BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY DAKOTA RANGE I, LLC AND DAKOTA RANGE II,LLC FOR A PERMIT OF A WIND ENERGY FACILITY IN GRANT COUNTY AND CODINGTON COUNTY, SOUTH DAKOTA FOR THE RANGE WIND PROJECT	DIRECT TESTIMONY OF Teresa D. Kaaz EL18-003

Teresa D Kaaz, 15610 459th Ave South Shore, SD 57263
Direct testimony and attachments

Thank you all for giving me the opportunity to give my testimony.

I attended grade school at Grant-Deuel School, Revillo, SD attended Deuel High School, Clear Lake, SD, received GED and the attended LATI, Watertown, SD, took Banking and Finance.

In 2001 My Husband, Daniel Kaaz and I purchased 15.5 acres abandoned homestead and moved on our trailer house, from rural Watertown and also moved on a shop that his grandfather Karl Kaaz built. Years later we moved a 2 ½ story 1920 farmhouse on. We remodeled and restored it with new wiring, new windows, new roof, and all new plumbing. All we have left is finishing the basement and new siding which was scheduled for this spring but we put those renovations on hold.
If this application is approved these turbines could potentially be only 1000 feet from my house because of an outdated Codington county ordinance that was in affect when this CUP was approved. The towers proposed for this Wind facility are 4.2 mw Vestas and stand almost 500 feet tall. Turbines of this size have never been built in South Dakota before. I do not feel as if myself our any other person should be asked to live that close to these industrial turbines. Our view shed will be destroyed. The flicker day and night as we have clear view of sun rise and set and also moon rising and falling. I can look at the stars from our bedroom window and the red flashing lights will block that also. I spend my days at home so I will live with the constant noise 24 7. I don't feel as if I can afford to put any more money into my property as I will never get a return on investment. My property value will be devastated if not become completely unlivable. This is my home, our paw family is buried there. My husband and myself have grown up in this area all our lives and wanted to make this our forever home till we were too old to take care of it.
The current setback ordinance that this CUP granted by Codington county has taken away the full use of my property by trespass zoning. We will not be able to build a bigger shop, or put in a shelterbelt because the safety zone is 1640 feet so in case of a fire or brake failure the WES employees

are required to stay that far away until turbine is shut off. What am I suppose do, watch from my window or evacuate my home? It will effect the county economically as new families will not move into the area because there will be no land available that can be permitted to build.

A home buyer who wants to live in the country, they do so because of the peace and quiet, and the view. This will never be the same as previous generations have enjoyed. The current inhabitants will have sleepless nights due to the noise which their bodies will not get used to. Small towns will be unable to grow as they will not be able to increase their city limits.

Many small towns are not even able to build over two story buildings when surrounded by leased land owners industrial wind systems.

On April 17th 2018 just before sunset I took the pictures of a family of eagles feeding on a deer carcass in the right of way on highway which are included in attachments right outside to the north of Stockholm, SD about 1/8 mile from Stockholm sign. The second set of pictures titled, eagle Hamanns, was taken 3 22 2018 one and one half mile to the east of me at the Gary Hamann, address 46058 SD Hwy 20, South Shore, SD, residence in their shelterbelt. There location is in the footprint as application as well. This is why in first data request I have asked for new rapture study be completed. It has been our largest achievement we have done for ourselves and our family.

We have dedicated the past few years to improve our property. Our county tax rates have increased due to the improvements made. Our entire family has helped us through this project with long hours and dedication to make it our dream home. That could be all gone with an outdated ordinance in place at our county level.

We have met many new people through this process. It has been incredibly heartbreaking to see families give up their savings because they have to fight for their property rights. Others have made the decision to move away. But our family is here and we never had any intentions to move away from this area. We all understand the concept of renewable energy, but did not ever imagine that that was going to include loosig property values and rights.

In previous studies I have not seen a study which includes abandoned farm sights caused by wind turbine sittings. That would a give a more correct study of how WES effect property values and communities.




003191

WIND TURBINE NOISE, SLEEP AND HEALTH

Dr Christopher Hanning. BSc, MB, BS, MRCS, LRCP, FRCA, MD

November 2010

This paper is based on proofs of evidence produced for several UK Planning Inquiries. As such, it concentrates on the regulatory system in the UK. Other jurisdictions will have different systems.

The aim is to inform those seeking to regulate the siting of wind turbines close to human habitation.

The contents may be used freely without acknowledgement.

The paper will be updated from time to time so please check that you have the latest version from the Society for Wind Vigilance website: www.windvigilance.com

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Summary

Section 1 sets out my expertise in sleep medicine and physiology, my brief from CFA, the scope of the report and source material.

Section 2 reviews the basic physiology of sleep. Noise can disturb sleep by causing awakenings, which are remembered and arousals, which are not recalled but are more likely. Both disrupt sleep making it unrefreshing. Research on the effects of wind turbine noise has concentrated on remembered awakenings and has thus underestimated the effects.

Inadequate or poor quality sleep has many health consequences apart from daytime sleepiness and fatigue. These include obesity, poor memory, increased risk of diabetes, heart disease and high blood pressure. Vulnerable groups such as children and the elderly may be at greater risk.

Section 3 reviews research on wind turbine noise, sleep disturbance and health. These include the major contributions of van den Berg and Pedersen and the dose-response relationship derived from their data. Also considered are the Salford study and the Hayes McKenzie Partnership study commissioned by the DTI.

Recent major reports by WHO and RIVM are reviewed, both of which mandate lower night time noise levels than are permitted by ETSU-R-97. Predicted external turbine noise should not exceed 35dB to avoid disturbance to sleep and 40dB to avoid risks to health. Experience of existing wind farms mandates a setback of at least 1.5km in order to avoid disturbance to sleep.

It is concluded that there is compelling evidence that wind turbine noise can and does disturb sleep and impair the health of those living too close and that current guidance is inadequate protection.

Section 4 reviews the means of mitigating wind turbine noise to prevent sleep disturbance. It is concluded that external turbine noise levels of less than 35dB(A) or a setback of at least 1.5km of the turbines is necessary to prevent unacceptable levels of sleep disturbance and potential risk to health.

Section 5 reviews UK planning guidance and argues that the evidence presented constitute material considerations

Section 6 presents the conclusions of the report.

Section 7 lists the documents cited in support of this paper.

Figure 1. Sound level and annoyance for different noise sources
Figure 2. Sound level and annoyance for different noise sources
Figure 3. Noise levels and proportion of respondents disturbed in the sleep
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Table 1. Response to wind turbine noise outdoors or indoors
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1. Introduction

1.1 The author

1.1.1. My name is Dr Christopher Hanning, Honorary Consultant in Sleep Disorders Medicine to the University Hospitals of Leicester NHS Trust, based at Leicester General Hospital, having retired in September 2007 as Consultant in Sleep Disorders Medicine. In 1969, I obtained a First class Honours BSc in Physiology and, in 1972, qualified in medicine, MB, BS, MRCS, LRCP from St Bartholomew's Hospital Medical School. After initial training in anaesthesia, I became a Fellow of the Royal College of Anaesthetists by examination in 1976 and was awarded a doctorate from the University of Leicester in 1996. I was appointed Senior Lecturer in Anaesthesia and Honorary Consultant Anaesthetist to Leicester General Hospital in 1981. In 1996, I was appointed Consultant Anaesthetist with a special interest in Sleep Medicine to Leicester General Hospital and Honorary Senior Lecturer to the University of Leicester.

1.1.2. My interest in sleep and its disorders began over 30 years ago and has grown ever since. I founded and ran the Leicester Sleep Disorders Service, one of the longest standing and largest services in the country, until retirement. The University Hospitals of Leicester NHS Trust named the Sleep Laboratory after me as a mark of its esteem. I was a founder member and President of the British Sleep Society and its honorary secretary for four years and have written and lectured extensively on sleep and its disorders and continue to be involved in research. My expertise in this field has been accepted by the civil, criminal and family courts. I chaired the Advisory panel of the SOMNIA study, a major project investigating sleep quality in the elderly, and sit on Advisory panels for several companies with interests in sleep medicine. I am an Associate Member of the General Medical Council, chairing Investigation Committee hearings and Registration Panels. In 2010, I was invited to join the Board of the Society for Wind Vigilance.

1.2. Scope of report.

1.2.1. This report centres on the effects of industrial wind turbine noise on sleep and consequent effects on health as this is the particular area of expertise of the author.

1.3. Source material

1.3.1. A full list of the publications cited and other source material is given in Section 7 and are cited in the text. Material was obtained by searching the Web of Science database using the search terms “Noise”, “Sleep” and “Wind turbine”, internet searches using the same words and scrutiny of the reference lists of published articles and reviews. Where several articles come to the same conclusion, only the most recent may be cited, in the interests of brevity. As far as possible, articles published in peer reviewed journals are cited. However, it is inevitable that some of the material is available only on the internet reflecting the paucity of government sponsored research, particularly in the UK.

2. Background

2.1. Introduction

2.1.1. There can be no reasonable doubt that industrial wind turbines whether singly or in groups ("wind farms") generate sufficient noise to disturb the sleep and impair the health of those living nearby and this is now widely accepted. In reviewing potential health impacts of sustainable energy sources, three leading members of the National Institute of Environmental Health Sciences, part of the US National Institutes of Health, state: *"Wind energy will undoubtedly create noise, which increases stress, which in turn increases the risk of cardiovascular disease and cancer."* (Gohlke et al. 2008. Section 5.1.1 of the draft New Zealand standard on wind farm noise, 2009, states: *"Limits for wind farm noise are required to provide protection against sleep disturbance and maintain reasonable residential amenity."* ETSU-R-97, the UK guidance on wind turbine noise, is predicated in part on the WHO guidelines available at the time and so was intended to avoid sleep disturbance. As will be demonstrated, the ETSU-R-97 night time limits were set too high to prevent sleep disturbance. Reports from many different locations and different countries have a common set of symptoms and have been documented by Frey and Hadden (2007). New cases are documented regularly on the Internet. The symptoms include sleep disturbance, fatigue, headaches, dizziness, nausea, changes in mood and inability to concentrate and have been named "wind turbine syndrome" by Dr Nina Pierpont (2006). The experiences of the Davis (2008) and Rashleigh (2008) families from Lincolnshire whose homes were around 900m from wind turbines make salutary reading. The noise, sleep disturbance and ill health eventually drove them from their homes. Similar stories have been reported from around the world, usually in anecdotal form but in considerable numbers.

2.1.2 The WHO Environmental Burden of Disease – European countries project (EBoDE) (WHO, 2009a) selected nine environmental stressors for study, including noise (S6). *"The health effects of environmental noise were selected to cover psychosocial (sleep disturbance), cardiovascular effects*

(elevated blood pressure, IHD including myocardial infarction) and learning performance." These choices emphasise the importance that WHO place upon the effects of environmental noise on sleep disturbance.

2.1.3. One New York based wind turbine developer is reported as offering future neighbours of wind turbines payments of $5,000 in exchange for a waiver promising not to complain about excessive noise of the turbines once the turbines become operational (Yardley, 2010) which may be interpreted as tacit acceptance by at least one developer that noise complaints are highly likely.

2.2. Sleep, sleep physiology and the effects of noise

2.2.1. Sleep is a universal phenomenon. Every living organism contains, within its DNA, genes for a body clock which regulates an activity-inactivity cycle. In mammals, including humans, this is expressed as one or more sleep periods per 24 hours. Sleep was previously thought to be a period of withdrawal from the world designed to allow the body to recuperate and repair itself. However, modern research has shown that sleep is primarily by the brain and for the brain. The major purpose of sleep seems to be the proper laying down and storage of memories, hence the need for adequate sleep in children to facilitate learning and the poor memory and cognitive function in adults with impaired sleep from whatever cause.

2.2.2. Inadequate sleep has been associated not just with fatigue, sleepiness and cognitive impairment but also with an increased risk of obesity, impaired glucose tolerance (risk of diabetes), high blood pressure, heart disease, cancer, depression and impaired immunity as shown by susceptibility to the common cold virus. Sleepy people have an increased risk of road traffic accidents. Sleepiness, as a symptom, has as much impact on health as epilepsy and arthritis. It is not insignificant.

2.2.3 Humans have two types of sleep, slow wave (SWS) and rapid eye movement (REM). SWS is the deep sleep which occurs early in the night while REM or

dreaming sleep occurs mostly in the second half of the night. Sleep is arranged in a succession of cycles, each lasting about 90 minutes. We commonly wake between cycles, particularly between the second and third, third and fourth and fourth and fifth cycles. Awakenings are not remembered if they are less than 30 seconds in duration. As we age, awakenings become more likely and longer so we start to remember them.

Even while deeply asleep, the brain is processing sounds and deciding whether they merit awakening either because the sound has meaning or constitutes a threat. For example, at the same noise level, awakening is more likely when one's name is called rather than a non-specific noise. Similarly, a mother will wake when her baby cries but not for a passing car.

2.2.4. Noise interferes with sleep in several ways. Firstly, it may be sufficiently audible and annoying to prevent the onset of sleep or the return to sleep following an awakening. It is clear also that some types of noise are more annoying than others. Constant noise is less annoying than irregular noise which varies in frequency and loudness, for example, snoring, particularly if accompanied by the snorts of sleep apnoea (breath holding). The swishing or thumping impulsive noise associated with wind turbines seems to be particularly annoying as the frequency and loudness varies with changes in wind speed and local atmospheric conditions and the character of the noise may be perceived as threatening. While there is no doubt of the occurrence of these noises and their audibility over long distances, up to 3-4km in some reports, the actual cause has not yet been fully elucidated (Bowdler 2008). Despite recommendations by the Government's own Noise Working Group, government sponsored research in this area has been stopped. Stigwood (2008), an independent noise consultant, has demonstrated that this noise pattern is common with large turbines.

2.2.5. Secondly, noise experienced during sleep may arouse or awaken the sleeper. A sufficiently loud or prolonged noise will result in full awakening which may be long enough to recall. Short awakenings are not recalled as, during the transition from sleep to wakefulness, one of the last functions to

recover is memory (strictly, the transfer of information from short term to long term memory). The reverse is true for the transition from wakefulness to sleep. Thus only awakenings of longer than 20-30 seconds are subsequently recalled. Research that relies on recalled awakenings alone will therefore underestimate the effect.

2.2.6. Noise insufficient to cause awakening may cause an arousal. An arousal is brief, often only a few seconds long, with the sleeper moving from a deep level of sleep to a lighter level and back to a deeper level. Because full wakefulness is not reached, the sleeper has no memory of the event but the sleep has been disrupted just as effectively as if wakefulness had occurred. It is possible for several hundred arousals to occur each night without the sufferer being able to recall any of them. The sleep, because it is broken, is unrefreshing resulting in sleepiness, fatigue, headaches and poor memory and concentration (Martin 1997), many of the symptoms of “wind turbine syndrome”. Recent research (Dang-Vu, 2010) has shown that some subjects are more easily aroused than others.

Arousals are associated not just with an increase in brain activity but also with physiological changes, an increase in heart rate and blood pressure, which are thought to be responsible for the increase in cardiovascular risk. A clear relationship between high blood pressure and aircraft noise exposure has been shown by the HYENA consortium (Haralabidis 2008, Jarup 2008) and between traffic noise and high blood pressure for adults (Barregard 2009) and, worryingly, for preschool children (Belojevic 2008). The MESA study has suggested a link between exposure to traffic and alterations in heart function (Van Hee 2009) and Selander and colleagues (2009) have suggested a link with myocardial infarction (heart attack) but neither could separate noise effects from pollution. Arousals occur naturally during sleep and increase with age (Boselli 1998), as do awakenings which may make the elderly more vulnerable to wind turbine noise. Arousals may be caused by sound events as low as 32 dB(A) and awakenings with events of 42dB(A) (Muzet and Miedema 2005). The studies of Dang-Vu and colleagues (2010) suggest that arousals may occur at even lower sound levels in susceptible

individuals (Fig 4). Arousals in SWS may trigger a parasomnia (sleep walking, night terrors etc.). Pierpont (2009) notes that parasomnias developed in some of the children exposed to turbine noise in her study group.

2.2.7. Arousals are caused by aircraft, railway and traffic noise. In one study of aircraft noise, arousals were four times more likely to result than awakenings (Basner 2008a) and resulted in daytime sleepiness (Basner 2008b). Freight trains are more likely to cause arousals than passenger trains, presumably because they are slower, generating more low frequency noise and taking longer to pass (Saremi 2008). The noise of wind turbines has been likened to a “passing train that never passes” which may explain why wind turbine noise is prone to cause sleep disruption. A recent study of over 18000 subjects has shown a link between exposure to traffic noise and “the risk of getting up tired and not rested in the morning (de Kluizenaar, 2009). This study, together with that of Basner (2008b) confirms that excessive noise disturbs sleep sufficiently to impair its restorative properties and adds credence to the anecdotal reports of those living near wind turbines.

2.2.8. Studies of different alarm signals have shown that arousals and awakenings occur at lower sound levels with low frequency sounds than those of higher frequency (Bruck 2009). Repeated short beeps of 400-520Hz were most intrusive, leading to arousal and awakening. Wind turbine noise often has a considerable low frequency component and has an impulsive nature which may, in part, explain its adverse effect on sleep.

2.2.9. It is often claimed that continual exposure to a noise results in habituation, i.e. one gets used to the noise. There is no research to confirm this assertion although it has been suggested that the absence of noise for those usually subjected to high levels may cause insomnia (HPA 2009 5.29). A recent small study (Pirrera et al. 2009) looking at the effects of traffic noise on sleep efficiency suggests that habituation does not occur. Griefahn and colleagues (2008) have shown that the increases in heart rate with traffic noise induced arousals show no habituation.

2.2.10. Sleep disturbance and impairment of the ability to return to sleep is not trivial as almost all of us can testify. The elderly may be more vulnerable, not just because they have more spontaneous awakenings than the young but because their high frequency hearing loss may remove some of the masking of the lower frequency noise characteristic of wind turbines. In the short term, the resulting deprivation of sleep results in daytime fatigue and sleepiness, poor concentration and memory function. Accident risks increase. In the longer term, sleep deprivation is linked to depression, weight gain, diabetes, high blood pressure and heart disease. There is a very large body of literature but please see Meerlo et al., 2008 for recent work on this subject as well as the 2009 WHO/EU Night Noise Guidelines for Europe (WHO, 2009) and the recent reports of the Health Protection Agency (HPA 2009) and DEFRA (Berry and Flindell, 2009).

2.2.11. Sleep spindles are short bursts of high frequency oscillation seen in the brain's electrical activity (electroencephalogram, EEG) during SWS and are a marker of sleep stability. Recent research has shown that subjects with a higher spindle rate are less likely to show an arousal in response to a transient noise than a subject with a lesser rate and are less likely to report that noise disturbs their sleep (Dang-Vu et al., 2010). The spindle rate decreases with age, explaining the vulnerability of the elderly to noise induced sleep disruption. Insomniacs, when asleep, do not have necessarily have reduced spindle counts, thus suggesting that sensitivity to noise while asleep is not purely psychological but has a physical basis thus confirming the finding that noise sensitivity is, to a large degree, inherited.

A plot of sound level against the probability of stable sleep is presented (Figure 4). This is effectively an inverted dose-response curve of log sound pressure against the likelihood of an arousal. The study only examined noise stimuli of 40-70dB(A). However, it is reasonable to extrapolate backwards to lower noise levels. For subjects with a low spindle rate, even at a stimulus level of 35dB(A) there is an approximate 50% probability of an arousal and a 30% probability at 30dB(A). The subjects were 26.3 (± 7.5)

years of age. Older subjects would be expected to have even fewer spindles and to be even more sensitive to noise.

2.3. Psychological factors and Noise sensitivity

2.3.1. There is considerable interaction between the psychological response to noise and sleep disturbance, each worsening the other. It is well recognised that psychological factors and personality traits influence the response to noise. Approximately 15% of the population are noise sensitive and have both a lowered annoyance level and an enhanced cortisol response, a physiological marker of stress. Noise sensitivity is considered to be a stable, partly heritable, personality trait; the noise sensitive being at one end of a continuum with the noise tolerant at the other. It is often implied that those who are highly annoyed by noise, including wind turbine noise, are motivated simply by a dislike of the noise source or are psychologically disturbed in some way. This is simply not the case, the response of the noise sensitive being as normal a reaction as that of the noise tolerant.

2.3.2. The noise sensitive are more likely to have stress related disorders, anxiety, headaches etc and poor sleep than the average. They are more likely to be found in the countryside where noise disturbance is less. Pedersen (2004) reported that 50% of her rural subjects were rather or very noise sensitive. Noise sensitivity is more likely in those with brain injury and psychological disorders such as dyslexia and increased community noise may exacerbate depression in susceptible individuals.

Flindell and Stallen (1999) listed factors influencing the degree of annoyance to noise:

- Perceived predictability of the noise level changing
- Perceived control, either by the individual or others
- Trust and recognition of those managing the noise source
- Voice, the extent to which concerns are listened to
- General attitudes, fear of crashes and awareness of benefits

- Personal benefits, how one benefits from the noise source
- Compensation, how one is compensated due to noise exposure
- Sensitivity to noise
- Home ownership, concern about plummeting house values
- Accessibility to information relating to the noise source

to which may be added:

- Perceived value of the noise source
- Expectation of peace and quiet
- Visual impact

Disempowerment and loss of control is a common theme from reports of those subjected to excessive wind turbine noise. The impulsive character of the noise is perceived as threatening and it can not be escaped being audible within the home, the usual source of refuge and quiet to permit restoration (Pedersen 2008). The end result is fear and anger at loss of control over the living environment with increased stress responses including increased difficulty in initiating and maintaining sleep. The increased wakefulness at night and the lower quality sleep increase the impact of nocturnal turbine noise on sleep, increasing the daytime fatigue and stress and so on in a reinforcing cycle.

2.3.3. Petrie, a New Zealand health psychologist, in evidence for the developers to the Wellington Environment Court, claims that reactions to wind turbine noise are akin to the health scares associated with new technologies and draws parallels with previous health scares such as mobile phone masts and electricity (Petrie, 2010). He claims that this explains adverse responses to wind turbine noise at sound levels deemed safe by regulators such as the WHO. In so doing, he makes the unwarranted assumption that the sound levels are indeed safe and overlooks the many observations that turbine noise is often greater than predicted and more intrusive and annoying than other noise sources. Wind turbine noise contains more low frequency sound than other common noises also. Previous health scares he cites have generally been about emanations which are undetectable by the

human senses, such as microwave radiation, and where there is no obvious mechanism for the putative harm. This is certainly not true for wind turbine noise which is readily detected and the mechanism for harm clear. There is no dispute that psychological factors play a part in any reaction to turbine noise, to suggest that they are the sole explanation is contrary to the evidence.

2.3.4. The psychological response to noise and noise sensitivity is a complex area and an excellent review is given by Shepherd, a psychoacoustician (Shepherd 2010).

3. Wind turbine noise, sleep and health

3.1. Introduction

3.1.1. The evidence above demonstrates that it is entirely plausible that wind turbine noise has the potential to cause arousals, sleep fragmentation and sleep deprivation. As noted above, the draft New Zealand standard on wind farm noise (2009) acknowledges that sleep disturbance is the major adverse consequence of wind turbine noise for humans.

3.1.2 Unfortunately **all** government and industry sponsored research in this area has used **reported awakenings** from sleep as an index of the effects of turbine noise and tend to dismiss the subjective symptoms. Because most of the sleep disturbance is not recalled, this approach seriously **underestimates** the effects of wind turbine noise on sleep. It may be argued also that it is not the number of awakenings or arousals that are important but their overall effects on those subjected to the noise. Assessments of sleep quality and daytime functioning (sleepiness, fatigue and cognitive function) would be more appropriate outcome measures.

3.2. Early research.

3.2.1. Surveys of residents living in the vicinity of industrial wind turbines show high levels of disturbance to sleep and annoyance. A 2005 survey of 200 residents living within 1km of a 6 turbine, 9MW installation in France showed that 27% found the noise disturbing at night (Butre 2005). A similar US survey in 2001 (Kabes 2001) of a "wind farm" in Kewaunee County, Wisconsin reported that 52% of those living within 400-800 metres found the noise to be a problem, 32% of those living within 800-1600 metres and 4% of those within 1600 and 3200 metres. 67% of those living within 250 to 400 metres and 35% of those within 400-800 metres reported being awoken by the sound in the previous year. The principal health problem reported by the 223 respondents was sleep loss. The landscape of Kewaunee County is described as "undulating to gently rolling". Pedersen and Waye (2004) reported that "16% (*n*=20, 95%CI: 11%–20%) of the 128 respondents living at calculated external turbine noise exposure above 35.0 dB LAeq stated that they were disturbed in their sleep by wind turbine noise." All of these studies use reported awakenings and may therefore underestimate the effects of wind turbine noise on sleep.

3.2.2. Phipps and others (2007) surveyed 1100 New Zealand households sited up to 3.5 km from a wind farm, 604 responded. 75% of all respondents reported being able to hear the noise. Two separate developments have placed over 100 turbines with capacities from 600kW to 1.65MW in a hilly to mountainous area. It has been suggested that mountainous areas may allow low frequency noise to travel further which may explain the long distance over which the turbines were heard. This suggestion tends to be confirmed by a recent study which is detailed below for convenience.

Phipps (2007a) has reported a further analysis of this data. All subjects lived more than 2km from the turbines, 85% living within 3.5km. 13% of 284 respondents heard the turbines at night either frequently or most of the time. 42 households reported occasional sleep disturbance from turbine noise and 26 were disturbed either frequently or most of the time. Phipps

concludes that the New Zealand Standard for Wind Turbine Noise should be modified so that "the sound level from the wind farm should not exceed, at any residential site, and at any of the nominated wind speeds, the background sound level (L_{95}) by more than 5 dBA, or a level of 30 dBA L_{95}, whichever is less."

3.2.3. Bakker and colleagues (Bakker 2009) report their observations on noise problems, including sleep deprivation, associated with wind turbines at least 3km from the affected properties. The Tararua, New Zealand, turbines are sited on a ridge and the affected properties are to the east in a river valley. Noise problems persisted despite the installation of sound reducing glazing. Nocturnal seismic noise monitoring showed noise bursts lasting at least 10 seconds, associated with an easterly wind, which the authors were confident originated from the turbines. The residents confirmed that the noise recorded was identical with that which disturbed their sleep. The authors speculate that the noise was transmitted through the ground. The importance of this report is not the mechanism for sound transmission but scientific confirmation that wind turbines can disturb sleep at distances of 3km. Previous anecdotal reports have often be dismissed as fanciful with assertions that sound transmission over such distances is impossible. While this seems, so far, to be an isolated case, it adds further evidence that much greater setbacks than those currently required are necessary to obviate sleep disturbance.

3.2.4. Van den Berg (2004) found that residents up to 1900 m from a wind farm expressed annoyance with the noise, a finding replicated in his more recent study reported below. Dr Amanda Harry (2007), a UK GP, conducted surveys of a number of residents living near several different turbine sites and reported a similar constellation of symptoms from all sites. A study of 42 respondents showed that 81% felt their health had been affected, in 76% it was sufficiently severe to consult a doctor and 73% felt their life quality had been adversely impacted. This study is open to criticism for its design which invited symptom reporting and was not controlled. While the proportion of those affected may be questioned it nevertheless indicates strongly that

some subjects are severely affected by wind turbine noise at distances thought by governments and the industry to be safe.

3.3. Project WINDFARMperception

3.3.1. van den Berg and colleagues (2008) from the University of Groningen in the Netherlands have published a major questionnaire study of residents living within 2.5km of wind turbines, Project WINDFARMperception. A random selection of 1948 residents were sent a similar questionnaire to that used by Pedersen in her studies in Sweden (2003, 2004, 2007 and 2008), questions on health, based on the validated General Heath Questionnaire (GHQ), were added. 725 (37%) replied which is good for a survey of this type but, nevertheless, may be a weakness. Non-respondents were asked to complete a shortened questionnaire. Their responses did not differ from full respondents suggesting the latter are representative of the population as a whole.

Questions on wind turbine noise were interspersed with questions on other environmental factors to avoid bias. The sound level at the residents' dwellings was calculated, knowing the turbine type and distance, according to the international ISO standard for sound propagation, the almost identical Dutch legal model and a simple (non spectral) calculation model. The indicative sound level used was the sound level when the wind turbines operate at 8 m/s in daytime -that is: at high, but not maximum power. Ground absorption was set to 1.0, a 100% sound absorbing surface. Typical values are around 0.5 and thus the sound levels may have been under-estimated. Noise exposure ranged between 24 and 54dB LAeq. It is worth noting that the wind industry was approached for assistance in the research but refused. Complaints such as annoyance, waking from sleep, difficulty in returning to sleep and other health complaints were related to the calculated noise levels.

Relevant conclusions include. *"Sound was the most annoying aspect of wind turbines"* and was more of an annoyance at night. Interrupted sleep

and difficulty in returning to sleep increased with calculated noise level as did annoyance, both indoors and outdoors. Even at the lowest noise levels, 20% of respondents reported disturbed sleep at least one night per month. At a calculated noise level of 30-35dB LAeq, 10% were rather or very annoyed at wind turbine sound, 20% at 35-40dB LAeq and 25% at 40-43dB LAeq, equivalent to 38-41dB LA_{90}, less than the permitted minimum ETSU-R-97 night time level.

3.3.2. Project WINDFARMperception further found that *"Three out of four participants declare that swishing or lashing is a correct description of the sound from wind turbines. Perhaps the character of the sound is the cause of the relatively high degree of annoyance. Another possible cause is that the sound of modern wind turbines on average does not decrease at night, but rather becomes louder, whereas most other sources are less noisy at night. At the highest sound levels in this study (45 decibel or higher) there is also a higher prevalence of sleep disturbance."* The lack of a control group prevents this group from making firmer conclusions about turbine noise and sleep disturbance but it is clear that as ETSU-R-97 permits an exterior night time noise level of 43dB, relying on its calculations will guarantee disturbed sleep for many of those living nearby.

3.3.3. van den Berg concluded also that, contrary to industry belief, road noise does not adequately mask turbine noise and reduce annoyance and disturbance. In addition, the authors compared their results with studies by Miedema on the annoyance from road, rail and air related noise. Wind turbine noise was several times more annoying than the other noise sources for equivalent noise levels (**Fig 1**). Similar data is given by Pedersen (2004) (**Fig 2**) – **see end of text**.

3.3.4 With regard to health it was concluded that: *"There is no indication that the sound from wind turbines had an effect on respondents' health, except for the interruption of sleep. At high levels of wind turbine sound (more than 45 dB(A)) interruption of sleep was more likely than at low levels. Higher levels of background sound from road traffic also increased the odds for*

interrupted sleep. Annoyance from wind turbine sound was related to difficulties with falling asleep and to higher stress scores. From this study it cannot be concluded whether these health effects are caused by annoyance or vice versa or whether both are related to another factor." The conclusions regarding general health are not justified from the data for the reasons given below and must be disregarded.

3.3.5. Project WINDFARMperception is currently the largest study in this field but the study is not without considerable flaws. The study may be criticised for using calculated noise levels and for not having a control group (residents not living near turbines). While several of the contributors have expertise in the investigation of health matters, none has specific expertise in the physiology and pathophysiology of sleep. The purpose of the study, as its title suggested, was the public perception of wind turbines and their noise. Health questions were added but were of a very general nature. The small number of respondents suggests that any conclusions as to the apparent lack of an effect on health must be regarded as tentative.

3.3.6. The analysis of reported sleep interruption and wind turbine sound levels is flawed by the use of subjects exposed to calculated external turbine sound levels of <30dB(A) (p53) as the "controls". It has been noted by several studies that calculated turbine noise is often less than measured noise and that levels as low as 30dB(A) can cause annoyance (Pedersen 2007). Examination of the odds ratio for different calculated sound levels (Table 7.42) shows that it increases progressively with increasing sound levels starting at 30-35dB(A) and becomes statistically significant for levels >45dB(A). If, as is not impossible, the "control" group had its sleep disturbed by wind turbine noise then the actual effect would be underestimated.

3.3.7. The major objection to the conclusions on health is that the study is grossly under-powered (insufficient subjects were studied for any degree of statistical confidence). Marked ill-health, "Wind turbine syndrome", to the degree reported by Pierpont (2009), does not seem to be common even amongst those exposed to high noise levels. The study tried to detect

chronic disease with the GHQ, which is a fairly crude instrument. Assuming that “wind turbine syndrome” affects 1% of those exposed to calculated sound levels >45dB(A) and that 25% of the general population suffer from chronic disease (p47) then at least 30,000 subjects would need to be studied in each group (>45dB(A) v <30dB(A)) to be able to prove a difference with 95% certainty. Even if a prevalence of “wind turbine syndrome” of 5% of those exposed to >45dB(A) is assumed, then there must be at least 1250 subjects in each group. It is possible also that those with a degree of ill health are more vulnerable and more likely to develop symptoms. A general health questionnaire will not detect such people and symptom specific surveys will be required. This study therefore can not conclude that wind turbines do not cause ill health of any degree, it can not even make conclusions about severe ill health.

3.3.8. Pedersen, van den Berg and others (Pedersen 2009a&b) have further analysed the data in an attempt to model a generalised dose-response relationship for wind turbine noise. A noise metric, Lden, was calculated (Miedema 2000). Lden is based on long-term equivalent sound pressure levels adjusted for day (d), evening (e) and night). Penalties of 5 and 10dB are added for evening and night hours respectively to reflect the need for quietness at those times. dB(A) LAeq values for wind turbines may be transformed to Lden values by adding 4.7±1.5 dB (van den Berg 2008). Annoyance is used as the principal human response to wind turbine noise in this analysis. In this context, “annoyance” is more than simply irritation but is a measure of lack of well-being in a wider sense (Pedersen 2009a) and is contrary to the WHO definition of health.

Annoyance increased with increasing sound levels, both indoors and outdoors. The proportion who were rather and very annoyed at different sound levels are shown in Table I. In summary, when outside, 18% were rather or very annoyed at sound levels of 35-40 and 40-45 dB LAeq compared to 7% at 30-35dB LAeq and 2% at <30dB LAeq. When inside, the equivalent figures were 1% at <30dB LAeq, 4% at 30-35dB LAeq, 8% at 35-40dB LAeq and 18% at 40-45dB LAeq. Those respondents who had an

economic interest in the turbines had lower levels of annoyance while negative views of the visual impact of turbines increased the likelihood of annoyance.

Although the authors do not seek to recommend minimum sound levels, they do note that turbine noise was more annoying than other sources, with the possible exception of railway shunting yards and was more noticeable at night. They conclude that: *"...night time conditions should be treated as crucial in recommendations for wind turbine noise limits."* Nevertheless, it is clear from this analysis that external predicted turbine sound levels should be less than 35dB LAeq (33dB LA_{90}), considerably less than those permitted by ETSU R 97, in order to reduce effects on nearby residents to acceptable levels.

3.3.8. Pedersen (2009a&b) has recently combined the datasets from three studies (Pedersen 2004 (SWE00)) and 2007 (SWE05) and van den Berg 2008 (NL07)) as they used similar questionnaires giving a total of 1764 subjects. A strong correlation was seen in all studies between calculated A weighted sound pressure levels and outdoor annoyance as noted above.

Even at sound pressures of 30-35 dB LAeq, 5-12% of subjects were very annoyed. Correlations were found also between annoyance and symptoms of stress (headache, tiredness, tension and irritability) confirming that "annoyance" is more than irritation and is a marker of impaired health. The sleep disturbance question did not ask causation of the sleep disturbance and a background level would therefore be expected from other causes (traffic noise, weather, etc). Nevertheless, there was a clear increase in levels of sleep disturbance with A-weighted sound pressure in studies SWE00 and NL005. **(Figure 3)**. Pedersen states *"In the first Swedish study (SWE00) the increase of respondents that reported sleep interruption appears to be between the sound level interval 35-40 dB(A) and 40-45 dB(A). The increase came at higher sound levels in the Dutch study (NL07); between the interval 40-45 dB(A) and >45 dB(A)"*. All values are LAeq. There is no true measurement of background levels of sleep disturbance as

no study had a control group, it is difficult therefore to determine at what sound pressure level turbine noise begins to have an effect. but even the conservative levels suggested above are less than those permitted by ETSU R 97. **Fig 3 see end of text.**

3.3.9. Jabben and colleagues (2009) from RIVM, the Dutch National Institute for Public Health and Environment, were commissioned by the Dutch Government to examine the impact of different values of Lden on the ability to meet targets for onshore wind power generation. They reviewed current evidence and noted that, at present, 440,000 inhabitants (2.5% of the population) were *"receiving significant noise contribution from wind turbine noise of which 1,500 are expected to suffer severe annoyance. It is remarkable that almost half of this number already occurs within the range Lden 30-40db(A)".* Despite this, they recommend an Lden of no more than 40dB(A), which corresponds to a calculated external turbine noise level of about 35dB(A), in order for the Dutch Government to meet its 2011 target for wind turbine installations.

3.3.10. All of the studies cited in this section have used reported sleep disturbance and annoyance in determining maximum sound levels. As noted in Section 2.2, reported sleep disturbances underestimate sleep disturbance and may not reflect actual physiological consequences. The precautionary principle demands that lower sound levels be selected in order to leave a margin of safety.

3.4. Pierpont studies

3.4.1. Pierpont (2009) has recently completed a detailed case-series study of 10 families around the world who have been so affected by wind turbine noise that they have had to leave their homes, nine of them permanently. Subjects were selected from respondents to an appeal for those regarding themselves as suffering from ill health as a result of exposure to turbine noise. The turbines ranged from 1.5 to 3MW capacity at distances between 305 to 1500m. The group comprised 21 adults, 7 teenagers and 10 children

of whom 23 were interviewed. While this is a highly selected group, the recording of symptoms before, during and after exposure to turbine noise gives it a strength rarely found in similar case-series studies. The subjects described the symptoms of wind turbine syndrome outlined above and confirmed that they were not present before the turbines started operation and resolved once exposure ceased. There was a clear relationship between the symptoms, even in children, and the noise exposure. Pierpont reports also that all adult subjects reported *"feeling jittery inside"* or *"internal quivering"*, often accompanied by anxiety, fearfulness, sleep disturbance and irritability. Pierpont hypothesises that these symptoms are related to low frequency sound and suggests physiological mechanisms to explain the link between turbine exposure and the symptoms.

3.4.2. Of particular concern were the observed effects on children, include toddlers and school and college aged children. Changes in sleep pattern, behaviour and academic performance were noted. 7 of 10 children had a decline in their school performance while exposed to wind turbine noise which recovered after exposure ceased. In total, 20 of 34 study subjects reported problems with concentration or memory.

3.4.3. Pierpont's study mostly addresses the mechanism for the health problems associated with exposure to wind turbine noise rather than the likelihood of an individual developing symptoms. Nevertheless, it convincingly shows that wind turbine noise is strongly associated with the symptoms she describes, including sleep disturbance. She concludes by calling for further research, particularly in children, and a 2km setback distance.

3.4.4. A recent paper (Todd et al, 2008) has shown that the vestibular system in the human ear, the part concerned with detection of movement and balance, is exquisitely sensitive to vibration at frequencies of around 100Hz. Pierpont claims that these findings support her hypotheses although Todd has contradicted these assertions. More recently, Salt (Salt 2010) has suggested that some parts of the inner ear may be sensitive to low

frequency noise below the limit of audibility and raises the possibility of influencing function or causing unfamiliar sensations.

3.4.5. Leventhall, formerly Professor and Head of the Institute of Environmental Engineering at South Bank University and an expert on low frequency noise, accepts that the symptoms described by Pierpont's subjects are real but maintains that the low frequency sound energy created by wind turbines is too low to cause direct physiological effects (Pool, 2009 and personal communication 2009). He suggests that the symptoms are a result of psychological stress secondary to noise annoyance, particularly low frequency noise. and sleep disturbance. Similar symptoms were described by Møller and Lydolf (2002).

The NHS Knowledge Service reviewed Dr Pierpont's book (NHS 2009) and concluded: *"No firm conclusions can be drawn from this study as the design was weak and included only 38 people. Participants were asked about their symptoms before they were exposed to wind turbines to provide a control for their symptoms after exposure. This was not a sufficient control as many of the participants were reportedly already convinced that wind turbines caused their symptoms and were actively trying to move out of their homes or had already moved. Further study is needed."*

The call for further research has been heeded in Japan, Yomiuri Shimbun, a leading Japanese newspaper, (November 29th 2009) reports that the Japanese Environment Ministry has commissioned a four year study into the effects of low frequency turbine noise on human health. The question as whether "wind turbine syndrome" is a distinct clinical entity remains unsettled at this time.

A Japanese newspaper, Asahi Shimbun, (Ito and Takeda 2009) in a report of the decision of the Japanese Environment Ministry to investigate the potential health effects of wind turbine noise has reported it's own survey of complaints of wind turbine noise directed at state and local authorities and wind turbine operators in Japan. 30 of 376 locations (8%) had received

complaints, 90% of which concerned health problems which included insomnia, headaches, dizziness and buzzing in the ear.

Izumi Ushiyama, president of the Ashikaga Institute of Technology and an expert on wind power generation, is quoted as saying that: "*operators must listen to residents before pushing their projects. Some operators make light of communications with residents in carrying out their projects, which causes friction. This has tarnished the image of wind power generation and blocked its promotion."*

Ushiyama is quoted also as saying that a third-party "communicator," trusted by both operators and residents, must be called upon to make adjustments because the two sides may become involved in confrontations if left alone to discuss the issue.

This report shows that not only are complaints about wind turbine noise consistent across cultures so also are the symptoms.

3.5. DTI report

3.5.1. The UK Department of Trade and Industry (DTI) commissioned a report from the Hayes McKenzie Partnership (HMP) in 2006 which investigated low frequency noise at three UK wind farms. As far as can be determined, no medical or physiological expertise was used in the design of the study. Sound measurements were taken at three of five sites where complaints had been recorded over periods from 1-2 months.

Communication with residents other than those who complained was minimal. However, they did confirm that *"some wind farms clearly result in modulation at night which is greater than that assumed with the ETSU-R-97 guidelines".* Measured *"internal noise levels were insufficient to wake up residents at these three sites. However, once awoken, this noise can result in difficulties in returning to sleep."*

The lack of physiological expertise in the investigators in not recognising that noise can disturb sleep without actual recalled awakening is a major methodological flaw rendering the conclusions unreliable, as is the short recording period. It is well recognised also that not every resident affected by a nuisance such as noise will actually register a complaint (Health Protection Agency 2009). Many will not be sufficiently literate or confident so to do and others may wish to avoid drawing attention to the problem to protect property prices. They may assume also that protest is futile, which seems to be the experience of many with wind turbine noise. The WHO and other research by DEFRA suggest complaints may represent between 5-20% of sufferers with others seeking alternative coping strategies. Recorded complaints are thus the tip of the iceberg.

3.5.2. It will be claimed also that only 5 of 126 wind energy developments at the time of the study had attracted complaints of noise and thus the matter is trivial. This assertion is, to say the least, disingenuous. Many of the developments at that time were of small turbines set in isolated areas of the countryside, well away from habitation. In addition, as noted above, the proportion of those affected by wind turbine noise who formally complain to their local authority is very small. Research into wind farm noise and health issues in the UK is virtually non-existent and of poor quality. To suggest that there is “no problem” when faced with the large body of evidence presented here is perverse. The conclusion is also contradicted by Moorhouse’s study (vide infra) which showed a complaint rate of 20%.

3.5.3. Draft versions of the report (DTI 2006a,b,c) have recently come to light as a result of Freedom of Information requests. They show that HMP had recommended a reduction of the ETSU-R-97 permitted night time limits to 38dB LA90 (40dB LAeq) in the absence of AM with a further penalty of up to 5dB in the presence of modulation. These recommendations were removed from the final version of the report. No scientific explanation for their removal seems to have been offered. An example of removed text follows:

"The analysis of the external and internal noise levels indicates that it may be appropriate to re-visit the issue of the absolute night-time noise criterion specified within ETSU-R-97. To provide protection to wind farm neighbours, it would seem appropriate to reduce the absolute noise criterion for periods when background noise levels are low. In the absence of high levels of modulation, then a level of 38 dB LA90 (40 dB LAeq) will reduce levels to an internal noise level which lies around or below 30 dB LAeq with windows open for ventilation. In the presence of high levels of aerodynamic modulation of the incident noise, then a correction for the presence of the noise should be considered."

Similarly, references to WHO guidance for the protection of sleep disturbance which supported HMP's recommendations for a reduction in ETSU-R-97 night time noise limits were removed. The removed text follows:

"If one takes the guidance within the WHO for the protection against sleep disturbance of 30dB LAEq, and apply a 5 dB correction for the presence of high levels of [aerodynamic] modulation within the incident noise, then this gives rise to an internal noise criterion of 25dB LAeq. Based upon the measured building attenuation performances at Site 1 & 2, then an external level between 35 – 40dB LAEq (33-38 dB LA90) would provide sufficient protection to neighbouring occupants to minimise the risk of disturbance from the modulation of aerodynamic noise."

It is quite clear that relying on the conclusions of this report, as published, is unwise as they are, at best, misleading.

3.6. Salford study

3.6.1. Moorhouse of the University of Salford (2007) were commissioned by DEFRA to conduct a study of Aerodynamic Modulation of Wind Turbine Noise. A survey was made of the local authorities responsible for wind farms in, or adjacent to, their area. 133 wind farms were identified of which 27 (20%) had attracted complaints. An attempt was made to correlate

complaint logs with recorded wind speed and direction. Once again the methodology is fundamentally flawed. Complaints were solicited from local authorities and not from residents. The review was entirely theoretical with no communication with residents and relied on the opinions of environmental health officers. The conclusions were that AM was such a minor problem that no further research was warranted.

3.6.2. The Editor of Noise Bulletin greeted the publication of the report thus:

"`New report eases concerns over wind turbine noise' trumpets the Government press release, then saying aerodynamic modulation is `not an issue for the UK's wind farm fleet'. This conclusion is not justified based on the report, and by halting further research work without transparently monitoring the wind farms subject to complaints will inflame, not ease concern of objectors ... Only when the public can trust the Government and wind farm developers on noise issues will there be a chance that the public will accept them without a fight ..."
(Pease J. *Noise Bulletin*, Issue 15, Aug/Sept. 2007 page 5).

3.6.3. On 2 August 2007, Dick Bowdler, an acoustician and member of the Noise Working Group which commissioned the report, resigned from the NWG. This highly unusual step was taken because, as his letter states:

"I have read the Salford Report and the Government Statement. As a result I feel obliged to resign from the Noise Working Group.
The Salford Report says that the aims of this study are to ascertain the prevalence of AM from UK wind farm sites, to try to gain a better understanding of the likely cause, and to establish whether further research into AM is required. This bears little relation to what we asked for which is clearly set out in the minutes of the meeting in August 2006. We all knew then (as was recorded in the original notes of the meeting) that complaints concerning wind farm noise are currently the exception rather than the rule. The whole reason for needing the research was that `The trend for larger more sophisticated turbines could lead to an increase in noise from AM'.
It was not the intended purpose of the study to establish whether more research was required. We all agreed at the August 2006 meeting that such research was needed. That was precisely the outcome of the meeting. The prime purpose of what eventually became the Salford Report was to identify up to 10 potential sites which could be used to carry out objective noise measurements. The brief for the Salford report, which was never circulated to the NWG, completely ignored the NWG views.
Additionally, I find it entirely unacceptable that we are not to be told the names of the wind farms listed in the Salford report. So the only part of the

report of any value to assist future research is inaccessible to those of us who would like to progress matters further.
Looking at the Government Statement it is clear that the views of the NWG (that research is needed into AM to assist the sustainable design of wind farms in the future) have never been transmitted to government and so the Statement is based on misleading information".
(*Noise Bulletin*, Issue 15, Aug/Sept. 2007 page 5)

3.6.4. If both a leading commentator in the field and a leading member of the Government's own working group have no faith in the study then its conclusions may safely be dismissed.

3.6.5. Following a refusal by the Salford research team and the DTI to share the study's full data, the actual questionnaire response forms were finally made available after a Freedom of Information request by the Renewable Energy Foundation. The low quality of this research is evident from the poor responses from many local authorities, many of whom clearly did not understand the concept of AM, compounded by the questionnaire design and the phrasing of the questions. This further serves to demonstrate that current planning guidance, and in particular ETSU R 97, are inadequate at preventing noise annoyance.

3.7. Acoustician opinions

3.7.1. George Kamperman, (2008 personal communication) a distinguished US noise engineer, is quoted in Pierpont's book as saying, *"After the first day of digging into the wind turbine noise impact problems in different countries, it became clear the health impact on persons living within about two miles from 'wind farms' all had similar complaints and health problems. I have never seen this type of phenomenon [in] over fifty plus years of consulting on industrial noise problems. The magnitude of the impact is far above anything I have seen before at such relatively low sound levels. I can see the devastating health impact from wind turbine noise but I can only comment on the physical noise exposure. From my viewpoint we desperately need noise exposure level criteria."* Kamperman's recommended setback of at least 1km (Kamperman & James 2008) has changed to at least 2km as a result of Dr Pierpont's evidence (Kamperman

2008 personal communication). He has recently published a more detailed set of recommendations to determine setback distances (Kamperman & James 2008b) which, amongst others, require that turbine noise should not be more than 5dB(A) above background and should not exceed 35dB(A) within 30m of any occupied structure.

3.7.2. Dr Robert Thorne, an Australian acoustician has investigated wind turbine noise at several sites in Australia and New Zealand. His conclusions can be found in several expert reports submitted to Planning Inquiries, most recently Turitea (Thorne 2010a & b) and Yaloak (Thorne 2010c). He states (Thorne 2010c para 6.18):

"I am of the opinion, based on my own research, that wind farm noise can and does create unreasonable noise within residences and consequential adverse effects in the sense of sleep disturbance, annoyance and potential adverse health effects to residents living within 2000 metres of large wind turbines set in a wind farm. These risks are quantifiable and are of high probability. The effect is significantly more than minor."

3.7.3. Dr Dan Driscoll, formerly a noise control engineer for the New York Public Service Commission, answered questions at an Environmental Stakeholder Roundtable on Wind Power sponsored by the New York State Energy Research and Development Agency held in New York on the 16th June 2009 (Driscoll 2009). He takes as the basis for his thesis the well established US Environmental Protection Agency's (EPA) paper on Levels of Environmental Noise. The EPA uses a day/night average sound level, L_{dn}, similar to the L_{den} recommended in Europe, with a 10dB(A) penalty for night noise. An L_{dn} of 55dB(A) is recommended as adequate to protect from outdoor activity interference and annoyance. Various research studies suggest that a normalised L_{dn} of 55dB(A) would cause little or no community reaction although the noise would be noticeable. The estimated sound output L_{dn} is normalised by adjusting for a range of factors; in this case, 10dB is added for a quiet suburban or rural setting, 5dB if the community has no prior experience with the noise and 5dB if the sound is impulsive. He calculates that a 2.5MW turbine producing an

L_{eq} of 49dB(A) at 500ft would have an uncorrected L_{dn} of 55dB. Adding the adjustments gives a normalised turbine L_{dn} of 75dB which is a level at which the EPA expects that community reaction would include threats of legal action and strong appeals to stop the noise. This certainly corresponds with the current reaction to turbine noise in all parts of the world, including the UK. Using EPA data, Driscoll estimates that a normalised L_{dn} of 59dB would be sufficient to reduce community reaction to sporadic complaints which equates to an external turbine noise of 33dB(A) and a setback of about 1km. It is noteworthy that the conclusions of this noise control approach are in accord with the recommendations of Kamperman and James (Section 3.7.1), Hayes in his recommendations to the DTI (Section 3.5.3) and my own estimations based upon the work of Pedersen and others (Section 3.3.8).

3.7.4 A similar approach has been taken by Ambrose and Rand (Ambrose 2010). They produce a similar graph to Driscoll (Figure 5) but add the annoyance levels determined by Pedersen and Persson Waye (Pedersen 2004). Both studies confirm that an unacceptable level of adverse community response is likely for wind turbine noise levels above 32dBA.

3.8. WindVoice

3.8.1 WindVoice (2010) have recently published the initial results of a self-reporting survey of communities affected by wind turbine noise. As of July 2010, 144 responses had been received of which 118 reported one or more health effects. 84 (58%) reported sleep disturbance and 85 (59%). There were no age differences between those that reported sleep disturbance (51.5 yr (19-79)) and those that did not (52.2 yr (26-86)).

Those that reported sleep disturbance lived an average of 897m (360-5000) from turbines compared to 890m (350-3500) for those who did not. The similarity in distance from turbines for the two groups suggests that noise sensitivity may be significant factor in sleep disturbance. A slightly greater

proportion of females reported sleep disturbance than males. Caution must be exercised in drawing conclusions from self reporting surveys. Nevertheless, it is evident that significant numbers of individuals are reporting sleep disturbance and health issues at distances considerably greater than those currently deemed safe. All bar five of those reporting sleep disturbance live within 1500m of the turbines adding further support to a minimum setback of at least that distance.

3.9. World Health Organisation/European Community recommendations

3.9.1. The WHO Regional Office for Europe in collaboration with the EU established a working party in 2003 to examine the effects of night time noise on sleep disturbance and health. Their brief was to review the current evidence and produce recommendations on permissible night time noise levels. Inevitably, the work concentrates on road traffic and aircraft noise as generating the most complaints and the subjects of most research.

3.9.2. A preliminary report was published in 2007 (WHO 2007). They reported that:

"The review of available evidence leads to the following conclusions.

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

stressed that a plausible biological model is available with sufficient evidence for the elements of the causal chain."

"For the primary prevention of subclinical adverse health effects in the population related to night noise, it is recommended that the population should not be exposed to night noise levels greater than 30 dB of $L_{night,outside}$ during the night when most people are in bed. Therefore, $L_{night,outside}$ 30 dB is the ultimate target of Night Noise Guideline (NNGL) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise."

The report described a new noise metric, $L_{night,outside}$, which is the yearly average of night noise level outside the facade. This seems to have been chosen as more appropriate for health effects that require long term noise exposure, such as high blood pressure, than those related to short term disturbance such as sleep disturbance and insomnia.

3.9.3. A further report was published in 2009 (WHO 2009). A similar approach was taken to that of Pedersen (2009a&b) and the report seeks to establish a No Observed Effect Level (NOEL) and a Lowest Observed Adverse Effect level (LOAEL) for noise and various measures of health. While a useful approach, it must be remembered that the LOAEL will vary with the noise frequency and pattern, the age of the subjects studied and the sensitivity of the measurement of the effect. There will also be a range of LOAEL within the population depending upon noise sensitivity. Allowance should be made for those who are most sensitive. With respect to noise and health, it can not be assumed that all noise is the same; as noted above, several studies have shown that wind turbine noise is more annoying than traffic or aircraft noise. Children and the elderly may be more sensitive than adults who are studied most often. While blood pressure and heart attacks are well defined and easily measured, sleep disturbance, fatigue, mood and similar subjective symptoms are less easily measured and distinguished from the background levels present in the population.

An $L_{night,outside}$ of 40dB was recommended as representing the LOAEL. They state for $L_{night,outside}$ of 30-40dB:

"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 lowest observed adverse effect level (LOAEL) for night noise."

Body movements, awakenings, self-reported sleep disturbance and arousals will all impact on a subject's sleep and cause impaired daytime functioning. Whether or not this results in long term harm, it remains an effect on the subject which is contrary to the WHO definition of health, i.e. it constitutes ill health.

3.9.4. The recommendation that an $L_{night,outside}$ of 40dB should be the night noise guideline for Europe seems perverse in the light of the conclusions of the effects of sound levels between 30 and 40dB above. A value of 21dB was used for sound attenuation from outside a building to inside. This is greater than the 10-15dB usually cited. Bearing in mind the reservations expressed in Section 3.9.3 and, in particular the nature of wind turbine noise with it's high levels of low frequency noise, an external noise level of 40dB must be regarded as the absolute maximum permissible and must be fully justified, for example by the subject having a financial interest in the turbines. Noise exposure above this level will be associated with a risk of ill health. Kamperman and Pedersen's recommendations of a maximum external limit of 35dB(A) and HMP's recommendations of 33-38 dB(A) would be appropriate for wind turbine noise to prevent annoyance and sleep disturbance and is supported by the WHO/EU findings quoted above.

3.10 Nissenbaum

3.10.1. Nissenbaum (2010) has presented the preliminary results of a study of residents living downwind and within 300-1100m (mean 800m) of a wind farm at Mars Hill, Maine, USA. The 28 1.5MW turbines are sited on a 200m high ridge overlooking the homes. 22 of about 35 adult residents have

been interviewed so far and compared with a randomly selected control group living a mean 6km away. 18/22 reported new or worsened sleep onset disturbance at least twice a week, for 9 at least 5 times per week (controls 1/28). 8/22 reported new or worsened headaches (controls 1/28) and 18/22 reported new or worsened mental health symptoms (stress 12/22, anger 18/22, anxiety 8/22, hopelessness 12/22, depression 10/22) (controls 0/28).

The 22 subjects received 15 new or increased prescriptions from their physicians in the 18 months between the start of turbine operation and the study, the majority for psychoactive medication (controls 4 prescriptions, none for psychoactive medication). 21/22 reported reduced quality of life and 20/22 considered moving away (controls 0/28 for both).

3.10.2. As a result of the complaints, noise monitoring during turbine operation was undertaken at the community test sites at which background noise monitoring and calculated turbine noise levels had been derived during the planning stage. The residents surveyed generally lived between the 40-45dB contours, two lived within the 45-50dB contours. Noise control regulations in Maine call for test sites to be more than 500ft from “protected properties”. Six test sites are relevant to the study group and the results are given below.

Site No.	Model estimate (dB)	Range of measured sound levels (dB)
1	51	42-52
5	39	39-40
6	43	39-45
6A	42	38-44
7	40	39-44
8	47.5	41-50

It can be seen that model estimates generally underestimated the actual noise levels by between 1 and 4dB. Exceedances of ETSU-R-97 night time levels of 43dB are generally small, 1-2dB and only exceed by 7-9dB at the two closest sites. It is clear that the majority of residents were living at distances and sound levels that would be permitted under ETSU-R-97 but nevertheless report high levels of sleep disturbance and health impairment.

3.10.3. The study may be criticised for it's relatively small numbers of subjects but the presence of a control group, well matched for age and gender, adds considerable power. All differences between the groups are statistically highly significant. The turbine noise levels may be enhanced by the high concentration of turbines and the geography but the severe sleep disturbance, psychiatric symptomatology and increased medication requirement in the study group confirms the potential of wind turbine noise to adversely affect health at distances claimed to be safe.

3.11 Shepherd

3.11.1. Dr Daniel Shepherd, (2010a) a psychoacoustician from the University of Aukland, New Zealand, has presented a preliminary report of a case-control study of the health status of residents living within 2km of the Makara windfarm. The results were presented at an International Symposium on Sustainability in Acoustics, Sydney, Australia, August 29th-31st 2010. Health related quality of life (HRQoL) was measured using the WHO QOL-BREF which has four subscales, physical, including sleep, psychological, social and environmental. Questions on neighbourhood problems, amenity and noise and air pollution annoyance were added, partly as distractors.

26 of 84 questionnaires were returned by the Makara residents (31%) and 173 of 500 (34%) in a control group from a matched area without wind turbines. Return rates are reasonable for such a study. The groups were evenly matched except the control group had a slightly higher proportion of older people.

The Makara residents reported significantly lower amenity levels than the controls. Overall HRQoL was much lower in the Makara residents and this difference was statistically highly significant ($p=0.033$) (See Table below). Makara residents scored lower in all subscales except social. The differences were statistically significant ($p<0.05$) for the physical and environmental subscales.

Subscale	Mean Rank	Significance (two-tailed)
Physical Makara Control	 75.25 100.09	*U*=1505.5, *z*=-2.049, *p*=.040
Psychological Makara Control	 78.48 99.07	*U*=1883.5, *z*=-1.524, *p*=.088
Social Makara Control	 96.49 92.63	*U*=1923.05, *z*=-0.325, *p*=.745
Environmental Makara Control	 73.89 97.92	*U*=1423.5, *z*=-1.983, *p*=.047
Overall QOL Makara Control	 76.81 99.87	*U*=1543.5, *z*=-2.133, *p*=.033

This preliminary report of well designed study adds further weight to the argument that wind turbine noise causes ill health in those living within 2km.

3.12. Literature Reviews.

In recent months, a number of "reviews" of the literature relating to wind turbine noise and health have been published. In general, those which are industry or government sponsored tend to suggest that there is no problem while those produced independently confirm that there is a problem.

3.12.1 The American and Canadian Wind Energy Associations (ACANWEA) have recently commissioned a review of the literature on wind turbine noise and health effects (Colby et al., 2009). The panel concluded that:

"• There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects.

• The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans.

• *The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds and the panel's experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences."*

The quality and authority of this review and its conclusions are open to considerable doubt. The medical members of the panel comprised a microbiologist, an otolaryngologist and an occupational health physician specialising in respiratory disease. From their biographies, none seems to have any expertise in sleep medicine or in psychology. The reference list shows that the literature review was far from complete. The panel admits that wind turbine noise causes annoyance which can lead to sleep disturbance but dismisses these findings. It is clear that they did not understand the significance of "annoyance" in a health context and neither did they comprehend the importance of sleep disturbance in causing ill-health.

The NHS Knowledge Service reviewed the paper (NHS 2010) and concluded: *"This research is unlikely to resolve the controversy over the potential health effects from wind turbines. This is mainly because the research on which the review was based is not sufficient to prove or disprove that there are health effects. The review itself also had some methodological shortcomings, and the reviewing group did not include an epidemiologist, usually a given for assessing potential environmental health hazards. Further research on this issue is needed."*

The Society for Wind Vigilance (Society for Wind Vigilance, 2010a&b) has reviewed the ACANWEA paper, publishing a detailed critique and concluded: *"It is apparent from this analysis that the A/CanWEA Panel Review is neither authoritative nor convincing. The work is characterized by commission of unsupportable statements and confirmation bias in the use of references. Many important references have been omitted and not*

considered in the discussion. Furthermore the authors have taken the position that the World Health Organization standards regarding community noise are irrelevant to their deliberation - a remarkable presumption."

3.12.2. The Chief Medical Officer of Health of Ontario published a review in May 2010 on the Potential Health Impact of Wind Turbines (CMOH, 2010). This document has a number of shortfalls, not least in the selective nature of the literature reviewed, the dismissal of annoyance as a health issue and the ignoring of sleep disturbance as a concern. A comprehensive rebuttal of this paper has been published by the Society for Wind Vigilance (Society for Wind Vigilance 2010c).

3.12.3. The Australian National Health and Medical Research Council published a "Rapid Review of the Evidence" of Wind Turbines and Health in July 2010 (NHMRC, 2010). It starts with the premise that there is no evidence of any health concern and then proceeds, through a very selective use of literature, to prove it. It claims to use peer reviewed literature but only 8 of 29 citations are actually peer reviewed, one of the remainder being an internet blog, "Croakey the Crikey Health Blog". The WHO acceptance of annoyance as an adverse health effect is stated as "not universally accepted" but no references are given to support this extraordinary assertion. A comprehensive rebuttal of this paper has been published by the Society for Wind Vigilance (Society for Wind Vigilance 2010d).

3.12.4. Phillips, an epidemiologist, has prepared an analysis of the epidemiology and related evidence on the health effects of wind turbines on local residents as evidence to the Wisconsin Public Service Commission (Phillips, 2010). He concludes: *"There is ample scientific evidence to conclude that wind turbines cause serious health problems for some people living nearby." "The reports that claim that there is no evidence of health effects are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing prima facie, they do not represent proper*

scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis."

He further notes that subjects' revealed preferences, moving out of their bedrooms or houses to avoid the noise is strong evidence in favour of the effects being real rather than a psychologically induced "nocebo" effect.

3.12.5. Horonjeff, an acoustician, has reviewed the siting of wind turbines with respect to noise emissions and the health and welfare effects on humans as evidence to the Public Service Commission of Wisconsin (Horonjeff, 2010). He notes that wind turbine noise is different in character from other noise sources and, after suggesting appropriate noise levels and a setback 1.5-2 miles, concludes: *"Wind turbine noise appears to be eliciting annoyance and physiological responses not experienced from other noise sources of similar sound level."*

3.12.6. Punch and colleagues (Punch, 2010) reviewed wind turbine noise for audiologists and concluded: *"Noise from modern wind turbines is not known to cause hearing loss, but the low-frequency noise and vibration emitted by wind turbines may have adverse health effects on humans and may become an important source of community noise concern."*

3.12.7. The Clean Energy Council of Australia, the trade body representing and advocating on behalf of the wind industry and other "renewable" energy suppliers, commissioned Sonus, an acoustic consulting firm that works extensively with the wind industry, to review environmental noise and wind farms (CEC 2010). No individual authors are listed in the report but none of the staff listed on the company's website has any medical, epidemiological or health expertise. Nevertheless, they confidently conclude: "There is detailed and extensive research and evidence that indicates that the noise from wind farms developed and operated in accordance with the current (Australian) Standards and Guidelines will not have any direct adverse health effects." Review of the cited literature produces no such extensive research nor evidence other than the usual reviews cited in similar wind

industry and government sponsored documents. The literature reviewed omits much peer-reviewed and other literature which contradicts the conclusions.

3.13. Conclusions

3.13.1. There is no peer-reviewed research showing that industrial wind turbines do not significantly affect sleep at the distances and external noise levels deemed to be safe in most jurisdictions. On the other hand, there is a large body of literature suggesting very strongly that sleep is disturbed to a degree that affects daytime functioning. Many of the studies are surveys using self-completed questionnaires. Response rates have generally been good for this type of enquiry, which may reflect the public interest and concern that wind turbines generate. Nevertheless, it is inevitable that it is more likely that those who feel they have been affected will respond rather than those who have not. The questionnaires themselves have not always have been well drafted. Most do not have a control group, a separate group not exposed to turbine noise with whom to make comparisons. The studies are all post hoc, initiated after the turbines have been operating and generally in response to complaints. The lack of pre-exposure data weakens the studies but does not invalidate them totally. Many of the authors have been criticised for their presumed lack of expertise in this area. Because governments and industry have refused funding and co-operation, individuals have had to rely on their own resources in order to conduct research, which though propelled by a concern for public health, has also enforced limits on their extents. Initial clinical investigations often rely on self-completed questionnaires in order to define, refine, and establish future research projects and this work should not simply be dismissed.

Nevertheless, the number of reports, and in particular the most recent, and the weight of evidence demonstrating the impacts on sleep quality and health of wind turbine noise from existing installations is such that it can be firmly concluded that present guidance to determine setbacks is inadequate.

3.13.2. The UK government, in acknowledging the deleterious effect of noise on human well being, have published two reports through the Health Protection Agency (HPA 2009) and DEFRA (Berry and Flindell, 2009). The former, which is in draft form awaiting comments, reviews the evidence for the effects of noise on health. Traffic, aircraft, railway and industrial noise is considered but, surprisingly, there is no consideration of wind turbines despite the government's plans for a major increase in size and capacity and their proposed placement in generally previously tranquil but well populated areas of countryside. The report calls for more research, including in the areas of sleep disturbance, cardiovascular effects and children's health. They commend the use of dose-response relationships to inform planning policy. The latter report reviews dose-response relationships between noise exposure and human health and concludes that such is a useful approach worthy of further research. They commend the work of RIVM, who were extensively consulted in preparing the report.

3.13.3. The recent analyses of the WINDFARMPerception and earlier Swedish studies by Pedersen and her colleagues gives, for the first time, robust evidence that wind turbines cause sleep disturbance and impair health and that this occurs at set-back distances previously regarded as adequate. However, it must be noted that the measures used in these studies are relatively imprecise. As noted in Section 2.2, arousals due to noise are several times more likely to occur than awakenings but are as destructive to sleep quality. More precise measures such as the Brief Fatigue Inventory, Pittsburgh Sleep Quality Index and Epworth Sleepiness Score or direct assessment of sleep quality are needed to determine a correct dose-response relationship between turbine noise and sleep disturbance. In the meantime, the precautionary principle should prevail and setbacks determined appropriately.

3.13.4. In weighing the evidence, I find that, on the one hand, there are large numbers of reported cases of sleep disturbance and other adverse effects on health, as a result of exposure to noise from wind turbines, supported by an increasing number of research reports that confirm the validity of the

anecdotal reports and provide a reasonable basis for the complaints. On the other, we have badly designed, and improperly edited, industry and government reports, which seek to show that there is no problem. I find the latter unconvincing.

3.13.5. The recent RIVM and WHO reports and the draft DTI/HMP reports confirm the potential for noise to adversely effect health through sleep disturbance and set maximum permissible night time noise levels which are less than those permitted by ETSU-R-97.

3.13.6. **In my expert opinion, from my knowledge of sleep physiology and a review of the available research, I have no doubt that wind turbine noise emissions have been clearly associated with sleep disturbances.**

Further, the evidence now available is quite clear that present noise guidelines are inadequate to protect the sleep of residents living too close to wind turbines.

4. Preventing sleep disturbance from wind turbine noise.

4.1 Background

4.1.1. Developers of noisy industrial processes, including wind turbines, seek to mitigate the disturbance by siting them in areas of high ambient noise, such as close to major roads. In the case of wind turbines, it is assumed that rising wind speed will not only increase turbine noise but ambient noise also. The degree to which this occurs depends on the proximity of vegetation and other structures. Motorway noise diminishes at night as the volume of traffic decreases. In addition, it is common for wind speeds to diminish at ground level as night falls while being maintained at turbine hub level, wind shear (Pedersen E and Persson Waye K. 2003, Schneider 2007). In both cases, the turbine noise will be much more audible as ambient noise decreases and explains why complaints of nocturnal noise and disturbed sleep are common. The importance of wind shear has been acknowledged in a recent technical contribution to Acoustics Bulletin (March/April 2009) from some members of the NWG calling for all noise levels to be referenced to wind speed at turbine hub height. Conditions which favour wind shear also favour amplitude modulation (Palmer 2009). Temperature inversion, where ground level air is cooler than higher level air also increases sound propagation by reflection of the noise from the boundary layer (Irvine. 2009). These conditions, which are most likely to occur at night, early morning and in winter have not received as much attention as wind shear but may be a further reason why turbine noise may be heard over greater distances than predicted.

4.1.2. Schneider (Schneider 2007) found that night time turbine noise was between 3 and 7dB(A) greater than predicted during periods of atmospheric stability: "*summer, night-time noise levels exceeded levels predicted for two sites within the Maple Ridge Wind Farm. For winds above generator cut-in speed (e.g., 3.0 m/s @ 80-m), the measured noise was 3-7 dBA above predicted levels. The decoupling of ground level winds from higher level winds, i.e.,*

atmospheric stability, was apparent in the noise data at both sites during evening and night-time periods. At wind speeds below 3.0 m/s, when wind turbines were supposedly inoperative, noise levels were 18.9 and 22.6 dBA above the expected background levels for each of the sites and these conditions occurred a majority of the time."

In addition, as noted above, the characteristics of wind turbine noise are such that it can be heard despite road noise.

4.1.3. van den Berg, in a paper presented at Euronoise 2003, investigated the relationship between calculated noise generated by wind turbines and that actually measured. He confirmed that the turbines were more audible at night principally due to amplitude modulation. To quote his paper: *"As measured immission levels near the wind park Rhede show, the discrepancy may be very large: sound levels are up to 15 dB (!) higher than expected at 400 m from the wind park. At a distance of 1500 m actual sound levels are 18 dB higher than expected, 15 dB of this because of the higher sound emission and 3 dB because sound attenuation is less than predicted by the sound propagation model."* This study, is further confirmation that calculated measures of wind turbine noise may be woefully inadequate.

4.1.4. In contrast, Bullmore and colleagues (2009) reported, from studies of four established large wind farms, that ISO 9613 predicted turbine noise immissions with reasonable accuracy and, at three of the sites, over estimated the measured sound levels. However, the actual location of the sites was not revealed although some detail was given. No attempt was made to determine the degree of wind shear during the measurement period.

4.1.5. Nelson (2007), in a small laboratory based study examined the ability of background noise to mask turbine noise. When background noise and turbine noise where adjusted to the same loudness, the residual perceived loudness of the turbine noise was approximately half of its unmasked value (1.8sone). Even when the background noise was increased from 41 to

49dB(A) the turbine noise was not fully masked. Hayes (2007) has interpreted this by stating that: *"one would expect the wind turbine (warranted to be free of tonal noise) to be audible even if the turbine noise was 10 - 15 dB below the background noise level".* It can be inferred that if tonal noise is present, the turbine noise will be audible at a greater level below background noise.

4.1.6. Bolin (2009) has reported an experimental study of the masking of wind turbine noise by vegetation noise (leaves rustling etc). Subjects were exposed to vegetation noise in a laboratory and turbine noise introduced at varying sound pressures and vice versa and a threshold for detection determined. The results were compared with the Moore and Glasberg methods for calculating masking. The results suggest that: *"....existing models of partial masking overestimate the ability to conceal wind turbine noise in ambient sounds."* In other words, wind turbine noise is not masked as well as current models predict and is thus more intrusive. This is in accord with the work of Nelson and of van den Berg and Miedema who show that traffic noise does not mask wind turbine noise as well as predicted.

4.2. Mitigation of wind turbine noise

4.2.1. Bowdler (2008) has reviewed the causation of the swishing and thumping noises associated with wind turbines. He concludes that, while there are several theories, no definitive mechanism can be established. It follows that industry claims to mitigate turbine noise by changing blade shape, pitch and turbine spacing should be treated with scepticism until definitive evidence of their efficacy are presented.

4.2.2. It follows that attempts to reduce wind turbine noise immissions after a plant becomes operational are unlikely to be successful. Noise mitigation will reduce power output, which will be opposed by the operators. The importance of assuring residents that noise limits are capable of being met before construction was emphasised by Mr Lavender, Inspector at the

Thackson's Well Inquiry (APP/E2530/A/08/2073384) who stated: *"securing compliance with noise limit controls at wind farms, in the event of a breach, is not as straightforward as with most other forms of noise generating development. This is because noise from turbines is affected primarily by external factors such as topography and wind strength, a characteristic that distinguishes them from many other sources of noise, such as internal combustion engines or amplified music, which can be more directly and immediately influenced by silencing equipment, insulation or operator control."* It follows that application of the precautionary principle is essential where there is any possibility of noise disturbance from wind turbines.

4.2.3. Thus, the **only** mitigation for wind turbine noise is to place a sufficient distance between the turbines and places of human habitation. PPS22 advises that ETSU-R-97 *should* (author's italics) be used to estimate noise levels around turbines which, taken with measurements of ambient noise, can, in theory, predict noise disturbance in adjacent properties. Many expert acousticians have severely criticised ETSU-R-97, not least Mr Dick Bowdler (2007), a former member of the Government's Noise Working Group considering ETSU-R-97. A number of Her Majesty's Inspectors have been equally critical, not least Mr Andrew Pykett (Appeal Ref: APP/Q1153/A/06/2017162) and Ms Elizabeth Ord (Appeal Ref: APP/W4705/A/09/2114165). As noted above, the recent recommendation by some members of the Noise Working Group to provide more allowance for wind shear in predicting turbine noise levels is a tacit admission of the unsuitability of ETSU-R-97 methodology for large turbines. In addition the suppressed recommendations by HMP, at least one of whose employees sat on the NWG, for a reduction in the ETSU-R-97 night time noise limits to 33-38dB(A) suggests very strongly that it is inappropriate to continue to rely on ETSU-R-97 as presently formulated.

4.2.4. Stigwood (2008) has shown that large turbines (hub heights 50-100m) are more likely than smaller turbines (hub height 30m) to cause excessive amplitude modulation, increased likelihood of low frequency noise and greater disturbance inside buildings. Internal noise can modulate over 15-

20dB, changes which is easily perceived. This is probably due to different wind speeds and atmospheric conditions at these heights. He concludes that ETSU-R-97, which was developed for smaller turbines, is inappropriate for large turbines.

4.2.5. Despite, or because of, ETSU-R-97, complaints of noise disturbance from industrial wind turbines continue and it is clear that ETSU-R-97 can not be relied upon to prevent sleep disturbance in those living near wind turbines. To quote Mr Peter Hadden in evidence to the House of Lords Economic Affairs Committee, printed 12th November 2008 para 6:

"There is material evidence available to show that ETSU R 97 has failed to provide a reasonable level of protection to family homes from unbearable noise pollution where wind turbines are located too close to homes. Symptoms include sleep disturbances and deprivation, sometimes so severe that families are forced to evacuate their homes in order to stabilise well-being and to resume normal family life. This is a worldwide phenomenon where wind turbines are located too close to homes."

4.2.6. It should be noted also that the application of ETSU-R-97 is advisory in PPS22, not mandatory (*should* not *must*). It is subordinate also to the precautionary principle set out in PPS 22. Rather than rely on a provably inadequate set of theoretical calculations to determine setback distance, it is logical to look at the real world and the relationship between setback and noise complaints from existing sites. Human senses and opinion are used to judge visual impact. It is therefore consistent and logical to rely on human senses and opinion in respect of noise impact. Many of these sites causing problems have been in place for several years. Current applications are generally for large 2.0-3MW turbines and thus allowance must be made for their additional noise in determining setback.

4.2.7. While it may be possible to produce a reasonable acoustically based theoretical approach to calculating set-back distances (Kamperman and James 2008b), it makes more sense to rely on recommendations from observations of the effects on real people at established wind farms and the dose-response relationship described by Pedersen (2009a&b) is relevant.

4.3. Conclusions

4.3.1. There are two possible approaches to judging an appropriate setback distance. The first is to determine a dose-response relationship between turbine noise and a health concern, for example, sleep disturbance. The next step is to determine an acceptable level of sleep disturbance. For example, should it be 0%, 1% or 5% of the population for 1 night per year, per month or per week? Consideration should be given to whether the measured concern, in this case reported sleep disturbance, is sufficiently sensitive. I have shown that reported sleep disturbance is the tip of an iceberg and that arousals with sleep fragmentation are likely to be more common and insidious with consequences including fatigue and elevated blood pressure In this situation, it would be appropriate to invoke the precautionary principle and select a conservative dose level (turbine noise) that minimises the measured response (sleep disturbance). Examination of data from the Swedish and Dutch studies suggests that an external predicted noise level of no more than 35dB(A) LA_{90} would be appropriate. This view is supported by a presentation by members of RIVM, the widely respected Dutch National Institute for Public Health and Environment, (Jabben et al 2009) which recommends an outdoor L_{den} limit of 40dB(A) which corresponds to an external noise level of about 35dB(A). The data is now available as a RIVM report (Verheijen et al., 2009) which recommends that wind turbine parks be designed so as to stay below L_{den} 40 dB at nearby dwellings which is regarded as the “no effect” level. L_{den} 45 dB(A) is recommended as a maximum allowable limit which should avoid severe effects and minimise health effects.

Hayes (2007), of the Hayes McKenzie Partnership. notes that “the intent of New Zealand Standard 6808 is not inaudibility but the prevention of severe annoyance”. The relevant section of that Standard states:

“***4.4.2 Acceptable limit***

As a guide to the limits of acceptability, the sound level from the WTG (or windfarm) should not exceed, at any residential site, and at any of the

nominated wind speeds, the background sound level (L_{95}) by more than 5dB(A), or a level of 40 dB(A) L_{95}, whichever is the greater.

Hayes therefore concedes that the noise level above which **severe annoyance** occurs is 40dB(A) L_{95}. Thorne (2010c), from an analysis of noise complaints concludes that **unreasonable** noise occurs at noise levels above 30dB(A)$_{LA90}$ in the presence of excess amplitude modulation. Together with van den Berg he states: "*We believe annoyance and loss of amenity will be protected when the wind turbine noise limit would be 30 dBA L_{95} in conditions of low wind speed at the dwellings and modulation restricted to 3dB"*.

Overall, it is apparent that the present ETSU-R-97 night time noise limits are too high to protect receptors from severe annoyance and sleep disturbance and that a level of 35dB(A) LA_{90} is appropriate, in the absence of excessive modulation.

4.3.2. The second approach is to correlate reports from those living in proximity to wind turbines to their distance to the turbines, the approach taken by, amongst others, WindVoice. This has the disadvantage that symptoms are generally self-reported and subjective. Nevertheless, it can be argued that it is logical to rely on the actual reports of human receptors in the same way that human opinions are used to judge visual amenity. It has the advantage also that it may better detect those subjects that are most sensitive to turbine noise than surveys. It has the merit also of simplicity. The New South Wales Legislative Council General Purpose Standing Committee No 5, under the Chairmanship of Mr Ian Cohen, a member of the Green Party, has recently published the report of an inquiry into rural wind farms (NSW 2009). Recommendation 7 to the NSW Planning Minister is for a minimum setback of 2 km. In the UK, Mr Peter Luff, MP for Mid-Worcestershire, was given leave to introduce a Bill to Parliament to establish a legal minimum setback distance. This Bill was lost with the recent dissolution of Parliament and election but Lord Reay has recently introduced a similar Bill in the House of Lords.

4.3.3. **Table II** (see end of text) shows recommendations for setback distance by a number of authorities. References can be found in the Bibliography. In general, noise engineers recommend lesser setback distances than physicians. The former rely more on measured and/or calculated sound pressures and the latter on clinical reports. It is logical to prefer the actual reports of the humans subjected to the noise rather than abstract calculations, even if the latter accurately measure ambient noise and allow for the low frequency components of wind turbine noise. Calculations can not measure annoyance and sleep disturbance, only humans can do so. **In my opinion, based on the reports cited in the table and the data from WindVoice, a minimum setback of 1.5km is appropriate.**

5. Planning considerations

5.1 ETSU-R-97

5.1.1. UK Government policy is that ETSU-R-97 should be used for the assessment of the likely impact of wind turbine noise and this was restated in a 2007 policy statement. Developers will often assert that, as it is government policy, ETSU-R-97 may not be questioned. However, as Mr Justice Mitting stated in a judicial review brought by the Renewable Energy Foundation (CO/9686/2007): "It will always be open to any objector to an application for permission to develop a site as a windfarm, to contend that the Statement is technically inadequate or erroneous." David Forsdick, of Landmark Chambers, a leading barrister with particular expertise in planning matters, stated, at a seminar on renewable energy on the 1st October 2008 (Forsdick 2008):

"...., general policy and guidance cannot prevent consideration of:

a. the specific facts of an individual case;

b. scientific information which suggests that the general methodology may need to be adjusted on the facts of an individual case; or

c. actual experience elsewhere on the ground which shows that the government approved methodology does not always accurately predict the impacts.

Thus, whilst it is undoubtedly true that it is not for parties to an inquiry to question the merits of government policy, their evidence on the matters in the previous paragraph is plainly capable of constituting "other material considerations" which the decision maker has to take into account and, in an appropriate case, reach a conclusion on.

5.1.2 It would seem logical that the specific facts of an individual case would include the presence of particularly sensitive or vulnerable receptors, such as the elderly and children, and the likelihood of excessive wind shear or amplitude modulation.

5.1.3. There is now a large body of scientific information showing that the ETSU-R-97 methodology is in need of adjustment for wind shear and amplitude modulation. Many developers have acknowledged this by making an allowance for wind shear. The evidence that adjustments are necessary for amplitude modulation is equally strong.

5.1.4. There is a large body of evidence also showing that ETSU-R-97 noise levels are too high for human health and well being. These include the 2009 WHO Night Noise Guidelines and the 2006 draft reports by HMP to DTI.

5.1.5. It follows that it is appropriate and reasonable for planners and decision makers not to rely exclusively on ETSU-R-97 methodology and to take account of the other material considerations set out in this paper.

6. Overall Conclusions

6.1. The appropriate mitigation of sleep disturbance and annoyance from industrial wind turbine noise is a maximum external turbine noise level of 35dB(A) or a setback of at least 1.5km.

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16th November 2010

7. Bibliography

Acoustic Ecology Institute. AEI special report: Wind energy noise impacts. http://www.acousticecology.org/srwind.html

Adams JW. 2008. The Public Health Issue. Essex County Wind Resistance. http://essexcountywind.wordpress.com/2008/09/26/public-health-and-industrial-wind-turbine-noise-in-ontario/

Ambrose S and Rand R. 2010.Wind turbine noise: noise complaints predictable. Herald Gazette 30th October 2010. http://knox.villagesoup.com/column/columnpost/wind-turbine-noise-noise-complaints-predictable/359597

Bakker H et al. 2009. Seismic Effect on Residents from 3 MW Wind Turbines Third International Meeting on Wind Turbine Noise Aalborg Denmark 17 – 19 June 2009

Barregard L, Bonde E and Ohrstrom E. 2009. Risk of hypertension from exposure to road traffic noise in a population based sample. Occup. Environ. Med. 66:410-415.

Basner M et al. 2008a. Aircraft noise: Effects on macro- and microstructure of sleep. Sleep Medicine, 9 (4): 382-387

Basner M. 2008b. Nocturnal aircraft noise exposure increases objectively assessed daytime sleepiness. Journal of Sleep Research 17:Supplement 1;P512

Belojevic G et al. 2008. Urban road traffic noise and blood pressure and heart rate in preschool children. Environment International. 34:226-231

Bennett D. 2008. Evidence to the Environment Court, Wellington, NZ. Appeal No. ENV-2007-WLG-000098 between Motorimu Wind Farm Ltd and Palmerston North City Council and Horowhenua District Council.

van den Berg GP. 2003. Wind turbines at night: acoustical practice and sound research. Euronoise 2003. Paper 160.

van den Berg GP. 2004. Effects of the wind profile at night on wind turbine sound. Journal of Sound and Vibration. 277:955-970

van den Berg GP. 2005: The beat is getting stronger: the effect of atmospheric stability on low frequency modulated sound of wind turbines, Journal of Low Frequency Noise, Vibration And Active Control24 (1), pp. 1-24

van den Berg G P. 2006. The sound of high winds: the effect of atmospheric stability on wind turbine sound and microphone noise *Doctoral Thesis* Groningen, The Netherlands; Rijksuniversiteit Groningen

van den Berg G P., et al. 2008. WINDFARMperception. Visual and acoustic impact of wind turbine farms on residents. FP6-2005-Science-and-Society-20. Specific Support Action Project no. 044628

Berry B and Flindell I. 2009. Estimating Dose-response relationships between noise exposure and human health impacts in the UK. Final Project Report BEL 2009-001. Berry Environmental Ltd (BEL).

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

Boselli M et al. 1998. Effect of age on EEG arousals in normal sleep. Sleep, 21 (4): 351-357

Bowdler D. 2007. ETSU-R-97: why it is wrong. New Acoustics. www.newacoustics.co.uk

Bowdler D. 2008. Amplitude modulation of Wind Turbine Noise. A Review of the Evidence

Bruck D et al. 2009. How does the pitch and pattern of a signal affect auditory arousal? Journal of Sleep Research 18:196-203

Bullmore A et al. 2009. Wind farm noise predictions and comparison with measurements. Third International Meeting on Wind Turbine Noise, Aalborg, 17-19 June 2009.

