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Mr. Reg Karg, Chairman
Riga Township Planning Commission
12164 Riga Hwy.
Ottawa Lake, MI 49267

Mr. Karg,

On request of interested parties in Riga Township, I am writing to provide important information about siting wind turbines to protect public health with an adequate margin of safety. I am a Member of the Institute of Noise Control Engineering with over thirty years of experience in acoustics including many years working in industrial power generation noise control. I have conducted independent studies of wind turbine noise including actual field measurements of operating wind turbines in the State of Maine over the last year, where significant community reaction has occurred near wind turbine facilities equipped with smaller wind turbines than proposed for the Riga Township.

I understand that there have been suggestions of using a wind turbine noise limit of 45 dBA at a distance of 1300 feet or so in Riga Township. Experience in New England has proven that these noise levels at these distances for wind turbines sited in rural areas are associated with significant adverse community reactions, widespread complaints, appeals to stop the noise, and legal action. When siting large industrial wind turbines in quiet rural areas, lower maximum noise levels and farther distances are recommended to prevent adverse community reaction and protect public health and welfare with an adequate margin of safety.

This letter presents a discussion of community reactions to noise, guidelines for appropriate maximum permissible noise limits in rural areas, measured noise levels versus distance and observed community responses. I appreciate your consideration of this letter and believe you will find this information useful in your determinations of how to protect the health and welfare of Riga Township.

Please call me if you have any questions.

Respectfully submitted,

Community reactions to noise

People react to changes in noise level and to unusual or unpredictable noise character. People respond to the change in the sound level from the background to which they are accustomed, as follows:

Figure 1. Estimated Community Response to Noise Increase

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

In *rural* areas (such as Riga Township) it is generally found that background sound levels *in the absence of industrial noise, traffic or insects* falls in around 35 dBA or lower during the day and 25 dBA or lower at night. An adverse community response could occur if a new and unfamiliar noise source was introduced at night at levels of 35 dBA or higher in a quiet rural area.

In contrast for example, consider Hull Massachusetts, a city that experiences pervasive noise from auto traffic and aircraft flyovers from Logan Airport, with typical background sound levels of 40 to 55 dBA at night [1]. With two large industrial wind turbines operating in Hull and sited close to residential neighborhoods, there are few or no complaints from the wind turbine noise there. Does this make sense? Actually, it does. Hull experiences *urban and aircraft* sound levels that are *much higher* than those found in rural areas.

Let's say that a wind turbine produces a sound level of 45 dBA at 1300 feet. In a *rural* area with a nighttime background sound level of 25 dBA or less, the

increase is 20 dBA and the expected community reaction is strong, with "Vigorous Community Action" ranging to "Threats of Community Action" and "Widespread Complaints" with farther distances from the wind turbine. In contrast, in an *urban residential* area like Hull, Massachusetts, with background sound levels similar to or higher than the wind turbines (depending on distance) and a sound signature similar to jet aircraft, there may be no perceptible noise change at nearby residential neighborhoods due to the wind turbine and thus, no reaction.

Noise criteria for noise-producing facilities

Noise-producing facilities are usually required to meet certain noise limits or "criteria" when operating in order to protect the welfare of nearby residents. In many cases criteria are taken directly from local ordinances or State regulations that specify noise limits at specific locations such as property lot lines. However "just meeting" these limits may not prevent an adverse community reaction, depending on the apparent loudness of the noise source when compared to the existing expected background sound levels.

By now most people are aware of the reports of adverse community reactions near some wind turbine facilities. From investigations made around New England, adverse community reactions appear to occur mostly when there are residential homes in quiet rural areas within a mile or so of a wind turbine facility. The noise limits for these sites are always above 35 dBA. Coincidence? No.

