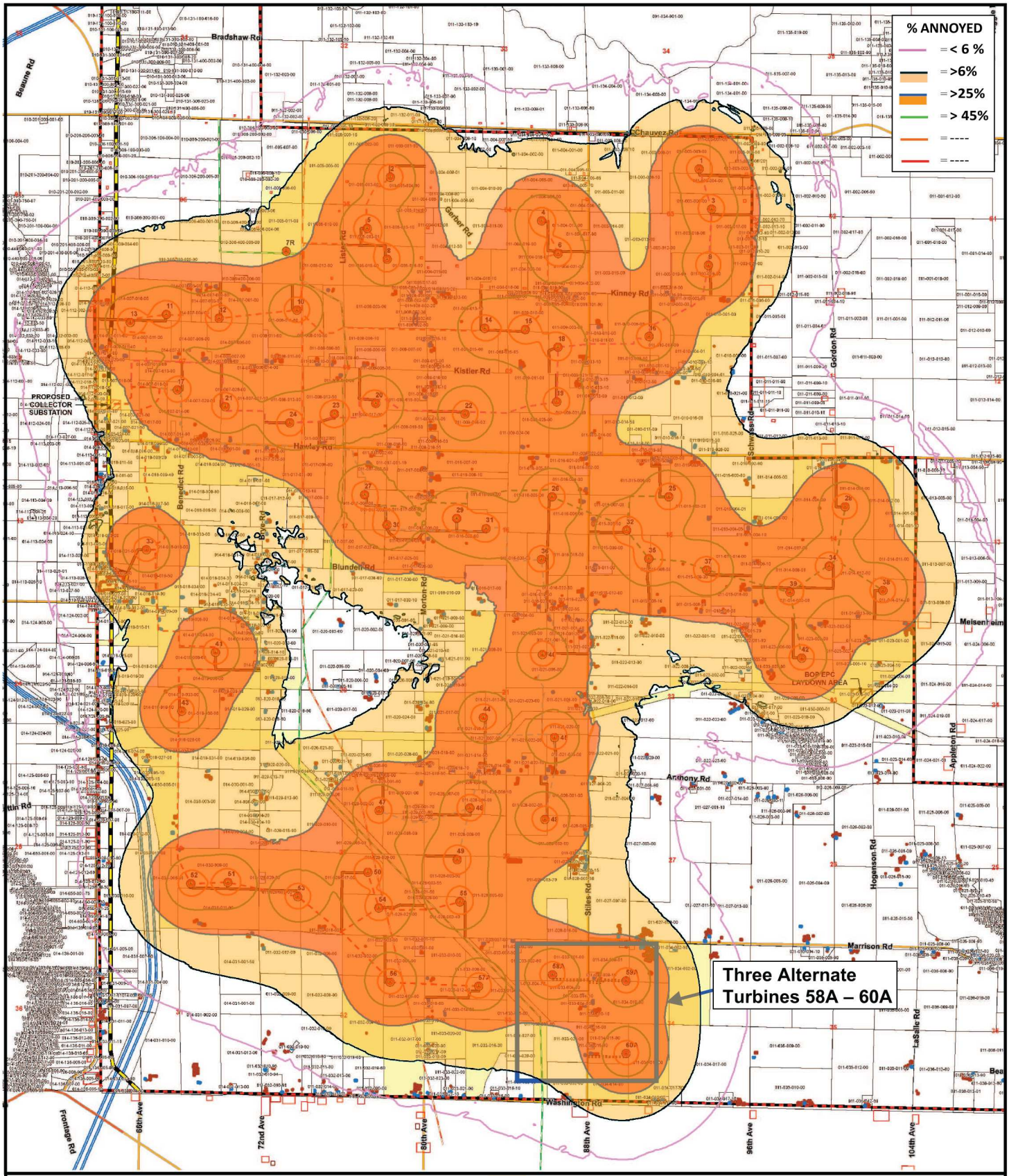


Figure 2-*B. Annoyance (Pedersen et al 2004).*

Maximum Sound Levels (dBA) for the Consumers Energy Co. Lake Winds™ Energy Park 56 V100 Turbine Layout + 3 Alternate Locations, Design Wind Speed Conditions

25% or more highly annoyed, with activity interference.

6% and more highly annoyed, with activity interference.

TECH environmental
FOCUSED KNOWLEDGE. REAL SOLUTIONS.

Source: Report on Acoustic Modeling, LakeWinds Energy Park, Tech Environmental, June 2011.
Review and overlays: Rand Acoustics, 6-23-2011.