Butré J-L. 2005. French St. Crepin windplant noise survey results (2005), cited as a personal communication from J-L Butre, Ventducobage, 11-5-05 in Pierpont N. 2006.

CMOH. 2010. The potential health impact of wind turbines. Chief Medical Officer of Health, Ontario, Report No 014894

Chouard C-H. 2006. Le retentissement du fonctionnement des eoliennes sur la sante de l'homme [Repercussions of wind turbine operations on human health]. French National Academy of Medicine. Panorama du medecin, 20 March 2006

Clean Energy Council. 2010. Wind Farms Technical Paper: Environmental Noise. S3387C6 http://www.cleanenergycouncil.org.au/cec/resourcecentre/reports.html

Colby et al. 2009. Wind Turbine Sound and Health Effects; An Expert Panel Review. American and Canadian Wind Energy Associations.

Dang-Vu et al. 2010. Spontaneous brain rhythms predict sleep stability in the face of noise. Current Biology. 20:R626-7.

Davis J and Davis S. Noise pollution from wind turbines – living with amplitude modulation, low frequency emissions and sleep deprivation. Wind Turbine Noise 2007.

Dixsaut G et al. 2008. Wind turbines and noise: is there a minimal siting distance? Epidemiology. 19(6) Supplement S216.

Driscoll D. 2009. Environmental Discussion – response to questions about noise. Presented at Environmental Stakeholder Roundtable on Wind Power. New York State Energy Research and Development Agency. June 16th 2009.

DTI. 2006. The Measurement of Low Frequency Noise at Three UK Wind Farms – W/45/00656/00/00 – Hayes McKenzie Partnership. Plus draft reports 2006a, b, c.

Flindell IH, Stallen PM. 1999. Non-acoustical factors in environmental noise. Noise Health;1:11-6

Forsdick D. 2008 Noise and wind turbine proposals. Renewable Energy Seminar paper, 1st October 2008. http://www.landmarkchambers.co.uk /__data/assets/pdf_file/0004/32539/3.2_Noise__and__Wind_Turbines.pdf

Frey BJ. and Hadden PJ. 2007. Noise radiation from wind turbines installed near homes: effects on health. www.windnoisehealthhumanrights.com

Gohlke JM et al. 2008. Health, economy and environment: sustainable energy choices for a nation. Environmental Health Perspectives. 116:A236-7

Griefahn B; et al. 2008. Autonomic arousals related to traffic noise during sleep. Sleep. 31:569-577.

Haralabidis AS et al. 2009 Acute effects of night-time noise exposure on blood pressure in populations living near airports. European Heart Journal March 2008; 29: 658 – 664

Harry A. 2007. Wind turbines, noise and health. www.savewesternny.org/pdf/wtnoise_health_2007_a_barry.pdf

Hayes M. 2007. Affidavit in reply. Makara Wind Farm. New Zealand Environmental Court. W59/2007

Health Protection Agency 2009. Environmental Noise and Health in the UK – Draft. Ed. Dr A Moorhouse.

Horonjeff RD. 2010. Siting of wind turbines with respect to noise emissions and their health and welfare effects on humans. Document prepared in response to the Public Service Commission of Wisconsin “Measurement protocol for sound and vibration assessment of proposed and existing wind electric generation plans.” May 2010.

Irvine T. 2009. Wind Turbine Noise. Vibrationdata Newsletter May 2009 pp12-22. http://www.vibrationdata.com/Newsletters/June2009_NL.pdf

Ito A and Takeda T. 2010. Sickness claims prompt study of wind turbines.The Asahi Shimbun. 19th January 2010

Jabben J, -Verheijen E and Schreurs E. 2009. Impact of wind turbine noise in the Netherlands. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Jarup L et al. 2008. Hypertension and Exposure to Noise Near Airports: the HYENA Study. Environmental Health Perspectives. 116:329–333

Kabes DE and Smith C. 2001. Lincoln Township Wind Turbine Survey, Agricultural Resource Center, University of Wisconsin Extension/Cooperative Extension, May 16, 2001.

Kamperman GW and James RR. 2008. Simple guidelines for siting wind turbines to prevent health risks. Noise-Con 2008. Dearborn, Michigan.

Kamperman GW and James RR. 2008b. The "How To" guide to siting wind turbines to prevent health risks from sound. http://www.windturbinesyndrome.com/wp-content/uploads/2008/11/kamperman-james-10-28-08.pdf

de Kluizenaar, Y et al. 2009. Long-term road traffic noise exposure is associated with an increase in morning tiredness. J Acoust Soc Am 126:626-33

Martin SE. et al. 1997. The effect of nonvisible sleep fragmentation on daytime function. American Journal of Respiratory and Critical Care Medicine, 155 (5): 1596-1601

Meerlo, P et al. 2008 Restricted and disrupted sleep: Effects on autonomic function, neuroendocrine stress systems and stress responsivity. Sleep Med Rev. 12:197-210

Miedema, H. et al. 2000. Community reaction to aircraft noise; time-of-day penalty and tradeoff between levels of overflights. J. Acoust. Soc. Am. 107, 3245–3253.

Møller, H., and Lydolf, M. 2002: A questionnaire survey of complaints of infrasound and low frequency noise. *Jnl Low Freq Noise Vibn* 21, 53 - 65.

Moorhouse A et al. 2007. Research into Aerodynamic Modulation of Wind Turbine Noise. Final Report. DEFRA Contract NANR233

Muzet A, Miedema H. 2005. Short-term effects of transportation noise on sleep with specific attention to mechanisms and possible health impact. Draft paper presented at the Third Meeting on Night Noise Guidelines, WHO European Center for Environment and Health, Lisbon, Portugal 26-28 April 2005. Pp. 5-7 in *Report on the Third Meeting on Night Noise Guidelines*, available at: http://www.euro.who.int/Document/NOH/3rd_NNG_final_rep_rev.pdf.

NHMRC 2010. Wind Turbines and Health: A rapid review of the evidence. Australian Government National Health and Medical Research Council.

National Health Service, News Service. 2009. Are wind farms a health risk? http://www.nhs.uk/news/2009/08August/Pages/Arewindfarmsahealthrisk.aspx

National Health Service, News Service. 2010. Wind turbine sound 'needs research'. http://www.nhs.uk/news/2010/01January/Pages/Wind-turbine-sound-and-health.aspx

New South Wales. Parliament. Legislative Council. General Purpose Standing Committee No. 5 2009. Rural wind farms / General Purpose Standing Committee No. 5. [Sydney, N.S.W.] : the Committee, 2009. – XXIV, 208 p. ; 30 cm. (Report ; no. 31)

New Zealand Standards. 2009. Acoustics – Wind farm noiseDZ6808/v2.4 Committee: 6808

Nissenbaum M. 2010. Mars Hill study, preliminary results. http://www.windvigilance.com/mars_hill.aspx

Palmer W. 2009. A new explanation for wind turbine woosh – wind shear. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Pedersen E and Persson Waye K. 2003. "Perception and annoyance of wind turbine noise in a flat landscape", Proceedings of Internoise 2002, Dearborn

Pedersen E and Persson Waye K. 2004. Perception and annoyance due to wind turbine noise—a dose-response relationship *J. Acoust. Soc. Am.* 116 3460–347

Pedersen E and Persson Waye K. 2007 Response to wind turbine noise in different living environments *Occup. Environ. Med.* 64 480–6

Pedersen E. and Persson Waye K. 2008. Wind turbines – low level noise sources interfering with restoration? Environmental Research Letters. 3:015002

Pedersen E. 2009a. Effects of wind turbine noise on humans. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Pedersen E et al. 2009b. Response to noise from modern wind farms in The Netherlands. J Acoust. Soc. Am. 126:634-643.

Petrie KJ. 2010. Statement of evidence on behalf of Meridian Energy Limited to the Environment Court, Wellington. ENV-2009-WLG-000060-63,65

Phillips CV. 2010. An analysis of the epidemiology and related evidence on the health effects of wind turbines on local residents. Evidence to the Public Service Commission of Wisconsin on behalf of the Brown County Citizens for Responsible Wind Energy. Docket 1-AC-231, Wind Siting Rules.

Phipps R et al. 2007. Visual and noise effects reported by residents living close to Manawatu wind farms: preliminary survey results. Evidence to the Joint Commissioners, 8th-26th March 2007, Palmerston North

Phipps R. 2007a. Evidence of Dr Robyn Phipps, In the Matter of Moturimu Wind Farm Application heard before the Joint Commissioners 8th – 26th March 2007 Palmerston North

Pierpoint N. 2005. Health, hazard, and quality of life. Wind power installations – how close is too close? www.windturbinesyndrome.com.

Pierpont N. 2006. Wind Turbine Syndrome: Noise, Shadow Flicker, and Health. www.windturbinesyndrome.com.

Pierpont N. 2009. Wind Turbine Syndrome: A Report on a Natural Experiment. K Selected Publications. Santa Fe, New Mexico.

Pirrera S, De Valck E, Cluydts R. 2009. Nocturnal road traffic noise and sleep quality: Habituation effects assessed in a test-retest field situation. Sleep 32:A422.

Pool R. 2009. A quiet revolution. E&T Magazine. 5th October. Institute of Engineering and Technology.

Punch J et al. 2010. Wind turbine noise: what audiologists should know. Audiology Today. JulyAug2010:20-31.

Rashleigh S. 2008 and 2009. Evidence to the Montreathmont Public Enquiry, Angus, Scotland. See also: http://www.spaldingtoday.co.uk/news/Bicker-house-blighted-by-turbines.4378933.jp

Salt AN and Hullar TE. 2010. Responses of the ear to low frequency sounds, infrasound and wind turbines. Hearing Research. In press.

Saremi M et al. 2008. Sleep related arousals caused by different types of train. Journal of Sleep Research 17:Supplement 1;P394

Schneider CP. 2007. Accuracy of Model Predictions and the Effects of Atmospheric Stability on Wind Turbine Noise at the Maple Ridge Wind Power Facility, Lowville, NY.

Scottish Executive. 2007. Scottish Planning Policy SPP 6 Renewable Energy. Annex A.

Selander J et al. 2009. Long term exposure to raod traffic noise and myocardial infarction. Epidemiology. 20:272-279

Shepherd D. 2010. Wind turbine noise and health in the New Zealand context. In: Rapley, B. I. and Bakker, H. H. C., Sound, Noise, Flicker and the Human Perception of Wind Farm Activity. Atkinson & Rapley Consulting Ltd, Palmerston North, New Zealand. ISBN 978-0-473-16558-1.

Shepherd D et al. 2010a. Opposition to wind turbines: noise about nothing?. Presentation to the International Symposium on Sustainability in Acoustics, Sydney. August 29th-31st 2010.

Stigwood M. 2008. Evidence to the Public Enquiry into the proposed North Dover Wind Park. PINS Ref: APP/X2220/A/08/2071880/NWF.

Society for Wind Vigilance 2010 a & b. An Analysis of the American/Canadian Wind Energy Association sponsored: “Wind Turbine Sound and Health Effects: An Expert Panel Review, December 2009”.

Society for Wind Vigilance 2010c. Delay, Denial and Disappointment. An Analysis of the Chief Medical Officer of Health (CMOH) of Ontario. “The Potential Health Impacts of Wind Turbines May 2010”

Society for Wind Vigilance 2010d. Haste Makes Waste. An Analysis of the National Health and Medical Research Council “Wind Turbines and Health A Rapid Review of the Evidence July 2010”

The Noise Association. 2006. Location, location, location. An investigation into wind farms and noise by The Noise Association.

Thorne R. 2010a & b. Statement of Evidence (and Addenda) of Dr. Robert Thorne Called by Huatau Marae for the Mighty River Power Turitea Redesign, February 2010. New Zealand.

Thorne R. 2010c. Noise Impact Assessment with respect to the Yaloak Wind Farm. Evidence to the Yaloak Wind Farm inquiry. PL-SP/05/0098. Australia

Todd N et al. 2008. Tuning and sensitivity of the human vestibular system to low-frequency vibration. Neuroscience Letters 444;36–41

Van Hee VC et al. 2009. Exposure to traffic and left ventricular mass and function. The Multi-ethnic study of atherosclerosis (MESA). Am J Respir Crit Care Med. 179:827-834.

Verheijen E et al. 2009. Evaluatie nieuwe normstelling windturbinegeluid. RIVM-rapport 680300007/2009

Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxvi, para 71

WindVoice. 2010. A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance. http://windvigilance.com/down.aspx

World Health Organisation. 2009. Night noise guidelines for Europe. Copenhagen.

World Health Organisation. 2009a. Environmental Burden of Disease – European countries (EBoDE) project. Report of the first project meeting, Bonn, Germany, 12th-13th February 2009.

Yardley W. 2010. Turbines too loud? Here, take $5,000. New York Times July 31, 2010.

Figure 1. Sound level and annoyance for different noise sources (van den Berg 2008)

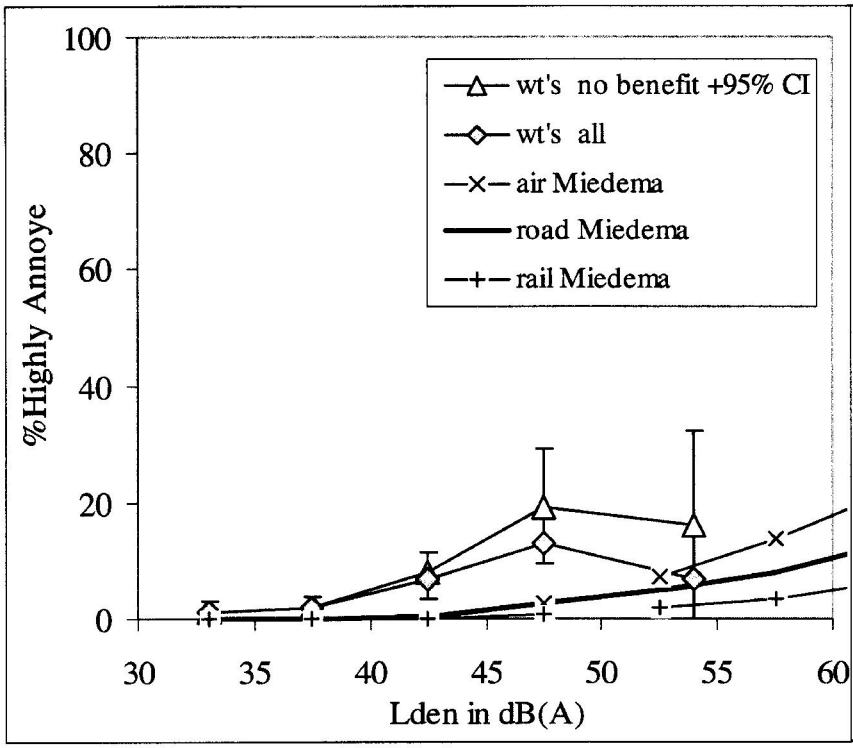
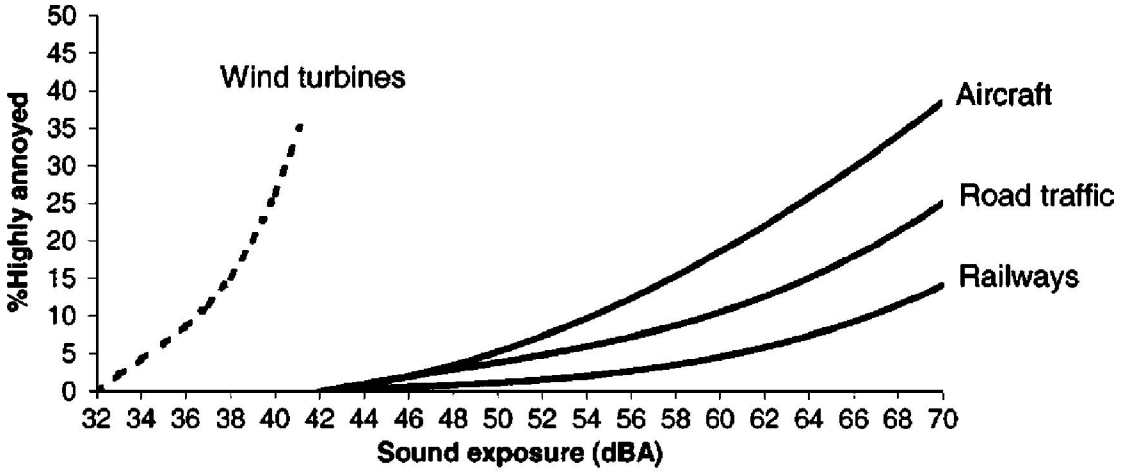


Figure 8.1: relation between sound level Lden and percentage highly annoyed residents exposed to that sound, for three transportation noise sources and for wind turbines; the relation is given for all respondents and for those that have no economical benefit from a wind turbine.

Bars denote 95% confidence interval for non-benefitters.

Figure 2. Sound level and annoyance for different noise sources (Pedersen E and Persson Waye, 2004)



Sound exposure is for wind turbines calculated A-weighted L_{eq} for a hypothetical time period and for transportation DNL.

Figure 3. Relationship between A-weighted sound pressure levels (equivalent levels at wind speed 8 m/s, 10 m over the ground) and proportion of respondents disturbed in the sleep by noise in three studies: SWE00 (*n* = 341), SWE05 (*n* = 746) and NL07 (only respondents that did not benefit economically from wind turbines; *n* = 593). (Pedersen 2009)

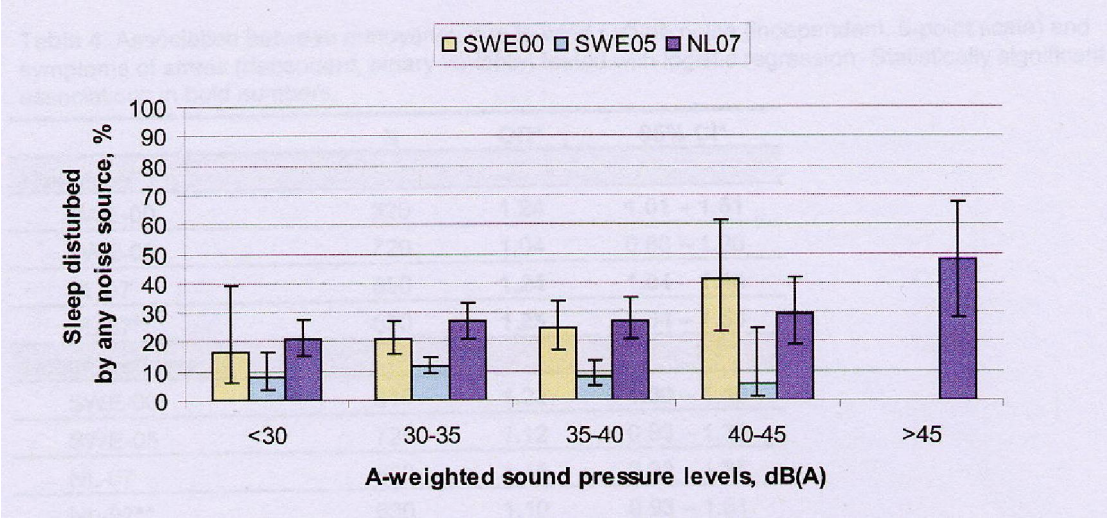


Figure 4. Spindle rate and sleep stability. Observations were pooled among subjects in the lower and upper halves of the spindle rate distribution (ranges 4.57-5.44 and 5.58-6.14 spindles/min respectively) based on EEG lead C3 during stage N2. Corresponding sleep survival curves were derived from each pool in stage N2 using the Kaplan-Meier (product-limit) method.

Backward extrapolation of the response curve for low spindle rate subjects shows only a 50% likelihood of stable sleep at noise levels of 35 dB(A) and 75% likelihood for those with high spindle rates. From Dang-Vu et al., 2010

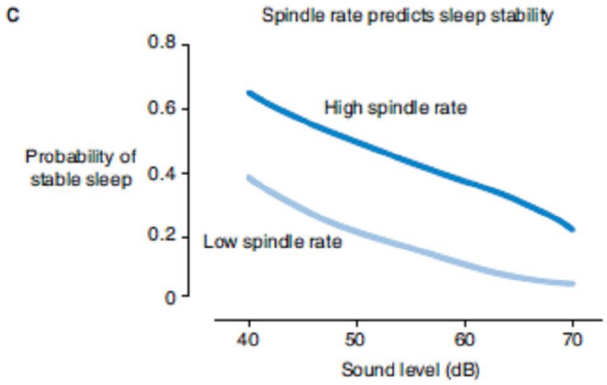


Figure 5. Percent of community highly annoyed by wind turbine noise correlated to normalized EPA community reactions to intrusive noise. From Ambrose 2010

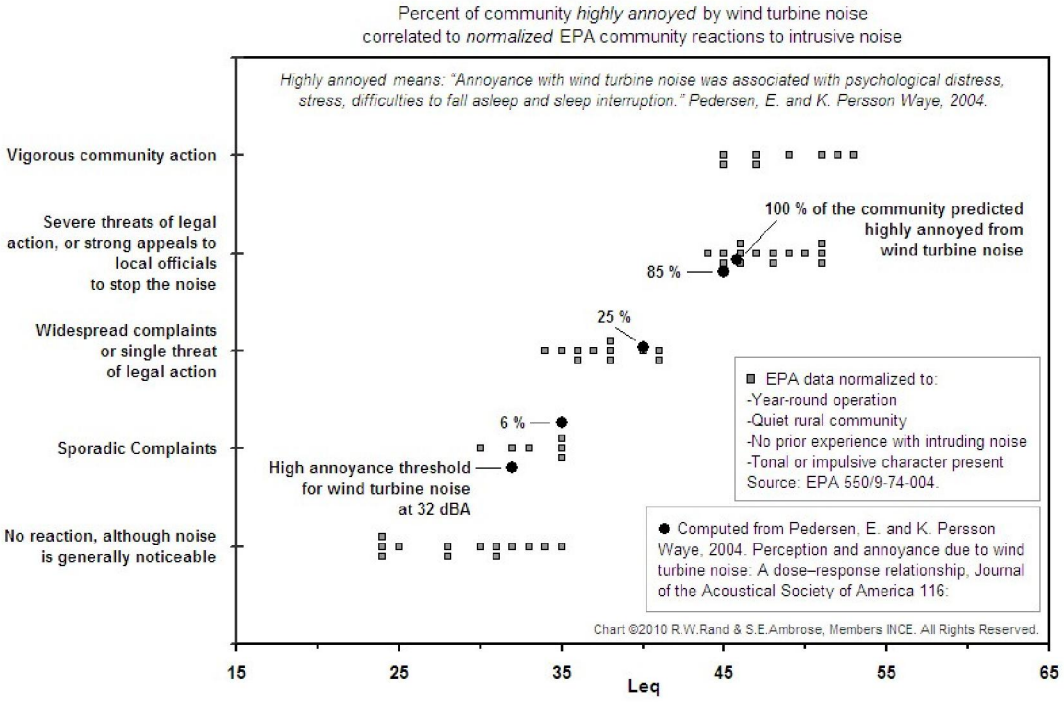


Table I. Response to wind turbine noise outdoors or indoors, proportion of respondents (*n*=708) according to 5-dB(A) sound level intervals, and 95% confidence intervals (95%CI). (From Pedersen 2009a)

	Predicted *A*-weighted sound pressure levels dB(A)				
	<30	30–35	35–40	40–45	>45
Outdoors *n*	178	213	159	93	65
Do not notice (%) (95%CI)	75 (68–81)	46(40–53)	21(16–28)	13 (8–21)	8(3–17)
Notice, but not annoyed (%) (95%CI)	20 (15–27)	36(30–43)	41(34–49)	46 (36–56)	58(46–70)
Slightly annoyed (%) (95%CI)	2 (1–6)	10(7–15)	20 (15–27)	23 (15–32)	22(13–33)
Rather annoyed (%) (95%CI)	1 (0–4)	6(4–10)	12 (8–18)	6 (3–13)	6(2–15)
Very annoyed (%) (95%CI)	1 (0–4)	1(0–4)	6 (3–10)	12 (7–20)	6(2–15)
Indoors, *n*	178	203	159	94	65
Do not notice (%) (95%CI)	87 (81–91)	73(67–79)	61(53–68)	37 (28–47)	46(35–58)
Notice, but not annoyed (%) (95%CI)	11(7–17)	15(11–20)	22 (16–29)	31(22–31)	38(28–51)
Slightly annoyed (%) (95%CI)	1 (0–4)	8(5–12)	9 (6–15)	16 (10–25)	9(4–19)
Rather annoyed (%) (95%CI)	0 (0–2)	3(1–6)	4 (2–8)	6 (3–13)	5(2–13)
Very annoyed (%) (95%CI)	1 (0–4)	1(0–4)	4 (2–8)	10 (5–17)	2(0–8)

Table II. Recommendations for setback of residential properties from industrial wind turbines

Note 1. The 2km limit from edges of towns and villages seems to have been set more for visual than noise reasons
Note 2. Dixsaut and colleagues (2009) report a review of this recommendation by AFSSET. They concluded that the 1.5km setback was “not relevant” and would compromise wind park development.

Authority	Year	Notes	Recommendation	
			Miles	Kilometres
Frey & Hadden	2007	Scientists. Turbines >2MW	>1.24	>2
Frey & Hadden	2007	Scientists. Turbines <2MW	1.24	2
Harry	2007	UK Physician	1.5	2.4
Pierpont	2008	US Physician	1.5	2.4
Welsh Affairs Select Committee	1994	Recommendation for smaller turbines	0.93	1.5
Scottish Executive	2007	See note 1.	1.24	2
Adams	2008	US Lawyer	1.55	2.5
Bowdler	2007	UK Noise engineer	1.24	2
French National Academy of Medicine	2006	French physicians See note 2	0.93	1.5
The Noise Association	2006	UK scientists	1	1.6
Kamperman & James	2008	US Noise engineers	>.62	>1
Kamperman	2008	US Noise engineer	>1.24	>2
Bennett	2008	NZ Scientist	>0.93	>1.5
Acoustic Ecology Institute	2009	US Noise engineers	0.93	1.5
NSW General Purpose Standing Committee	2009	Legislators	1.24	2
Thorne	2010	Aus/NZ acoustician	1.24	2
Horonjeff	2010	US acoustician	1.5-2	2.4-3.2

THE "HOW TO" GUIDE
TO
SITING WIND TURBINES
TO PREVENT HEALTH RISKS FROM SOUND

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"A subset of society should not be forced to bear the cost of a benefit for the larger society."[1]

I. Introduction

A new source of community noise is spreading rapidly across the rural U.S. countryside. Industrial-scale wind turbines (WT), a common sight in many European countries, are now actively promoted by federal and state governments in the U.S. as a way to reduce coal-powered electrical generation and global warming. The presence of industrial wind projects is expected to increase dramatically over the next few years, given the tax incentives and other economic and political support currently available for renewable energy projects in the U.S.

As a part of the widespread enthusiasm for renewable energy, state and local governments are promoting "Model Ordinances" for siting industrial wind farms which establish limits for noise and other potential hazards. These are used to determine where wind projects can be located in communities, which are predominantly rural and often extremely quiet during the evening and night. Yet, complaints about noise from residents near existing industrial wind turbine installations are common. This raises serious questions about whether current state and local government siting guidelines for noise are sufficiently protective for people living close to the wind turbine developments. Research is emerging that suggests significant health effects are associated with living too close to modern industrial wind turbines. Research into the computer modeling and other methods used to determine the layout of wind turbine developments, including the distance from nearby residences, is at the same time showing that the output of the models may not accurately predict sound propagation. The models are used to make decisions about how close a turbine can be to a home or other sensitive property. The errors in the predicted sound levels can easily result in inadequate setback distances thus exposing the property owner to noise pollution and potential health risks. Current information suggests the models should not be used for siting decisions unless known errors and tolerances are applied to the results.

Our formal presentation and paper on this topic (*Simple guidelines for siting wind turbines to prevent health risks*) is an abbreviated version of this essay. The formal paper was presented to the Institute of Noise Control Engineers (INCE) at its July Noise-Con 2008 conference in Detroit, MI, A copy of

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[1] George S. Hawkins, Esq., *"One Page Takings Summary: U.S Constitution and Local Land Use,"* Stony Brook-Millstone Watershed Association; *"...nor shall private property be taken for public use, without just compensation."* Fifth Amendment, US Constitution.

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the paper is included at the end of this document. The formal paper covered the community noise studies performed in response to complaints, research on health issues related to wind turbine noise, critiques of noise studies performed by consultants working for the wind developer, and research/technical papers on wind turbine sound immissions and related topics. The formal paper also reviewed sound studies conducted by consultants for governments, the wind turbine owner, or the local residents for a number of sites with known health or annoyance problems. The purpose was to determine if a set of simple guidelines using dBA and dBC sound levels can serve as the 'safe' siting guidelines for noise and its effects on communities and people. The papers considered in our review included, but were not limited to, those listed in Tables 1-4 on pages 2 through 4 of the Noise-Con document.

This essay expands upon the Noise-Con paper and includes information to support the findings and recommended criteria. We are proposing very specific, yet reasonably simple to implement and assess criteria for audible and non-audible sound on adjacent properties and also present a sample noise ordinance and the procedures needed for pre-construction sound test, computer model requirements and follow-up tests (including those for assessing compliance).

The purpose of this expanded paper is to outline a rational, evidence-based set of criteria for industrial wind turbine siting in rural communities, using:

1) A review of the European and other wind turbine siting criteria and existing studies of the prevalence of noise problems after construction;
2) Primary review of sound studies done in a variety of locations in response to wind turbine noise complaints (Table 1);
3) Review of publications on health issues for those living in close proximity to wind turbines (Table 2);
4) Review of critiques of pre-construction developer noise impact statements (Table 3); and
5) Review of technical papers on noise propagation and qualities from wind turbines (Table 4).

The Tables are on pages 2-4 of the formal paper. We also cite standard international criteria for community noise levels and allowances for low-frequency noise.

The specific sections are:

1. Introduction (This section)
2. Results of Literature Review and Sound Studies
3. Development of Siting Criteria
4. Proposed Sound Limits
5. How to Include the Recommended Criteria in Local or State Noise Ordinances
6. Elements of a Wind Energy System Licensing Ordinance
7. Measurement Procedures (Appendix to Ordinance)
8. The Noise-Con 2008 paper "Simple guidelines for siting wind turbines to prevent health risks" with revisions not in the paper included in the conference's Proceedings.

The construction of large WT (industrial wind turbines) projects in the U.S. is a relatively recent phenomenon, with most projects built after 2000. Other countries, especially in Europe, have been using wind energy systems (WES) since the early 1990's or earlier. These earlier installations generally used turbines of less than 1 MW capacity with hub heights under 61 m (200 feet). Now, many of these earlier turbines reaching the end of their useful life, are being replaced with the

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larger 1.5 to 3 MW units. Thus, the concepts and recommendations in this article, developed for the 1.5 MW and larger turbines being build in the U.S, may also be applicable abroad.

II. Results of Literature Review and Sound Studies

In the U.K. there are currently about 133 operating WT developments. Many of these have been in operation for over 10 years. The Acoustic Ecology Institute[2] (AEI) reported that a Special Report for the British government titled "Wind Energy Noise Impacts,"[3] found that about 20% of the wind farms in the U.K. generated most of the noise complaints. Another study commissioned by British government, from the consulting firm Hayes, McKensie, reported that only five of 126 wind farms in the U.K. reported problems with the noise phenomenon known as aerodynamic modulation.[4] Thus, experience in the U. K. shows that not all WT projects lead to community complaints. AEI posed an important question: **"What are the factors in *those* wind farms that may be problematic, and how can we avoid replicating these situations elsewhere?"**

As experienced industrial noise consultants ourselves, we would have expected the wind industry, given the U.K. experience, to have attempted to answer this question, conducting extensive research -- using credible independent research institutions -- before embarking on wind power development in the U.S. The wind industry was aware, or should have been aware, that 20% of British wind energy projects provoked complaints about noise and/or vibration, even in a country with more stringent noise limits than in the U.S.

The wind industry complies with stricter noise limits in the U.K. and other countries than it does in the U.S., for example[5]:

- Australia: higher of 35 dBA or L_{90} + 5 dBA
- Denmark: 40 dBA
- France: L_{90} + 3 dBA (night) and L_{90} + 5 dBA (day)
- Germany: 40 dBA
- Holland: 40 dBA
- United Kingdom: 40 dBA (day) and 43 dBA or L_{90} + 5 dBA (night)
- Illinois: Octave frequency band limits of about 50 dBA (day) and about 46 dBA (night)
- Wisconsin: 50 dBA
- Michigan: 55 dBA

Industry representatives on state governmental committees have worked to establish sound limits and setbacks that are lenient and favor the industry. In Michigan, for example, the State Task Force (working under the Department of Labor and Economic Growth) recommended in its "Siting Guidelines for Wind Energy Systems" that the limits be set at 55 dBA or L_{90} + 5 dBA, whichever is higher. In Wisconsin, the State Task Force has recommended 50 dBA.

When Wisconsin's Town of Union wind turbine committee made an open records request to find out the scientific basis for the sound levels and setbacks in the state's draft model ordinance, it found that no scientific or medical data was used at all. Review of the meeting minutes provided

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[2] (http://www.acousticecology.org/srwind.html)

[3] AEI is a 501(c)3 non-profit organization based in Santa Fe, New Mexico, USA. The article is available at http://www.acousticecology.org/srwind.html

[4] Study review available at: http://www.berr.gov.uk/files/file35592.pdf

[5] Ramakrishnan, Ph. D., P. Eng., Ramani, "Wind Turbine Facilities Noise Issues" Dec. 2007 Prepared for the Ontario Ministry of Environment.

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under the request showed that the limits had been set by Task Force members representing the wind industry.[6] This may explain why state level committees or task forces have drafted ordinances with upper limits of 50 dBA or higher instead of the much lower limits applied to similar projects in other countries. There is no independent, scientific or medical support for claims that locating 400+ foot tall wind turbines as close as 1000 feet (or less) to non-participating properties will not create noise disturbances, economic losses or other risks.[7] But, there is considerable independent research supporting that this will result in public health risks and other negative impacts on people and property.

To illustrate the way a typical WT developer responds to a question raised by a community committee about noise and health the following example is presented and discussed:

> **Q: 19. What sound standards will EcoEnergy ensure that the turbines will be within, based on the setbacks EcoEnergy plans to implement, and what scientific and peer reviewed data do you have to ensure and support there will be no health and safety issues to persons within your setbacks?**
>
> **Answer:** As mentioned, turbines are sited to have maximum sound level of 45dBA. These sound levels are well below levels causing physical harm. Medical books on sound indicate sound levels above 80-90dBA cause physical (health) effects. The possible effects to a person's health due to "annoyance" are impossible to study in a scientific way, as these are often mostly psychosomatic, and are not caused by wind turbines as much as the individuals' obsession with a new item in their environment.
>
> **From EcoEnergy's "Response to the Town of Union Health & Safety Research Questionnaire"**
> By Curt Bjurlin, M.S., Wes Slaymaker, P.E., Rick Gungel, P.E., EcoEnergy, L.L.C., submitted to Town of Union, Wisconsin and Mr. Kendall Schneider, on behalf of the Town of Union

A serious question was asked and it deserves a responsible answer. The committee, charged with fact-finding, sought answers they presumed would be based on independent, peer-reviewed studies. Instead, the industry response was spurious and misleading, and did not address the question. It stated that the turbines will be located so as to produce maximum sound levels of 45 dBA, the tone and context implying that 45 dBA is fully compatible with the quiet rural community setting. No acknowledgement is made of the dramatic change this will be for the noise environment of nearby families. No mention is made of how the WT, once in operation, will raise evening and nighttime background sound levels from the existing background levels of 20 to 30 dBA to 45 dBA. There is no disclosure of the considerable low frequency content of the WT sound; in fact, there are often claims to the contrary. They fail to warn that the home construction techniques used for modern wood frame homes result in walls and roofs that cannot block out WT low frequencies.

There is no mention of the nighttime sound level recommendations set by the World Health Organization (WHO) in its reports, *Guidelines for Community Noise* [8] and "Report on the third

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[6] Lawton, Catharine M., Letter to Wisconsin's "Guidelines and Model Ordinances Ad Hoc Subcommittee of the Wisconsin Wind Power Siting Collaborative" in Response to Paul Helgeson's 9/20/00 "Wisconsin Wind Ordinance Egroups E-Mail Message," Sept. 20, 2000, a Public Record obtained through Open Meetings Act request by the Town of Union, Wisconsin, Large Wind Turbine Citizens Committee.

[7] It is worth noting that the 2007-06-29 version of the Vestas Mechanical Operating and Maintenance Manual for the model V90 – 3.0 MW VCRS 60 Hz turbine includes this warning for technicians and operators:

> **"2. Stay and Traffic by the Turbine**
>
> Do not stay within a radius of 400m (1300ft) from the turbine unless it is necessary. If you have to inspect an operating turbine from the ground, do not stay under the rotor plane but observe the rotor from the front.
> Make sure that children do not stay by or play nearby the turbine. ...."

[8] Available at http://www.who.int/docstore/peh/noise/guidelines2.html.

meeting on night noise guidelines.[9]" In these documents WHO recommends that **sound levels during nighttime and late evening hours should be less than 30 dBA during sleeping periods to protect children's health.** They noted that a child's autonomic nervous system is 10 to 15 dB more sensitive to noise than is an adult. Even for adults, health effects are first noted in some studies when the sound levels exceed 32 dBA L_{max}. These sounds are 10-20 dBA lower than the sound levels needed to cause awakening.

For sounds that contain a strong low frequency component, which is typical of wind turbines, WHO says that the limits may need to be even lower than 30 dBA to avoid health risks. Further, they recommend that the criteria use dBC frequency weighting instead of dBA for sources with low frequency content. When WT sound levels are 45 dBA outside a home, we may find that the interior sound levels will drop to the 30 dBA level recommended for sleeping areas but low frequency noise only decreased 6-7 dBC from outside to inside. That could create a sleep problem because the low frequency content of the noise can penetrate the home's walls and roof with little reduction. An example demonstrating how WT sound is affected by walls and windows is provided later in this document.

The wind turbine developers in the excerpt above do not disclose that the International Standards Organization (ISO) in ISO 1996-1971 recommends 25 dBA as the maximum night-time limit for rural communities. As can be seen in the table below, sound levels of 40 dBA and above are only appropriate in suburban communities during the day and urban communities during day and night. There are no communities where 45 dBA is considered acceptable at night.

ISO 1996-1971 Recommendations for Community Noise Limits (dBA)			
District Type	Daytime Limit	Evening Limit 7-11pm	Night Limit 11pm-7am
Rural	35dB	**30dB**	**25dB**
Suburban	40dB	35dB	**30dB**
Urban residential	45dB	40dB	35dB
Urban mixed	50dB	45db	40dB

Further, the wind industry claims, "*These sound levels are well below levels causing physical harm. Medical books on sound indicate sound levels above 80-90dBA cause physical (health) effects.*" Concern about sound levels in the 80-90 dBA range is for hearing health (your ears) and not the health-related issues of sleep disturbance and other symptoms associated with prolonged exposure to low levels of noise with low frequency and amplitude modulation such as the sound emitted by modern wind turbines. This type of response is a non-answer. It is an overt attempt to mislead while giving the appearance of providing a legitimate response.

Furthermore, the statement, "*The possible effects to a person's health due to 'annoyance' are impossible to study in a scientific way, as these are often mostly psychosomatic, and are not caused by wind turbines as much as the individuals' obsession with a new item in their environment,*" is both inaccurate and misleading. It ignores the work of researchers such as Pedersen, Harry, Phipps, and Pierpont on wind turbine effects specifically, and the numerous medical research studies reviewed by Frey and Hadden. The studies belie the claims of the wind industry. This "failure to locate" published

[9] Available at: http://www.euro.who.int/Noise/activities/20040721_1 References found in Report on third meeting at pages 13 and others

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studies that are readily available on the internet as to make some interpret the claim of "no medical research" as a conscious decision to not look for it. Those companies that do acknowledge the existence of medical research take the position that it is not credible for one or another reason and thus can be ignored.

Making statements outside their area of competence, wind industry advocates, without medical qualifications, label complaints of health effects as "psychosomatic" in a pejorative manner that implies the complaints can be discounted because they are not "really medical" conditions. Such a response cannot be considered to be based in fact. It is, at best, an opinion. It ignores the work of many researchers, including the World Health Organizations, on the effect of sounds during nighttime hours that result in sleep disturbance and other disorders with physical, not just psychological, pathologies.[10,11] Many people find it difficult to articulate what has changed. They know something is different from before the wind turbines were operating and they may express it as feeling uncomfortable, uneasy, sleepless, or some other symptom, without being able to explain why it is happening.

Our review of the studies listed in Tables 1-4 of our Noise-Con paper show that some residents living as far as 3 km (1.86 mi) from a wind farm complain of sleep disturbance from the noise. Many residents living 1/10 of this distance (300 m or 984 ft) from wind farms experience major sleep disruption and other serious medical problems from nighttime wind turbine noise. The peculiar acoustic characteristics of wind turbine noise immissions[12] cause the sounds at the receiving properties to be more annoying and troublesome than the more familiar noise from traffic and industrial factories. Limits used for these other community noise sources are not appropriate for siting modern industrial wind turbines. The residents who are annoyed by wind turbine noise complain of the repetitive, approximately once-per-second (1 Hz) "swoosh-boom-swoosh-boom" sound of the turbine blades and of "low frequency" noise. It is not clear to us whether the complaints about "low frequency" noise are about the audible low frequency part of the "swoosh-boom" sound, the once-per-second amplitude modulation (amplitude modulation means that the sound varies in loudness and other characteristics in a rhythmic pattern) of the "swoosh-boom" sound, or some combination of the two.

Figure 1 of our Noise Con paper, reproduced as Figure 1, below, shows the data from one of the complaint sites plotted against the sound immission spectra for a modern 2.5 MWatt wind turbine; A home in the United States at 2km distance, Young's threshold of perception for the 10% most sensitive population (ISO 0266); and a spectrum obtained for a rural community during a three hour, 20 minute test from 11:45 pm until 3:05 am on a windless June evening near Ubly, Michigan. This is a quiet rural community located in central Huron County (also called Michigan's Thumb). It is worth noting that this sound measurement sample demonstrates how quiet a rural community can be when located at a distance from industry, highways, and airport related noise emitters.

The line representing the threshold of perception is the focus of this graph. The remaining graphs show sound pressure levels (dB) at each of the frequency ranges from the lowest inaudible sounds at the left, to sounds that "rumble" (20Hz to about 200 Hz) and then those in the range of communication (200Hz through about 4000Hz) through high pitched sounds (up to 10,000 Hz). At

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[10] WHO European Centre for Environment and Health, Bonn Office, "Report on the third meeting on night noise guidelines," April 2005.

[11] According to Online Etymology Dictionary, *psychosomatic* means "pertaining to the relation between mind and body, ... applied from 1938 to physical disorders with psychological causes."

[12] *Emissions* refer to acoustic energy from the viewpoint of the sound emitter, while *immissions* refer to acoustic energy from the viewpoint of the receiver.

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each frequency where the graphs of sound pressures are above (exceed) the graph showing perception the wind turbine sounds would be perceptible or audible. The more the wind turbine sound exceeds the perception curve the more pronounced it will be. When it exceeds the quiet rural background sound level (L_{A90}) it will not be masked or obscured by the rural soundscape.

The over-all sounds from each of the frequency bands are summed and presented on the right hand side of the graph. These are presented with corrections for A-weighting (dBA) and C-weighting (dBC). These show that if only dBA criteria are used to assess and limit wind turbine sound the low frequency content of the wind turbines emissions are not revealed. Note that in many cases the values for dBC are almost 20 dB higher than the dBA values. This is the basis for the WHO warning that when low frequency sound content is present outside a home dBA is not an appropriate method of describing predicted noise impacts, sound limits, or criteria.

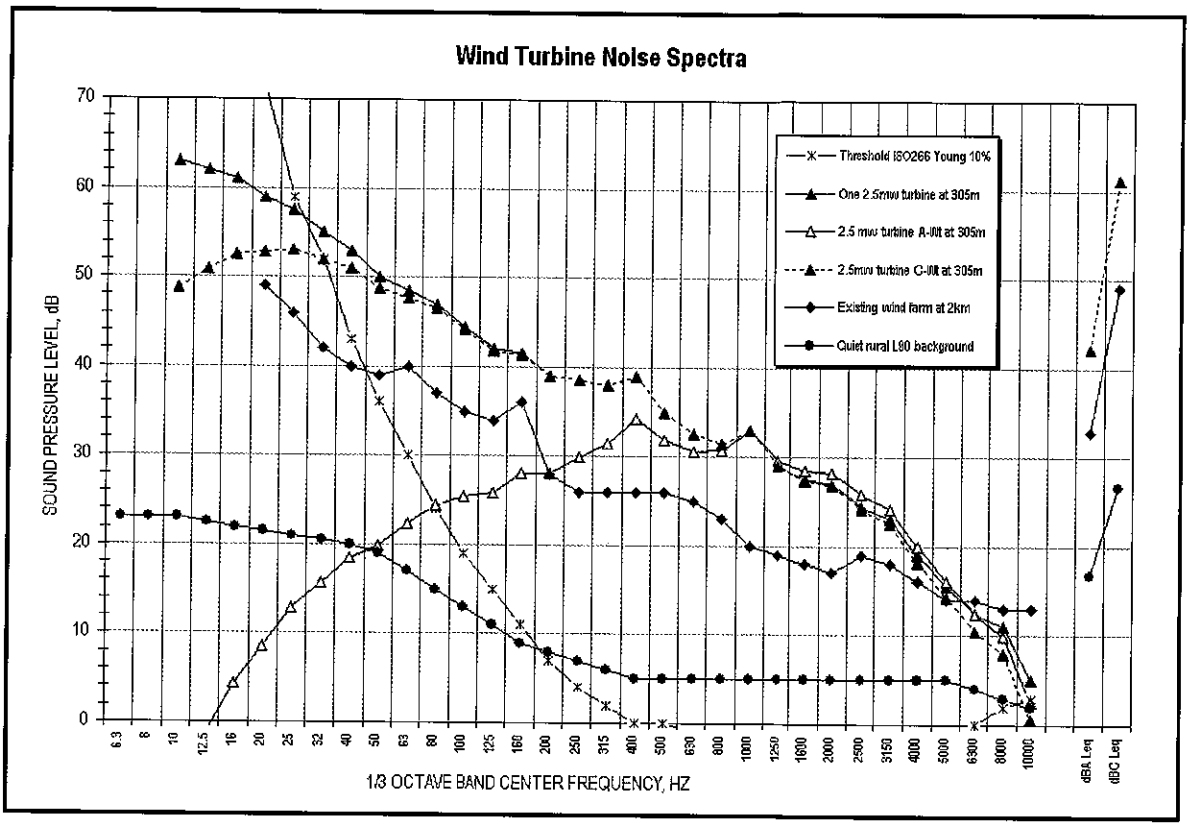


Figure 1-Graph Of Wind Turbine Sounds Vs. Rural Background And Threshold Of Perception

(Note: The lowest L_{Aeq} and L_{Ceq} shown at right are measured background L_{A90} and L_{C90}. The Leq values could be 0-5 dB higher)

Our review of the studies listed in Tables 1-4 in the Noise-Con paper at the end of this document, provided answers to a number of significant questions we had, as acoustical engineers, regarding the development of siting guidelines for industrial-scale wind turbines. They are provided below for easy of reading and continuity:

Do international, national, or local community noise standards for siting wind turbines near dwellings address the low frequency portion of the wind turbines' sound immissions? No. State and local governments are in the process of establishing wind farm noise limits and/or wind turbine setbacks from nearby residents, but the standards incorrectly assume that limits based on dBA levels are sufficient to protect the residents.

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Do wind farm developers have noise limit criteria and/or wind turbine setback criteria that apply to nearby dwellings? Yes. But the industry-recommended wind turbine noise levels (typically 50-55 dBA) are too high for the quiet nature of the rural communities and may be unsafe for the nearest residents. An additional concern is that some of the methods for pre-construction computer modeling may predict sound levels that are too low. These two factors combined can lead to post-construction complaints and health risks.

An example of a condition that complies with

Are all residents living near wind farms equally likely to be affected by wind turbine noise? No. Children, people with certain pre-existing medical conditions, and the elderly are likely to be the most susceptible. Some people are unaffected while nearby neighbors develop serious health problems caused by exposure to the same wind turbine noise.

How does wind turbine noise impact nearby residents? Wind turbine-associated symptoms include sleep disturbance, headache, ringing in the ears, dizziness, nausea, irritability, and problems with memory, concentration, and problem solving, as described in the first paper in this volume.

What are the technical options for reducing wind turbine noise immission at residences? There are only two options: 1) increase the distance between the source and receiver, or 2) reduce the source sound power emission. Either solution is incompatible with the objective of the wind farm developer, which is to maximize the wind power electrical generation within the land available.

Is wind turbine noise at a residence much more annoying than traffic noise? Yes. Researchers have found that, "Wind turbine noise was ... found to cause annoyance at sound pressure levels lower than those known to be annoying for other community noise sources, such as road traffic. ...Living in a clearly rural area in comparison with a suburban area increases the risk of annoyance with wind turbine noise.[13]" In other papers by Pedersen wind turbine noise was perceived by about 85% of respondents to the study at sound levels as low as 35.0-37.5 dBA.[14] Currently, this increased sensitivity is believed to be due to the presence of amplitude modulation in the wind turbine's sound emissions which limits the masking effect of other ambient sounds and the low frequency content which is associated with the sounds inside homes and other buildings.

Amplitude modulation is a continuing change in the sound level in synchronization with the turning of the wind turbine's blades. An example of amplitude modulation is shown in the figure 2 below. This figure shows the constantly varying dBA sound level in the graph at the top. The sound level varies from a low of 40 dBA to a high of 45 dBA repeating every 1.3 seconds continuously when the turbine is operating. The turbine is located approximately 1200 feet from the farmhouse. The photo shows the turbine that was dominant during this test.

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[13] Pedersen E, Bouma J, Bakker R and Van den Berg F, "Wind Farm perception- A study on acoustic and visual impact of wind turbines on residents in the Netherlands;" 2nd International Meeting on Wind Turbine Noise, Lyon France; Sept. 20-21, 2007 (Pages 2 and 3)

[14] Pedersen E and Persson Waye K. 2004. Perceptions and annoyance due to wind turbine noise -- a dose-response relationship. J Acoust Soc Am 116(6): 3460-3470

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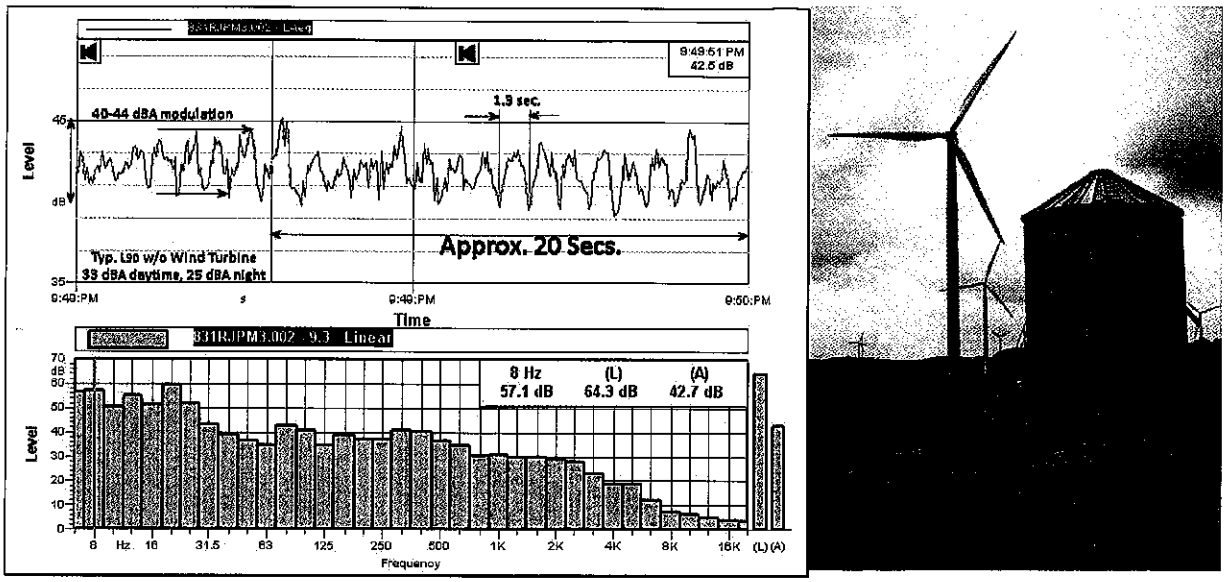


Figure 2 Amplitude Modulation at a farmhouse (Study sponsored by CCCRE, Calumet, Wisconsin)

It is worth noting that this measurement averages about 43 dBA (L_{eq}) which is very close to the sound level predicted for a single turbine at 1000 feet in Figure 1 (solid red line with solid triangle markers). The lower graph shows the frequency spectrum at approximately 9:49 PM at a low point in the amplitude modulation. (The frequency chart's cursor is the vertical line at the upper graph's midpoint.) Note the dominance of sound energy in the lower frequency range. This was also present in the model's predictions in Figure 1.

It is not hard to understand why many people in this community feel that they have been forced to accept noise pollution as a side effect of the wind project. Even though the 40 to 45 dBA sound levels in this example may comply with the 50 dBA limits adopted by the host county from the Wisconsin Model Ordinance the impact on the people near the wind project are subjected to noise pollution. This example demonstrates why criteria set at 50 dBA or higher do not protect the health and economic welfare of people living in the host communities. Adopting criteria such as those recommended later in this essay can prevent these situations from occurring.

Low frequency noise is a problem inside buildings

When low frequency sound is present outside homes and other occupied structures, it is often more an indoor problem than an outdoor one. This is very true for wind turbine sounds.

Why do wind turbine noise immissions of only 35 dBA disturb sleep at night? Affected residents complain of the middle- to high-frequency, repetitive swooshing sounds of the rotating turbine blades at a constant rate of about 1 Hz, plus low frequency noise. The amplitude modulation of the "swooshing" sound changes continuously. Residents also describe a thump or low frequency banging sound that varies in amplitude up to 10 dBA in the short interval between the swooshing sounds. This may be a result of sounds from multiple wind turbines with similar spectral content combining to increase and decrease the sound over and above the effects of modulation. [Note: These effects (e.g. phasing and coherence effects) are not normally considered in predictive models.] It may also be a result of turbulence of the air and wind on wind turbine operations when the blades are not at an optimum angle for noise emissions and/or power generation. It is also a result of sounds penetrating homes and other buildings at night and at other times where quiet is needed. When low frequency sound is present outside homes and other occupied structures, it is

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often more likely to be an indoor problem than an outdoor one. This is very true for wind turbine sounds.

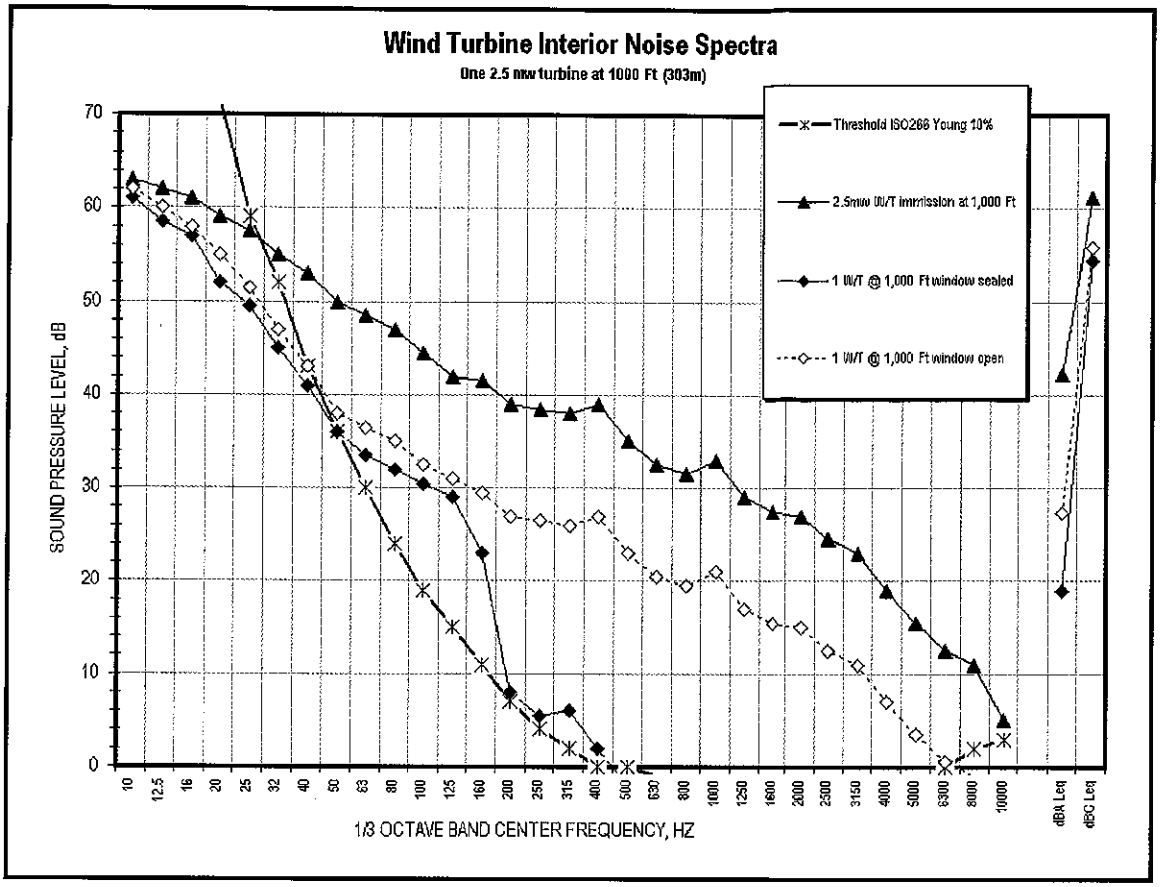


Figure 3-A Single Wind Turbine Sound Inside Home @ 1000 Feet

The usual assumption about wall and window attenuation being 15 dBA or more, which is valid for most sources of community noise, may not be sufficiently protective given the relatively high amplitude of the wind turbines' low frequency immission spectra. Figures 2 and 3 demonstrate the basis for this concern.

To demonstrate the effects of outdoor low frequency content from wind turbines we prepared Figure 1 showing the effect of a single turbine (propagation model based on sound power level test data) at 1000 feet and then in Figure 4 projected the impact of ten (10) similar turbines at one (1) mile. We applied the façade sound isolation data from the Canada Research Council to the wind turbine example used in our Noise-Con 2008 paper and shown in Figure 1 above. The graphs each show the outdoor sound pressure levels predicted for the distance of 1000 feet and one mile as the upper graph line respectively. The curve showing the threshold of human perception for sounds at each 1/3 octave band center is also plotted. When the graphs representing wind turbine sound have data points above this threshold curve the sounds will be perceptible to at least 10% of the population (which includes most children).

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In addition to the top graph line representing the sounds outside the home there are two other graph lines for the sounds inside the home[15]. One curve represents the condition of no open windows and the other represents one open window.

With just one turbine at 1,000 feet there is a significant amount of low frequency noise above hearing threshold within rooms having exterior walls without windows or very well sealed windows. Even with the windows closed the sound pressure levels in the 63 Hz to 200 Hz one-octave bands still exceed the perception curve, in many cases by more than 10 dB. Note the perceptible sound between 50 and 200 Hz with a wall resonance frequency at 125 Hz (2 X 4 studs on 16 inch centers) for the "windows closed" condition. This would be perceived as a constant low rumble, which would be present inside homes whenever the turbines are operating.

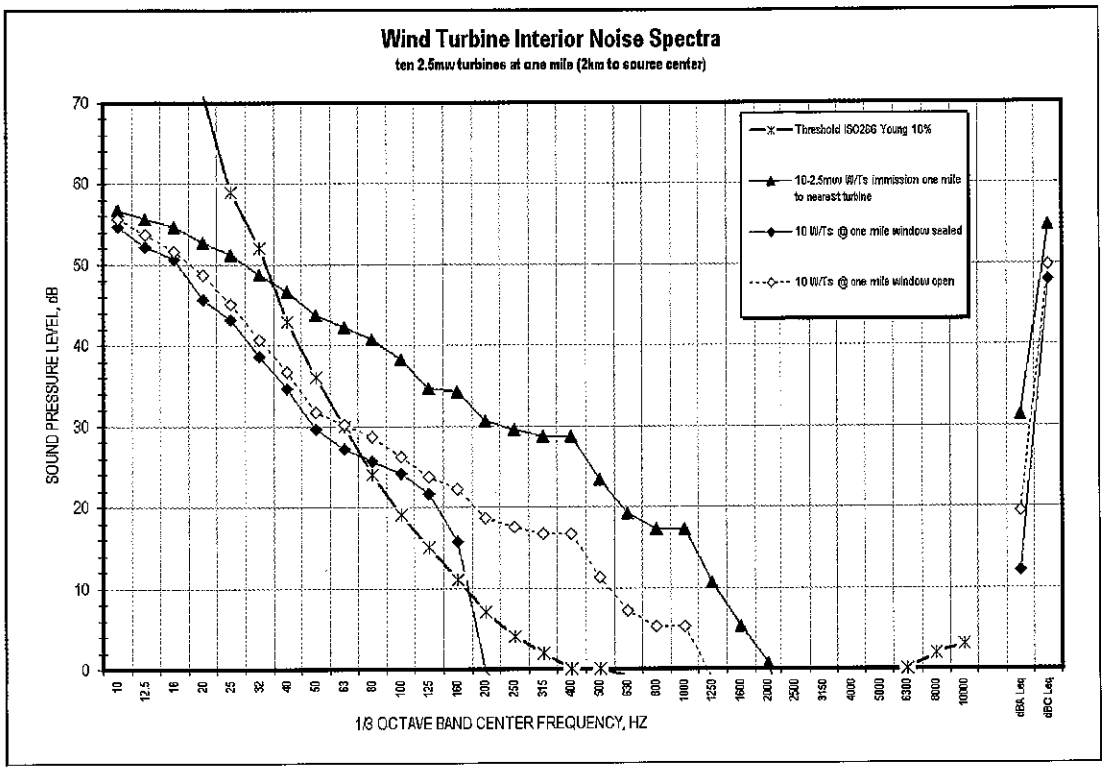


Figure 4-Sound from Ten (10) Wind Turbines inside home at One Mile

When comparing the dBC values the difference between inside sounds and outside is much less. The maximum difference in this example is only 7 dBC and that is for the situation with windows closed. With windows open the sound inside the home would be 56 dBC while it is 61 dBC outside; a difference of only 5 dBC[16,17,18]. If we looked only at dBA it would appear that the home's

[15] The typical wood stud exterior used in modern home construction is vinyl siding over 1/2 inch OSB or rigid fiberglass board applied to 2 X 4 studs with the stud space filled with thermal and 1/2 inch gypsum board applied on the exposed interior side. This has a mass of about 3-4 lbs/sq ft and low 26 STC.

[16] The basis for these predictions includes reports on aircraft sound insulation for dwellings and façade sound isolation data from the Canada Research Council.

[17] "On the sound insulation of wood stud exterior walls" by J. S. Bradley and J. S. Birta, institute for Research in Construction, National Research Council, Montreal Road, Ottawa K1A 0R6, Canada, published: J.Acoust. Soc. Am. 110 (6), December 2001

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walls and roof provide a reduction of 15 dBA or more. But, that that would be misleading because it ignores the effects of low frequency sound.

We next increased the number of 2.5 Mw turbines from one to ten and moved the receiver one mile from the closest turbine. We assumed the acoustic center for the ten turbines to be 2km (1-1/4 miles) from the receiver. These results are presented in Figure 4. We were surprised to find that the one mile low frequency results are only 6.3 dB below the 1,000 foot one turbine example.

There is one other characteristic of wind turbine sound that increases the sleep disturbance potential above that of other long-term noise sources. The amplitude modulation of the sound emissions from the wind turbines create a repetitive rise and fall in sound levels synchronized to the blade rotation speed. Many common weather conditions increase the magnitude of amplitude modulation. Most of these occur at night. The graph in Figure 5 shows this effect in the first floor bedroom of a farm home in the U.K. The home is located 930 meters (3,050 feet) from the nearest turbine. The conditions documented by an independent acoustical consultant show the sound level varying over 9 dBA range from 28 to 37 dBA. The pattern repeats approximately every second often for hours at a time. For many people, especially seniors, children and those with pre-existing medical conditions, this represents a major challenge to restful sleep.

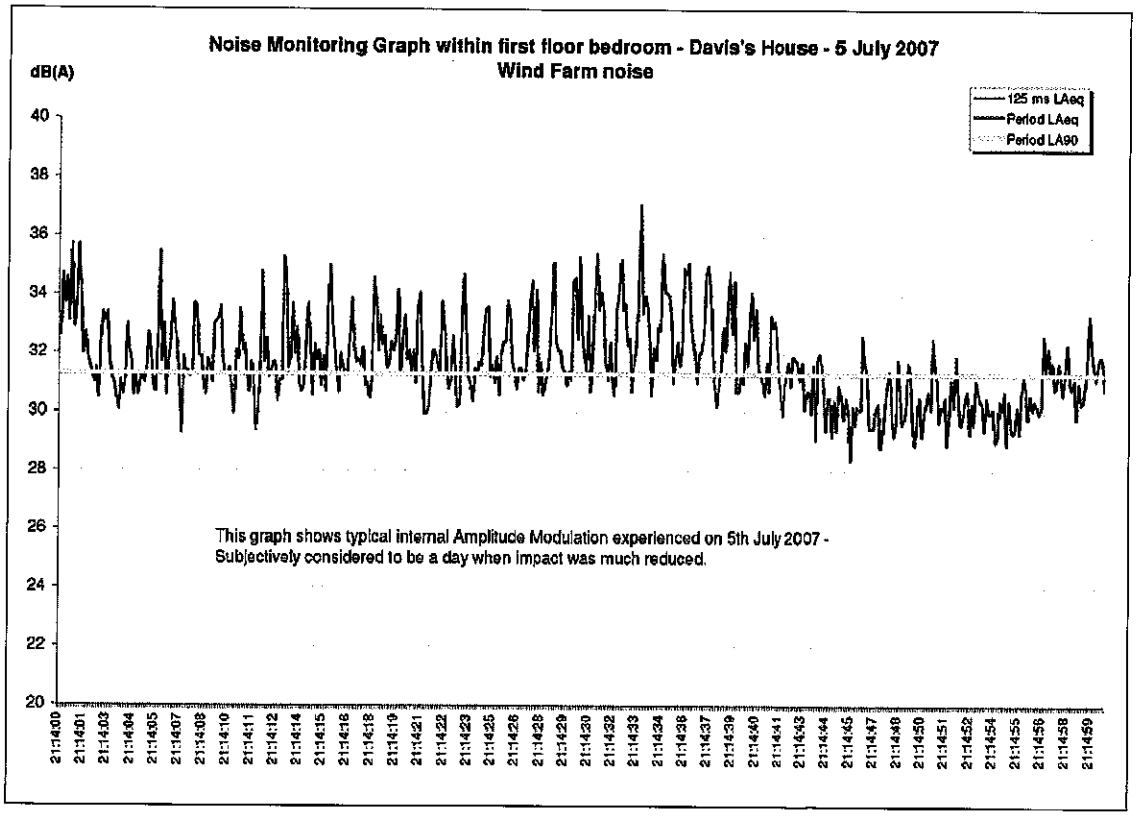


Figure 5- Amplitude modulation in a home 930 meters (3000 feet) from the nearest turbine.[19]

This may explain why some residents as far as two (2) miles from a wind farm find the wind turbines sounds highly annoying. It also demonstrates the primary reason why relying on dBA

[18] Dan Hoffmeyer, Birger Plovsing: "Low Frequency Noise from Large Wind Turbines, Measurements of Sound Insulation of Facades." Journal no. AV 1097/08, Client: Danish Energy Authority, Amaliegade 44, 1256 Copenhagen

[19] This chart used with permission of Mike Stigwood, MIOA, FRSH, MAS Environmental, U.K. and the Davis family.

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alone will not work for community noise criteria. It is the low frequency phenomena associated with wind turbine emissions that makes the dBC test criteria an important part of the proposed criteria[20].

III. Development of Siting Criteria

Basis For Using L_{A90} To Determine Pre-Construction Long-Term Background Sound

We began our research into guidelines for proper siting by reviewing guidelines used in other countries to limit WT sound emissions. A recent compendium of these standards was presented in the report "Wind Turbine Facilities Noise Issues."[21] We found common ground in many of them. Some set explicit not-to-exceed sound level limits, for example, in Germany, 40 dBA nighttime in residential areas and 35 dBA nighttime in rural and other noise-sensitive areas. Other countries use the existing background sound levels for each community as the basis for establishing the sound level limits for the WES project. This second method has the advantage of adjusting the allowable limits for various background soundscapes. It makes use of a standard method for assessing background sound levels by measuring over a specified period of observation to determine the sound level exceeded 90% of the time (L_{90}) during the night. The night is important because it is the most likely time for sleep disturbance. Then, using the background sound level as the base, the WES project is allowed to increase it by 5 dBA. It is this second method (L_{90} + 5 dBA) that was adopted for the criteria in this document. It has the advantage of adjusting the criteria for each community without the need for tables of allowable limits for different community types. The focus is only on the nighttime criteria. This is because the WES will operate 24 hours a day and the nighttime limits will be the controlling limits whether or not there are other limits for daytime.

Wind turbine noise is more annoying than other noises and needs lower limits

Since many rural communities are very quiet, it is possible that some will have L_{90} values of 25 dBA or lower. This may seem extreme when compared to limits usually imposed on other sources of community noise. However, wind turbine sounds are not comparable to the more common noise sources of vehicles, aircraft, rail, and industry. Several studies have shown that annoyance to wind turbine sounds begins at levels as low as 30 dBA.[22] This is especially true in quiet rural communities that have not had previous experience with industrial noise sources. This increased sensitivity may be due to the periodic 'swoosh' from the blades in the quiet rural soundscape, or it may be more complex. In either case, it is a legitimate response to wind turbine sound documented in peer-reviewed research.

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[20] Hessler Jr., George F., "Proposed criteria in residential communities for low-frequency noise emissions from industrial sources," 52(4), 179-185, (July-Aug 2004)

[21] Ramani Ramakrishnan, Ph.D., P. Eng., "Wind Turbine Facilities Noise Issues," December 2007. Prepared for the Ontario Ministry of Environment.

[22] Eja Pedersen, "Human response to wind turbine noise: perception, annoyance and moderating factors." Dissertation, Occupational and Environmental Medicine, Department of Public Health and Community Medicine, Goteborg University, Goteborg, Sweden, 2007, and

Van den Berg F, Pedersen E, Bouma J, and Bakker R, Wind Farm Perception, Final Report Project no. 044628, University of Gothenburg and Medical Center Groningen, Netherlands June 3, 2008

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Noise criteria need to take into account low frequency noise

In the table to the right are a series of observations and recommendations by the World Health Organization (WHO) supporting the need for stricter limits when there is substantial low frequency content in outdoor sound. Our review of other studies, and our own measurements, has demonstrated that wind turbine sound includes considerable low frequency content. We include a dBC limit in our guidelines to address the WHO recommendation that when low frequency sound may be present, criteria based on measurements using a C-weighting filter on the sound level meter (dBC) are needed in addition to dBA criteria.

The World Health Organization recognizes the special place of low frequency noise as an environmental problem. Its publication "Community Noise" (Berglund et al., 2000) makes a number of references to low frequency noise, some of which are as follows:

- "It should be noted that low frequency noise... can disturb rest and sleep even at low sound levels.
- For noise with a large proportion of low frequency sounds a still lower guideline (than 30dBA) is recommended.
- When prominent low frequency components are present, noise measures based on A-weighting are inappropriate.
- Since A-weighting underestimates the sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting.
- It should be noted that a large proportion of low frequency components in a noise may increase considerably the adverse effects on health."

WHO also states: "The evidence on low frequency noise is sufficiently strong to warrant immediate concern."

Available at http://www.who.int/docstore/peh/noise/guidelines2.html, References found at pages ix, xii through xv and others.

IV. Proposed Sound Limits

The simple fact that so many residents complain of low frequency noise from wind turbines is clear evidence that the single A-weighted (dBA) noise descriptor used in most jurisdictions for siting turbines is not adequate. The only other simple audio frequency weighting that is standardized and available on sound level meters is C-weighting or dBC. A standard sound level meter set to measure dBA is increasingly less sensitive to low frequency below 500 Hz (one octave above middle-C). The same sound level meter set to measure dBC is equally sensitive to all frequencies above 32 Hz (lowest note on grand piano). It is generally accepted that dBC readings are more predictive of perceptual loudness than dBA readings if low frequency sounds are significant.

We are proposing to use the commonly accepted dBA criteria that is based on the pre-existing background sound levels allowing the wind turbine development to increase this by 5 dB (e.g. L_{90A} +5) by the audible sounds from wind turbines. According to the New York State Energy Research & Development Authority:

- "... A change in sound level of 5 dB will typically result in a noticeable community response; and
- "... A 10 dB increase is subjectively heard as an approximate doubling in loudness, and almost always causes an adverse community response." [23]

To address the lower frequencies that are not considered in A-weighted measurements we are proposing to add limits based on dBC that follow the same scheme as used for dBA limits. The Proposed Sound Limits are presented in the text box at the end of this section.

For the current industrial grade wind turbines in the 1.5 to 3 MWatt (or over) range, the addition of the dBC requirement may result in an increased distance between wind turbines and the nearby

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[23] (*Wind Energy Development: A Guide for Local Authorities in New York*; page 30; New York State Energy Research & Development Authority, Albany, NY October 2002)

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residents. For the conditions shown in Figure 1, the distances would need to be increased significantly. This would result in setbacks in the range of 1 km or greater for the current generation of wind turbines if they are to be located in rural areas with little or no low frequency sound from man-made noise sources and where the L_{A90} background sound levels are 30 dBA or lower. In areas with higher background sound levels, turbines could be located somewhat closer, but still at a distance greater than the 305 m (1000 ft.) or smaller setbacks commonly seen in U.S. based wind turbine standards set by many states and used for wind turbine developments.

Following are some additional Questions and Answers that summarize the major points of this discussion relevant to criteria.

What are the typical wind farm noise immission criteria or standards? Limits are not consistent and may vary even within a particular country. Examples are listed above in the section on Results of Literature and Sound Studies.

What is a reasonable wind farm sound immission limit to protect the health of residences? We are proposing a not-to-exceed immission limit of 35 L_{Aeq} and a site-specific limit of L_{A90} + 5 dBA at the closest property line, whichever is exceeded first. We also propose the use of C-weighted criteria to address complaints of wind turbine low frequency noise. For the C-weighted criteria, we propose a site-specific limit of L_{C90} + 5 dBC. We also require that the site-specific L_{Ceq} (dBC) sound level at a receiving property line not exceed the pre-existing L_{A90} dB background sound level + 5dB by more than 20 dB. In other words, the dBC operating immission limit (as L_{Ceq}) at the receiving property line should not be more than 20 dB above the measured dBA (as L_{A90}) pre-construction long-term background sound level + 5dB.[24] This criterion prevents an Immission Spectra Imbalance that often leads to complaints about rumble or other low frequency problems. We also include a not-to-exceed immission limit of 55 and 60 L_{Ceq} at the receiving property line.[25] Use of the multiple metrics and weightings will address the audible and inaudible low frequency portions of wind turbine sound emissions. Exceedances of any of the limits establish non-compliance.

Why should the dBC immission limit not be permitted to be more than 20 dB above the background measured L_{A90}+5 dB? The World Health Organization and others[26] have determined that if a noise has a measured difference between dBC and dBA more than 20 dB, the noise is highly likely to create an annoyance because of the low frequency component.

Isn't L_{A90} the <u>minimum</u> background noise level? Not exactly. This is the sound level that represents the quietest 10% of the time. It is often considered to be the sound level that represents the sounds one hears late in the evening or at night when there are no near-by or short term sounds present. It is very important to establish this "long term background" noise environment at the property line for a potentially impacted residence (L_{A90}) during the **quietest** sleeping hours of the night, between 10 p.m. and 4 a.m.. Why? Because nighttime sleep disturbance has generated the majority of wind farm noise complaints throughout the world those conditions should guide the design of wind projects. ANSI standards define the "long term background sound" as excluding all short term sounds from the test sample using carefully selected sampling times and conditions using ten (10) minute long samples. This means that nature sounds not present during all seasons and wind noise are not to be included in the measurement. Following the procedures in ANSI S12.9, Part 3 for long term background sound the L_{A90} and L_{C90} can be measured with one or more 10-minute

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[24] Hessler Jr., George F., Proposed criteria in residential communities for low-frequency noise emissions from industrial sources, Noise Control Engineering Journal; 52(4), pg. 180 in "2. Purpose of Proposed Criteria," (July-Aug 2004)

[25] Ibid, pg. 180 in "3. Proposed Criteria."

[26] Ibid

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measurements during any night when the atmosphere is classified as stable with a light wind from the area of the proposed wind farm. The basis for the immission limits for the proposed wind farm would then be the Nighttime Immission Limits, which we propose to be the minimum ten (10) minute nighttime L_{A90} and L_{C90} plus 5 dB, a test for Spectra Imbalance, and not-to-exceed limits for the period of 10 p.m. to 7 a.m. Daytime Limits (7 a.m. to 10 p.m.) could be set using daytime measurements, but unless the wind utility only operates during the day, the nighttime limit will always be the limiting sound level. Thus, daytime limits are not normally needed.

A nearby industrial scale wind utility meeting these noise immission criteria would occasionally be audible to the residents during nighttime and daytime. However, it would be unlikely for it to be an indoor problem.

The method used for establishing the background sound level at a proposed wind farm in many of the studies in Table 1, does not meet the requirements set by ANSI S12.9 Part 3 for outdoor measurements and determination of long-term background sound levels. Instead, they use unattended noise monitors to record hundreds of 10-minute or one-hour un-observed measurements that include the short term sounds from varying community and wind conditions over a period of days or weeks. The results for daytime and nighttime are usually combined to determine the average wind noise at the microphone as a function of wind velocity measured at a height of ten (10) meters. This provides an enormous amount of data, but the results have little relationship to wind turbine sound immissions or to potential for turbine noise impacts on nearby residents. They also do not comply with ANSI standards for methodology or quality and as such are not suitable for use in measurements that will be used to assess compliance with other standards and guidelines. This exhaustive exercise often only demonstrates how much 'pseudo-noise' is generated by instruments located in a windy environment that exceeds the capability of the instrument's wind screen to protect the microphone. In many cases, this unqualified data is used to support a claim that the wind noise masks the turbines' sound immissions.

The major complaints of residents living near wind farms is sleep disruption at night when there is little or no wind near ground level and the wind turbines located at a much higher elevation are turning and generating near or at maximum power and maximum noise emission. There is usually more surface wind and turbulence during daytime caused by solar radiation. Thus, the use of averaged data involving one or more 24-hour periods is of little value in predicting conditions that will result in people who cannot sleep in their homes during the night because of loud intrusive wind turbine noise.

The methodology used to predict the sound propagation from the turbines into the community also fails to represent the conditions of maximum turbine noise impact on nearby residents. This should be expected given the limitations of models based on ISO 9613-2[27]. They also do not consider the effects of a frequent nighttime condition when winds at the ground are calm and the winds at the hub are at or above nominal operating speed. This condition is often referred to as a "stable" atmosphere. During this condition, the wind turbines can be producing the maximum or near maximum power while the wind at ground level is calm and the background noise level is low. The Michigan rural night test data in the earlier figure shows how quiet a night can be in the absence of wind at the ground. This common condition is known to directly cause chronic sleep

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[27] The ISO 9613-2 sound propagation model formulas have known errors of 3 dB even when the conditions being modeled are a perfect match to the limiting conditions specified in the standard. Wind turbines operate far outside the limits for wind speed, height of the noise source above the ground, and other factors identified in the standard thus increasing the likelihood for error above the specified 3 dB. In addition, there are known measurement errors in the IEC61400-11 test that add another 2 dB of uncertainty to the model's predictions.

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disruption. Further, the studies report average sound levels and do not disclose the effects of amplitude modulation or low frequency sound which makes the turbine's sound more objectionable and likely to cause sleep problems.

Are there additional noise data to be recorded for a pre-wind turbine noise survey near selected dwellings? Yes. The precision measuring sound level meter(s) need to be programmed to include measurement of L_{Aeq}, L_{A10}, L_{A90}, L_{Ceq}, L_{C10}, and L_{C90}, with starting time and date for each 10-minute sample. The L_{10} results will be used to validate the L_{90} data. For example, on a quiet night one might expect L_{10} and L_{90} to show similar results within 5 to 10 dB between L_{10} and L_{90} for each weighting scale. On a windy night or one with nearby short term noise sources the difference between L_{10} and L_{90} may be more than 20 dB. There is also often a need to obtain a time-averaged, one-third octave band analysis over the frequency range from 6.3 Hz to 10 kHz during the same ten minute sample. The frequency analysis is very helpful for identifying and correcting for extraneous sounds such as interfering insect noise. An integrating averaging sound level meter meeting ANSI or IEC Type 1 standards has the capability to perform all of the above acoustic measurements simultaneously and store the results internally. There is also a requirement for measurement of the wind velocity near the sound measurement microphone continuously throughout each 10-minute recorded noise sample. The 10-minute maximum wind speed near the microphone must be less than 2 m/s (4.5 mph) during measurements of background noise (L_{90}), and the maximum wind speed for noise measurements during turbine operation must be less than 4 m/s (9 mph). Measurements should be observed (without contaminating the data) and notes identifying short-term noises should be taken for these tests.

Is there a need to record weather data during the background noise recording survey? One weather monitor is required at the proposed wind farm on the side nearest the residents. The weather station sensors are at the standard 10 meter height above ground. It is critical that the weather be recorded every 10 minutes, synchronized with the clocks in the sound level recorders without ambiguity, at the start and end time of each 10 minute period. The weather station should record wind speed and direction, temperature, humidity and rain.

Why do Canada and some other countries base the permitted wind turbine noise immission limits on the operational wind velocity at the 10m height wind speed instead of a maximum dBA or L_{90} + 5 dBA immission level? First, it appears that the wind turbine industry will take advantage of every opportunity to elevate the maximum permitted noise immission level to reduce the setback distance from the nearby dwellings. Including wind as a masking source in the criteria is one method for elevating the permissible limits. The background noise level does indeed increase with surface wind speed. When this happens, it can be argued that the increased wind noise provides some masking of wind turbine noise. However, this is not true if the surface winds are calm. After sunset, when the ground cools (e.g. in the middle of the night), the lower level atmosphere can separate from the higher-level atmosphere. Then, the winds at the ground will be calm while wind at the turbine hub is very strong. Under this condition, the wind velocity at a 10-meter high wind monitoring station (such as those often used for weather reporting) may be ¼ to ½ the speed of the wind at the hub, yet drop to calm at ground level. The result is that no ground level wind noise is present to mask the sound of the wind turbines, which can be operating at or close to full capacity.

This condition is one of the major causes of wind turbine related noise complaints for residents within 3 km (1.86 miles) of a wind farm. When the turbines are producing high sound levels, it is quiet outside the surrounding homes. The PhD thesis of G.P. van den Berg, *The Sounds of High*

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Winds, is very enlightening on this issue (Table 3). See also the letter by John Harrison in Ontario "On Wind Turbine Guidelines.[28]"

What sound monitor measurements would be needed for enforcement of the wind turbine sound ordinance? A similar set of sound tests using the ten (10) minute series of measurements would be repeated, with and without the operation of the wind turbines, at the location where noise was measured before construction, which is closest to the resident registering the wind turbine noise complaint. If the nighttime background (L_{90}) noise level (turbines off) was found to be slightly higher than the measured background prior to the wind farm installation, then the results with the turbines operating must be corrected using standard acoustical engineering methods to determine compliance with the pre-turbine established sound limits.

Who should conduct the sound measurements? An independent acoustics expert should be retained who reports to the County Board or other responsible governing body. This independent acoustics expert should be responsible for all the acoustic measurements including setup and calibration of instruments and interpretation of recorded results. He or she should perform all pre-turbine background noise measurements and interpretation of results to establish the nighttime (and daytime, if applicable) industrial wind turbine sound immission limits, and to monitor compliance.

At present, the acoustical consultants are retained by, and work directly for, the wind farm developers. This presents a serious problem with conflict of interest on the part of the consultants. The wind farm developer would like to show that a significant amount of wind noise is present to mask the sounds of the wind turbine immissions. The community is looking for authentic results showing that the wind turbine noise will be only barely perceptible, and then only occasionally, during the night or daytime.

Is frequency analysis required either during the pre-construction background noise survey or for compliance measurements? Normally one-third octave or narrower band analysis would only be required if there is a complaint of tones immission from the wind farm. Although only standardized dBA and dBC measurements are required to meet the proposed criteria, the addition of one-third octave band analysis is often useful to validate the dBA and dBC results.

The following summarizes the criteria necessary when siting wind turbines to minimize the risk of adverse impacts from noise on the adjacent community[29]. For those not familiar with acoustical annotation the table and its formulas may seem overly complex, but the criteria are defined in this manner to be as unambiguous as possible. They will be clear for those who are familiar with acoustical terminology. Definitions are provided in a later section of this essay.

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[28] Harrison, J., *Wind Turbine Guidelines*, available at http://amherstislandwindinfo.com/

[29] The authors have based these criteria, procedures, and language on their current understanding of wind turbine sound emissions, land-use compatibility, and the effects of sound on health. However, use of the following, in part or total, by any party is strictly voluntary and the user assumes all risks. Please seek professional assistance in applying the recommendations of this document to any specific community or WES development.

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NOISE CRITERIA FOR SITING WIND TURBINES TO PREVENT HEALTH RISKS[29]

1. Establishing Long-Term Background Noise Level

a. Instrumentation: ANSI or IEC Type 1 Precision Integrating Sound Level Meter plus meteorological instruments to measure wind velocity, temperature and humidity near the sound measuring microphone. Measurement procedures must meet ANSI S12.9, Part 3 except as noted in Section 4. below.

b. Measurement location(s): Nearest property line(s) from proposed wind turbines representative of all non-participating residential property within 2.0 miles.

c. Time of measurements and prevailing weather: The atmosphere must be classified as stable with no vertical heat flow to cause air mixing. Stable conditions occur in the evening and middle of the night with a clear sky and very little wind near the surface. Sound measurements are only valid when the measured wind speed at the microphone is less than 2 m/s (4.5 mph).

d. Long-Term Background sound measurements: All data recording shall be a series of contiguous ten (10) minute measurements. The measurement objective is to determine the quietest ten minute period at each location of interest. Nighttime test periods are preferred unless daytime conditions are quieter. The following data shall be recorded simultaneously for each ten (10) minute measurement period: dBA data includes L_{A90}, L_{A10}, L_{Aeq} and dBC data includes L_{C90}, L_{C10}, and L_{Ceq}. Record the maximum wind speed at the microphone during the ten minutes, a single measurement of temperature and humidity at the microphone for each new location or each hour whichever is oftener shall also be recorded. A ten (10) minute measurement contains valid data provided: Both L_{A10} minus L_{A90} and L_{C10} minus L_{C90} are not greater than 10 dB and the maximum wind speed at the microphone is less than 2 m/s during the same ten (10) minute period as the acoustic data.