Many ordinances and regulations in the United States developed in the last thirty years took their guidance from the EPA's 1974 "Levels Document" [2] and used the EPA's "guideline" of the *Ldn55* (55 dBA day, 45 dBA night), maximum permissible sound level (for urban residential areas) as a noise limit or criterion, whether the ordinance or regulation was applied to urban residential, rural, or wilderness areas. In developing its guidelines, the EPA's primary focus (as expressed in the Levels Document) was on preventing hearing loss and speech interference, writing that "*The level of 55 dB [note: Ldn- 55 dBA day, 45 dBA night] is identified as maximum level compatible with adequate speech*

communication indoors and outdoors. With respect to complaints and long-term annoyance, this level is clearly a maximum serving a large majority of the population. However specific local situations, attitudes and conditions may make lower levels desirable for some locations."

The "large majority" that the EPA wrote of can be seen below in Figure 2. Of the roughly 214 million people living in the US in 1974, some *100 million* lived in areas with existing background sound levels *above* Ldn 55. Over *10 million* lived with background sound levels above *Ldn 70.*

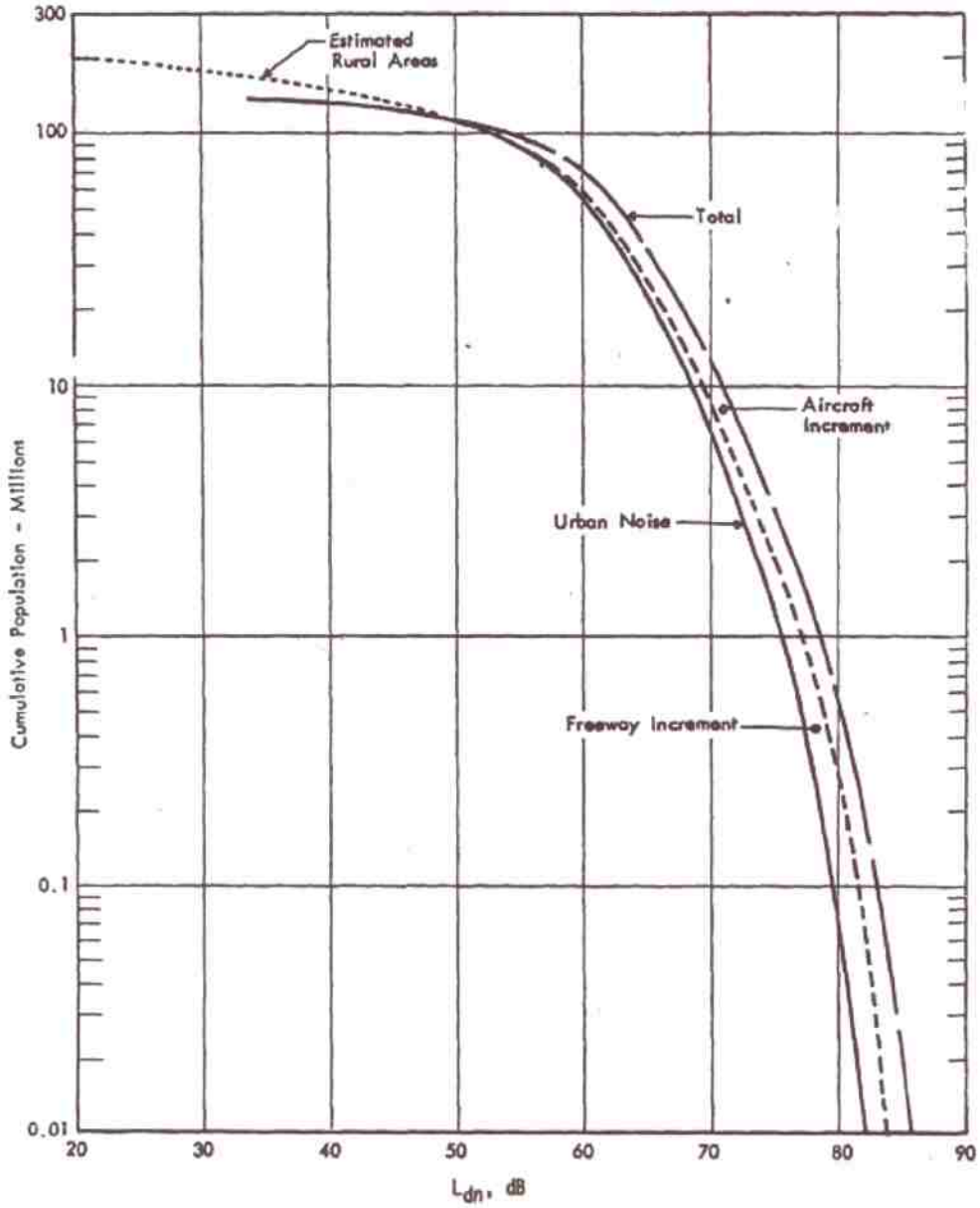


Figure 2 Residential Noise Environment of the National Population As A Function of Exterior Day-Night Average Sound Level (Ref B-5)