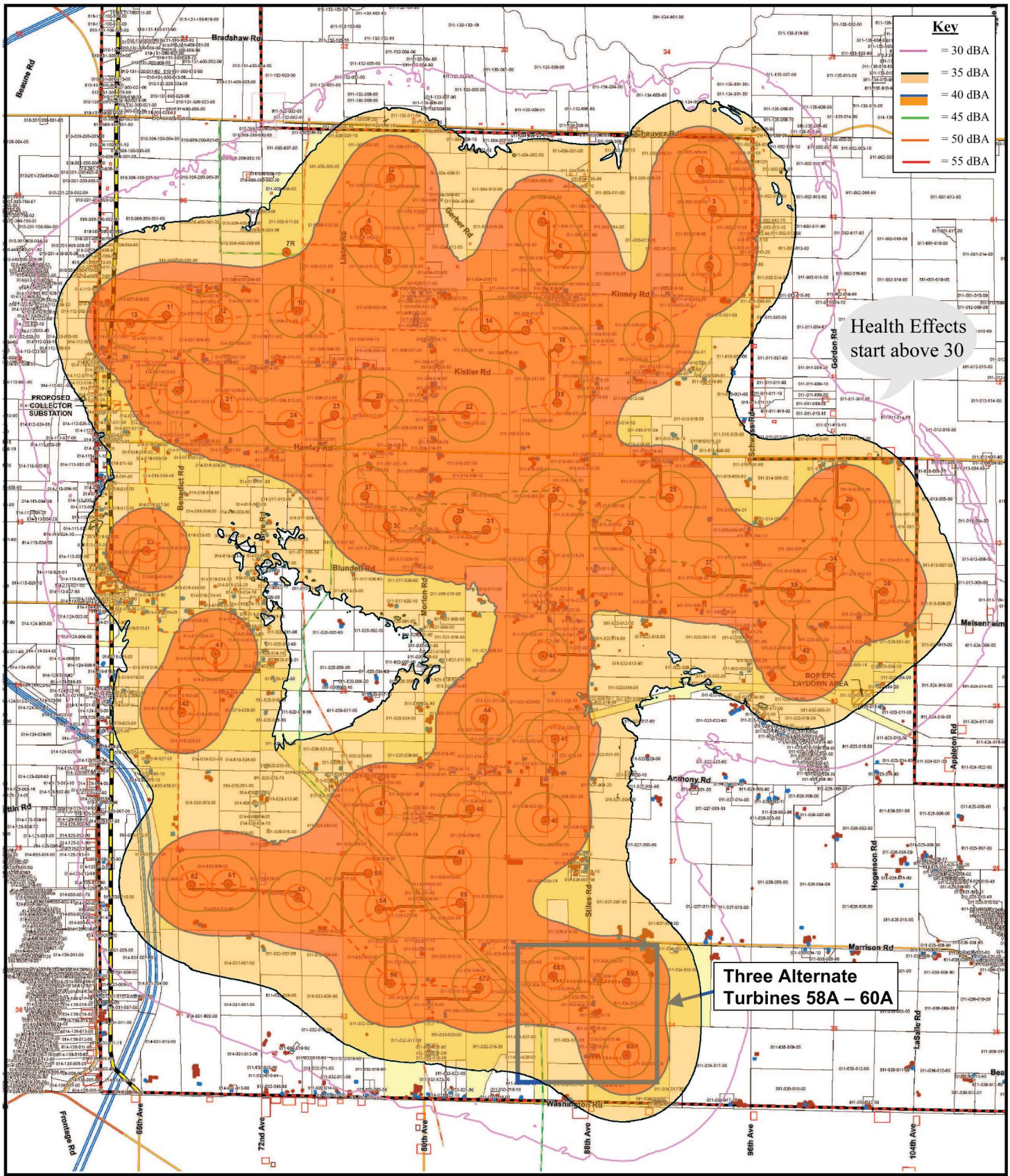


Figure 2-*C. Health effects (WHO 2009).*

Maximum Sound Levels (dBA) for the Consumers Energy Co. Lake Winds™ Energy Park 56 V100 Turbine Layout + 3 Alternate Locations, Design Wind Speed Conditions

Increasing adverse health impacts.

Sleep interference. Risk groups susceptible to adverse impacts.

TECH environmental
FOCUSED KNOWLEDGE. REAL SOLUTIONS.

Source: Report on Acoustic Modeling, LakeWinds Energy Park, Tech Environmental, June 2011.
Review and overlays: Rand Acoustics, 6-23-2011.