2. Wind Turbine Sound Immission Limits

No wind turbine or group of turbines shall be located so as to cause wind turbine sound immission at any location on non-participating property containing a residence in excess of the limits in the following table:

Table of Not-To-Exceed Property Line Sound Immission Limits [1]			
Criteria	**Condition**	**dBA**	**dBC**
A	Immission above pre-construction background:	$L_{Aeq} = L_{A90} + 5$	$L_{Ceq} = L_{C90} + 5$
B	Maximum immission:	35 L_{Aeq}	55 L_{Ceq} for quiet[2] rural environment 60 L_{Ceq} for rural-suburban environment
C	Immission spectra imbalance	L_{Ceq} (immission) minus (L_{A90} (background) +5) $\leq$ 20 dB	
D	Prominent tone penalty:	5 dB	5 dB
Notes			
1	Each Test is independent and exceedances of any test establishes non-compliance. Sound "immission" is the wind turbine noise emission as received at a property.		
2	A "Quiet rural environment" is a location >2 miles from a major transportation artery without high traffic volume during otherwise quiet periods of the day or night.		
3	Prominent tone as defined in IEC 61400-11. This Standard is not to be used for any other purpose.		

[1] Procedures provided in Section 7. Measurement Procedures (ANSI 12.9 Part 3 with Amendments) of the most recent version of **"The How To Guide To Siting Wind Turbines To Prevent Health Risks From Sound"** by Kamperman and James and the apply to this table.

3. Wind Farm Noise Compliance Testing

All of the measurements outlined above in 1. Establishing Nighttime Background Noise Level must be repeated to determine compliance with 2. Wind Turbine Sound Immission Limits. The compliance test location is to be the pre-turbine background noise measurement location nearest to the home of the complainant in line with the wind farm and nearer to the wind farm. The time of day for the testing and the wind farm operating conditions plus wind speed and direction must replicate the conditions that generated the complaint. Procedures of ANSI S12.9- Part 3 apply except as noted in Section 4. The effect of instrumentation limits for wind and other factors must be recognized and followed.

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4. ANSI S12.9 Part 3 Selected Options and Requirement Amendments

For measurements taken to assess the preceding criteria specific options provided for in ANSI S12.9-Part 3 (2008) shall be followed along with any additional requirements included below:

5.2 Background Sound: Use definition (1): 'long-term'

5.2 long-term background sound: The L_{90} excludes short term background sounds

5.3 basic measurement period: Ten (10) minutes $L_{90(10\ min)}$

5.6 Sound Measuring Instrument: Type 1 Precision meeting ANSI S1.43 or IEC 61672-1. The sound level meter shall cover the frequency range from 6.3 Hz to 20k Hz and simultaneously measure dBA L_N and dBC L_N. The instrument must also be capable of accurately measuring low-level background sounds down to 20 dBA.

6.5 Windscreen: Required

6.6(a) An anemometer accurate to ± 10% at 2m/s to full-scale accuracy. The anemometer shall be located 1.5 to 2 meters above the ground and orientated to record maximum wind velocity. The maximum wind velocity, wind direction, temperature and humidity shall be recorded for each ten (10) minute sound measurement period observed within 5 m. of the measuring microphone.

7.1 Long-term background sound

7.2 Data collection Methods: Second method with observed samples to avoid contamination by short term sounds (purpose: to avoid loss of statistical data)

8. Source(s) Data Collection: All requirements in ANSI S12.18 Method #2, Precision to the extent possible while still permitting testing of the conditions that lead to complaints. The meteorological requirements in ANSI S12.18 may not be applicable for some complaint tests. For sound measurements in response to a complaint, the compliance sound measurements should be made under conditions that replicate the conditions that caused the complaint without exceeding instrument and windscreen limits and tolerances.

8.1(b) Measuring microphone with windscreen shall be located 1.2m to 1.8m (1.5 preferred) above the ground and greater than 8 m. from large sound reflecting surface.

8.3(a) All meteorological observations required at both (not either) microphone and nearest 10 m. weather reporting station.

8.3(b) For a ten (10) minute background sound measurement to be valid the wind velocity shall be less then 2m/s (4.5 mph) measured less than 5 m. from the microphone. Compliance sound measurements shall be taken when winds are less than 4m/s at the microphone.

8.3(c) In addition to the required acoustic calibration checks, the sound measuring instrument internal noise floor, including microphone, must also be checked at the end of each series of ten minute measurements and no less frequently than once per day. Insert the microphone into the acoustic calibrator with the calibrator signal off. Record the observed dBA and dBC reading on the sound level meter to determine an approximation of the instrument self noise. Perform this test before leaving the background measurement location. The calibrator-covered microphone must demonstrate the results of this test are at least 5 dB below the immediately previous ten (10) minute acoustic test results, for the acoustic background data to be valid. This test is necessary to detect undesired increase in the microphone and sound level meter internal self-noise. As a precaution sound measuring instrumentation should be removed from any air conditioned space at least an hour before use. Nighttime measurements are often performed very near the meteorological dew point. Minor moisture condensation inside a microphone or sound level meter can increase the instrument self noise and void the measured background data.

8.4 The remaining sections, starting at 8.4 in ANSI S12.9 Part 3 Standard do not apply.

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V. How to Include the Recommended Criteria in Ordinances and/or Community Noise Limits

The following two sections present the definitions, technical requirements, and complaint resolution processes that support the recommended criteria. Following the formal elements is a section discussing the measurement procedures and requirements for enforcement of these criteria. For the purpose of the following sections the government authority will be referred to as the Local Government Authority (LGA) as a place marker for State, County, Township or other authorized authority. The abbreviation 'WES' is used for industrial scale wind energy system.

The authors have based these criteria, procedures, and language on their current understanding of wind turbine sound emissions, land-use compatibility, and the effects of sound on health. However, use of the following, in part or total, by any party is strictly voluntary and the user assumes all risks. Please seek professional assistance in applying the recommendations of this document to any specific community or WES development.

VI. ELEMENTS OF A WIND ENERGY SYSTEMS LICENSING ORDINANCE FOR SOUND

I. Purpose and Intent.

Based upon the findings stated above, it is the intended purpose of the LGA to regulate Wind Energy Systems to promote the health, safety, and general welfare of the citizens of the Town and to establish reasonable and uniform regulations for the operation thereof so as to control potentially dangerous effects of these Systems on the community.

II. Definitions.

The following terms have the meanings indicated:

"**Aerodynamic Sound**" means a noise that is caused by the flow of air over and past the blades of a WES.

"**Ambient Sound**" Ambient sound encompasses all sound present in a given environment, being usually a composite of sounds from many sources near and far. It includes intermittent noise events, such as, from aircraft flying over, dogs barking, wind gusts, mobile farm or construction machinery, and the occasional vehicle traveling along a nearby road. The ambient also includes insect and other nearby sounds from birds and animals or people. The near-by and transient events are part of the ambient sound environment but are not to be considered part of the long-term background sound.

"American National Standards Institute (ANSI)" Standardized acoustical instrumentation and sound measurement protocol shall meet all the requirements of the following ANSI Standards:

ANSI S1.43 Integrating Averaging Sound Level Meters: Type-1 (or IEC 61672-1)

ANSI S1.11 Specification for Octave and One-third Octave-Band Filters (or IEC 61260)

ANSI S1.40 Verification Procedures for Sound Calibrators

ANSI S12.9 Part 3 Procedures for Measurement of Environmental Sound

ANSI S12.18 Measurement of Outdoor Sound Pressure Level

IEC 61400-11 Wind turbine generator systems -Part 11: Acoustic noise measurements

"**Anemometer**" means a device for measuring the speed and direction of the wind.

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"**Applicant**" means the individual or business entity that seeks to secure a license under this section of the Town municipal code.

"**A-Weighted Sound Level (dBA)**" A measure of over-all sound pressure level designed to reflect the response of the human ear, which does not respond equally to all frequencies. It is used to describe sound in a manner representative of the human ear's response. It reduces the effects of the low with respect to the frequencies centered around 1000 Hz. The resultant sound level is said to be "A-weighted" and the units are "dBA." Sound level meters have an A-weighting network for measuring A-weighted sound levels (dBA) meeting the characteristics and weighting specified in ANSI Specifications for Integrating Averaging Sound Level Meters, S1.43-1997 for Type 1 instruments and be capable of accurate readings (corrections for internal noise and microphone response permitted) at 20 dBA or lower. In this document dBA means L_{Aeq} unless specified otherwise.

"**Background Sound (L_{90})**" refers to the sound level present at least 90% of the time. Background sounds are those heard during lulls in the ambient sound environment. That is, when transient sounds from flora, fauna, and wind are <u>not</u> present. Background sound levels vary during different times of the day and night. Because WES operates 24/7 the background sound levels of interest are those during the quieter periods which are often the evening and night. Sounds from the WES of interest, near-by birds and animals or people must be excluded from the background sound test data. Nearby electrical noise from streetlights, transformers and cycling AC units and pumps etc must also be excluded from the background sound test data.

Background sound level (dBA and dBC (as L_{90})) is the sound level present 90% of the time during a period of observation that is representative of the quiet time for the soundscape under evaluation and with duration of ten (10) continuous minutes. Several contiguous ten (10) minute tests may be performed in one hour to determine the statistical stability of the sound environment. Measurement periods such as at dusk when bird and insect activity is high or the early morning hours when the 'dawn chorus' is present are not acceptable measurement times. Longer term sound level averaging tests, such as 24 hours or multiple days are not at all appropriate since the purpose is to define the quiet time background sound level. It is defined by the L_{A90} and L_{C90} descriptors. It may be considered as the quietest one (1) minute during a ten (10) minute test. L_{A90} results are valid only when L_{A10} results are no more than 10 dB above L_{A90} for the same period. L_{C10} less L_{C90} are not to exceed 10 dB to be valid.

The background noise environment consists of a multitude of distant sources of sound. When a new nearby source is introduced the new background noise level would be increased. The addition of a new source with a noise level 10 below the existing background would increase the new background 0.4 dB. If the new source has the same noise level as the existing background then the new background is increased 3.0 dB. Lastly, if the new source is 3.3 dB above the existing background then the new background would have increased 5 dB. For example, to meet the requirement of L_{90A} + 5 dB = 31 dBA if the existing quiet nighttime background sound level is 26 dBA, the maximum wind turbine noise immission contribution independent of the background cannot exceed 29.3 dBA L_{eq} at a dwelling. When adding decibels, a 26 dBA background combined with 29.3 dBA from the turbines (without background) results in 31 dBA.

Further, background L_{90} sound levels documenting the pre-construction baseline conditions should be determined when the ten (10) minute maximum wind speed is less than 2 m/s (4.5 mph) near ground level/microphone location 1.5 m height.

"**Blade Passage Frequency**" (BPF) means the frequency at which the blades of a turbine pass a particular point during each revolution (e.g. lowest point or highest point in rotation) in terms of

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events per second. A three bladed turbine rotating at 28 rpm would have a BPF of 1.4 Hz. [E.g. ((3 blades times 28rpm)/60 seconds per minute = 1.4 Hz BPF)]

"**C-Weighted Sound Level (dBC)**" Similar in concept to the A-Weighted sound Level (dBA) but C-weighting does not de-emphasize the frequencies below 1k Hz as A-weighting does. It is used for measurements that must include the contribution of low frequencies in a single number representing the entire frequency spectrum. Sound level meters have a C-weighting network for measuring C-weighted sound levels (dBC)meeting the characteristics and weighting specified in ANSI S1.43-1997 Specifications for Integrating Averaging Sound Level Meters for Type 1 instruments. In this document dBC means L_{Ceq} unless specified otherwise.

"**Decibel (dB)**" A dimensionless unit which denotes the ratio between two quantities that are proportional to power, energy or intensity. One of these quantities is a designated reference by which all other quantities of identical units are divided. The sound pressure level (Lp) in decibels is equal to 10 times the logarithm (to the base 10) of the ratio between the pressure squared divided by the reference pressure squared. The reference pressure used in acoustics is 20 MicroPascals.

"**Emission**" Sound energy that is emitted by a noise source (wind farm) is transmitted to a receiver (dwelling) where it is immitted (see "immission).

"**Frequency**" The number of oscillations or cycles per unit of time. Acoustical frequency is usually expressed in units of Hertz (Hz) where one Hz is equal to one cycle per second.

"**Height**" means the total distance measured from the grade of the property as existed prior to the construction of the wind energy system, facility, tower, turbine, or related facility at the base to its highest point.

"**Hertz (Hz)**" Frequency of sound expressed by cycles per second.

"**Immission**" Noise immitted at a receiver (dwelling) is transmitted from noise source (wind turbine) that emitted sound energy (see "emission").

"**Immission spectra imbalance**" The spectra are not in balance when the C-weighted sound level is more than 20 dB greater than the A-weighted sound level. For the purposes of this requirement, the A-weighted sound level is defined as the long-term background sound level (L_{A90}) +5 dBA. The C-weighted sound level is defined as the L_{Ceq} measured during the operation of the wind turbine operated so as to result in its highest sound output. A Complaint test provided later in this document is based on the immission spectra imbalance criteria.

"**Infra-Sound**" sound with energy in the frequency range of 0-20 Hz is considered to be infra-sound. It is normally considered to not be audible for most people unless in relatively high amplitude. However, there is a wide range between the most sensitive and least sensitive people to perception of sound and perception is not limited to stimulus of the auditory senses. The most significant exterior noise induced dwelling vibration occurs in the frequency range between 5 Hz and 50 Hz. Moreover, levels below the threshold of audibility can still cause measurable resonances inside dwelling interiors. Conditions that support or magnify resonance may also exist in human body cavities and organs under certain conditions. Although no specific test for infrasound is provided in this document, the test for immission spectra imbalance will limit low frequency sound and thus, indirectly limit infrasound. See low-frequency noise (LFN) for more information.

"**Low Frequency Noise (LFN)**" refers to sounds with energy in the lower frequency range of 20 to 200 Hz. LFN is deemed to be excessive when the difference between a C-weighted sound level and an A-weighted sound level is greater than 20 decibels at any measurement point outside a residence or

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other occupied structure. The criteria for this condition is the "Immission Spectra Imbalance" entry in the **Table of Not-To-Exceed Property Line Sound Immission Limits."**

"**Measurement Point (MP)**" means location where sound measurements are taken such that no significant obstruction blocks sound from the site. The Measurement Point should be located so as to not be near large objects such as buildings and in the line-of-sight to the nearest turbines. Proximity to large buildings or other structures should be twice the largest dimension of the structure, if possible. Measurement Points should be at quiet locations remote from street lights, transformers, street traffic, flowing water and other local noise sources.

"**Measurement Wind Speed**" For measurements conducted to establish the background noise levels ($L_{A90\ 10\ min}$, $L_{C90\ 10\ min}$, and etc.) the maximum wind speed, sampled within 5m of the microphone and at its height, shall be less than 2 m/s (4.5 mph) for valid background measurements. For valid wind farm noises measurements conducted to establish the post-construction sound level the maximum wind speed, sampled within 5m of the microphone and at its height, shall be less than 4m/s (9 mph). The wind speed at the WES blade height shall be at or above the nominal rated wind speed and operating in its highest sound output mode. For purposes of enforcement, the wind speed and direction at the WES blade height shall be selected to reproduce the conditions leading to the enforcement action while also restricting maximum wind speeds at the microphone to less than 4 m/s (9 mph).

For purposes of models used to predict the sound levels and sound pressure levels of the WES to be submitted with the Application, the wind speed shall be the speed that will result in the worst-case L_{Aeq} and L_{Ceq} sound levels at the nearest non-participating properties to the WES. If there may be more than one set of nearby sensitive receptors, models for each such condition shall be evaluated and the results shall be included in the Application.

"**Mechanical Noise**" means sound produced as a byproduct of the operation of the mechanical components of a WES(s) such as the gearbox, generator and transformers.

"**Noise**" means any unwanted sound. Not all noise needs to be excessively loud to represent an annoyance or interference.

"**Project Boundary**" means the external property boundaries of parcels owned by or leased by the WES developers. It is represented on a plot plan view by a continuous line encompassing all WES(s) and related equipment associated with the WES project.

"**Property Line**" means the recognized and mapped property parcel boundary line.

"**Qualified Independent Acoustical Consultant**" Qualifications for persons conducting baseline and other measurements and reviews related to the application for a WES or for enforcement actions against an operating WES include, at a minimum, demonstration of competence in the specialty of community noise testing. An example is a person with Full Membership in the Institute of Noise Control Engineers (INCE). There are scientists and engineers in other professional fields that have been called upon by their local community for help in the development of a WES Noise Ordinance. Many of these scientists and engineers have recently spent hundreds of hours learning many important aspects of noise related to the introduction of WES into their communities. Then with field measurement experience with background data and wind turbine noise emission, they have become qualified independent acoustical consultants for WES siting. Certifications such as Professional Engineer (P.E.) do not test for competence in acoustical principles and measurement and are thus not, without further qualification, appropriate for work under this document. The Independent Qualified Acoustical Consultant can have no financial or other connection to a WES developer or related company.

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"**Sensitive Receptor**" means places or structures intended for human habitation, whether inhabited or not, public parks, state and federal wildlife areas, the manicured areas of recreational establishments designed for public use, including but not limited to golf courses, camp grounds and other nonagricultural state or federal licensed businesses. These areas are more likely to be sensitive to the exposure of the noise, shadow or flicker, etc. generated by a WES or WESF. These areas include, but are not limited to: schools, daycare centers, elder care facilities, hospitals, places of seated assemblage, non-agricultural businesses and residences.

"**Sound**" A fluctuation of air pressure which is propagated as a wave through air

"**Sound Power**" The total sound energy radiated by a source per unit time. The unit of measurement is the watt. Abbreviated as L_w. This information is determined for the WES manufacturer under laboratory conditions specified by IEC 61400-11 and provided to the local developer for use in computer model construction. There is known measurement error in this test procedure that must be disclosed and accounted for in the computer models. Even with the measurement error correction it cannot be assumed that the reported L_w values represent the highest sound output for all operating conditions. They reflect the operating conditions required to meet the IEC 61400-11 requirements. The lowest frequency is 50 Hz for acoustic power (L_w) requirement (at present) in IEC 61400-11. This Ordinance requires wind turbine certified acoustic power (L_w) levels at rated load for the total frequency range from 6.3 Hz to 10k Hz in one-third octave frequency bands tabulated to the nearest 1 dB. The frequency range of 6.3 Hz to 10k Hz shall be used throughout this Ordinance for all sound level modeling, measuring and reporting.

"**Sound Pressure**" The instantaneous difference between the actual pressure produced by a sound wave and the average or barometric pressure at a given point in space.

"**Sound Pressure Level (SPL)**" 20 times the logarithm, to the base 10, of the ratio of the pressure of the sound measured to the reference pressure, which is 20 micronewtons per square meter. In equation form, sound pressure level in units of decibels is expressed as SPL (dB) = 20 log p/pr.

"**Spectrum**" The description of a sound wave's resolution into its components of frequency and amplitude. The WES manufacturer is required to supply a one-third octave band frequency spectrum of the wind turbine sound emission at 90% of rated power. The published sound spectrum is often presented as A-weighted values but C-weighted values are preferred. This information is used to construct a model of the wind farm's sound immission levels at locations of interest in and around the WES. The frequency range of interest for wind turbine noise is approximately 6 Hz to 10k Hz.

"**Statistical Noise Levels**" Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{NA}, where L_{NA} is the A-weighted sound level exceeded for N% of a given measurement period. For example, L_{10} is the noise level exceeded for 10% of the time. Of particular relevance, are: L_{A10} and L_{C10} the noise level exceed for 10% of the ten (10) minute interval. This is commonly referred to as the average maximum noise level. L_{A90} and L_{C90} are the A-weighted and C-weighted sound levels exceeded for 90% of the ten (10) minute sample period. The L_{90} noise level is defined by ANSI as the long-term background sound level (i.e. the sounds one hears in the absence of the noise source under consideration and without short term or near-by sounds from other sources), or simply the "background level." L_{eq} is the A or C-weighted equivalent noise level (the "average" noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

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"**Tonal sound or tonality**" Tonal audibility. A sound for which the sound pressure is a simple sinusoidal function of the time, and characterized by its singleness of pitch. Tonal sound can be simple or complex.

"**Wind Energy Systems (WES)**" means equipment that converts and then transfers energy from the wind into usable forms of electrical energy.

"**Wind Turbine" or "Turbine" (WT)** means an industrial scale mechanical device which captures the kinetic energy of the wind and converts it into electricity. The primary components of a wind turbine are the blade assembly, electrical generator and tower.

III. APPLICATION PROCEDURE FOR WIND ENERGY SYSTEMS AND TECHNICAL REQUIREMENTS FOR LICENSING

This ordinance is intended to promote the safety and health of the community through criteria limiting sound emissions during operation of Wind Energy Systems. It is recognized that the requirements herein are neither exclusive, nor exhaustive. In instances where a health or safety concern is known to the wind project developer or identified by other means with regard to any application for a Wind Energy System, additional and/or more restrictive conditions may be included in the license to address such concerns. All rights are reserved to impose additional restrictions as circumstances warrant. Such additional or more restrictive conditions may include, without limitation (a) greater setbacks, (b) more restrictive noise limitations, or (c) limits restricting operation during night time periods or for any other conditions deemed reasonable to protect the community.

A. Application

Any Person desiring to secure a Wind Energy Systems license shall file an application form provided by the LGA Clerk, together with two additional copies of the application with the LGA Clerk.

B. Information to be submitted with Application

1. Information regarding the:

- Make and model of all turbines potentially used in this project,
- Sound Power Levels (L_w) for each 1/3 octave band from 6.3 Hz to 10,000 Hz, and
- A sound propagation model predicting the sound levels immitted into the community computed using at minimum 1/1 octave band sound power levels to compute the L_{Ceq} and L_{Aeq} levels to generate L_{Aeq} and L_{Ceq} contours in 5 dB increments overlaying an aerial view and property survey map from the WES property out to a distance to include all residential property within two (2) miles of the WES Property. Appropriate corrections for model algorithm error, IEC61400-11 test measurement accuracy, and directivity patterns of for each model of WT shall be disclosed and accounted for in the model(s). Predictions shall be made at all property lines within and outward for two (2) miles from the project boundary for the wind speed, direction and operating mode that would result in the worst case WT nighttime sound emissions.

The prediction model shall assume that the winds at hub height are sufficient for the highest sound emission operating mode. The projection shall include a description of all assumptions made in the model's construction and algorithms. If the model does not consider the effects of wind direction, geography of the terrain, and/or the effects of reinforcement from coherent sounds or tones from

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the turbines all these items should be identified and all other means used to adjust the model's output to account for these factors. The results shall be displayed as a contour map of the predicted levels as over-all L_{Aeq} and L_{Ceq} contours out to 2 miles from the WES property, and shall also include a table showing the 1/3 or 1/1 octave band sound pressure as L_{Ceq} levels for the nearest property line(s) for sensitive receptor sites (including residences) within the model's boundaries. The predicted values must include the over-all sound levels and 1/1 or 1/3 octave band sound pressure levels from 6 Hz to 10k Hz in data tables that include the location of each receiving point by GPS location or other repeatable means.

C. Preconstruction Background Noise Survey

1. The Town reserves the right to require the preparation of (a) a preconstruction noise survey for each proposed Wind Turbine location conducted per procedures provided in the section on Measurement Procedures showing long-term background L_{A90} and L_{C90} sound levels. This must be completed and accepted prior to approval of the final layout and issuance of project permits.

    a. If any proposed wind farm project locates a WES within two miles of a sensitive receptor these studies are mandatory. The preconstruction baseline studies shall be conducted by an Independent Qualified Acoustical Consultant selected and hired by the LGA.

    b. The applicant shall be responsible for paying the consultant's fees and costs associated with conducting the study. These fees and cost shall be negotiated with the consultant and determined prior to any work being done on the study. The applicant shall be required to set aside 100% of these fees in an escrow account managed by the LGA, before the study is commenced by the consultant. Payment for this study does not require the WES developer's acceptance of the study's results.

    c. If the review shows that the predicted L_{Aeq} and L_{Ceq} sound levels exceed any of the criteria specified in the **Table of Not-To-Exceed Property Line Sound Immission Limits** then the application cannot be approved.

2. The LGA will refer the application to the LGA engineer (if qualified in acoustics) or an independent qualified acoustical consultant for further review and comparison of the long-term background sound levels against the predicted L_{Aeq} and L_{Ceq} sound levels reported for the model using the criteria in the **Table of Not-To-Exceed Property Line Sound Immission Limits**. The reasonably necessary costs associated with such a review shall be the responsibility of the applicant, in accord with the terms of this ordinance.

D. Post Construction Noise Measurement Requirements

1. **Sound Regulations Compliance**: A WES shall be considered in violation of the conditional use permit unless the applicant demonstrates that the project complies with all sound level limits using the procedures specified in this ordinance. Sound levels in excess of the limits established in this ordinance shall be grounds for the LGA to order immediate shut down of all non-compliant WT units.

2. **Post-Construction Sound Measurements**: Within twelve months of the date when the project is fully operational, and within four weeks of the anniversary date of the pre-construction background noise measurements, repeat the existing sound environment measurements taken before the project approval. Post-construction sound level measurements shall be taken both with all WES's running and with all WES's off. At the discretion of the Town, the Pre-construction background sound levels (L_{A90} and L_{C90}) can be substituted for the "all WES off' tests if a random sampling of 10% of the pre-construction study sites shows that background L_{90A} and L_{90C} conditions have increased less than 3 dB from those measured under the pre-

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construction nighttime conditions. The post-construction measurements will be reported to the LGA (available for public review) using the same format as used for the preconstruction sound studies. Post-construction noise studies shall be conducted by a firm chosen and hired by the LGA. Costs of these studies are to be reimbursed by the Licensee in a similar manner to that described above. The wind farm developer's may ask to have its own consultant observe the publicly retained consultant at the convenience of the latter. The WES Licensee shall provide all technical information and wind farm data required by the qualified independent acoustical consultant before, during, and/or after any acoustical studies required by this document and for acoustical measurements.

3. Sound Limits

1. Establishing Long-Term Background Sound Level

a. Instrumentation: ANSI or IEC Type 1 Precision Integrating Sound Level Meter plus meteorological instruments to measure wind velocity, temperature and humidity near the sound measuring microphone. Measurement procedures must meet ANSI S12.9, Part 3 and Measurement Procedures Appendix to Ordinance following next Section.

b. Measurement location(s): Nearest property line(s) from proposed wind turbines representative of all non-participating residential property within 2.0 miles.

c. Time of measurements and prevailing weather: The atmosphere must be classified as stable with no vertical heat flow to cause air mixing. Stable conditions occur in the evening and middle of the night with a clear sky and very little wind near the surface. Sound measurements are only valid when the measured maximum wind speed at the microphone must be less than 2 m/s (4.5 mph).

d. Long-Term Background sound measurements: All data recording shall be a series of contiguous ten (10) minute measurements. The measurement objective is to determine the quietest ten minute period at each location of interest. Nighttime test periods are preferred unless daytime conditions are quieter. The following data shall be recorded simultaneously for each ten (10) minute measurement period: dBA data includes L_{A90}, L_{A10}, L_{Aeq} and dBC data includes L_{C90}, L_{C10}, and L_{Ceq}. The maximum wind speed at the microphone during the ten minutes, a single measurement of temperature and humidity at the microphone for each new location or each hour whichever is oftener shall also be recorded. A ten (10) minute measurement contains valid data provided: Both L_{A10} minus L_{A90} and L_{C10} minus L_{C90} are not greater than 10 dB and the maximum wind speed at the microphone is less than 2 m/s during the same ten (10) minute period as the acoustic data.

2. Wind Turbine Sound Immission Limits

No wind turbine or group of turbines shall be located so as to cause wind turbine sound immission at any location on non-participating property containing a residence in excess of the limits in the following table:

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Table of Not-To-Exceed Property Line Sound Immission Limits [1]			
Criteria	**Condition**	**dBA**	**dBC**
A	Immission above pre-construction background:	$L_{Aeq} = L_{A90} + 5$	$L_{Ceq} = L_{C90} + 5$
B	Maximum immission:	35 L_{Aeq}	55 L_{Ceq} for quiet[2] rural environment 60 L_{Ceq} for rural-suburban environment
C	Immission spectra imbalance (C - A $\leq$ 20dB)	L_{Ceq} (immission) minus (L_{A90} (background) +5 dB) $\leq$ 20 dB	
D	Prominent tone penalty:	5 dB	5 dB
Notes			
1	Each Test is independent and exceedances of any test establishes non-compliance Sound "immission" is the wind turbine sound emission as received at a property.		
2	A "quiet rural environment" is a location 2 miles from a major transportation artery without high traffic volume during otherwise quiet periods of the day or night.		
3	Prominent tone as defined in IEC 61400-11. This Standard is not to be used for any other purpose.		
[1] Required Procedures provided in VIII Reference Standards including ANSI 12.9 Part 3 as Amended			

3. Wind Farm Noise Compliance Testing

All of the measurements outlined above in 1. Establishing Long Term Background Noise Level must be repeated to determine compliance with 2. Wind Turbine Sound Immission Limits. The compliance test location is to be the pre-turbine background noise measurement location nearest to the home of the complainant in line with the wind farm and nearer to the wind farm. The time of day for the testing and the wind farm operating conditions plus wind speed and direction must replicate the conditions that generated the complaint. Procedures of ANSI S12.9- Part 3 apply as amended in the Appendix to Ordinance. The effect of instrumentation limits for wind and other factors must be recognized and followed.

3. Operations

The WES/WT is non-compliant and must be shut down immediately if it exceeds any of the limits in the **Table of Not-To-Exceed Property Line Sound Immission Limits.**

4. Complaint Resolution

1. The owner/operator of the WES shall respond within five (5) business days after notified of a noise complaint by any property owner within the project boundary and a one-mile radius beyond the project boundary.
2. The tests shall be performed by a qualified independent acoustical consultant acceptable to the complainant and the local agency charged with enforcement of this ordinance.
3. Testing shall commence within ten (10) working days of the request. If testing cannot be initiated within ten (10) days, the WES(s) in question shall be shut down until the testing can be started.
4. A copy of the test results shall be sent to the property owner, and the LGA's Planning or Zoning department within thirty (30) days of test completion.
5. If a Complaint is made, the presumption shall be that it is reasonable. The LGA shall undertake an investigation of the alleged operational violation by a qualified individual mutually acceptable to the LGA.

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a) The reasonable cost and fees incurred by the LGA in retaining said qualified individual shall be reimbursed by the owner of the WESF.

b) Funds for this assessment shall be paid or put into an escrow account prior to the study and payment shall be independent of the study findings.

6. After the investigation, if the LGA reasonably concludes that operational violations are shown to be caused by the WESF, the licensee/operator/owner shall use reasonable efforts to mitigate such problems on a case-by-case basis including such measures as not operating during the nighttime or other noise sensitive period if such operation was the cause of the complaints.

5. Reimbursement of Fees and Costs.

Licensee/operator/owner agrees to reimburse the LGA 's reasonable fees and costs incurred in the preparation, negotiation, administration and enforcement of this Ordinance, including, without limitation, the LGA 's attorneys' fees, engineering and/or consultant fees, LGA meeting and hearing fees and the costs of public notices. If requested by the LGA the funds shall be placed in an escrow account under the management of the LGA. The preceding fees are payable within thirty (30) days of invoice. Unpaid invoices shall bear interest at the rate of 1% per month until paid. The LGA may recover all reasonable costs of collection, including attorneys' fees.

VII. MEASUREMENT PROCEDURES

SUPPLEMENT TO WIND ENERGY SYSTEMS LICENSING ORDINANCE FOR SOUND

I. Introduction

The potential impact of sound and sound induced building vibration associated with the operation of wind powered electric generators is often a primary concern for citizens living near proposed wind energy systems (WES(s)). This is especially true of projects located near homes, residential neighborhoods, businesses, schools, and hospitals in quiet residential and rural communities. Determining the likely sound and vibration impacts is a highly technical undertaking and requires a serious effort in order to collect reliable and meaningful data for both the public and decision makers.

This protocol is based in part on criteria published in American National Standards S12.9 -Part 3 Quantities and Procedures for Description and Measurement of Environmental Sound, and S12.18 and for the measurement of sound pressure level outdoors.

The purpose is to first, establish a consistent and scientifically sound procedure for evaluating existing background levels of audible and low frequency sound in a WES project area, and second to use the information provided by the Applicant in its Application showing the predicted over-all sound levels in terms of L_{Aeq} and L_{Ceq} and 1/3 or 1/1 octave bands as part of the required information submitted with the application.

The over-all values shall be presented as overlays to the applicant's iso-level plot plan graphics and, for 1/1 or 1/3 octave data, in tabular form with location information sufficient to permit comparison of the baseline results to the predicted levels. This comparison will use the level limits of the ordinance to determine the likely impact operation of a new wind energy system project will have on the existing community soundscape. If the comparison demonstrates that the WES project will not exceed any of the level limits the project will be considered to be within allowable limits for safety and health. If the Applicant submits only partial information required for this comparison

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the application cannot be approved. In all cases the burden to establish the operation as meeting safety and health limits will be on the Applicant.

Next, it covers requirements for the sound propagation model to be supplied with the application.

Finally, if the project is approved, this section covers the study needed to compare the post-build sound levels to the predictions and the baseline study. The level limits in the ordinance apply to the post-build study. In addition, if there have been any complaints about WES sound or low frequency noise emissions or wind turbine noise induced dwelling vibration by any resident of an occupied dwelling that property will be included in the post-build study for evaluation against the rules for sound level limits and compliance.

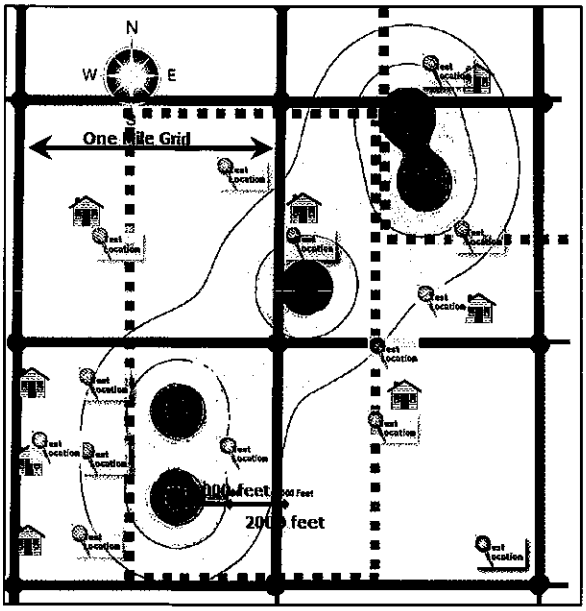
The characteristics of the proposed WES project and the features of the surrounding environment will influence the design of the sound and vibration study. Site layout, types of WES(s) selected and the existence of other significant local audible and low frequency sound sources and sensitive receptors should be taken into consideration when designing a sound study. The work will be performed by a qualified independent acoustical consultant for both the pre-construction background and post-construction sound studies as described in the body of the ordinance.

II. Instrumentation

All instruments and other tools used to measure audible, inaudible and low frequency sound shall meet the requirements for ANSI or IEC Type 1 Integrating Averaging Sound Level Meter Standards The principle standard reference for this document is ANSI 12.9/Part 3 with important additional specific requirements for the measuring instrumentation and measurement protocol.

III. Measurement of Pre-Construction Sound Environment (Base-line)

An assessment of the proposed WES project areas existing sound environment is necessary in order to predict the likely impact resulting from a proposed project. The following guidelines must be used in developing a reasonable estimate of an area's existing background sound environment. All testing is to be performed by an independent qualified acoustical consultant approved by the LGA as provided in the body of the ordinance. The WES applicant may file objections detailing any concerns it may have with the LGA's selection. These concerns will be addressed in the study. Objections must be filed prior to the start of the noise study. All measurements are to be conducted with ANSI or IEC Type 1 certified and calibrated test equipment per reference specification at the end of this section. Test results will be reported to the LGA or its appointed representative.



Sites with No Existing Wind Energy Systems (Base-line Sound Study)

Sound level measurements shall be taken as follows:

The results of the model showing the predicted worst case L_{Aeq} and L_{Ceq} sound emissions of the proposed WES project will be overlaid on a map (or separate L_{Aeq} and L_{Ceq} maps) of the project area. An example (right) shows an approximately two (2) mile square section with iso-level contour lines prepared by the

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applicant, sensitive receptors (homes) and locations selected for the baseline sound tests whichever are the controlling metric. The test points shall be located at the property line bounding the property of the turbine's host closest to the wind turbine. Additional sites may be added if appropriate. A grid comprised of one (1) mile boundaries (each grid cell is one (1) square mile) should be used to assist in identifying between two (2) to ten (10) measurement points per cell. The grid shall extend to a minimum of two (2) miles beyond the perimeter of the project boundary. This may be extended to more than two (2) miles at the discretion of the LGA. The measurement points shall be selected to represent the noise sensitive receptor sites based on the anticipated sound propagation from the combined WT in the project. Usually, this will be the closest WT. If there is more than one WT near-by then more than one test site may be required.

The intent is to anticipate the locations along the bounding property line that will receive the highest sound immissions. The site that will most likely be negatively affected by the WES project's sound emissions should be given first priority in testing. These sites may include sites adjacent to occupied dwellings or other noise sensitive receptor sites. Sites shall be selected to represent the locations where the background soundscapes reflect the quietest locations of the sensitive receptor sites. Background sound levels (and 1/3 octave band sound pressure levels if required) shall be obtained according to the definitions and procedures provided in the ordinance and recognized acoustical testing practice and standards.

All properties within the proposed WES project boundaries will be considered for this study.

One test shall be conducted during the period defined by the months of April through November with the preferred time being the months of June through August. These months are normally associated with more contact with the outdoors and when homes may have open windows during the evening and night. Unless directed otherwise by the LGA the season chosen for testing will represent the background soundscape for other seasons. At the discretion of the LGA, tests may be scheduled for other seasons.

All measurement points (MPs) shall be located with assistance from the LGA staff and property owner(s) and positioned such that no significant obstruction (building, trees, etc.) blocks sound and vibration from the nearest proposed WES site.

Duration of measurements shall be a minimum of ten (10) continuous minutes for all criteria at each location. The duration must include at least six (6) minutes that are not affected by transient sounds from near-by and non-nature sources. Multiple ten (10) minute samples over longer periods such as 30 minutes or one (1) hour may be used to improve the reliability of the L_{A90} and L_{C90} values. The ten (10) minute sample with the lowest valid L_{90} values will be used to define the background sound.

The tests at each site selected for this study shall be taken during the expected 'quietest period of the day or night' as appropriate for the site. For the purpose of determining background sound characteristics the preferred testing time is from 10pm until 4 am. If circumstances indicated that a different time of the day should be sampled the test may be conducted at the alternate time if approved by the Town.

Sound level measurements shall be made on a weekday of a non-holiday week. Weekend measurements may also be taken at selected sites where there are weekend activities that may be affected by WT sound.

Measurements must be taken with the microphone at 1.2 to 1.5 meters above the ground and at least 15 feet from any reflective surface following ANSI 12.9 Part 3 protocol including selected options and other requirements outlined later in this Section.

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Reporting

1. For each Measurement Point and for each qualified measurement period, provide each of the following measurements:

a. L_{Aeq}, L_{A10}, and L_{A90}, and

b. L_{Ceq} , L_{C10}, and L_{C90}

2. A narrative description of any intermittent sounds registered during each measurement. This may be augmented with video and audio recordings.

3. A narrative description of the steady sounds that form the background soundscape. This may be augmented with video and audio recordings.

4. Wind speed and direction at the microphone (Measurement Point), humidity and temperature at time of measurement will be included in the documentation. Corresponding information from the nearest 10 meter weather reporting station shall also be obtained.

Measurements taken only when wind speeds are less than 2m/s (4.5 mph) at the microphone location will be considered valid for this study. A windscreen of the type recommended by the monitoring instrument's manufacturer must be used for all data collection.

5. Provide a map and/or diagram clearly showing (Using plot plan provided by LGA or Applicant):

- The layout of the project area, including topography, the project boundary lines, and property lines.
- The locations of the Measurement Points.
- The distance between any Measurement Points and the nearest WT(s).
- The location of significant local non-WES sound and vibration sources.
- The distance between all MPs and significant local sound sources. And,
- The location of all sensitive receptors including but not limited to: schools, day-care centers, hospitals, residences, residential neighborhoods, places of worship, and elderly care facilities.

Sites with Existing Wind Energy Systems

Two complete sets of sound level measurements must be taken as defined below:

1. One set of measurements with the wind generator(s) off unless the LGA elects to substitute the sound data collected for the background sound study. Wind speeds must be suitable for background sound tests as specified elsewhere in this ordinance.

2. One set of measurements with the wind generator(s) running with wind speed at hub height sufficient to meet nominal rated power output or higher and less than 2 m/s below at the microphone location. Conditions should reflect the worst case sound emissions from the WES project. This will normally involve tests taken during the evening or night when winds are calm (less than 2m/sec) at the ground surface yet, at hub height, sufficient to power the turbines.

Sound level measurements and meteorological conditions at the microphone shall be taken and documented as discussed above.

Sound level Estimate for Proposed Wind Energy Systems (when adding more WT to existing project)

In order to estimate the sound impact of the proposed WES project on the existing environment an estimate of the sound produced by the proposed WES(s) under worst-case conditions for

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producing sound emissions must be provided. This study may be conducted by a firm chosen by the WES operator with oversight provided by the LGA.

The qualifications of the firm should be presented along with details of the procedure that will be used, software applications, and any limitations to the software or prediction methods as required elsewhere in this ordinance for models.

Provide the manufacturer's sound power level (L_{Aw}) and (L_{Cw}) characteristics for the proposed WES(s) operating at full load utilizing the methodology in IEC 61400-11 Wind Turbine Noise Standard. Provide one-third octave band sound power level information from 6.3 Hz to 10k Hz. Furnish the data using no frequency weighting. A-weighted data is optional. Provide sound pressure levels predicted for the WES(s) in combination and at full operation and at maximum sound power output for all areas where the predictions indicate L_{Aeq} levels of 30 dBA and above. The same area shall be used for reporting the predicted L_{Ceq} levels. Contour lines shall be in increments of 5 dB.

Present tables with the predicted sound levels for the proposed WES(s) as L_{Aeq} and L_{Ceq} and at all octave band centers (8 Hz to 10k Hz) for distances of 500, 1000, 1500, 2000, 2500 and 5000 feet from the center of the area with the highest density of WES(s). For projects with multiple WES(s), the combined sound level impact for all WES(s) operating at full load must be estimated.

The above tables must include the impact (increased dBA and dBC (L_{eq}) above baseline L_{90} background sound levels) of the WES operations on all residential and other noise sensitive receiving locations within the project boundary. To the extent possible, the tables should include the sites tested (or likely to be tested) in the background study.

Provide a contour map of the expected sound level from the new WES(s), using 5dB L_{Aeq} and L_{Ceq} increments created by the proposed WES(s) extending out to a distance of two (2) miles from the project boundary, or other distance necessary, to show the 25 L_{Aeq} and 50 L_{Ceq} boundaries.

Provide a description of the impact of the proposed sound from the WES project on the existing environment. The results should anticipate the receptor sites that will be most negatively impacted by the WES project and to the extent possible provide data for each MP that are likely to be selected in the background sound study (note the sensitive receptor MPs):

1. Report expected changes to existing sound levels for L_{Aeq} and L_{A90}
2. Report expected changes to existing sound levels for L_{Ceq} and L_{C90}
3. Report the expected changes to existing sound pressure levels for each of the 1/1 or 1/3 octave bands in tabular form from 8 Hz to 10k Hz.
4. Report all assumptions made in arriving at the estimate of impact, any limitations that might cause the sound levels to exceed the values of the estimate, and any conclusions reached regarding the potential effects on people living near the project area. If the effects of coherence, worst case weather, or operating conditions are not reflected in the model a discussion of how these factors could increase the predicted values is required.
5. Include an estimate of the number of hours of operation expected from the proposed WES(s) and under what conditions the WES(s) would be expected to run. Any differences from the information filed with the Application should be addressed.

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IV. Post-Construction Measurements

Post Construction Measurements should be conducted by a qualified noise consultant selected by and under the direction of the LGA. The requirements of this Appendix for Sites with Existing Wind Energy Systems shall apply

1. Within twelve months of the date when the project is fully operational, preferably within two weeks of the anniversary date of the pre-construction background sound measurements, repeat the measurements. Post-construction sound level measurements shall be taken both with all WES(s) running and with all WES(s) off except as provided in this ordinance.

2. Report post-construction measurements to the LGA using the same format as used for the background sound study.

VIII. REFERENCE Standards and ANSI S12.9 Part 3 with Required Amendments

ANSI/ASA S12.9-1993/Part 3 (R2008) - American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound, Part 3: Short-Term Measurements with an Observer Present.

This standard is the second in a series of parts concerning description and measurement of outdoor environmental sound. The standard describes recommended procedures for measurement of short-term, time-average environmental sound outdoors at one or more locations in a community for environmental assessment or planning for compatible land uses and for other purposes such as demonstrating compliance with a regulation. These measurements are distinguished by the requirement to have an observer present. Sound may be produced by one or more separate, distributed sources of sound such as a highway, factory, or airport. Methods are given to correct the measured levels for the influence of background sound.

Wind Turbine Siting Acoustical Measurements
ANSI S12.9 Part 3 Selected Options and Requirement Amendments

For the purposes of this ordinance specific options provided in ANSI S12.9-Part 3 (2008) shall apply with the additional following requirements to Sections in ANSI S12.9/Part 3:

5.2 background sound: Use definition (1) 'long-term'
5.2 long-term background sound: The L_{90} excludes short term background sounds
5.3 basic measurement period: Ten (10) minutes $L_{90(10\ min)}$
5.6 Sound Measuring Instrument: Type 1 Integrating Meter meeting ANSI S1.43 or IEC 61672-1. The sound level meter shall cover the frequency range from 6.3 Hz to 20k Hz and simultaneously measure dBA L_N and dBC L_N. The instrument must also be capable of accurately measuring low-level background sounds down to 20 dBA.
6.5 Windscreen: Required
6.6(a) An anemometer accurate to ± 10% at 2m/s. to full scale accuracy. The anemometer shall be located 1.5 to 2m above the ground and orientated to record maximum wind velocity. The maximum wind velocity, wind direction, temperature and humidity shall be recorded for each ten (10) minute sound measurement period observed within 5 m. of the measuring microphone..
7.1 Long-term background sound
7.2 Data collection Methods: Second method with observed samples to avoid contamination by short term sounds (purpose: to avoid loss of statistical data)
8 Source(s) Data Collection: All requirements in ANSI S12.18 Method #2 precision to the extent possible while still permitting testing of the conditions that lead to complaints. The

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meteorological requirements in ANSI S12.18 may not be applicable for some complaints. For sound measurements in response to a complaint, the compliance sound measurements should be made under conditions that replicate the conditions that caused the complaint without exceeding instrument and windscreen limits and tolerances.

8.1(b) Measuring microphone with windscreen shall be located 1.2m to 1.8m (1.5m preferred) above the ground and greater than 8m from large sound reflecting surface.

8.3(a) All meteorological observations required at both (not either) microphone and nearest 10m weather reporting station.

8.3(b) For a 10 minute background sound measurement to be valid the wind velocity shall be less then 2m/s (4.5 mph) measured less than 5m from the microphone. Compliance sound measurements shall be taken when winds shall be less than 4m/s at the microphone.

8.3(c) In addition to the required acoustic calibration checks, the sound measuring instrument internal noise floor, including microphone, must also be checked at the end of each series of ten minute measurements and no less frequently than once per day. Insert the microphone into the acoustic calibrator with the calibrator signal off. Record the observed dBA and dBC reading on the sound level meter to determine an approximation of the instrument self noise. Perform this test before leaving the background measurement location. This calibrator-covered microphone must demonstrate the results of this test are at least 5 dB below the immediately previous ten-minute acoustic test results, for the acoustic background data to be valid. This test is necessary to detect undesired increase in the microphone and sound level meter internal self-noise. As a precaution sound measuring instrumentation should be removed from any air-conditioned space at least an hour before use. Nighttime measurements are often performed very near the meteorological dew point. Minor moisture condensation inside a microphone or sound level meter can increase the instrument self noise and void the measured background data.

8.4 The remaining sections starting at 8.4 in ANSI S12.9 Part 3 Standard do not apply.

ANSI S12.18-1994 (R2004) American National Standard Procedures for Outdoor Measurement of Sound Pressure Level

This American National Standard describes procedures for the measurement of sound pressure levels in the outdoor environment, considering the effects of the ground, the effects of refraction due to wind and temperature gradients, and the effects due to turbulence. This standard is focused on measurement of sound pressure levels produced by specific sources outdoors. The measured sound pressure levels can be used to calculate sound pressure levels at other distances from the source or to extrapolate to other environmental conditions or to assess compliance with regulation. This standard describes two methods to measure sound pressure levels outdoors. METHOD No. 1: general method; outlines conditions for routine measurements. METHOD No. 2: precision method; describes strict conditions for more accurate measurements. This standard assumes the measurement of A-weighted sound pressure level or time-averaged sound pressure level or octave, 1/3-octave or narrow-band sound pressure level, but does not preclude determination of other sound descriptors.

ANSI S1.43-1997(R2007) American National Standard Specifications for Integrating Averaging Sound Level Meters

This Standard describes instruments for the measurement of frequency-weighted and time-average sound pressure levels. Optionally, sound exposure levels may be measured. This standard is consistent with the relevant requirements of ANSI S1.4-1983(R 1997) American National Standard Specification for Sound Level Meters, but specifies additional characteristics that are necessary to

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measure the time-average sound pressure level of steady, intermittent, fluctuating, and impulsive sounds.

ANSI S1.11-2004 American National Standard 'Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters'

This standard provides performance requirements for analog, sampled-data, and digital implementations of band-pass filters that comprise a filter set or spectrum analyzer for acoustical measurements. It supersedes ANSI S1.11-1986 (R1998) American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters, and is a counterpart to International Standard IEC 61260:1995 Electroacoustics - Octave-Band and Fractional-Octave-Band Filters. Significant changes from ANSI S1.11-1986 have been adopted in order to conform to most of the specifications of IEC 61260:1995. This standard differs from IEC 61260:1995 in three ways: (1) the test methods of IEC 61260 clauses 5 is moved to an informative annex, (2) the term 'band number,' not present in IEC 61260, is used as in ANSI S1.11-1986, (3) references to American National Standards are incorporated, and (4) minor editorial and style differences are incorporated.

ANSI S1.40-2006 American National Standard Specifications and Verification Procedures for Sound Calibrators

IEC 61400-11

Second edition 2002-12, Amendment 1 2006-05

IEC 61400-11

Second edition 2002-12, Amendment 1 2006-0

Wind turbine generator systems –Part 11: Acoustic noise measurement techniques

The purpose of this part of IEC 61400 is to provide a uniform methodology that will ensure consistency and accuracy in the measurement and analysis of acoustical emissions by wind turbine generator systems. The standard has been prepared with the anticipation that it would be applied by:

- the wind turbine manufacturer striving to meet well defined acoustic emission performance requirements and/or a possible declaration system;
- the wind turbine purchaser in specifying such performance requirements;
- the wind turbine operator who may be required to verify that stated, or required, acoustic performance specifications are met for new or refurbished units;
- the wind turbine planner or regulator who must be able to accurately and fairly define acoustical emission characteristics of a wind turbine in response to environmental regulations or permit requirements for new or modified installations.

This standard provides guidance in the measurement, analysis and reporting of complex acoustic emissions from wind turbine generator systems. The standard will benefit those parties involved in the manufacture, installation, planning and permitting, operation, utilization, and regulation of wind turbines. The measurement and analysis techniques recommended in this document should be applied by all parties to insure that continuing development and operation of wind turbines is carried out in an atmosphere of consistent and accurate communication relative to environmental concerns. This standard presents measurement and reporting procedures expected to provide accurate results that can be replicated by others.

End of Measurement Procedure

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VIII. Noise-Con 2008 Paper

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Simple guidelines for siting wind turbines to prevent health risks[30]

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Revision: 2.1[31]

Industrial scale wind turbines are a familiar part of the landscape in Europe, U.K. and other parts of the world. In the U.S., however, similar industrial scale wind energy developments are just beginning operation. The presence of industrial wind projects will increase dramatically over the next few years given the push by the Federal and state governments to promote renewable energy sources through tax incentives and other forms of economic and political support. States and local governments in the U.S. are promoting what appear to be lenient rules for how industrial wind farms can be located in communities, which are predominantly rural and often very quiet. Studies already completed and currently in progress describe significant health effects associated with living in the vicinity of industrial grade wind turbines. This paper reviews sound studies conducted by consultants for governments, the wind turbine owner, or the local residents for a number of sites with known health or annoyance problems. The purpose is to determine if a set of simple guidelines using dBA and dBC sound levels can serve as the 'safe' siting guidelines. Findings of the review and recommendations for sound limits will be presented. A discussion of how the proposed limits would have affected the existing sites where people have demonstrated pathologies apparently related to wind turbine sound will also be presented.

Background

A relatively new source of community noise is spreading rapidly across the rural U.S. countryside. Industrial grade wind turbines, a common sight in many European countries, are now being promoted by Federal and state governments as the way to minimize coal powered electrical energy and its effects on global warming. But, the initial developments using the newer 1.5 to 3 MWatt wind turbines here in the U.S. has also led to numerous complaints from

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[31] The criteria table at the end of this paper and portions of the narrative have been revised to reflect our current understanding of how to specify the sound limits with less ambiguity and to use the new format for presenting them.

residents who find themselves no longer in the quiet rural communities they were living in before the wind turbine developments went on-line. Questions have been raised about whether the current siting guidelines being used in the U.S. are sufficiently protective for the people living closest to the developments. Research being conducted into the health issues using data from established wind turbine developments is beginning to appear that supports the possibility there is a basis for the health concerns. Other research into the computer modeling and other methods used for determining the layout of the industrial wind turbine developments and the distances from residents in the adjacent communities are showing that the output of the models should not be considered accurate enough to be used as the sole basis for making the siting decisions.

The authors have reviewed a number of noise studies conducted in response to community complaints for wind energy systems sited in Europe, Canada, and the U.S. to determine if additional criteria are needed for establishing safe limits for industrial wind turbine sound immissions in rural communities. In several cases, the residents who filed the complaints have been included in studies by medical researchers who are investigating the potential health risks associated with living near industrial grade wind turbines 365 days a year. These studies were also reviewed by the authors to help in identifying what factors need to be considered in setting criteria for 'safe' sound limits at receiving properties. Due to concerns about medical privacy, details of these studies are not discussed in this paper. Current standards used in the U.S. and in most other parts of the world rely on not-to-exceed dBA sound levels, such as 50 dBA, or on not-to-exceed limits based on the pre-construction background sound level plus an adder (e.g. L_{90A} + 5 dBA).

Our review covered the community noise studies performed in response to complaints, research on health issues related to wind turbine noise, critiques of noise studies performed by consultants working for the wind developer, and research/technical papers on wind turbine sound immissions and related topics. The papers are listed in Tables 1-4.

Table 1-List of Studies Related to Complaints

Resource Systems Engineering, Sound Level Study - Ambient & Operations Sound Level Monitoring, Maine Department of Environmental Protection Order No. L-21635-26-A-N, June 2007
ESS Group, Inc., Draft Environmental Impact Statement For The Dutch Hill Wind Power Project - Town of Cohocton, NY, November 2006
David M. Hessler, Environmental Sound Survey and Noise Impact Assessment - Noble Wethersfield Wind park - Towns of Wethersfield and Eagle NY For: Noble Environmental Power, LLC January 2007
George Hessler, "Report Number 101006-1, Noise Assessment Jordanville Wind Power Project," October 2006
HGC Engineering, "Environmental Noise Assessment Pubnico Point Wind Farm, Nova Scotia, Natural Resources Canada Contract NRCAN-06-0046," August 23, 2006
John I. Walker, Sound Quality Monitoring, East Point, Prince Edward Island" by Jacques Whitford, Consultants for Prince Edward Island Energy Corporation, May 28, 2007

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Table 2- List of Studies related to Health

Nina Pierpont, "Wind Turbine Syndrome – Abstract" from draft article and personal conversations. www.ninapierpont.com
Nina Pierpont, "Letter from Dr. Pierpont to a resident of Ontario, Canada, re: Wind Turbine Syndrome," Autumn 2007
Amanda Harry, "Wind Turbine Noise and Health" (2007)
Barbara J. Frey and Peter J. Hadden, "Noise Radiation from Wind Turbines Installed Near Homes, Effects on Health" (2007)
Eja Pedersen, "Human response to wind turbine noise – Perception, annoyance and moderating factors, Occupational and Environmental Medicine," The Sahlgrenska Academy, Gotenborg 2007
Robin Phipps, "In the Matter of Moturimu Wind Farm Application, Palmerston North, Australia," March 2007
WHO European Centre for Environment and Health, Bonn Office, "Report on the third meeting on night noise guidelines," April 2005

Table 3-List of Studies that review Siting Impact Statements

Richard H. Bolton, "Evaluation of Environmental Noise Analysis for 'Jordanville Wind Power Project,'" December 14, 2006 Rev 3.
Clifford P. Schneider, "Accuracy of Model Predictions and the Effects of Atmospheric Stability on Wind Turbine Noise at the Maple Ridge Wind Power Facility," Lowville, NY – 2007

Table 4-List of Research and Technical papers included in review process

Anthony L. Rogers, James F. Manwell, Sally Wright, "Wind Turbine Acoustic Noise," Renewable Energy Research Laboratory, Dept. of ME and IE, U of Mass, Amherst, amended June 2006
ISO. 1996. Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation. International Organization of Standardization. ISO 9613-2. p. 18.
G.P. van den Berg, "The Sounds of High Winds – the effect of atmospheric stability on wind turbine sound and microphone noise," Ph.D. thesis, 2006
Fritz van den Berg, "Wind Profiles over Complex Terrain," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
William K. G. Palmer, "Uncloaking the Nature of Wind Turbines-Using the Science of Meteorology," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
Soren Vase Legarth, "Auralization and Assessment of Annoyance from Wind Turbines," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
Julian T. and Jane Davis, "Living with aerodynamic modulation, low frequency vibration

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and sleep deprivation - how wind turbines inappropriately placed can act collectively and destroy rural quietitude," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
James D. Barnes, "A Variety of Wind Turbine Noise Regulations in the United States - 2007," Proceedings of Second International Meeting on Wind Turbine Noise, Lyons, France, Sept. 2007
M. Schwartz and D. Elliott, Wind Shear Characteristics at Central Plains Tall Towers, NREL 2006
IEC 61400 "Wind turbine generator systems, Part 11: Acoustic noise measurement techniques,".rev:2002

Discussion

After reviewing the materials in the tables; we have arrived at our current understanding of wind turbine noise and its impact on the host community and its residents. The review showed that some residents living as far as 3 km (two (2) miles) from a wind farm complain of sleep disturbance from the noise. Many residents living one-tenth this distance (300 m. or 1000 feet) from a wind farm are experiencing major sleep disruption and other serious medical problems from nighttime wind turbine noise. The peculiar acoustic characteristics of wind turbine noise immissions cause the sounds heard at the receiving properties to be more annoying and troublesome than the more familiar noise from traffic and industrial factories. Limits used for these other community noise sources do not appear to be appropriate for siting industrial wind turbines. The residents who are annoyed by wind turbine noise complain of the approximately one (1) second repetitive swoosh-boom-swoosh-boom sound of the turbine blades and "low frequency" noise. It is not apparent to these authors whether the complaints that refer to "low frequency" noise are about the audible low frequency part of the swoosh-boom sound, the one hertz amplitude modulation of the swoosh-boom sound, or some combination of both acoustic phenomena.

To assist in understanding the issues at hand, the authors developed the 'conceptual' graph for industrial wind turbine sound shown in Figure 1. This graph shows the data from one of the complaint sites plotted against the sound immission spectra for a modern 2.5 MWatt wind turbine; Young's threshold of perception for the 10% most sensitive population (ISO 0266); and a spectrum obtained for a rural community during a three hour, 20 minute test from 11:45 pm until 3:05 am on a windless June evening in near Ubly, Michigan a quiet rural community located in central Huron County. (Also called: Michigan's "Thumb.") It is worth noting that this rural community demonstrates how quiet a rural community can be when located at a distance from industry, highways, and airport related noise emitters.

During our review we posed a number of questions to ourselves related to what we were learning. The questions (italics) and our answers are:

Do National or International or local community Noise Standards for siting wind turbines near dwellings address the low frequency portion of the wind turbine's sound immissions?[32] No! State and Local governments are in the process of establishing wind farm noise limits and/or wind turbine

[32] Emissions refer to acoustic energy from the 'viewpoint' of the sound emitter, while immissions refer to acoustic energy from the viewpoint of the receiver.

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setbacks from nearby residents, but the standards incorrectly presume that limits based on dBA levels are sufficient to protect the residents.

Do wind farm developers have noise limit criteria and/or wind turbine setback criteria that apply to nearby residents? Yes! But the Wind Industry recommended residential wind turbine noise levels (typically 50-55 dBA) are too high for the quiet nature of the rural communities and may be unsafe for the nearest residents. An additional concern is that some of the methods for implementing pre-construction computer models may predict sound levels that are too low. These two factors combined can lead to post-construction complaints and health risks.

Are all residents living near wind farms equally affected by wind turbine noise? No, children, people with pre-existing medical conditions, especially sleep disorders, and the elderly are generally the most susceptible. Some people are unaffected while some nearby neighbors develop serious health effects caused by exposure to the same wind turbine noise.

How does wind turbine noise impact nearby residents? Initially, the most common problem is chronic sleep deprivation during nighttime. According to the medical research documents, this may develop into far more serious physical and psychological problems

What are the technical options for reducing wind turbine noise immission at residences? There are only two options: 1) increase the distance between source and receiver, and/or 2) reduce the source sound power immission. Either solution is incompatible with the objective of the wind farm developer to maximize the wind power electrical generation within the land available.

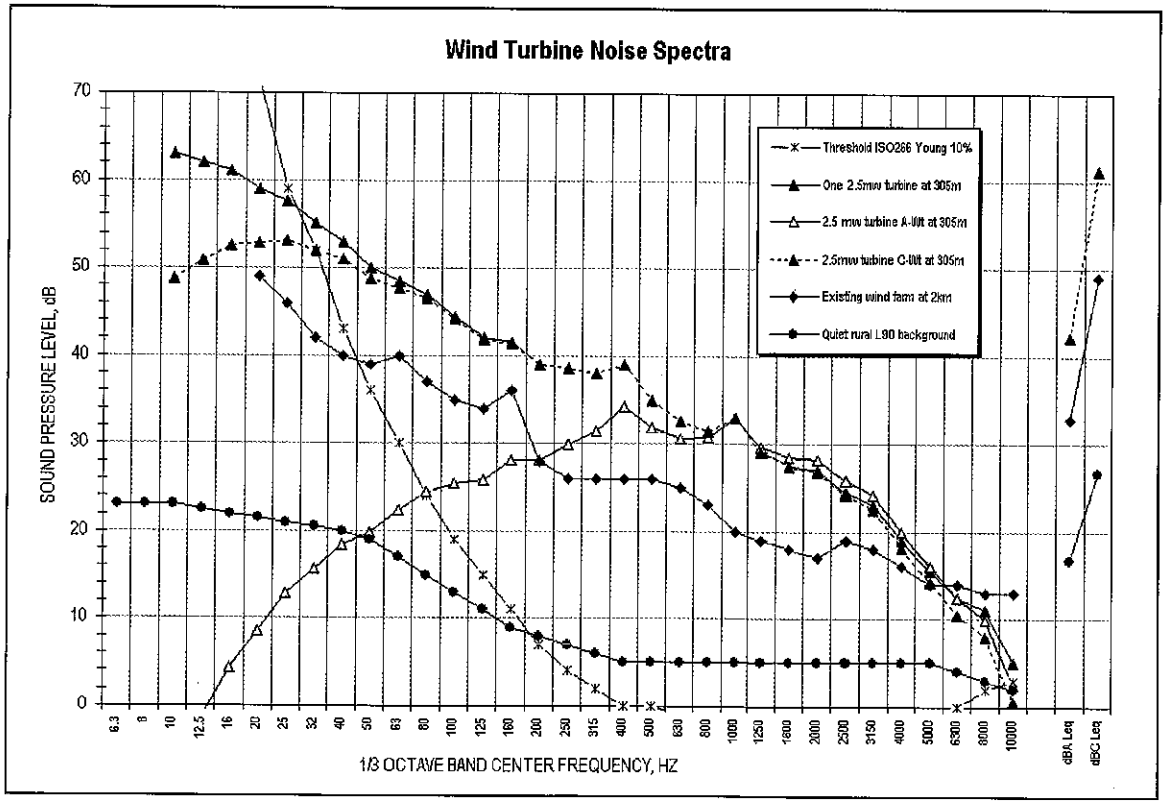


Figure 1-Generalized Sound Spectra vs. perception and rural community L_{90A} background 1/3 octave SPL

Is wind turbine noise at a residence much more annoying than traffic noise? Yes, researchers have found that "Wind turbine noise was perceived by about 85% of the respondents even when the calculated A-weighted SPL were as low as 35.0–37.5 dB. This could be due to the presence of

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amplitude modulation in the noise, making it easy to detect and difficult to mask by ambient noise." [JASA 116(6), December 2004, pgs 3460-3470, "Perception and annoyance due to wind turbine noise-a dose-relationship" Eja Pedersen and Kerstin Persson Waye, Dept of Environmental Medicine, Goteborg University, Sweden]

Why do wind turbine noise immissions of only 35 dBA disturb sleep at night? This issue is now being studied by the medical profession. The affected residents complain of the middle to high frequency swooshing sounds of the rotating turbine blades at a constant repetitive rate of about 1 hertz plus low frequency noise. The amplitude modulation of the swooshing sound changes continuously. The short time interval between the blade's swooshing sounds described by residents as sometimes having a thump or low frequency banging sound that varies in amplitude up to 10 dBA. This may be a result of phase changes between turbine emissions, turbulence, or an operational mode.. The assumptions about wall and window attenuation being 15 dBA or more may not be sufficiently protective considering the relatively high amplitude of the wind turbine's low frequency immission spectra.

What are the typical wind farm noise immission criteria or standards? Limits are not consistent and may vary even within a particular country. Example criteria include: Australia-the lower of 35 dBA or L_{90} + 5 dBA, Denmark-40 dBA, France L_{90} + 3 (night) and L_{90} + 5 (day), Germany-40 dBA, Holland-40 dBA, United Kingdom-40 dBA (day) and 43 dBA (night) or L_{90} + 5 dBA, Illinois-55 dBA (day) and 51 dBA (night), Wisconsin-50 dBA and Michigan-55 dBA. Note: Illinois statewide limits are expressed only in nine contiguous octave frequency bands and no mention of A-weighting for the hourly l_{eq} limits. Typically, wind turbine noise just meeting the octave band limits would read 5 dB below the energy sum of the nine octave bands after applying A-weighting. So the Illinois limits are approximately 50 dBA (daytime 7 AM to 10 PM) and 46 dBA at night, assuming a wind farm is a Class C Property Line Noise Source.

What is a reasonable wind farm sound immission limit to protect the health of residences? We are proposing an immission limit of 35 dBA or L_{90A} + 5 dBA whichever is lower and also a C-weighted criteria to address the impacted resident's complaints of wind turbine low frequency noise: For the proposed criteria the dBC sound level at a receiving property shall not exceed L_{90A} + 20dB. In other words, the dBC operating immission limit shall not be more than 20 dB above the measured dBA (L_{90A}) pre-construction nighttime background sound level. A maximum not-to-exceed limit of 50 dBC is also proposed.

Why should the dBC immission limit not be permitted to be more than 20 dB above the background measured L_{90A}? The World Health Organization and others have determined a sound emitter's noise that results in a difference between the dBC and dBA value greater than 20 dB will be an annoying low frequency issue.

Is not L_{90A} the minimum dBA background noise level? This is not exactly correct. The L_{90} is the statistical descriptor representing the quietest 10% of the time. It may be understood as the sounds one hears when there are no nearby or short-term sounds from man-made or natural sources. It excludes sounds that are not part of the soundscape during all seasons. It is very important to establish the statistical average background noise environment outside a potentially impacted residence during the quietest (10 pm to 4 am) sleeping hours of the night. This nighttime sleep disturbance has generated the majority of the wind farm noise complaints throughout the world. The basis for a community's wind turbine sound immission limits would be the minimum 10 minute nighttime L_{90A} plus 5 dB for the time period of 10 pm to 7 am. This would become the Nighttime Immission Limits for the proposed wind farm. This can be accomplished with one or several ten (10) minute measurements during any night when the

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atmosphere is classified stable with a light wind from the area of the proposed wind farm. The Daytime Limits (7 am to 7 pm) could be set 10 dB above the minimum nighttime L_{90A} measured noise, but the nighttime criteria will always be the limiting sound levels.

A nearby wind farm meeting these noise immission criteria will be clearly audible to the residents occasionally during nighttime and daytime. Compliance with this noise standard would be determined by repeating the initial nighttime minimum nighttime L_{90A} tests and adding the dBC (L_{eqC}) noise measurement with the turbines on and off. If the nighttime background noise level (turbines off) was found to be slightly higher than the measured background prior to the wind farm installation, then the results with the turbines on must be corrected to determine compliance with the pre-turbine established sound limits.

The common method used for establishing the background sound level at a proposed wind farm used in many of the studies in Table 1 was to use unattended noise monitors to record hundreds of ten (10) minute measurements to obtain a statistically significant sample over varying wind conditions or a period of weeks. The measured results for daytime and nighttime are combined to determine the statically average wind noise as a function of wind velocity measured at a height of ten (10) meters. This provides an enormous amount of data but the results have little relationship to the wind turbine sound immission or turbine noise impact in nearby residents. The purpose of this exhaustive exercise often only demonstrates how much noise is generated by the wind. In some cases it appears that the data is used to 'prove' that the wind noise masks the turbine's sound immissions.

The most glaring failure of this argument occurs during the frequent nighttime condition of a stable atmosphere. Then, the wind turbines operate at full or near full power and noise output while the wind at ground level is calm and the background noise level is low. This is the condition of maximum turbine noise impact on nearby residents. It is the condition which most directly causes chronic sleep disruption. Furthermore, the measurement methodology is usually faulty, as much of the wind noise measured by unattended sound monitors is the pseudo-wind noise generated by failure of the microphone's windscreen. This results in totally erroneous background sound levels being used for permitting and siting decisions. (See studies in Table 3, esp. Van den Berg)

Are there additional noise data to be recorded for a pre-wind turbine noise survey near selected dwellings? Yes, The measuring sound level meter(s) need document the L_{Aeq} , L_{A10}, L_{A90} and L_{Ceq} , L_{C10}, L_{C90} sound levels plus start time & date for each 10 minute sample. The L_{10} results will be utilized to help validate that conditions were appropriate for measuring the L_{90} long term background sound levels. For example, on a quiet night one would expect L_{A10} to be less than 10 dB higher than the L_{A90} long-term background sound level. On a windy night or day the difference may be more than 20 dB. There is a requirement for measurement of the wind velocity near the sound measurement microphone continuously throughout each ten (10) minute recorded noise sample. The ten (10) minute average of the wind speed near the microphone shall not exceed 2 m/s (4.5 mph) and the maximum wind speed for operational tests shall not exceed 4 m/s (9 mph). It is strongly recommended that observed samples be used for these tests.

Is there a need to record weather data during the background noise recording survey? One weather monitor is required at the proposed wind farm on the side nearest the residents. The weather station sensors are at standard ten (10) meter height above ground. It is critical the weather be recorded every ten (10) minutes synchronized with the clocks in the sound level recorders without ambiguity in the start and end time of each ten (10) minute period. The weather station should record wind speed and direction, temperature, humidity and rain.

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Why do Canada and some other countries base the permitted wind turbine noise immission limits on the operational wind velocity at the 10m height wind speed instead of a maximum dBA or L_{A90} + 5 dBA immission level? First, it appears that the wind turbine industry will take advantage of every opportunity to elevate the maximum permitted noise immission level to reduce the setback distance from the nearby dwellings. Including wind as a masking source in the criteria is one method for elevating the permissible limits. Indeed the background noise level does increase with surface wind speed. When it does occur, it can be argued that the increased wind noise provides some masking of the wind farm turbine noise emission. However, in the middle of the night when the atmosphere is defined as stable (no vertical flow from surface heat radiation) the layers of the lower atmosphere can separate and permit wind velocities at the turbine hubs to be 2 to 4 times the wind velocity at the 10m high wind monitor but remain near calm at ground level. The result is the wind turbines can be operating at or close to full capacity while it is very quiet outside the nearby dwellings.

This is the heart of the wind turbine noise "problem" for residents within 3 km (approx. two miles) of a wind farm. When the turbines are producing the sound from operation it is quietest outside the surrounding homes. The PhD thesis of P.G. van den Berg "The Sounds of High Winds" is very enlightening on this issue. See also the letter by John Harrison in Ontario "On Wind Turbine Guidelines."

What sound monitor measurements would be needed for enforcement of the wind turbine sound ordinance? A similar sound and wind 10 minute series of measurements would be repeated at the pre-wind farm location nearest the resident registering the wind turbine noise complaint, with and without the operation of the wind turbines. An independent acoustics expert should be retained who reports to the County Board or other responsible governing body. This independent acoustics expert shall be responsible for all the acoustic measurements including instrumentation setup, calibration and interpretation of recorded results. An independent acoustical consultant shall also perform all pre-turbine background noise measurements and interpretation of results to establish the Nighttime (and Daytime if applicable) industrial wind turbine sound immission limits. At present the acoustical consultants are retained by, and work directly for, the wind farm developer.

This presents a serious problem with conflict of interest on the part of the consultant. The wind farm developer would like to show the significant amount of wind noise that is present to mask the sounds of the wind turbine immissions. The wind farm impacted community would like to know that wind turbine noise will be only barely perceptible and then only occasionally during the night or daytime.

Is frequency analysis required either during pre-wind farm background survey or for compliance measurements? Normally one-third octave or narrower band analysis would only be required if there is a complaint of tones immission from the wind farm.

Proposed Sound Limits

The simple fact that so many residents complain of low frequency noise from wind turbines is clear evidence that the single A-weighted (dBA) noise descriptor used in most jurisdictions for siting turbines is not adequate. The only other simple audio frequency weighting that is standardized and available on all sound level meters is C-weighting or dBC. A standard sound level meter set to measure dBA is increasingly less sensitive to low frequency below 500 Hz (one octave above middle-C). The same sound level meter set to measure dBC is equally sensitive to all frequencies above 32 Hz (lowest note on grand piano). It is well accepted that dBC readings

Prepared for: www.windturbinesyndrome.com

are more predictive of perceptual loudness than dBA readings if low frequency sounds are significant.

We are proposing to use the commonly accepted dBA criteria that is based on the pre-existing background sound levels plus a 5 dB allowance for the wind turbine's immissions (e.g. L_{90A} +5) for the audible sounds from wind turbines. In addition, to address the lower frequencies that are not considered in A-weighted measurements we are proposing to add limits based on dBC. The Proposed Sound Limits are presented in the text box at the end of this paper.

For the current industrial grade wind turbines in the 1.5 to 3 MWatt range, the addition of the dBC requirement will result in an increased distance between wind turbines and the nearby residents. For the generalized graphs shown in Figure 1, the distances would need to be approximately double the current distance. This will result in setbacks in the range of 1 km or greater for the current generation of wind turbines if they are to be located in rural areas where the L_{90A} background sound levels are 30 dBA or lower. When no man-made sounds are audible they can even be under 20 dBA. In areas with higher background sound levels, turbines could be located somewhat closer, but still at a distance greater than the 305 m (1000 ft.) or less setbacks commonly seen in U.S. based wind turbine standards set by many states and used for wind turbine developments.

Prepared for: www.windturbinesyndrome.com

1. Establishing Long-Term Background Noise Level

a. Instrumentation: ANSI or IEC Type 1 Precision Integrating Sound Level Meter plus meteorological instruments to measure wind velocity, temperature and humidity near the sound measuring microphone. Measurement procedures must meet ANSI S12.9, Part 3.

b. Measurement location(s): Nearest property line(s) from proposed wind turbines representative of all non-participating residential property within 2.0 miles.

c. Time of measurements and prevailing weather: The atmosphere must be classified as stable with no vertical heat flow to cause air mixing. Stable conditions occur in the evening and middle of the night with a clear sky and very little wind near the surface. Sound measurements are only valid when the measured wind speed at the microphone does not exceed 2 m/s (4.5 mph).

d. Long-Term Background sound measurements: All data recording shall be a series of contiguous ten (10) minute measurements. The measurement objective is to determine the quietest ten minute period at each location of interest. Nighttime test periods are preferred unless daytime conditions are quieter. The following data shall be recorded simultaneously for each ten (10) minute measurement period: dBA data includes L_{A90}, L_{A10}, L_{Aeq} and dBC data includes L_{C90}, L_{C10}, and L_{Ceq}. The maximum wind speed at the microphone during the ten minutes, a single measurement of temperature and humidity at the microphone for each new location or each hour whichever is oftener shall also be recorded. A ten (10) minute measurement contains valid data provided: Both L_{A10} minus L_{A90} and L_{C10} minus L_{C90} are not greater than 10 dB and the maximum wind speed at the microphone did not exceed 2 m/s during the same ten (10) minute period as the acoustic data.

2. Wind Turbine Sound Immission Limits

No wind turbine or group of turbines shall be located so as to cause wind turbine sound immission at any location on non-participating property containing a residence in excess of the limits in the following table:

Table of Not-To-Exceed Property Line Sound Immission Limits [1]

Criteria	Condition	dBA	dBC
A	Immission above pre-construction background:	$L_{Aeq} = L_{A90} + 5$	$L_{Ceq} = L_{C90} + 5$
B	Maximum immission:	35 L_{Aeq}	55 L_{Ceq} for quiet[2] rural environment 60 L_{Ceq} for rural-suburban environment
C	Immission spectra imbalance	L_{Ceq} (immission) minus (L_{A90} (background)+5) $\leq$ 20 dB	
D	Prominent tone penalty:	5 dB	5 dB

Notes	
1	Each Test is independent and exceedances of any test establishes non-compliance Sound "immission" is the wind turbine noise emission as received at a property
2	A "Quiet rural environment" is a location 2 miles from a state road or other major transportation artery without high traffic volume during otherwise quiet periods of the day or night.
3	Prominent tone as defined in IEC 61400-11. This Standard is not to be used for any other purpose.

[1] Procedures provided in Section 7. Measurement Procedures (Appendix to Ordinance) of the most recent version of "**The How To Guide To Siting Wind Turbines To Prevent Health Risks From Sound**" by Kamperman and James apply to this table.

3. Wind Farm Noise Compliance Testing

All of the measurements outlined above in 1. Establishing the Long-Term Background Noise Level must be repeated to determine compliance with 2. Wind Turbine Sound Immission Limits. The compliance test location is to be the pre-turbine background noise measurement location nearest to the home of the complainant in line with the wind farm and nearer to the wind farm. The time of day for the testing and the wind farm operating conditions plus wind speed and direction must replicate the conditions that generated the complaint. Procedures of ANSI S12.9-Part 3 apply as amended. Instrumentation limits for wind and other factors must be recognized and followed.

The authors have based these criteria, procedures, and language on their current understanding of wind turbine sound emissions, land-use compatibility, and the effects of sound on health. However, use of the following, in part or total, by any party is strictly voluntary and the user assumes all risks. Please seek professional assistance in applying the recommendations of this document to any specific community or WES development.

Harm from Wind Turbines *

What has been known for decades

University of Waterloo Seminar

May 7, 2014

Carmen Krogh, BScPharm

* Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Environmental Review Tribunal, Decision, p 207

Audio clarifications: May 9 2014

- Please note the audio clarifications related to:
  - Slide 40: Modern upwind wind turbines are typically utilized where the rotor is in the front of the unit rather than behind the unit. [1]
  - Slide 43: the distance cited is 1 km rather than 1 meter. [2]
    - 1. Formerly slide 39
    - 2. Formerly slide 42

40 to 45 Minutes

- Setting the stage
- Snapshot of some of the evidence
- Wrap-up
  - *All slides referenced*
  - *Not exhaustive: errors/omissions unintended*
  - *Emphasis sometimes added to original quotes highlighting key points*



Personal disclosure

- Education / research: no funding, no per diems
  - Sometimes travel / accommodation provided
- Member of the Board: the Society for Wind Vigilance
  - International federation of physicians, acousticians, other professionals
  - Members are volunteers / independent
  - Peer reviewed and published
- Objective - to site wind turbines to prevent harm

Published: author/co-author

Peer reviewed [9]

- Roy D. Jeffery, Carmen M.E. Krogh, and Brett Horner, Industrial wind turbines and adverse health effects Can J Rural Med 2014;19(1) http://www.cma.ca/multimedia/staticContent/HTML/N0/l2/cjrm/vol-19/issue-1/pdf/pg21.pdf
- Roy D. Jeffery, Carmen Krogh, and Brett Horner, Adverse health effects of industrial wind turbines Can Fam Physician 2013; 59: 473-475 (Commentary) http://www.cfp.ca/content/59/5/473.full
- Roy D. Jeffery MD FCFP, Carmen Krogh, Brett Horner CMA, Adverse health effects of industrial wind turbines, Letter to editor, Vol 59: September • septembre 2013, Canadian Family Physician • Le Médecin de famille canadien
- Carmen M.E. Krogh, Industrial Wind Turbine Development and Loss of Social Justice? Bulletin of Science Technology & Society 2011 31: 321, DOI: 10.1177/0270467611412550, http://bst.sagepub.com/content/31/4/321
- Carmen M.E. Krogh, Lorrie Gillis, Nicholas Kouwen, and Jeffery Aramini, WindVOiCe, a Self-Reporting Survey: Adverse Health Effects, Industrial Wind Turbines, and the Need for Vigilance Monitoring Bulletin of Science Technology & Society 2011 31: 334, DOI: 10.1177/0270467611412551. http://bst.sagepub.com/content/31/4/334
- Brett Horner, Roy D. Jeffery and Carmen M. E. Krogh, Literature Reviews on Wind Turbines and Health: Are They Enough? Bulletin of Science Technology & Society 2011 31: 399. DOI: 10.1177/0270467611421849 http://bst.sagepub.com/content/31/5/399
- Stephen E. Ambrose, Robert W. Rand and Carmen M. E. Krogh, Wind Turbine Acoustic Investigation: Infrasound and Low-Frequency Noise--A Case Study, Bulletin of Science Technology & Society published online 17 August 2012 DOI: 10.1177/0270467612455734, http://bst.sagepub.com/content/early/2012/07/30/0270467612455734
- Robert W. Rand, Stephen E. Ambrose, and Carmen M. E. Krogh, Occupational Health and Industrial Wind Turbines: A Case Study, Bulletin of Science Technology & Society 2011 31: 359DOI: 10.1177/0270467611417849. http://bst.sagepub.com/content/31/5/359
- Birds and Bird Habitat: What Are the Risks From Industrial Wind Turbine Exposure? Terry Sprague, M. Elizabeth Harrington, and Carmen M. E. Krogh, DOI: 10.1177/0270467611417844 http://bst.sagepub.com/content/31/5/377

Published: author / co-author

Conference papers [7]

- Wind Turbine Facilities' Perception: A Case Study from Canada Peter N. Cole MD, MHSc, FRCP(C) and Carmen Krogh, BScPharm 5th International Conference on Wind Turbine Noise Denver 28 – 30 August 2013 (published in proceedings but not presented)
- Audit report: literature reviews on wind turbine noise and health Brett Horner, Carmen ME Krogh, Roy D Jeffery Paper presented at the Wind Turbine Noise conference 2013, August 28 to 30, Denver, Colorado, USA
- Trading off human health: Wind turbine noise and government policy Carmen ME Krogh, Joan Morris, Murray May, George Papadopoulos, Brett Horner Paper presented at the Wind Turbine Noise conference 2013, August 28 to 30, Denver, Colorado, USA
- Carmen ME Krogh, Roy D Jeffery, Jeff Aramini, Brett Horner, Wind turbines can harm humans: a case study, Paper presented at Inter-noise 2012, New York City, NY
- Carmen ME Krogh, Roy D Jeffery, Jeff Aramini, Brett Horner, Wind turbine noise perception, pathways and effects: a case study Paper presented at Inter-noise 2012, New York City, NY
- Carmen ME Krogh, Roy D Jeffery, Jeff Aramini, Brett Horner, Annoyance can represent a serious degradation of health: wind turbine noise a case study, Paper presented at Inter-noise 2012, New York City, NY
- Stephen E. Ambrose, Robert W. Rand and Carmen M. E. Krogh, Falmouth, Massachusetts wind turbine infrasound and low frequency noise measurements, Invited paper presented at Inter-noise 2012m New York City, NY

Setting the stage

Definitions

Symptoms

Direct and indirect pathways

Government policy

1948 Definition of health

CONSTITUTION OF THE WORLD HEALTH ORGANIZATION[1]

THE STATES Parties to this Constitution declare, in conformity with the Charter of the United Nations, that the following principles are basic to the happiness, harmonious relations and security of all peoples:

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.