For those living with elevated background sound levels in urban areas, the EPA's guideline of a maximum Ldn 55 was well positioned to assure no hearing loss, nor any speech interference within a reasonable speaking distance. However, for the some 100 million people living *outside* urban areas, with existing background sound levels *below* Ldn 55, the EPA's guideline has no protective effect. Indeed, the use of Ldn 55 as a "permitted" maximum level can serve to *degrade* the acoustic environment in quiet rural and wilderness areas by allowing *much higher* intrusive sound levels where existing background sound levels were much lower. *This was never the EPA's intent.*

For an *urban residential* area like Hull, a 45-dBA nighttime limit (the nighttime limit in Ldn55) *could* be effective at producing a "No Reaction" community response. However, if a criteria of 45 dBA were selected for a *rural* area with minimum background sound levels of 25 dBA or less, that allows a *20 dB increase* over the pre-existing night time levels. The predicted community reaction would be strong and adverse, and the ordinance would not be experienced as a protection to well-being in the much quieter rural setting.

With this general framework now presented to you, how can community reactions to wind turbine sound levels be assessed and appropriate criteria developed for rural areas such as Riga Township? Fortunately there is an established method for determining community reaction to noise.

Noise impact assessment: EPA

The USEPA's 1974 "Levels Document" recognized the range of community reactions in different areas and presented 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 reviewer to

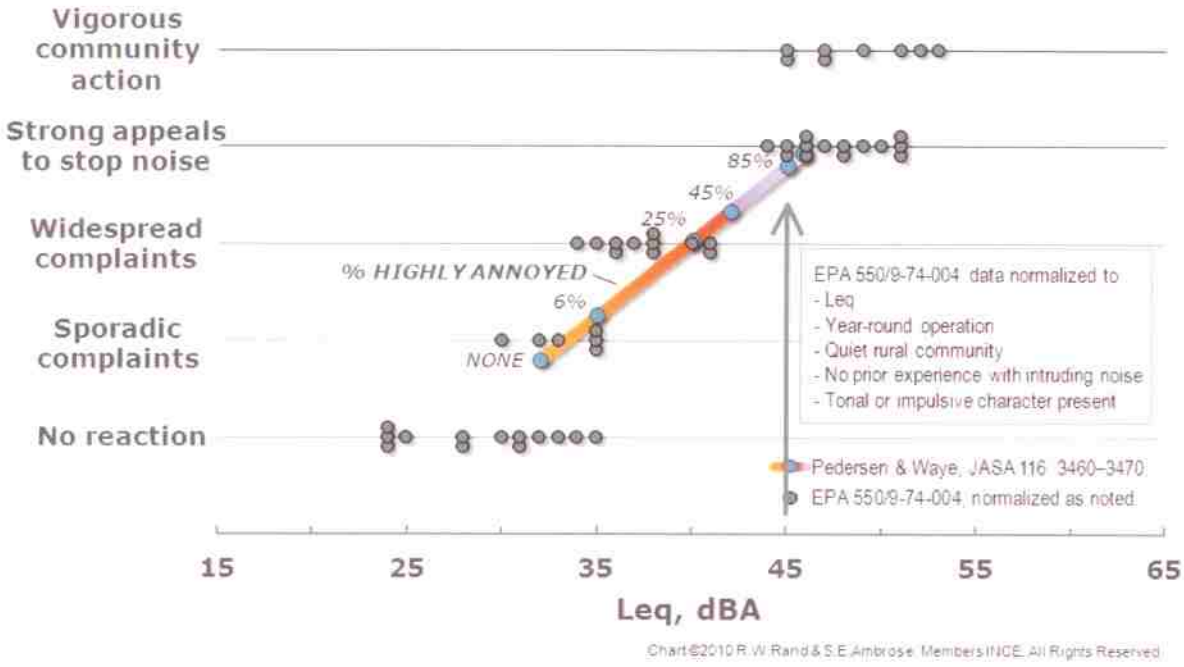
account for the features of wind turbine noise that distinguish it from other noise sources.