Acknowledgement: annoyance

- Annoyance is acknowledged to be an adverse health effect. [1,2,3,4,5]

- 1. Health Canada, Community Noise Annoyance, Its Your Health, (2005, September)
- 2. Michaud, D. S., Keith, S. E., & McMurchy, D., “Noise Annoyance in Canada”, Noise Health, 7, 39-47. (2005)
- 3. Pedersen, E., & Persson Waye, K., “Wind Turbine Noise, Annoyance and Self-Reported Health and Well Being in Different Living Environments”, Occupational and Environmental Medicine, 64, 480-486, (2007) doi:10.1136/oem.2006.031039
- 4. Suter, A. H., Noise and Its Effects, Washington, DC: Administrative Conference of theUnited States, (1991)
- 5. New South Wales. Parliament. Legislative Council. General Purpose Standing Committee No. 5, Rural Wind Farms (2009, December)

Definition: sound versus noise

- World Health Organization defines noise as “unwanted sound” [1]
- Sound meters can assess sound; however, humans assess “noise”
- Humans are being considered as “objective measuring instruments (New Experts), whose reports and descriptions must be taken seriously and quantified by technical measurements.” [2]

References: sound versus noise

1. Berglund, B., Lindvall, T., & Schwela, D. H., *Guidelines for Community Noise*, Geneva, Switzerland: World Health Organization, (1999)

2. Bray Wade, Acoustical Society of America 164th Meeting, Kansas City, MO 22 - 26 October, 2012, 2aNS6, Relevance and applicability of the Soundscape concept to physiological or behavioural effects caused by noise at very low frequencies which may not be audible.

   www.acoustics.org/press/164th/Bray_2aNS6.html

2009 Commonly reported symptoms



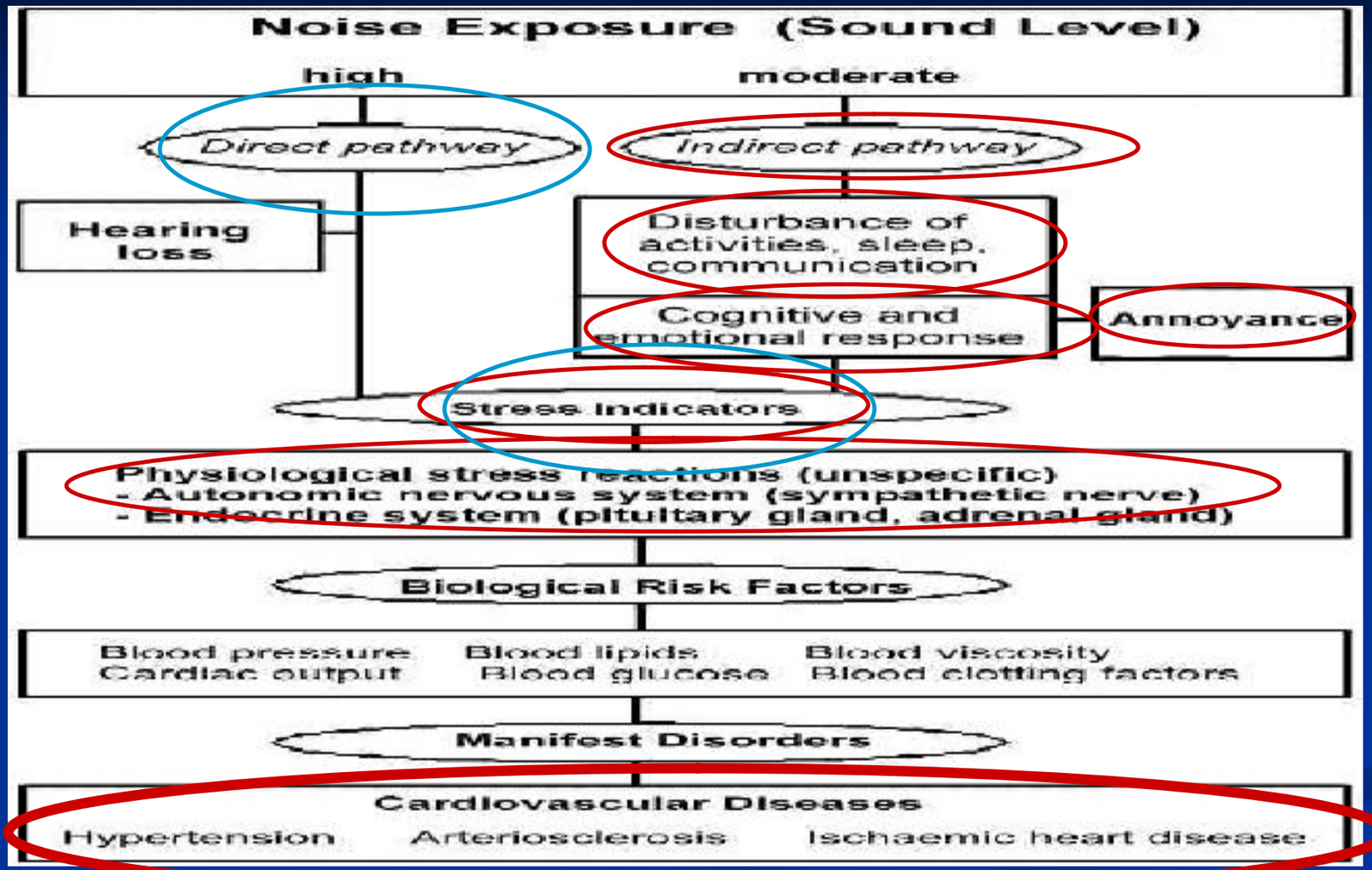
- Dr. Nina Pierpont documented symptoms reported by individuals exposed to wind turbines which include: sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic episodes associated with sensations of internal pulsation or quivering when awake or asleep.

- Pierpont, N., *Wind Turbine Syndrome: A Report on a Natural Experiment*, Santa Fe, NM: K-Selected Books, (2009)

Commonly reported symptoms

	"I am happy to accept these symptoms… what Pierpont describes is effects of annoyance by noise – a stress effect …"
	"… well-known stress effects of exposure to noise…"
	"… Wind Turbine Syndrome is the result of stress from annoyance by audible noise from wind turbines…"

Noise: direct and indirect pathways



- World Health Organization, Night Noise Guidelines for Europe, 2009

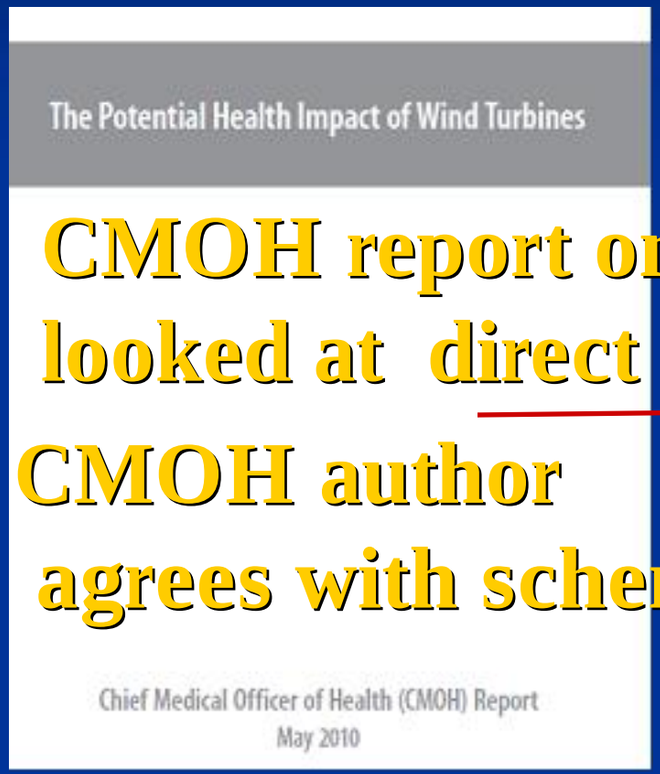
2010 ON Chief Medical Officer of Health

- "While some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a **direct** causal link between wind turbine noise and adverse health effects."



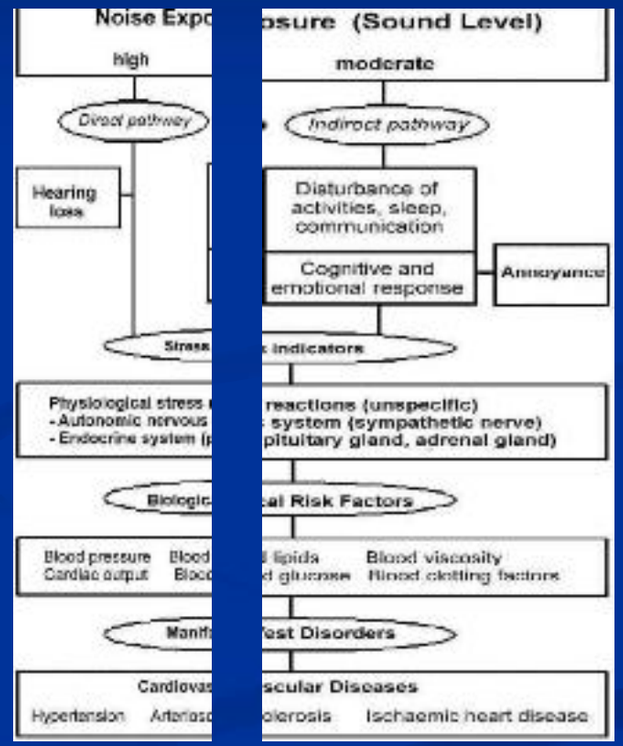
- Chief Medical Officer of Health. The potential health impact of wind turbines. http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf

2011 Ontario Chief Medical Officer Health author



CMOH report only looked at direct links [2]

CMOH author agrees with schema [1]



- Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Transcript of Dr. G. Rachamin, Mar, 4, 2011 [1] p. 211, [2] p. 216

2011 Direct and indirect impacts

- "… The Tribunal has found above that "serious harm to human health" includes both direct impacts (e.g., a passer-by being injured by a falling turbine blade or a person losing hearing) or indirect impacts (e.g., a person being exposed to noise and then exhibiting stress and developing other related symptoms). This approach is consistent with both the WHO definition of health and Canadian jurisprudence on the topic."

  - Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Environmental Review Tribunal, Decision, p190

2011 Indirect health effects & precaution



- The ERT Decision expressed concerns :

  "…about the Director's apparent lack of consideration of indirect health effects and the need for further work on the MOE's practice of precaution…"

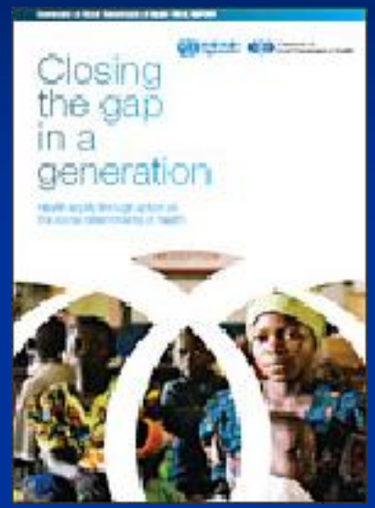
  - Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Environmental Review Tribunal, Decision, p 206

1986 Policy: Health Canada



- "It is clear … that existing policies and practices are not sufficiently effective to ensure that Canadian men and women of all ages and backgrounds can have an equitable chance of achieving health … Conflicting interests may exist between sectors."

2008 Policy: World Health Organisation



- "Different government policies, depending on their nature, can either improve or worsen health and health equity."

Green Energy Act, 2009

Ontario

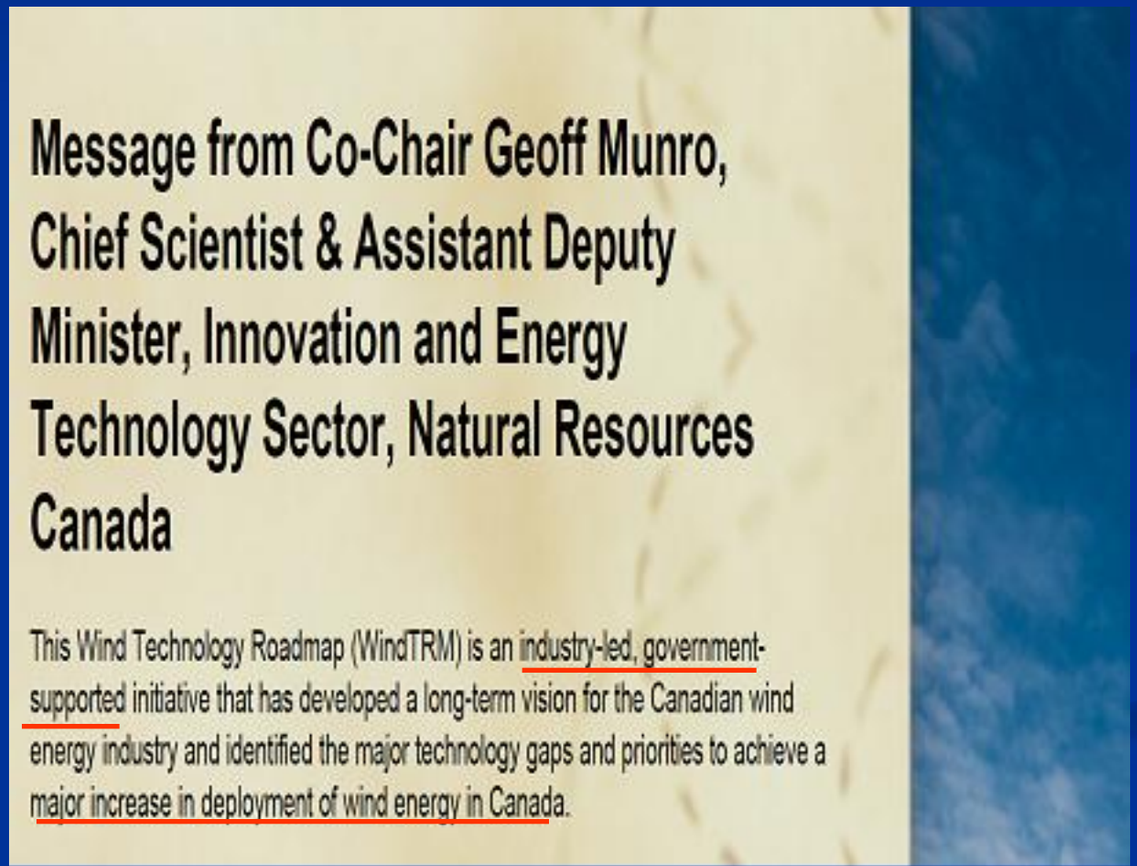
Preamble

The Government of Ontario is committed to fostering the growth of renewable energy projects, which use cleaner sources of energy, and to removing barriers to and promoting opportunities for renewable energy projects and to promoting a green economy.

S.O. 2009, CHAPTER 12
SCHEDULE A

Industry-led : government-supported

Wind Technology Road Map



Yesterday's and Today's Industrial Wind Turbines

La Gaspésie Quebec



Courtesy of Eco Awareness Society, Nova Scotia

Germany



Michigan USA



Source: Appraisal Institute Webinar – October, 2012

Perspective visuals: Ontario



Photo courtesy of Bonny McKeough, Ontario, estimate 0.5 mile from home

Amherst Island Ontario - projected model



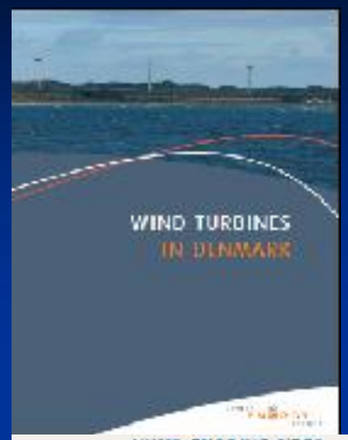
Prince Edward Island

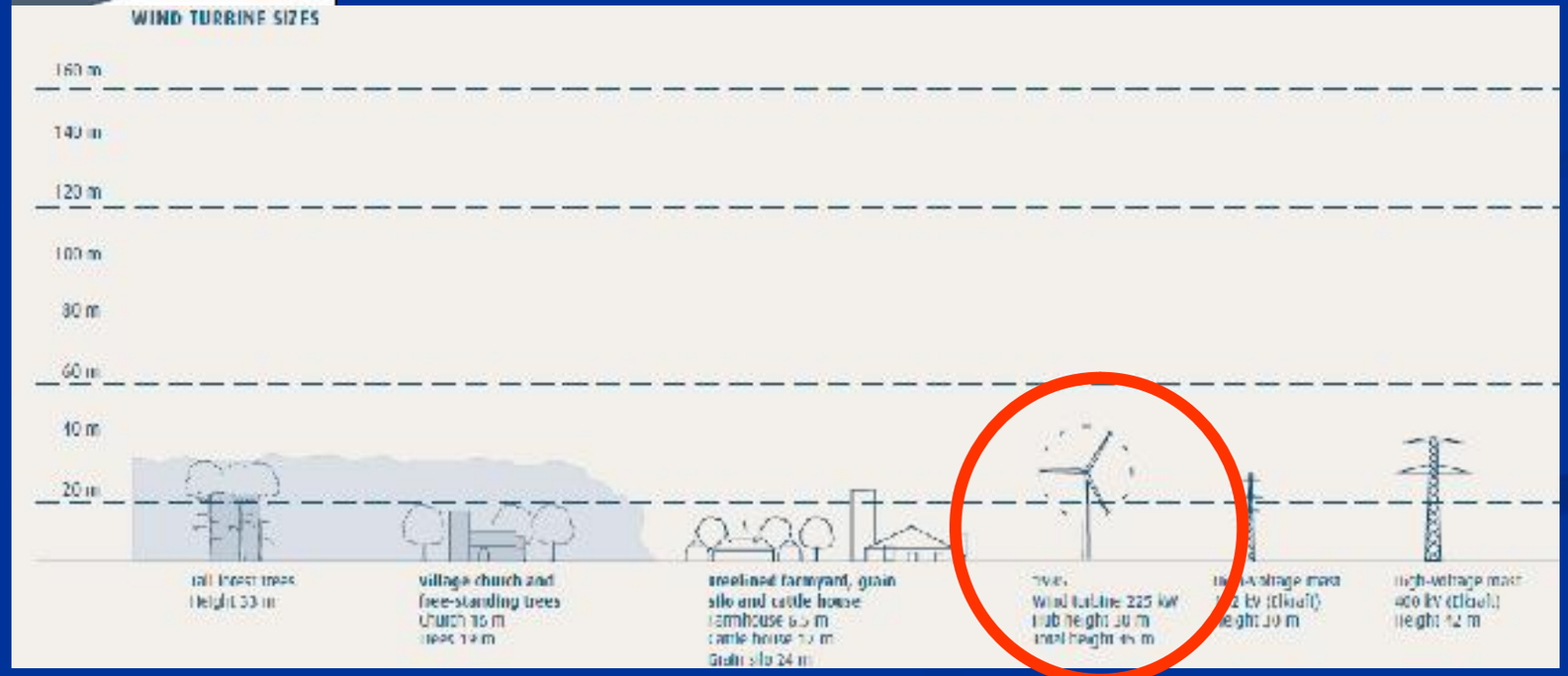


Palm Springs California

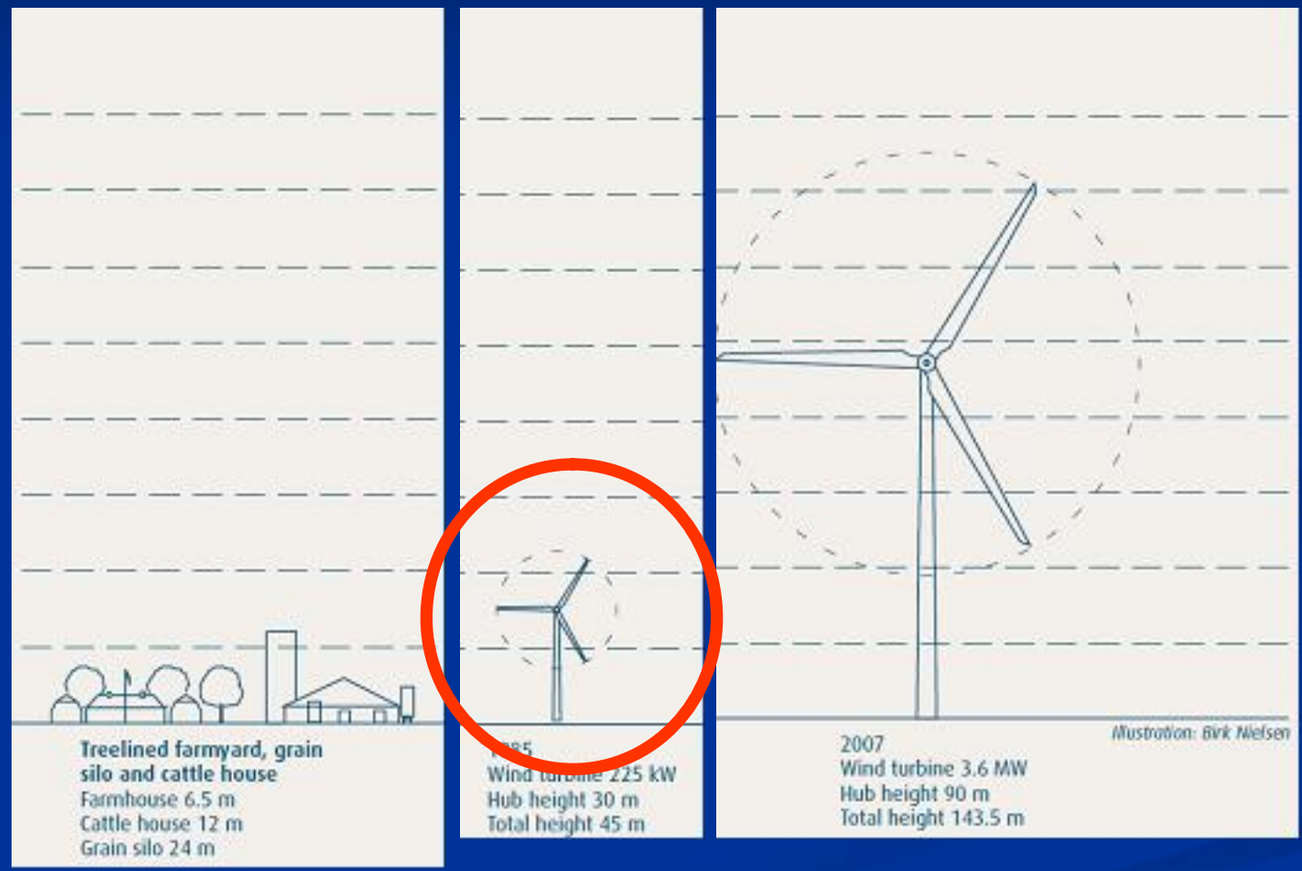


Wind turbines 1985





2007 Wind turbines today





Real property value: Demark



DANISH ENERGY AGENCY

OIL AND GAS | SUPPLY | CONSTRUCTION | CONSUMPTION AND SAVINGS | CLIMATE AND CO2 | POLICY

›Frontpage›Supply›Renewable energy›Wind Power›Onshore Wind Power›Loss of value to real property

Loss of value to real property due the erection of wind turbines

An erector of a wind turbine has a duty to pay compensation for loss of value of real property following the erection of the wind turbine. The size of the loss of value is determined by an appraisal authority.

CONTACT

Jens Bengtsson

Energy Supply

Phone: +45 3392 6776

›jbe@ens.dk



- Danish Energy Agency, "Loss of value to real property due the erection of wind turbines", http://www.ens.dk/en-US/supply/Renewable-energy/WindPower/Onshore-Wind-Power/Loss-of-value-to-real-property/Sider/Forside.aspx , Cited August 21, 2012

2011 Ontario disclosure

OREA Ontario Real Estate Association

Seller Property Information Statement
Residential

Form 220
for use in the Province of Ontario

ANSW
inform
broker
inform
even i
accura

ENVIRONMENTAL: (Provide Applicable ADDITIONAL COMMENTS)

	YES	NO	UNKNOWN	NOT APPLICABLE
1. Are you aware of possible environmental problems or soil contamination of any kind on the property or in the immediate area? eg: radon gas, toxic waste, underground gasoline or fuel tanks etc.				
2. Are there any existing or proposed waste dumps, disposal sites or land fills in the immediate area?				
3. Are there any hydro generating projects planned for the immediate area? eg: Wind Turbines				

- Ontario Real Estate Association, Seller Property Information Statement, Form 220 for use in the Province of Ontario, Revised 2011

Reviews

Other research

2004 Special edition

Noise & Health
A Bimonthly Inter-disciplinary International Journal

- "It is difficult for residents to protect themselves against low frequency emissions."
- "Conventional methods of assessing annoyance, typically based on Aweighed equivalent sound level, are inadequate for low frequency noise and lead to incorrect decisions by regulatory authorities.
- Experiments with both animals and humans have shown that the vibroacoustic stress or causes thickening of cardiovascular structures (cardiac muscle and blood vessels).

EDITORIAL
Year : 2004 | Volume : 6 | Issue : 23 | Page : 1-2

2007 Examples of reviews

- "LFN-exposed animal models: "LFN is an agent of disease and the respiratory tract is one of its preferential targets."
  - Branco NA et al 2007 Respiratory pathology in vibroacoustic disease: 25 years of research. [Review] Revista Portuguesa de Pneumologia. 13(1):129-35, 2007 Jan-Feb [27 refs]
- "Patients and animals: At present, infrasound (0-20 Hz) and low-frequency noise (20-500 Hz) (ILFN, 0-500 Hz) are agents of disease that go unchecked."
- "Frequency-specific effects are not yet known, valid dose-responses have been difficult to identify, and large-scale epidemiological studies are still lacking."
  - Alves-Pereira M & Branco NA Vibroacoustic disease: biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling. [Review] Progress in Biophysics & Molecular Biology. 93(1-3):256-79, 2007 Jan-Apr. [123 refs]

2011 Review

Wind Turbine Infra and Low-Frequency Sound: Warning Signs That Were Not Heard

There is sufficient research and history to link the sensitivity of some people to inaudible amplitude-modulated infra and low-frequency noise to the type of symptoms described by those living near industrial wind turbines.

This information should have served as a warning sign.

- James, Richard R. Wind Turbine Infra and Low-Frequency Sound: Warnings Signs That Were Not Heard DOI: 10.1177/0270467611421845Bulletin of Science Technology & Society published online 15 December 2011 http://bst.sagepub.com/content/early/2011/11/07/0270467611421845

Reviews

Other research

1982 Investigation

A Methodology for Assessment of Wind Turbine Noise Generation

- Upwind 2 MW, MOD - turbine (Boone, North Carolina):
  - “unexpected noise complaints from a few residents within 3 km”

N. D. Kelley

R. R. Hemphill

H. E. Mc Kenna

Solar Energy Research Institute, Golden, Colo. 80401

Journal of Solar Energy Engineering

MAY 1982, Vol. 104 / 119

Audio clarification: Modern upwind wind turbines are typically utilized where the rotor is in the front of the unit rather than behind the unit.

1982 Results

A Methodology for Assessment of Wind Turbine Noise Generation

- "… hypothesize one of the causal factors related to annoyance associated with the pulsating pressure fields in the rooms measured is a coupling with human body resonances … creating a sensation of a whole-body vibration."

- "This perception is more noticeable indoors…"

1987 Proposed Metric

A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions

Prepared under Task No. WE721201
Program No. 8

Solar Energy Research Institute
A Division of Midwest Research Institute

1617 Cole Boulevard
Golden, Colorado 80401-3393

Prepared for the
U.S. Department of Energy
Contract No. DE-AC02-83CH10093

Presented at the Windpower '87
Conference and Exposition
October 5-8, 1987
San Francisco, California

November 1987

N.D. Kelley

1987 Proposed Metric

A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions

- "… over a range of 5-100 Hz…"
- "4. Calculate the equivalent PLSL or PC levels at the reference distance of 1 km …"
- "Add 15 dB to the results of step (4)"

Audio clarification: the distance cited is 1 km rather than 1 meter

1995

Sources and effects of low-frequency noise

Birgitta Berglund[a)] and Peter Hassmén
Institute of Environmental Medicine, Karolinska Institute and Department of Psychology, Stockholm University, Stockholm, Sweden

VIII. RECOMMENDATIONS

A. Research needs

Further research is needed in relation to a number of features and outcomes of low-frequency noise. These needs include the following.

(1) In general, there has been too little research on the role of different frequency spectra of noise in the production of effects on humans. Greater consideration of this factor in many studies of noise is desirable.

(2) Most of the research of adverse effects of low-frequency noise in humans has used short durations of exposure. It is of great importance to research prolonged expo-

J. Acoust. Soc. Am. **99** (5), May 1996

2000 WHO on low frequency noise in general

- "Health effects due to low-frequency components in noise are estimated to be more severe than for community noises in general"
  - World Health Organization, Guidelines for Community Noise, 2000 http://www.euro.who.int/mediacentre/PR/2009/20091008_1

2004 Low frequency noise exposure in general

- "… chronic psychophysiological damage may result from long-term exposure to low-level low frequency noise."

- 'The claim that their "lives have been ruined" by the noise is not an exaggeration…'

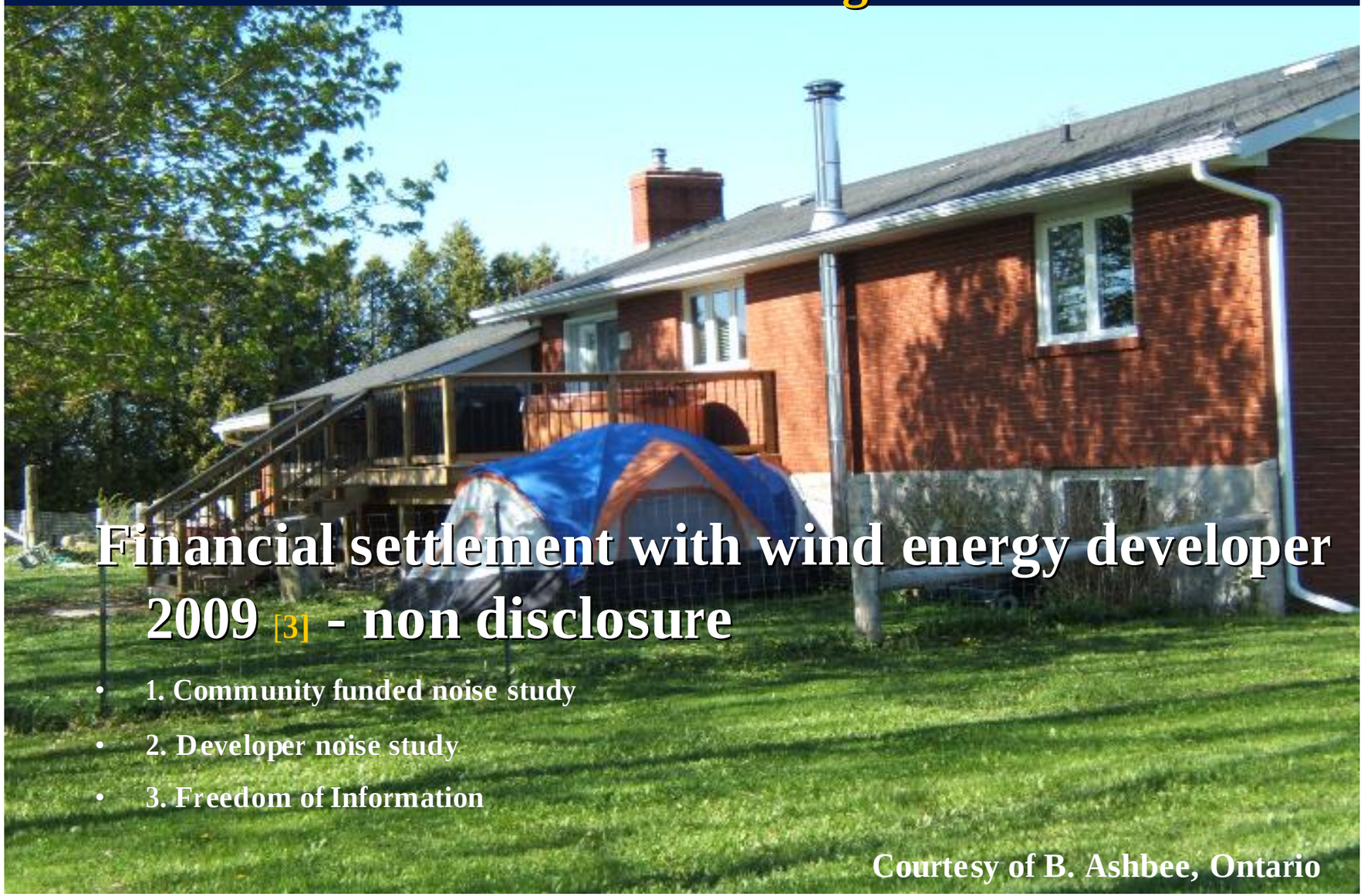
  - Leventhall HG. Low frequency noise and annoyance. Noise Health [serial online] 2004 [cited 2009 Dec 31];6:59-72. Available from: http://www.noiseandhealth.org/text.asp?2004/6/23/59/31663

2004 Low frequency noise annoyance

- ‘Those exposed may adopt protective strategies, such as sleeping in their garage if the noise is less disturbing there. Or they may sleep elsewhere, returning to their own homes only during the day.’

  - Leventhall HG. Low frequency noise and annoyance. Noise Health [serial online] 2004 [cited 2009 Dec 31];6:59-72. Available from: http://www.noiseandhealth.org/text.asp?2004/6/23/59/31663

2009 Escaping wind turbine LFN [1, 2, 3] – 5 shut down at night



Financial settlement with wind energy developer 2009 [3] - non disclosure

- 1. Community funded noise study
- 2. Developer noise study
- 3. Freedom of Information

Courtesy of B. Ashbee, Ontario

2007 National Research Council

The National Research Council:

- "Low-frequency vibration and its effects on humans are not well understood. Sensitivity to such vibration resulting from wind-turbine noise is highly variable among humans…. studies on human sensitivity to very low frequencies are recommended."

  - National Research Council (NRC). Environmental Impacts of Wind-Energy Projects, 2007 NRC, Washington, DC

2007 Wind turbine noise characteristics

- ‘Sound generated by wind turbines has particular characteristics and it creates a different type of nuisance compared to usual urban, industrial, or commercial noise.’

  - Soysai, H., and O. Soysai. Wind farm noise and regulations in the eastern United States. 2007. Proceedings of the Second International Meeting on Wind Turbine Noise. Lyon, France: September 20-21, 2007. INCE/Europe.

2008 Wind turbine noise is more annoying

- '…wind turbine sound is relatively annoying, more so than equally loud sound from aircraft or road traffic.'

- '…and (more) sound mitigation measures must be considered.'

  - Pedersen et al., 2008,Project WINDFARMperception Visual and acoustic impact of wind turbine farms on residents Netherlands

2010 to 2014 Inner ear research

- 2010 “In this review, we consider possible ways that low frequency sounds, at levels that may or may not be heard, could influence the function of the ear.” [1]
- 2011 “Based on our current knowledge of how the ear works, it is quite possible that low-frequency sounds at the levels generated by wind turbines could affect those living nearby.” [2]
- 2012 “… we have to be concerned that sounds that are not perceived are clearly transduced by the ear and may still affect people in ways that have yet to be fully understood.” [3]
- 2014 “Based on well-established principles of the physiology of the ear and how it responds to very low-frequency sounds, there is ample justification to take this problem more seriously than it has been to date.” [4]

2010 to 2014 Inner ear research references

1. Salt, Alec N. and Hullar, T.E. Responses of the ear to low frequency sounds, infrasound and wind turbines. Department of Otolaryngology, Washington University School of Medicine, St. Louis, MO, 63110, USA. Hearing Research 2010 Sep 1; 268(1-2):12-21. Epub 2010 Jun 16

2. Salt, Alec N. and Kaltenbach, James A. Infrasound From Wind Turbines Could Affect Humans Bulletin of Science Technology & Society 2011 31: 296, DOI: 10.1177/0270467611412555 http://bst.sagepub.com/content/31/4/296

3. Salt, Alec N. and Lichtenhan, Jeffery T. Perception-based protection from low-frequency sounds may not be enough Invited paper presented at Inter-noise 2012, New York City, NY4.

4. Salt AN and Lichtenhan JT, How Does Wind Turbine Noise Affect People? Acoustics Today. A publication of the Acoustical Society of America. Volume 10: Issue One: Winter 2014

Acknowledgements

2012 - 2014

2012 Wisconsin: Brown County Board of Health



HEALTH DEPARTMENT

Brown County

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JUDY FRIEDERICHS, R.N., B.S.
DIRECTO

THEREFORE, BE IT RESOLVED that the Brown County Board of Health formally requests temporary emergency financial relocation assistance from the State of Wisconsin for those Brown County families that are suffering adverse health effects and undue hardships caused by the irresponsible placement of industrial wind turbines around their homes and property. The State of Wisconsin emergency financial assistance is requested until the conditions that have caused these undue hardships are studied and resolved, allowing these families to once again return safely to their homes and property.

Audrey S. Murphy, BSN
Chairman
Brown County Board of Health

Jay J. Tibbetts, MD
Vice-Chairman
Brown County Board of Health

2012

A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin

Prepared Cooperatively By:

Channel Islands Acoustics, Camarillo, CA
Principal: Dr. Bruce Walker

Hessler Associates, Inc., Haymarket, VA
Principals: George F. and David M. Hessler

Rand Acoustics, Brunswick, ME
Principal: Robert Rand

Schomer and Associates, Inc., Champaign, IL
Principal: Dr. Paul Schomer

Report Number 122412-1
Issued: December 24, 2012

2012

A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin

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

2012

Falmouth Health Department

The Falmouth Board of Health requests that **Mass DPH immediately initiate a health assessment of the impacts of the operation of wind turbines in Falmouth.** This appeal is compelled by two years of consistent and persistent complaints of health impacts during turbine operation.

Due to the increasing intensity of the reported health impacts, the Board is considering emergency actions. To determine the appropriateness of such actions, the Board requests immediate guidance on interim measures to protect the health of affected individuals while the complete health assessment is being conducted.

FALMOUTH, MASSACHUSETTS June 11, 2012

2013

TOWN OF FALMOUTH

vs.

TOWN OF FALMOUTH ZONING BOARD OF APPEALS & others[1]

ORDER

By order of the court, preliminary injunction shall issue until further order of the court.

1. The Town of Falmouth, its Selectmen, agents and persons acting in concert shall be restrained from operating the Wind Turbines located at the Waste Water Treatment Facility except during the hours of 7am to 7pm, every day of the week except Sunday. This schedule shall commence on November 22, 2013. Additionally, the same parties shall be restrained from operating said turbines in any fashion on the following limited dates: November 27, 2013; December 25, 2013; and January 1, 2014.

SUPERIOR COURT
CIVIL ACTION
NO. BACV2013-00281

Dated: November 21, 2013

Judicial processes in other venues

- 2012 Supreme Court Bavaria Germany:
  - 3 dB addition for pulsed noise for the E82 and compensation
- 2012 High Court UK:
  - Viewscape/landscape
- 2013 Supreme Court Portugal *
  - Removal of 4 turbines and compensation

** by Google Translate which may not reflect exact wording*

Children and vulnerability to noise

WHO: vulnerable groups

- "VULNERABLE GROUPS OF CHILDREN
  - The fetus and babies
  - Preterm, low birth weight and small for gestational age babies
  - Children with dyslexia and hyperactivity
  - Children on ototoxic medication"

    - World Health Organization, Children and Noise, Children's Health and the Environment, WHO Training Package for the Health Sector, www.who.int/ceh

Children: direct and indirect effects

- Direct:
  - ear damage

- Indirect (physiological and psychological effects)
  - impaired cognition
  - stress-related somatic effects (stress hormone, blood pressure and muscle spasm)
  - psychological effects
    - annoyance / isolation
    - sleep disturbance and mental health issues
    - cognitive effects - reading, concentration, memory and attention issues, (reading comprehension and long term memory)
    - Academic performance affects

      - World Health Organization, Children and Noise, Children's Health and the Environment, WHO Training Package for the Health Sector, www.who.int/ceh

Pre-existing medical conditions

- Autism [1,2,3]
- Asthma [4,5]
- Migraine [6,7]
- Bronchitis [8]
- Epilepsy [9,10]
- Childhood asthma [11] and migraine [12] can be triggered by stress

Pre-existing medical conditions references

- [1] Cristina Becchio, Morena Mari, Umberto Castiello, (2010). Perception of Shadows in Children with Autism Spectrum Disorders PLoS ONE | May 2010 | Volume 5 | Issue 5 | e10582. Retrieved from www.plosone.org
- [2] Catherine Purple Cherry and Lauren Underwood. The ideal home for the autistic child: physiological rationale for design strategies. Autism Science Digest: The Journal Of Autismone, Issue 03 Retrieved from www.purplecherry.com.
- [3] Flavia Cortesi, Flavia Giannotti, Anna Ivanenko, Kyle Johnson (2010). Sleep in children with autistic spectrum disorder, Sleep Medicine 11 (2010) 659–664 Retrieved from www.elsevier.com/locate/sleep
- [4] Hartmut Ising, Martin Ising (2002), Chronic cortisol increases in the first half of the night caused by road traffic noise. Noise and Health 2002,4:16:p13-21 Retrieved from http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2002;volume=4;issue=16;spage=13;epage=21;aulast=Ising
- [5] Bockelbrink A, Willich SN, Dirzus I, Reich A, Lau S, Wahn U, Keil T. (2008) Environmental noise and asthma in children: sex specific differences J Asthma. 2008 Nov;45(9):770-3. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18972293
- [6] Neut D, Fily A, Cuvellier JC, Vallée L (2011),. The prevalence of triggers in paediatric migraine: a questionnaire study in 102 children and adolescents. J Headache Pain. 2011 Nov 1. [Epub ahead of print] Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22042255
- [7] Doreen Wagner, Velitchko Manahilov, Gunter Loffler, Gael E. Gordon, and Gordon N. Dutton, Visual Noise Selectively Degrades Vision in Migraine Investigative Ophthalmology & Visual Science, April 2010, Vol. 51, No. 4 Retrieved from http://www.iovs.org/content/51/4/2294.full.pdf
- [8] Ising H, Lange-Asschenfeldt H, Moriske HJ, Born J, Eilts M., Low frequency noise and stress: bronchitis and cortisol in children, Noise Health. 2004 Apr-Jun;6(23):21-8
- [9] Gilboa T.Epilepsia. 2011 Dec 9. Emotional stress-induced seizures: Another reflex epilepsy? doi: 10.1111/j.1528-1167.2011.03342.x. [Epub ahead of print] Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22150553
- [10] Epilepsy Facts - Epilepsy Canada Cited March 2012, Retrieved from www. epilepsy@epilepsy.ca
- [11] Hartmut Ising, Martin Ising (2002), Chronic cortisol increases in the first half of the night caused by road traffic noise. Noise and Health 2002,4:16:p13-21 Retrieved from http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2002;volume=4;issue=16;spage=13;epage=21;aulast=Ising
- [12] Neut D, Fily A, Cuvellier JC, Vallée L. The prevalence of triggers in paediatric migraine: a questionnaire study in 102 children and adolescents. J Headache Pain. 2011 Nov 1. [Epub ahead of print] http://www.ncbi.nlm.nih.gov/pubmed/22042255

2003 Children and possible irreversible negative consequences

- "It is likely that children represent a group which is particularly vulnerable to the non-auditory health effects of noise.

- "… there is a possible risk that exposure to an environmental stressor such as noise may have irreversible negative consequences for this group…"

  - Stephen A Stansfeld and Mark P Matheson (2003), Noise pollution: non-auditory effects on health, British Medical Bulletin 2003; 68: 243–257 DOI: 10.1093/bmb/ldg033 Retrieved from http://bmb.oxfordjournals.org/content/68/1/243.full.pdf

2009 Children & learning

- "The American National Standards Institute emphasizes that school buildings' sound isolation should prevent two types of noise: … outside of the school building … within the school building such as unwanted speech."

  - Robert Ljung, Patrik Sorqvist and Staffan Hygge (2009) Effects of road traffic noise and irrelevant speech on children's reading and mathematical performance. Noise and Health, Oct-Dec 2009 http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2009;volume=11;issue=45;spage=194;epage=198;aulast=Ljung

2010

Review article

Long-term sleep disturbances in children: A cause of neuronal loss

- "Animal experiments unequivocally show that sleep loss even for three or four days can adversely and permanently affect neurophysiological functions and neurogenesis."

- "This review summarises the increasing evidence … that chronic disturbances of sleep adversely affect brain development … Pediatric neurologists, the scientific community and the public must be aware of these recent scientific developments. Further studies are urgently required."

James E. Jan [a,b,*], Russ J. Reiter [c], Martin C.O. Bax [d], Urs Ribary [e], Roger D. Freeman [f,g], Michael B. Wasdell [h]

EUROPEAN JOURNAL OF PAEDIATRIC NEUROLOGY 14 (2010) 380–390

2012 WHO: short- and long-term health problems

- **“Facts and figures**
  - Noise is an underestimated threat that can cause a number of short- and long-term health problems, such as for example sleep disturbance, cardiovascular effects, poorer work and school performance, hearing impairment, etc.”
    - World Health Organization Noise Facts and Figures, Sited December 23, 2012, http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/noise/facts-and-figures cited dec 23 2012

Low frequency noise guidelines

2009 Low frequency noise guidelines

From: Minister, MOE (ENE)
Sent: July 13, 2009 3:56 PM

It is proposed that wind turbines would not be permitted less than 550 metres from the nearest dwelling and this minimum setback would increase with the number and loudness of turbines. It is also proposed that there would be setback distances from all roads, railways, and property side and rear lot lines, and there would be ongoing requirements to monitor and address low frequency noise and vibrations.

Sincerely,

John Gerretsen
Minister

2009 LFN / infrasound guidelines

- "…CanWEA submits that the proposed requirement for infrasound or low frequency noise monitoring as a condition of the REA be removed."

  - CanWEA EBR Posting 010-6516 (Proposed Ministry of the Environment Regulations to Implement the Green Energy and Green Economy Act. 2009) – CanWEA's Supplemental Submission Dated July 24, 2009, EBR Comment ID 123788. Signed Robert Hornung President.

2011 LFN / infrasound guidelines

Vestas

In fact, according to our analyses, the most economical turbines, the 3 MW category, are the ones that will be strongly affected by the new rules. This applies to open terrain in particular, where in future low frequency noise will dictate and increase the distance requirements to neighbours for close to half of the projects that we are already aware of over the next 2 to 3 years.

The proposed low frequency limit values may hinder the development of onshore wind in Denmark, including meeting our commitments in relation to the EEC. Ultimately, we consider there is a danger that the regulations will be copied by other countries and accordingly this will provide an obstacle to the popularisation of wind energy at a global level. Both issues will damage Vestas as a business, including affecting Danish activities.

Vestas Wind systems A/S

[Signature]
Ditlev Engel
Chief Executive Officer

Date
Randers, 29 June 2011/erkjs



Wrap up

2009 Health effect "Conclusively demonstrated"

"Health Canada provides advice on the health effect of noise and low-frequency electric and magnetic fields from proposed wind turbine projects, particularly for environmental assessments done under the Canadian Environmental Assessment Act. To date, their examination of the scientific literature on wind turbine noise is that the only health effect conclusively demonstrated from exposure to wind turbine noise is an increase of self-reported general annoyance and complaints (i.e., headaches, nausea, tinnitus, vertigo)." [48]



Honourable Rona Ambrose, P.C., M.P.
L'honorable Rona Ambrose, C.P., députée

JUL 30 2009

Health Canada provides advice on the health effects of noise and low-frequency electric and magnetic fields from proposed wind turbine projects, particularly for environmental assessments done under the Canadian Environmental Assessment Act. To date, their examination of the scientific literature on wind turbine noise and health is that the only health effect conclusively demonstrated from exposure to wind turbine noise is an increase in self-reported general annoyance and complaints (i.e., headaches, nausea, tinnitus, vertigo).

Correspondence from the Honourable Rona Ambrose, June 30, 2009

2010 ON Freedom of Information - 30 to 32 dBA recommended



April 9, 2010

MEMORANDUM

FROM:

Re:

- "… the setback distances should be calculated using a sound level limit of **30 to 32 dBA** at the receptor, instead of the 40 dBA sound level limit."

  - MOE memorandum, Ontario Senior Environmental Officer, April 9, 2010

2010 MOE Freedom of Information on setback / noise



Ministry of the Environment
Guelph District Office

Ministère de l'Environnement

Ontario

April 9, 2010

MEMORANDUM

TO: Jane Glassco, District Manager, Guelph District Office — and — Dave Bray, Supervisor, Guelph District Office

FROM: Cameron Hall, Senior Environmental Officer, Guelph District Office

Re: Comments - March 1, 2010 draft document, "Renewable Energy Approvals Technical Bulletin Six Required Setbacks for Wind Turbines"

- "It appears compliance with the minimum setbacks and the noise study approach currently being used to approve the siting of WTGs **will result or likely result in adverse effects**…"

  - MOE memorandum, Ontario Senior Environmental Officer, April 9, 2010

2010 Setbacks and noise levels expected to adversely affect some



- "The audible sound from wind turbines, at the levels experienced at typical receptor distances in Ontario, is nonetheless **expected to result in a non-trivial percentage of persons being highly annoyed.** As with sounds from many sources, research has shown that **annoyance associated with sound from wind turbines can be expected to contribute to stress related health impacts** in some persons."

  - Low frequency Noise and Infrasound Associated with Wind Turbine Generation Systems, A Literature Review, Ontario Ministry of Environment RFP December 10, 2010 [MOE consultant report]

2011 Environmental Review Tribunal



- "This case has successfully shown that the debate should not be simplified to one about whether wind turbines **can cause harm** to humans. The evidence presented to the Tribunal demonstrates that **they can**, if facilities are placed too close to residents. The debate has now evolved to one of degree."

  - Case Nos.: 10-121/10-122 Erickson v. Director, Ministry of the Environment Environmental Review Tribunal, Decision, p 207

2013 Health Canada wind turbine noise study

Dr. Michaud acknowledged that there is credible scientific support for an association between wind turbine noise and community annoyance. He explained that the study will help to build the evidence base to determine the link between noise created by wind turbines, including infrasound and low frequency, and variables like sleep disturbance, stress, quality of life and annoyance.

Dr. David Michaud, meeting with MP Poilieve June 2013 newsletter

2012 – 2014 Reported wind turbine health effects

- Austrian Medical Association Issues Warning, Calls for Comprehensive Studies on Wind Turbine Noise and minimum safety distances to populated areas. April 30 2014 http://waubrafoundation.org.au/2014/austrian-medical-association-issues-warning-calls-for-comprehensive-studies-wind-turbine-noise/

- Roy D. Jeffery, Carmen M.E. Krogh, and Brett Horner, Industrial wind turbines and adverse health effects Can J Rural Med 2014;19(1) http://www.cma.ca/multimedia/staticContent/HTML/N0/l2/cjrm/vol-19/issue-1/pdf/pg21.pdf

- Enbom H and Enbom IM, Infrasound from wind turbines: An overlooked health hazard," Läkartidningen, vol. 110 (2013), pp. 1388-89.

- Roy D. Jeffery, Carmen Krogh, and Brett Horner, Adverse health effects of industrial wind turbines Can Fam Physician 2013; 59: 473-475 (Commentary) http://www.cfp.ca/content/59/5/473.full

- Roy D. Jeffery MD FCFP, Carmen Krogh, Brett Horner CMA, Adverse health effects of industrial wind turbines, Letter to editor, Vol 59: September • septembre 2013, Canadian Family Physician • Le Médecin de famille canadien

- Hanning, Christopher D. and Evans, Alun Editorial: Wind turbine noise British Medical Journal, BM J2 012;344 doi: 10.1136/ bmj.e1527 (8 March 2012)www.bmj.com

- Nissenbaum, Michael A.; Aramini, Jeffery J.; and Hanning, Christopher D. Effects of industrial wind turbine noise on sleep and health Noise & Health, September-October 2012, Volume 14, p243 www.noiseandhealth.org

1999 WHO precaution in general

- "…where there is a reasonable possibility that public health will be damaged, action should be taken to protect public health without awaiting full scientific proof."

  - World Health Organization, Guidelines for Community Noise, WHO (1999). http://www.who.int/docstore/peh/noise/guidelines2.html

Children: precaution

- Policy Interpretation Network on Children's Health and Environment:
  - "Policies that may protect children's health or may minimise irreversible health effects should be implemented, and policies or measures should be applied based on the precautionary principle, in accordance with the Declaration of the WHO Fourth Ministerial Conference on Environment and Health in Budapest in 2004."
    - Report WP7 Summary PINCHE policy recommendations Policy Interpretation Network on Children's Health and Environment (PINCHE) Policy Interpretation Network on Children's Health and Environment QLK4-2002-02395

Observations

- Government lack of acknowledgement of health issues
- Burden of proof of causality before prevention and precaution
- Reported loss of trust in the processes/systems
- Loss of decision-making rights (imposed without consent)
- Characterizations: “NIMBYISM” [not in my backyard]; “anti-wind”, “anti-wind activist”; “opponent”; and attributing negative effects based on fright factors/lack of financial agreements/*nocebo* effect.
- Community / individual financial burdens: consultation and appeal processes; relocate; remain exposed; enter into legal actions

Conclusion

- Acknowledge that:
  - Experimental and human research on noise including low frequency noise/infrasound and risk factors are available.
  - If sited too close to residences, wind turbines can cause harm to humans.
  - Children are vulnerable to effects of noise.
- Invoke prevention and precaution before approving more projects.
- Provide relief/remedy to those reporting harm.
- Implement vigilance and long term surveillance monitoring.

For more information

carmen.krogh@gmail.com

Cell: 613 312 9663

WIND TURBINE NOISE, SLEEP AND HEALTH

Dr Christopher Hanning. BSc, MB, BS, MRCS, LRCP, FRCA, MD

November 2010

This paper is based on proofs of evidence produced for several UK Planning Inquiries. As such, it concentrates on the regulatory system in the UK. Other jurisdictions will have different systems.

The aim is to inform those seeking to regulate the siting of wind turbines close to human habitation.

The contents may be used freely without acknowledgement.

The paper will be updated from time to time so please check that you have the latest version from the Society for Wind Vigilance website: www.windvigilance.com

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    2.3 Psychological factors and noise sensitivity

3. Wind turbine noise, sleep and health
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Summary

Section 1 sets out my expertise in sleep medicine and physiology, my brief from CFA, the scope of the report and source material.

Section 2 reviews the basic physiology of sleep. Noise can disturb sleep by causing awakenings, which are remembered and arousals, which are not recalled but are more likely. Both disrupt sleep making it unrefreshing. Research on the effects of wind turbine noise has concentrated on remembered awakenings and has thus underestimated the effects.

Inadequate or poor quality sleep has many health consequences apart from daytime sleepiness and fatigue. These include obesity, poor memory, increased risk of diabetes, heart disease and high blood pressure. Vulnerable groups such as children and the elderly may be at greater risk.

Section 3 reviews research on wind turbine noise, sleep disturbance and health. These include the major contributions of van den Berg and Pedersen and the dose-response relationship derived from their data. Also considered are the Salford study and the Hayes McKenzie Partnership study commissioned by the DTI.

Recent major reports by WHO and RIVM are reviewed, both of which mandate lower night time noise levels than are permitted by ETSU-R-97. Predicted external turbine noise should not exceed 35dB to avoid disturbance to sleep and 40dB to avoid risks to health. Experience of existing wind farms mandates a setback of at least 1.5km in order to avoid disturbance to sleep.

It is concluded that there is compelling evidence that wind turbine noise can and does disturb sleep and impair the health of those living too close and that current guidance is inadequate protection.

Section 4 reviews the means of mitigating wind turbine noise to prevent sleep disturbance. It is concluded that external turbine noise levels of less than 35dB(A) or a setback of at least 1.5km of the turbines is necessary to prevent unacceptable levels of sleep disturbance and potential risk to health.

Section 5 reviews UK planning guidance and argues that the evidence presented constitute material considerations

Section 6 presents the conclusions of the report.

Section 7 lists the documents cited in support of this paper.

Figure 1. Sound level and annoyance for different noise sources
Figure 2. Sound level and annoyance for different noise sources
Figure 3. Noise levels and proportion of respondents disturbed in the sleep
Figure 4. Sound level and probability of stable sleep

Table 1. Response to wind turbine noise outdoors or indoors
Table 2. Recommendations for setback from industrial wind turbines

1. Introduction

1.1 The author

1.1.1. My name is Dr Christopher Hanning, Honorary Consultant in Sleep Disorders Medicine to the University Hospitals of Leicester NHS Trust, based at Leicester General Hospital, having retired in September 2007 as Consultant in Sleep Disorders Medicine. In 1969, I obtained a First class Honours BSc in Physiology and, in 1972, qualified in medicine, MB, BS, MRCS, LRCP from St Bartholomew's Hospital Medical School. After initial training in anaesthesia, I became a Fellow of the Royal College of Anaesthetists by examination in 1976 and was awarded a doctorate from the University of Leicester in 1996. I was appointed Senior Lecturer in Anaesthesia and Honorary Consultant Anaesthetist to Leicester General Hospital in 1981. In 1996, I was appointed Consultant Anaesthetist with a special interest in Sleep Medicine to Leicester General Hospital and Honorary Senior Lecturer to the University of Leicester.

1.1.2. My interest in sleep and its disorders began over 30 years ago and has grown ever since. I founded and ran the Leicester Sleep Disorders Service, one of the longest standing and largest services in the country, until retirement. The University Hospitals of Leicester NHS Trust named the Sleep Laboratory after me as a mark of its esteem. I was a founder member and President of the British Sleep Society and its honorary secretary for four years and have written and lectured extensively on sleep and its disorders and continue to be involved in research. My expertise in this field has been accepted by the civil, criminal and family courts. I chaired the Advisory panel of the SOMNIA study, a major project investigating sleep quality in the elderly, and sit on Advisory panels for several companies with interests in sleep medicine. I am an Associate Member of the General Medical Council, chairing Investigation Committee hearings and Registration Panels. In 2010, I was invited to join the Board of the Society for Wind Vigilance.

1.2. Scope of report.

1.2.1. This report centres on the effects of industrial wind turbine noise on sleep and consequent effects on health as this is the particular area of expertise of the author.

1.3. Source material

1.3.1. A full list of the publications cited and other source material is given in Section 7 and are cited in the text. Material was obtained by searching the Web of Science database using the search terms “Noise”, “Sleep” and “Wind turbine”, internet searches using the same words and scrutiny of the reference lists of published articles and reviews. Where several articles come to the same conclusion, only the most recent may be cited, in the interests of brevity. As far as possible, articles published in peer reviewed journals are cited. However, it is inevitable that some of the material is available only on the internet reflecting the paucity of government sponsored research, particularly in the UK.

2. Background

2.1. Introduction

2.1.1. There can be no reasonable doubt that industrial wind turbines whether singly or in groups ("wind farms") generate sufficient noise to disturb the sleep and impair the health of those living nearby and this is now widely accepted. In reviewing potential health impacts of sustainable energy sources, three leading members of the National Institute of Environmental Health Sciences, part of the US National Institutes of Health, state: *"Wind energy will undoubtedly create noise, which increases stress, which in turn increases the risk of cardiovascular disease and cancer."* (Gohlke et al. 2008. Section 5.1.1 of the draft New Zealand standard on wind farm noise, 2009, states: *"Limits for wind farm noise are required to provide protection against sleep disturbance and maintain reasonable residential amenity."* ETSU-R-97, the UK guidance on wind turbine noise, is predicated in part on the WHO guidelines available at the time and so was intended to avoid sleep disturbance. As will be demonstrated, the ETSU-R-97 night time limits were set too high to prevent sleep disturbance. Reports from many different locations and different countries have a common set of symptoms and have been documented by Frey and Hadden (2007). New cases are documented regularly on the Internet. The symptoms include sleep disturbance, fatigue, headaches, dizziness, nausea, changes in mood and inability to concentrate and have been named "wind turbine syndrome" by Dr Nina Pierpont (2006). The experiences of the Davis (2008) and Rashleigh (2008) families from Lincolnshire whose homes were around 900m from wind turbines make salutary reading. The noise, sleep disturbance and ill health eventually drove them from their homes. Similar stories have been reported from around the world, usually in anecdotal form but in considerable numbers.

2.1.2 The WHO Environmental Burden of Disease – European countries project (EBoDE) (WHO, 2009a) selected nine environmental stressors for study, including noise (S6). *"The health effects of environmental noise were selected to cover psychosocial (sleep disturbance), cardiovascular effects*

(elevated blood pressure, IHD including myocardial infarction) and learning performance." These choices emphasise the importance that WHO place upon the effects of environmental noise on sleep disturbance.

2.1.3. One New York based wind turbine developer is reported as offering future neighbours of wind turbines payments of $5,000 in exchange for a waiver promising not to complain about excessive noise of the turbines once the turbines become operational (Yardley, 2010) which may be interpreted as tacit acceptance by at least one developer that noise complaints are highly likely.

2.2. Sleep, sleep physiology and the effects of noise

2.2.1. Sleep is a universal phenomenon. Every living organism contains, within its DNA, genes for a body clock which regulates an activity-inactivity cycle. In mammals, including humans, this is expressed as one or more sleep periods per 24 hours. Sleep was previously thought to be a period of withdrawal from the world designed to allow the body to recuperate and repair itself. However, modern research has shown that sleep is primarily by the brain and for the brain. The major purpose of sleep seems to be the proper laying down and storage of memories, hence the need for adequate sleep in children to facilitate learning and the poor memory and cognitive function in adults with impaired sleep from whatever cause.

2.2.2. Inadequate sleep has been associated not just with fatigue, sleepiness and cognitive impairment but also with an increased risk of obesity, impaired glucose tolerance (risk of diabetes), high blood pressure, heart disease, cancer, depression and impaired immunity as shown by susceptibility to the common cold virus. Sleepy people have an increased risk of road traffic accidents. Sleepiness, as a symptom, has as much impact on health as epilepsy and arthritis. It is not insignificant.

2.2.3 Humans have two types of sleep, slow wave (SWS) and rapid eye movement (REM). SWS is the deep sleep which occurs early in the night while REM or

dreaming sleep occurs mostly in the second half of the night. Sleep is arranged in a succession of cycles, each lasting about 90 minutes. We commonly wake between cycles, particularly between the second and third, third and fourth and fourth and fifth cycles. Awakenings are not remembered if they are less than 30 seconds in duration. As we age, awakenings become more likely and longer so we start to remember them.

Even while deeply asleep, the brain is processing sounds and deciding whether they merit awakening either because the sound has meaning or constitutes a threat. For example, at the same noise level, awakening is more likely when one's name is called rather than a non-specific noise. Similarly, a mother will wake when her baby cries but not for a passing car.

2.2.4. Noise interferes with sleep in several ways. Firstly, it may be sufficiently audible and annoying to prevent the onset of sleep or the return to sleep following an awakening. It is clear also that some types of noise are more annoying than others. Constant noise is less annoying than irregular noise which varies in frequency and loudness, for example, snoring, particularly if accompanied by the snorts of sleep apnoea (breath holding). The swishing or thumping impulsive noise associated with wind turbines seems to be particularly annoying as the frequency and loudness varies with changes in wind speed and local atmospheric conditions and the character of the noise may be perceived as threatening. While there is no doubt of the occurrence of these noises and their audibility over long distances, up to 3-4km in some reports, the actual cause has not yet been fully elucidated (Bowdler 2008). Despite recommendations by the Government's own Noise Working Group, government sponsored research in this area has been stopped. Stigwood (2008), an independent noise consultant, has demonstrated that this noise pattern is common with large turbines.

2.2.5. Secondly, noise experienced during sleep may arouse or awaken the sleeper. A sufficiently loud or prolonged noise will result in full awakening which may be long enough to recall. Short awakenings are not recalled as, during the transition from sleep to wakefulness, one of the last functions to

recover is memory (strictly, the transfer of information from short term to long term memory). The reverse is true for the transition from wakefulness to sleep. Thus only awakenings of longer than 20-30 seconds are subsequently recalled. Research that relies on recalled awakenings alone will therefore underestimate the effect.

2.2.6. Noise insufficient to cause awakening may cause an arousal. An arousal is brief, often only a few seconds long, with the sleeper moving from a deep level of sleep to a lighter level and back to a deeper level. Because full wakefulness is not reached, the sleeper has no memory of the event but the sleep has been disrupted just as effectively as if wakefulness had occurred. It is possible for several hundred arousals to occur each night without the sufferer being able to recall any of them. The sleep, because it is broken, is unrefreshing resulting in sleepiness, fatigue, headaches and poor memory and concentration (Martin 1997), many of the symptoms of “wind turbine syndrome”. Recent research (Dang-Vu, 2010) has shown that some subjects are more easily aroused than others.

Arousals are associated not just with an increase in brain activity but also with physiological changes, an increase in heart rate and blood pressure, which are thought to be responsible for the increase in cardiovascular risk. A clear relationship between high blood pressure and aircraft noise exposure has been shown by the HYENA consortium (Haralabidis 2008, Jarup 2008) and between traffic noise and high blood pressure for adults (Barregard 2009) and, worryingly, for preschool children (Belojevic 2008). The MESA study has suggested a link between exposure to traffic and alterations in heart function (Van Hee 2009) and Selander and colleagues (2009) have suggested a link with myocardial infarction (heart attack) but neither could separate noise effects from pollution. Arousals occur naturally during sleep and increase with age (Boselli 1998), as do awakenings which may make the elderly more vulnerable to wind turbine noise. Arousals may be caused by sound events as low as 32 dB(A) and awakenings with events of 42dB(A) (Muzet and Miedema 2005). The studies of Dang-Vu and colleagues (2010) suggest that arousals may occur at even lower sound levels in susceptible

individuals (Fig 4). Arousals in SWS may trigger a parasomnia (sleep walking, night terrors etc.). Pierpont (2009) notes that parasomnias developed in some of the children exposed to turbine noise in her study group.

2.2.7. Arousals are caused by aircraft, railway and traffic noise. In one study of aircraft noise, arousals were four times more likely to result than awakenings (Basner 2008a) and resulted in daytime sleepiness (Basner 2008b). Freight trains are more likely to cause arousals than passenger trains, presumably because they are slower, generating more low frequency noise and taking longer to pass (Saremi 2008). The noise of wind turbines has been likened to a “passing train that never passes” which may explain why wind turbine noise is prone to cause sleep disruption. A recent study of over 18000 subjects has shown a link between exposure to traffic noise and “the risk of getting up tired and not rested in the morning (de Kluizenaar, 2009). This study, together with that of Basner (2008b) confirms that excessive noise disturbs sleep sufficiently to impair its restorative properties and adds credence to the anecdotal reports of those living near wind turbines.

2.2.8. Studies of different alarm signals have shown that arousals and awakenings occur at lower sound levels with low frequency sounds than those of higher frequency (Bruck 2009). Repeated short beeps of 400-520Hz were most intrusive, leading to arousal and awakening. Wind turbine noise often has a considerable low frequency component and has an impulsive nature which may, in part, explain its adverse effect on sleep.

2.2.9. It is often claimed that continual exposure to a noise results in habituation, i.e. one gets used to the noise. There is no research to confirm this assertion although it has been suggested that the absence of noise for those usually subjected to high levels may cause insomnia (HPA 2009 5.29). A recent small study (Pirrera et al. 2009) looking at the effects of traffic noise on sleep efficiency suggests that habituation does not occur. Griefahn and colleagues (2008) have shown that the increases in heart rate with traffic noise induced arousals show no habituation.

2.2.10. Sleep disturbance and impairment of the ability to return to sleep is not trivial as almost all of us can testify. The elderly may be more vulnerable, not just because they have more spontaneous awakenings than the young but because their high frequency hearing loss may remove some of the masking of the lower frequency noise characteristic of wind turbines. In the short term, the resulting deprivation of sleep results in daytime fatigue and sleepiness, poor concentration and memory function. Accident risks increase. In the longer term, sleep deprivation is linked to depression, weight gain, diabetes, high blood pressure and heart disease. There is a very large body of literature but please see Meerlo et al., 2008 for recent work on this subject as well as the 2009 WHO/EU Night Noise Guidelines for Europe (WHO, 2009) and the recent reports of the Health Protection Agency (HPA 2009) and DEFRA (Berry and Flindell, 2009).

2.2.11. Sleep spindles are short bursts of high frequency oscillation seen in the brain's electrical activity (electroencephalogram, EEG) during SWS and are a marker of sleep stability. Recent research has shown that subjects with a higher spindle rate are less likely to show an arousal in response to a transient noise than a subject with a lesser rate and are less likely to report that noise disturbs their sleep (Dang-Vu et al., 2010). The spindle rate decreases with age, explaining the vulnerability of the elderly to noise induced sleep disruption. Insomniacs, when asleep, do not have necessarily have reduced spindle counts, thus suggesting that sensitivity to noise while asleep is not purely psychological but has a physical basis thus confirming the finding that noise sensitivity is, to a large degree, inherited.

A plot of sound level against the probability of stable sleep is presented (Figure 4). This is effectively an inverted dose-response curve of log sound pressure against the likelihood of an arousal. The study only examined noise stimuli of 40-70dB(A). However, it is reasonable to extrapolate backwards to lower noise levels. For subjects with a low spindle rate, even at a stimulus level of 35dB(A) there is an approximate 50% probability of an arousal and a 30% probability at 30dB(A). The subjects were 26.3 (± 7.5)

years of age. Older subjects would be expected to have even fewer spindles and to be even more sensitive to noise.

2.3. Psychological factors and Noise sensitivity

2.3.1. There is considerable interaction between the psychological response to noise and sleep disturbance, each worsening the other. It is well recognised that psychological factors and personality traits influence the response to noise. Approximately 15% of the population are noise sensitive and have both a lowered annoyance level and an enhanced cortisol response, a physiological marker of stress. Noise sensitivity is considered to be a stable, partly heritable, personality trait; the noise sensitive being at one end of a continuum with the noise tolerant at the other. It is often implied that those who are highly annoyed by noise, including wind turbine noise, are motivated simply by a dislike of the noise source or are psychologically disturbed in some way. This is simply not the case, the response of the noise sensitive being as normal a reaction as that of the noise tolerant.

2.3.2. The noise sensitive are more likely to have stress related disorders, anxiety, headaches etc and poor sleep than the average. They are more likely to be found in the countryside where noise disturbance is less. Pedersen (2004) reported that 50% of her rural subjects were rather or very noise sensitive. Noise sensitivity is more likely in those with brain injury and psychological disorders such as dyslexia and increased community noise may exacerbate depression in susceptible individuals.

Flindell and Stallen (1999) listed factors influencing the degree of annoyance to noise:

- Perceived predictability of the noise level changing
- Perceived control, either by the individual or others
- Trust and recognition of those managing the noise source
- Voice, the extent to which concerns are listened to
- General attitudes, fear of crashes and awareness of benefits

- Personal benefits, how one benefits from the noise source
- Compensation, how one is compensated due to noise exposure
- Sensitivity to noise
- Home ownership, concern about plummeting house values
- Accessibility to information relating to the noise source

to which may be added:

- Perceived value of the noise source
- Expectation of peace and quiet
- Visual impact

Disempowerment and loss of control is a common theme from reports of those subjected to excessive wind turbine noise. The impulsive character of the noise is perceived as threatening and it can not be escaped being audible within the home, the usual source of refuge and quiet to permit restoration (Pedersen 2008). The end result is fear and anger at loss of control over the living environment with increased stress responses including increased difficulty in initiating and maintaining sleep. The increased wakefulness at night and the lower quality sleep increase the impact of nocturnal turbine noise on sleep, increasing the daytime fatigue and stress and so on in a reinforcing cycle.

2.3.3. Petrie, a New Zealand health psychologist, in evidence for the developers to the Wellington Environment Court, claims that reactions to wind turbine noise are akin to the health scares associated with new technologies and draws parallels with previous health scares such as mobile phone masts and electricity (Petrie, 2010). He claims that this explains adverse responses to wind turbine noise at sound levels deemed safe by regulators such as the WHO. In so doing, he makes the unwarranted assumption that the sound levels are indeed safe and overlooks the many observations that turbine noise is often greater than predicted and more intrusive and annoying than other noise sources. Wind turbine noise contains more low frequency sound than other common noises also. Previous health scares he cites have generally been about emanations which are undetectable by the

human senses, such as microwave radiation, and where there is no obvious mechanism for the putative harm. This is certainly not true for wind turbine noise which is readily detected and the mechanism for harm clear. There is no dispute that psychological factors play a part in any reaction to turbine noise, to suggest that they are the sole explanation is contrary to the evidence.

2.3.4. The psychological response to noise and noise sensitivity is a complex area and an excellent review is given by Shepherd, a psychoacoustician (Shepherd 2010).

3. Wind turbine noise, sleep and health

3.1. Introduction

3.1.1. The evidence above demonstrates that it is entirely plausible that wind turbine noise has the potential to cause arousals, sleep fragmentation and sleep deprivation. As noted above, the draft New Zealand standard on wind farm noise (2009) acknowledges that sleep disturbance is the major adverse consequence of wind turbine noise for humans.

3.1.2 Unfortunately **all** government and industry sponsored research in this area has used **reported awakenings** from sleep as an index of the effects of turbine noise and tend to dismiss the subjective symptoms. Because most of the sleep disturbance is not recalled, this approach seriously **underestimates** the effects of wind turbine noise on sleep. It may be argued also that it is not the number of awakenings or arousals that are important but their overall effects on those subjected to the noise. Assessments of sleep quality and daytime functioning (sleepiness, fatigue and cognitive function) would be more appropriate outcome measures.

3.2. Early research.

3.2.1. Surveys of residents living in the vicinity of industrial wind turbines show high levels of disturbance to sleep and annoyance. A 2005 survey of 200 residents living within 1km of a 6 turbine, 9MW installation in France showed that 27% found the noise disturbing at night (Butre 2005). A similar US survey in 2001 (Kabes 2001) of a "wind farm" in Kewaunee County, Wisconsin reported that 52% of those living within 400-800 metres found the noise to be a problem, 32% of those living within 800-1600 metres and 4% of those within 1600 and 3200 metres. 67% of those living within 250 to 400 metres and 35% of those within 400-800 metres reported being awoken by the sound in the previous year. The principal health problem reported by the 223 respondents was sleep loss. The landscape of Kewaunee County is described as "undulating to gently rolling". Pedersen and Waye (2004) reported that "16% (*n*=20, 95%CI: 11%–20%) of the 128 respondents living at calculated external turbine noise exposure above 35.0 dB LAeq stated that they were disturbed in their sleep by wind turbine noise." All of these studies use reported awakenings and may therefore underestimate the effects of wind turbine noise on sleep.

3.2.2. Phipps and others (2007) surveyed 1100 New Zealand households sited up to 3.5 km from a wind farm, 604 responded. 75% of all respondents reported being able to hear the noise. Two separate developments have placed over 100 turbines with capacities from 600kW to 1.65MW in a hilly to mountainous area. It has been suggested that mountainous areas may allow low frequency noise to travel further which may explain the long distance over which the turbines were heard. This suggestion tends to be confirmed by a recent study which is detailed below for convenience.

Phipps (2007a) has reported a further analysis of this data. All subjects lived more than 2km from the turbines, 85% living within 3.5km. 13% of 284 respondents heard the turbines at night either frequently or most of the time. 42 households reported occasional sleep disturbance from turbine noise and 26 were disturbed either frequently or most of the time. Phipps

concludes that the New Zealand Standard for Wind Turbine Noise should be modified so that "the sound level from the wind farm should not exceed, at any residential site, and at any of the nominated wind speeds, the background sound level (L_{95}) by more than 5 dBA, or a level of 30 dBA L_{95}, whichever is less."

3.2.3. Bakker and colleagues (Bakker 2009) report their observations on noise problems, including sleep deprivation, associated with wind turbines at least 3km from the affected properties. The Tararua, New Zealand, turbines are sited on a ridge and the affected properties are to the east in a river valley. Noise problems persisted despite the installation of sound reducing glazing. Nocturnal seismic noise monitoring showed noise bursts lasting at least 10 seconds, associated with an easterly wind, which the authors were confident originated from the turbines. The residents confirmed that the noise recorded was identical with that which disturbed their sleep. The authors speculate that the noise was transmitted through the ground. The importance of this report is not the mechanism for sound transmission but scientific confirmation that wind turbines can disturb sleep at distances of 3km. Previous anecdotal reports have often be dismissed as fanciful with assertions that sound transmission over such distances is impossible. While this seems, so far, to be an isolated case, it adds further evidence that much greater setbacks than those currently required are necessary to obviate sleep disturbance.

3.2.4. Van den Berg (2004) found that residents up to 1900 m from a wind farm expressed annoyance with the noise, a finding replicated in his more recent study reported below. Dr Amanda Harry (2007), a UK GP, conducted surveys of a number of residents living near several different turbine sites and reported a similar constellation of symptoms from all sites. A study of 42 respondents showed that 81% felt their health had been affected, in 76% it was sufficiently severe to consult a doctor and 73% felt their life quality had been adversely impacted. This study is open to criticism for its design which invited symptom reporting and was not controlled. While the proportion of those affected may be questioned it nevertheless indicates strongly that

some subjects are severely affected by wind turbine noise at distances thought by governments and the industry to be safe.

3.3. Project WINDFARMperception

3.3.1. van den Berg and colleagues (2008) from the University of Groningen in the Netherlands have published a major questionnaire study of residents living within 2.5km of wind turbines, Project WINDFARMperception. A random selection of 1948 residents were sent a similar questionnaire to that used by Pedersen in her studies in Sweden (2003, 2004, 2007 and 2008), questions on health, based on the validated General Heath Questionnaire (GHQ), were added. 725 (37%) replied which is good for a survey of this type but, nevertheless, may be a weakness. Non-respondents were asked to complete a shortened questionnaire. Their responses did not differ from full respondents suggesting the latter are representative of the population as a whole.

Questions on wind turbine noise were interspersed with questions on other environmental factors to avoid bias. The sound level at the residents' dwellings was calculated, knowing the turbine type and distance, according to the international ISO standard for sound propagation, the almost identical Dutch legal model and a simple (non spectral) calculation model. The indicative sound level used was the sound level when the wind turbines operate at 8 m/s in daytime -that is: at high, but not maximum power. Ground absorption was set to 1.0, a 100% sound absorbing surface. Typical values are around 0.5 and thus the sound levels may have been under-estimated. Noise exposure ranged between 24 and 54dB LAeq. It is worth noting that the wind industry was approached for assistance in the research but refused. Complaints such as annoyance, waking from sleep, difficulty in returning to sleep and other health complaints were related to the calculated noise levels.

Relevant conclusions include. *"Sound was the most annoying aspect of wind turbines"* and was more of an annoyance at night. Interrupted sleep

and difficulty in returning to sleep increased with calculated noise level as did annoyance, both indoors and outdoors. Even at the lowest noise levels, 20% of respondents reported disturbed sleep at least one night per month. At a calculated noise level of 30-35dB LAeq, 10% were rather or very annoyed at wind turbine sound, 20% at 35-40dB LAeq and 25% at 40-43dB LAeq, equivalent to 38-41dB LA_{90}, less than the permitted minimum ETSU-R-97 night time level.

3.3.2. Project WINDFARMperception further found that *"Three out of four participants declare that swishing or lashing is a correct description of the sound from wind turbines. Perhaps the character of the sound is the cause of the relatively high degree of annoyance. Another possible cause is that the sound of modern wind turbines on average does not decrease at night, but rather becomes louder, whereas most other sources are less noisy at night. At the highest sound levels in this study (45 decibel or higher) there is also a higher prevalence of sleep disturbance."* The lack of a control group prevents this group from making firmer conclusions about turbine noise and sleep disturbance but it is clear that as ETSU-R-97 permits an exterior night time noise level of 43dB, relying on its calculations will guarantee disturbed sleep for many of those living nearby.

3.3.3. van den Berg concluded also that, contrary to industry belief, road noise does not adequately mask turbine noise and reduce annoyance and disturbance. In addition, the authors compared their results with studies by Miedema on the annoyance from road, rail and air related noise. Wind turbine noise was several times more annoying than the other noise sources for equivalent noise levels (**Fig 1**). Similar data is given by Pedersen (2004) (**Fig 2**) – **see end of text**.

3.3.4 With regard to health it was concluded that: *"There is no indication that the sound from wind turbines had an effect on respondents' health, except for the interruption of sleep. At high levels of wind turbine sound (more than 45 dB(A)) interruption of sleep was more likely than at low levels. Higher levels of background sound from road traffic also increased the odds for*

interrupted sleep. Annoyance from wind turbine sound was related to difficulties with falling asleep and to higher stress scores. From this study it cannot be concluded whether these health effects are caused by annoyance or vice versa or whether both are related to another factor." The conclusions regarding general health are not justified from the data for the reasons given below and must be disregarded.

3.3.5. Project WINDFARMperception is currently the largest study in this field but the study is not without considerable flaws. The study may be criticised for using calculated noise levels and for not having a control group (residents not living near turbines). While several of the contributors have expertise in the investigation of health matters, none has specific expertise in the physiology and pathophysiology of sleep. The purpose of the study, as its title suggested, was the public perception of wind turbines and their noise. Health questions were added but were of a very general nature. The small number of respondents suggests that any conclusions as to the apparent lack of an effect on health must be regarded as tentative.

3.3.6. The analysis of reported sleep interruption and wind turbine sound levels is flawed by the use of subjects exposed to calculated external turbine sound levels of <30dB(A) (p53) as the "controls". It has been noted by several studies that calculated turbine noise is often less than measured noise and that levels as low as 30dB(A) can cause annoyance (Pedersen 2007). Examination of the odds ratio for different calculated sound levels (Table 7.42) shows that it increases progressively with increasing sound levels starting at 30-35dB(A) and becomes statistically significant for levels >45dB(A). If, as is not impossible, the "control" group had its sleep disturbed by wind turbine noise then the actual effect would be underestimated.

3.3.7. The major objection to the conclusions on health is that the study is grossly under-powered (insufficient subjects were studied for any degree of statistical confidence). Marked ill-health, "Wind turbine syndrome", to the degree reported by Pierpont (2009), does not seem to be common even amongst those exposed to high noise levels. The study tried to detect

chronic disease with the GHQ, which is a fairly crude instrument. Assuming that “wind turbine syndrome” affects 1% of those exposed to calculated sound levels >45dB(A) and that 25% of the general population suffer from chronic disease (p47) then at least 30,000 subjects would need to be studied in each group (>45dB(A) v <30dB(A)) to be able to prove a difference with 95% certainty. Even if a prevalence of “wind turbine syndrome” of 5% of those exposed to >45dB(A) is assumed, then there must be at least 1250 subjects in each group. It is possible also that those with a degree of ill health are more vulnerable and more likely to develop symptoms. A general health questionnaire will not detect such people and symptom specific surveys will be required. This study therefore can not conclude that wind turbines do not cause ill health of any degree, it can not even make conclusions about severe ill health.

3.3.8. Pedersen, van den Berg and others (Pedersen 2009a&b) have further analysed the data in an attempt to model a generalised dose-response relationship for wind turbine noise. A noise metric, Lden, was calculated (Miedema 2000). Lden is based on long-term equivalent sound pressure levels adjusted for day (d), evening (e) and night). Penalties of 5 and 10dB are added for evening and night hours respectively to reflect the need for quietness at those times. dB(A) LAeq values for wind turbines may be transformed to Lden values by adding 4.7±1.5 dB (van den Berg 2008). Annoyance is used as the principal human response to wind turbine noise in this analysis. In this context, “annoyance” is more than simply irritation but is a measure of lack of well-being in a wider sense (Pedersen 2009a) and is contrary to the WHO definition of health.

Annoyance increased with increasing sound levels, both indoors and outdoors. The proportion who were rather and very annoyed at different sound levels are shown in Table I. In summary, when outside, 18% were rather or very annoyed at sound levels of 35-40 and 40-45 dB LAeq compared to 7% at 30-35dB LAeq and 2% at <30dB LAeq. When inside, the equivalent figures were 1% at <30dB LAeq, 4% at 30-35dB LAeq, 8% at 35-40dB LAeq and 18% at 40-45dB LAeq. Those respondents who had an

economic interest in the turbines had lower levels of annoyance while negative views of the visual impact of turbines increased the likelihood of annoyance.

Although the authors do not seek to recommend minimum sound levels, they do note that turbine noise was more annoying than other sources, with the possible exception of railway shunting yards and was more noticeable at night. They conclude that: *"...night time conditions should be treated as crucial in recommendations for wind turbine noise limits."* Nevertheless, it is clear from this analysis that external predicted turbine sound levels should be less than 35dB LAeq (33dB LA_{90}), considerably less than those permitted by ETSU R 97, in order to reduce effects on nearby residents to acceptable levels.

3.3.8. Pedersen (2009a&b) has recently combined the datasets from three studies (Pedersen 2004 (SWE00)) and 2007 (SWE05) and van den Berg 2008 (NL07)) as they used similar questionnaires giving a total of 1764 subjects. A strong correlation was seen in all studies between calculated A weighted sound pressure levels and outdoor annoyance as noted above.

Even at sound pressures of 30-35 dB LAeq, 5-12% of subjects were very annoyed. Correlations were found also between annoyance and symptoms of stress (headache, tiredness, tension and irritability) confirming that "annoyance" is more than irritation and is a marker of impaired health. The sleep disturbance question did not ask causation of the sleep disturbance and a background level would therefore be expected from other causes (traffic noise, weather, etc). Nevertheless, there was a clear increase in levels of sleep disturbance with A-weighted sound pressure in studies SWE00 and NL005. **(Figure 3)**. Pedersen states *"In the first Swedish study (SWE00) the increase of respondents that reported sleep interruption appears to be between the sound level interval 35-40 dB(A) and 40-45 dB(A). The increase came at higher sound levels in the Dutch study (NL07); between the interval 40-45 dB(A) and >45 dB(A)"*. All values are LAeq. There is no true measurement of background levels of sleep disturbance as

no study had a control group, it is difficult therefore to determine at what sound pressure level turbine noise begins to have an effect. but even the conservative levels suggested above are less than those permitted by ETSU R 97. **Fig 3 see end of text.**

3.3.9. Jabben and colleagues (2009) from RIVM, the Dutch National Institute for Public Health and Environment, were commissioned by the Dutch Government to examine the impact of different values of Lden on the ability to meet targets for onshore wind power generation. They reviewed current evidence and noted that, at present, 440,000 inhabitants (2.5% of the population) were *"receiving significant noise contribution from wind turbine noise of which 1,500 are expected to suffer severe annoyance. It is remarkable that almost half of this number already occurs within the range Lden 30-40db(A)".* Despite this, they recommend an Lden of no more than 40dB(A), which corresponds to a calculated external turbine noise level of about 35dB(A), in order for the Dutch Government to meet its 2011 target for wind turbine installations.

3.3.10. All of the studies cited in this section have used reported sleep disturbance and annoyance in determining maximum sound levels. As noted in Section 2.2, reported sleep disturbances underestimate sleep disturbance and may not reflect actual physiological consequences. The precautionary principle demands that lower sound levels be selected in order to leave a margin of safety.

3.4. Pierpont studies

3.4.1. Pierpont (2009) has recently completed a detailed case-series study of 10 families around the world who have been so affected by wind turbine noise that they have had to leave their homes, nine of them permanently. Subjects were selected from respondents to an appeal for those regarding themselves as suffering from ill health as a result of exposure to turbine noise. The turbines ranged from 1.5 to 3MW capacity at distances between 305 to 1500m. The group comprised 21 adults, 7 teenagers and 10 children

of whom 23 were interviewed. While this is a highly selected group, the recording of symptoms before, during and after exposure to turbine noise gives it a strength rarely found in similar case-series studies. The subjects described the symptoms of wind turbine syndrome outlined above and confirmed that they were not present before the turbines started operation and resolved once exposure ceased. There was a clear relationship between the symptoms, even in children, and the noise exposure. Pierpont reports also that all adult subjects reported *"feeling jittery inside"* or *"internal quivering"*, often accompanied by anxiety, fearfulness, sleep disturbance and irritability. Pierpont hypothesises that these symptoms are related to low frequency sound and suggests physiological mechanisms to explain the link between turbine exposure and the symptoms.

3.4.2. Of particular concern were the observed effects on children, include toddlers and school and college aged children. Changes in sleep pattern, behaviour and academic performance were noted. 7 of 10 children had a decline in their school performance while exposed to wind turbine noise which recovered after exposure ceased. In total, 20 of 34 study subjects reported problems with concentration or memory.

3.4.3. Pierpont's study mostly addresses the mechanism for the health problems associated with exposure to wind turbine noise rather than the likelihood of an individual developing symptoms. Nevertheless, it convincingly shows that wind turbine noise is strongly associated with the symptoms she describes, including sleep disturbance. She concludes by calling for further research, particularly in children, and a 2km setback distance.

3.4.4. A recent paper (Todd et al, 2008) has shown that the vestibular system in the human ear, the part concerned with detection of movement and balance, is exquisitely sensitive to vibration at frequencies of around 100Hz. Pierpont claims that these findings support her hypotheses although Todd has contradicted these assertions. More recently, Salt (Salt 2010) has suggested that some parts of the inner ear may be sensitive to low

frequency noise below the limit of audibility and raises the possibility of influencing function or causing unfamiliar sensations.

3.4.5. Leventhall, formerly Professor and Head of the Institute of Environmental Engineering at South Bank University and an expert on low frequency noise, accepts that the symptoms described by Pierpont's subjects are real but maintains that the low frequency sound energy created by wind turbines is too low to cause direct physiological effects (Pool, 2009 and personal communication 2009). He suggests that the symptoms are a result of psychological stress secondary to noise annoyance, particularly low frequency noise. and sleep disturbance. Similar symptoms were described by Møller and Lydolf (2002).

The NHS Knowledge Service reviewed Dr Pierpont's book (NHS 2009) and concluded: *"No firm conclusions can be drawn from this study as the design was weak and included only 38 people. Participants were asked about their symptoms before they were exposed to wind turbines to provide a control for their symptoms after exposure. This was not a sufficient control as many of the participants were reportedly already convinced that wind turbines caused their symptoms and were actively trying to move out of their homes or had already moved. Further study is needed."*

The call for further research has been heeded in Japan, Yomiuri Shimbun, a leading Japanese newspaper, (November 29th 2009) reports that the Japanese Environment Ministry has commissioned a four year study into the effects of low frequency turbine noise on human health. The question as whether "wind turbine syndrome" is a distinct clinical entity remains unsettled at this time.

A Japanese newspaper, Asahi Shimbun, (Ito and Takeda 2009) in a report of the decision of the Japanese Environment Ministry to investigate the potential health effects of wind turbine noise has reported it's own survey of complaints of wind turbine noise directed at state and local authorities and wind turbine operators in Japan. 30 of 376 locations (8%) had received

complaints, 90% of which concerned health problems which included insomnia, headaches, dizziness and buzzing in the ear.

Izumi Ushiyama, president of the Ashikaga Institute of Technology and an expert on wind power generation, is quoted as saying that: "*operators must listen to residents before pushing their projects. Some operators make light of communications with residents in carrying out their projects, which causes friction. This has tarnished the image of wind power generation and blocked its promotion."*

Ushiyama is quoted also as saying that a third-party "communicator," trusted by both operators and residents, must be called upon to make adjustments because the two sides may become involved in confrontations if left alone to discuss the issue.

This report shows that not only are complaints about wind turbine noise consistent across cultures so also are the symptoms.

3.5. DTI report

3.5.1. The UK Department of Trade and Industry (DTI) commissioned a report from the Hayes McKenzie Partnership (HMP) in 2006 which investigated low frequency noise at three UK wind farms. As far as can be determined, no medical or physiological expertise was used in the design of the study. Sound measurements were taken at three of five sites where complaints had been recorded over periods from 1-2 months.

Communication with residents other than those who complained was minimal. However, they did confirm that *"some wind farms clearly result in modulation at night which is greater than that assumed with the ETSU-R-97 guidelines".* Measured *"internal noise levels were insufficient to wake up residents at these three sites. However, once awoken, this noise can result in difficulties in returning to sleep."*

The lack of physiological expertise in the investigators in not recognising that noise can disturb sleep without actual recalled awakening is a major methodological flaw rendering the conclusions unreliable, as is the short recording period. It is well recognised also that not every resident affected by a nuisance such as noise will actually register a complaint (Health Protection Agency 2009). Many will not be sufficiently literate or confident so to do and others may wish to avoid drawing attention to the problem to protect property prices. They may assume also that protest is futile, which seems to be the experience of many with wind turbine noise. The WHO and other research by DEFRA suggest complaints may represent between 5-20% of sufferers with others seeking alternative coping strategies. Recorded complaints are thus the tip of the iceberg.

3.5.2. It will be claimed also that only 5 of 126 wind energy developments at the time of the study had attracted complaints of noise and thus the matter is trivial. This assertion is, to say the least, disingenuous. Many of the developments at that time were of small turbines set in isolated areas of the countryside, well away from habitation. In addition, as noted above, the proportion of those affected by wind turbine noise who formally complain to their local authority is very small. Research into wind farm noise and health issues in the UK is virtually non-existent and of poor quality. To suggest that there is “no problem” when faced with the large body of evidence presented here is perverse. The conclusion is also contradicted by Moorhouse’s study (vide infra) which showed a complaint rate of 20%.

3.5.3. Draft versions of the report (DTI 2006a,b,c) have recently come to light as a result of Freedom of Information requests. They show that HMP had recommended a reduction of the ETSU-R-97 permitted night time limits to 38dB LA90 (40dB LAeq) in the absence of AM with a further penalty of up to 5dB in the presence of modulation. These recommendations were removed from the final version of the report. No scientific explanation for their removal seems to have been offered. An example of removed text follows:

"The analysis of the external and internal noise levels indicates that it may be appropriate to re-visit the issue of the absolute night-time noise criterion specified within ETSU-R-97. To provide protection to wind farm neighbours, it would seem appropriate to reduce the absolute noise criterion for periods when background noise levels are low. In the absence of high levels of modulation, then a level of 38 dB LA90 (40 dB LAeq) will reduce levels to an internal noise level which lies around or below 30 dB LAeq with windows open for ventilation. In the presence of high levels of aerodynamic modulation of the incident noise, then a correction for the presence of the noise should be considered."

Similarly, references to WHO guidance for the protection of sleep disturbance which supported HMP's recommendations for a reduction in ETSU-R-97 night time noise limits were removed. The removed text follows:

"If one takes the guidance within the WHO for the protection against sleep disturbance of 30dB LAEq, and apply a 5 dB correction for the presence of high levels of [aerodynamic] modulation within the incident noise, then this gives rise to an internal noise criterion of 25dB LAeq. Based upon the measured building attenuation performances at Site 1 & 2, then an external level between 35 – 40dB LAEq (33-38 dB LA90) would provide sufficient protection to neighbouring occupants to minimise the risk of disturbance from the modulation of aerodynamic noise."

It is quite clear that relying on the conclusions of this report, as published, is unwise as they are, at best, misleading.

3.6. Salford study

3.6.1. Moorhouse of the University of Salford (2007) were commissioned by DEFRA to conduct a study of Aerodynamic Modulation of Wind Turbine Noise. A survey was made of the local authorities responsible for wind farms in, or adjacent to, their area. 133 wind farms were identified of which 27 (20%) had attracted complaints. An attempt was made to correlate

complaint logs with recorded wind speed and direction. Once again the methodology is fundamentally flawed. Complaints were solicited from local authorities and not from residents. The review was entirely theoretical with no communication with residents and relied on the opinions of environmental health officers. The conclusions were that AM was such a minor problem that no further research was warranted.

3.6.2. The Editor of Noise Bulletin greeted the publication of the report thus:

"`New report eases concerns over wind turbine noise' trumpets the Government press release, then saying aerodynamic modulation is `not an issue for the UK's wind farm fleet'. This conclusion is not justified based on the report, and by halting further research work without transparently monitoring the wind farms subject to complaints will inflame, not ease concern of objectors ... Only when the public can trust the Government and wind farm developers on noise issues will there be a chance that the public will accept them without a fight ..."
(Pease J. *Noise Bulletin*, Issue 15, Aug/Sept. 2007 page 5).

3.6.3. On 2 August 2007, Dick Bowdler, an acoustician and member of the Noise Working Group which commissioned the report, resigned from the NWG. This highly unusual step was taken because, as his letter states:

"I have read the Salford Report and the Government Statement. As a result I feel obliged to resign from the Noise Working Group.
The Salford Report says that the aims of this study are to ascertain the prevalence of AM from UK wind farm sites, to try to gain a better understanding of the likely cause, and to establish whether further research into AM is required. This bears little relation to what we asked for which is clearly set out in the minutes of the meeting in August 2006. We all knew then (as was recorded in the original notes of the meeting) that complaints concerning wind farm noise are currently the exception rather than the rule. The whole reason for needing the research was that `The trend for larger more sophisticated turbines could lead to an increase in noise from AM'.
It was not the intended purpose of the study to establish whether more research was required. We all agreed at the August 2006 meeting that such research was needed. That was precisely the outcome of the meeting. The prime purpose of what eventually became the Salford Report was to identify up to 10 potential sites which could be used to carry out objective noise measurements. The brief for the Salford report, which was never circulated to the NWG, completely ignored the NWG views.
Additionally, I find it entirely unacceptable that we are not to be told the names of the wind farms listed in the Salford report. So the only part of the

report of any value to assist future research is inaccessible to those of us who would like to progress matters further.
Looking at the Government Statement it is clear that the views of the NWG (that research is needed into AM to assist the sustainable design of wind farms in the future) have never been transmitted to government and so the Statement is based on misleading information".
(*Noise Bulletin*, Issue 15, Aug/Sept. 2007 page 5)

3.6.4. If both a leading commentator in the field and a leading member of the Government's own working group have no faith in the study then its conclusions may safely be dismissed.

3.6.5. Following a refusal by the Salford research team and the DTI to share the study's full data, the actual questionnaire response forms were finally made available after a Freedom of Information request by the Renewable Energy Foundation. The low quality of this research is evident from the poor responses from many local authorities, many of whom clearly did not understand the concept of AM, compounded by the questionnaire design and the phrasing of the questions. This further serves to demonstrate that current planning guidance, and in particular ETSU R 97, are inadequate at preventing noise annoyance.

3.7. Acoustician opinions

3.7.1. George Kamperman, (2008 personal communication) a distinguished US noise engineer, is quoted in Pierpont's book as saying, *"After the first day of digging into the wind turbine noise impact problems in different countries, it became clear the health impact on persons living within about two miles from 'wind farms' all had similar complaints and health problems. I have never seen this type of phenomenon [in] over fifty plus years of consulting on industrial noise problems. The magnitude of the impact is far above anything I have seen before at such relatively low sound levels. I can see the devastating health impact from wind turbine noise but I can only comment on the physical noise exposure. From my viewpoint we desperately need noise exposure level criteria."* Kamperman's recommended setback of at least 1km (Kamperman & James 2008) has changed to at least 2km as a result of Dr Pierpont's evidence (Kamperman

2008 personal communication). He has recently published a more detailed set of recommendations to determine setback distances (Kamperman & James 2008b) which, amongst others, require that turbine noise should not be more than 5dB(A) above background and should not exceed 35dB(A) within 30m of any occupied structure.

3.7.2. Dr Robert Thorne, an Australian acoustician has investigated wind turbine noise at several sites in Australia and New Zealand. His conclusions can be found in several expert reports submitted to Planning Inquiries, most recently Turitea (Thorne 2010a & b) and Yaloak (Thorne 2010c). He states (Thorne 2010c para 6.18):

"I am of the opinion, based on my own research, that wind farm noise can and does create unreasonable noise within residences and consequential adverse effects in the sense of sleep disturbance, annoyance and potential adverse health effects to residents living within 2000 metres of large wind turbines set in a wind farm. These risks are quantifiable and are of high probability. The effect is significantly more than minor."

3.7.3. Dr Dan Driscoll, formerly a noise control engineer for the New York Public Service Commission, answered questions at an Environmental Stakeholder Roundtable on Wind Power sponsored by the New York State Energy Research and Development Agency held in New York on the 16th June 2009 (Driscoll 2009). He takes as the basis for his thesis the well established US Environmental Protection Agency's (EPA) paper on Levels of Environmental Noise. The EPA uses a day/night average sound level, L_{dn}, similar to the L_{den} recommended in Europe, with a 10dB(A) penalty for night noise. An L_{dn} of 55dB(A) is recommended as adequate to protect from outdoor activity interference and annoyance. Various research studies suggest that a normalised L_{dn} of 55dB(A) would cause little or no community reaction although the noise would be noticeable. The estimated sound output L_{dn} is normalised by adjusting for a range of factors; in this case, 10dB is added for a quiet suburban or rural setting, 5dB if the community has no prior experience with the noise and 5dB if the sound is impulsive. He calculates that a 2.5MW turbine producing an

L_{eq} of 49dB(A) at 500ft would have an uncorrected L_{dn} of 55dB. Adding the adjustments gives a normalised turbine L_{dn} of 75dB which is a level at which the EPA expects that community reaction would include threats of legal action and strong appeals to stop the noise. This certainly corresponds with the current reaction to turbine noise in all parts of the world, including the UK. Using EPA data, Driscoll estimates that a normalised L_{dn} of 59dB would be sufficient to reduce community reaction to sporadic complaints which equates to an external turbine noise of 33dB(A) and a setback of about 1km. It is noteworthy that the conclusions of this noise control approach are in accord with the recommendations of Kamperman and James (Section 3.7.1), Hayes in his recommendations to the DTI (Section 3.5.3) and my own estimations based upon the work of Pedersen and others (Section 3.3.8).

3.7.4 A similar approach has been taken by Ambrose and Rand (Ambrose 2010). They produce a similar graph to Driscoll (Figure 5) but add the annoyance levels determined by Pedersen and Persson Waye (Pedersen 2004). Both studies confirm that an unacceptable level of adverse community response is likely for wind turbine noise levels above 32dBA.

3.8. WindVoice

3.8.1 WindVoice (2010) have recently published the initial results of a self-reporting survey of communities affected by wind turbine noise. As of July 2010, 144 responses had been received of which 118 reported one or more health effects. 84 (58%) reported sleep disturbance and 85 (59%). There were no age differences between those that reported sleep disturbance (51.5 yr (19-79)) and those that did not (52.2 yr (26-86)).

Those that reported sleep disturbance lived an average of 897m (360-5000) from turbines compared to 890m (350-3500) for those who did not. The similarity in distance from turbines for the two groups suggests that noise sensitivity may be significant factor in sleep disturbance. A slightly greater

proportion of females reported sleep disturbance than males. Caution must be exercised in drawing conclusions from self reporting surveys. Nevertheless, it is evident that significant numbers of individuals are reporting sleep disturbance and health issues at distances considerably greater than those currently deemed safe. All bar five of those reporting sleep disturbance live within 1500m of the turbines adding further support to a minimum setback of at least that distance.

3.9. World Health Organisation/European Community recommendations

3.9.1. The WHO Regional Office for Europe in collaboration with the EU established a working party in 2003 to examine the effects of night time noise on sleep disturbance and health. Their brief was to review the current evidence and produce recommendations on permissible night time noise levels. Inevitably, the work concentrates on road traffic and aircraft noise as generating the most complaints and the subjects of most research.

3.9.2. A preliminary report was published in 2007 (WHO 2007). They reported that:

"The review of available evidence leads to the following conclusions.

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

stressed that a plausible biological model is available with sufficient evidence for the elements of the causal chain."

"For the primary prevention of subclinical adverse health effects in the population related to night noise, it is recommended that the population should not be exposed to night noise levels greater than 30 dB of $L_{night,outside}$ during the night when most people are in bed. Therefore, $L_{night,outside}$ 30 dB is the ultimate target of Night Noise Guideline (NNGL) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise."

The report described a new noise metric, $L_{night,outside}$, which is the yearly average of night noise level outside the facade. This seems to have been chosen as more appropriate for health effects that require long term noise exposure, such as high blood pressure, than those related to short term disturbance such as sleep disturbance and insomnia.

3.9.3. A further report was published in 2009 (WHO 2009). A similar approach was taken to that of Pedersen (2009a&b) and the report seeks to establish a No Observed Effect Level (NOEL) and a Lowest Observed Adverse Effect level (LOAEL) for noise and various measures of health. While a useful approach, it must be remembered that the LOAEL will vary with the noise frequency and pattern, the age of the subjects studied and the sensitivity of the measurement of the effect. There will also be a range of LOAEL within the population depending upon noise sensitivity. Allowance should be made for those who are most sensitive. With respect to noise and health, it can not be assumed that all noise is the same; as noted above, several studies have shown that wind turbine noise is more annoying than traffic or aircraft noise. Children and the elderly may be more sensitive than adults who are studied most often. While blood pressure and heart attacks are well defined and easily measured, sleep disturbance, fatigue, mood and similar subjective symptoms are less easily measured and distinguished from the background levels present in the population.

An $L_{night,outside}$ of 40dB was recommended as representing the LOAEL. They state for $L_{night,outside}$ of 30-40dB:

"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 lowest observed adverse effect level (LOAEL) for night noise."

Body movements, awakenings, self-reported sleep disturbance and arousals will all impact on a subject's sleep and cause impaired daytime functioning. Whether or not this results in long term harm, it remains an effect on the subject which is contrary to the WHO definition of health, i.e. it constitutes ill health.

3.9.4. The recommendation that an $L_{night,outside}$ of 40dB should be the night noise guideline for Europe seems perverse in the light of the conclusions of the effects of sound levels between 30 and 40dB above. A value of 21dB was used for sound attenuation from outside a building to inside. This is greater than the 10-15dB usually cited. Bearing in mind the reservations expressed in Section 3.9.3 and, in particular the nature of wind turbine noise with it's high levels of low frequency noise, an external noise level of 40dB must be regarded as the absolute maximum permissible and must be fully justified, for example by the subject having a financial interest in the turbines. Noise exposure above this level will be associated with a risk of ill health. Kamperman and Pedersen's recommendations of a maximum external limit of 35dB(A) and HMP's recommendations of 33-38 dB(A) would be appropriate for wind turbine noise to prevent annoyance and sleep disturbance and is supported by the WHO/EU findings quoted above.

3.10 Nissenbaum

3.10.1. Nissenbaum (2010) has presented the preliminary results of a study of residents living downwind and within 300-1100m (mean 800m) of a wind farm at Mars Hill, Maine, USA. The 28 1.5MW turbines are sited on a 200m high ridge overlooking the homes. 22 of about 35 adult residents have

been interviewed so far and compared with a randomly selected control group living a mean 6km away. 18/22 reported new or worsened sleep onset disturbance at least twice a week, for 9 at least 5 times per week (controls 1/28). 8/22 reported new or worsened headaches (controls 1/28) and 18/22 reported new or worsened mental health symptoms (stress 12/22, anger 18/22, anxiety 8/22, hopelessness 12/22, depression 10/22) (controls 0/28).

The 22 subjects received 15 new or increased prescriptions from their physicians in the 18 months between the start of turbine operation and the study, the majority for psychoactive medication (controls 4 prescriptions, none for psychoactive medication). 21/22 reported reduced quality of life and 20/22 considered moving away (controls 0/28 for both).

3.10.2. As a result of the complaints, noise monitoring during turbine operation was undertaken at the community test sites at which background noise monitoring and calculated turbine noise levels had been derived during the planning stage. The residents surveyed generally lived between the 40-45dB contours, two lived within the 45-50dB contours. Noise control regulations in Maine call for test sites to be more than 500ft from “protected properties”. Six test sites are relevant to the study group and the results are given below.

Site No.	Model estimate (dB)	Range of measured sound levels (dB)
1	51	42-52
5	39	39-40
6	43	39-45
6A	42	38-44
7	40	39-44
8	47.5	41-50

It can be seen that model estimates generally underestimated the actual noise levels by between 1 and 4dB. Exceedances of ETSU-R-97 night time levels of 43dB are generally small, 1-2dB and only exceed by 7-9dB at the two closest sites. It is clear that the majority of residents were living at distances and sound levels that would be permitted under ETSU-R-97 but nevertheless report high levels of sleep disturbance and health impairment.

3.10.3. The study may be criticised for it's relatively small numbers of subjects but the presence of a control group, well matched for age and gender, adds considerable power. All differences between the groups are statistically highly significant. The turbine noise levels may be enhanced by the high concentration of turbines and the geography but the severe sleep disturbance, psychiatric symptomatology and increased medication requirement in the study group confirms the potential of wind turbine noise to adversely affect health at distances claimed to be safe.

3.11 Shepherd

3.11.1. Dr Daniel Shepherd, (2010a) a psychoacoustician from the University of Aukland, New Zealand, has presented a preliminary report of a case-control study of the health status of residents living within 2km of the Makara windfarm. The results were presented at an International Symposium on Sustainability in Acoustics, Sydney, Australia, August 29th-31st 2010. Health related quality of life (HRQoL) was measured using the WHO QOL-BREF which has four subscales, physical, including sleep, psychological, social and environmental. Questions on neighbourhood problems, amenity and noise and air pollution annoyance were added, partly as distractors.

26 of 84 questionnaires were returned by the Makara residents (31%) and 173 of 500 (34%) in a control group from a matched area without wind turbines. Return rates are reasonable for such a study. The groups were evenly matched except the control group had a slightly higher proportion of older people.

The Makara residents reported significantly lower amenity levels than the controls. Overall HRQoL was much lower in the Makara residents and this difference was statistically highly significant ($p=0.033$) (See Table below). Makara residents scored lower in all subscales except social. The differences were statistically significant ($p<0.05$) for the physical and environmental subscales.

Subscale	Mean Rank	Significance (two-tailed)
Physical Makara Control	 75.25 100.09	*U*=1505.5, *z*=-2.049, *p*=.040
Psychological Makara Control	 78.48 99.07	*U*=1883.5, *z*=-1.524, *p*=.088
Social Makara Control	 96.49 92.63	*U*=1923.05, *z*=-0.325, *p*=.745
Environmental Makara Control	 73.89 97.92	*U*=1423.5, *z*=-1.983, *p*=.047
Overall QOL Makara Control	 76.81 99.87	*U*=1543.5, *z*=-2.133, *p*=.033

This preliminary report of well designed study adds further weight to the argument that wind turbine noise causes ill health in those living within 2km.

3.12. Literature Reviews.

In recent months, a number of "reviews" of the literature relating to wind turbine noise and health have been published. In general, those which are industry or government sponsored tend to suggest that there is no problem while those produced independently confirm that there is a problem.

3.12.1 The American and Canadian Wind Energy Associations (ACANWEA) have recently commissioned a review of the literature on wind turbine noise and health effects (Colby et al., 2009). The panel concluded that:

"• There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects.

• The ground-borne vibrations from wind turbines are too weak to be detected by, or to affect, humans.

• *The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds and the panel's experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences."*

The quality and authority of this review and its conclusions are open to considerable doubt. The medical members of the panel comprised a microbiologist, an otolaryngologist and an occupational health physician specialising in respiratory disease. From their biographies, none seems to have any expertise in sleep medicine or in psychology. The reference list shows that the literature review was far from complete. The panel admits that wind turbine noise causes annoyance which can lead to sleep disturbance but dismisses these findings. It is clear that they did not understand the significance of "annoyance" in a health context and neither did they comprehend the importance of sleep disturbance in causing ill-health.

The NHS Knowledge Service reviewed the paper (NHS 2010) and concluded: *"This research is unlikely to resolve the controversy over the potential health effects from wind turbines. This is mainly because the research on which the review was based is not sufficient to prove or disprove that there are health effects. The review itself also had some methodological shortcomings, and the reviewing group did not include an epidemiologist, usually a given for assessing potential environmental health hazards. Further research on this issue is needed."*

The Society for Wind Vigilance (Society for Wind Vigilance, 2010a&b) has reviewed the ACANWEA paper, publishing a detailed critique and concluded: *"It is apparent from this analysis that the A/CanWEA Panel Review is neither authoritative nor convincing. The work is characterized by commission of unsupportable statements and confirmation bias in the use of references. Many important references have been omitted and not*

considered in the discussion. Furthermore the authors have taken the position that the World Health Organization standards regarding community noise are irrelevant to their deliberation - a remarkable presumption."

3.12.2. The Chief Medical Officer of Health of Ontario published a review in May 2010 on the Potential Health Impact of Wind Turbines (CMOH, 2010). This document has a number of shortfalls, not least in the selective nature of the literature reviewed, the dismissal of annoyance as a health issue and the ignoring of sleep disturbance as a concern. A comprehensive rebuttal of this paper has been published by the Society for Wind Vigilance (Society for Wind Vigilance 2010c).

3.12.3. The Australian National Health and Medical Research Council published a "Rapid Review of the Evidence" of Wind Turbines and Health in July 2010 (NHMRC, 2010). It starts with the premise that there is no evidence of any health concern and then proceeds, through a very selective use of literature, to prove it. It claims to use peer reviewed literature but only 8 of 29 citations are actually peer reviewed, one of the remainder being an internet blog, "Croakey the Crikey Health Blog". The WHO acceptance of annoyance as an adverse health effect is stated as "not universally accepted" but no references are given to support this extraordinary assertion. A comprehensive rebuttal of this paper has been published by the Society for Wind Vigilance (Society for Wind Vigilance 2010d).

3.12.4. Phillips, an epidemiologist, has prepared an analysis of the epidemiology and related evidence on the health effects of wind turbines on local residents as evidence to the Wisconsin Public Service Commission (Phillips, 2010). He concludes: *"There is ample scientific evidence to conclude that wind turbines cause serious health problems for some people living nearby." "The reports that claim that there is no evidence of health effects are based on a very simplistic understanding of epidemiology and self-serving definitions of what does not count as evidence. Though those reports probably seem convincing prima facie, they do not represent proper*

scientific reasoning, and in some cases the conclusions of those reports do not even match their own analysis."

He further notes that subjects' revealed preferences, moving out of their bedrooms or houses to avoid the noise is strong evidence in favour of the effects being real rather than a psychologically induced "nocebo" effect.

3.12.5. Horonjeff, an acoustician, has reviewed the siting of wind turbines with respect to noise emissions and the health and welfare effects on humans as evidence to the Public Service Commission of Wisconsin (Horonjeff, 2010). He notes that wind turbine noise is different in character from other noise sources and, after suggesting appropriate noise levels and a setback 1.5-2 miles, concludes: *"Wind turbine noise appears to be eliciting annoyance and physiological responses not experienced from other noise sources of similar sound level."*

3.12.6. Punch and colleagues (Punch, 2010) reviewed wind turbine noise for audiologists and concluded: *"Noise from modern wind turbines is not known to cause hearing loss, but the low-frequency noise and vibration emitted by wind turbines may have adverse health effects on humans and may become an important source of community noise concern."*

3.12.7. The Clean Energy Council of Australia, the trade body representing and advocating on behalf of the wind industry and other "renewable" energy suppliers, commissioned Sonus, an acoustic consulting firm that works extensively with the wind industry, to review environmental noise and wind farms (CEC 2010). No individual authors are listed in the report but none of the staff listed on the company's website has any medical, epidemiological or health expertise. Nevertheless, they confidently conclude: "There is detailed and extensive research and evidence that indicates that the noise from wind farms developed and operated in accordance with the current (Australian) Standards and Guidelines will not have any direct adverse health effects." Review of the cited literature produces no such extensive research nor evidence other than the usual reviews cited in similar wind

industry and government sponsored documents. The literature reviewed omits much peer-reviewed and other literature which contradicts the conclusions.

3.13. Conclusions

3.13.1. There is no peer-reviewed research showing that industrial wind turbines do not significantly affect sleep at the distances and external noise levels deemed to be safe in most jurisdictions. On the other hand, there is a large body of literature suggesting very strongly that sleep is disturbed to a degree that affects daytime functioning. Many of the studies are surveys using self-completed questionnaires. Response rates have generally been good for this type of enquiry, which may reflect the public interest and concern that wind turbines generate. Nevertheless, it is inevitable that it is more likely that those who feel they have been affected will respond rather than those who have not. The questionnaires themselves have not always have been well drafted. Most do not have a control group, a separate group not exposed to turbine noise with whom to make comparisons. The studies are all post hoc, initiated after the turbines have been operating and generally in response to complaints. The lack of pre-exposure data weakens the studies but does not invalidate them totally. Many of the authors have been criticised for their presumed lack of expertise in this area. Because governments and industry have refused funding and co-operation, individuals have had to rely on their own resources in order to conduct research, which though propelled by a concern for public health, has also enforced limits on their extents. Initial clinical investigations often rely on self-completed questionnaires in order to define, refine, and establish future research projects and this work should not simply be dismissed.

Nevertheless, the number of reports, and in particular the most recent, and the weight of evidence demonstrating the impacts on sleep quality and health of wind turbine noise from existing installations is such that it can be firmly concluded that present guidance to determine setbacks is inadequate.

3.13.2. The UK government, in acknowledging the deleterious effect of noise on human well being, have published two reports through the Health Protection Agency (HPA 2009) and DEFRA (Berry and Flindell, 2009). The former, which is in draft form awaiting comments, reviews the evidence for the effects of noise on health. Traffic, aircraft, railway and industrial noise is considered but, surprisingly, there is no consideration of wind turbines despite the government's plans for a major increase in size and capacity and their proposed placement in generally previously tranquil but well populated areas of countryside. The report calls for more research, including in the areas of sleep disturbance, cardiovascular effects and children's health. They commend the use of dose-response relationships to inform planning policy. The latter report reviews dose-response relationships between noise exposure and human health and concludes that such is a useful approach worthy of further research. They commend the work of RIVM, who were extensively consulted in preparing the report.

3.13.3. The recent analyses of the WINDFARMPerception and earlier Swedish studies by Pedersen and her colleagues gives, for the first time, robust evidence that wind turbines cause sleep disturbance and impair health and that this occurs at set-back distances previously regarded as adequate. However, it must be noted that the measures used in these studies are relatively imprecise. As noted in Section 2.2, arousals due to noise are several times more likely to occur than awakenings but are as destructive to sleep quality. More precise measures such as the Brief Fatigue Inventory, Pittsburgh Sleep Quality Index and Epworth Sleepiness Score or direct assessment of sleep quality are needed to determine a correct dose-response relationship between turbine noise and sleep disturbance. In the meantime, the precautionary principle should prevail and setbacks determined appropriately.

3.13.4. In weighing the evidence, I find that, on the one hand, there are large numbers of reported cases of sleep disturbance and other adverse effects on health, as a result of exposure to noise from wind turbines, supported by an increasing number of research reports that confirm the validity of the

anecdotal reports and provide a reasonable basis for the complaints. On the other, we have badly designed, and improperly edited, industry and government reports, which seek to show that there is no problem. I find the latter unconvincing.

3.13.5. The recent RIVM and WHO reports and the draft DTI/HMP reports confirm the potential for noise to adversely effect health through sleep disturbance and set maximum permissible night time noise levels which are less than those permitted by ETSU-R-97.

3.13.6. **In my expert opinion, from my knowledge of sleep physiology and a review of the available research, I have no doubt that wind turbine noise emissions have been clearly associated with sleep disturbances.**

Further, the evidence now available is quite clear that present noise guidelines are inadequate to protect the sleep of residents living too close to wind turbines.

4. Preventing sleep disturbance from wind turbine noise.

4.1 Background

4.1.1. Developers of noisy industrial processes, including wind turbines, seek to mitigate the disturbance by siting them in areas of high ambient noise, such as close to major roads. In the case of wind turbines, it is assumed that rising wind speed will not only increase turbine noise but ambient noise also. The degree to which this occurs depends on the proximity of vegetation and other structures. Motorway noise diminishes at night as the volume of traffic decreases. In addition, it is common for wind speeds to diminish at ground level as night falls while being maintained at turbine hub level, wind shear (Pedersen E and Persson Waye K. 2003, Schneider 2007). In both cases, the turbine noise will be much more audible as ambient noise decreases and explains why complaints of nocturnal noise and disturbed sleep are common. The importance of wind shear has been acknowledged in a recent technical contribution to Acoustics Bulletin (March/April 2009) from some members of the NWG calling for all noise levels to be referenced to wind speed at turbine hub height. Conditions which favour wind shear also favour amplitude modulation (Palmer 2009). Temperature inversion, where ground level air is cooler than higher level air also increases sound propagation by reflection of the noise from the boundary layer (Irvine. 2009). These conditions, which are most likely to occur at night, early morning and in winter have not received as much attention as wind shear but may be a further reason why turbine noise may be heard over greater distances than predicted.

4.1.2. Schneider (Schneider 2007) found that night time turbine noise was between 3 and 7dB(A) greater than predicted during periods of atmospheric stability: "*summer, night-time noise levels exceeded levels predicted for two sites within the Maple Ridge Wind Farm. For winds above generator cut-in speed (e.g., 3.0 m/s @ 80-m), the measured noise was 3-7 dBA above predicted levels. The decoupling of ground level winds from higher level winds, i.e.,*

atmospheric stability, was apparent in the noise data at both sites during evening and night-time periods. At wind speeds below 3.0 m/s, when wind turbines were supposedly inoperative, noise levels were 18.9 and 22.6 dBA above the expected background levels for each of the sites and these conditions occurred a majority of the time."

In addition, as noted above, the characteristics of wind turbine noise are such that it can be heard despite road noise.

4.1.3. van den Berg, in a paper presented at Euronoise 2003, investigated the relationship between calculated noise generated by wind turbines and that actually measured. He confirmed that the turbines were more audible at night principally due to amplitude modulation. To quote his paper: *"As measured immission levels near the wind park Rhede show, the discrepancy may be very large: sound levels are up to 15 dB (!) higher than expected at 400 m from the wind park. At a distance of 1500 m actual sound levels are 18 dB higher than expected, 15 dB of this because of the higher sound emission and 3 dB because sound attenuation is less than predicted by the sound propagation model."* This study, is further confirmation that calculated measures of wind turbine noise may be woefully inadequate.

4.1.4. In contrast, Bullmore and colleagues (2009) reported, from studies of four established large wind farms, that ISO 9613 predicted turbine noise immissions with reasonable accuracy and, at three of the sites, over estimated the measured sound levels. However, the actual location of the sites was not revealed although some detail was given. No attempt was made to determine the degree of wind shear during the measurement period.

4.1.5. Nelson (2007), in a small laboratory based study examined the ability of background noise to mask turbine noise. When background noise and turbine noise where adjusted to the same loudness, the residual perceived loudness of the turbine noise was approximately half of its unmasked value (1.8sone). Even when the background noise was increased from 41 to

49dB(A) the turbine noise was not fully masked. Hayes (2007) has interpreted this by stating that: *"one would expect the wind turbine (warranted to be free of tonal noise) to be audible even if the turbine noise was 10 - 15 dB below the background noise level".* It can be inferred that if tonal noise is present, the turbine noise will be audible at a greater level below background noise.

4.1.6. Bolin (2009) has reported an experimental study of the masking of wind turbine noise by vegetation noise (leaves rustling etc). Subjects were exposed to vegetation noise in a laboratory and turbine noise introduced at varying sound pressures and vice versa and a threshold for detection determined. The results were compared with the Moore and Glasberg methods for calculating masking. The results suggest that: *"....existing models of partial masking overestimate the ability to conceal wind turbine noise in ambient sounds."* In other words, wind turbine noise is not masked as well as current models predict and is thus more intrusive. This is in accord with the work of Nelson and of van den Berg and Miedema who show that traffic noise does not mask wind turbine noise as well as predicted.

4.2. Mitigation of wind turbine noise

4.2.1. Bowdler (2008) has reviewed the causation of the swishing and thumping noises associated with wind turbines. He concludes that, while there are several theories, no definitive mechanism can be established. It follows that industry claims to mitigate turbine noise by changing blade shape, pitch and turbine spacing should be treated with scepticism until definitive evidence of their efficacy are presented.

4.2.2. It follows that attempts to reduce wind turbine noise immissions after a plant becomes operational are unlikely to be successful. Noise mitigation will reduce power output, which will be opposed by the operators. The importance of assuring residents that noise limits are capable of being met before construction was emphasised by Mr Lavender, Inspector at the

Thackson's Well Inquiry (APP/E2530/A/08/2073384) who stated: *"securing compliance with noise limit controls at wind farms, in the event of a breach, is not as straightforward as with most other forms of noise generating development. This is because noise from turbines is affected primarily by external factors such as topography and wind strength, a characteristic that distinguishes them from many other sources of noise, such as internal combustion engines or amplified music, which can be more directly and immediately influenced by silencing equipment, insulation or operator control."* It follows that application of the precautionary principle is essential where there is any possibility of noise disturbance from wind turbines.

4.2.3. Thus, the **only** mitigation for wind turbine noise is to place a sufficient distance between the turbines and places of human habitation. PPS22 advises that ETSU-R-97 *should* (author's italics) be used to estimate noise levels around turbines which, taken with measurements of ambient noise, can, in theory, predict noise disturbance in adjacent properties. Many expert acousticians have severely criticised ETSU-R-97, not least Mr Dick Bowdler (2007), a former member of the Government's Noise Working Group considering ETSU-R-97. A number of Her Majesty's Inspectors have been equally critical, not least Mr Andrew Pykett (Appeal Ref: APP/Q1153/A/06/2017162) and Ms Elizabeth Ord (Appeal Ref: APP/W4705/A/09/2114165). As noted above, the recent recommendation by some members of the Noise Working Group to provide more allowance for wind shear in predicting turbine noise levels is a tacit admission of the unsuitability of ETSU-R-97 methodology for large turbines. In addition the suppressed recommendations by HMP, at least one of whose employees sat on the NWG, for a reduction in the ETSU-R-97 night time noise limits to 33-38dB(A) suggests very strongly that it is inappropriate to continue to rely on ETSU-R-97 as presently formulated.

4.2.4. Stigwood (2008) has shown that large turbines (hub heights 50-100m) are more likely than smaller turbines (hub height 30m) to cause excessive amplitude modulation, increased likelihood of low frequency noise and greater disturbance inside buildings. Internal noise can modulate over 15-

20dB, changes which is easily perceived. This is probably due to different wind speeds and atmospheric conditions at these heights. He concludes that ETSU-R-97, which was developed for smaller turbines, is inappropriate for large turbines.

4.2.5. Despite, or because of, ETSU-R-97, complaints of noise disturbance from industrial wind turbines continue and it is clear that ETSU-R-97 can not be relied upon to prevent sleep disturbance in those living near wind turbines. To quote Mr Peter Hadden in evidence to the House of Lords Economic Affairs Committee, printed 12th November 2008 para 6:

"There is material evidence available to show that ETSU R 97 has failed to provide a reasonable level of protection to family homes from unbearable noise pollution where wind turbines are located too close to homes. Symptoms include sleep disturbances and deprivation, sometimes so severe that families are forced to evacuate their homes in order to stabilise well-being and to resume normal family life. This is a worldwide phenomenon where wind turbines are located too close to homes."

4.2.6. It should be noted also that the application of ETSU-R-97 is advisory in PPS22, not mandatory (*should* not *must*). It is subordinate also to the precautionary principle set out in PPS 22. Rather than rely on a provably inadequate set of theoretical calculations to determine setback distance, it is logical to look at the real world and the relationship between setback and noise complaints from existing sites. Human senses and opinion are used to judge visual impact. It is therefore consistent and logical to rely on human senses and opinion in respect of noise impact. Many of these sites causing problems have been in place for several years. Current applications are generally for large 2.0-3MW turbines and thus allowance must be made for their additional noise in determining setback.

4.2.7. While it may be possible to produce a reasonable acoustically based theoretical approach to calculating set-back distances (Kamperman and James 2008b), it makes more sense to rely on recommendations from observations of the effects on real people at established wind farms and the dose-response relationship described by Pedersen (2009a&b) is relevant.

4.3. Conclusions

4.3.1. There are two possible approaches to judging an appropriate setback distance. The first is to determine a dose-response relationship between turbine noise and a health concern, for example, sleep disturbance. The next step is to determine an acceptable level of sleep disturbance. For example, should it be 0%, 1% or 5% of the population for 1 night per year, per month or per week? Consideration should be given to whether the measured concern, in this case reported sleep disturbance, is sufficiently sensitive. I have shown that reported sleep disturbance is the tip of an iceberg and that arousals with sleep fragmentation are likely to be more common and insidious with consequences including fatigue and elevated blood pressure In this situation, it would be appropriate to invoke the precautionary principle and select a conservative dose level (turbine noise) that minimises the measured response (sleep disturbance). Examination of data from the Swedish and Dutch studies suggests that an external predicted noise level of no more than 35dB(A) LA_{90} would be appropriate. This view is supported by a presentation by members of RIVM, the widely respected Dutch National Institute for Public Health and Environment, (Jabben et al 2009) which recommends an outdoor L_{den} limit of 40dB(A) which corresponds to an external noise level of about 35dB(A). The data is now available as a RIVM report (Verheijen et al., 2009) which recommends that wind turbine parks be designed so as to stay below L_{den} 40 dB at nearby dwellings which is regarded as the “no effect” level. L_{den} 45 dB(A) is recommended as a maximum allowable limit which should avoid severe effects and minimise health effects.

Hayes (2007), of the Hayes McKenzie Partnership. notes that “the intent of New Zealand Standard 6808 is not inaudibility but the prevention of severe annoyance”. The relevant section of that Standard states:

“***4.4.2 Acceptable limit***

As a guide to the limits of acceptability, the sound level from the WTG (or windfarm) should not exceed, at any residential site, and at any of the

nominated wind speeds, the background sound level (L_{95}) by more than 5dB(A), or a level of 40 dB(A) L_{95}, whichever is the greater.

Hayes therefore concedes that the noise level above which **severe annoyance** occurs is 40dB(A) L_{95}. Thorne (2010c), from an analysis of noise complaints concludes that **unreasonable** noise occurs at noise levels above 30dB(A)$_{LA90}$ in the presence of excess amplitude modulation. Together with van den Berg he states: "*We believe annoyance and loss of amenity will be protected when the wind turbine noise limit would be 30 dBA L_{95} in conditions of low wind speed at the dwellings and modulation restricted to 3dB"*.

Overall, it is apparent that the present ETSU-R-97 night time noise limits are too high to protect receptors from severe annoyance and sleep disturbance and that a level of 35dB(A) LA_{90} is appropriate, in the absence of excessive modulation.

4.3.2. The second approach is to correlate reports from those living in proximity to wind turbines to their distance to the turbines, the approach taken by, amongst others, WindVoice. This has the disadvantage that symptoms are generally self-reported and subjective. Nevertheless, it can be argued that it is logical to rely on the actual reports of human receptors in the same way that human opinions are used to judge visual amenity. It has the advantage also that it may better detect those subjects that are most sensitive to turbine noise than surveys. It has the merit also of simplicity. The New South Wales Legislative Council General Purpose Standing Committee No 5, under the Chairmanship of Mr Ian Cohen, a member of the Green Party, has recently published the report of an inquiry into rural wind farms (NSW 2009). Recommendation 7 to the NSW Planning Minister is for a minimum setback of 2 km. In the UK, Mr Peter Luff, MP for Mid-Worcestershire, was given leave to introduce a Bill to Parliament to establish a legal minimum setback distance. This Bill was lost with the recent dissolution of Parliament and election but Lord Reay has recently introduced a similar Bill in the House of Lords.

4.3.3. **Table II** (see end of text) shows recommendations for setback distance by a number of authorities. References can be found in the Bibliography. In general, noise engineers recommend lesser setback distances than physicians. The former rely more on measured and/or calculated sound pressures and the latter on clinical reports. It is logical to prefer the actual reports of the humans subjected to the noise rather than abstract calculations, even if the latter accurately measure ambient noise and allow for the low frequency components of wind turbine noise. Calculations can not measure annoyance and sleep disturbance, only humans can do so. **In my opinion, based on the reports cited in the table and the data from WindVoice, a minimum setback of 1.5km is appropriate.**

5. Planning considerations

5.1 ETSU-R-97

5.1.1. UK Government policy is that ETSU-R-97 should be used for the assessment of the likely impact of wind turbine noise and this was restated in a 2007 policy statement. Developers will often assert that, as it is government policy, ETSU-R-97 may not be questioned. However, as Mr Justice Mitting stated in a judicial review brought by the Renewable Energy Foundation (CO/9686/2007): "It will always be open to any objector to an application for permission to develop a site as a windfarm, to contend that the Statement is technically inadequate or erroneous." David Forsdick, of Landmark Chambers, a leading barrister with particular expertise in planning matters, stated, at a seminar on renewable energy on the 1st October 2008 (Forsdick 2008):

"...., general policy and guidance cannot prevent consideration of:

a. the specific facts of an individual case;

b. scientific information which suggests that the general methodology may need to be adjusted on the facts of an individual case; or

c. actual experience elsewhere on the ground which shows that the government approved methodology does not always accurately predict the impacts.

Thus, whilst it is undoubtedly true that it is not for parties to an inquiry to question the merits of government policy, their evidence on the matters in the previous paragraph is plainly capable of constituting "other material considerations" which the decision maker has to take into account and, in an appropriate case, reach a conclusion on.

5.1.2 It would seem logical that the specific facts of an individual case would include the presence of particularly sensitive or vulnerable receptors, such as the elderly and children, and the likelihood of excessive wind shear or amplitude modulation.

5.1.3. There is now a large body of scientific information showing that the ETSU-R-97 methodology is in need of adjustment for wind shear and amplitude modulation. Many developers have acknowledged this by making an allowance for wind shear. The evidence that adjustments are necessary for amplitude modulation is equally strong.

5.1.4. There is a large body of evidence also showing that ETSU-R-97 noise levels are too high for human health and well being. These include the 2009 WHO Night Noise Guidelines and the 2006 draft reports by HMP to DTI.

5.1.5. It follows that it is appropriate and reasonable for planners and decision makers not to rely exclusively on ETSU-R-97 methodology and to take account of the other material considerations set out in this paper.

6. Overall Conclusions

6.1. The appropriate mitigation of sleep disturbance and annoyance from industrial wind turbine noise is a maximum external turbine noise level of 35dB(A) or a setback of at least 1.5km.

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16th November 2010

7. Bibliography

Acoustic Ecology Institute. AEI special report: Wind energy noise impacts. http://www.acousticecology.org/srwind.html

Adams JW. 2008. The Public Health Issue. Essex County Wind Resistance. http://essexcountywind.wordpress.com/2008/09/26/public-health-and-industrial-wind-turbine-noise-in-ontario/

Ambrose S and Rand R. 2010.Wind turbine noise: noise complaints predictable. Herald Gazette 30th October 2010. http://knox.villagesoup.com/column/columnpost/wind-turbine-noise-noise-complaints-predictable/359597

Bakker H et al. 2009. Seismic Effect on Residents from 3 MW Wind Turbines Third International Meeting on Wind Turbine Noise Aalborg Denmark 17 – 19 June 2009

Barregard L, Bonde E and Ohrstrom E. 2009. Risk of hypertension from exposure to road traffic noise in a population based sample. Occup. Environ. Med. 66:410-415.

Basner M et al. 2008a. Aircraft noise: Effects on macro- and microstructure of sleep. Sleep Medicine, 9 (4): 382-387

Basner M. 2008b. Nocturnal aircraft noise exposure increases objectively assessed daytime sleepiness. Journal of Sleep Research 17:Supplement 1;P512

Belojevic G et al. 2008. Urban road traffic noise and blood pressure and heart rate in preschool children. Environment International. 34:226-231

Bennett D. 2008. Evidence to the Environment Court, Wellington, NZ. Appeal No. ENV-2007-WLG-000098 between Motorimu Wind Farm Ltd and Palmerston North City Council and Horowhenua District Council.

van den Berg GP. 2003. Wind turbines at night: acoustical practice and sound research. Euronoise 2003. Paper 160.

van den Berg GP. 2004. Effects of the wind profile at night on wind turbine sound. Journal of Sound and Vibration. 277:955-970

van den Berg GP. 2005: The beat is getting stronger: the effect of atmospheric stability on low frequency modulated sound of wind turbines, Journal of Low Frequency Noise, Vibration And Active Control24 (1), pp. 1-24

van den Berg G P. 2006. The sound of high winds: the effect of atmospheric stability on wind turbine sound and microphone noise *Doctoral Thesis* Groningen, The Netherlands; Rijksuniversiteit Groningen

van den Berg G P., et al. 2008. WINDFARMperception. Visual and acoustic impact of wind turbine farms on residents. FP6-2005-Science-and-Society-20. Specific Support Action Project no. 044628

Berry B and Flindell I. 2009. Estimating Dose-response relationships between noise exposure and human health impacts in the UK. Final Project Report BEL 2009-001. Berry Environmental Ltd (BEL).

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

Boselli M et al. 1998. Effect of age on EEG arousals in normal sleep. Sleep, 21 (4): 351-357

Bowdler D. 2007. ETSU-R-97: why it is wrong. New Acoustics. www.newacoustics.co.uk

Bowdler D. 2008. Amplitude modulation of Wind Turbine Noise. A Review of the Evidence

Bruck D et al. 2009. How does the pitch and pattern of a signal affect auditory arousal? Journal of Sleep Research 18:196-203

Bullmore A et al. 2009. Wind farm noise predictions and comparison with measurements. Third International Meeting on Wind Turbine Noise, Aalborg, 17-19 June 2009.

Butré J-L. 2005. French St. Crepin windplant noise survey results (2005), cited as a personal communication from J-L Butre, Ventducobage, 11-5-05 in Pierpont N. 2006.

CMOH. 2010. The potential health impact of wind turbines. Chief Medical Officer of Health, Ontario, Report No 014894

Chouard C-H. 2006. Le retentissement du fonctionnement des eoliennes sur la sante de l'homme [Repercussions of wind turbine operations on human health]. French National Academy of Medicine. Panorama du medecin, 20 March 2006

Clean Energy Council. 2010. Wind Farms Technical Paper: Environmental Noise. S3387C6 http://www.cleanenergycouncil.org.au/cec/resourcecentre/reports.html

Colby et al. 2009. Wind Turbine Sound and Health Effects; An Expert Panel Review. American and Canadian Wind Energy Associations.

Dang-Vu et al. 2010. Spontaneous brain rhythms predict sleep stability in the face of noise. Current Biology. 20:R626-7.

Davis J and Davis S. Noise pollution from wind turbines – living with amplitude modulation, low frequency emissions and sleep deprivation. Wind Turbine Noise 2007.

Dixsaut G et al. 2008. Wind turbines and noise: is there a minimal siting distance? Epidemiology. 19(6) Supplement S216.

Driscoll D. 2009. Environmental Discussion – response to questions about noise. Presented at Environmental Stakeholder Roundtable on Wind Power. New York State Energy Research and Development Agency. June 16th 2009.

DTI. 2006. The Measurement of Low Frequency Noise at Three UK Wind Farms – W/45/00656/00/00 – Hayes McKenzie Partnership. Plus draft reports 2006a, b, c.

Flindell IH, Stallen PM. 1999. Non-acoustical factors in environmental noise. Noise Health;1:11-6

Forsdick D. 2008 Noise and wind turbine proposals. Renewable Energy Seminar paper, 1st October 2008. http://www.landmarkchambers.co.uk /__data/assets/pdf_file/0004/32539/3.2_Noise__and__Wind_Turbines.pdf

Frey BJ. and Hadden PJ. 2007. Noise radiation from wind turbines installed near homes: effects on health. www.windnoisehealthhumanrights.com

Gohlke JM et al. 2008. Health, economy and environment: sustainable energy choices for a nation. Environmental Health Perspectives. 116:A236-7

Griefahn B; et al. 2008. Autonomic arousals related to traffic noise during sleep. Sleep. 31:569-577.

Haralabidis AS et al. 2009 Acute effects of night-time noise exposure on blood pressure in populations living near airports. European Heart Journal March 2008; 29: 658 – 664

Harry A. 2007. Wind turbines, noise and health. www.savewesternny.org/pdf/wtnoise_health_2007_a_barry.pdf

Hayes M. 2007. Affidavit in reply. Makara Wind Farm. New Zealand Environmental Court. W59/2007

Health Protection Agency 2009. Environmental Noise and Health in the UK – Draft. Ed. Dr A Moorhouse.

Horonjeff RD. 2010. Siting of wind turbines with respect to noise emissions and their health and welfare effects on humans. Document prepared in response to the Public Service Commission of Wisconsin “Measurement protocol for sound and vibration assessment of proposed and existing wind electric generation plans.” May 2010.

Irvine T. 2009. Wind Turbine Noise. Vibrationdata Newsletter May 2009 pp12-22. http://www.vibrationdata.com/Newsletters/June2009_NL.pdf

Ito A and Takeda T. 2010. Sickness claims prompt study of wind turbines.The Asahi Shimbun. 19th January 2010

Jabben J, -Verheijen E and Schreurs E. 2009. Impact of wind turbine noise in the Netherlands. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Jarup L et al. 2008. Hypertension and Exposure to Noise Near Airports: the HYENA Study. Environmental Health Perspectives. 116:329–333

Kabes DE and Smith C. 2001. Lincoln Township Wind Turbine Survey, Agricultural Resource Center, University of Wisconsin Extension/Cooperative Extension, May 16, 2001.

Kamperman GW and James RR. 2008. Simple guidelines for siting wind turbines to prevent health risks. Noise-Con 2008. Dearborn, Michigan.

Kamperman GW and James RR. 2008b. The "How To" guide to siting wind turbines to prevent health risks from sound. http://www.windturbinesyndrome.com/wp-content/uploads/2008/11/kamperman-james-10-28-08.pdf

de Kluizenaar, Y et al. 2009. Long-term road traffic noise exposure is associated with an increase in morning tiredness. J Acoust Soc Am 126:626-33

Martin SE. et al. 1997. The effect of nonvisible sleep fragmentation on daytime function. American Journal of Respiratory and Critical Care Medicine, 155 (5): 1596-1601

Meerlo, P et al. 2008 Restricted and disrupted sleep: Effects on autonomic function, neuroendocrine stress systems and stress responsivity. Sleep Med Rev. 12:197-210

Miedema, H. et al. 2000. Community reaction to aircraft noise; time-of-day penalty and tradeoff between levels of overflights. J. Acoust. Soc. Am. 107, 3245–3253.

Møller, H., and Lydolf, M. 2002: A questionnaire survey of complaints of infrasound and low frequency noise. *Jnl Low Freq Noise Vibn* 21, 53 - 65.

Moorhouse A et al. 2007. Research into Aerodynamic Modulation of Wind Turbine Noise. Final Report. DEFRA Contract NANR233

Muzet A, Miedema H. 2005. Short-term effects of transportation noise on sleep with specific attention to mechanisms and possible health impact. Draft paper presented at the Third Meeting on Night Noise Guidelines, WHO European Center for Environment and Health, Lisbon, Portugal 26-28 April 2005. Pp. 5-7 in *Report on the Third Meeting on Night Noise Guidelines*, available at: http://www.euro.who.int/Document/NOH/3rd_NNG_final_rep_rev.pdf.

NHMRC 2010. Wind Turbines and Health: A rapid review of the evidence. Australian Government National Health and Medical Research Council.

National Health Service, News Service. 2009. Are wind farms a health risk? http://www.nhs.uk/news/2009/08August/Pages/Arewindfarmsahealthrisk.aspx

National Health Service, News Service. 2010. Wind turbine sound 'needs research'. http://www.nhs.uk/news/2010/01January/Pages/Wind-turbine-sound-and-health.aspx

New South Wales. Parliament. Legislative Council. General Purpose Standing Committee No. 5 2009. Rural wind farms / General Purpose Standing Committee No. 5. [Sydney, N.S.W.] : the Committee, 2009. – XXIV, 208 p. ; 30 cm. (Report ; no. 31)

New Zealand Standards. 2009. Acoustics – Wind farm noiseDZ6808/v2.4 Committee: 6808

Nissenbaum M. 2010. Mars Hill study, preliminary results. http://www.windvigilance.com/mars_hill.aspx

Palmer W. 2009. A new explanation for wind turbine woosh – wind shear. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Pedersen E and Persson Waye K. 2003. "Perception and annoyance of wind turbine noise in a flat landscape", Proceedings of Internoise 2002, Dearborn

Pedersen E and Persson Waye K. 2004. Perception and annoyance due to wind turbine noise—a dose-response relationship *J. Acoust. Soc. Am.* 116 3460–347

Pedersen E and Persson Waye K. 2007 Response to wind turbine noise in different living environments *Occup. Environ. Med.* 64 480–6

Pedersen E. and Persson Waye K. 2008. Wind turbines – low level noise sources interfering with restoration? Environmental Research Letters. 3:015002

Pedersen E. 2009a. Effects of wind turbine noise on humans. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Pedersen E et al. 2009b. Response to noise from modern wind farms in The Netherlands. J Acoust. Soc. Am. 126:634-643.

Petrie KJ. 2010. Statement of evidence on behalf of Meridian Energy Limited to the Environment Court, Wellington. ENV-2009-WLG-000060-63,65

Phillips CV. 2010. An analysis of the epidemiology and related evidence on the health effects of wind turbines on local residents. Evidence to the Public Service Commission of Wisconsin on behalf of the Brown County Citizens for Responsible Wind Energy. Docket 1-AC-231, Wind Siting Rules.

Phipps R et al. 2007. Visual and noise effects reported by residents living close to Manawatu wind farms: preliminary survey results. Evidence to the Joint Commissioners, 8th-26th March 2007, Palmerston North

Phipps R. 2007a. Evidence of Dr Robyn Phipps, In the Matter of Moturimu Wind Farm Application heard before the Joint Commissioners 8th – 26th March 2007 Palmerston North

Pierpoint N. 2005. Health, hazard, and quality of life. Wind power installations – how close is too close? www.windturbinesyndrome.com.

Pierpont N. 2006. Wind Turbine Syndrome: Noise, Shadow Flicker, and Health. www.windturbinesyndrome.com.

Pierpont N. 2009. Wind Turbine Syndrome: A Report on a Natural Experiment. K Selected Publications. Santa Fe, New Mexico.

Pirrera S, De Valck E, Cluydts R. 2009. Nocturnal road traffic noise and sleep quality: Habituation effects assessed in a test-retest field situation. Sleep 32:A422.

Pool R. 2009. A quiet revolution. E&T Magazine. 5th October. Institute of Engineering and Technology.

Punch J et al. 2010. Wind turbine noise: what audiologists should know. Audiology Today. JulyAug2010:20-31.

Rashleigh S. 2008 and 2009. Evidence to the Montreathmont Public Enquiry, Angus, Scotland. See also: http://www.spaldingtoday.co.uk/news/Bicker-house-blighted-by-turbines.4378933.jp

Salt AN and Hullar TE. 2010. Responses of the ear to low frequency sounds, infrasound and wind turbines. Hearing Research. In press.

Saremi M et al. 2008. Sleep related arousals caused by different types of train. Journal of Sleep Research 17:Supplement 1;P394

Schneider CP. 2007. Accuracy of Model Predictions and the Effects of Atmospheric Stability on Wind Turbine Noise at the Maple Ridge Wind Power Facility, Lowville, NY.

Scottish Executive. 2007. Scottish Planning Policy SPP 6 Renewable Energy. Annex A.

Selander J et al. 2009. Long term exposure to raod traffic noise and myocardial infarction. Epidemiology. 20:272-279

Shepherd D. 2010. Wind turbine noise and health in the New Zealand context. In: Rapley, B. I. and Bakker, H. H. C., Sound, Noise, Flicker and the Human Perception of Wind Farm Activity. Atkinson & Rapley Consulting Ltd, Palmerston North, New Zealand. ISBN 978-0-473-16558-1.

Shepherd D et al. 2010a. Opposition to wind turbines: noise about nothing?. Presentation to the International Symposium on Sustainability in Acoustics, Sydney. August 29th-31st 2010.

Stigwood M. 2008. Evidence to the Public Enquiry into the proposed North Dover Wind Park. PINS Ref: APP/X2220/A/08/2071880/NWF.

Society for Wind Vigilance 2010 a & b. An Analysis of the American/Canadian Wind Energy Association sponsored: “Wind Turbine Sound and Health Effects: An Expert Panel Review, December 2009”.

Society for Wind Vigilance 2010c. Delay, Denial and Disappointment. An Analysis of the Chief Medical Officer of Health (CMOH) of Ontario. “The Potential Health Impacts of Wind Turbines May 2010”

Society for Wind Vigilance 2010d. Haste Makes Waste. An Analysis of the National Health and Medical Research Council “Wind Turbines and Health A Rapid Review of the Evidence July 2010”

The Noise Association. 2006. Location, location, location. An investigation into wind farms and noise by The Noise Association.

Thorne R. 2010a & b. Statement of Evidence (and Addenda) of Dr. Robert Thorne Called by Huatau Marae for the Mighty River Power Turitea Redesign, February 2010. New Zealand.

Thorne R. 2010c. Noise Impact Assessment with respect to the Yaloak Wind Farm. Evidence to the Yaloak Wind Farm inquiry. PL-SP/05/0098. Australia

Todd N et al. 2008. Tuning and sensitivity of the human vestibular system to low-frequency vibration. Neuroscience Letters 444;36–41

Van Hee VC et al. 2009. Exposure to traffic and left ventricular mass and function. The Multi-ethnic study of atherosclerosis (MESA). Am J Respir Crit Care Med. 179:827-834.

Verheijen E et al. 2009. Evaluatie nieuwe normstelling windturbinegeluid. RIVM-rapport 680300007/2009

Welsh Affairs Committee, *Wind Energy*, 13 July 1994, HC 336-I 1993-94, xxvi, para 71

WindVoice. 2010. A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance. http://windvigilance.com/down.aspx

World Health Organisation. 2009. Night noise guidelines for Europe. Copenhagen.

World Health Organisation. 2009a. Environmental Burden of Disease – European countries (EBoDE) project. Report of the first project meeting, Bonn, Germany, 12th-13th February 2009.

Yardley W. 2010. Turbines too loud? Here, take $5,000. New York Times July 31, 2010.

Figure 1. Sound level and annoyance for different noise sources (van den Berg 2008)

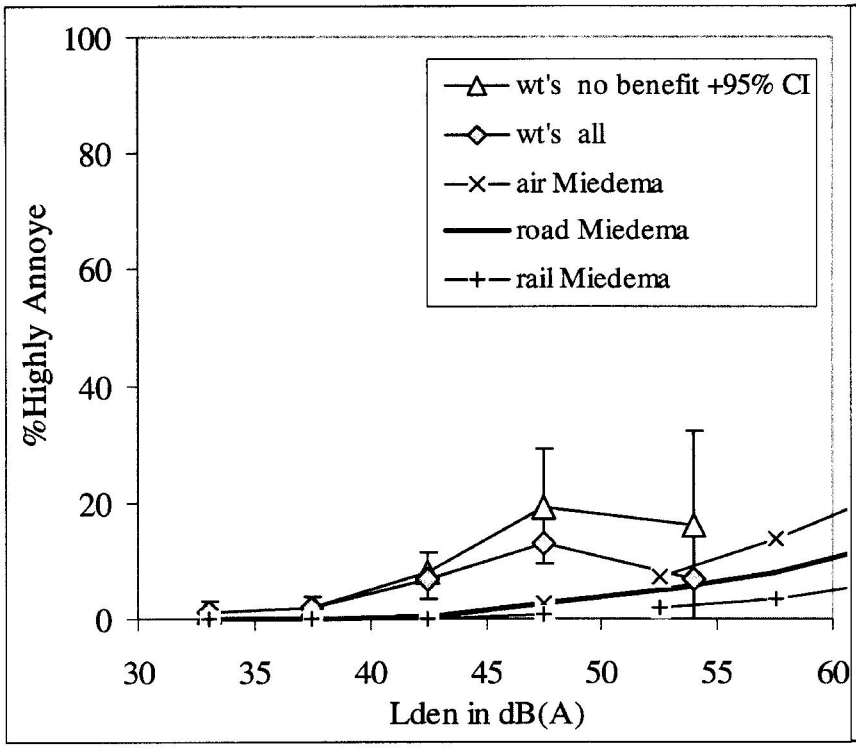
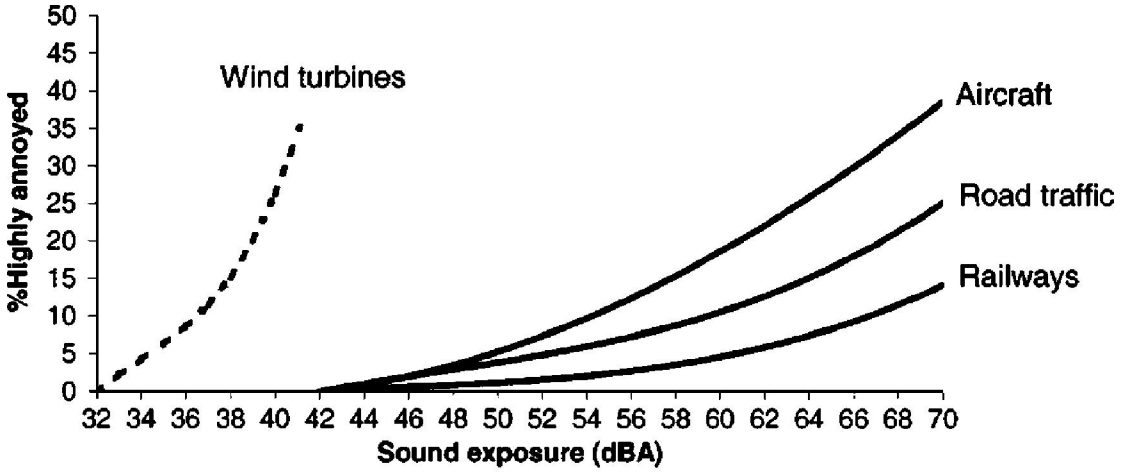


Figure 8.1: relation between sound level Lden and percentage highly annoyed residents exposed to that sound, for three transportation noise sources and for wind turbines; the relation is given for all respondents and for those that have no economical benefit from a wind turbine.

Bars denote 95% confidence interval for non-benefitters.

Figure 2. Sound level and annoyance for different noise sources (Pedersen E and Persson Waye, 2004)



Sound exposure is for wind turbines calculated A-weighted L_{eq} for a hypothetical time period and for transportation DNL.

Figure 3. Relationship between A-weighted sound pressure levels (equivalent levels at wind speed 8 m/s, 10 m over the ground) and proportion of respondents disturbed in the sleep by noise in three studies: SWE00 (*n* = 341), SWE05 (*n* = 746) and NL07 (only respondents that did not benefit economically from wind turbines; *n* = 593). (Pedersen 2009)

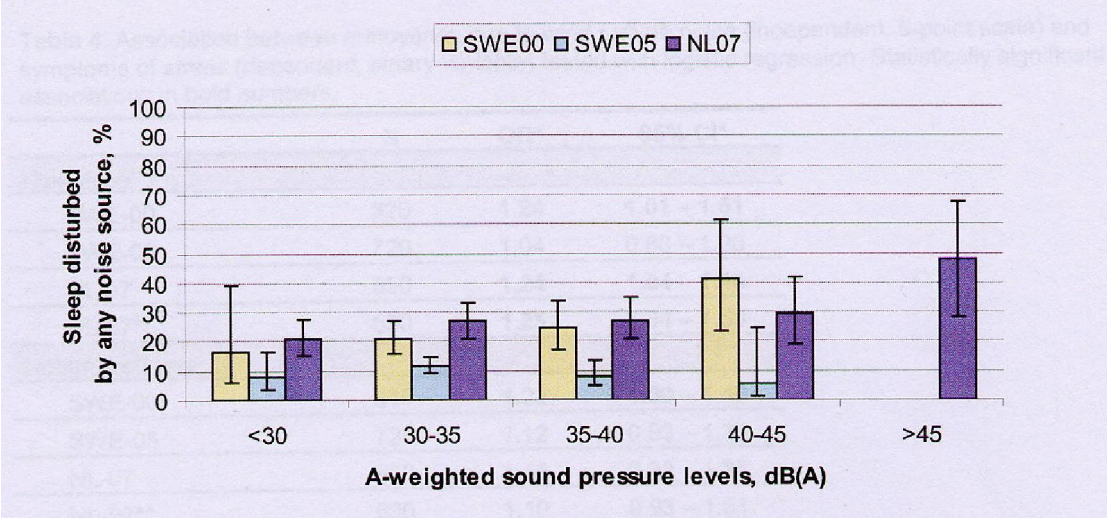


Figure 4. Spindle rate and sleep stability. Observations were pooled among subjects in the lower and upper halves of the spindle rate distribution (ranges 4.57-5.44 and 5.58-6.14 spindles/min respectively) based on EEG lead C3 during stage N2. Corresponding sleep survival curves were derived from each pool in stage N2 using the Kaplan-Meier (product-limit) method.

Backward extrapolation of the response curve for low spindle rate subjects shows only a 50% likelihood of stable sleep at noise levels of 35 dB(A) and 75% likelihood for those with high spindle rates. From Dang-Vu et al., 2010

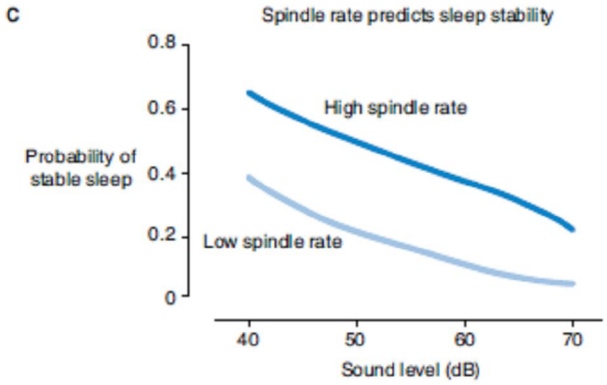


Figure 5. Percent of community highly annoyed by wind turbine noise correlated to normalized EPA community reactions to intrusive noise. From Ambrose 2010

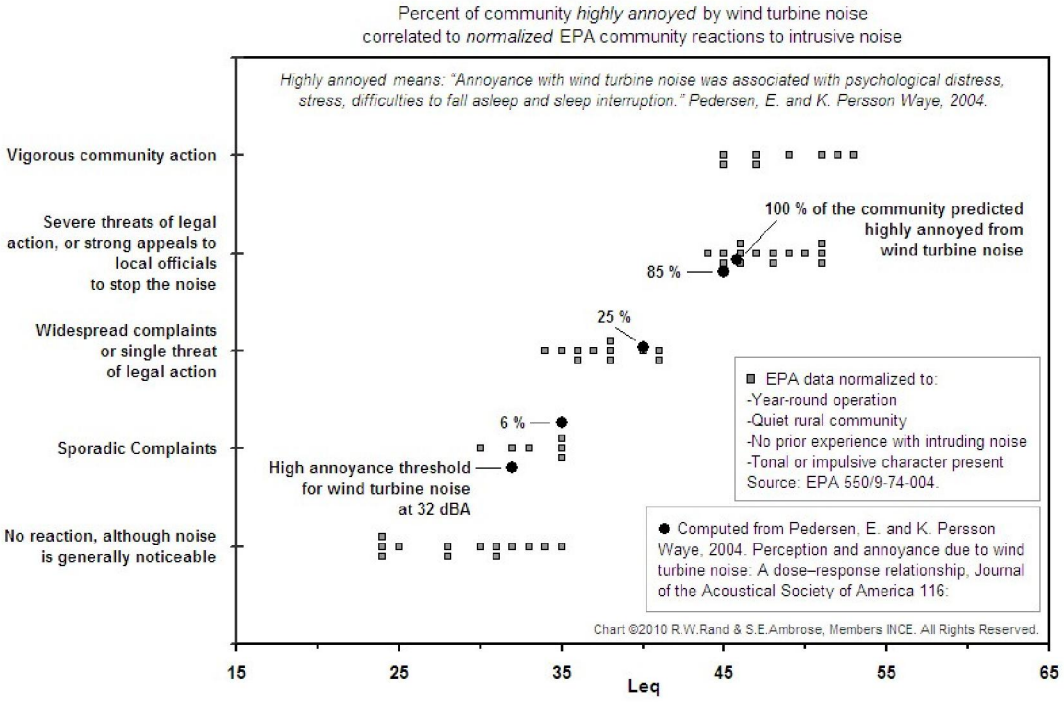


Table I. Response to wind turbine noise outdoors or indoors, proportion of respondents (*n*=708) according to 5-dB(A) sound level intervals, and 95% confidence intervals (95%CI). (From Pedersen 2009a)

	Predicted *A*-weighted sound pressure levels dB(A)				
	<30	30–35	35–40	40–45	>45
Outdoors *n*	178	213	159	93	65
Do not notice (%) (95%CI)	75 (68–81)	46(40–53)	21(16–28)	13 (8–21)	8(3–17)
Notice, but not annoyed (%) (95%CI)	20 (15–27)	36(30–43)	41(34–49)	46 (36–56)	58(46–70)
Slightly annoyed (%) (95%CI)	2 (1–6)	10(7–15)	20 (15–27)	23 (15–32)	22(13–33)
Rather annoyed (%) (95%CI)	1 (0–4)	6(4–10)	12 (8–18)	6 (3–13)	6(2–15)
Very annoyed (%) (95%CI)	1 (0–4)	1(0–4)	6 (3–10)	12 (7–20)	6(2–15)
Indoors, *n*	178	203	159	94	65
Do not notice (%) (95%CI)	87 (81–91)	73(67–79)	61(53–68)	37 (28–47)	46(35–58)
Notice, but not annoyed (%) (95%CI)	11(7–17)	15(11–20)	22 (16–29)	31(22–31)	38(28–51)
Slightly annoyed (%) (95%CI)	1 (0–4)	8(5–12)	9 (6–15)	16 (10–25)	9(4–19)
Rather annoyed (%) (95%CI)	0 (0–2)	3(1–6)	4 (2–8)	6 (3–13)	5(2–13)
Very annoyed (%) (95%CI)	1 (0–4)	1(0–4)	4 (2–8)	10 (5–17)	2(0–8)

Table II. Recommendations for setback of residential properties from industrial wind turbines

Note 1. The 2km limit from edges of towns and villages seems to have been set more for visual than noise reasons
Note 2. Dixsaut and colleagues (2009) report a review of this recommendation by AFSSET. They concluded that the 1.5km setback was “not relevant” and would compromise wind park development.

Authority	Year	Notes	Recommendation	
			Miles	Kilometres
Frey & Hadden	2007	Scientists. Turbines >2MW	>1.24	>2
Frey & Hadden	2007	Scientists. Turbines <2MW	1.24	2
Harry	2007	UK Physician	1.5	2.4
Pierpont	2008	US Physician	1.5	2.4
Welsh Affairs Select Committee	1994	Recommendation for smaller turbines	0.93	1.5
Scottish Executive	2007	See note 1.	1.24	2
Adams	2008	US Lawyer	1.55	2.5
Bowdler	2007	UK Noise engineer	1.24	2
French National Academy of Medicine	2006	French physicians See note 2	0.93	1.5
The Noise Association	2006	UK scientists	1	1.6
Kamperman & James	2008	US Noise engineers	>.62	>1
Kamperman	2008	US Noise engineer	>1.24	>2
Bennett	2008	NZ Scientist	>0.93	>1.5
Acoustic Ecology Institute	2009	US Noise engineers	0.93	1.5
NSW General Purpose Standing Committee	2009	Legislators	1.24	2
Thorne	2010	Aus/NZ acoustician	1.24	2
Horonjeff	2010	US acoustician	1.5-2	2.4-3.2


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Vestas®

4 MW PLATFORM



Wind. It means the world to us.™

003465

Are you looking for the maximum return on **your investment** in wind energy?

Wind energy means the world to us. And we want it to mean the world to our customers, too, by maximising your profits and strengthening the certainty of your investment in wind power.

That's why, together with our partners, we always strive to deliver cost-effective wind technologies, high quality products and first class services throughout the entire value chain. And it's why we put so much emphasis on the reliability, consistency and predictability of our technology.

We have more than 35 years' experience in wind energy. During that time, we've delivered 90 GW of installed capacity in 77 countries. That is more than anyone else in the industry. We currently monitor over 33,000 wind turbines across the globe. All tangible proof that Vestas is the right partner to help you realise the full potential of your wind site.

What is the 4 MW Platform today?
The Vestas 4 MW platform* was introduced in 2010 with the launch of the V112-3.0 MW®. Over 17 GW of the 4 MW platform has been installed all over the world onshore and offshore making it the obvious choice for customers looking for highly flexible and trustworthy turbines.

Since then the 4 MW platform was upgraded and new variants were introduced utilising untapped potential of the platform. All variants carry the same nacelle design and the hub design has been re-used to the largest extend possible. In addition, our engineers have increased the nominal power across the entire platform improving your energy production significantly.

With this expansion, the 4 MW platform covers all IEC wind classes with a variety of rotor sizes and a higher rated output power of up to 4.2 MW.

You can choose from the following turbines on the 4 MW platform:
- V105-3.45 MW™ – IEC IA
- V112-3.45 MW® – IEC IA
- V117-3.45 MW® – IEC IB/IEC IIA
- V117-4.2 MW™ – IEC IB/IEC IIA/IEC S
- V126-3.45 MW® – IEC IIB/IEC IIA
- V136-3.45 MW® – IEC IIB/IEC IIIA
- V136-4.2 MW™ – IEC IIB/IEC S
- V150-4.2 MW™ – IEC IIIB/IEC S

All variants of the 4 MW platform are based on the proven technology of the V112-3.0 MW® with a full-scale converter, providing you with superior grid performance.

Our 4 MW platform is designed for a broad range of wind and site conditions, enabling you to mix turbines across your site or portfolio of sites, delivering industry-leading reliability, serviceability and exceptional energy capture, optimising your business case.

All turbine variants are equipped with the same ergonomically designed and very spacious nacelle which makes it easier for maintenance crews to gain access, so they can reduce the time spent on service while maximizing the uptime without compromising safety. All turbines can be installed and maintained using standard installation and servicing tools and equipment further reducing the operation and maintenance costs by minimising your stock level of spare parts.

*Formerly named the Vestas 3 MW platform



+63,000

The V112-3.45 MW® and the other 4 MW variants advance the already proven technology powering over 63,000 installed Vestas turbines worldwide - more than any other supplier.

How does our technology generate **more energy?**

More power for every wind site
V112-3.45 MW®, V117-3.45 MW®, V117-4.2 MW™, V126-3.45 MW®, V136-3.45 MW®, V136-4.2 MW™ and V150-4.2 MW™ are available with several Sound Optimised Modes to meet sound level restrictions with an optimised production. The power system enables superior grid support and it is capable of maintaining production across severe drops in grid voltage, while simultaneously minimising tower and foundation loads. It also allows rapid down-rating of production to 10 per cent nominal power.

Proven technologies - from the company that invented them
The 4 MW platform is a low-risk choice. It is based on the proven technologies that underpin more than 62,000 Vestas turbines installed around the world. Using the best features from across the range, as well as some of the industry's most stringently tested components and systems, the platform's reliable design minimises downtime – helping to give you the best possible return on your investment.

With an operating range that covers all wind classes, our 4 MW platform delivers unrivalled energy production. The proven blade technology from the V112-3.0 MW® is used on the V105-3.45 MW™, the V112-3.45 MW®, V117-3.45 MW® and V117-4.2 MW™. The industry known structural shell blades are used on the V126-3.45 MW®, V136-3.45 MW®, V136-4.2 MW™ and V150-4.2 MW™- a technology which is also used on the 2 MW V110-2.0 MW®, V116-2.0 MW™ and V120-2.0 MW™ variants.

Reliable and robust
The Vestas Test Centre is unrivalled in the wind industry. We test most nacelle components using Highly Accelerated Life Testing (HALT) to ensure reliability. For critical components, HALT identifies potential failure modes and mechanisms. Specialised test rigs ensure strength and robustness for the gearbox, generator, yaw and pitch system, lubrication system and accumulators. Our quality-control system ensures that each component is manufactured to design specifications and performs at site. We systematically monitor measurement trends that are critical to quality, locating defects before they occur.

The 4 MW platform covers all wind segments enabling you to find the best turbine for your specific site.

WINDCLASSES - IEC

TURBINE TYPE	IEC III (6.0 - 7.5 m/s)	IEC II (7.5 - 8.5 m/s)	IEC I (8.5 - 10.0 m/s)
4 MW TURBINES			
V105-3.45 MW™ IEC IA			■
V112-3.45 MW® IEC IA			■
V117-3.45 MW® IEC IB/IEC IIA		■	■
V117-4.2 MW™ IEC IB/IEC IIA/IEC S		■	■
V126-3.45 MW® IEC IIA/ IEC IIB	■	■	■
V136-3.45 MW® IEC IIB/ IEC IIIA	■	■	■
V136-4.2 MW™ IEC IIB/IEC S	■	■	■
V150-4.2 MW™ IEC IIIB/IEC S	■	■	

■ Standard IEC conditions ■ Site dependent

Options available for the 4 MW platform

An option is an extra feature that can be added to the turbine to suit a project's specific needs. By adding options to the standard turbine, we can enhance the performance and adaptability of the wind power project and facilitate a shorter permitting cycle at restricted sites. The options can even be a decisive factor in realising your specific project, and the business case certainty of the investment.

Here is a list of the options available for the 4 MW platform:

- Power Optimised Modes
- Load Optimised Modes
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Vestas De-Icing
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

Life testing

The Vestas Test Centre has the unique ability to test complete nacelles using technologies like Highly Accelerated Life Testing (HALT). This rigorous testing of new components ensures the reliability of the 4 MW platform.



Is the 4 MW platform the optimal choice for **your specific site?**

One common nacelle – six different rotor sizes
The wind conditions on a wind project site are often not identical. The 4 MW platform features a range of turbines that cover all wind classes and combined across your site they can maximise the energy output of your wind power plant.

Tip-height restrictions and strict grid requirements
With a rotor size of 105 m, the V105-3.45 MW™ IEC IA is the turbine that fits the most severe wind conditions. It has an extremely robust design for tough site conditions and is especially suited for markets with tip-height restrictions and high grid requirements.

Like all the other 4 MW turbines, the V105-3.45 MW™ is equipped with a full-scale converter ensuring full compliance with the challenging grid codes in countries like the UK and Ireland.

Cold climates
The V112-3.45 MW®, V117-3.45 MW® , V117-4.2 MW™, V126-3.45MW®, V136-3.45 MW® can be combined with Vestas De-Icing and Vestas Ice Detection ensuring optimum production in cold climates.

The Vestas De-Icing System is fully SCADA integrated and can be triggered automatically or manually depending on your de-icing strategy. Automatic control protects your investment, optimising the trigger point so the turbine only stops to de-ice when there is an expected net power production gain.

High- and medium-wind sites
The V112-3.45 MW® IEC IA is a high-wind turbine and has a very high capacity factor. Similar to the other 4 MW turbines, the V112-3.45 MW® IEC IA turbine makes efficient use of its grid compatibility and is an optimal choice for sites with MW constraints.

On medium wind-sites, the V117-3.45 MW® IEC IB/IEC IIA, V126-3.45 MW® IEC IIA/IEC IIB, V136-3.45 MW® IEC IIB/IEC IIIA and V136-4.2 MW IEC IIB/IEC S are excellent turbine choices. A combination of the variants can optimise your site layout and improve your production significantly on complex sites.

Low-wind sites
Built on the same proven technology as the V112-3.0 MW®, the V150-4.2 MW™ IEC IIIB/IEC S is our best performer on low-wind sites. The larger rotor enable greater wind capture, which in turn produces more energy to reduce levelised cost of energy (LCOE). The result is exceptional profitability in areas with low wind, and new frontiers for wind energy investment.

Large Diameter Steel Towers (LDST) support the added rotor size and rating of Vestas turbines to increase Annual Energy Production on low-wind sites. LDST is specially designed with a larger diameter in the bottom section that allows for optimal strength at high hub heights.

Maximising old permits
Although the V150-4.2 MW™ is one of the highest producing low wind turbines available, some old permits may simply be too tight to accept it. Although the V117-3.45 MW®, V126-3.45 MW®, V136-3.45 MW® and V136-4.2 MW™ are medium-wind turbines, they still deliver an excellent business case on low-wind sites.

Due to the similar electrical properties and nacelle design, it is easy to mix and match the turbines from the 4 MW platform to maximise production on heavily constrained sites.



003471

Would you **benefit** from uninterrupted control of wind energy production?



Knowledge about wind project planning is key
Getting your wind energy project up and operating as quickly as possible is fundamental to its long-term success. One of the first and most important steps is to identify the most suitable location for your wind power plant. Vestas' SiteHunt® is an advanced analytical tool that examines a broad spectrum of wind and weather data to evaluate potential sites and establish which of them can provide optimum conditions for your project.

In addition, SiteDesign® optimises the layout of your wind power plant. SiteDesign® runs Computational Fluid Dynamics (CFD) software on our powerful in-house supercomputer Firestorm to perform simulations of the conditions on site and analyse their effects over the whole operating life of the plant. Put simply, it finds the optimal balance between the estimated ratio of annual revenue to operating costs over the lifetime of your plant, to determine your project's true potential and provide a firm basis for your investment decision.

The complexity and specific requirements of grid connections vary considerably across the globe, making the optimal design of electrical components for your wind power plant essential. By identifying grid codes early in the project phase and simulating extreme operating conditions, Electrical PreDesign provides you with an ideal way to build a grid compliant, productive and highly profitable wind power plant. It allows customised collector network cabling, substation protection and reactive power compensation, which boost the cost efficiency of your business.

Advanced monitoring and real-time plant control
All our wind turbines can benefit from VestasOnline® Business, the latest Supervisory Control and Data Acquisition (SCADA) system for modern wind power plants.

This flexible system includes an extensive range of monitoring and management functions to control your wind power plant. VestasOnline® Business enables you to optimise production levels,



+33,000

The Vestas Performance and Diagnostics Centre monitors more than 33,000 turbines worldwide. We use this information to continually develop and improve our products and services.

monitor performance and produce detailed, tailored reports from anywhere in the world. The VestasOnline® Power Plant Controller offers scalability and fast, reliable real-time control and features customisable configuration, allowing you to implement any control concept needed to meet local grid requirements.

Surveillance, maintenance and service

Operating a large wind power plant calls for efficient management strategies to ensure uninterrupted power production and to control operational expenses. We offer 24/7 monitoring, performance reporting and predictive maintenance systems to improve turbine performance and availability. Predicting faults in advance is essential, helping to avoid costly emergency repairs and unscheduled interruptions to energy production.

Our Condition Monitoring System (CMS) assesses the status of the turbines by analysing vibration signals. For example, by measuring the vibration of the drive train, it can detect faults at an early stage and monitor any damage. This information allows pre-emptive maintenance to be carried out before the component fails, reducing repair costs and production loss.

Additionally, our Active Output Management® (AOM) concept provides detailed plans and long term agreements for service and maintenance, online monitoring, optimisation and troubleshooting. It is possible to get a full scope contract, combining your turbines' state-of-the-art technology with guaranteed time or energy-based availability performance targets, thereby creating a solid base for your power plant investment. The Active Output Management® agreement provides you with long term and financial operational peace of mind for your business case.