Figure D-7 in Attachment 1 shows the EPA normalized Ldn values with no corrections. The process used for this review analysis starts with converting the EPA's Ldn data to Leq (the *energy-average* sound level). To convert the EPA data from Ldn to Leq, a 6 dB factor is employed assuming steady operation day and night. For example, Ldn 51 equals an Leq of 45 dBA for a steady-state noise source. Then, the community noise impact assessment for a wind turbine facility uses the following normalizing correction factors to the EPA's data to bring them into an Leq chart:

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

With the conversion to Leq and the correction factors applied, the EPA data now appear at the normalized Leq values shown in Figure 3. Now, the predicted wind turbine Leq can be assessed directly with the EPA's normalized data, which is now expressed in a normalized Leq with associated normalized community reactions. Figure 3 shows the Leq noise level on the 'X-axis' and normalized EPA community reactions on the 'Y-axis'. The community reaction is determined by finding, as an example, the proposed 45 dBA on the figure as shown and moving straight up the chart to find the occurrences of community reaction. The Leq 45 value actually intersects the normalized community reactions at two reaction levels: "Strong appeals to stop the noise" and the highest level "Vigorous action".

Figure 3 – Community Impact Assessment



The EPA method indicates that the 45-dBA limit suggested for nearest neighbors in the quiet areas of Riga Township is associated with the EPA-based normalized community impact reactions of "Strong Appeals To Stop Noise" to "Vigorous Community Action." The proper way to design noise-producing facilities is to perform a community noise impact assessment to ensure that noise emissions result in "No Reaction" or no more than "Sporadic Complaints."

How can the EPA's guideline of Ldn 55 (55 dBA day, 45 dBA night) be adjusted for noise impacts from wind turbines in the quiet, rural setting? Accounting for ALL the correction factors in the EPA's community reaction assessment method as discussed above, the resulting total correction of 20 dB leads to the conclusion that the EPA's maximum permissible noise limits should be adjusted downward from their urban residential guideline of Ldn 55 to a *rural* Ldn 35, or 35 dBA, day and 25 dBA, night. These levels are consistent with background sound levels normally found in rural areas and would be expected to produce "No Reaction."