V105-3.45 MW™ IEC IA

Facts & figures

POWER REGULATION — Pitch regulated with variable speed

OPERATING DATA

Rated power	3,450 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Re cut-in wind speed	23 m/s
Wind class	IEC IA

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C

*Subject to different temperature options

SOUND POWER

Maximum	104.5 dB(A)**

**Sound Optimised Modes dependent on site and country

ROTOR

Rotor diameter	105 m
Swept area	8,659 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub height	72.5 m (IEC IA)

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

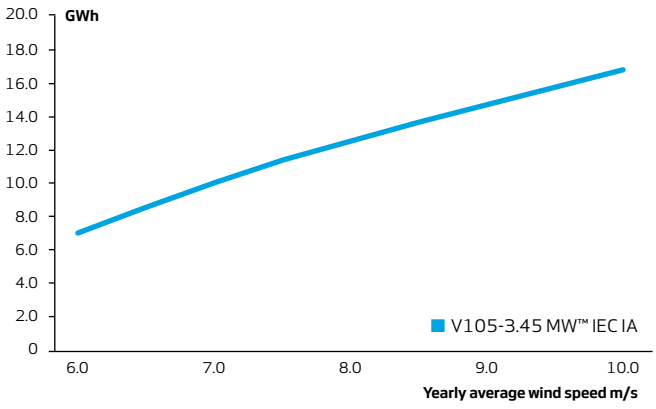
Length	51.2 m
Max. chord	4 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- High Wind Operation
- Power Optimised Mode up to 3.6 MW (site specific)
- Load Optimised Modes down to 3.0 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Low Temperature Operation to -30°C
- Fire Suppression
- Shadow Detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

003474

V112-3.45 MW®
IEC IA
Facts & figures

POWER REGULATION — Pitch regulated with variable speed

OPERATING DATA

Rated power	3,450 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Re cut-in wind speed	23 m/s
Wind class	IEC IA

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C

*subject to different temperature options

SOUND POWER

Maximum	105.4 dB(A)**

**Sound Optimised Modes dependent on site and country

ROTOR

Rotor diameter	112 m
Swept area	9,852 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub height	69 m (IEC IA) and 94 m (IEC IA)

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

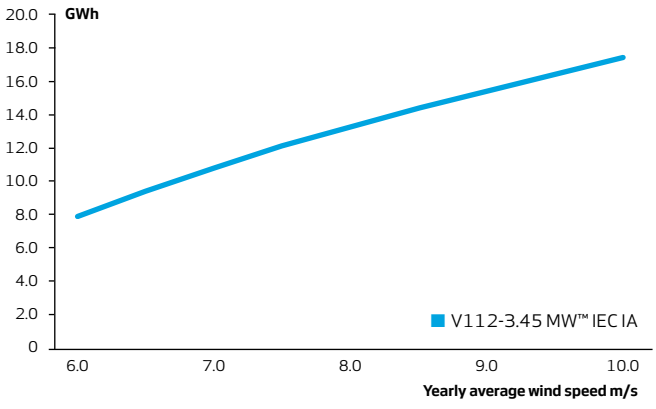
Length	54.7 m
Max. chord	4 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- High Wind Operation
- Power Optimised Mode up to 3.6 MW (site specific)
- Load Optimised Modes down to 3.0 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Vestas De-Icing
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

003475

V117-3.45 MW®
IEC IB/IEC IIA
Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Rated power	3,450 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Re cut-in wind speed	23 m/s
Wind class	IEC IB/IEC IIA

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C

*subject to different temperature options

SOUND POWER

Maximum	106.8 dB(A)**

**Sound Optimised Modes dependent on site and country

ROTOR

Rotor diameter	117 m
Swept area	10,751 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	80 m (IEC IB), 91.5 m (IEC IB) and 116.5 m (IEC IB/IEC IIA/DIBtS)

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

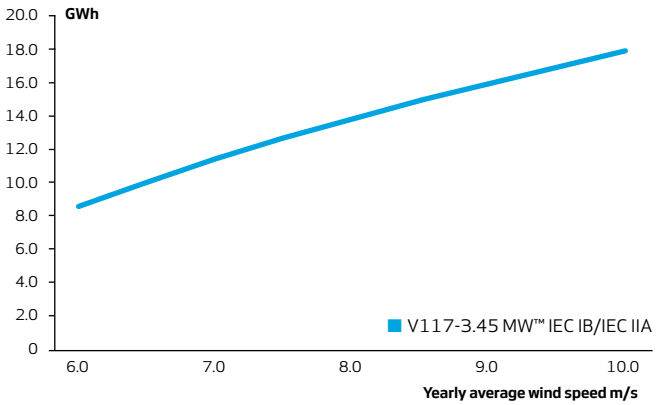
Length	57.2 m
Max. chord	4 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- High Wind Operation
- Power Optimised Mode up to 3.6 MW (site specific)
- Load Optimised Modes down to 3.0 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Vestas De-Icing
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

003476

V117-4.2 MW™ IEC IB/IEC IIA/IEC S

Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Rated power	4,000 kW/4,200 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Re cut-in wind speed	23 m/s
Wind class	IEC IB/IEC IIA/IEC S

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C (4,000 kW)

*subject to different temperature options

SOUND POWER

Maximum	106 dB(A)**

**Sound Optimised Modes dependent on site and country

ROTOR

Rotor diameter	117 m
Swept area	10,751 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	91.5 m (IEC IB) 84 m (IEC IIA)

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

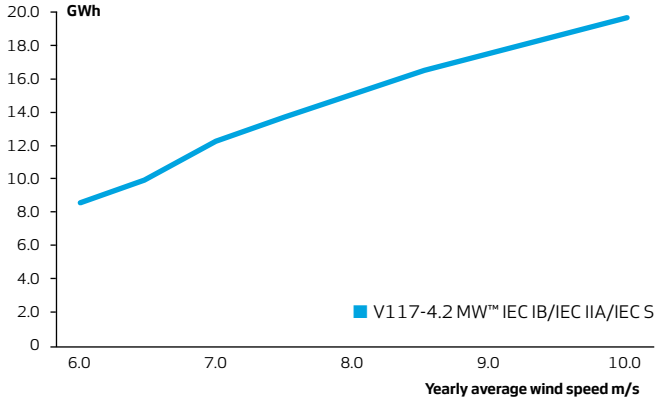
Length	57.2 m
Max. chord	4 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- High Wind Operation
- 4.2 MW Power Optimised Mode (site specific)
- Load Optimised Modes down to 3.6 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Vestas De-icing
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight®

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor = 2, Standard air density = 1.225, wind speed at hub height

003477

V126-3.45 MW®
IEC IIB/IEC IIA
Facts & figures

POWER REGULATION — Pitch regulated with variable speed

OPERATING DATA

Rated power	3,450 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	22.5 m/s
Re cut-in wind speed	20 m/s
Wind class	IEC IIB/IEC IIA

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C

*subject to different temperature options

SOUND POWER

Maximum	104.4 dB(A)**/ 107.3 dB(A)**

**Sound Optimised Modes dependent on site and country

ROTOR

Rotor diameter	126 m
Swept area	12,469 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights 87 m (IEC IIB/IEC IIA),117 m (IEC IIB/IECIIA/DIBtS), 137 m (IEC IIIA/DIBtS), 147 m (IEC IIIA), 149 m (DIBtS) and 166 m (DIBtS)

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

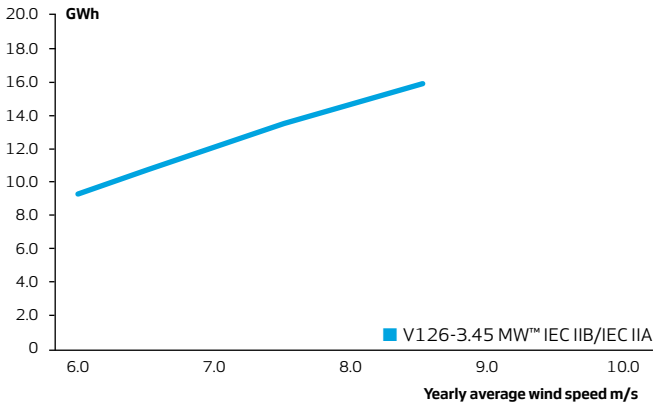
Length	61.7 m
Max. chord	4 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- High Wind Operation
- Power Optimised Mode up to 3.6 MW (site specific)
- Load Optimised Modes down to 3.0 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Vestas De-Icing
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

003478

V136-3.45 MW®
IEC IIB/IEC IIIA
Facts & figures

POWER REGULATION	Pitch regulated with variable speed

OPERATING DATA

Rated power	3,450 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	22.5 m/s
Re cut-in wind speed	20 m/s
Wind class	IEC IIB/IEC IIIA

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C

*subject to different temperature options

SOUND POWER

Maximum	105.5 dB(A)**

**Sound Optimised Modes dependent on site and country

ROTOR

Rotor diameter	136 m
Swept area	14,527 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights 82 m (IEC IIB/IEC IIIA), 105 m (IEC IIIA), 112 m (IEC IIB/IEC IIIA), 132 m (IEC IIB/IEC IIIA/ DIBt2), 142 m (IEC IIIA), 149 m (DIBtS), and 166 m (DIBtS)

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

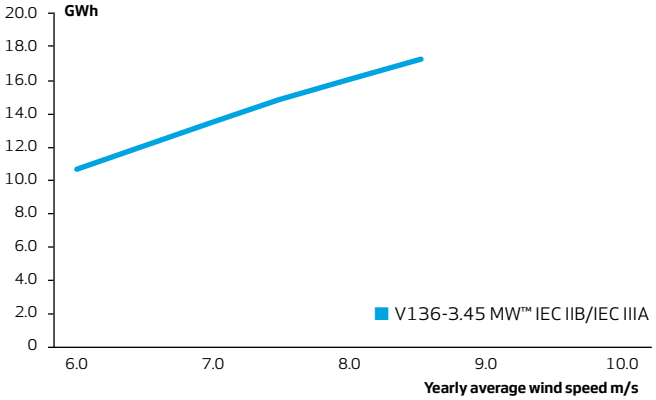
Length	66.7 m
Max. chord	4.1 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- High Wind Operation
- Power Optimised Mode up to 3.6 MW (site specific)
- Load Optimised Modes down to 3.0 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Vestas De-Icing
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight™

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

003479

V136-4.2 MW™ IEC IIB/IEC S

Facts & figures

POWER REGULATION — Pitch regulated with variable speed

OPERATING DATA

Rated power	4,000 kW/4,200 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Re cut-in wind speed	23 m/s
Wind class	IEC IIB/IEC S

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C (4,000 kW)

*subject to different temperature options

SOUND POWER

Maximum	103.9 dB(A)**

**Sound Optimised modes dependent on site and country

ROTOR

Rotor diameter	136 m
Swept area	14,527 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	Site and country specific

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

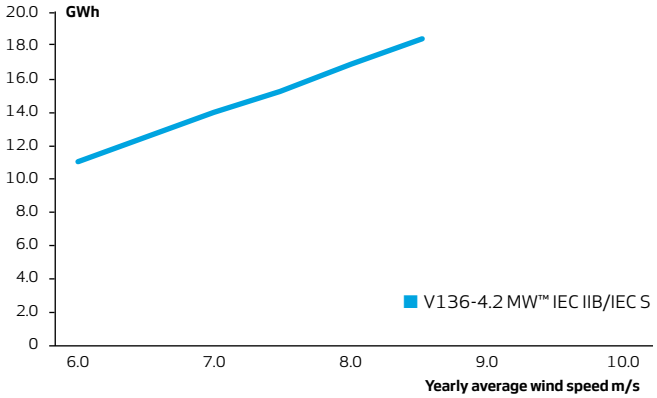
Length	66.7 m
Max. chord	4.1 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- High Wind Operation
- 4.2 MW Power Optimised Mode (site specific)
- Load Optimised Modes down to 3.6 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight®

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor = 2, Standard air density = 1.225, wind speed at hub height

003480

V150-4.2 MW™ IEC IIIB/IEC S
Facts & figures

POWER REGULATION — Pitch regulated with variable speed

OPERATING DATA

Rated power	4,000 kW/4,200 kW
Cut-in wind speed	3 m/s
Cut-out wind speed	22.5 m/s
Re cut-in wind speed	20 m/s
Wind class	IEC IIIB/IEC S

Standard operating temperature range from -20°C* to +45°C with de-rating above 30°C (4,000 kW)

*subject to different temperature options

SOUND POWER

Maximum	104.9 dB(A)**

**Sound Optimised modes dependent on site and country

ROTOR

Rotor diameter	150 m
Swept area	17,671 m²
Air brake	full blade feathering with 3 pitch cylinders

ELECTRICAL

Frequency	50/60 Hz
Converter	full scale

GEARBOX

Type	two planetary stages and one helical stage

TOWER

Hub heights	Site and country specific

NACELLE DIMENSIONS

Height for transport	3.4 m
Height installed (incl. CoolerTop®)	6.9 m
Length	12.8 m
Width	4.2 m

HUB DIMENSIONS

Max. transport height	3.8 m
Max. transport width	3.8 m
Max. transport length	5.5 m

BLADE DIMENSIONS

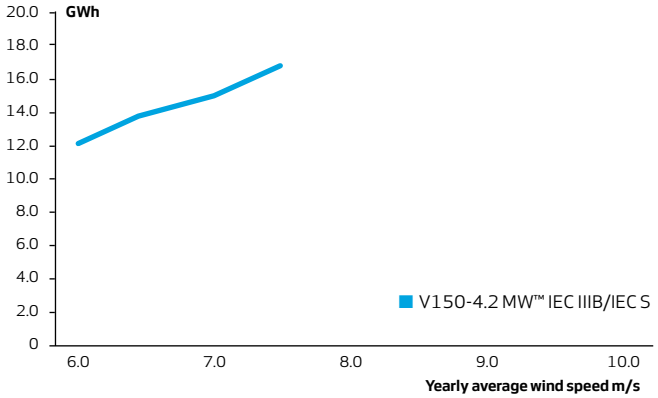
Length	73.7 m
Max. chord	4.2 m

Max. weight per unit for transportation	70 metric tonnes

TURBINE OPTIONS

- 4.2 MW Power Optimised Mode (site specific)
- Load Optimised Modes down to 3.6 MW
- Condition Monitoring System
- Service Personnel Lift
- Vestas Ice Detection
- Low Temperature Operation to - 30°C
- Fire Suppression
- Shadow detection
- Increased Cut-In
- Aviation Lights
- Aviation Markings on the Blades
- Vestas InteliLight®

ANNUAL ENERGY PRODUCTION



Assumptions
One wind turbine, 100% availability, 0% losses, k factor =2, Standard air density = 1.225, wind speed at hub height

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Adverse health effects of industrial wind turbines

Roy D. Jeffery MD FCFP Carmen Krogh Brett Horner CMA

Canadian family physicians can expect to see increasing numbers of rural patients reporting adverse effects from exposure to industrial wind turbines (IWTs). People who live or work in close proximity to IWTs have experienced symptoms that include decreased quality of life, annoyance, stress, sleep disturbance, headache, anxiety, depression, and cognitive dysfunction. Some have also felt anger, grief, or a sense of injustice. Suggested causes of symptoms include a combination of wind turbine noise, infrasound, dirty electricity, ground current, and shadow flicker.[1] Family physicians should be aware that patients reporting adverse effects from IWTs might experience symptoms that are intense and pervasive and might feel further victimized by a lack of caregiver understanding.

Background

There is increasing concern that energy generation from fossil fuels contributes to climate change and air pollution. In response to these concerns, governments around the world are encouraging the installation of renewable energy projects including IWTs. In Ontario, the Green Energy Act was designed, in part, to remove barriers to the installation of IWTs.[2] Noise regulations can be a considerable barrier to IWT development, as they can have a substantial effect on wind turbine spacing, and therefore the cost of wind-generated electricity.[3] Industrial wind turbines are being placed in close proximity to family homes in order to have access to transmission infrastructure.[4]

In Ontario and elsewhere,[5] some individuals have reported experiencing adverse health effects resulting from living near IWTs. Reports of IWT-induced adverse health effects have been dismissed by some commentators including government authorities and other organizations. Physicians have been exposed to efforts to convince the public of the benefits of IWTs while minimizing the health risks. Those concerned about adverse effects of IWTs have been stereotyped as "NIMBYs" (not in my backyard).[6,7]

Global reports of effects

During the past few years there have been case reports of adverse effects. A 2006 Académie Nationale de Médecine working group report notes that noise is the most frequent complaint. The noise is described as piercing, preoccupying, and continually surprising, as it is irregular in intensity. The noise includes grating and incongruous sounds that distract the attention or disturb rest. The spontaneous recurrence of these noises disturbs the sleep, suddenly awakening the subject when the wind rises and preventing the subject from going back to sleep. Wind turbines have been blamed for other problems experienced by people living nearby. These are less precise and less well described, and consist of subjective (headaches, fatigue, temporary feelings of dizziness, nausea) and sometimes objective (vomiting, insomnia, palpitations) manifestations.[8]

A 2009 literature review prepared by the Minnesota Department of Health[9] summarized case reports by Harry (2007),[10] Phipps et al (2007),[11] the Large Wind Turbine Citizens Committee for the Town of Union (2008),[12] and Pierpont (2009).[13] These case studies catalogued complaints of annoyance, reduced quality of life, and health effects associated with IWTs, such as sleeplessness and headaches.[9]

In 2010, Nissenbaum et al used validated questionnaires in a controlled study of 2 Maine wind energy projects. They concluded that "the noise emissions of IWTs disturbed the sleep and caused daytime sleepiness and impaired mental health in residents living within 1.4 km of the two IWT installations studied."[14]

Reports of adverse health effects[15] and reduced quality of life[16] are also documented in IWT projects in Australia and New Zealand.

A 2012 board of health resolution in Brown County in Wisconsin formally requested financial relocation assistance for "families that are suffering adverse health effects and undue hardships caused by the irresponsible placement of industrial wind turbines around their homes and property."[17]

An Ontario community-based self-reporting health survey, WindVOiCe, identified the most commonly reported IWT-induced symptoms as altered quality of life, sleep disturbance, excessive tiredness, headache, stress, and distress. Other reported effects include migraines, hearing problems, tinnitus, heart palpitations, anxiety, and depression.[18] In addition, degraded living conditions and adverse socioeconomic effects have been reported. In some cases the effects were severe enough that individuals in Ontario abandoned their homes or reached financial agreements with wind energy developers.[19]

La traduction en français de cet article se trouve à www.cfp.ca dans la table des matières du numéro de mai 2013 à la page e218.

This article has been peer reviewed.
Can Fam Physician 2013;59:473-5

After considering the evidence and testimony presented by 26 witnesses, a 2011 Ontario environmental review tribunal decision acknowledged IWTs can harm human health:

> This case has successfully shown that the debate should not be simplified to one about whether wind turbines can cause harm to humans. The evidence presented to the Tribunal demonstrates that they can, if facilities are placed too close to residents. The debate has now evolved to one of degree.[20]

Indirect effects and annoyance

When assessing the adverse effects of IWTs it is important to consider what constitutes human health. The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."[21]

Despite being widely accepted, the WHO definition of health is frequently overlooked when assessing the health effects of IWTs. Literature reviews commenting on the health effects of IWTs have been produced with varying degrees of completeness, accuracy, and objectivity.[22] Some of these commentators accept the plausibility of the reported IWT health effects and acknowledge that IWT noise and visual effects might cause annoyance, stress, or sleep disturbance, which can have other consequences. However, these IWT health effects are often discounted because "direct pathological effects" or a "direct causal link" have not been established. In 2010, the Ontario Chief Medical Officer of Health released *The Potential Health Impact of Wind Turbines,* which acknowledged that some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance but concluded "the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects."[23] The lead author of the report,[23] Dr Gloria Rachamin, acknowledged under oath that the literature review looked only at direct links to human health.[24]

Focusing on "direct" causal links limits the discussion to a small slice of the potential health effects of IWTs. The 2011 environmental review tribunal decision found that *serious harm to human health* includes "indirect impacts (e.g., a person being exposed to noise and then exhibiting stress and developing other related symptoms)."[20]

According to the night noise guidelines for Europe:

> Physiological experiments on humans have shown that noise of a moderate level acts via an indirect pathway and has health outcomes similar to those caused by high noise exposures on the direct pathway. The indirect pathway starts with noise-induced disturbances of activities such as communication or sleep.[25]

Pierpont documented symptoms reported by individuals exposed to wind turbines, which include sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic episodes associated with sensations of internal pulsation or quivering when awake or asleep.[13] The American Wind Energy Association and the Canadian Wind Energy Association convened a panel literature review that determined these symptoms are the "well-known stress effects of exposure to noise," or in other words, are "a subset of annoyance reactions."[26]

Noise-induced annoyance is acknowledged to be an adverse health effect.[27-30] Chronic severe noise annoyance should be classified as a serious health risk.[31] According to the WHO guidelines for community noise, "[t]he capacity of a noise to induce annoyance depends upon many of its physical characteristics, including its sound pressure level and spectral characteristics, as well as the variations of these properties over time."[32] Industrial wind turbine noise is perceived to be more annoying than transportation noise or industrial noise at comparable sound pressure levels.[33] Industrial wind turbine amplitude modulation,[34] audible low frequency noise,[35] tonal noise, infrasound,[36] and lack of nighttime abatement have been identified as plausible noise characteristics that could cause annoyance and other health effects.

Health effects in Ontario expected

Evidence-based health studies were not conducted to determine adequate setbacks and noise levels for the siting of IWTs before the implementation of the Ontario renewable energy policy. In addition, provision for vigilance monitoring was not made. It is now clear that the regulations are not adequate to protect the health of all exposed individuals.

A 2010 report commissioned by the Ontario Ministry of the Environment concludes:

> The audible sound from wind turbines, at the levels experienced at typical receptor distances in Ontario, is nonetheless expected to result in a non-trivial percentage of persons being highly annoyed .... [R]esearch has shown that annoyance associated with sound from wind turbines can be expected to contribute to stress related health impacts in some persons.[37]

Consequently, physicians will likely be presented with patients reporting health effects.

Family physicians should be aware that patients reporting adverse effects from IWTs might experience symptoms that are intense and pervasive and that they might feel further victimized by a lack of caregiver understanding. Those adversely affected by IWTs

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might have already pursued other avenues to mitigate the health effects with little or no success. It will be important to identify the possibility of exposure to IWTs in patients presenting with appropriate clinical symptoms.[38]

Conclusion

Industrial wind turbines can harm human health if sited too close to residents. Harm can be avoided if IWTs are situated at an appropriate distance from humans. Owing to the lack of adequately protective siting guidelines, people exposed to IWTs can be expected to present to their family physicians in increasing numbers. The documented symptoms are usually stress disorder–type diseases acting via indirect pathways and can represent serious harm to human health. Family physicians are in a position to effectively recognize the ailments and provide an empathetic response. In addition, their contributions to clinical studies are urgently needed to clarify the relationship between IWT exposure and human health and to inform regulations that will protect physical, mental, and social well-being.

Dr Jeffery is a family physician in the Northeastern Manitoulin Family Health Team in Little Current, Ont. **Ms Krogh** is a retired pharmacist and a former Editor-in-Chief of the Compendium of Pharmaceutical Specialties. **Mr Horner** is a Certified Management Accountant.

Competing interests

Dr Jeffery, Ms Krogh, and **Mr Horner** are on the Board of Directors for the Society for Wind Vigilance, an international federation of physicians, acousticians, engineers, and other professionals who share scientific research on the topic of health and wind turbines.

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The opinions expressed in commentaries are those of the authors. Publication does not imply endorsement by the College of Family Physicians of Canada.

References

1. Havas M, Colling D. Wind turbines make waves: why some residents near wind turbines become ill. *Bull Sci Technol Soc* 2011(5);31:414-26.
2. Government of Ontario [website]. *Chapter 12. An act to enact the Green Energy Act, 2009 and to build a green economy, to repeal the Energy Conservation Leadership Act, 2006 and the Energy Efficiency Act and to amend other statutes.* Toronto, ON: Government of Ontario; 2009. Available from: **www.e-laws.gov.on.ca/html/source/statutes/english/2009/elaws_src_s09012_e.htm#**. Accessed 2013 Mar 26.
3. Canadian Wind Energy Association [website]. *Letter to Neil Parish re: sound level limits for wind farms*. Ottawa, ON: Canadian Wind Energy Association; 2004. Available from: **www.canwea.ca/images/uploads/File/Wind_Energy_Policy/Environmental_Issues/SoundLevels.pdf**. Accessed 2013 Mar 26.
4. Hornung R. *Business of green: wind energy and budget expectations* [video]. Toronto, ON: Business News Network; 2010. Available from: **http://watch.bnn.ca/clip272347**. Accessed 2013 Apr 4.
5. Hanning CD, Evans A. Wind turbine noise. *BMJ* 2012;344:e1527.
6. Martin C. NIMBY mentality unacceptable when it comes to green-energy projects, McGuinty says. *London Free Press* 2009 Feb 12.
7. Schliesmann P. Wind turbine debate swirls. *Kingston Whig-Standard* 2010 Jan 2. Available from: **www.thewhig.com/ArticleDisplay.aspx?e=2244137&archive=true**. Accessed 2013 Mar 26.
8. Académie Nationale de Médecine Groupe de Travail. *Le retentissement du fonctionnement des éoliennes sur la santé de l'homme*. Paris, France: Académie Nationale de Médecine; 2006. Available from: **www.academie-medecine.fr/sites_thematiques/EOLIENNES/chouard_rapp_14mars_2006.htm**. Accessed 2013 Mar 26.
9. Minnesota Department of Health [website]. *Public health impacts of wind turbines*. St Paul, MN: Minnesota Department of Health; 2009. Available from: **www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf**. Accessed 2013 Mar 26.
10. Harry A. *Wind turbines, noise and health*. Rowe, MA: National Wind Watch; 2007. Available from: **http://docs.wind-watch.org/wtnoise_health_2007_a_harry.pdf**. Accessed 2013 Mar 26.
11. Phipps R, Amati M, McCoard S, Fisher R. *Visual and noise effects reported by residents living close to Manawatu wind farms: preliminary survey results*. Rowe, MA: National Wind Watch; 2007. Available from: **http://docs.wind-watch.org/phipps-visualnoiseeffects.pdf**. Accessed 2013 Mar 26.
12. Large Wind Turbine Citizens Committee for the Town of Union. *Setback recommendations report*. Rowe, MA: National Wind Watch; 2008. Available from: **http://docs.wind-watch.org/LWTCC-Town-of-Union_FinalReport_01-14-08.pdf**. Accessed 2013 Mar 26.
13. Pierpont N. *Wind turbine syndrome: a report on a natural experiment*. Santa Fe, NM: K-Selected Books; 2009.
14. Nissenbaum MA, Aramini JJ, Hanning CD. Effects of industrial wind turbine noise on sleep and health. *Noise Health* 2012;14(60):237-43.
15. Thorne B. The problems with "noise numbers" for wind farm noise assessment. *Bull Sci Technol Soc* 2011;31(4):262-90.
16. Shepherd D, McBride D, Welch D, Dirks KN, Hill EM. Evaluating the impact of wind turbine noise on health-related quality of life. *Noise Health* 2011;13(54):333-9.
17. *Brown County board of health resolution requesting emergency state aid for families suffering around industrial wind turbines.* Rowe, MA: National Wind Watch; 2012. Available from: **http://docs.wind-watch.org/Brown%20County%20Board%20of%20Health%20Resolution%20011012.pdf.** Accessed 2013 Mar 28.
18. Krogh CME, Gillis L, Kouwen N, Aramini J. WindVOiCe, a self-reporting survey: adverse health effects, industrial wind turbines, and the need for vigilance monitoring. *Bull Sci Technol Soc* 2011;31(4):334-45.
19. Krogh CME. Industrial wind turbine development and loss of social justice? *Bull Sci Technol Soc* 2011;31(4):321-33.
20. *Erickson v. Director, Ministry of the Environment*. Environmental Review Tribunal Nos. 10-121 and 10-122. 2011. Available from: **www.ert.gov.on.ca/files/201108/00000300-AKT5757C7CO026-BHH51C7A7SO026.pdf**. Accessed 2013 Mar 28.
21. World Health Organization. Definition of health. In: *Preamble to the Constitution of the World Health Organization*. Geneva, Switz: World Health Organization; 1948. Available from: **www.who.int/about/definition/en/print.html**. Accessed 2013 Mar 28.
22. Horner B, Jeffery RD, Krogh CME. Literature reviews on wind turbines and health: are they enough? *Bull Sci Technol Soc* 2011;31(5):399-413.
23. Chief Medical Officer of Health. *The potential health impact of wind turbines*. Toronto, ON: Ministry of Health and Long-Term Care; 2010. Available from: **http://health.gov.on.ca/en/common/ministry/publications/reports/wind_turbine/wind_turbine.pdf**. Accessed 2013 Mar 27.
24. *Erickson v. Director, Ministry of the Environment*. Environmental Review Tribunal Nos. 10-121 and 10-122. Transcript of Dr G. Rachamin. 2011 Mar 4.
25. World Health Organization Europe. *Night noise guidelines for Europe.* Copenhagen, Denmark: World Health Organization Europe; 2009. Available from: **www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf**. Accessed 2013 Mar 27.
26. Colby WD, Dobie R, Leventhall G, Lipscomb DM, McCunney RJ, Seilo MT, et al. *Wind turbine sound and health effects. An expert panel review*. Washington, DC: American Wind Energy Association, Canadian Wind Energy Association; 2009. Available from: **www.canwea.ca/pdf/talkwind/Wind_Turbine_Sound_and_Health_Effects.pdf**. Accessed 2013 Mar 27.
27. Health Canada [website]. *Community noise annoyance*. Ottawa, ON: Health Canada; 2005. Available from: **www.hc-sc.gc.ca/hl-vs/iyh-vsv/life-vie/community-urbain-eng.php**. Accessed 2013 Mar 27.
28. Suter AH. *Noise and its effects.* Washington, DC: Administrative Conference of the United States; 1991. Available from: **www.nonoise.org/library/suter/suter.htm**. Accessed 2013 Mar 27.
29. Michaud DS, Keith SE, McMurchy D. Noise annoyance in Canada. *Noise Health* 2005;7(27):39-47.
30. Pedersen E, Persson Waye K. Wind turbine noise, annoyance and self-reported health and well-being in different living environments. *Occup Environ Med* 2007;64(7):480-6. Epub 2007 Mar 1.
31. Maschke C, Niemann A. Health effects of annoyance induced by neighbour noise. *Noise Control Eng J* 2007;55(3):348-56.
32. Berglund B, Lindvall T, Schwela DH, editors. *Guidelines for community noise*. Geneva, Switz: World Health Organization; 1999.
33. Pedersen E, van den Berg F, Bakker R, Bouma J. Response to noise from modern wind farms in the Netherlands. *J Acoust Soc Am* 2009;126(2):634-43.
34. Leventhall G. Infrasound from wind turbines—fact, fiction or deception. *Can Acoust* 2006;34(2):29-36.
35. Møller H, Pedersen CS. Low-frequency noise from large wind turbines. *J Acoust Soc Am* 2011;129(6):3727-44.
36. Salt AN, Kaltenbach JA. Infrasound from wind turbines could affect humans. *Bull Sci Technol Soc* 2011;31(4):296-302.
37. Howe Gastmeier Chapnik Limited. *Low frequency noise and infrasound associated with wind turbine generator systems. A literature review.* Toronto, ON: Ontario Ministry of the Environment; 2010. Available from: **www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_092086.pdf**. Accessed 2013 Mar 27.
38. McMurtry RY. Toward a case definition of adverse health effects in the environs of industrial wind turbines: facilitating a clinical diagnosis. *Bull Sci Technol Soc* 2011;31(4):316-20.

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MaROUS & COMPANY

April 6, 2018

Apex Clean Energy, Inc.
8665 Hudson Boulevard North - Suite 110
Lake Elmo, Minnesota 55402

Attention: Mr. Mark Mauersberger, Senior Development Manager

Subject: Market Impact Analysis
Proposed Dakota Range Wind Project
Codington County and Grant County, South Dakota

Dear Mr. Mauersberger,

In accordance with your request, the proposal to develop a wind farm in Codington County and Grant County, South Dakota, has been analyzed and this market impact analysis has been prepared.

MaRous & Company has conducted similar market impact studies for a variety of clients and for a number of different proposed developments over the last 30 years. Clients have ranged from municipalities, counties, and school districts, to corporations, developers, and citizen's groups. The types of proposals analyzed include: commercial developments such as shopping centers and big-box retail facilities; religious facilities such as mosques and mega-churches; residential developments such as high-density multifamily and congregate-care buildings and large single-family subdivisions; recreational uses such as skate parks and lighted high school athletic fields; and industrial uses such as waste transfer stations, land-fills, and quarries. We also have analyzed the impact of high-tension electric wires on adjacent residential uses. Energy-related projects include a number of proposed natural gas-fired electric plants in various locations, and the Grand Ridge V and Otter Creek wind farms, in LaSalle County, the Pleasant Ridge Wind Farm, in Livingston County, the Walnut Ridge Wind Farm, in Bureau County, the McLean County Wind Farm, in McLean County, the Twin Forks Wind Farm, in Macon County, all in Illinois; the Freeborn County Wind Farm, in Freeborn County, Minnesota; the Ida II Wind Farm, in Ida County, the Palo Alto County Wind Farm, in Palo Alto County, both in Iowa; the Orangeville Wind Farm, in Wyoming County, New York; the Dorchester County Solar Farms, in Dorchester County, Maryland; and the Badger Hollow Solar Farm, in Iowa County, Wisconsin. In addition, we are in the process of completing market impact studies for multiple wind projects in South Dakota.

In addition to this experience, MaRous & Company has appraised a variety of properties in the large market area of the proposed project in South Dakota, in North Dakota, in Iowa, and in Minnesota in the last 3 years, including: industrial facilities, food processing plants, and warehouse and distribution facilities ranging in size from 50,000 to 1,000,000 square feet, and more than 20 major retail facilities.

Mr. Mark Mauersberger
Proposed Dakota Range Wind Project
April 6, 2018

Purpose and Intended Use of the Study

The purpose of this appraisal assignment is to analyze the potential impact, if any, on the value of the surrounding rural residential and agricultural properties due to the development of the proposed wind farm. Specifically, this study is designed to address the question of whether the development of the proposed wind farm will have an effect on the value of residential uses and/or agricultural land in proximity to the turbines. Any other use or user of this report is considered to be unintended.

Executive Summary

As a result of the market impact analysis undertaken, I concluded that there is no market data indicating the Project will have a negative impact on either rural residential or agricultural property values in the surrounding area. Further, market data from South Dakota, as well as other states, supports the conclusion that the Project will not have a negative impact on rural residential or agricultural property values in the surrounding area. Finally, for agricultural properties that host turbines, the additional income from the wind lease may increase the value and marketability of those properties. These conclusions are based on the following:

- The proposed use will meet or exceed all the required development and operating standards;
- Controls, such as setbacks and noise limits, are in place to insure on-going compliance;
- There are significant financial benefits to the local economy and to the local taxing bodies from the development of the proposed wind farm;
- The proposed wind farm will create well-paid jobs in the area which will benefit overall market demand;
- An analysis of recent residential sales proximate to existing wind farms, which includes residential sales within three to five times turbine tip height, did not support any finding that proximity to a wind turbine had any impact on property values;
- An analysis of agricultural land values in the area and in other areas of the state with wind farms did not support any finding that the agricultural land values are negatively impacted by the proximity to wind turbines;
- Studies indicate that wind turbine leases add value to participant land owner's agricultural land;
- A survey of County Assessors in six South Dakota counties in which wind farms are located concluded that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm, and that there were no reductions in assessed valuations;
- A survey of County Assessors in eight Minnesota counties in which wind farms are located concluded that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm, and that there were no reductions in assessed valuations;

- A survey of County Assessors in 26 Iowa counties in which wind farms are located concluded that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm, and that there were no reductions in assessed valuations; and
- A survey of County Assessors in 18 Illinois counties in which wind farms are located concluded that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm, and that there were no reductions in assessed valuations.

Definition of Market Value

When discussing market value, the following definition is used:

> The most probable price a property should bring in a competitive and open market under all conditions requisite to a fair sale, the buyer and seller each acting prudently and knowledgeably, and assuming the price is not affected by undue stimulus. Implicit in this definition is the consummation of a sale as of a specified date and the passing of title from seller to buyer under conditions whereby:
>
> - Buyer and seller are typically motivated;
> - Both parties are well informed or well advised, and acting in what they consider their own best interests;
> - A reasonable time is allowed for exposure in the open market;
> - Payment is made in terms of cash in U.S. dollars or in terms of financial arrangements comparable thereto; and
> - The price represents the normal consideration for the property sold unaffected by special or creative financing or sales concessions granted by anyone associated with the sale.[1]

Scope of Work and Reporting Process

Information was gathered concerning the real estate market generally and the market of the area surrounding the proposed conditional use specifically. The uses in the surrounding area were considered. The following summarizes the actions taken:

- Review of the Codington County Zoning Ordinance Chapter 5.22 and other public documents;
- Review of the Grant County Zoning Ordinance 2004-1 Chapter 11-2 and other public documents;

1 *(12 C.F.R. Part 34.42(g); 55 Federal Register 34696, August 24, 1990, as amended at 57 Federal Register 12202, April 9, 1992; 59 Federal Register 29499, June 7, 1994)*

- Review of the preliminary information for the proposed wind farm from Apex Clean Energy, Inc.,;
- Review of the *Application to the South Dakota Public Utilities Commission for a Facility Permit* for the proposed wind farm from Dakota Range I, LLC and Dakota Range II, LLC, including associated Appendices ;
- Review of the demographics in the area of the proposed wind farm, based on 2017 census data;
- Data on the general market area, or the geographical area where people buy goods or services, of the proposed wind farm, and on the other areas in South Dakota and/or Codington and Grant counties in which existing wind farms are located;
- Data on the market for single-family houses in the immediate area of the proposed wind farm and from other areas in the county from public sources, from the Codington County and Grant County public records, and public records from eight other counties in South Dakota[2];
- Local real estate professionals were interviewed concerning recent sales in the area, local market conditions, and the impact of wind turbines on property values in the area;
- Properties used for development of the matched pairs were physically inspected on the exterior, and photographs of the interiors were reviewed where available;
- Inspections were performed of the project area and the areas in nearby counties with existing wind farms by Michael S. MaRous and Joseph M. MaRous on February 18-19, 2018. As well as inspections of nearby Deuel County by Michael S. MaRous on October 4-5, 2017.

This document is considered to conform to the requirements of the *Uniform Standards of Professional Appraisal Practice and Advisory Opinions* (USPAP). This letter is a brief recapitulation of the appraisal data, analyses, and conclusions; additional supporting documentation is retained in the MaRous and Company office file. There are no extraordinary assumptions or hypothetical conditions included in the market study.

In order to form a judgment concerning the potential impact, if any, on the value of the surrounding residential and agricultural properties of the proposed wind farm, I have considered the following:

- The character and the value of the residential and agricultural properties in the general area of the proposed wind farm;
- Agricultural land values in Codington County, Grant County, and in other South Dakota counties in which wind farms are located;
- Market trends for both residential and agricultural land up to the past 5 years;
- The economic impact on the larger community by the approval of the conditional use as proposed; and
- The impact on the value of the surrounding residential and agricultural properties by the approval of the proposed wind farm.

2 Deuel County, Day County, Clark County, Aurora County, Brookings County, Charles Mix County, Hyde County, and Jerauld County

Description of Area and Proposed Development

Area Analysis

Codington County and Grant County are located in the Northeast region of the state of South Dakota. The 2017 population for Codington County was estimated to be 28,572 persons, up from 27,227 in 2010. This population is situated in approximately 12,119 households as of 2017.[3] The median household income was estimated to be $50,501. Of the total approximately 13,145 housing units in the county, 1,026 or approximately 7.8 percent are vacant. The median single-family house value was $164,097.

The 2017 population for Grant County was estimated to be 7,237 persons, down from 7,356 in 2010. This population is situated in approximately 3,031 households as of 2017. The median household income was estimated to be $52,346. Of the total approximately 3,526 housing units in the county, 495 or approximately 14 percent are vacant. The median single-family house value was $126,829.

The total population directly within the footprint of the project is reported to be fewer than 1,000 persons, according to Apex's on-site supervisor, David Lau.

The unemployment rate in Codington County as of 2017 was 1.3 percent, and the median weekly household wage in 2017 was $971. The unemployment rate in Grant County as of 2017 was 1.9 percent, and the median weekly household wage in 2017 was $1,006.

The largest city in the northeast corner of the state is Watertown, with 22,172 persons, and it is approximately 15 miles south of the project's southern border. Watertown is also the Codington County Seat. Milbank is the largest city in Grant County, with 3,203 persons, and it is approximately 17 miles east of the project's eastern border. Milbank is also the Grant County Seat.

The proposed wind farm is located on the border of Codington County and Grant County, and will encompass the townships; Leola and Germantown, in Codington County; and, Lura and Mazeppa, in Grant County. A copy of a map of the proposed footprint of the wind farm is located in the addenda to this report.

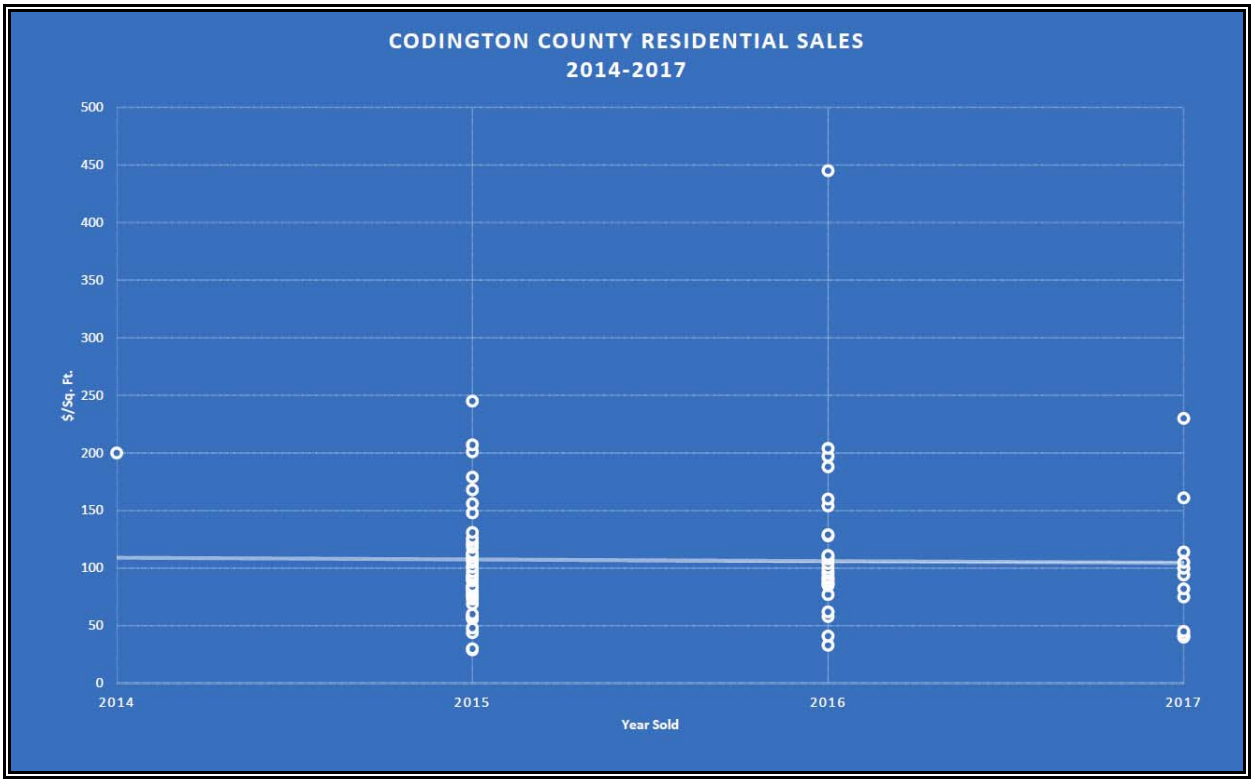
3 The demographic data included in this section of the report are taken from Site-to-do-Business, https://www.stdb.com. Unless otherwise indicated, the data is from 2017.

Like the majority of South Dakota, this area is primarily rural in nature. In addition to farms, there are single-family houses situated on either smaller lots or larger farmsteads. The following table summarizes recent sales of these types of residences in the general area of the proposed Dakota Range Wind Project. A map illustrating the location of each of these sales is included in the addenda to this market impact study.

RECENT SINGLE-FAMILY RESIDENTIAL SALES SUMMARY
IN THE AREA OF PROPOSED DAKOTA RANGE WIND PROJECT

No.	Location	Sale Price	Sale Date	Site Size (Acres)	Year Built	Building Size Sq. Ft.	Sale Price Per Sq. Ft. of Bldg. Area Incl. Land
1	101 2nd Ave. Waverly, South Dakota	$66,800	8/16	0.38	1900	2,016	$33.13
2	46274 154th St. South Shore, South Dakota	$135,000	9/15	5.28	1953	1,516	$89.05
3	45624 165th St. Watertown, South Dakota	$142,500	12/17	7.57	N/A	3,200	$44.53
4	14419 468th Ave. Twin Brooks, South Dakota	$145,000	9/15	5.25	1974	2,316	$62.61
5	47724 144th St. Milbank, South Dakota	$349,900	8/16	10.00	2002	3,224	$108.53

A sample size of 90 residential sales throughout Codington County from year 2014 to 2017 also was compiled and was analyzed. Codington County was chosen to represent the market in this overall analysis due to the county's much larger population compared to that of Grant County. The sales were compiled from public sources and were broken down by price per square foot and year sold.



Noting the trend line, indicated in the data in the charts above, the overall residential market has been declining slowly throughout the past 4 years

Proposed Project

The proposed project currently plans to generate approximately 300 megawatts from up to 72 wind turbines. Construction will begin in 2019 and is expected to be online in 2021. The turbines will Vestas V136-4.2MW that have a capacity of 4.2 megawatts each, with a total capacity of 302.4 megawatts, and will be approximately 492 feet to the top of the blade tip. The proposed wind farm is split between the border of Codington County and Grant County, South Dakota, covering approximately 44,500 acres of land. The proposed project footprint is described in a map in the addenda to this market study. All turbines will be new, and none will be experimental or prototype equipment. The turbine specifications are described in the following table.

Manufacturer	Model	Diameter	Height	Capacity
Vestas	V136-4.2MW	136 m (466')	150 m (492')	4.2 MW

The total project cost is estimated to be $380,000,000 with a possible fluctuation of +/- 20 percent. Ancillary construction includes 16-foot to 36-foot wide gravel-covered access roads, a wind electrical collection system with 34.5 kV lines trenched 30 inches below ground, a collector substation that will increase voltage from 34.5 kV to 345 kV, an interconnection switching station adjacent to the Big Stone South-to-Ellendale 345 kV line, five permanent meteorological towers, a "SCADA" or Supervisory Control and Data Acquisition system, and an operations and maintenance building. Agreements with Codington and Grant counties and with townships impacted will identify roads to be used, and will require repairing of any damage caused by the project. The Codington and Grant counties' setback standards of 110 percent of tip height or 1,000 feet, from nonparticipating residences and public roads, and 500 feet, from participating residences, will be met with the closest turbine to an residence at greater than 1,300 feet away. Dakota Range Wind Project has also agreed to a voluntary setback of 2 miles from the shoreline of Punished Woman's Lake, which will be met with the closest turbine to be located approximately 2.75 miles away from the nearest residence. Both Codington County and Grant County also require the noise level at any residence, business, or government building to not exceed 50 dBA, at the property line for Codington County and at the specific structure for Grant County. The project will also implement a voluntary maximum annual shadow flicker level for nonparticipants of 30 hours per year or less. Per information reviewed these requirements will be met by the project.

Project Benefits

In accordance with the State of South Dakota's property assessment requirements for wind turbines, local real estate tax benefits for the entire Dakota Range Wind Project are estimated to be greater than $1,000,000 per year if the full capacity of the project is constructed. The estimated breakdown of local tax allocation is described in the following table.

	Yearly
School District Tax Revenue	$505,000
Township Tax Revenue	$151,000
County Tax Revenue	$360,000
Total Local Tax	$1,016,000

Annual payments to participating landowners and good-neighbor agreements will add significantly to the local economy. Prior to construction, participating landowners will have received more than $500,000 in development payments. The project has acquired approximately 45 participating landowners within the project boundary of Codington County. As seen in the table above, the local community and school districts will receive sizable amounts of funding from the project taxes. Additionally, the project will generate approximately 300 temporary construction jobs and is expected to create approximately 10 permanent jobs when fully operational.

Further direct and indirect impacts from the construction of the project, including permits and construction jobs, as well as "induced impacts" from the increase in household spending also are anticipated.

Market Impact Analysis

A market impact analysis is undertaken to develop an opinion as to whether the proposed wind farm will have an effect on the value of residential uses and/or agricultural land in proximity to the turbines. This

analysis includes:

- A matched pair analyzing the impact on value of residential properties proximate to a wind farm in Brookings County, South Dakota, as well as matched pairs developed in counties with similar demographics, land use, and economic characteristics, just east of this area in Minnesota, and in similarly rural counties in Iowa and Illinois;
- The value of agricultural land in Codington and Grant counties and in other counties with existing wind farms;
- Interviews of local real estate professionals;
- The results of a survey of assessors in South Dakota, Iowa, Minnesota, and Illinois with existing wind farms in their respective jurisdictions; and
- The results of several academic and peer-reviewed studies of the impact of wind turbines on residential property values.

Matched Pair Analysis

A matched pair analysis is a methodology which analyzes the importance of a selected characteristic, in this instance proximity to a wind turbine, to the value of a property.[4] This technique compares the sale of a property in proximity to the selected characteristic to the sale of a similar property in the same market area and under similar market conditions but without the proximity to the selected characteristic.

It is difficult to find properties that are identical except for proximity to a wind turbine, and which also occurred under substantially similar market conditions, especially in rural areas. Many sales in the area are also conducted privately from family member to family member, or passed down from generation to generation, causing there to be a lack of sale information or, at most times, do not sell at full value. The research throughout Codington County and Grant County indicated that there were no sales proximate to wind turbines in either county. The only sale found in South Dakota that is located in the general market area of a wind farm, based on data research from the entire state, was a residence within four miles to the Buffalo Ridge Wind Farms in nearby Brookings County. This sale provided some basis for a comparison analysis due to the similar demographics and land use of the surrounding area. However, the sale is not close enough to a wind turbine to serve as a proximate sale. Thus, while a paired sales analysis is

4 See the discussion "Paired Sales Analysis" and "Sale/Resale Analysis" in Bell, Randall, MAI, *Real Estate Damages, Applied Economics and Detrimental Conditions, Second Edition*, Appraisal Institute, 2008, pages 25-27. The ideal is to review a sale and resale of a property in proximity to a selected characteristic, to compare it to a sale and resale of a similar property without such proximity, and to then analyze whether the proximity to the selected characteristic influenced the change in value. However, in rural areas it usually is not possible to find data for this type of "pure pair" analysis.

provided, it is not considered a proximate and not proximate matched pair for purposes of determining potential impact on value due to proximity to a wind farm.

Due to the lack of sales data proximate to wind turbines in South Dakota, data from nearby states that have a stronger presence of wind turbines, similar demographics, similar economics, and similar agricultural characteristics, have been analyzed.

Details of the sales included in this analysis are retained in my office files; maps in the addenda to this report illustrate the location of the properties. Unless otherwise indicated, none of the purchasers in these transactions appear to own any other property in proximity, and none of the transactions appear to have a wind turbine lease associated with the property.

Brookings County No. 1 - Residences Not Proximate to Wind Turbines

The Buffalo Ridge Wind Farms are located in Brookings County in the East-Central region of South Dakota and consists of 129 turbines that began commercial operations in 2009. Phases I and II are both located primarily in Brookings County. Phase I came online in 2009 with 24 turbines generating approximately 50.4 MW of power. Phase II was much larger, following the first phase the next year in 2010 with 105 turbines generating approximately 210 MW of power. A property located at 19937 473rd Avenue, White, South Dakota, sold in May 2015 for $169,500. The sale previously sold in July 2014 for $121,640. The nearest turbine is approximately 4 miles to the east of this property.

This property is compared with a similar property located at 5705 Rathum Loop, Brookings, South Dakota, that sold in June 2015, which is not located proximate to any wind turbines within 10 miles. The salient details of these two properties are summarized in the table below.

The following aerial map illustrates the relationship of the 473rd Avenue property to the closest wind turbines.



BROOKINGS COUNTY NO. 1

	1A - Within 4 Miles to a Wind Turbine	1B - Over 10 Miles From a Wind Turbine
Address	19937 473rd Ave. White, SD 57276	5705 Rathum Loop Brookings, SD 57006
Distance from Turbine	4 Miles (nearest)	13 Miles
Sale Date	May 20, 2015	June 5, 2015
Sale Price	$169,500	$142,000
Sale Price/Sq. Ft. (A.G.)	$61.68	$68.33
Year Built	1908	1973
Building Size	2,748 sq. ft.	2,078 sq. ft.
Lot Size	14.8 acres	0.49 acre
Style	Two-story; frame (vinyl) 5 bdrms., 2.0 ba.	One-story; frame (vinyl) 9 rms., 3 bdrms.
Basement	Full, unfinished	Crawlspace
Utilities	Central air; Electric & forced-air heat; Well & septic	Central air; Forced-air heat; Well & septic
Other	Large detached barn; Shed, utility buildings	1-car attached garage 3-car detached garage Patio, deck, utility buildings



19937 473rd Avenue



5705 Rathum Loop

Although the 473rd Avenue property is a two-story farmstead, and the Rathum Loop property is technically a ranch-style house, both properties have similar amenities, and are situated in similar exterior surroundings. An upward adjustment for the superior building size of Rathum Loop is required. In the case of the 473rd Avenue property, there is a large detached barn, a shed, and utility buildings. The property is also in a very rural area of the county. In the case of the Rathum Loop property, there are two garages and a multiple utility buildings. The Rathum Loop building is of relatively newer construction, yet is still approximately 50 years old, compared to the 473rd Avenue property that is closer to 100 years old; both properties are considered to be in normal condition by the Brookings County Assessor. An upward adjustment is made for the basement area of Rathum Loop. The 473rd Avenue property is situated on a much larger lot than that of the Rathum Loop property requiring an upward adjustment; however, both lots are surrounded by agricultural and pasture land, which mitigates the size differential to some degree.

ADJUSTMENT GRID

SALE NO.	LOCATION	SALE DATE	YEAR BUILT	BUILDING SIZE	LOT SIZE	STYLE	BASEMENT	UTILITIES	OUT-BUILDINGS
1B	5705 Rathum Loop Brookings, SD 57006	○	-	+	+	+	+	○	○

\+ Positive adjustment based on comparable being inferior in comparison to property #1A
\- Negative adjustment based on comparable being superior in comparison to property #1A
○ No adjustment necessary

When adjustments noted in the above table for newer construction, yet smaller size of the Rathum Loop property, the lower price of the 473rd property is justified by the factors noted in the above description.

Matched Pair Analysis- Minnesota, Iowa, and Illinois Counties

In addition to analyzing sales in the subject project area, I have researched sales in proximity to several existing wind farms in rural areas of Minnesota, Iowa, and Illinois, to determine whether residential property values in these areas were impacted by their locations in relation to wind farms. The following are the results of the most recent of these studies.

As with the Brookings County research, details of these sales are retained in my office files; maps in the addenda to this report illustrate the location of these matched pairs. Unless otherwise indicated, none of the purchasers in these transactions appear to own any other property in proximity, and none of the transactions appear to have a wind turbine lease associated with the property.

MINNESOTA MATCHED PAIR STUDY
Freeborn County Matched Pair No. 1

Freeborn County, Minnesota, is located north adjacent to central Iowa. Matched Pair #1 considers the sale of a property in the footprint of the Bent Tree Wind Farm in Freeborn County, which has been operational since February 2011. A house located at 69525 305th Street, Hartland, sold in March 2016. This house is approximately 2,375 feet from the nearest turbine; there are several turbines located to the south and southeast.

This sale is compared with a similar property located at 70308 240th Street, Albert Lea, that sold in May 2016. Although it is not located near wind turbines, several are visible from the house, but are more than 1.5 miles away. The location is very rural in nature. Market conditions are considered to be substantially similar at the dates of sale. The salient details of these two properties are summarized in the table below.

FREEBORN COUNTY MATCHED PAIR NO. 1

	1A - Proximate to a Wind Turbine	1B - Not Proximate to a Wind Turbine
Address	69525 305th St. Hartland, MN 56042	70308 240th St. Albert Lea, MN 56007
Ft. from Turbine	2,375 (nearest)	NA
Sale Date	March 31, 2016	May 16, 2016
Sale Price	$89,000	$100,000*
Sale Price/Sq. Ft. (A.G.)	$57.12	$61.80
Year Built	1880	1925
Building Size	1,558 sq. ft.	1,618 sq. ft.
Lot Size	5.51 acres	4.01 acres
Style	Farm house; frame (vinyl) 3 or 4 bdrms., 2.0 ba.	Farm house; frame (vinyl) 3 bdrms., 2.0 ba.
Basement	Full, unfinished	Partial, unfinished
Utilities	No central air; propane heat; Well & septic	Central air; natural gas heat; Well & septic
Other	2-car detached garage Deck, outbuildings	2.5-car detached garage Deck, outbuildings

* This is the sale price reported by the Assessor.



69525 305th Street



70308 240th Street

Both properties are older, farm-house style and of frame construction with vinyl siding. They are somewhat similar in size. However, the 240th Street house is superior to the 305th Street house in condition; it is classified by the Assessor as being in better condition, and is described in the online listing as having been renovated recently. The 305th Street house does not have central air conditioning, and does not have natural gas available; however, the 240th Street house has both. Both the central air conditioning and the availability of natural gas are considered superior factors for 240th Street requiring a downward adjustment. An upward adjustment for the full basement of 305th Street compared to the partial basement of 240th Street.

The house on 240th Street has a site size approximately 1.5 acres smaller than that of the 305th Street house. However, this is more than offset by the location on a hard-surface road, as well as the proximity to Interstate 90 access and to the city of Albert Lea.

ADJUSTMENT GRID

SALE NO.	LOCATION	SALE DATE	YEAR BUILT	BUILDING SIZE	LOT SIZE	STYLE	BASEMENT	UTILITIES	OUT-BUILDINGS
1B	70308 240th St. Albert Lea, MN 56007	○	-	○	○	○	+	-	○

\+ Positive adjustment based on comparable being inferior in comparison to property #1A
\- Negative adjustment based on comparable being superior in comparison to property #1A
○ No adjustment necessary

When the adjustments noted above for superior condition, air conditioning, and the availability of natural gas are made to the sale price of the 240th Street house, the two properties have essentially the same per square foot value. In other words, the higher per foot sale price for the 240th Street house is justified by its superior condition and amenities. Thus, the difference in the sale price does not support the conclusion that proximity to the wind turbines had a negative impact on the sale price of the property at 69525 305th Street.

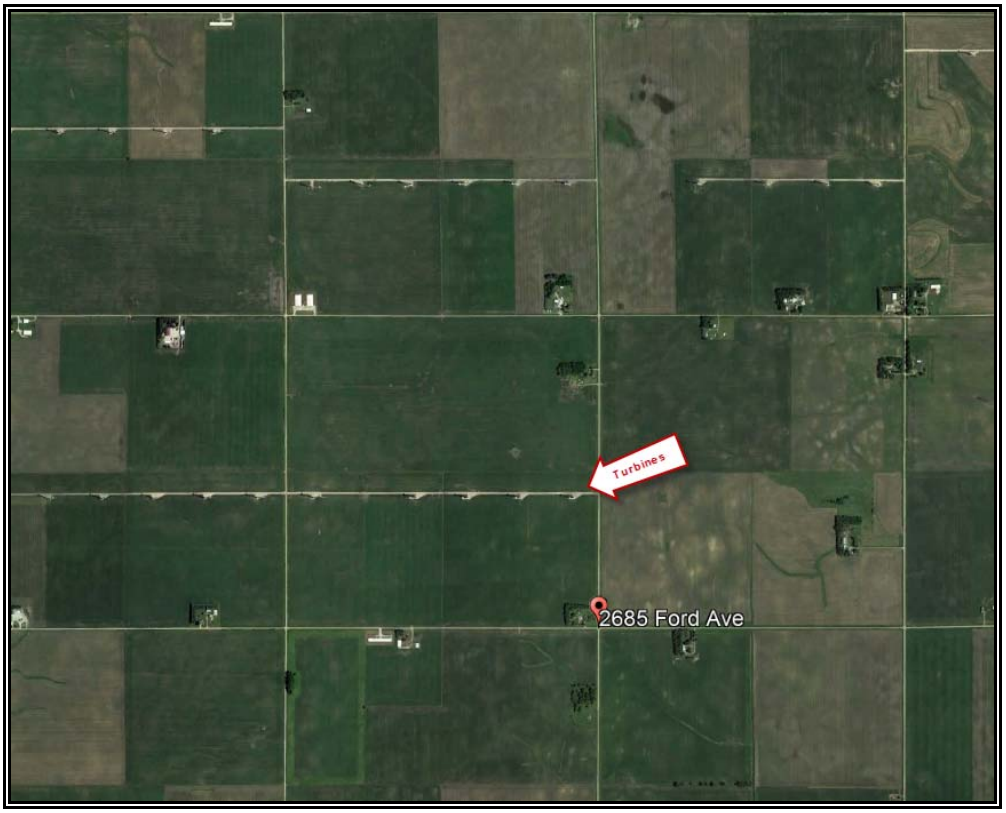
IOWA MATCHED PAIR STUDY

Hancock County is located in northern Iowa and is a largely rural county, primarily agricultural in nature. The county has two areas of wind turbines, the Hancock County wind farm in the southeast portion of Hancock County and the Crystal Lake Energy Center in the northwest portion of Hancock County.

Hancock County Matched Pair No. 1

Crystal Lake I Wind Farm is located in Hancock County in north central Iowa and consists of 100 turbines that began commercial operations in 2008. Phases II and III were located primarily in Winnebago County; which added another 80 and 44 turbines, respectively, and began operations in approximately 2009. A property located at 2685 Ford Avenue, Britt, sold in May 2016, for $155,400. The sale previously sold in October 2012 for $150,000. The nearest turbine is approximately 2,000 feet to the north and west of this property.

The following aerial map illustrates the relationship of the Ford Avenue property to the closest wind turbines.



This property is compared with a similar property located at 2855 Taft Avenue that sold in December 2014, and is not located proximate to any wind turbines. Market conditions between December 2014 and May 2016 are considered to have been stable in this area of Iowa. The salient details of these two properties are summarized in the table below.

HANCOCK COUNTY MATCHED PAIR NO. 1

	1A - PROXIMATE TO A WIND TURBINE	1B - NOT PROXIMATE TO A WIND TURBINE
Address	2685 Ford Ave. Britt, IA 50423	2855 Taft Ave. Garner, IA 50438
Ft. from Turbine	2,020 (nearest)	NA
Sale Date	May 20, 2016	December 22, 2014
Sale Price	$155,400	$190,000
Sale Price/Sq. Ft. (A.G.)	$81.62	$94.25
Year Built	1959	1975
Building Size	1,904 sq. ft.	2,016 sq. ft.
Lot Size	2.08 acres	1.22 acres.
Style	Ranch; frame (metal siding) 3 bdrms., 2.0 ba.	Split level; frame 3 bdrms., 2.0 ba.
Basement	Full, finished	None; slab
Utilities	Central air; Well & septic	In-wall air; Electric heat Well & septic
Other	2-car attached garage; 1-car detached garage; Patio, porch, shed	2.5-car attached garage; Patio, deck, utility buildings



2685 Ford Avenue



2855 Taft Avenue

Although the Ford Avenue property technically is a ranch-style house, and the Taft Avenue property is a split-level-style house, both properties have lower levels that comprise a family room and an additional room. An upward adjustment for the superior market condition of Ford Avenue is made. In the case of the Ford Avenue property, the additional lower-level room is a kitchen, and the basement square footage is not included in the building size and an upward adjustment is made for this feature. In the case of the Taft Avenue property, the lower level is not below grade, and the area, which includes a family room and a bedroom, is included in the square footage. The Taft Avenue building is of newer construction and a downward adjustment is made; however, the Ford Avenue property has been adequately maintained; both properties are considered to be in normal condition by the Hancock County Assessor. An upward adjustment is made for the central air of Ford Avenue compared to the in-wall air of Taft Avenue. The Ford Avenue property is situated on a larger lot than that of the Taft Avenue property; however, both lots have wooded areas along the rear property line, which mitigates the size differential to a large degree.

ADJUSTMENT GRID

Sale No.	Location	Sale Date	Year Built	Building Size	Lot Size	Style	Basement	Utilities	Out-Buildings
1B	2855 Taft Ave. Garner, IA 50438	+	-	○	○	○	+	+	○

\+ Positive adjustment based on comparable being inferior in comparison to property #1A
\- Negative adjustment based on comparable being superior in comparison to property #1A
○ No adjustment necessary

When the adjustments noted above for newer construction and the superior above-grade location of the second family room are made to the sale price of the Taft Avenue house, the two properties have essentially the same per square foot value. In other words, the higher per foot sales price for the Taft Avenue house is justified by its superior condition and location. Thus, the difference in the sales price does not support the conclusion that proximity to the wind turbines had a negative impact on the value of the Ford Avenue property.

Mr. Mark Mauersberger
Proposed Dakota Range Wind Project
April 6, 2018

ILLINOIS MATCHED PAIR STUDY

Macon County Matched Pair No. 1

Matched Pair #1 considers the recent sale of a property located at 8873 North Glasgow Road, Warrensburg, that is 1,855 feet from the nearest wind turbine located within the subject, Twin Forks Wind Farm, with approximately four additional turbines visible from the property to the north and west.

MACON COUNTY MATCHED PAIRS NO. 1

	1A PROXIMATE TO A WIND TURBINE	1A PRIOR SALE	1C NOT PROXIMATE TO A WIND TURBINE
Address	8873 North Glasgow Road Warrensburg, IL 62573	8873 North Glasgow Road Warrensburg, IL 62573	1511 Hunters View Drive Mount Zion, Illinois 62549
Ft. from Turbine	1,855 (nearest)	N/A	N/A
Sale Date	June 12, 2017	March 25, 2014	June 31, 2013
Sale Price	$214,000	$184,000	$193,000
Sale Price/Sq. Ft. (A.G.)	$124.35	$106.91	$91.90
Year Built	2006	2006	2006
Building Size	1,721 sq. ft.	1,721 sq. ft.	2,100 sq. ft.
Lot Size	1.04 acres	1.35 acres	0.21 acres
Style	1-story, frame (vinyl) 4 bdrms., 2 ba.	1-story, frame (vinyl) 3 bdrms., 2 ba.	2-story, frame (vinyl/brick) 4 bdrms.; 2.1 ba.
Basement	Full; partially finished	Full; unfinished	Full; finished
Utilities	Geothermal heat & cooling Well & septic	Geothermal heat & cooling Well & septic	Central Air; Forced-air heat Public Sewer
Other	2.5-car attached garage; Front porch and deck	2.5-car attached garage; Front porch	3-car attached garage Patio



8873 North Glasgow Road

1511 Hunters View Drive



The house at 8873 North Glasgow Road, is located approximately 8 miles northwest of Decatur, in a rural area. According to the Macon County Assessor's records, this house previously sold in March 2014 for $184,000. This indicates an increase in value of approximately 16 percent during a period where residential sale prices generally were not increasing. There is no lease for a wind turbine on this property. According to the most recent selling broker there was an issue with the well test; the yard was dug up to find the well and treat the problem. The yard is now back to normal condition. The broker also says that the house is in excellent condition and showed very well. The sellers added a wrap-around deck and finished part of the basement to add a fourth bedroom. The seller was being relocated and was offered a low price for the relocation fee, so the sellers put it on the market themselves and were able to sell it almost immediately for greater than the asking price. The broker stated that the turbine being installed proximate to the property is a possible reason for the quick sale at a higher price, so having a turbine close to this property potentially had a positive effect on the sale.

The house at 1511 Hunters View Drive, Mount Zion, has a similar, rural location, yet is settled in a suburban setting, and is approximately 4 miles south of Decatur. Although this house sits on a smaller lot than the Glasgow property, this is offset by the extra bedroom and the second floor. There is no lease for a wind turbine near this property.

ADJUSTMENT GRID

Sale No.	Location	Sale Date	Year Built	Building Size	Lot Size	Style	Basement	Utilities	Out-Buildings
1B	1511 Hunters View Drive Mount Zion, Illinois 62549	+	○	-	+	○	○	+	○

\+ Positive adjustment based on comparable being inferior in comparison to property #1A
\- Negative adjustment based on comparable being superior in comparison to property #1A
○ No adjustment necessary

The comparison will be made to the March 2014 date of sale because it is most similar in time to the sale date of the Mount Zion property.

Upward adjustments are made for the superior market conditions, larger lot size, and geothermal heating and cooling system of the Glasgow property. Downward adjustments are made for the superior building size of the Mount Zion property. When the adjustments noted above are made to the sale price of the Glasgow house, the two properties have essentially the same per square foot value. In other words, although the Mount Zion house is larger, the higher per foot sales price for the Glasgow house is justified by its superior condition and amenities, and its larger lot size. Thus, the difference in the sales price does not support the conclusion that there is any diminution in value resulting from the proximity of the Glasgow property to wind turbines. This is further supported by the subsequent sale of the Glasgow property, where the 2017 sale price increased by $17.44 per square foot over the 2014 sale price.

Logan County Matched Pair No. 1

Matched Pair #1 considers the recent sale of a property located at 2558 1254th Avenue, Emden, that is 2,200 feet from the nearest wind turbine located in the Rail Splitter Wind Farm, with approximately four additional turbines visible from the property to the northwest. Rail Splitter Wind Farm was constructed in 2008-2009 and came on line in July 2009.

LOGAN COUNTY MATCHED PAIR NO. 1

	1A PROXIMATE TO A WIND TURBINE	1B NOT PROXIMATE TO A WIND TURBINE
Address	2558 1254th Ave. Emden, Illinois	801 1250th Ave. Lincoln, Illinois
Ft. from Turbine	2,200 (nearest)	N/A
Sale Date	March 19, 2015	January 15, 2015
Sale Price	$108,000	$97,900
Sale Price/Sq. Ft. (A.G.)	$62.21	$71.46
Year Built	1965	1970
Building Size	1,736 sq. ft.	1,370 sq. ft.
Lot Size	1.38 acres	1.33 acres.
Style	Ranch; frame (brick) 3 bdrms., 2 ba.	Ranch; frame (vinyl/stone) 3 bdrms., 2 ba.
Basement	N/A	Full; unfinished
Other	2-car 460 sq. ft. attached garage enclosed porch	2-car 672 sq. ft. attached garage



2558 1254th Avenue



801 1250th Avenue

The house at 2558 1254th Avenue, Emden[5], is located approximately 8 miles north of Lincoln, in a rural area. According to the Logan County Assessor's records, this house previously sold in November 2011 for $102,500. This indicates an increase in value of approximately 5 percent during a period when residential sale prices generally were not increasing. There is no lease for a wind turbine on this property.

The house at 801 1250th Avenue, Lincoln, has a similar, rural location, approximately 8 miles south of Lincoln. According to the Logan County Assessor's records, this house sold in June 2010 for $128,500, and then was sold in July 2014 in a Sheriff's sale. The January 2015 sale is considered arm's length by the Assessor. The Lincoln house is approximately 20 percent smaller in size than the Emden property, a significant upward adjustment is considered appropriate. A downward adjustment is made for the full basement of the Lincoln property compared to the lack of a basement of the Emden property. The lack of an enclosed porch is offset by the larger garage size.

ADJUSTMENT GRID

Sale No.	Location	Sale Date	Year Built	Building Size	Lot Size	Style	Basement	Utilities	Out-Buildings
1B	801 1250th Ave. Lincoln, Illinois	○	○	+	○	○	-	○	○

\+ Positive adjustment based on comparable being inferior in comparison to property #1A
\- Negative adjustment based on comparable being superior in comparison to property #1A
○ No adjustment necessary

5 This address is taken from the Logan County records; some maps indicate that this property is located at 2558 1250th Avenue, in either unincorporated Emden or Atlanta.

There is a $9.25 per square foot difference in sale price between the Emden house and the Lincoln house, in favor of the Emden house. However, when the adjustments noted above are taken into consideration, the difference in the per square foot sale price of the two properties is fully justified. Thus, the difference in the sales price does not support the conclusion that there is any diminution in value resulting from the proximity of the Emden property to wind turbines.

Matched Pair Analysis Conclusions

Based on these matched pairs and sales/resales of properties proximate to wind turbines, there does not appear to have been any measurable negative impact on surrounding property values due to the proximity of a wind farm.

Agricultural Land Values

Agricultural land values are typically tied to the productivity of the land and to the commodity prices of crops like corn and soy beans. Other factors include favorable interest rates, and the supply of land compared to the number of buyers. The most recent "Ag Letter" for the 9th District, which includes South Dakota, and is published by the Federal Reserve of Minneapolis, indicated a modest 3 percent increase in agricultural land values after 3 years of mild downward year-over-year changes.

The South Dakota Agricultural Land Trends produced by South Dakota State University[6] reported agricultural land values in Deuel County averaged $4,613 per acre in 2016, and $5,066 per acre in 2015. A more recent survey covering the period between February 2016, and February 2017 supported the Fed's report of an increase in average land value with an average land value of $4,654 per acre.[7] The most likely buyer of agricultural land in South Dakota is an existing farmer, with neighboring farmers paying higher prices than investors. The prognosis appears to be for stable, if not slightly rising land values. The following table and map illustrates values as of February 1, 2017, by region, including Codington and Grant counties in the Northeast region.

6 https://igrow.org/up/resources/07-3007-2017.pdf, 2017 SDSU South Dakota Farm Real Estate Survey

7 https://igrow.org/up/resources/07-3007-2017.pdf, 2017 SDSU South Dakota Farm Real Estate Survey

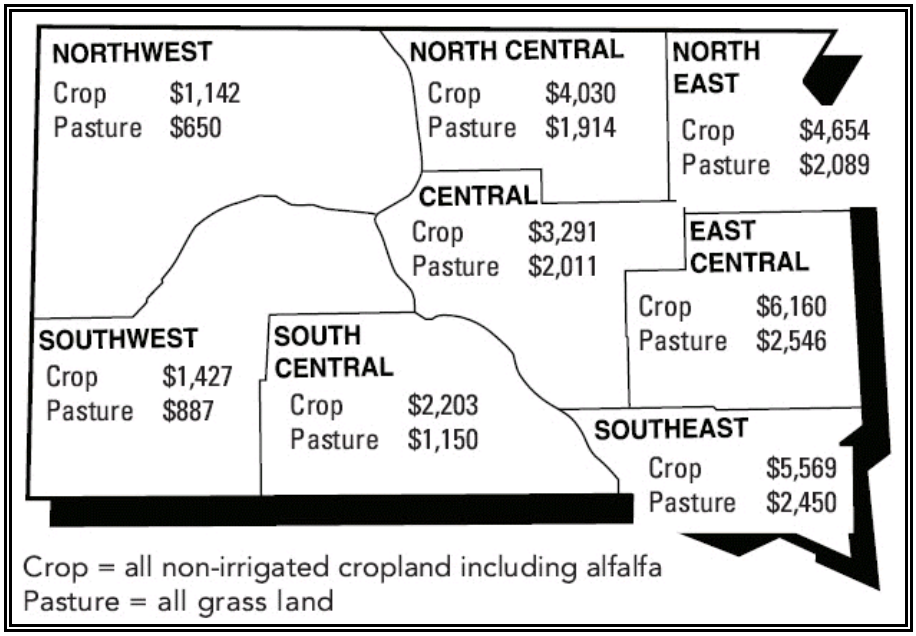


Table 3. Average reported value and annual percentage change in value of South Dakota agricultural land by type of land by region, February 2013-2017.

Type of Land	Southeast	East Central	Northeast	North Central	Central	South Central	Southwest	Northwest	STATE
	dollars per acre								
Nonirrigated Cropland									
Average value, 2017*	$5,569	$6,160	$4,654	$4,030	$3,291	$2,203	$1,427	$1,142	$3,903
Average value, 2016	$5,653	$6,116	$4,613	$4,177	$3,843	$2,168	$1,264	$1,187	$4,094
Average value, 2015	$5,887	$6,329	$5,066	$4,275	$3,895	$2,283	$1,347	$1,193	$4,265
Average value, 2014	$6,331	$7,114	$5,291	$4,614	$3,953	$2,087	$820	$870	$4,478
Average value, 2013	$5,903	$6,828	$4,843	$4,562	$3,580	$1,994	$900	$792	$4,249
Annual % change 17/16	-1.5%	0.7%	0.9%	-3.5%	-14.4%	1.6%	12.9%	-3.8%	-4.7%
Pasture/ Rangeland**									
Average value, 2017**	$2,450	$2,546	$2,089	$1,914	$2,011	$1,150	$887	$650	$1,215
Average value, 2016	$2,566	$2,781	$2,028	$1,957	$2,219	$1,330	$715	$760	$1,222
Average value, 2015	$2,719	$2,727	$2,136	$1,758	$2,100	$1,338	$851	$630	$1,187
Average value, 2014	$2,698	$2,861	$1,859	$1,600	$1,828	$1,187	$571	$436	$987
Average value, 2013	$2,308	$2,765	$1,759	$1,473	$1,636	$994	$529	$444	$909
Annual % change 17/16	-4.5%	-8.5%	3.0%	-2.2%	-9.4%	-13.5%	24.1%	-14.5%	-0.6%

Source: 2017 and earlier South Dakota Farm Real Estate Market Surveys
*cropland now includes all alfalfa acres
** 2017 pasture land variable has been redefined and includes all grass acres
Statewide average land values are based on 2002 land use weights

The following table summarizes recent agricultural land sales larger than 10 acres in Codington County in or near the footprint of the proposed wind farm. There were no recent agricultural land sales in Grant County.

LAND SALES SUMMARY

Sale No.	Location	Sale Price	Sale Date	Land Area (Acres)	NCCPIs*	Sale Price Per Acre
1	15496 County Road 9 1/10 South Shore, South Dakota	$50,000	4/15	99.00	0.41	$505.05
2	15629 457th Ave. South Shore, South Dakota	$53,500	1/14	118.90	0.34	$449.96
3	15511 460th Ave. South Shore, South Dakota	$60,000	12/15	37.90	0.46	$1,583.11
4	45323 157th St. South Shore, South Dakota	$140,000	10/16	63.40	0.36	$2,208.20
5	46156 155th St. South Shore, South Dakota	$272,079	12/15	315.10	0.30	$863.47

*National Commodity Crop Productivity Index - based on AcreValue.com GIS informational map. The NCCPI uses a scale of 0 to 1, with 0 having a lower productivity potential and 1 a higher potential. This scale was developed using soil chemical and physical properties, water availability, climate, and landscape values. The NCCPI has indexes for corn, wheat and cotton (USDA, 2008)

Agricultural Land Sales and Wind Farms

The above land sales reveal that the agricultural land in the area of the project footprint is far below average for the northeast region of South Dakota, and adding wind turbines and land leases should only benefit the land prices and productivity. I was unable to discover any sales of South Dakota farmland in which the transaction included a wind turbine, and upon closer inspection, the existing wind farms are located in extremely remote areas of the state with few or no residential houses within 3 miles. However, there were a few sales in the neighboring state of Minnesota in Freeborn County, which is home to the Bent Tree Wind Farm and provides similar demographics to the project area of Dakota Range. The following table summarizes the three sales in 2015 and 2016 of farmland with turbine leases. Although this survey is not exhaustive, it appears that the turbines may have had a positive impact on the sale price.

AGRICULTURAL LAND VALUES WITH TURBINES - FREEBORN COUNTY

	2015			2016		
	No. Of Sales	Range in Sale Price/Ac.	Average Sale Price/Ac.	No. Of Sales	Range in Sale Price/Ac.	Average Sale Price/Ac.
Bent Tree Wind Farm	2	$7,011 to $9,502	$8,257	1	$7,011	$7,011
County Average			$6,547			$6,416

Wind turbines typically are considered to be of significant benefit to farmers; Iowa farmers interviewed by the *Omaha World Herald*, were positive about the stable income as opposed to the vicissitudes of commodity prices.[8] Franklin County reported lowering real estate taxes for the county as a whole because of the taxes generated by the wind turbines in that county. Support for good prices comes from the lack of land for sale, stable commodity prices, and low interest rates. Marginal land in areas where wind turbines are located or proposed is popular with investors.[9]

Although there has been no study of the impact of wind turbines on agricultural land sales for South Dakota that I could discover, a report in Illinois, the *2016 Illinois Land Values and Lease Trends*, indicated that the impact of wind turbine leases is being felt in McLean, Livingston, and Woodford counties, where turbine leases have provided "income diversification, beyond agriculture, which makes these tracts more attracting to an outside investor."[10] Further, they noted that "investors are still paying a little more of a premium for the wind turbines just as they had in the past few years."[11] The report notes that the premium is related directly to the number of years left on the lease.

Overall, it appears that there is little or no relationship between agricultural land values and the location of wind farms, with productivity being the driving force behind land values. However, wind farm lease revenue does appear to add to the marketability and value.

Local Real Estate Professionals

Local real estate professionals were contacted to discuss market conditions, specific market transactions, and to investigate whether they had experience with, or knowledge of any impact of wind farms on residential property values. Jim Aesoph of Aesoph Real Estate, Inc. is a broker with 27 years of experience in northeast South Dakota. MaRous and Company contacted Mr. Aesoph due to his highly regarded reputation in the area of the Dakota Range Wind Project. He stated that he contacted the assessors of Codington, Grant, and Roberts counties to discuss land prices in their respective county, and each of them informed Jim that although they have heard that the project is in production, they are not

8 http://www.omaha.com/money/turning-to-turbines-as-commodity-prices-remain-low-wind-energy/article_2814e2cf-83a3-547d-a09e-f039e935f399.html Accessed September 18, 2107.

9 http://www.agriculture.com/farm-management/farm-land/farmland-sales-hard-to-find-as-growers-hold-tight-keeping-land-value Accessed September 18, 2017.

10 Klein, David E., and Schnitkey, Gary, *2016 Illinois Land Values and Lease Trends*, Illinois Society of Professional Farm Managers and Rural Appraisers, Page 38.

11 Ibid. Page 42.

aware of any effect on land prices. He also stated that five years ago land prices were roughly $6,000 per acre, and now the average acre is approximately $4,000. The reduction in land prices, he mentions, is not due to the wind project, but due to the production of corn on the land.

Rick Mummert of Ron Holton Real Estate reported that residential conditions in both Freeborn and Mower counties in Minnesota had been stable through the last 3 years, primarily due to the very rural nature of the area however the area is benefitting from the low interest rates. He reported that the Highway 14 corridor had experienced increases in residential values; in his opinion, the difference was due to the more developed nature of the area and the availability of jobs.

Interviews with brokers proximate to wind farms in Illinois yielded similar results. Although a number of them wished to remain anonymous, they stated that they did not believe that the proximity to wind turbines had any bearing on the sale prices of residential properties in the area.

Michael Crowley, Sr., SRA of Real Estate Consultants, Ltd., Spring Valley, Illinois, has had extensive experience with wind farm development in Central Illinois, including projects in Bureau, Whiteside, and Lee counties. Mr. Crowley has been unable to document any loss in property values attributable to the proximity of wind turbines.

South Dakota Assessors Survey - November 2017

In November 2017 my office conducted a survey of the supervisor of assessments or a deputy supervisor in six counties in South Dakota in which wind farms with more than 25 turbines currently are operational, and South Dakota has more than seven wind farms with 400 wind turbines. As of 2016, the AWEA reported there were approximately 14 wind projects with approximately 583 wind turbines in the state with additional farms being added each year. The interviews were intended to allow the assessment officials to share their experience regarding the wind farm(s) impact upon the market values and/or assessed values of surrounding properties. The detailed analysis is attached in the addenda at the end of this report. The following is a summary of the results of that survey:

- Without exception, the interviewees reported that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm facility. In some counties, this results from the very rural nature of the area in which the projects are located;
- In the past 5 years, the assessor's offices have not experienced a real estate tax appeal based upon wind farm-related concerns. There have been no reductions in assessed valuations related to wind turbines.
- As the available market data do not support the claim of a negative impact upon residential or agricultural values, residential and agricultural assessed values have fluctuated consistently within counties as influenced by market conditions, with no regard for proximity to a wind farm.
- Virtually all assessors volunteered that the wind farms provided positive economic benefits to their counties and, in fact, had a positive impact on real estate values.

Iowa Assessors Survey - August/September 2017

In August and September 2017 my office conducted a survey of the supervisor of assessments or a staff member in 26 counties in Iowa in which wind farms with more than 25 turbines currently are operational, and Iowa has more than 38 wind farms with 3,706 wind turbines. As of 2016, the AWEA reported there were approximately 107 wind projects with approximately 4,143 wind turbines in the state with additional farms being added each year. The interviews were intended to allow the assessment officials to share their experience regarding the wind farm(s) impact upon the market values and/or assessed values of surrounding properties. The following is a summary of the results of that survey:

- Without exception, the interviewees reported that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm facility. In some counties, this results from the very rural nature of the area in which the projects are located;

- In the past 18 months, the assessor's offices have not experienced a real estate tax appeal based upon wind farm-related concerns. There have been no reductions in assessed valuations related to wind turbines.
- As the available market data do not support the claim of a negative impact upon residential values, residential assessed values have fluctuated consistently within counties as influenced by market conditions, with no regard for proximity to a wind farm.
- Virtually all assessors volunteered that the wind farms provided positive economic benefits to their counties and, in fact, had a positive impact on real estate values.
- Agricultural properties are taxed based upon a productivity formula that is not impacted by market data and external influences.

Minnesota Assessors Survey - January 2017

In late January 2017, my office conducted a survey of the Assessors or a staff member in eight Minnesota counties where large numbers of wind turbines currently are operational. There are several counties with small numbers of wind turbines that were not included in the survey. As of 2015, the AWEA reported there were approximately 97 wind projects with approximately 2,400 wind turbines in the state with additional farms being added each year. The interviews were intended to allow the assessment officials to share their experience regarding the wind farm(s) impact upon the market values and/or assessed values of surrounding properties. The following is a summary of the results of that survey:

- With one exception, the interviewees reported that there was no market evidence to support a finding that there has been a negative impact upon residential property values as a result of the development of and the proximity to a wind farm facility. In some counties, the assessors believed this to be the result of the very rural nature of the area in which the projects are located.
- The exception, the Dodge County Assessor, reported receiving two complaints from residential property owners regarding the value impact of proximity to wind turbines; however, the Assessor was unable to find data to support the contentions.
- Without exception, where there was sufficient data to analyze, the County Assessors reported that both residential and agricultural assessed property values within the wind farm footprints have fluctuated consistently within counties as influenced by market conditions, with no regard for proximity to a wind farm.

Based on Bruce Nielson's, Lincoln County Assessor, report, a recent residential transaction in a township in which wind turbines are located sold $70,000 higher than the assessor's opinion of market value.

Illinois Assessors Survey - Updated October 6 - 19, 2016

In March 2015, and updated in October 2016, my office conducted a survey of the supervisor of assessments or a staff member in 18 counties in Illinois in which wind farms currently are operational. As of 2016, the AWEA reported there were approximately 48 wind projects with approximately 2,579 wind turbines in the state with additional farms being added each year. The interviews were intended to allow the assessment officials to share their experience regarding the wind farm(s) impact upon the market values and/or assessed values of surrounding properties. The following is a summary of the results of that survey:

- Without exception, the interviewees reported that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm facility. In some counties, this results from the very rural nature of the area in which the projects are located;
- In the past 18 months, the assessor's offices have not experienced a real estate tax appeal based upon wind farm-related concerns. As of the date of this report, there are more than 46 wind farms with 2,348 wind turbines and more than 1,000,000 properties in these counties. There have been no reductions in assessed valuations related to wind turbines.[12]
- As the available market data do not support the claim of a negative impact upon residential values, residential assessed values have fluctuated consistently within counties as influenced by market conditions, with no regard for proximity to a wind farm.
- Agricultural properties are taxed based upon a productivity formula that is not impacted by market data and external influences.

12 A law suit was apparently filed in 2013 against the Supervisor of Assessments in Vermilion County by a homeowner proximate to wind turbines; however, there has been no further action on the matter.

Literature Review

I am familiar with several academic and peer-reviewed studies of the impact of wind turbines on residential property values. There are no peer reviewed studies for the state of South Dakota, however the following studies are consistent with our findings in South Dakota.[13] These are summarized below:

Municipal Property Assessment Corporation (MPAC) Study, Ontario, Canada

This study originally was conducted in 2008 and was updated in 2012 and 2016. The conclusions in all three studies are similar: "there is *no statistically significant impact on sale prices* of residential properties in these market areas resulting from proximity to an IWT, when analyzing sale prices." (Emphasis in original. IWT is Industrial Wind Turbine. 2012 Page 5) Using 2,051 properties and generally accepted time adjustment techniques, MPAC "cannot conclude any loss in price due to the proximity of an IWT." (2012 Page 29) Further, Appendix G of the 2012 MPAC report states "Re-sale Analysis" states in the "Summary of Findings" "MPAC's own re-sale analysis using a generally accepted methodology for time adjustment factors indicates no loss in price based on proximity to the nearest IWT."

Lawrence Berkeley National Laboratory (LBNL) Studies, Nationwide, 2009, and 2013

The 2009 study included analysis of 7,489 sales within 10 miles of 11 wind farms and 125 post-construction sales within 1 mile of a wind turbine. The study used rural settings and wind farms of more than 50 turbines, and considered area stigma, scenic vista sigma, and nuisance stigma in varying distances from a wind turbine. The 2013 LBNL study included 51,276 sales located in nine states and proximate to 67 wind farms, and 376 post-construction sales within 1 mile of a wind turbine. Like the 2009 study, all were located in rural settings and near wind farms of more than 50 turbines. This study concentrated on nuisance stigma in varying distances from a wind turbine. The study found no statistically significant evidence that turbines affect sale prices. Neither study found statistical evidence that home values near turbines were affected.

University of Rhode Island, Rhode Island, 2013

Structured similarly to the LBNL studies, this study included 48,554 total sales proximate to 10 wind farms, and 412 post-construction sales within 1 mile of a turbine. These wind farms were mostly small facilities in urban settings. The study included nuisance and scenic vista stigmas. Page 421 of the report stated, "Both the whole sample analysis and the repeat sales analysis indicate that houses within a half mile had essentially no price change ..." after the turbines were erected.

13 Although I have read these studies, the substance of these summaries was taken from a seminar conducted by the Appraisal Institute on March 5, 2015.

University of Guelph, Melancthon Township, Ontario, Canada, 2013

This study analyzed two wind farms in the township, using 5,414 total sales and 18 post-construction sales within 1 kilometer of a wind turbine. The study included nuisance and scenic vista stigmas. Page 365 of the study stated that "(T)hese results do not corroborate the concerns regarding potential negative impacts of turbines on property values."

University of Connecticut/LBNL, Massachusetts, 2014

This study included 312,677 total sales proximate to 26 wind farms, and 1,503 post-construction sales within 1 mile of a wind turbine. These wind farms were located in urban settings and primarily were proximate to small wind farms. The study included wind turbines and other environmental amenities/disamenities (including beaches and open spaces/landfills, prisons, highways, major road, and transmission lines) together, for nuisance stigma. "Although the study found the effects from a variety of negative features ... and positive features ... the study found no net effects due to the arrival of turbines."

These studies had a combined number of 2,500 transactions within 1 mile of operating turbines and found no evidence of value impact.

Conclusions

As a result of the market impact analysis undertaken, I concluded that there is no market data indicating the Project will have a negative impact on either rural residential or agricultural property values in the surrounding area. Further, market data from South Dakota, as well as other states, supports the conclusion that the Project will *not* have a negative impact on rural residential or agricultural property values in the surrounding area. Finally, for agricultural properties that host turbines, the additional income from the wind lease may increase the value and marketability of those properties. These conclusions are based on the following:

- The proposed use will meet or exceed all the required development and operating standards;
- Controls, such as setbacks and noise limits, are in place to insure on-going compliance;
- There are significant financial benefits to the local economy and to the local taxing bodies from the development of the proposed wind farm;
- The proposed wind farm will create well-paid jobs in the area which will benefit overall market demand;
- An analysis of residential sales proximate to wind farms did not support any finding that proximity to a wind turbine had a negative impact on property values;
- An analysis of agricultural land values in Iowa did not support any finding that agricultural land values are negatively impacted by the proximity to wind turbines;
- Reports from Minnesota, Iowa, and Illinois indicate that wind turbine leases add value to agricultural land; and
- A survey of County Assessors in 6 South Dakota counties, 26 Iowa counties, 8 Minnesota counties, and 18 Illinois counties in which wind farms with more than 25 turbines are located determined that there was no market evidence to support a negative impact upon residential property values as a result of the development of and the proximity to a wind farm, and that there were no reductions in assessed valuation.

This report is based on market conditions existing as of January 29, 2018. This market impact study has been prepared specifically for the use of the client and to potentially support an application to allow the development of the Dakota Range Wind Project, in Codington County and Grant County, South Dakota. Any other use or user of this report is considered to be unintended.

Respectfully submitted,
MaRous & Company



Michael S. MaRous, MAI, CRE
South Dakota Certified General #1639-T-2018 (8/27/18 expiration)
Illinois Certified General - #553.000141 (9/19 expiration)

CERTIFICATE OF REPORT

I do hereby certify that:

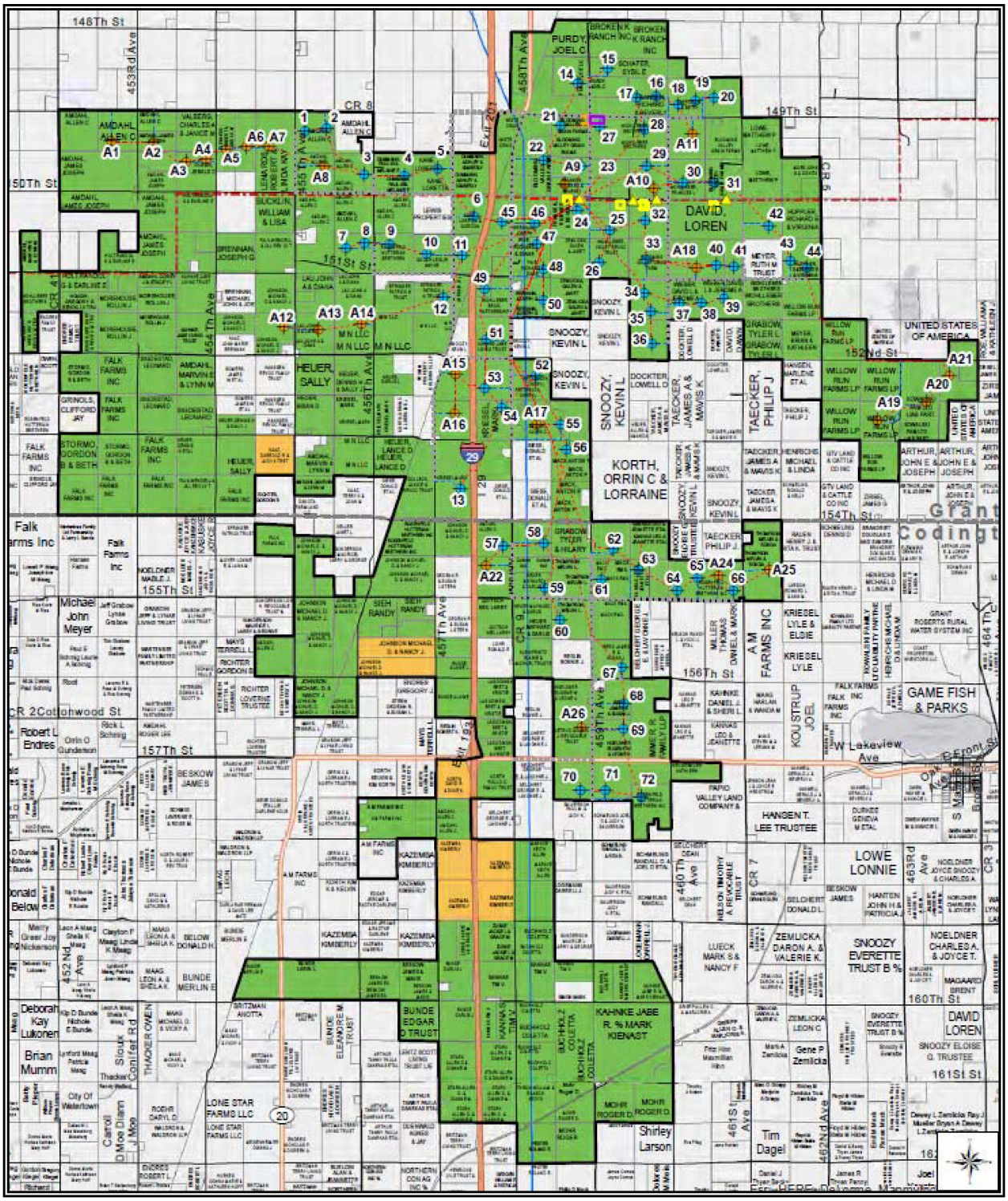
1. The statements of fact contained in this report are true and correct;
2. The reported analyses, opinions, and conclusions are limited only by the reported assumptions and limiting conditions, and are my personal, impartial, and unbiased professional analyses, opinions, conclusions, and recommendations:
3. I have no present or prospective personal interest in the property that is the subject of this report and no personal interest with respect to the parties involved;
4. I have performed no services, as an appraiser or in any other capacity, regarding the property that is the subject of this report within the three-year period immediately preceding acceptance of this assignment;
5. I have no bias with respect to the property that is the subject of the work under review or to the parties involved with this assignment;
6. My engagement in this assignment was not contingent upon developing or reporting predetermined results;
7. My compensation for completing this assignment is not contingent upon the development or reporting of predetermined value or direction in value that favors the cause of the client, the amount of the value opinion, the attainment of a stipulated result, or the occurrence of a subsequent event directly related to the intended use of this appraisal consulting assignment;
9. My analyses, opinions, and conclusions were developed, and this report has been prepared in conformity with the *Uniform Standards of Professional Appraisal Practice;*
10. I have made a personal inspection of the subject of the work under review;
11. Joseph M. MaRous provided significant appraisal review assistance to the person signing this certification;
12. The reported analysis, opinions, and conclusions were developed, and this report has been prepared, in conformity with the Code of Professional Ethics and Standards of Professional Appraisal Practice of the Appraisal Foundation;
12. The use of the report is subject to the requirements of the Appraisal Institute relating to review by its duly authorized representatives; and
13. As of the date of this report, Michael S. MaRous, MAI, CRE, has completed the continuing education requirements for Designated Members of the Appraisal Institute.

Respectfully submitted,
MaRous & Company

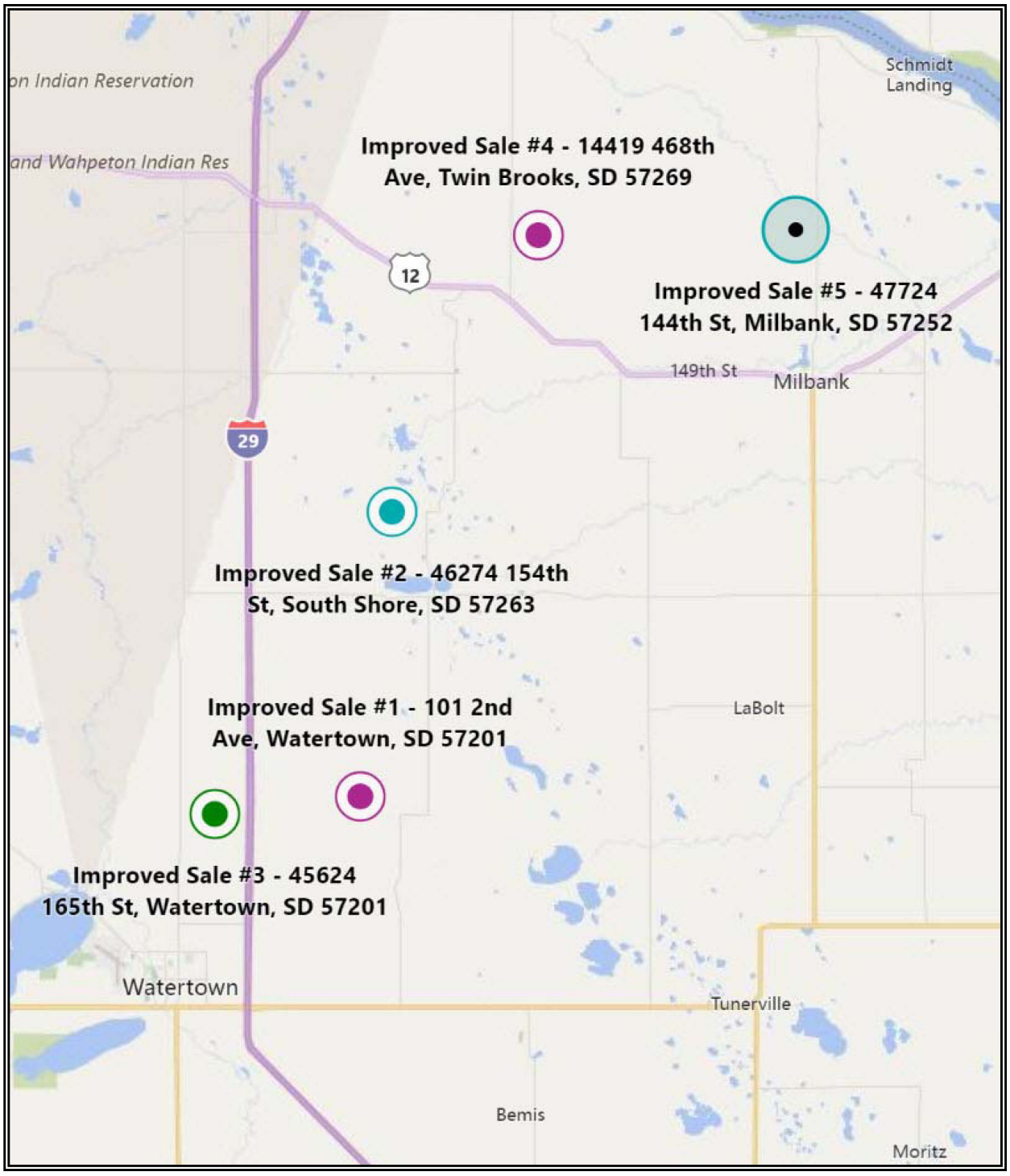


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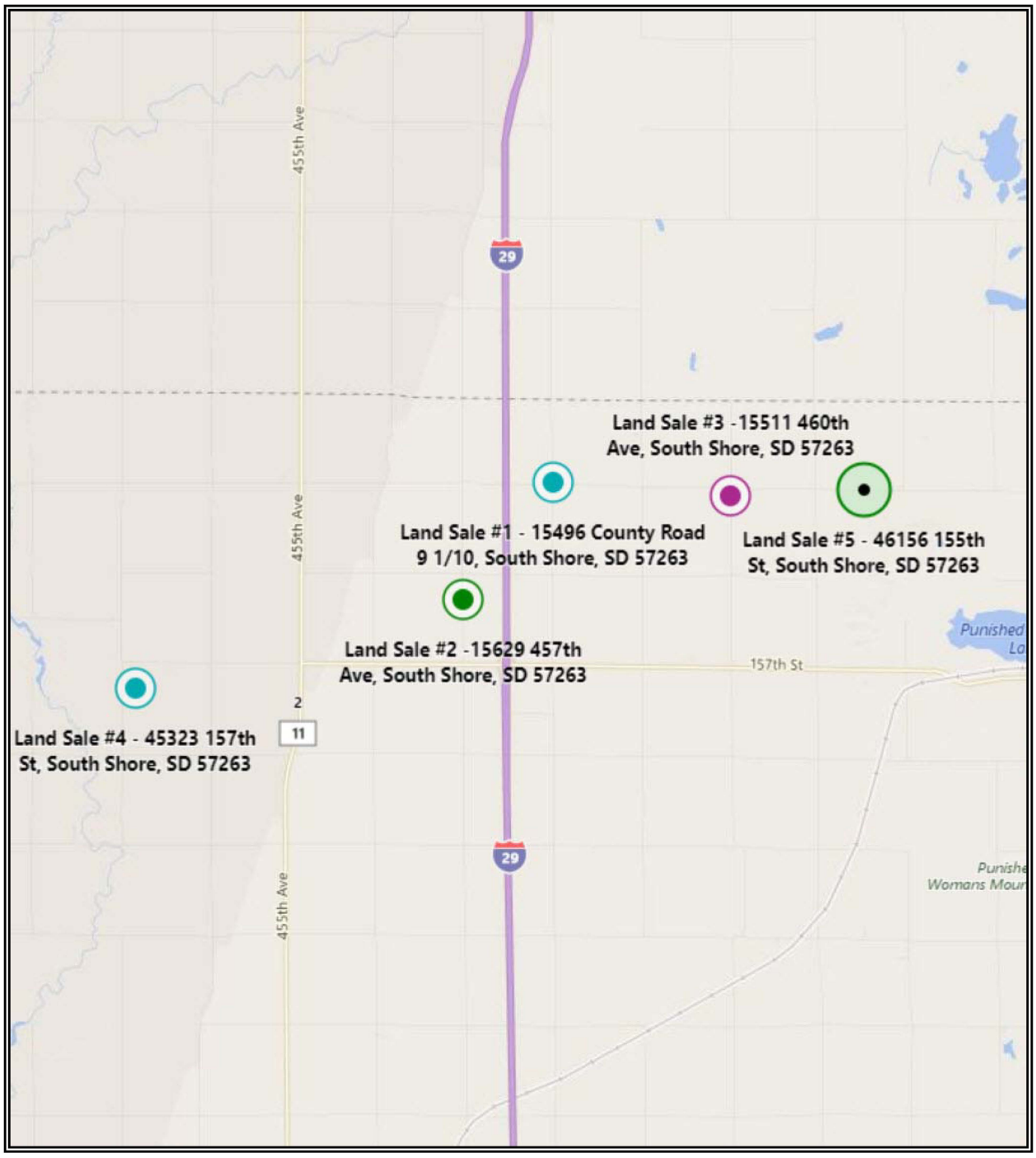
ADDENDA



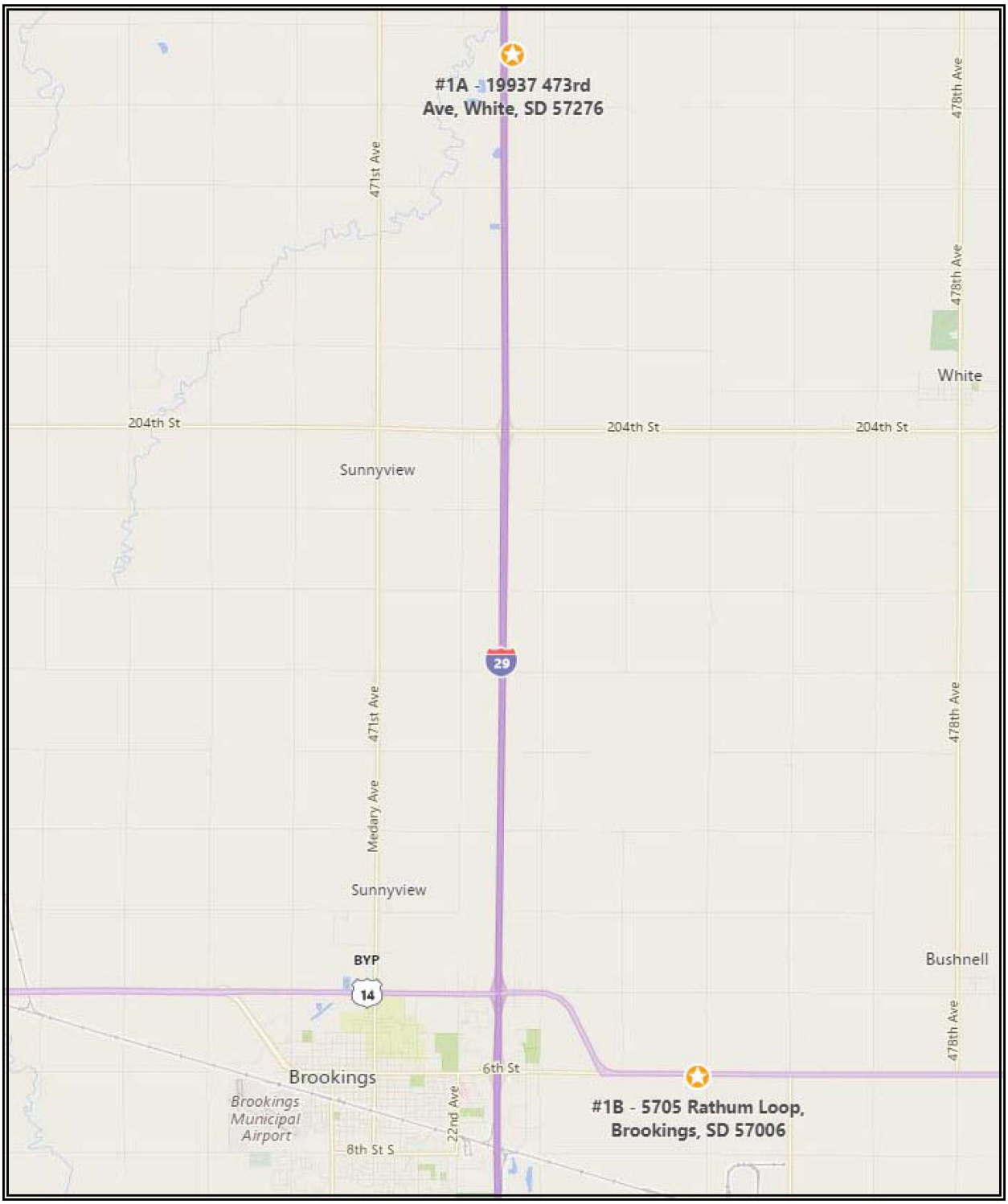
DAKOTA RANGE WIND PROJECT FOOTPRINT



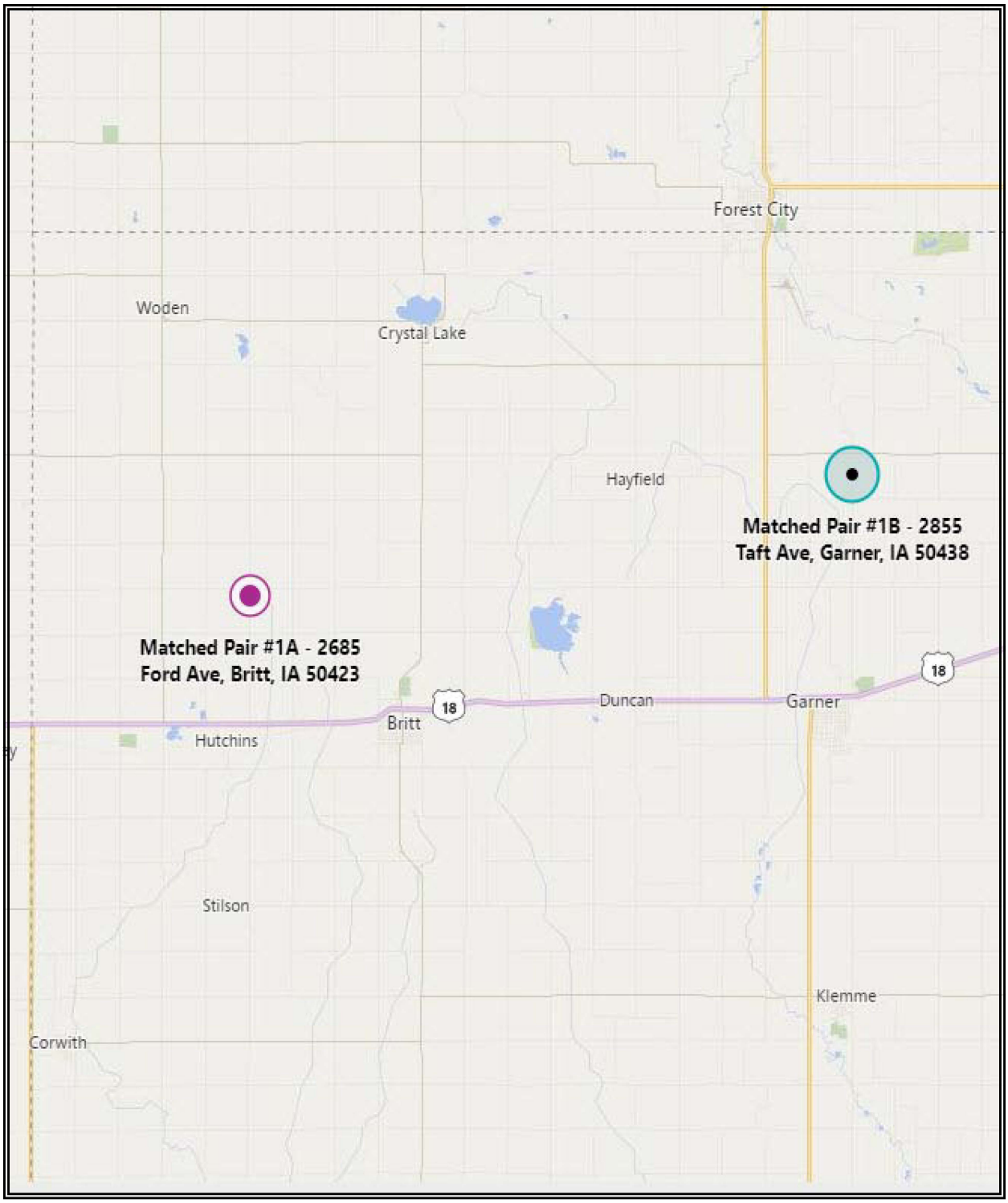
RECENT SINGLE-FAMILY HOUSE SALES LOCATION MAP



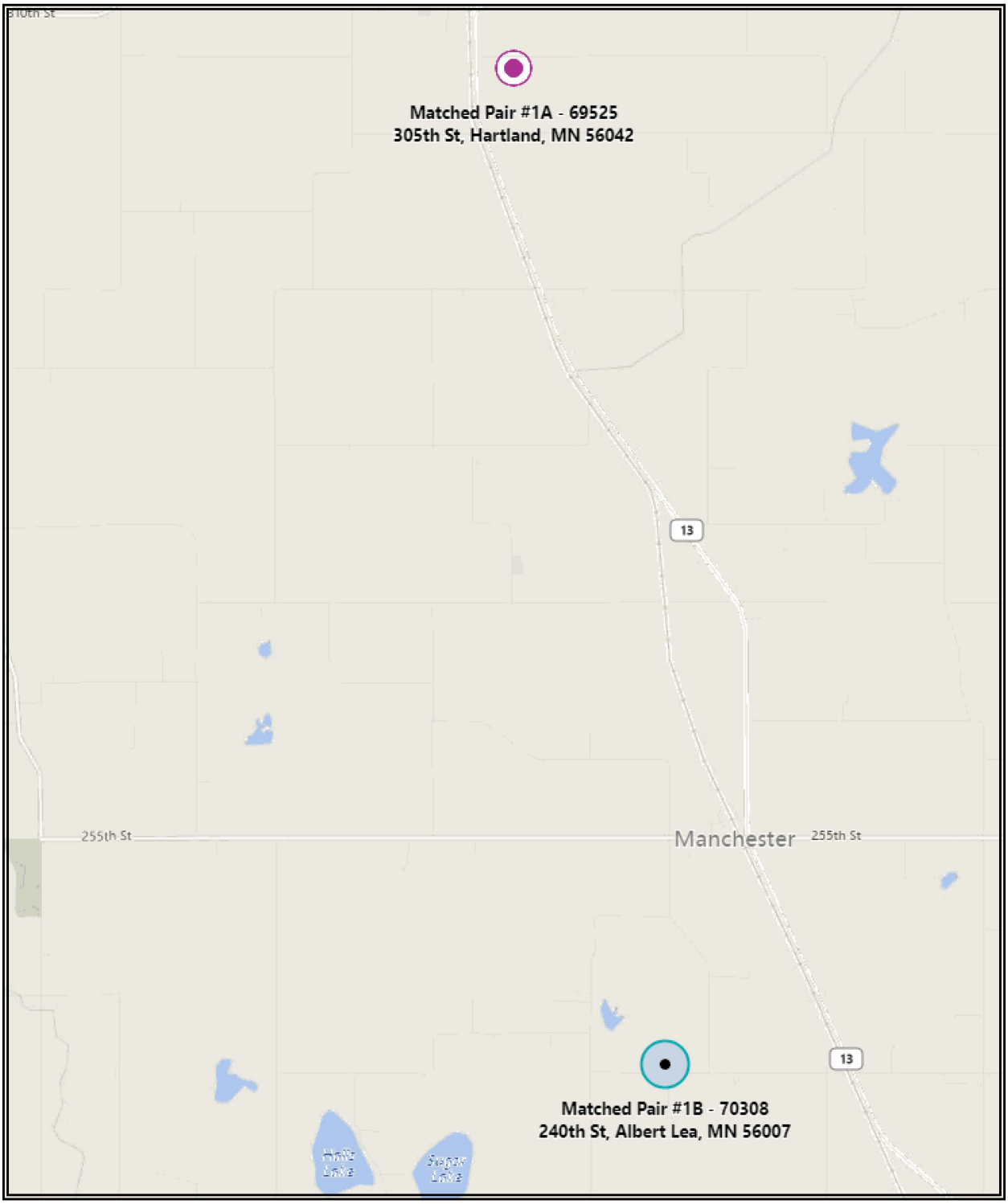
LAND SALES LOCATION MAP



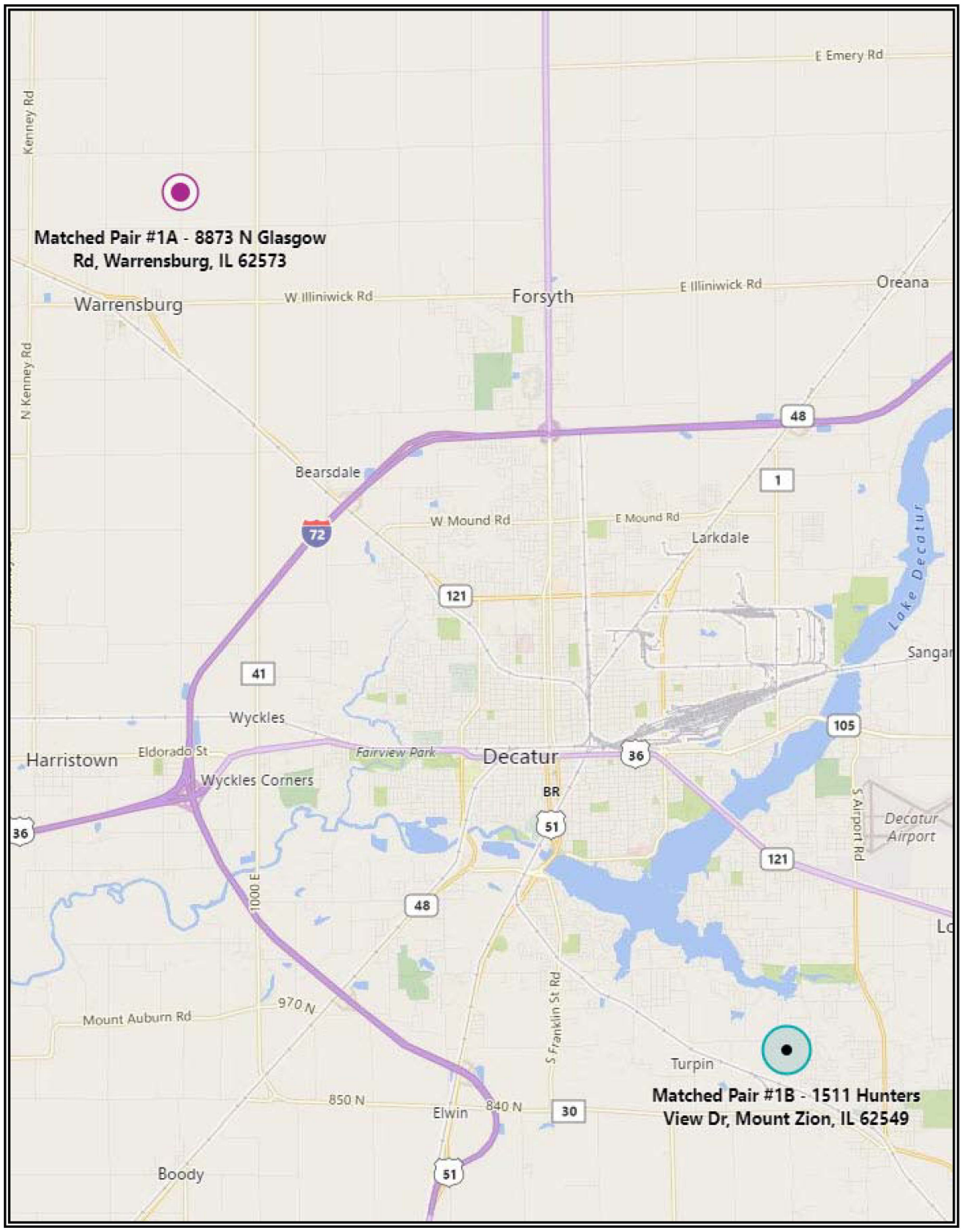
BROOKINGS COUNTY, SOUTH DAKOTA RESIDENCE LOCATION MAP



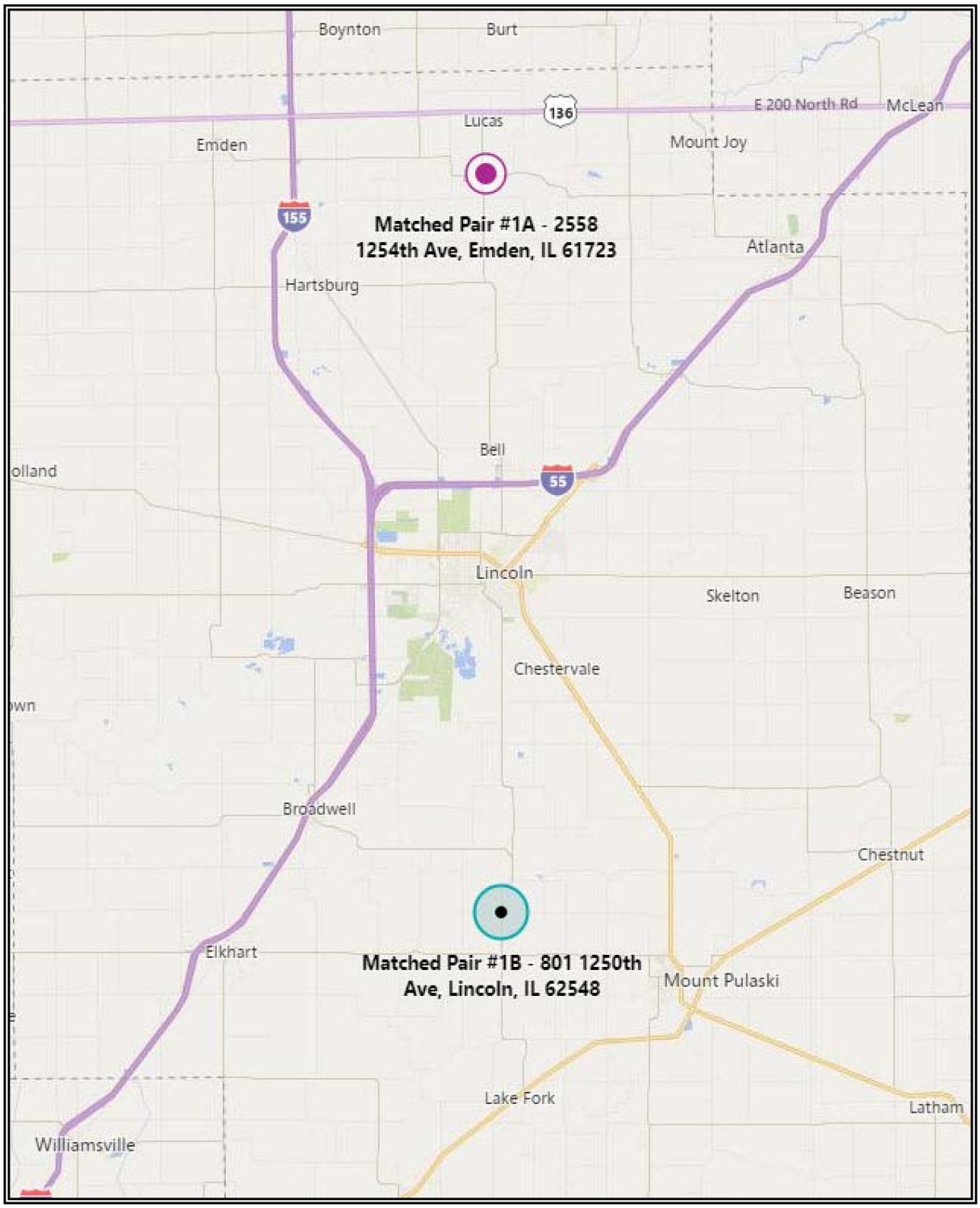
HANCOCK COUNTY, IOWA MATCHED PAIR LOCATION MAP



FREEBORN COUNTY, MINNESOTA MATCHED PAIR LOCATION MAP



MACON COUNTY, ILLIONOIS MATCHED PAIR LOCATION MAP



LOGAN COUNTY, ILLINOIS MATCHED PAIR LOCATION MAP

IMPROVED SALE PHOTOGRAPHS



101 2nd Avenue, Waverly



46274 154th Street, South Shore



45264 165th Street, Watertown



14419 468th Avenue, Twin Brooks



47724 144th Street, Milbank

South Dakota County Assessor Survey

South Dakota County Assessor Survey Analysis

A survey of assessors in 6 counties in South Dakota which wind farms currently are operational has been undertaken. The supervisors or deputy supervisors of assessments were interviewed. The interviews were intended to allow the assessment officials to share their experiences regarding the impact of the wind farm(s) upon the market values and/or the assessed values of surrounding properties. The interviews were conversational, but thoroughly discussed residential and agricultural values and impacts. The interviews were conducted on November 7, 2017.

Conclusions of the Study

Based on these interviews:

- Without exception, the interviewees reported that there was no market evidence to support a negative impact upon residential property values as a result of the development of, and the proximity to, a wind farm facility. In some counties, this results from the very rural nature of the area in which the projects are located.
- There have been no tax appeals in any county based upon wind farm-related concerns.
- In the past 18 months, the assessor's offices have not experienced a real estate tax appeal based upon wind farm-related concerns. As of the date of this report, there are more than 7 wind farms with 400 wind turbines within these counties. There have been no reductions in assessed valuations related to wind turbines.
- Residential assessed values have fluctuated consistently countywide as influenced by market conditions, with no regard for proximity to a wind farm.
- Agricultural properties are taxed based upon a productivity formula that is not impacted by market data and by external influences.

Scope of Project

The supervisors or deputy supervisors of assessments were interviewed. Each of the interviewees was familiar with the wind farm(s) located within their respective county. The following is the list of County Supervisors of Assessments contacted:

1. Aurora County	Ms. Leah Vissia	605-942-7164
2. Brookings County	Mr. Jacob Brehmer (Deputy)	605-696-8220
3. Charles Mix County	Ms. Denise Weber	605-487-7382
4. Day County	Ms. Dari Schlotte	605-345-9502
5. Hyde County	Ms. Carrie Stevenson	605-852-2070
6. Jerauld County	Ms. Janice Bender	605-539-9701

A map indicating the number of wind farms in each of these counties is included in this memorandum. A second map illustrates the number of the wind farms located in each of these counties.

Residential Market Values

Without exception, the interviewees reported that there was no market evidence to support a negative impact upon residential property values as a result of the development of, and the proximity to, a wind farm facility. Either as a request by a county board, in an attempt to appropriately assess newly constructed residences, or to support current assessed values, the supervisors of assessments have been particularly attentive to market activity in the area of the wind farms.

Aurora, Brookings, and Day Counties' Supervisors of Assessments all stated that a majority of the wind turbines were place with grazing and pasture land used for raising cattle. Each one of the assessors made it a point to note that they had personally witnessed the cows grazing right alongside turbines, indicating that the turbines had no effect, of any kind, on the animals.

Residential Assessed Values, Complaints/Tax Appeal Filings

The assessors reported that there have been no tax appeal filings based upon wind farm issues.

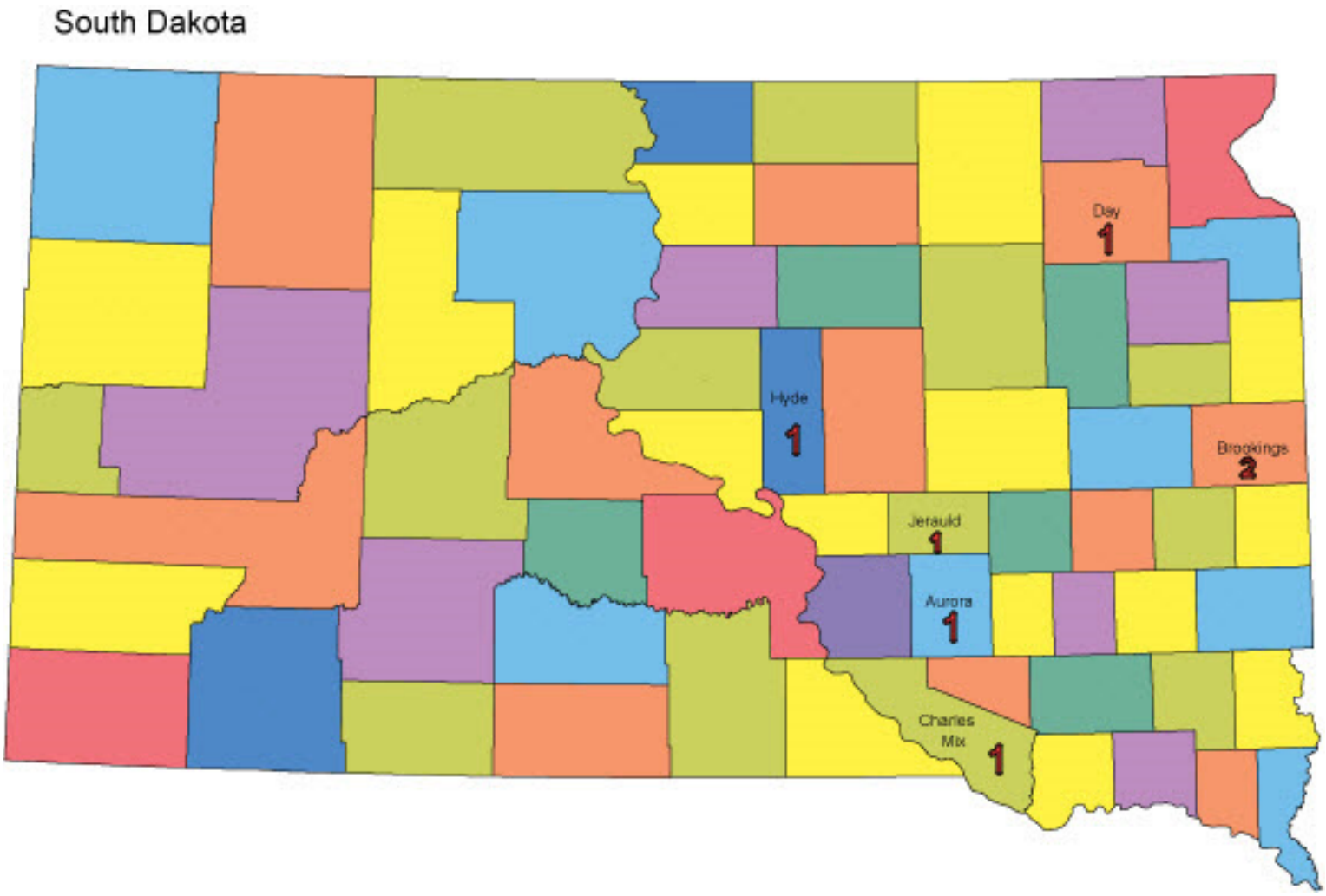
Ms. Carrie Stevenson, the Hyde County supervisor of assessments, did mention that the morning on the day the survey was taken Hyde County held its County Commissioners meeting. The topic of some of the meeting revolved around wind farms in the county. In attendance were approximately 30 residents, or a little over 2% of the total population of Hyde County. These residents showed up to voice their various complaints to the County Commissioners. The complaints were listened to and validated, yet in the end, there were no changes to property values given.

Consistently, the assessors reported that whatever initial concern there may have been regarding property values during the planning and approval stages of the various wind farms dissipated once the wind farm was constructed. Repeatedly, the assessors would state that the revenue that would come into the county and to each individual farmer would outweigh any initial concern that the residents would have about the wind farms joining their communities.

Agricultural Values/Assessed Values

The assessed values of agricultural properties are established based upon a productivity formula and are not driven by market data. Reportedly, assessed values of agricultural properties have been steady or increasing in recent years and are projected to continue increasing for the near future. The assessors reported that no major complaints have been received and/or no tax appeal filings have been filed for agricultural properties within the wind farm footprint.

Based on this survey, it does not appear that the Supervisors of Assessments in the 6 surveyed in South Dakota have reason to believe that the location of wind turbines in their county has had a negative impact on property values.



Map of South Dakota Counties Surveyed

Wind Farm Count by County

25 Turbines or Higher



Note: As depicted on this map, the locations of certain wind farms are approximations. In some instances, the wind farms are incorrectly shown to be located in adjacent counties. This map, as of the date of this survey, also shows the locations of smaller wind farms, but for the accuracy of this study we have only focused on the farms with 25 turbines or higher.

MICHAEL S. MAROUS
STATEMENT OF QUALIFICATIONS

Michael S. MaRous, MAI, CRE, is president and owner of MaRous and Company. He has appraised more than $15 billion worth of primarily investment-grade real estate in more than 25 states. In addition to providing documented appraisals, he has served as an expert witness in litigation proceedings for many law firms; financial institutions; corporations; builders and developers; architects; local, state, county, and federal governments and agencies; and school districts in the Chicago metropolitan area. His experience in partial interest, condemnation, damage impact, easement (including aerial and subsurface), marital dissolutions, bankruptcy proceedings, and other valuation issues is extensive. He has provided highest and best use, marketability, and feasibility studies for a variety of properties. Many of the largest redevelopment areas and public projects, including Interstate 355, the Chicago O'Hare International Airport expansion, the Chicago Midway International Airport expansion, and the McCormick Place expansion, are part of Mr. MaRous' experience. Mr. MaRous also has experience in regard to mediation and arbitration proceedings. Also, he has purchased and developed real estate for his own account.

APPRAISAL AND CONSULTATION EXPERIENCE

Industrial Properties

Business Parks	Manufacturing Facilities	Self-storage Facilities
Distribution Centers	Research Facilities	Warehouses

Commercial Properties

Auto Sales/Service Facilities	Gasoline Stations	Restaurants
Banquet Halls	Hotels and Motels	Shopping Centers
Big Box Stores	Office Buildings	Theaters

Special-Purpose Properties

Bowling Alleys	Nurseries	Tank Farms
Cemeteries	Riverboat Gambling Facilities	Underground Gas Aquifers
Farms	Schools	Utility Corridors
Golf Courses	Stadium Expansion Issues	Waste Transfer Facilities
Lumber Yards		Wind Farms

Residential Properties

Apartment Complexes	Condominium Developments	Subdivision Developments
Condominium Conversions	Single-family Residences	Townhouse Developments

Vacant Land

Agricultural	Easements	Rights of Way
Alleys	Industrial	Streets
Commercial	Residential	Vacations

Clients

Corporations	Law Firms	Private Parties
Financial Institutions	Not-for-profit Associations	Public Entities

EDUCATION

B.S., Urban Land Economics, University of Illinois, Urbana-Champaign
Continuing education seminars and programs through the Appraisal Institute
and the American Society of Real Estate Counselors, and real estate brokerage classes

PUBLIC SERVICE

Mayor, City of Park Ridge, Illinois (2003-2005)
Alderman, City of Park Ridge, including Liaison to the Zoning Board of Appeals and Planning and Zoning and
Chairman of the Finance and Public Safety Committees (1997-2005)

PROFESSIONAL AFFILIATIONS AND LICENSES

Appraisal Institute, MAI designation, Number 6159
Counselors of Real Estate, CRE designation
Illinois Certified General Real Estate Appraiser, License Number 553.000141 (9/19)
Indiana Certified General Real Estate Appraiser, License Number CG41600008 (6/18)
Wisconsin Certified General Real Estate Appraiser, License Number 1874-10 (12/19)
Minnesota Certified General Real Estate Appraiser, License Number 40330656 (8/18)
Pennsylvania Certified General Real Estate Appraiser, License Number GA004181 (6/19)
Iowa Certified General Real Estate Appraiser, License Number CG03468 (6/19)
South Dakota Certified General Real Estate Appraiser, Temporary License Number 1639-T-2018 (8/18)
Licensed Real Estate Broker (Illinois)

PROFESSIONAL ACTIVITIES

Mr. MaRous is past president of the Chicago Chapter of the Appraisal Institute. He is former chair and vice chair of the National Publications Committee and has sat on the board of *The Appraisal Journal*. In addition, he has served on and/or chaired more than 15 other committees of the Appraisal Institute, the Society of Real Estate Appraisers, and the American Institute of Real Estate Appraisers.

Mr. MaRous served as chair of the Midwest Chapter of the Counselors of Real Estate in 2006 and 2007 and has served on the National CRE Board since 2011. He sat on the Midwest Chapter Board of Directors, the Editorial Board of *Real Estate Issues,* and on various other committees.

Mr. MaRous also is past president of the Illinois Coalition of Appraisal Professionals. He also has been involved with many other professional associations, including the Real Estate Counseling Group of America, the Northwest Suburban Real Estate Board, the National Association of Real Estate Boards, and the Northern Illinois Commercial Association of Realtors.

PUBLICATIONS AND PROFESSIONAL RECOGNITION

Mr. MaRous has spoken at more than 20 programs and seminars related to real estate appraisal and valuation.

Author

"Low-income Housing in Our Backyards," *The Appraisal Journal*, January 1996
"The Appraisal Institute Moves Forward," *Illinois Real Estate Magazine*, December 1993
"Chicago Chapter, Appraisal Institute," *Northern Illinois Real Estate Magazine*, February 1993
"Independent Appraisals Can Help Protect Your Financial Base," *Illinois School Board Journal*, November-December 1990
"What Real Estate Appraisals Can Do For School Districts," *School Business Affairs*, October 1990

Awards

Appraisal Institute - George L. Schmutz Memorial Award, 2001
Chicago Chapter of the Appraisal Institute - Heritage Award, 2000
Chicago Chapter of the Appraisal Institute - Herman O. Walther, 1987 (Distinguished Chapter Member)

Reviewer or Citation in the Following Books

Rural Property Valuation, 2017
Real Estate Damages, 1999, 2008, and 2016
Golf Property Analysis and Valuation, 2016
Dictionary of Real Estate Appraisal, Fourth Edition, 2002 and Sixth Edition, 2015
Market Analysis for Real Estate, 2005 and 2014
Appraisal of Real Estate, Twelfth Edition, 2001, Thirteenth Edition, 2008, Fourteenth Edition, 2013
Shopping Center Appraisal and Analysis, 2009
Subdivision Valuation, 2008
Valuation of Apartment Properties, 2007
Valuation of Billboards, 2006
Appraising Industrial Properties, 2005
Valuation of Market Studies for Affordable Housing, 2005
Valuing Undivided Interest in Real Property: Partnerships and Cotenancies, 2004
Analysis and Valuation of Golf Courses and Country Clubs, 2003
Valuing Contaminated Properties: An Appraisal Institute Anthology, 2002
Hotels and Motels: Valuation and Market Studies, 2001
Land Valuation: Adjustment Procedures and Assignments, 2001
Appraisal of Rural Property, Second Edition, 2000
Capitalization Theory and Techniques, Study Guide, Second Edition, 2000
Guide to Appraisal Valuation Modeling Land, 2000
Appraising Residential Properties, Third Edition, 1999
Business of Show Business: The Valuation of Movie Theaters, 1999
GIS in Real Estate: Integrating, Analyzing and Presenting Locational Information, 1998
Market Analysis for Valuation Appraisals, 1995

REPRESENTATIVE WORK OF MICHAEL S. MAROUS

Headquarters/Corporate Office Facilities in Illinois

Fortune 500 corporation facility, 200,000 sq. ft., Libertyville
Corporate headquarters, 300,000 sq. ft. and 500,000 sq. ft., Chicago
Fortune 500 corporation facility, 450,000 sq. ft., Northfield
Major airline headquarters, 1,100,000 million sq. ft. on 47 acres, Elk Grove Village
Former communications facility, 1,400,000 million sq. ft. on 62 acres, Skokie and Niles
Corporate Headquarters, 1,500,000+ sq. ft., Lake County
Former Sears Headquarters Redevelopment Project, Chicago

Office Buildings in Chicago

401 South LaSalle Street, 140,000 sq. ft.
134 North LaSalle Street, 260,000 sq. ft.
333 North Michigan Avenue, 260,000 sq. ft.
171 West Randolph Street, 360,000 sq. ft.
20 West Kinzie Street, 405,000 sq. ft.
55 East Washington Street, 500,000 sq. ft.
10 South LaSalle Street, 870,000 sq. ft.
222 West Adams Street, 1,000,000 sq. ft.
141 West Jackson Boulevard, 1,065,000 sq. ft.
333 South Wabash Avenue, 1,125,000 sq. ft.
155 North Wacker Drive, 1,406,000 sq. ft.
70 West Madison Street, 1,430,000 sq. ft.
111 South Wacker Drive, 1,454,000 sq. ft.
175 West Jackson Boulevard, 1,450,000 sq. ft.
227 West Monroe Street, 1,800,000 sq. ft.
10 South Dearborn Street, 1,900,000 sq. ft.

Hotels in Chicago

One West Wacker Drive (Renaissance Chicago Hotel)
10 East Grand Avenue (Hilton Garden Inn)
106 East Superior Street (Peninsula Hotel)
120 East Delaware Place (Four Seasons)
140 East Walton Place (The Drake Hotel)
160 East Pearson Street (Ritz Carlton)
301 East North Water Street (Sheraton Hotel)
320 North Dearborn Street (Westin Chicago River North)
401 North Wabash Avenue (Trump Tower)
505 North Michigan Avenue (Hotel InterContinental)
676 North Michigan Avenue (Omni Chicago Hotel)
800 North Michigan Avenue (The Park Hyatt)

Large Industrial Properties in Illinois

Large industrial complexes, 400,000 sq. ft., 87th Street and Greenwood Avenue, Chicago
Distribution warehouse, 580,000 sq. ft. on 62 acres, Champaign
Publishing house, 700,000 sq. ft. on 195 acres, U.S. Route 45, Mattoon
AM Chicago International, 700,000± sq. ft. on 41 acres, 1800 West Central Road, Mount Prospect
Nestlé distribution center, 860,000 sq. ft. on 153 acres, DeKalb
U.S. Government Services Administration distribution facility, 860,000 sq. ft., 76th Street and Kostner Avenue, Chicago
Fortune 500 company distribution center, 1,000,000 sq. ft., Elk Grove Village
Caterpillar Distribution Facility, 2,231,000 sq. ft., Morton
Self-storage facilities, various Chicago metropolitan locations

Airport Related Properties

Mr. MaRous has performed valuations on more than 100 parcels in and around Chicago O'Hare International Airport, Chicago Midway International Airport, Palwaukee Municipal Airport, Chicago Aurora Airport, DuPage Airport, and Lambert-St. Louis International Airport

Vacant Land in Illinois

15 acres, office, Northbrook
20 acres, residential, Glenview
25 acres, Hinsdale
55 acres, mixed-use, Darien
68 acres, Roosevelt Road and the Chicago River
75 acres, I-88 at I-355, Downers Grove
100± acres, various uses, Lake County
100 acres, Western Springs
140 acres, Flossmoor
142 acres, residential, Lake County
160 acres, residential, Cary
200 acres, mixed-use, Bartlett
250 acres, Island Lake
450 acres, residential, Wauconda
475± acres, various uses, Lake County
650 acres, Hawthorne Woods
650 acres, Waukegan/Libertyville
800 acres, Woodridge
900 acres, Matteson
1,000± acres, Batavia area
2,000± acres, Northern Lake County
5,000 acres, southwest suburban Chicago area
Landfill expansion, Lake County

Retail Facilities

20 Community shopping centers, various Chicago metropolitan locations
Big-box uses, various Chicago metropolitan locations and the Midwest
Gasoline Stations, various Chicago metropolitan locations
More than 50 single-tenant retail facilities larger than 80,000 sq. ft., various Midwest metropolitan locations

Residential Projects

Federal Square townhouse development project, 118 units, $15,000,000+ sq. ft. project, Dearborn Place, Chicago
Marketability and feasibility study, 219 East Lake Shore Drive, Chicago
Riverview II, Chicago; Old Town East and West, Chicago; Museum Park Lofts II, Museum Park Tower 4, University Commons, Two River Place, River Place on the Park, Chicago;
Timber Trails, Western Springs, Illinois

Market Impact Studies

Land-fill projects in various locations
Quarry expansions in Boone and Kendall counties
Commercial development and/or parking lots in various communities
Zoning changes in various communities
Waste transfer stations in various communities

Energy Projects

Oakwood Hills Energy Center, McHenry County Illinois, market impact analysis
Walnut Ridge Wind Farm, Bureau County, Illinois, market impact analysis
Twin Forks Wind Farm, Macon County, Illinois, market impact analysis
Twin Groves Wind Farm, McLean County, Illinois, market impact analysis
Otter Creek Wind Farm, LaSalle County, Illinois, market impact analysis
Pleasant Ridge Wind Farm, Livingston County, Illinois, consulting
Commonwealth Edison, high tension lines, market impact analysis
Lackawanna Power Plant, Lackawanna County, Pennsylvania, market impact analysis
Brookhaven, New York, solar energy production facility, consulting

Business and Industrial Parks

Chevy Chase Business Park, 30 acres, Buffalo Grove
Carol Point Business Center, 300-acre industrial park, Carol Stream, $125,000,000+ project
Internationale Centre, approximately 1,000 acre-multiuse business park, Woodridge

Properties in Other States

330,000 sq. ft., Newport Beach, California
Former government depot/warehouse and distribution center, 2,500,000 sq. ft. on 100+ acres, Ohio
Shopping Center, St. Louis, Missouri
Office Building, Clayton, Missouri
Condominium Development, New York, New York
Hormel Foods, various Midwest locations
Wisconsin Properties including Lowes, Menards, Milwaukee Zoo, CVS Pharmacys in Milwaukee, Dairyland Race Track, Major Industrial Property in Manawa , Class A Office Buildings and Vacant Land

REPRESENTATIVE CLIENT LISTING OF MICHAEL S. MAROUS

Law Firms

Alschuler, Simantz & Hem LLC
Ancel, Glink, Diamond, Bush, DiClanni & Krafthefer
Arnstein & Lehr LLP
Berger, Newmark & Fenchel P.C.
Berger Schatz
Botti Law Firm, P.C.
Carmody MacDonald P.C.
Carr Law Firm
Crane, Heyman, Simon, Welch & Clar
Daley & Georges, Ltd.
Day, Robert & Morrison, P.C.
Dentons US LLP
DiMonte & Lizak LLC
DLA Piper
Dreyer, Foote, Streit, Furgason & Slocum, P.A.
Drinker, Biddle & Reath LLP
Figliulo & Silverman, P.C.
Foran, O'Toole & Burke LLC
Franczek Radelet P.C.
Fredrikson & Byron, P.A.
Freeborn & Peters LLP
Gould & Ratner LLP
Greenberg Traurig LLP
Helm & Wagner
Robert Hill Law, Ltd.
Hinshaw & Culbertson LLP
Holland & Knight LLP
Ice Miller LLP
Jenner & Block
Katz & Stefani, LLC
Kinnally, Flaherty, Krentz, Loran, Hodge & Mazur PC
Kirkland & Ellis LLP
Klein, Thorpe & Jenkins, Ltd.
McDermott, Will & Emery
Mayer Brown
Michael Best & Friedrich LLP
Morrison & Morrison, Ltd.
Bryan E. Mraz & Associates
Neal, Gerber & Eisenberg, LLP
Neal & Leroy LLC
O'Donnell Haddad LLC
Prendergast & DelPrincipe
Rathje & Woodward, LLC
Righeimer, Martin & Cinquino, P.C.
Robbins, Salomon & Patt, Ltd.
Rosenfeld Hafron Shapiro & Farmer
Rosenthal, Murphey, Coblentz & Donahue
Rubin & Associates, P.C.
Ryan and Ryan, P.C.
Reed Smith LLP
Sarnoff & Baccash
Scariano, Himes & Petrarca, Chtd.
Schiff Hardin LLP
Schiller, DuCanto & Fleck LLP
Schirott, Luetkehans & Garner, LLC
Schuyler, Roche & Crisham, P.C.
Sidley Austin LLP
Storino, Ramello & Durkin
Thomas M. Tully & Associates
Thompson Coburn, LLP
Tuttle, Vedral & Collins, P.C.
Vedder Price
von Briesen & Roper, SC
Winston & Strawn LLP
Worsek & Vihon LLP

Financial Institutions

AmericaUnited Bank Trust
BMO Harris Bank
Charter One
Citibank
Cole Taylor Bank
First Bank of Highland Park
First Financial Northwest Bank
First Midwest Bank
First State Financial
Glenview State Bank
Itasca Bank & Trust Co.
Lake Forest Bank & Trust Co.
MB Financial Bank
Midwest Bank
Northern Trust
Northview Bank & Trust
The Private Bank
Wintrust

Corporations

Advocate Health Care System
Alliance Property Consultants
American Stores Company
Archdiocese of Chicago
Arthur J. Rogers and Company
Avangrid Renewables, LLC
BHE Renewables
BP Amoco Oil Company
Christopher B. Burke Engineering, Ltd.
Cambridge Homes
Canadian National Railroad
Capital Realty Services, Inc.
Chicago Cubs
Children's Memorial Hospital
Chrysler Realty Corporation
Citgo Petroleum Corporation
CorLands
CVS
Edward R. James Partners, LLC
Enterprise Development Corporation
Enterprise Leasing Company
Exxon Mobil Corporation
Hamilton Partners
Hollister Corporation
Imperial Realty Company
Invenergy LLC
Kimco Realty Corporation
Kinder Morgan, Inc.
Lakewood Homes
Lowe's Companies, Inc.
Loyola University Health System
Marathon Oil Corporation
Meijer, Inc.
Menards
Mesirow Stein Real Estate, Inc.
Paradigm Tax Group
Prime Group Realty Trust
Public Storage Corporation
RREEF Corporation
Shell Oil Company
Union Pacific Railroad Company
United Airlines, Inc.

Public Entities

Illinois Local Governments and Agencies

Village of Arlington Heights
Village of Barrington
Village of Bartlett
Village of Bellwood
Village of Brookfield
Village of Burr Ridge
City of Canton
Village of Cary
City of Chicago
Village of Deer Park
City of Des Plaines
Des Plaines Park District
Downers Grove Park District
City of Elgin
Elk Grove Village
City of Elmhurst
Village of Elmwood Park
City of Evanston
Village of Forest Park
Village of Franklin Park
Village of Glenview
Glenview Park District
Village of Harwood Heights
City of Highland Park
Village of Hinsdale
Village of Inverness
Village of Kenilworth
Village of Kildeer
Village of Lake Zurich
Leyden Township
Village of Lincolnshire
Village of Lincolnwood
Village of Morton Grove
Village of Mount Prospect
Village of North Aurora
Village of Northbrook
City of North Chicago
Village of Northfield
Northfield Township
Village of Oak Brook
Village of Orland Park
City of Palos Hills
City of Peoria
City of Prospect Heights
City of Rolling Meadows
Village of Rosemont
City of St. Charles
Village of Schaumburg
Village of Schiller Park
Village of Skokie
Village of South Barrington
Village of Streamwood
Metropolitan Water Reclamation District of Greater Chicago
City of Waukegan
Village of Wheeling
Village of Wilmette
Village of Willowbrook
Village of Winnetka
Village of Woodridge

County Governments and Agencies

Boone County State's Attorney's Office
Forest Preserve of Cook County
Cook County State's Attorney's Office
DuPage County Board of Review
Forest Preserve District of DuPage County
Kane County
Kendall County Board of Review
Lake County
Lake County Forest Preserve District
Lake County State's Attorney's Office
Morton Township
Peoria County

State and Federal Government Agencies

Federal Deposit Insurance Corporation
U.S. General Services Administration
Illinois Housing Development Authority
Illinois State Toll Highway Authority
Internal Revenue Service
The U.S. Postal Service

Schools

Argo Community High School District No. 217
Arlington Heights District No. 25 Township High School District No. 214, Arlington Heights
Barrington Community Unit District No. 220
Chicago Board of Education
Chicago Ridge District No. 127½
College of Lake County
Community Consolidated School District No. 15
Community Consolidated School District No. 146
Community School District No. 200
Consolidated High School District No. 230
Darien District No. 61
DePaul University
Elk Grove Community Consolidated District No. 59
Elmhurst Community Unit School District No. 205
Glen Ellyn School District No. 41
Glenbard High School District No. 87
Indian Springs School District No. 109
LaGrange School District No. 105
Lake Forest Academy
Leyden Community High School District No. 212
Loyola University
Lyons Township High School District No. 204
Maine Township High School District No. 207
Niles Elementary District No. 71
North Shore District No. 112, Highland Park
Northwestern University
Orland Park School District No. 135
Palatine High School District #211
Rhodes School District No. 84-1/2
Riverside-Brookfield High School District No. 208
Rosalind Franklin University
Roselle School District No. 12
Schaumburg Community Consolidated District No. 54
Sunset Ridge School District No. 29
Township High School District No. 211
Township High School District No. 214
Triton College
University of Illinois
Wheeling Community Consolidated District No. 21
Wilmette District No. 39

JOSEPH M. MAROUS
STATEMENT OF QUALIFICATIONS

Joseph M. MaRous is an Associate Appraiser with MaRous and Company, with a focus on the renewable and alternative energy industry.

EDUCATION

Purdue University - West Lafayette, Indiana

Bachelor of Science – Building Construction Management

Focus in residential and green build construction

CERTIFICATIONS

Certified Green Build Professional

OSHA Safety Certified

USPAP Certified

CONSTRUCTION

Professional in the construction industry for 10 years

- Residential
- Commercial
- Industrial
- Municipal
- Tenant Improvement
- Schools
- Media Studios
- Automobile Dealerships

APPRAISAL

Wind Projects
- Illinois
- Iowa
- South Dakota
- New York

Solar Projects
- Maryland
- Wisconsin

- Vacant Land
- Auto Dealerships
- Religious Facilities
- Residential
- Commercial
- Retail

For more details visit: linkedin.com/in/joemarous

ORDINANCE #65
ZONING ORDINANCE

FOR

CODINGTON COUNTY

PREPARED BY

THE CODINGTON COUNTY PLANNING COMMISSION

WITH ASSISTANCE FROM
THE FIRST DISTRICT ASSOCIATION OF LOCAL GOVERNMENTS

Text in highlight and ~~strikethrough~~ font to be removed from Ordinance #15
Text in highlight, **bold**, and/or underline font to be added from Ordinance #15

~~SECTION~~ ARTICLE I
GENERAL PROVISIONS

~~This Ordinance, from the date of its passage, shall be for the purpose of promoting the health, safety, morals, and general welfare of the people in the unincorporated areas of Codington County, South Dakota. To this end, this Ordinance will lessen the congestion from fire, panic, and other dangers; providing adequate light and air; preventing the overcrowding of land; avoiding undue concentration of population; facilitating the adequate provision of transportation, water and sewerage, schools, parks, and other public requirements; regulation and restricting the height, number of stories, and bulk of building and other structures; the percentage of lots that may be occupied; the size of yards, courts, and other open spaces; the location and use of other purposes; and regulating and restricting the erection, construction, reconstruction, alteration, repair, and use of building, structures, and land.~~

CHAPTER 1.01. TITLE AND APPLICATION.

Section 1.01.01. Title.

This Ordinance may be known and may be cited and referred to as the "Codington County Zoning Ordinance" to the same effect as if the full title were stated.

Section 1.01.02. Jurisdiction.

Pursuant to SDCL 11-2, 1967, as amended, the provisions of this Ordinance shall apply within the unincorporated areas of Codington County, South Dakota, as established on the map entitled "The Official Zoning Map of Codington County, South Dakota."

Section 1.01.03. Purpose.

The Zoning Ordinance is adopted to protect and to promote the public health, safety, peace, comfort, convenience, prosperity and general welfare. More specifically, the Zoning Ordinance is adopted in order to achieve the following objectives:

1. To assist in the implementation of Codington County's Comprehensive Land Use Plan which in its entirety represents the foundation upon which this Ordinance is based.

2. To foster a harmonious, convenient, workable relationship among land uses.

3. To promote the stability of existing land uses that conform with the Comprehensive Land Use Plan and to protect them from inharmonious influences and harmful intrusions.

4. To insure that public and private lands ultimately are used for the purposes which are most appropriate and most beneficial from the standpoint of the "county community" as a whole.

5. To prevent excessive population densities and overcrowding of the land with structures.

6. To protect and enhance real estate values.

7. To facilitate the adequate provision of transportation, water and sewerage, schools, parks, and other public requirements;

8. To regulate and restrict the height, number of stories, and bulk of building and other structures; the percentage of lots that may be occupied; the size of yards, courts, and other open spaces; and the location and use of other purposes;

9. To regulate and restrict the erection, construction, reconstruction, alteration, repair, and use of building, structures, and land.

10. To place the power and responsibility of the use of land in the hands of the property owner contingent upon the compatibility of surrounding uses and the Comprehensive Land Use Plan.

CHAPTER 1.02. ORDINANCE PROVISIONS.

Section 1.02.01. Provisions of Ordinance Declared to be Minimum Requirements.

In their interpretation and application, the provisions of this Ordinance shall be held to be minimum requirements, adopted for the promotion of the public health, safety, morals, or general welfare. Wherever the requirements of this Ordinance are at variance with the requirements of any other lawfully adopted rule, ordinance, or Board of Adjustment decision, the most restrictive or that imposing the higher standards, shall govern.

Section 1.02.02. Purpose of Catch Heads.

The catch heads appearing in connection with the foregoing sections are inserted simply for convenience, to serve the purpose of an index and they shall be wholly disregarded by any person, officer, court or other tribunal in construing the terms and provisions of this Ordinance.

Section 1.02.03. Violation and Penalty.

1. Violations of the ordinance shall be treated in the manner specified below.

    a. Any person who starts work for which a permit (building, conditional use, variance, rezoning) is required by this Zoning Ordinance, without first securing such permit and paying the prescribed fee, shall be charged according to the provisions of this section. All fees assessed there under shall be rounded to the nearest whole dollar.

        i. Upon finding such violation, Codington County Planning and Zoning Staff shall notify the owner of property involved verbally or by sending a written notification of the requirement that a permit be obtained to the owner of the property involved by certified mail with return receipt requested. If application for said permit is filed within seven (7) working days from the verbal notification or date of receipt of the letter, an administrative fee shall be assessed in the amount of one hundred percent (100%) of the normal fee for the associated building permit, variance, conditional use, and/or rezoning plus the cost of the postage for mailing the aforementioned notice. In no case shall this administrative fee be less than five dollars ($5.00), including the postage

costs.

ii. If application for said permit is filed after the deadline of seven (7) working days following the verbal notice or receipt of the notification of the requirement therefore, there shall be imposed an administrative fee in the amount of two (2) times the normal fee for the associated building permit, variance, conditional use, and/or rezoning building permit fee plus the cost of the postage for mailing the aforementioned notice. The payment of the administrative fee shall not relieve such person from the provisions of paragraph (b) below.

iii. Any administrative fee or penalty imposed under the provisions of this Zoning Ordinance shall be in addition to any other fees or charges required under this Zoning Ordinance.

b. It is declared unlawful for any person to violate any of the terms and provisions of these regulations or other official control adopted by the Board of County Commissioners pursuant thereto. Any person who violates, disobeys, omits, neglects or refuses to comply with or resists the enforcement of any provision of this Zoning Ordinance may be subject to a civil or criminal penalty. The penalty for violation of this Zoning Ordinance shall be two hundred dollars ($200.00) or imprisonment for not more than thirty (30) days, or both, and in addition the violator shall pay all costs and expenses involved in the case. Each and every day that such violation continues after notification may constitute a separate offense. All fines for violation shall be paid to the County Auditor and shall be credited to the General Fund of the County.

c. In the event, any building or structure is erected, constructed, reconstructed, altered, repaired, converted or maintained, or any building, structure or land is used in violation of these regulations, the appropriate authorities of Codington County in addition to other remedies, may institute injunction, mandamus or other appropriate actions or proceedings in a court of competent jurisdiction to prevent, restrain, correct or abate such violation or threatened violation

d. Any taxpayer of the County may institute mandamus proceedings in Circuit Court to compel specific performance by the proper official or officials of any duty required by these regulations.

Section 1.02.04. Separability Clause.

Should any article, chapter, section, or provision of this ordinance be declared by the courts to be unconstitutional or invalid, such decision shall not affect the validity of the ordinance as a whole, or any part other than the part so declared to be unconstitutional or invalid.

Section 1.02.05. Repeal of Conflicting Ordinances.

All ordinances or resolutions or part of ordinances or resolutions in conflict with this Ordinance or inconsistent with the provisions of this Ordinance are repealed entirely.

Section 1.02.06. Effective Date.

This Ordinance shall take effect and be in force from and after its passage and publication according to law.

CHAPTER 1.03. OFFICIAL ZONING MAP.

Section 1.03.01. Official Zoning Map.

1. The **unincorporated area of the** County is hereby divided into zones, or districts, as shown on the Official Zoning Map **and Official Map of the Rural Residential District** which, together with all explanatory matter thereon, is hereby adopted by reference and declared to be a part of this Ordinance. The Official Zoning Map shall be identified by the signature of the Chairperson of the Board of County Commissioners attested by the County Auditor and bearing the seal of the County under the following words: "This is to certify that this is the Official Zoning Map referred to in Chapter ~~6.3~~ **1.03** of Ordinance Number **65**~~15~~ of Codington County, State of South Dakota," together with the date of the adoption of this Ordinance. The Official Zoning Map shall be on file at the office of the County Auditor. **Further, the Official Map of the Rural Residential District shall be identified by the signature of the Chairperson of the Board of County Commissioners attested by the County Auditor and bearing the seal of the County under the following words: "This is to certify that this is the Official Map of the Rural Residential District referred to in Chapter 1.03 of Ordinance Number 65~~55~~, an Amendment to Ordinance Number 15~~30~~ of Codington County, State of South Dakota," together with the date of the adoption of this Ordinance."**

2. Regardless of the existence of purported copies of the Official Zoning Map which may from time to time be made or published, the Official Zoning Map, which shall be located in the office of the County Auditor ~~offices~~, shall be the final authority as to the current zoning status of land and water areas, buildings, and other structures in the County.

Section 1.03.02. Amendment of the Official Zoning Map.

1. If, in accordance with the provisions of this Ordinance changes are made in district boundaries or other matter portrayed on the Official Zoning Map, such changes shall be entered on the Official Zoning Map promptly after the amendment has been approved by the Board of County Commissioners, **with an entry on the Official Zoning Map as follows: "On (date of adoption) by official action of the Board of County Commissioners, the following change(s) were made on the Official Zoning Map:" (brief description of nature of change), which entry shall be signed by the Chairman of the Board of County Commissioners and attested by the County Auditor** ~~and has become law according to the statutes of the State of South Dakota~~.

2. No amendment of this Ordinance which involves matter portrayed on the Official Zoning Map shall become effective until after such change and entry has been made on the Official Zoning Map.

3. No changes of any nature shall be made on the Official Zoning Map or matter shown thereon except with conformity with the procedure set forth in this Ordinance. Any unauthorized change of whatever kind by any person or persons shall be considered a violation of this Ordinance ~~and punishable as provided by this Ordinance~~.

Section 1.03.03. Interpretation of District Boundaries.

Where uncertainty exists as to the boundaries of districts as shown on the Official Zoning Map, the following rules shall apply:

1. **A district name or letter symbol shown on the district map indicates that the regulations pertaining to the district designated by that name or symbol extend throughout the whole area in the unincorporated portions of the County bounded by the district boundary lines.**

2. **Boundaries indicated at approximately following the center lines of streets, highways, or alleys, shall be construed to follow such center lines;**

3. **Boundaries indicated as approximately following platted lot lines shall be construed as following such lot lines;**

4. **Boundaries indicated as approximately following city limits shall be construed as following such city limits;**

5. **Boundaries indicated as following railroad lines shall be construed to be midway between the main tracks;**

6. **Boundaries indicated as following shore lines shall be construed to follow such shore lines, and in the event of change in the shore line shall be construed as moving with the actual shore line; boundaries indicated as approximately following the center lines of streams, rivers, canals, lakes, or other bodies of water shall be construed to follow such center lines;**

7. **Boundaries indicated as parallel to or extensions of features indicated in subsections 1 through 6 above shall be so construed. Distances not specifically indicated on the Official Zoning Map shall be determined by the scale of the map; and**

8. **Where physical or cultural features existing on the ground are at variance with those shown on the Official Zoning Map, or in other circumstances not covered by subsections 1 through 7 above, the Board of Adjustment shall interpret the district boundaries.**

Section 1.03.04. Changes and/or Replacement of Official Zoning Map.

In the event that the Official Zoning Map becomes damaged, destroyed, lost or difficult to interpret because of the nature or number of changes and additions, the Board of County Commissioners may by ordinance adopt a new Official Zoning Map, which shall supersede the prior Official Zoning Map. The new Official Zoning Map may correct drafting or other errors or omissions in the prior Official Zoning Map, but no such corrections shall have the effect of amending the original Official Zoning Map or any subsequent amendment thereof.

The new Official Zoning Map shall be identified by the signature of the Chairperson attested by the County Auditor, and bearing the seal of the County under the following words: "This is to certify that this Official Zoning Map supersedes and replaces the Official Zoning Map adopted (date of adoption of map being replaced) as part of the Zoning Ordinance of Codington County, State of South Dakota."

Unless the prior Official Zoning Map has been lost, or has been totally destroyed, the prior map or any significant parts thereof remaining shall be preserved together with all available records pertaining to its adoption or amendment.

~~SECTION~~ ARTICLE II
DEFINITIONS

~~For the purpose of this Regulation, certain terms and words are herein defined as follows, except where the context would plainly indicate a different intent:~~

For the purpose of this Ordinance, certain terms and words are hereby defined. Words used in the present tense shall include the future; the singular number shall include the plural and the plural the singular; the word "building" shall include the word "structure", the word "shall" is mandatory and not discretionary; the word may is permissive; the word person includes a firm, association, organization, partnership, trust, company or corporation, as well as, an individual; the word lot includes the word plat or parcel; and the words used or occupied include the words intended, designed, or arranged to be used or occupied. Any word not herein defined shall be as defined in any recognized Standard English dictionary.

Accessory Buildings and Uses. ~~An accessory building is a subordinate building, or portion of the main building, the use of which is incidental or subordinate to that of the main building.~~ **A subordinate building or portion of the principal building, the use of which is incidental to and customary in connection with the principal building or the main use of the premises and which is located on the same lot with such principal building or use. An accessory use is a use which is incidental to the main use of the premises.**

Accessory Uses/buildings: Accessory uses and/or buildings are those buildings and uses customarily incident to any permitted use in the district.

Adult. A person, one who has reached the age of eighteen (18).

Adult Amusement or Entertainment. Amusement or entertainment which is distinguished or characterized by an emphasis on material depicting, describing or relating to 'specified sexual activities' or 'specified anatomical areas' or which features topless dancers, exotic dancers, strippers, male or female impersonators, or similar entertainment.

Adult Bookstores. An establishment having, as a substantial portion of its stock in trade, books, magazines, films or videotapes for sale or viewing on the premises by use of motion picture devices or other coin-operated means, and other periodicals which are distinguished by their emphasis on matter depicting, describing or relating to specified Sexual Activities or Specified Anatomical Areas as such terms are defined in this section, or an establishment with a segment or section devoted to the sale or display of such material. Adult bookstores may alternatively or in conjunction with the above stock in trade sell undergarments and other clothing designed for the display of Specified Anatomical Areas or for the enhancement of Specified Sexual Activities. Further, an adult bookstore may alternatively or in conjunction with the above stock in trade sell prosthetic devices, dolls, candles, vibrators and other objects for sexual gratification which take the form of Specified Anatomical Areas and for the purpose of enhancing Specified Sexual Activities.

Adult Entertainment Cabaret. Means an establishment offering to its patrons, as entertainment, any exhibition or display or any theatrical or other live performances which include topless or go-go dancers, exotic dancers, strippers, male or female impersonators, or similar entertainers, or any persons singing, reading, posing,

modeling, or serving food or beverages, where the exhibition, performance, display or dance is intended to sexually arouse the entertainer or the patrons, or where the attire of persons involved is such as to expose specified anatomical areas, as defined in this section.

Adult Motion Picture Theater. An enclosed building, regardless of its seating capacity, which is used to present for public view on the premises, films, movies, previews, trailers or advertisements which are distinguished by their emphasis on matter depicting, describing or relating to specified sexual activities or specified anatomical areas, as defined in this section.

Adult Photo Studio. An establishment which, on payment of a fee, provides photographic equipment and/or models for the purpose of photographing "specified anatomical areas", as herein defined.

Adult Use. The term "adult use" shall include adult entertainment cabaret, adult bookstores, adult motion picture theaters, and adult photo studios as defined in this section.

Agriculture. The use of land for agricultural purposes including farming, dairying, raising, breeding, or management of livestock, poultry, or honey bees, truck gardening, forestry, horticulture, floriculture, viticulture, and the necessary accessory uses for packaging, treating or storing the produce providing that the operation of any such accessory use shall be secondary to the normal agricultural activities. This definition shall not include intensive agricultural activities such as concentrated animal feeding operations and agribusiness activities.

Airport. A place where aircraft can land and takeoff, usually equipped with hangers, facilities for refueling and repair, and various accommodations for passengers, including heliports.

Animal Manure. Poultry, livestock, or other animal excreta or mixture of excreta with feed, bedding or other materials.

Animal Unit. See Section 5.~~1~~4**21**.

Animal Waste, Incorporated. Animal waste applied to the land surface and mechanically mixed into the soil within 24 hours.

Animal Waste, Injected. Animal waste injected or tilled into the soil at the time of application.

Animal Waste, Surface Applied. Animal waste applied to the land surface without benefit of incorporation or injection. This shall not include the use of animal waste in irrigation waters.

Animal Husbandry. The dairying, raising of livestock, breeding or keeping of animals, fowl or birds as a business for gainful occupation.

Applicant (when used in regard to concentrated animal feeding operations). An individual, a corporation, a group of individuals, partnership, joint venture, owners, or any other business entity having charge or control of one or more concentrated animal feeding operations.

Area of Special Flood Hazard. Means the land in the floodplain subject to a one (1) percent or greater chance of flooding in any given year. The area of a special flood hazard refers top the area subject to inundation during the base 100-year flood.

Bar/Tavern. An establishment that is licensed to sell alcoholic beverages by the drink.
Base Flood. Base Flood means the flood having a one (1) percent chance of being equaled or exceeded in any given year.

Basement. A basement has more than one-half (½) of its height below grade. A basement is counted as a story for the purpose of height regulations if subdivided and used for dwelling purposes.

Bed and Breakfast ~~Home~~ (B & B's). ~~An owner occupied home in which not to exceed five (5) rooms are rented.~~ **A private single-family residence, which is used to provide, limited meals and temporary accommodations for a charge to the public. Such establishments should be located where there will be minimal impact on surrounding properties and should comply with the following conditions:**

1. **B & B's shall be limited to residential structures with an overall minimum of one thousand eight hundred (1,800) square feet of floor. Preference will be given to structures with historic or other unique qualities.**

2. **They shall be in compliance with applicable state laws including registration with the South Dakota Department of Health, maintaining a guest list, and providing a smoke detector in each sleeping room.**

3. **Accessory use signs shall be based on similar requirements for a home occupation permit and shall not be more than sixteen (16) square foot in area.**

4. **Such uses shall be an incidental use with an owner occupied principal dwelling structure provided that not more than four (4) bedrooms in such dwelling structure shall be used for such purpose.**

5. **Off-street parking requirements shall be one (1) space per guestroom and shall be in addition to parking requirements for the principal use. Off-street parking shall not be located in a required front or side yard and screening shall be required when adjacent to residentially used property.**

6. **The length of stay shall not exceed fourteen (14) days during any one hundred twenty (120) day consecutive period.**

7. **Meals shall be limited to breakfast, which is prepared in a common facility (household kitchen). Meals may be served only to overnight registered guests and cooking is not permitted in the sleeping rooms.**

8. **The building shall meet all building codes and zoning requirements. A site plan showing the location of guest parking spaces and floor plan showing a location of the**

sleeping rooms, lavatories, and bathing facilities, and kitchen shall be submitted with application.