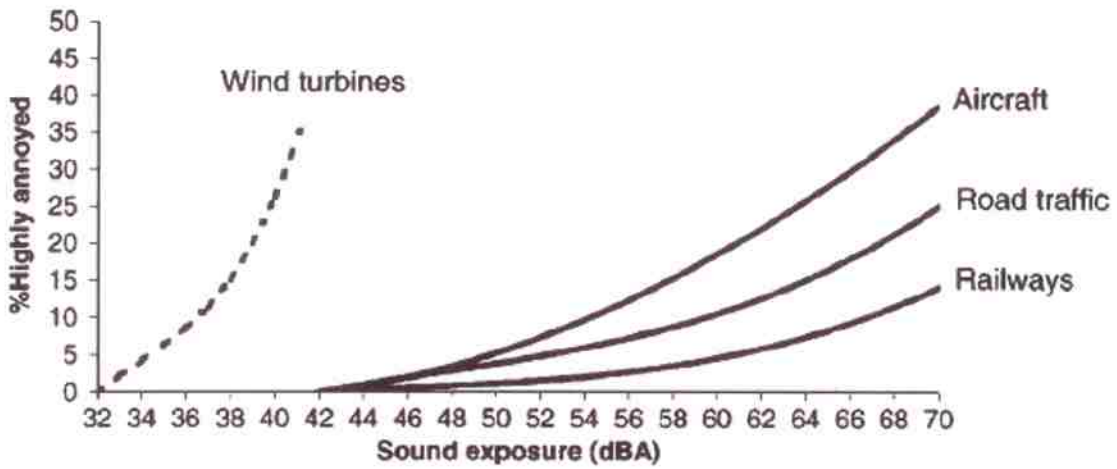
If a criterion were developed by making EPA's 10 dB correction from urban residential to *rural*, without considering the impact of 1) a new noise and 2) the

impulsive, low-frequency sound character, it follows that the EPA's Ldn 55 (55 day, 45 night) maximum permissible noise limits would be corrected to Ldn 45, with a night limit *not to exceed 35 dBA*. The predicted community reaction at the nearest neighbors could be "Sporadic Complaints" to "Widespread Complaints".

Does a maximum permissible limit of 45 dBA provide adequate provision to prevent an adverse noise impact from the wind turbines on public welfare (well-being) in *rural* areas? The answer is clearly, no, and this is why.

Figure 3 includes the results of independent wind turbine noise research by Pedersen & Waye in 2004 [3]. Their data confirm that there can be an adverse community reaction, with associated *activity interference*, including and especially *sleep interference*, for wind turbine noise levels above 32 dBA in rural areas. It should be noted that Pedersen & Waye data included on Figure 3 were obtained around multiple wind turbine sites with sizes ranging from 150kw to 600kw, much smaller than the Vestas V100 wind turbines proposed for Riga Township. The original Pedersen & Waye chart is provided as Figure 4 below showing the adverse community response ramping up quickly starting around 32 dBA, a full *10 dB below* the level where an adverse response from transportation noise starts up.

Figure 4 – Wind turbine noise compared to transportation



When the wind turbine sound level increases from 35 to 42 dBA, Pedersen & Waye found that increasingly, 6 to 45 percent of the community were highly annoyed, with the associated adverse health effects of *"psychological distress, stress, difficulties to fall asleep and sleep interruption."*[4]. Their 2004 best-fit equation suggests the *potential* for most of the community to be highly annoyed for noise levels around 45 dBA. This inference is noted in this letter's Figure 2 as a light extension through 45 dBA. The Pedersen & Waye research strongly suggests that wind turbine noise levels at 45 dBA in the *quiet rural* areas will result in the highest possible negative community response, with essentially all who can be affected highly annoyed, and the associated adverse health effects and activity interferences noted.

When the EPA and Pedersen & Waye assessments are taken together, there is strong evidence that the state of *well-being* (welfare) and being in a state of "*highly annoyed*" cannot coexist.

Have such adverse community noise reactions been observed near wind turbine facilities in quiet rural areas? *Yes.* Operating sound levels compiled for Mars Hill, Maine as well as field data acquired at Freedom, Maine and Vinalhaven, Maine have been charted for community reaction with sound level versus distance and, these clearly illustrate community reactions to those sites well known from news reports as correlated with the predicted community reactions from the EPA method. The charts are provided in Attachment 2.

<u>What criteria to use?</u>

A 45-dBA noise limit at 1/4 mile or so appears to be ineffective to prevent an adverse community reaction or protect public welfare at nearest neighbors from wind turbine noise in quiet rural areas. As a Member of INCE, I am pledged to protect public health as outlined in the INCE Canon of Ethics. The first Fundamental Canon reads as follows.

1. Hold paramount the safety, health and welfare of the public.