Best Management Practices. Measures contained in Soil Conservation Service South Dakota Technical Guide, either managerial or structural, that are determined to be the most effective, practical means of preventing or reducing pollution inputs from non-point sources to water bodies.

Board of County Commissioners. The governing body of Codington County.

Buildable Area. That portion of the lot that can be occupied by the principal use, thus excluding the front, rear, and side yards.

Building. The word "building" includes the word "structure" and is a structure which is entirely separated from any other structure by space or by walls in which there are no communicating doors, windows, or similar openings **and is designed for the support, shelter and protection of persons, animals, or property**.

Building, Height of. The vertical distance from the grade to the highest point of the coping of a flat roof or to the deck line of a mansard roof, or to the mean height level between the eaves and ridge for gable, hip and gambrel roofs.

Campground. Shall mean a plot of ground for public use upon which two or more campsites are located, established, maintained, advertised, or held out to the public, to be a place where camping units an be located and occupied as temporary living quarters. Campgrounds for tent trailers and recreational vehicles should be sited with consideration for access to the property. The campground should be designed to minimize the impact from adjacent major thoroughfares.

Change in Operation. Change in operation means a cumulative increase of more than **three hundred** (300) animal units, or change in animal species, after July 1, 1997, which are confined at an unpermitted concentrated animal feeding operation.

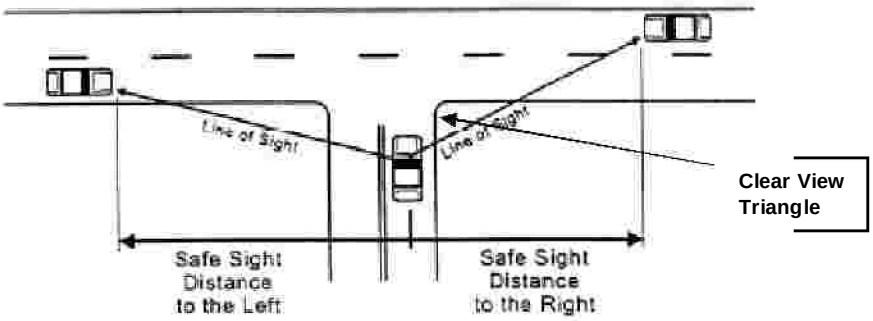
Chemigation. The process of applying agricultural chemicals (fertilizer or pesticides) through an irrigation system by injecting the chemicals into the water.

Church. A building wherein persons regularly assemble for religious worship and which is maintained and controlled by a religious body organized to sustain public worship, together with all accessory buildings and uses customarily associated with such primary purpose. Includes synagogue, temple, mosque, or other such place for worship and religious activities

Class V Injection Well. A conduit through which potentially contaminated but generally non-hazardous fluids can move below land surface into or above an aquifer. The types of primary concern in Codington County are 5W20-industrial process water and waste disposal wells and 5X28-automobile service station disposal wells. Typically, 5W20 types are commercial/ industrial facility septic tanks used to dispose of more than domestic wastewater. 5X28 types are dry wells for wastes from repair bay drains at facilities servicing internal combustion vehicles and equipment.

Clear View Triangle. A triangular-shaped portion of land established at street intersections and ingress/egress points in which there are restrictions on things erected,

placed or planted which would limit or obstruct the sight distance of motorists entering or leaving the intersection (see illustration below).



Closed Zoning District. A zoning district for which amendment to the district boundaries may only be initiated by the Planning Commission.

Club, Private. Building and facilities owned or operated by a corporation, association, person, or persons for a social, educational, or recreational purpose, but not primarily for profit and not primarily to render a service which is customarily carried on as a business. The structure is not available for public use or participation.

Commercial Vehicles. Any motor vehicle licensed by the state as a commercial vehicle.

Comprehensive Plan. The adopted long-range plan intended to guide the growth and development of Codington County.

Concentrated Animal Feeding Operation. A Concentrated Animal Feeding Operation is defined as a lot, yard, corral, building or other area where animals have been, are, or will be stabled or confined for a total of forty-five (45) days or more during any twelve (12)-month period, and where crops, vegetation, forage growth, or post harvest residues are not sustained over any portion of the lot or facility. Two (2) or more animal feeding operations under common ownership are single animal operation if they adjoin each other, or if they use a common area, or if they use a common area or system for disposal of manure.

Conditional Use. A conditional use is any use that, owing to certain special characteristics attendant to its operation, may be permitted in a zoning district subject to requirements that are different from the requirements imposed for any use permitted by right in the zoning district. Conditional uses are subject to the evaluation and approval by the Board of Adjustment and are administrative in nature

Contamination. The process of making impure, unclean, inferior or unfit for use by introduction of undesirable elements.

Contingency Plans. Detailed plans for control, containment, recovery and clean up of hazardous materials released during floods, fires, equipment failures, leaks and spills.

Contractor Shops and Yards. Those facilities to include structures and land areas where the indoor or outdoor storage of equipment and supplies used for various types of construction are stored. Examples of equipment and supplies include but are not limited to the following – road construction, building construction, gravel operations, and

general contracting services.

Convenience Store. Any retail establishment offering for sale pre-packaged food products, household items, and other goods commonly associated with the same, at which a customer typically purchases only a few items during a short visit.

Density. The number of families, individuals, dwelling units, or housing structures per unit of land.

Development. The carrying out of any surface or structure construction, reconstruction or alteration of land use or intensity of use.

~~**District**. A section or sections of the County for which the regulations governing the use, the construction, and location of buildings and the occupancy of buildings and premises are the same.~~

District, Zoning. A section or sections of the County for which regulations governing the use of buildings and premises, the height of buildings, the size of yards, and the intensity of use are uniform.

~~**Dog Kennel.** A commercial or non-commercial establishment where more than three adult dogs are kept boarded.~~

Domestic Sanitary Sewage Treatment Facility. Shall mean the structures equipment and processes required to collect, carry away, and treat and dispose of domestic wastewater, industrial wastes, and or sludge.

Dwelling. Any building, including seasonal housing structures, or a portion thereof, which is designed and used exclusively for residential purposes. This definition does not include a mobile home or manufactured home.

Dwelling, Farm. Any dwelling owned or occupied by the farm owners, operators, tenants, or seasonal or year-around hired workers.

Dwelling, Multiple-family. A building occupied by two (2) or more families.

Dwelling, Non-Farm. Any occupied dwelling which is not a farm dwelling.

Dwelling, Single-Family. A building occupied exclusively by one (1) family.

Dwelling. One (1) or more rooms, containing sleeping quarters, in a dwelling occupied as separate living quarters by a single-family.

Electrical Substation. A premises which may or may not contain buildings, where the interconnection and usual transformation of electrical service takes place between systems. An electrical substation shall be secondary, supplementary, subordinate, and auxiliary to the main system.

Eligible Building Site (Building Eligibility). A site which fulfills the requirements for the construction or placement of a building.

Engineer. Means any engineer licensed by the State of South Dakota.

Essential Public Services. Overhead or underground electrical, gas, steam or water transmission or distribution systems and structures, or collection, communication, supply or disposal systems and structures used by public for protection of the public health, safety or general welfare, including towers, poles, wires, mains drains, sewers, pipes, conduits, cables satellite dishes, and accessories in connection therewith.

Established Residence. A dwelling established before June 30, 1997 or a dwelling located greater than one-half (1/2) mile from any existing concentrated animal feeding operation at the time of the dwelling's construction.

Existing Farmstead. An existing farmstead shall include a livable house occupied by the owner or tenant within the last three (3) years and shall have been existing on the site for at least five (5) years and the site shall have been used in the past as a farmstead for normal farming operation. **In addition** the ~~Planning Commission~~ **Board of Adjustment** may consider defining an identifiable parcel as an existing farmstead if the proposed site meets the following criterion:

1. Evidence that the proposed site was once used for human habitation **within the last fifty 50) years**. This may be determined by existence of buildings/foundations ~~and/or an established shelterbelt~~.
2. **Evidence that the proposed site was used as a farmstead supporting normal farming operations prior to October 26, 1976.**

3. Information regarding the location of flood plain, access to roads and utilities, and other appropriate site information may be considered by the ~~Planning Commission~~ **Board of Adjustment** in determining the suitability of the parcel for development.

Extended Home Occupation. A home occupation conducted outside of the residence and/or in an accessory building

Facility. Something built, installed or established for a particular purpose.

Family. ~~One or more individuals living, sleeping, cooking, or eating on the premises as a single housekeeping unit; however, it shall not include a group of more than two (2) individuals not related by blood or marriage.~~ **One (1) or more persons related by blood, marriage, or adoption occupying a dwelling unit as a single household unit. A family shall not include more than three (3) adults who are unrelated by blood or law. This definition shall not include foster families as regulated by the State of South Dakota.**

Farm. An area with or without a dwelling which is used for the growing of the usual farm products, such as vegetables, fruit, trees and grain, and their storage on the area, as well as for the raising, feeding, or breeding thereon of the usual farm poultry and farm animals, such as horses, cattle, sheep and swine all of the foregoing farm products and animals are raised for income. The term "farming" includes the operating of such an area for one or more of the above uses, including dairy farms with the necessary accessory uses for treating or storing the produce; provided, however, that the operation of such accessory uses shall be secondary to that of the normal farming activities.

Fence. A structure used as a boundary, screen, separation, means of privacy, protection or confinement, and is constructed of wood, plastic, metal, wire mesh, masonry or other similar materials and is used as a barrier of some sort.

Firearm. Means a gun that discharges shot, bullet or other projectile by means of an explosive, gas, compressed air, or other propellant.

Five-Year Time of Travel Distance. The distance that ground water will travel in five years. This distance is a function of aquifer permeability and water table slope.

Flood or Flooding. Means a general and temporary condition of partial or complete inundation of normally dry land areas from:

1. The overflow of inland or tidal waters and/or

2. The unusual and rapid accumulation of runoff of surface waters from any source.

Flood Insurance Rate Map (FIRM). Means an official map of a community on which the Federal Emergency Management Agency has delineated areas of special flood hazard designated as Zone A.

Floodway. The channel and the adjacent areas that must be reserved in order to meet the minimum requirement of the National Flood Insurance Program of providing for the discharge of the base flood without cumulatively increasing the water surface elevation more than one (1) foot. However if there are identifiable flood impacts either upstream or downstream, based upon a scientific engineering study, a more stringent definition of floodway may be justified. That definition would include the channel and the adjacent areas that must be reserved in order to provide for the discharge of the base flood without cumulatively increasing the water surface elevation to a point which may result in additional damages to upstream/downstream properties.

Frontage. All the property on one (1) side of a street or road.

~~**Front Yard**: A yard extending between the side lot lines across the front of a lot adjoining a public right-of-way. In the case of corner lots, front yards shall be provided on both streets.~~

Game Lodge. A building or group of two (2) or more detached, or semi-detached, or attached buildings occupied or used as a temporary abiding place of sportsmen, hunters and fishermen, who are lodged with or without meals, and in which there are sleeping quarters.

Garage, Private. An accessory building used for the storage of not more than four (4) vehicles owned and used by the occupant of the building to which it is necessary. Vehicles include cars, pickups, trailers, and boats.

Governmental Agency. An organized entity which, in addition to having governmental character, has sufficient discretion in the management of its own affairs to distinguish it as separate from the administrative structure of any other governmental unit. This definition shall be deemed to include, but is not limited to Codington County, the State of South Dakota, and any School District or Municipality located in Codington County.

Grade. The finished grade of premises improved by a building **or structure** is the **average natural** elevation **or slope** of the surface of the ground **within fifty (50) feet** ~~adjoining~~ **of** the building **or structure**.

Greenhouse. A building whose roof and sides are made largely of glass or other transparent or translucent material and in which the temperature and humidity can be regulated for the cultivation of delicate or out-of-season plants for subsequent sale or for personal enjoyment.

Grey Water. All domestic wastewater except toilet discharge water.

Ground Water. Subsurface water that fills available openings in rock or soil materials such that it may be considered water saturated.

Group Home. A supervised living or counseling arrangement in a family home context providing for the twenty-four (24) hour care of children or adults.

Hazardous Materials. A material which is defined in one or more of the following categories:

A. Ignitable: A gas, liquid or solid which may cause fires through friction, absorption of moisture, or which has low flash points. Examples: white phosphorous and gasoline.

B. Carcinogenic: A gas, liquid or solid which is normally considered to be cancer causing or mutagenic. Examples: PCBs in some waste oils.

C. Explosive: A reactive gas, liquid or solid which will vigorously and energetically react uncontrollably if exposed to heat, shock, pressure or combinations thereof. Examples: dynamite, organic peroxides and ammonium nitrate.

D. Highly Toxic: A gas, liquid or solid so dangerous to man as to afford an unusual hazard to life. Examples: parathion and chlorine gas.

E. Moderately Toxic: A gas, liquid or solid which through repeated exposure or in a single large does can be hazardous to man. Example: atrazine.

F. Corrosive: Any material, whether acid or alkaline, which will cause severe damage to human tissue, or in case of leakage might damage or destroy other containers of hazardous materials and cause the release of their contents. Examples: battery acid and phosphoric acid.

~~**Height of Building**. The height of a building shall be the vertical distance measured, in the case of flat roofs, from the mean level of the established grade to the level of the highest point of the roof beam adjacent to the street, and in the case of a pitched roof, from such grade to the mean height level of the upper side of the rafters of the roof. Where no roof beams exist or there are structures wholly or partially above the roof, the height shall be measured from the established grade to the level of the highest point of the building.~~

Home Occupation. An occupation engaged in by the occupants of a dwelling provided that:

A. No person other than members of the family residing on the premises shall be engaged in such occupation;

B. The use of the dwelling unit for the home occupation shall be clearly incidental and subordinate to its use of residential purposes by its occupants, and not more than twenty-five (25) percent of the floor area of the dwelling unit shall be used in the conduct of the home occupation;

C. There shall be no change in the outside appearance of the building or premises, or other visible evidence of the conduct of such home occupation other than one (1) **on-premise** sign, not to exceed ~~four~~ **sixteen (16)** square feet in area, non-illuminated.

D. Off premise signage for home occupations shall be limited to South Dakota Department of Transportation (SDDOT) commercial, directional signs, also known as "Blue Signs". These signs, with SDDOT approval, may be located adjacent to State and Federal Highways.

~~D.~~**E.** No home occupation shall be conducted in any accessory building. ~~in connection with a non-farm dwelling. Accessory building use in connection with a farm dwelling shall be agricultural-related;~~

~~E.~~**F.** No traffic shall be generated by such home occupation in greater volumes than would normally be expected in a residential neighborhood, and any need of parking generated by the conduct of such home occupation shall be provided off the street and other than in a required front yard;

~~F.~~**G.** No equipment or process shall be used in such home occupation which creates noise, vibration, glare, fumes, odors, or electrical interference detectable to the normal senses off the lot. In the case of electrical interference, no equipment or process shall be used which creates visual or audible interference in any radio or television receivers off the premises, or causes fluctuations in line voltage off the premises.

H.The only retail sales allowed shall consist of the sale of commodities/products prepared on the premises in connection with such occupation or activity.

Horticultural services. Commercial services which are oriented to support the science or practical application of the cultivation of fruits, vegetables, flowers, and plants.

Junk Yard. An area of land with or without buildings used for, or occupied by, a deposit, collection, or the storage outside of a completely enclosed building, or used and/or discarded materials such as waste paper, rags or scrap metal, used building materials, home furnishings, machinery, vehicles, or parts thereof, with or without the dismantling, processing, salvage, sale, or other use or disposition of the same.

Kennel. Any premise or portion thereon where more than five (5) dogs, cats, or other household pets are bred, raised, trained, boarded, harbored, or kept for remuneration. Veterinary clinics, animal hospitals and animal shelters are specifically excluded.

Leaks and Spills. Any unplanned or improper discharge of a potential containment including any discharge of a hazardous material.

Light Manufacturing. Those manufacturing processes which are not obnoxious due to dust, odor, noise, vibration, pollution, smoke, heat or glare. These commercial and industrial uses are characterized by generally having all aspects of the process carried on within the building itself.

Lot. A lot is any lot, plot, or parcel of land under one ownership, occupied ~~by one principal building or united group of buildings~~, and the accessory building or buildings customarily incident to such principal building or buildings ~~to include all open spaces required by this regulation~~.**or intended for occupancy by a use permitted in this Ordinance including one**

(1) principal building together with its accessory buildings, open spaces and parking spaces required by this ordinance.

~~A. Lot Area. The lot area is the land in square feet within the lot line.~~

~~B. Lot Depth. The depth of a lot is the mean distance from the front side or road line of the lot to its rear line, measured in the general direction of the side lines of the lot.~~

~~C. Lot Width. The width of a lot is the mean distance between straight side lot lines measured at a point fifty (50) feet back from the front line thereof.~~

Lot Area. The lot area is the land in square feet or acres within the lot line.

Lot, Corner. A lot abutting upon two (2) or more streets at their intersection.

Lot, Depth of. The average horizontal distance between the front and rear lot lines.

Lot, Double Frontage. A lot having a frontage of two (2) streets as distinguished from a corner lot.

Lot of Record. A subdivision, the plat of which has been recorded in the office of the Register of Deeds, or a parcel of land the deed or agreement to convey to which was recorded in the office of the Register of Deeds. For the minimum lot area requirement (35 acres) not to apply in the "A" Agriculture Zoning District, such lot of record had to be recorded prior to October 26, 1976. For the minimum lot area requirement (10 acres) not to apply in the "C" Commercial Zoning District or "I" Industrial District, such lot of record had to be recorded prior to July 31, 2001. For the minimum lot area requirement (2 acres) not to apply in the "LP" Lake Park Zoning District, such lot of record had to be recorded prior to June 18, 1974.

Lot Width. The width of a lot is the mean distance between straight side lot lines measured at a point fifty (50) feet back from the front line thereof.

Manufactured ~~and Mobile~~ Home. **See Chapter 5.11**

~~A. For the purpose of this Regulation, manufactured homes and mobile homes will be regulated by types. Three types of homes are defined under these regulations.~~

~~1. Type A manufactured home shall:~~

~~a. Have more than 1,100 square feet of occupied space in a double-section or larger multi-section unit.~~

~~b. Must not be older than five years from the date of manufacture.~~

~~c. Utilize a permanent perimeter enclosure of metal, vinyl, wood or styrofoam in accordance with manufacturer's specifications.~~

~~d. Be anchored to the ground, in accordance with manufacturer's specifications, or as prescribed by the ANSI/NFPA 501A standards.~~

~~e. Have a gabled roof with a pitch of at least 2/12 feet.~~

f. Have siding material of a type customarily used on site-constructed residences.

g. Have roofing material of a type customarily used on site-constructed residences.

2. Type B manufactured home shall:

a. Have more than 700 square feet of occupied space in a single, double, expando or multi-section unit.

b. Utilize a permanent perimeter enclosure of metal, vinyl, wood or styrofoam in accordance with manufacturer's specifications.

c. Be anchored to the ground, in accordance with manufacturer's specifications, or as prescribed by the ANSI/NFPA 501A Standards.

d. Have siding material of a type customarily used on site-constructed residences.

e. Have roofing material of a type customarily used on site-constructed residences.

f. Be placed onto a support system, in accordance with approved installation standards, as specified in subsection (b), Installation Standards.

3. A Type C manufactured home shall:

a. Have more than 700 square feet of occupied space in a single, double, expando or multi-section unit.

b. Utilize a permanent perimeter enclosure of metal, vinyl, wood or styrofoam in accordance with manufacturer's specifications.

c. Be anchored to the ground, in accordance with manufacturer's specifications or as prescribed by the ANSI/NFPA 501A Standards.

d. Be placed onto a support system in accordance with approved installation standards, as specified in subsection (b), Installation Standards.

B. Installation Standards.

1. Support System.

a. All HUD-Code manufactured homes of the Type A classification shall be installed with load bearing foundations in conformance with the manufacturer's installation specifications.

b. Type B and C manufactured homes not placed on a permanent foundation shall be installed on a support system in conformance with the manufacturer's installation specifications or with the support systems regulations in the ANSI/NFPA 501A 1977 installation standards.

C. Nonconforming Homes.

~~A manufactured or mobile home placed and maintained on a tract of land and deemed to be a legal nonconforming use prior to the adoption of this Ordinance, shall continue to be a legal nonconforming use. If the nonconforming use is discontinued, the land thereafter must be used in conformity with all provisions of this Ordinance.~~

~~D. Replacement of Nonconforming Homes.~~

~~Thereafter, upon application to the Zoning Officer and subsequent approval thereof, a manufactured or mobile home, deemed a legal nonconforming use, may be replaced by a manufactured home, provided the replacement is of an equal or higher type. Equal or higher type means that a manufactured home may be replaced with a Type A, B or C manufactured home; a Type C manufactured home could be replaced with a Type A, B or C manufactured home; a Type B manufactured home could be replaced with a Type A or B manufactured home; a Type A manufactured home could be replaced with another Type A manufactured home.~~

~~E. Structural Alteration.~~

~~Due to its integral design, any structural alteration or modification of a manufactured or mobile home after it is placed on the site must be approved by the Zoning Officer.~~

Manufactured Home Park. ~~Any plot or plots of ground upon which one or more manufactured housing units, occupied for dwelling or sleeping purposes, can be or are intended to be located, regardless of whether or not a charge is made for such accommodations~~. **Any manufactured home court, camp, park, site, lot, parcel or tract of land intended for the purpose of supplying a location, or accommodations, for manufactured homes and upon which manufactured homes are parked and shall include all buildings used or intended for use as part of the equipment thereof whether a charge is made for the use of the manufactured home park and its facilities or not. "Manufactured Home Park" shall not include automobile or manufactured home sales lots on which unoccupied manufactured homes are parked for the purposes of inspection and sale.**

Manure Storage Area. An area for the containment of animal manure.

Mineral. An inanimate constituent of the earth in a solid, liquid or gaseous state which, when extracted from the earth, is useable in its natural form as a metal, a metallic compound, a chemical, an energy source, or a raw material for manufacturing or construction material. For the purpose of these regulations, this definition does not include surface or subsurface water, geothermal resources, or sand, gravel and quarry rock.

Mineral Extraction. The removal of a mineral from its natural occurrence on affected land. The term includes, but is not limited to, underground and surface mining.

Modular Home.

1. Modular homes shall meet the following regulations.

a. Modular homes shall meet or exceed Uniform Building Codes.

b. Modular homes will include all off-site constructed homes, which may be transported to the site in one or more sections.

c. Modular homes shall have more than one thousand (1,000) square feet in ranch style and 850 square feet split and be placed on a permanent foundation.

d. Modular homes shall not have attached running gear and a trailer hitch or the capacity to have attached running gear and trailer hitch.

e. Modular homes shall have a minimum of a 4/12-roof pitch.

f. Have siding material of a type customarily used on site-constructed residences.

g. Have roofing material of a type customarily used on site-constructed residences.

Motel/Hotel. A series of attached, semi-attached, or detached sleeping or living units, for the accommodation of transient guests and not customarily including individual cooking or kitchen facilities, said units having convenient access to off-street parking spaces for the exclusive use of guests or occupants.

Nonconforming Building or Structure or Use. ~~A non-conforming building or structure is a building or structure, the use of which, in whole or part, does not conform to the regulations of the District in which same is located.~~ Any building or use of land, land lawfully occupied by a use at the time of passage of this regulation or amendment thereto, which does not conform after the passage of this regulation or amendment.

~~**Non-Conforming Use**. A non-conforming use is a use in or of any building or structure which does not conform to the use regulations of the District in which such use exists.~~

Nonstandard Use. The category of nonconformance consisting of lots occupied by buildings or structures or uses which existed immediately prior to the effective date of this ordinance which fail to comply with any of the following: minimum lot requirements for the area, density, width, front yard, side yard, rear yard, height, unobstructed open space, or parking for the district in which they are located, even though the use of the premises conforms to the permitted uses within the district as set out in the provisions of this ordinance.

Outdoor Storage. The keeping, in an unroofed area, of any goods, junk, material, merchandise, or vehicles in the same place for more than twenty-four (24) hours.

Owner (when relating to Wireless Communication Towers). Means any Person with fee title or a long-term (exceeding ten (10) years) leasehold to any parcel of land within the County who desires to develop, or construct, build, modify, or erect a Tower upon such parcel of land.

Parking Space. An area, enclosed or unenclosed, sufficient in size to store one (1) automobile, together with a driveway connecting the parking space with a street or alley.

Parks and Recreation Areas. Public, non-commercial recreation facilities open to the general public an requiring minimal structural development, including, but not limited to playgrounds, parks, monuments, green strips, open space, mini-parks, athletic fields, boat launching ramps, piers and docks, picnic grounds, public campgrounds swimming pools, and wildlife and nature preserves, along with any necessary accessory facilities, rest rooms, bath houses, and the maintenance of such land and facilities, but not

including private, commercial campgrounds, commercial recreation and/or amusement centers.

Pasture. A field providing continuous forage to animals and where the concentration of animals is such that a vegetative cover is maintained during the growing season.

Permit. A permit required by these regulations unless stated otherwise.

Permitted Use. Any use allowed in a zoning district and subject to the restrictions applicable to that zoning district.

Plat. The maps, drawing, or chart on which a subdivider's plan of subdivision is legally recorded.

Potential Pollution Hazard. A concentrated animal feeding operation of **ten** (10) to **three hundred** (300) animal units may be classified as a Class 4 Operation by the County Zoning Officer when a potential pollution hazard exists. Factors to be considered by the Zoning Officer in determining a potential pollution hazard include the following:

A. The concentrated animal feeding operation does not meet the minimum setback and separation distances of these regulations.

B. A potential water pollution hazard exists due to siting over a shallow aquifer or drainage which contributes to the waters of the State.

Primary Containment Facility. A tank, pit, container, pipe or vessel of first containment of a liquid or chemical.

Principal Building. The structure in which the principal use of the lot is conducted. For Example a dwelling on a residential lot.

Principal Use. The primary use to which the premises are devoted.

~~**Private Dwellings**. A private dwelling is a detached building, designed for, or occupied exclusively by, one family.~~

~~**Private Garage**. A private garage is a garage with a capacity of not more than four (4) family cars and pickups for storage only.~~

Private Shooting Preserves. An acreage of at least one hundred and sixty (160) acres and not exceeding one thousand two hundred and eighty (1,280) acres either privately owned or leased on which hatchery raised game is released for the purpose of hunting, for a fee, over an extended season.

Private Wind Energy Conversion System (PWECS). Any mechanism or device, not owned by a public or private utility company, designed for the purpose of converting wind energy into electrical or mechanical power to be used on the site where said power is generated.

Process Generated Wastewater. Water directly or indirectly used in the operation of an animal feeding operation. The term includes spillage or overflow from watering systems; water and manure collected while washing, cleaning or flushing pens, barns, manure pits or other

areas; water and manure collected during direct contact swimming, washing or spray cooling of animals; and water used in dust control.

Process Wastewater. "Process wastewater" means any process generated wastewater and any precipitation (rain or snow) that comes into contact with the animals, manure, litter or bedding, feed, or other portions of the animal feeding operation. The term includes runoff from an open lot.

Quarter-Quarter Section. The Northeast, Northwest, Southwest, or Southeast quarter (1/4) of a quarter section delineated by the United States Public Land Survey or a government lot per such survey, if such lot contains a minimum of thirty-five (35) acres.

Range (Target/Shooting). Shall be defined as an area for the discharge of weapons for sport under controlled conditions where the object of the shooting is an inanimate object such as, but not limited to, paper, metal or wooden targets. A Range Officer shall be present on site at any Range when the range is in use. The term range includes archery ranges.

Range Officer. Means the person designated to be responsible at a Range at any given time during any activity.

~~**Rear Yard**. A yard across the whole width of a lot, extending from the rear line of the building to the rear line of the lot.~~

Religious Conference Facility. One or more buildings or structures whose primary purpose is to provide religious training/service and other associated activities. Such facilities may include but are not limited to recreational facilities; chapels/churches; incidental retail sales; food service; indoor and outdoor recreation – to include including therapeutic horse riding, group assembly, campgrounds; administrative offices; and on-site employee residences.

Religious Farming Community. A corporation formed primarily for religious purposes whose principle income is derived from agriculture and/or a farm which may or may not be held in collective ownership, in which multiple families reside on-site and use or conduct activities upon the property which are participated in, shared, or used in common by the members of the group residing thereon.

Resort. This category provides commercial hospitality lodgings in spacious settings that are principally intended for vacationing, relaxation and conference activities for visitors to the community.

Retail Sales and Trade. Establishments engaged in selling products, goods or merchandise to the general public for personal or household consumption; and establishments engaged in providing services or entertainment to the general public including eating and drinking establishments, hotels, motels, repair shops, indoor amusement, copying services, health, professional, educational, and social services, and other miscellaneous services.

Rubble Site. A site for the disposition of refuse as defined by the South Dakota Department of Environment and Natural Resources.

Sale or Auction Yard or Barn. A place or building where the normal activity is to sell or

exchange livestock. Livestock normally in yard or barn for one (1) day during sale or auction.

Sanitary Landfill. A government-owned site for the disposal of garbage and other refuse material.

Seasonal Camp Trailers or Recreational Vehicles. A vehicle designed for temporary seasonal living quarters.

Secondary Containment Facility. A second tank, catchment pit, pipe or vessel that limits and contains a liquid or chemical leaking or leaching from a primary containment area; monitoring and recovery systems are required.

Service Station, Automobile. Any building or premise which provides for the retail sale of gasoline, oil, tires, batteries, and accessories for motor vehicles and for certain motor vehicle services, including washings, tire changing, repair service, battery service, radiator service, lubrication, brake service, wheel service, and testing or adjusting of automotive parts. Automobile repair work may be done at a service station provided that no rebuilding of engines, spray paint operations, or body or fender repair is permitted. Gasoline pumps and gasoline pump islands shall be located more than twelve (12) feet from the nearest property line.

Setback. The setback of a building is the minimum horizontal distance between the street **or property** line and the front line of the building or any projection thereof, except cornices, unenclosed porches, and entrance vestibules and window bays projecting not more than three and one-half (3 1/2) feet from the building and having no more than fifty (50) square feet area and not extending above the first story of the building.

Setback Between Uses. Unless specifically mentioned within this ordinance, the setback or separation distance between uses is the minimum horizontal distance measured from the wall line of a neighboring principal building to the wall line of the proposed building/structure/use.

Shall means that the condition is an enforceable requirement of this regulation.

Shallow Aquifer. An aquifer vulnerable to contamination because the permeable material making up the aquifer (a) extends to the land surface so percolation water can easily transport contaminants from land surface to the aquifer, or (b) extends to near the land surface and lacks a sufficiently thick layer of impermeable material on the land or near the land surface to limit percolation water from transporting contaminants from the land surface to the aquifer.

Shallow Well. A well which is located in a shallow aquifer.

Shelterbelt. For the purposes of this ordinance a shelterbelt shall include ten (10) or more trees planted in a line, with each trees separated by a distance of forty (40) feet or less. Ornamental and/or shade trees, generally used in front yards and spaced further than thirteen (13) feet apart and further do extend lineally for a distance of over one hundred fifty (150) feet, are not considered shelterbelts.

Should. Means that the condition is a recommendation. If violations of this regulation occur, the County will evaluate whether the party implemented the recommendations contained in this regulation that may have helped the party to avoid the violation.

~~**Side Yard**. A yard between the building and the adjacent side line of the lot which separates it from another lot, extending from the front lot line to the rear yard.~~

Sign. Any device or structure, permanent or temporary, which directs attention to business, commodity, service or entertainment but excluding any flag, badge or insignia of any government agency, or any civic, charitable, religious, patriotic or similar organizations.

Sign, Abandoned. A sign or sign structure which contains no sign copy, contains obliterated or obsolete sign copy, or is maintained in an unsafe or unsightly condition for a period of three (3) months shall be considered an abandoned sign.

Sign Area: The total area or areas of all signs within the outer edges of the sign or advertising message. Sign area may be calculated in the following manners:

A. A single message on a single sign face.

B. Multiple messages on a single sign face:

C. (Adjacent to I-29 only) Multiple messages on stacked signs:

Sign. Off-premises. Any sign identifying or advertising a business, person, activity, goods, products or services at a location other than where such sign has been erected.

Sign, On-premises. Any sign identifying or advertising a business, person, activity, goods, products or services located on the premises where the sign has been erected.

Sign Structure. Any structure which supports, has supported, or is capable of supporting a sign, including decorative cover.

Significant Contributor of Pollution. To determine if a concentrated animal feeding operation meets this definition, the following factors are considered:

1. Size of feeding operation and amount of manure reaching waters of the state.

2. Location of the feeding operation in relation to waters of the state.

3. Means of conveyance of manure and process wastewater into waters of the state; and

4. The slope, vegetation, rainfall and other factors affecting the likelihood or frequency of discharge of animal wastes and process wastewater into waters of the state.

Sleeping Quarters. A room or an area contained within a dwelling unit utilized for the purpose of sleep.

Solution mining. The mining of an ore body with circulation of chemicals through injection and recovery wells. Solution Mining for minerals is prohibited.

~~**Special Exception.** A use that would not be appropriate generally or without restriction throughout the zoning district. The use may be appropriate in a zoning district specific standards and/or conditions are applied. The Board of Adjustment may permit such uses when specific provision is made in the zoning district regulations.~~

Specified Anatomical Areas. Means (1) Less than completely and opaquely covered human or animal genitals, pubic region, or pubic hair, buttocks; and female breasts below a point immediately above the top of the areola; and (2) Genitals of humans or animals in a discernible turgid state, even if completely or opaquely covered.

Specified Sexual Activities. Means (1) Human genitals in a state of sexual stimulation or arousal; (2) Acts or representations of acts of human or animal masturbation, sexual intercourse or sodomy, bestiality, oral copulation or flagellation; (3) Fondling or erotic touching of human or animal genitals, pubic region, buttock or female breast; and (4) Excretory functions as part of or in connection with any activities set forth in an Adult Bookstore or "Adult Entertainment Cabaret".

Stable. A building for the shelter and feeding of domestic animals, especially horses and cattle.

Stable, Commercial. A building for the shelter and feeding of domestic animals, especially horses and cattle where such domestic animals are raised, trained, boarded, harbored, or kept for remuneration. Veterinary clinics, animal hospitals and animal shelters are specifically excluded.

Stacked Signs: Two or more signs stacked vertically on a single sign structure.

Stealth. Means any Tower or Telecommunications Facility which is designed to enhance compatibility with adjacent land uses, including, but not limited to, architecturally screened roof-mounted antennas, antennas integrated into architectural elements, and Towers designed to look other than like a Tower such as light poles, power poles, and trees. The term Stealth does not necessarily exclude the use of uncamouflaged lattice, guyed, or monopole Tower designs.

Street, Highway or Road. ~~The term street shall include and apply to any public way except alleys.~~ **All property acquired or dedicated to the public and accepted by the appropriate governmental agency for street, highway or road purposes.**

A. **Street, Arterial.** A street designated as such on the **Major** ~~Official Road~~/Street Plan of the Comprehensive Plan of Codington County, South Dakota.

B. **Street, Collector.** A street designated as such upon the **Major** ~~Official Road~~/Street Plan of the Comprehensive Plan of Codington County, South Dakota.

C. **Street,** ~~Miner~~ **Local**. Any street which is not an arterial street or collector street.

~~**Street Line**. The street line is the dividing line between the street or road and the lot.~~**Street, Highway or Road Right-of-Way (ROW) Line. A dividing line between a lot or parcel of land and a contiguous street, highway or road.**

Structure. Anything constructed or erected, the use of which requires permanent location on the ground or attached to something having a permanent location on or below the ground.

Structure, Temporary. Anything constructed or erected, or placed, the use of which requires temporary location on the ground or attached to something having a temporary location on or below the ground.

Substantial improvement. Means any repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds fifty (50) percent of the market value of the structure either:

1. Before the improvement or repair is started, or

2. If the structure has been damaged and is being restored, before the damage occurred. For the purpose of this designation, "substantial improvement" is considered to occur when the first alteration of any wall, ceiling, floor, or other structural part of the building commences, whether or not that alteration affects the external dimensions of the structure.

The term does not, however, include either:

a. Any project for improvement of a structure to comply with existing State or local health, sanitary, or safety code specifications which are solely necessary to assure safe living conditions, or

b. Any alteration of a structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

Telecommunications Facilities. Means any cables, wires, lines, wave guides, antennas, and any other equipment or facilities associated with the transmission or reception of communications which a Person seeks to locate or has installed upon or near a Tower or Antenna Support Structure. However, Telecommunications Facilities shall not include:

1. Any satellite earth station antenna two (2) meters in diameter or less which is located in an area zoned industrial or commercial; or

2. Any satellite earth station antenna one (1) meter or less in diameter, regardless of zoning category.

Temporary Fireworks Sales Stand. A structure utilized for the licensed resale of fireworks during the time period allowed by South Dakota State Law.

Ten Year Time of Travel Distance. The distance that ground water will travel in ten years. This distance is a function of aquifer permeability and water table slope.

Tower. Means a self-supporting lattice, guyed, or monopole structure constructed from grade which supports Telecommunications Facilities. The term Tower shall not include amateur radio operators' equipment, as licensed by the FCC.

Tree, Ornamental. A deciduous tree which is typically grown because of its shape, flowering characteristics, or other attractive features, and which grows to a mature height of about twenty-five (25) feet or less.

Tree, Shade. For the purposes of this Ordinance, a shade tree is a deciduous tree which is has a mature crown spread of fifteen (15) feet or greater, and having a trunk with at least five (5) feet of clear stem at maturity.

Twin Homes. A two-family dwelling which has a common wall and is platted into two (2) separate lots.

Variance. A variance is a relaxation of the terms of the zoning ordinance where such variance will not be contrary to the public interest and where, owing to conditions peculiar to the property and not the result of the actions of the applicant, a literal enforcement of the ordinance would result in unnecessary and undue hardship. As used in this ordinance, a variance is authorized only for height, area, and size of structure or size of yards and open spaces; establishment or expansion of a use otherwise prohibited shall not be allowed by variance, nor shall a variance be granted because of the presence of nonconforming in the zoning district or uses in an adjoining zoning district.

Waters of the State. Means all waters within the jurisdiction of this state, including all streams, lakes, ponds, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, situated wholly or partly within or bordering upon the state.

Yard. An open space on the same lot with a building or group of buildings, which open space lies between the building or group of buildings and the nearest lot line. **In measuring a yard for**

the purpose of determining the width of a side yard, the depth of a front yard, or the depth of a rear yard, the minimum horizontal distance between the lot line and bearing wall of the main building shall be used.

Yard, Front. A yard extending across the front of a lot between the sideyard lines, and being the minimum horizontal distance between the road right-of-way line and the main bearing wall of the main building or any projections thereof other than the projections of the usual steps, unenclosed balconies or open porch.

Yard, Rear. A yard across the whole width of a lot, extending from the rear line of the building to the rear line of the lot.

Yard, Side. A yard between the building and the adjacent side line of the lot which separates it from another lot, extending from the front lot line to the rear yard.

Zoning Officer. The individual(s) appointed by the Board of County Commissioners and designated to administer and enforce the zoning ordinance.

Zone of Contribution. The entire area around a well or well field that contributes water to the well or wellfield.

~~SECTION~~ARTICLE III
~~ESTABLISHMENT OF ZONING~~ DISTRICT REGULATIONS

~~3.1 For the purpose of this Regulation, the unincorporated area of Codington County is hereby divided into the following zoning districts.~~

~~3.2 There may be one or more districts of each class and, where more than one district of a class exists, such districts may be entirely separate and distant from other districts of the same class.~~

~~3.3 No building or any part thereof shall be erected, constructed, reconstructed, converted, altered, enlarged, extended, raised, moved or used, and no premises shall be used for any purpose other than a purpose permitted in the District in which said building or premise is located, except as hereinafter provided.~~

~~3.4 For the purpose of this Regulation, the unincorporated area of the County is divided into zoning districts and said district boundaries are hereby established as indicated upon a map entitled "Official Zoning Use Districts, Codington County," said map being on file in the office of the County Planning Commission and the office of the County Auditor.~~

CHAPTER 3.01. APPLICATION OF DISTRICT REGULATIONS.

Section 3.01.01. Application of District Regulations.

The regulations set by this Ordinance within each District shall be minimum regulations and shall apply uniformly to each class or kind of structure of land, and particularly, except as hereinafter provided:

1. **No structure, permanent or temporary, shall be erected, converted, enlarged, reconstructed or structurally altered to exceed the height limit, area and parking requirements of the district in which the building is located. Further, no building or use of land shall be used except for a purpose permitted in the district in which the building or land is located.**

CHAPTER 3.02. NONCONFORMING USES.

Section 3.02.01. Purpose and Intent. The purpose of this article is to provide for the regulation of nonconforming uses, buildings, and structures, and to specify those circumstances under which they shall be permitted to continue. Further, it is intent of this Ordinance to permit these nonconformities to continue until they are removed, but not to encourage their survival.

Section 3.02.02. Continuation of Nonconforming Uses. Subject to the provisions of this article, the lawful use of a premise existing immediately prior to the effective date of this ordinance may be continued although such use does not conform to the provisions hereof.

Section 3.02.03. Use Becoming Nonconforming by Change in Law or Boundaries. Whenever the use of a premises becomes a nonconforming use through a change in zoning ordinance or district boundaries, such use may be continued, although the use does not conform to the provisions thereof.

Section 3.02.04. Extension or Enlargement. A nonconforming use shall not be enlarged, extended, converted, reconstructed, or structurally altered unless such use is changed to a use permitted in the district in which the premise is located.

Section 3.02.05. Restoration After Damage. When the use of a building is nonconforming as defined by this ordinance and such a building is damaged by a fire, explosion, act of God, or the public enemy to the extent of more than sixty (60) percent of its fair market value, it shall not be restored except in conformity with the provisions of the district in which the building is located.

Section 3.02.06. Repairs and Maintenance. On any nonconforming structure or portion of a structure containing a nonconforming use, work may be done on ordinary repairs, or on repairs or replacement of non-bearing walls, fixtures, wiring, or plumbing, provided that the nonconformity of the structure shall not be increased.

Section 3.02.07. Unsafe Nonconforming Use. If a nonconforming structure or portion of a structure containing a nonconforming use becomes physically unsafe or unlawful due to lack of repairs and maintenance, and is declared by any duly authorized official to be unsafe, or unlawful by reason of physical condition, it shall not thereafter be restored, repaired, or rebuilt except in conformity with the regulations of the district in which it is located.

Section 3.02.08. Discontinuance of Nonconforming Use. In the event that a nonconforming use is discontinued for more than one (1) year, any subsequent use shall thereafter be in conformity with the regulations of the district in which it is located.

Section 3.02.09. Effect on Use Which is Illegal Under Prior Law. Nothing in this ordinance shall be interpreted as authorization for, or approval of, the continuance of the use of a premises in violation of zoning regulations in effect immediately prior to the effective date of this ordinance.

Section 3.02.10. Powers of the Planning Commission/Board of Adjustment. Nothing contained in this Section shall be so construed as to abridge or curtail the powers of the County Planning Commission or Board of Adjustment as set forth elsewhere in this Ordinance.

Section 3.02.11. Continuation of Nonstandard Uses. Nonstandard uses existing immediately prior to the effective date of this ordinance may be continued, although such uses do not conform to the provisions hereof. Nonstandard buildings or structures may be enlarged or extended, converted, reconstructed, or structurally altered as follows:

1. **Enlargements, extensions, conversions, or structural alterations may be made as required by law or ordinance.**

2. **Structural alteration of buildings or structures may otherwise be made if such changes do not encroach into an existing front yard, side yard, or rear yard which is less than the minimum required yards for the district in which they are located.**

3. Enlargement, extension, conversion of buildings or structures may otherwise be made if such changes comply with the minimum required yards, lot area, height, landscaping, parking, and density for the district in which they are located.

Section 3.02.12. Nonconforming Lots of Record.

1. In any district in which single-family dwellings are permitted, a single-family dwelling and customary accessory buildings may be erected on any single lot of record at the effective date of adoption or amendment of this Ordinance, notwithstanding limitations imposed by other provisions of this Ordinance. Such lot must be in separate ownership and not of continuous frontage with other lots in the same ownership. This provision shall apply even though such lot fails to meet the requirements for area or width, or both, that are generally applicable in the district, provided that yard dimensions and requirements other than those applying to area or width, or both, of the lot shall conform to the regulations for the district in which such lot is located. Variance of yard requirements shall be obtained only through action of the Board of Adjustment.

2. If two (2) or more lots or combinations of lots and portions of lots with continuous frontage in single ownership are of record at the time of passage or amendment of this Ordinance, and if all or part of the lots do not meet the requirements established for lot width and area, the lands involved shall be considered to be an undivided parcel for the purposes of this Ordinance, and no portion of said parcel shall be used or sold in a manner which diminishes compliance with lot width and area requirements established by this Ordinance, nor shall any division of any parcel be made which creates a lot width or area below the requirements stated in this Ordinance.

3. Any area proposed or being developed for residential use in the "A" Agricultural Land District must provide for a minimum of thirty-five (35) acres per lot, unless platted prior to the adoption of Codington County Resolution 1167 (Adopted October 26, 1976). Exception to the lot size may be made according to Codington County Zoning Ordinance Section 3.04.03.

CHAPTER 3.03. ZONING DISTRICTS.

Section 3.03.01. Districts.

1. For the purpose of this Ordinance, the unincorporated areas of the County may be divided into any of the following zoning districts: A-Agricultural; C-Commercial; I-Industrial; LP-Lake Park; NR-Natural Resource; PR-Planned Residential; ~~and~~ TD-Town District and RR-Rural Residential District. In addition to zoning districts, the FP-Flood Protection and AP-Aquifer Protection zoning overlay districts impose special regulations on the property that may fall within these districts without abrogating the requirements imposed by the underlying land use district regulations.

2. The requirements as set forth below for each of the use districts listed as part of this Ordinance shall govern the development within the said districts as outlined on the map entitled "Official Zoning Map, Codington County, South Dakota~~.~~;" and "Official Map of the Rural Residential District."

3. "A" AGRICULTURAL LAND DISTRICT - ~~Agricultural Land District is primarily for the preservation of open space, and land currently used for intensive agriculture and considered not to be yet ready for further development~~. **This district is established to preserve open space and maintain and promote farming and related activities within an environment which is generally free of other land use activities. Residential development will be discouraged to minimize conflicts with farming activities and reduce the demand for expanded public services and facilities.**

4. "AP" AQUIFER PROTECTION OVERLAY DISTRICT - The purpose of the Aquifer Protection Overlay District is to protect public health and safety by minimizing contamination of the shallow aquifers of Codington County.

5. "C~~-2~~" ~~LOCAL~~ COMMERCIAL DISTRICT - The ~~Local~~ Commercial District is intended to provide areas for commercial activities oriented primarily to, and supportive of, farming and other activities which are determined to be appropriate in the rural area.

6. "FP" FLOOD ~~PRONE~~ **PROTECTION OVERLAY** DISTRICT - The Flood ~~Prone~~ **Protection Overlay** District is established to protect the natural environment and resources from destructive land uses and to protect lives and property along and adjacent to streams and rivers.

~~"I-1" LIGHT INDUSTRIAL DISTRICT~~

~~Light Industrial District for warehousing and light manufacturing.~~

~~"I-2" HEAVY INDUSTRIAL DISTRICT~~

~~Heavy Industrial District of all types of manufacturing which produces smoke, noise, dust, odor, and/or heavy traffic; also for storage areas for inflammable or otherwise dangerous materials.~~

7. "I" INDUSTRIAL DISTRICT - The Industrial District is established primarily for warehousing and light manufacturing. Heavy industrial uses such as manufacturing which produces smoke, noise, dust, odor, and/or heavy traffic; also for storage areas for inflammable or otherwise dangerous materials shall require special review and consideration.

8. "LP" LAKE-PARK DISTRICT - Lake Park District is to provide for orderly low residential and recreational development, together with certain public facilities, customary home occupations, and certain commercial establishments, along lakeshores.

9. "NR" NATURAL RESOURCE DISTRICT - The Natural Resource District is to provide for the retaining of natural vegetation of a particular area, to preserve the natural environment and resources from destructive land uses, and to protect wildlife habitat. Such areas may include, but are not limited to, flood plains of rivers, streams, and lakes, abandoned quarries, certain wetlands and natural prairies, and historical sites.

10. "PR" PLANNED RESIDENTIAL DISTRICT - The Planned Residential District is to provide for residential subdivisions which, through their design and development, will limit the amount of agricultural land that is taken out of production, will not require excessive public expenditures for roads or other improvements and services, and which will minimize the conflict between farm and non-farm uses.

11. "TD" TOWN DISTRICT - The Town District is established to provide for orderly low density residential development, together with certain public facilities, and commercial/industrial uses which are not detrimental in the unincorporated towns of Codington County.

12. "RR" RURAL RESIDENTIAL DISTRICT DISTRICT – See Section 3.13.01.

Section 3.03.02. Prohibited Uses.

All uses and structures not specifically listed as a permitted use or as a conditional use in a particular zoning district or overlay district shall be prohibited in said district.

~~**SECTION IV**~~
~~**DISTRICT REQUIREMENTS**~~

~~The requirements as set forth below for each of the use districts listed as part of this Regulation in Section III shall govern the development within the said districts as outlined on the map entitled "Zoning Use Districts, Codington County, South Dakota."~~

CHAPTER ~~4.1~~ ~~3~~.04. "A" AGRICULTURAL LAND DISTRICT.

Section 3.04.01. Permitted Uses.

1. ~~Animal husbandry service~~ **Agricultural activities and farm related buildings, including Type 5 Concentrated Animal Feeding Operations.**

2. ~~Field crops and grasslands~~ **One (1) single-family non-farm dwelling, including site-built homes, modular homes, and Type A manufactured homes for each quarter-quarter section not already containing a farm dwelling or a non-farm dwelling.**

3. ~~Fisheries services~~ **Farm dwellings and farm buildings.**

4. **Fisheries services and** Game propagation areas.

5. ~~Government grain storage sites~~ **Public park and recreation areas.**

6. ~~Horticultural services~~ **Field crops and grasslands.**

7. ~~Institution farms~~ **On-premise signs.**

8. ~~Farm dwellings and farm buildings~~ **Accessory uses and buildings.**

9. Orchards and tree farms.

10. Publ~~ic parks and recreation areas~~ **Temporary roadside stands for sales of agricultural products grown or produced on the premises.**

11. ~~Truck gardening~~ **Home occupation.**

12. Botanical gardens (nurseries and greenhouses) **– without retail sales.**

13. ~~One single-family, non-farm dwelling, including Type A manufactured home, for each quarter-quarter section not already containing a farm dwelling or a non-farm dwelling~~ **Stables**.

14. ~~Veterinarians offices and animal hospitals~~ **Private Wind Energy Conversion System (PWECs)**.

~~15. Schools;~~

~~16. Home occupations; and~~

~~17. Class 5 concentrated animal feeding operations.~~

~~18.Accessory Uses and buildings~~

Section 3.04.02. Conditional Uses.

~~B. The following are uses which may be permitted by a special exception permit issued by the Board of Adjustment. The permit may contain conditions and standards set forth within this ordinance and/or attached by the Board of Adjustment.~~

1. Airports and airstrips.

2. **Churches and** Cemeteries.

3. Commercial public entertainment enterprises not normally accommodated in commercial areas including, but not limited to, the following: music concerts, rodeos, tractor pulls, and animal and vehicle races.

4. ~~Extractive or mining and storage of these materials~~ **Sand, gravel or quarry operation; mineral exploration and extraction; rock crushers; and concrete and asphalt mixing plants provided:**

~~a. A requirement for receiving a permit for extractive/mining operations shall include a haul-road agreement between the applicant and appropriate governmental entity (Federal, State, County, Township, or Municipality).~~

a. The site meets the requirements of the State Department of Environment and Natural Resources.

b. A site plan is provided indicating the following information:

i. Present topography, soil types, and depth to groundwater.

ii. Location of existing water drainage, existing buildings, existing shelterbelts.

iii. Identification of roads leading to the site.

iv. Proposed changes at the site such as new shelterbelts, new buildings, changes in topography, new fence lines.

v. Proposed monitoring wells, etc.

vi. A requirement for receiving a permit for extractive/mining operations shall include a haul-road agreement between the applicant and appropriate governmental entity (Federal, State, County, Township, or Municipality).

vii. The applicant may be required to provide information regarding how potential air, noise, and water pollution would be minimized.

viii. The applicant shall provide for a plan for land reclamation of the land after mining is completed. Measures to be taken for surface reclamation shall take into account the impact on adjacent land uses and natural resources, and the proposed future use of the lands mined and adjacent lands. The reclamation plan shall include:

a. A reclamation schedule.

b. Methods of plugging drill holes.

b. Methods of severing and returning topsoil and subsoil.

c. Methods of grading, backfilling and contouring of exploration sites, access roads, and mining sites.

d. Methods of waste management and disposal, including liquid and solid wastes.

e. Method of revegetation.

ix. The applicant may be required to post a surety performance bond in an amount to be determined by the County Commission to assure that sufficient funds will be available to carry out required reclamation and, if necessary, decontamination of affected ground and surface waters. The amount shall be set by the County Commission based on an estimate of the cost of reclamation and decontamination. The bond shall be released five (5) years after mining and milling has ceased unless the Commissioners find, for good cause shown, that the water quality of the affected area has not been restored or the reclamation plan has not been completed. The amount of the surety bond may be reduced by the Commissioners if a bond is held by the State of South Dakota for the same purpose, by the same amount of the latter bond.

x. Sand, gravel or quarry operation; Mineral exploration and extraction operations; rock crushers; and concrete/ asphalt mixing plants will not be allowed within one thousand (1,000) feet of a residence. The setback will be measured from the mineral exploration and extraction operations; rock crushers; and/or concrete and asphalt mixing plant's property line to the nearest residence. The exception to this standard would apply to residences owned and lived in by the operator of the mineral exploration and extraction operations; rock crushers, and/or concrete/asphalt mixing plants.

xi. Sand, gravel or quarry operation; Mineral exploration and extraction; rock crushers; and/or concrete and asphalt mixing plants shall be set back at least sixty-five (65) feet from any public right-of-way.

5. Private club.

6. ~~Sanitary landfill dumping grounds but not within 160 rods of a residence or commercial establishment~~; **Sanitary landfills provided:**

   a. The site meets the requirements of the State Department of Environment and Natural Resources.

   b. A site plan is provided indicating the following information:

      i. Present topography, soil types, and depth to groundwater.

      ii. Location of existing water drainage, existing buildings, existing shelterbelts.

      iii. Identification of roads leading to the site.

      iv. Proposed changes at the site such as new shelterbelts, new buildings, changes in topography, new fence lines.

      v. Proposed monitoring wells, etc.

      vi. No sanitary landfill will be allowed within two thousand six hundred forty (2,640) feet from the landfill property line to the nearest residence or commercial use; excluding: the residence of the landfill operator.

7. ~~Sewage treatment plants, but not within 80 rods of a residence~~ **Domestic sanitary sewer treatment plant/facility.**

   a. The site meets the requirements of the State Department of Environment and Natural Resources.

   b. A site plan is provided indicating the following information:

      i. Present topography, soil types, and depth to groundwater.

      ii. Location of existing water drainage, existing buildings, existing shelterbelts.

      iii. Identification of roads leading to the site.

      iv. Proposed changes at the site such as new shelterbelts, new buildings, changes in topography, new fence lines.

      v. Proposed monitoring wells, etc.

      vi. No sewage treatment plant/facility will be allowed within one thousand three hundred twenty (1,320) feet from the sewage treatment plant/facility property line to the nearest residence; excluding: the residence of the landfill operator.

8. Class 1, Class 2, Class 3, and Class 4 concentrated animal feeding operations. See Concentrated Animal Feeding Operation, Section 5.~~21~~**14**.

9. **Commercial** Stables.

10. **Junkyards/salvage yards, provided that they meet the following minimum requirements and other restrictions that the Board of Adjustment may deem appropriate:**

    a. Junkyards/salvage yards shall be set back a minimum of one thousand three hundred twenty feet (1,320) feet from any adjoining road right-of-way.

    b. No junkyards will be allowed within three hundred thirty (330) feet from any adjoining property line.

    c. Junkyards shall be screened on all sides by a solid wall, with construction materials and design to be approved by the Board of Adjustment, at least two (2) feet above the highest stock pile or by a shelterbelt of shrubs and trees as approved by the Board of Adjustment; screening must be maintained in good repair.

    d. No junkyards will be allowed within one thousand (1,000) feet from the junkyard property line to the nearest residence; excluding: the residence of the junkyard operator.

    e. All junkyards must have a minimum lot area of ten (10) acres.

11. Public utility and public service structure including transmission lines, substations, gas regulator stations, pipelines, community equipment buildings, pumping stations, and reservoirs.

12. Land application of petroleum-contaminated soils.

11. Institution farms, including religious farming communities.

14. Bed and breakfast ~~home~~.

15. Wireless Telecommunications Towers and Facilities.

16. Extended home occupation (See Section 5.1~~3~~**2**).

17. Type B manufactured home not connected to an existing farmstead.

18. ~~Commercial hunting business~~ **Game Lodge**.

19. Group Homes.

20. ~~Dog~~ Kennels.

21. Wind Energy System (WES). (See Section 5.~~15~~**22**).

22. Public or private motorcycle recreation facilities.

23. **Target/Shooting Range.**

24. Veterinarians offices and animal hospitals.

25. Golf course, golf driving range, clubhouse.

26. Seasonal retail stands – including produce and fireworks - utilizing a permanent structure.

27. Livestock sales barns.

28. Fur farms.

29. Rubble sites, composting sites, waste tire sites, restricted use sites, and other sites governed by the South Dakota Department of Environment and Natural Resources permits for solid waste.

30. Government grain storage sites.

31. Horticultural services.

32. Orchards and tree farms with retail sales.

33. Truck gardening.

34. Botanical gardens (nurseries and greenhouses) with retail sales.

35. Schools.

36. Private shooting preserve.

37. Temporary roadside stands not utilizing a permanent structure for sales of fireworks.

38. Religious Conference Facility.

39. Storage of Fireworks in temporary structures.

40. Public building or facilities erected or established and operated by any governmental agency.

41. Single family dwelling (farm or non-farm) constructed less than one-half (1/2) mile from an existing concentrated animal feeding operation. See Chapter 5.29

Section 3.04.03 Area Regulations/Easement/Waivers

~~C. Area Regulations~~

All buildings shall be set back from street right-of-way lines and lot lines to comply with the following yard requirements:

1. Lot Size: All **eligible building** lots for **permitted uses** shall be a minimum of thirty-five (35) acres, except as provided in 7.a and 7.b of this Section. ~~Special exception uses shall have minimum area regulations determined by the Board of Adjustment~~

2. Lot Width: The lot width shall be a minimum of thirteen hundred (1,300) feet.

EXCEPTION: A residential dwelling may have a minimum lot width of six hundred fifty (650) feet if the depth of the lot is at least two thousand three hundred and forty-five (2,345) feet. This exception shall require Board of Adjustment approval.

3. Front Yard: The minimum depth of the front yard shall be sixty-five (65) feet and in no case shall an accessory building be located or extend into the front yard. In the case of a corner lot, front yards shall be provided on both streets.

4. **Conditional uses shall have minimum lot area and setback regulations determined by the Board of Adjustment.**

   a. EXCEPTION**S**:

      i. A structure with the floor space of less than two hundred (200) square feet **shall have a** front yard minimum depth **of** ~~shall be~~ one hundred sixty-five (165) feet.

      ii. Existing nonconforming residential structures, constructed prior to January 1, 2006, on a lot of record or on a lot containing at least thirty-five (35) acres although considered nonconforming, are eligible to be expanded or added onto, without Board of Adjustment Approval, as long as the existing front, side or rear yard setback(s) is not further encroached upon.

4. Side Yard: The minimum width of a side yard shall be twenty-five (25) feet.

5. Rear Yard: The minimum depth of a rear yard shall be twenty-five (25) feet.

6. Maximum Lot Coverage: Dwellings and buildings accessory thereto shall cover not more than twenty-five (25) percent of the lot area.

7. The Board of Adjustment may allow a smaller minimum lot requirement for the "A" Agricultural District under the following conditions:

   a. Where a permit for a**n additional** single-family ~~home~~ **farm dwelling** is requested on an existing farmstead, ~~so long as it is immediately connected to the existing farming operation~~ **provided**:

      1. The dwelling is located on the same legal description as the existing farmstead.

      2. The maximum number of dwelling units within the existing farmstead will not exceed two (2).

      3. The dwelling is occupied by employees or relatives of the farm owner.

      4. The additional single-family farm dwelling shall be removed in the event the structure becomes a non-farm dwelling.

   b. Where an existing farmstead is to be divided from adjacent farmland into a single separate parcel of five (5) acres or more.

~~8. Storage for junk yards shall be set back a minimum of eighty (80) rods from any adjoining road right-of-way and twenty (20) rods from any adjoining property line, and shall be~~

~~screened by a solid wall at least two (2) feet above the highest stock pile and maintained in a state of good repair. Further provided, that no storage yard for junk shall be allowed on any lot which is within sixty (60) rods from any residences other than that of the owner of the land.~~

~~D~~**8.** Height Regulations:

No principal building shall exceed two and one-half (2 1/2) stories or thirty-five (35) feet in height. Exceptions include the following structures:

1. Agricultural buildings.
2. Chimneys, smokestacks, cooling towers.
3. Radio and TV towers.
4. Water tanks.
5. Others, **as determined by the Board of Adjustment**, providing that they are not used for human occupancy.
6. Wind Energy System (WES).
7. Wireless Telecommunications Towers and Facilities.

~~E~~**9.** Agriculture Easement~~/Waiver~~

a. All new residential development (farm and non-farm) shall be required to file an "Agricultural Easement" **with the Register of Deeds** before the issuance of a building permit. **(See Chapter 5.27)**

~~**b. Applicants for residential development (farm and non-farm) are required to obtain a written waiver from the owner/operator of any existing concentrated animal feeding operation which is closer than one-half (1/2) mile from the proposed residential building site. If the applicant is unable to obtain the written waiver, he/she shall be required to file a waiver with the Register of Deeds waiving any or all common law challenges to future expansions of the said existing concentrated animal feeding operation. The waiver is to be filed with the Register of Deeds. (See Chapter 5.29)**~~

10. Access

a. The drive-way serving the parcel shall be separated from adjacent driveways on the same side of the road by the following distances depending upon road types:

i. Local road: 100 feet.

ii. Collector road: 300 feet.

iii. Arterial road: 500 feet.

iv. Minimum distance from intersection of two (2) or more of the above: 100 feet.

b. For all proposed uses and structures adjacent to a State highway, an access permit from the State of South Dakota Department of Transportation shall be required prior to the filing of a plat or the issuance of a building/use permit

CHAPTER ~~4.2~~ 3.05 "C~~-2~~" COMMERCIAL DISTRICT.

Section 3.05.01. Permitted Uses.

~~A. Uses Permitted~~

1. ~~Permitted uses in the A-Agricultural District except residential dwellings~~. **Field crops and grasslands**.

2. On~~/Off~~ **premise** signs.

3. Accessory uses and buildings.

4. Orchards and tree farms.

5. Temporary roadside stands for sales of agricultural products grown or produced on the premises.

Section 3.05.02. Conditional Uses.

~~B. Uses Permitted by Special Exception~~

1. ~~Abattoirs~~ **Wholesale warehouse and distributing**.

2. Welding and machine shops.

3. Gas, ~~and~~ oil, **liquid propane and liquid hydrogen** stations including bulk stations.

4. Public and private utilities.

5. Livestock sales.

6. Contractors' shops and yards including offices when in conjunction with a shop or yard.

7. ~~Other activities which are in general character of permitted uses in the "C-2" District~~ **Government-owned highway and street maintenance shops.**

8. Implement sales and service.

9. Truck terminals and freight warehouses.

10. Seed sales and grain storage, **fertilizer and chemical storage and sales**.

11. Recreation **vehicle sales and** park.

12. Bar/Tavern.

13. Commercial stables.

14. Kennel with or without animal grooming.

15. Veterinary clinics.

16. Wireless telecommunication towers and facilities.

17. Convenience store/service station.

18. Seasonal retail stands utilizing a structure (temporary or permanent).

19. Commercial orchards, tree farms, truck gardening, and greenhouses – with retail sales.

20. Motel/hotel.

21. Off-premise Signs.

22. Light manufacturing.

23. Commercial animal husbandry service.

24. Manufactured Home Park existing prior to June 18, 1974.

Section 3.05.03. Area Regulations.

~~C. Building Height Limits~~

~~1. No building shall exceed four (4) stories or fifty (50) feet in height.~~

~~2. Structures used for signs or other advertising purposes may not exceed one hundred twenty (120) feet in height.~~

~~D. Lot Requirements~~

~~1. Each lot shall contain a minimum of ten (10) acres and shall provide off-street parking at a ratio of three (3) square feet of parking area for each square foot of building area used as retail sales area; provided there shall be a minimum of 1,500 square feet of space for off-street parking.~~

~~2. Each lot which fronts on or has a side lot abutting any road shall have a building setback of at least one hundred (100) feet from said front or abutting lot line.~~

1. Lot Size. Each lot shall contain a minimum of ten (10) acres and shall provide off-street parking at a ratio of three (3) square feet of parking area for each square foot of building area used as retail sales area; provided there shall be a minimum of fifteen hundred (1,500) square feet of space for off-street parking.

2. Front Yard: The minimum depth of the front yard shall be one hundred (100) feet and in no case shall an accessory building be located or extend into the front yard. In the case of a corner lot, front yards shall be provided on both streets. Exception: The minimum front yard setback for off-premise signs, where the face of the sign is perpendicular to the Interstate 29 right-of-way, shall be ten (10) feet.

3. Building Height. No building shall exceed four (4) stories or fifty (50) feet in height.

4. Side and Rear Yard: The minimum side yard and rear yards shall be fifty (50) feet.

5. Access. For all proposed uses and structures adjacent to a State highway, an access permit from the State of South Dakota Department of Transportation shall be required prior to the filing of a plat or the issuance of a building/use permit.

6. Storage. All outdoor storage within five hundred (500) feet of a residential dwelling must be completely enclosed in a building or by a solid walled fence at least two (2) feet above the highest point of the stock pile which fence shall be maintained in safe and good repair. The County may require hard surfacing of parking lots.

4.3 I-1" LIGHT INDUSTRIAL DISTRICT

A. Uses Permitted

1. Agricultural uses as outlined under Agricultural Districts except residential dwellings;

2. On/Off site signs

B. Uses Permitted by Special Exception

1. The Board of Adjustment may permit other uses which, in its opinion, are not detrimental to other uses and are in the general character of other uses in the "I-1" Zone. These may include all manufacturing and processing uses, but do not include extractive or mining operations.

2. Automobile, truck and machinery sales;

3. Ag processing facilities;

4. Uses permitted by Special Exception in the C-2 Local Commercial District.

C. Building Height Limit

1. None.

D. Lot Requirements

1. Minimum lot area shall be ten (10) acres.

2. Each lot in the "I-1" Zone shall have a side yard of not less than twenty (20) feet.

3.Each lot in the "I-1" Zone shall have a rear yard of not less than twenty (20) feet.

4. Each building on a lot in the "I-1" Zone shall be set back not less than sixty-five (65) feet from any road right-of-way.

4.4 "I-2" HEAVY INDUSTRIAL DISTRICT

A. Uses Permitted

1. None

B. Uses Permitted by Special Exception.

1. The following uses or location of such uses may be approved by the Board of Adjustment:

a. Ag processing facilities;

b. Crematory;

~~c. Explosive manufacture or storage;~~

~~d. Fertilizer manufacture;~~

~~e. Incineration or reduction of garbage, dead animals, fat or refuse;~~

~~f. Soap manufacture;~~

~~g. Tanning of leather, rawhide, or skins;~~

~~h. And in general, those uses which have been declared a nuisance in any court of record, or which may be noxious or offensive by reason of odor, dust, gas, smoke or noise.~~

~~C. Building Height Limit~~

~~1. None.~~

~~D. Lot Requirements~~

~~1. Same as outlined under Lot Requirements for "I-1" Zone, sub-paragraphs 1, 2 and 4. And in addition, all storage within five hundred (500) feet of a Residential District must be completely enclosed in a building or by a solid walled fence at least two (2) feet above the highest point of the stock pile which fence shall be maintained in safe and good repair. The County may require hard surfacing of parking lots.~~

CHAPTER 3.06. "I" INDUSTRIAL DISTRICT.

Section 3.06.01. Permitted Uses.

1. **On-premise signs.**
2. **Field crops and grasslands.**
3. **Accessory uses and buildings.**

Section 3.06.02. Conditional Uses.

1. **Uses permitted by conditional use in the "C" Commercial District, except implement sales and service; recreation vehicle sales and parks, bar/tavern, commercial stables, veterinary clinics convenience store/service station, Seasonal retail stands utilizing a permanent structure, commercial orchards, tree farms, truck gardening, and greenhouses; and Motel/hotel.**
2. **Agricultural product processing facilities such as ethanol plants and corn/soybean processing.**
3. **Crematory.**
4. **Explosive manufacture or storage.**
5. **Fertilizer manufacture.**

6. Incineration or reduction of garbage, dead animals, fat or refuse.

7. Soap manufacture.

8. Tanning of leather, rawhide, or skins.

9. Off-premise signs.

10. Adult uses. (See Chapter 5.30).

11. Any permitted residential use in the "A" Agricultural District, where such use existed prior to June 18, 1974, and where such conditional use, if granted, will be limited to rebuilding, remodeling, of such pre-existing residence or construction of a new residence on the site of the pre-existing residence.

12. Other industrial or commercial uses determined by the Board of Adjustment to be consistent with the intent of this District that can meet the performance standards listed in section 3.06.04.

Section 3.06.03. Area Regulations.

1. Lot Area. Lot area shall be determined by need, setback, side yards, rear yards, parking requirements, freight handling requirements, building site and future expansion; however, in no case shall a lot have less than ten (10) acres. An applicant for a conditional use shall provide a proposed site plan which can be reviewed by the Board of Adjustment.

2. Front Yard: The minimum depth of the front yard shall be one hundred (100) feet and in no case shall an accessory building be located or extend into the front yard. In the case of a corner lot, front yards shall be provided on both streets. Exception: The front yard setback for off-premise signs, where the face of the sign is perpendicular to the Interstate 29 right-of-way, shall be ten (10) feet.

3. Side Yards. On lots adjacent to a residential area, all buildings and incidental areas shall be located so as to provide a minimum side yard of one hundred (100) feet, which shall be landscaped on the side adjacent to the residential area. All other side yards shall be a minimum of fifty (50) feet.

4. Rear Yards. No building shall be constructed within fifty (50) feet of the rear lot line. The rear yard shall be one hundred (100) feet if the lot abuts a major highway.

5. Height Regulations. None.

6. Storage. All outdoor storage within five hundred (500) feet of a residential dwelling shall be completely enclosed in a building or by a solid walled fence at least two (2) feet above the highest point of the stock pile which fence shall be maintained in safe and good repair. The County may require hard surfacing of parking lots.

7. Access. For all proposed uses and structures adjacent to a State highway, an access permit from the State of South Dakota Department of Transportation shall be required prior to the filing of a plat or the issuance of a building/use permit.

Section 3.06.04. Performance Standards.

1. **Noise. All noise shall be muffled so as not to be objectionable due to intermittence, beat frequency or shrillness.**

2. **Air Pollution. State emission standards shall be met by all possible sources of air pollution. In any case, there shall not be discharged from any sources whatsoever such quantities of air contaminants, smoke or detriment, nuisance or annoyance to any considerable number of persons or to the public in general to endanger the comfort, health or safety of any such considerable number of persons or have a natural tendency to cause injury or damage to business, vegetation or property.**

3. **Odor. The emission of odorous matter in such quantities as to be readily detectable at any point along lot lines or to produce a public nuisance or hazard beyond lot lines is prohibited.**

4. **Glare, Heat or Radiation. Every use shall be so operated that there is no emission of heat, glare or radiation visible or discernable beyond the property line.**

5. **Vibration. Every use shall be so operated that the ground vibration inherently and recurrently generated is not perceptible, without instruments, at any point on the property line.**

6. **Sewage and Liquid Wastes. No operation shall be carried on which involves the discharge into a sewer, watercourse, river or the ground of liquid wastes of any radioactive nature, or liquid wastes of chemical nature, which are detrimental to normal sewage plant operations or corrosive or damaging to sewer pipes and installations.**

7. **Fire Hazard. All flammable substances involved in any activity or use, shall be handled in conformance with the standard of the National Board of Fire Underwriters and any additional regulations that may from time to time be adopted by the County Commissioners**

8. **Physical Appearance. All operations shall be carried on within an enclosed building except that new or operable equipment may be displayed or stored in the open and waste materials stored in enclosed containers not readily visible from the street.**

CHAPTER ~~4.5~~ 3.07 "LP" LAKE PARK DISTRICT.

~~A. Intent~~

~~Lake Park District is to provide for orderly low residential and recreational development, together with certain public facilities, customary home occupations, and certain commercial establishments along lake shores.~~

Section 3.07.01. ~~B~~ Areas Contained in Lake Park District.

All land unless otherwise zoned, within **one thousand** (1,000) feet of the **State Established** normal high water elevation of **Lake Pelican, Punished Woman Lake or** a designated lake, **as identified on the Official Zoning Map**, shall be contained in the Lake Park District and usage shall conform to the regulations for this district.

Section 3.07.02. ~~C~~ Permitted Uses.

1. ~~Single-family residential usage, including Type A manufactured homes; and (Type B manufactured homes provided that provisions of Section 5.7 are met)~~ **Site-built single-family dwelling.**
2. Public ~~and private~~ parks **and recreation areas**.
3. Agricultural or horticulture uses **excluding concentrated animal feeding operations.**
4. ~~Commercial outdoor recreation areas similar to public areas~~ **Modular home**.
5. ~~Home occupations~~ **Type A manufactured home.**
6. **Attached garages and unattached private garages with sidewalls less than ten (10) feet and conform to the design of the house.**
7. **Essential public services.**
8. **Accessory uses to include but not limited to boathouses further than fifty (50') feet from the highwater mark, or sheds, piers and docks.**

Section 3.07.03. Conditional Uses.

1. **Twin homes.**
2. **Private parks and campgrounds.**
3. **Boathouses within fifty (50) feet of high water mark.**
4. **Multiple family dwellings, including condominiums.**
5. **Unattached garages with sidewalls greater than ten (10) feet or do not conform to the design of the house.**
6. **Type B manufactured home.**

7. Commercial storage garages.

8. Home occupation.

9. Extended home occupation.

Section 3.07.04 ~~D~~ Area Regulations

~~D. Minimum Lot Requirements~~

~~Each lot shall have a depth of not less than 200 feet and shall have a shoreline frontage width of not less than 165 feet. The minimum road frontage shall be not less than 50 feet in width. Lots shall be a minimum of two (2) acres.~~

~~E. Minimum Setback~~

~~Each building on a lot shall be set back not less than sixty-five (65) feet from the normal high water mark and a minimum of sixty-five (65) feet from all roads. Side yards shall not be less than twenty-five (25) feet from the property line.~~

1. Table 3.07.04.1 Lots Adjacent to Lake

	Minimum Lot Area (Sq. Ft)	Minimum Lot Width	Minimum Lot Depth	Minimum Side Yard	Minimum Front Yard (1)	Minimum Rear Yard (Lake Front)	Maximum Height
Central Sewer or Holding Tank and Rural or Municipal Water							
Single Family Dwelling	15,000	75’	200’	8’	30’	65’	30’
Multiple Family Dwelling	20,000	100’	200’	10’	30’	65’	45’
Septic Tank with Drain Field or Mound system combined with Private Well, Rural or Municipal Water							
Single Family Dwelling	87,120 (2 acres)	100’	200’	15’	30’	65’	30’

(1) Side of lot facing road right-of-way or access easement.

2. Table 3.07.04.2 Lots Not Adjacent to Lake

	Minimum Lot Area (Sq. Ft)	Minimum Lot Width	Minimum Lot Depth	Minimum Side Yard	Minimum Front Yard (1)	Minimum Rear Yard	Maximum Height
Central Sewer/Holding Tank and Rural or Municipal Water							
Single Family Dwelling	15,000	75'	200'	8'	30'	50'	30'
Multiple Family Dwelling	20,000	100'	200'	10'	30'	50'	45'
Septic Tank with Drain Field and Private Well, Rural or Municipal Water							
Single Family Dwelling	87,120 (2 acres)	100'	200'	25'	65'	50'	30'

i. Side of lot facing road right-of-way or access easement.

3. Regulations applicable to all lots in the Lake Park District:

a. On those lots platted prior to June 18, 1974 which have a lot width of less than seventy-five (75) feet, each building shall have a side yard of not less than a distance equal to ten (10) percent of the lot width. Under no circumstances shall a building have a side yard of less than five (5) feet. Roof overhangs may infringe upon the side yard requirements no more than one and one-half (1.5) feet.

b. Regarding Lake Pelican, no structure except piers and docks shall be placed at an elevation such that the lowest floor, including basement or crawl space, is less than one (1) foot above the base flood elevation of 1716.3' NGVD 1929 or 1717' NAVD 1988. In those instances where sufficient data on known high water levels are not available, the elevation line of permanent terrestrial vegetation shall be used as the estimated high water elevation. When fill is required to meet this elevation, the fill shall be required to stabilize or be tamped down before construction is begun.

c. Regarding other Lake Park Districts, no structure except piers and docks shall be placed at an elevation such that the lowest floor, including basement or crawl space, is less than one (1) foot above the base flood elevation. In those instances where sufficient data on known high water levels are not available, the elevation line of permanent terrestrial vegetation shall be used as the estimated high water elevation. When fill is required to meet this elevation, the fill shall be required to stabilize or be tamped down before construction is begun.

d. Sealed holding tanks for dwellings are required for all lots of record containing less than twenty thousand (20,000) square feet and not connected to a central sewer system. Existing septic tanks and drainfields (as of January 1, 2006) on lots with an area of less than twenty thousand (20,000) square feet are considered nonconforming uses and shall not be allowed to be replaced after the adoption of this ordinance.

e. There shall be no more than one (1) principal residential building on any parcel of land.

f. Where two (2) parcels of land are purchased and joined together by one (1) common boundary, the setbacks established above shall pertain to the perimeter of the combined lots.

g. The maximum size of attached and unattached garages shall be a function of the size of the lot area. The size of garages, attached and unattached, located on nonconforming lots of record shall conform to the following requirements Table 3.07.04.3:

Table 3.07.04.3

Lot Area	Maximum Size
1 to 10,000 Square Feet	Seven (7) percent of the lot area
10,001 to 20,000 Square Feet	Seven hundred (700) square feet or six (6) percent of the lot area – whichever is greater
20,0001 to 43,560 Square Feet	One thousand two hundred (1,200) square feet or five (5) percent of the lot area – whichever is greater
43,561 to 87,119 Square Feet	Two thousand one hundred seventy eight (2,178) square feet or four (4) percent of the lot area – whichever is greater
Over 87,120 Square Feet	Three thousand four hundred eighty five (3,485) square feet or three (3) percent of the lot area – whichever is greater

~~F. Permitted Accessory Uses~~

~~1. Boathouses, piers, and docks.~~

Section 3.07.05. ~~G~~ **Minimum** Shoreland **Alterations.**

1. These regulations are deemed necessary along the shores of natural waters to protect scenic beauty, control erosion, and reduce effluent and nutrient flow from the ~~shoreland~~ **shoreline**.

2. Removal of Shore Cover. Tree and shrub cutting in a strip paralleling the shoreline and extending a minimum of thirty-five (35) feet inland from all points along the normal high water mark of the shoreline shall be limited in accordance with the following provisions.

1. Cutting shall, at a minimum, leave sufficient cover to screen cars, buildings, except boathouses, as seen from the water; to preserve natural beauty and to control erosion.

2. Natural shrubbery shall, at a minimum, be preserved as far as practicable, and where removed it shall be replaced with other vegetation that is equally effective in retarding run-off, preventing erosion, and preserving natural beauty.

3. The removal of natural shrubbery and its replacement shall require the granting of a permit by the County Zoning Officer. Application for such permit shall be accompanied by a plan showing the work to be accomplished.

3. Shoreline Stabilization

Shoreline stabilization, including but not limited to riprapping and retaining walls, shall require the granting of a permit by the Zoning Officer.

Section 3.07.06. ~~H~~ **Filling, Grading, Lagooning, and Dredging.**

1. Filling, grading, lagooning, and dredging which would result in substantial detriment to natural waters by reason of erosion, sedimentation, or impairment of fish and aquatic life is prohibited within an "LP" District.

2. A permit shall be required for any filling or grading.

a. This does not apply to soil conservation practices such as terraces, run-off diversions and grassed waterways which are used for sediment retardation.

b. Issuance of the permit shall include review from the Corps of Engineers and/or other appropriate State and/or Federal agencies

3. A permit shall be required before constructing, dredging, or commencing work on an artificial waterway, canal, ditch, lagoon, pond, lake or similar waterway.

   a. This requirement does not apply to soil conservation practices such as terraces, run-off diversions, and grassed waterways which are used for sediment retardation.

   b. Issuance of the permit shall include review from the Corps of Engineers and/or other appropriate State and/or Federal agencies.

Section 3.07.07. ~~I~~ Sewage Systems.

1. The developer of any plat shall provide for **County approved** ~~adequate~~ sewage systems and provide provisions that are binding on the developer before such plat is approved. At a minimum, the installation and utilization of individual on-site wastewater systems shall meet state regulations, Chapter 74:53:01.

2. The developer of any plat shall be liable for the execution of the provisions required above to protect waters of the state from pollution and shall be liable for any pollution that occurs for failure to execute such provisions.

Section 3.07.08. ~~J~~ Agricultural Easement.

1. All new residential development (farm and non-farm) in the Lake Park District shall be required to file an "Agricultural Easement" before the issuance of a building permit.

~~K. Expansion of the Existing Lake Park District Boundaries~~

~~The Lake Park District may be expanded beyond the originally defined "within one thousand (1,000) feet of the normal high water line of a designated lake" boundary by an additional distance not to exceed twelve hundred (1,200) feet.~~

~~1. Lake Park District Expansion Development Standards and Requirements~~

~~a. The expansion of the Lake Park District shall not be permitted on a parcel of land less than twenty (20) acres in area.~~

~~b. All roads, common facilities, and open spaces within the Lake Park District Expansion shall be maintained by a homeowner's association.~~

~~c. Lake Park District expansions within two miles of Watertown and one (1) mile of any other incorporated community will be submitted to the community governing body for review and comment.~~

~~d. Where a proposed Lake Park District expansion is within two miles of Watertown or one (1) mile of any other incorporated area, the Codington County Planning Commission may request the developer to construct proposed improvements to specifications approved by the community's governing body.~~

~~e. Lake Park District Expansions must have access to a concrete or bituminous asphalt street.~~

~~f. Lake Park District Expansions are not allowed over the shallow aquifer or wellhead protection areas.~~

~~EXCEPTION: A Lake Park District expansion may be allowed over a shallow aquifer if a Board of Adjustment and DENR approved sanitary sewer system is implemented. Approved sanitary sewer systems are subject to the Department of Environment and Natural Resources regulations 74:53:01 and amendments thereto.~~

~~2. Procedure for expansion of Lake Park District~~

~~The procedure found in the 4.8 Planned Residential District Paragraph B shall be used in the expansion of the Lake Park District~~

CHAPTER ~~4.6~~ **3.08. "NR" NATURAL RESOURCE DISTRICT.**

Section 3.08.01. ~~A~~ **Permitted Uses**.

1. Wildlife production areas.
2. Game refuges.
3. Historic sites and/or monuments.
4. Designated natural prairies.
5. Public hunting and fishing access areas.

Section 3.08.02. Conditional Uses.

~~B. Uses Permitted by Special Permit if Deemed Not Detrimental to the District~~

1. Transportation and utility easements and rights-of-way.
2. Utility substations.
3. Public parks and/or playgrounds.
4. Horticulture uses and livestock grazing.

5. Essential services.

6. Mineral exploration and development, sand, gravel, or quarry operation.

Section 3.08.03. Shoreline Alterations, Filling, Grading, Dredging, and Lagooning.

1. Shoreline stabilization, filling, grading, dredging, and lagooning projects in the "NR" District shall be governed by Sections 3.07.05 and 3.07.06 of this ordinance.

CHAPTER ~~4.8~~ 3.09 "PR" PLANNED RESIDENTIAL DISTRICT.

~~The Planned Residential District is to provide for residential subdivisions which, through their design and development, will limit the amount of agricultural land that is taken out of production, will not require additional public expenditures for roads or other improvements and services, and which will minimize the conflict between farm and non-farm land uses~~.

Section 3.09.01. ~~A~~ Planned Residential District ~~Development~~ Standards and Requirements.

1. The use of land in the Planned Residential District shall be limited to non-farm single-family dwelling units and their supporting services. **However, the Board of Adjustment may consider commercial and/or public uses supportive of the proposed Planned Residential District.**

2. The Planned Residential District shall not be permitted on a parcel of land less than thirty-five (35) acres in area.

3. All roads, common facilities, and open spaces within the Planned Residential District shall be maintained by a homeowner's association.

4. Planned Residential Districts within two miles of Watertown and one (1) mile of any other incorporated community will be submitted to the community governing body for review and comment.

5. Where a proposed Planned Residential District is within two **(2)** miles of Watertown or one (1) mile of any other incorporated area, the Codington County Planning Commission may ~~request~~ **require** the developer to construct proposed improvements to specifications approved by the community's governing body.

6. Strip or linear development proposals along a road or highway will not qualify as a Planned Residential District.

7. The overall density of a Planned Residential District shall not be less than one (1) housing unit per three (3) acres of land.

8. Minimum lot size shall not be less than that required by the South Dakota Department of Environment and Natural Resources regulations on Private Sewage Disposal Systems (Chapter 34:04:01).

9. In addition to the Codington County Zoning Regulations, any proposed Planned Residential Districts are subject to platting and subdivision regulations of the county.

10. Access to public dedicated streets and roads shall be limited. **Dwelling units shall not access public road right-of-ways. Dwelling unit access shall be provided through the interior street/road system.**

11. Planned Residential Districts must have access to a concrete or bituminous-asphalt street. **Further all interior streets constructed within the Planned Residential District shall be either concrete or asphalt with the design to be approved by the County Highway Superintendent.**

12. Planned Residential Districts **are** not allowed over the shallow aquifer or wellhead protection areas.

EXCEPTION: A Planned Residential District may be allowed over a shallow aquifer if ~~a Board of Adjustment and DENR approved sanitary sewer system is implemented. Approved sanitary sewer systems are subject to the Department of Environment and Natural Resources regulations 74:53:01 and amendments thereto.~~ **the proposed Planned Residential District utilizes a Board of Adjustment approved central sanitary sewer collection system, which may consist of holding tanks, trunk lines, lift stations, and treatment facilities.**

13. ~~An~~ Easement**s per 3.04.03.9 of this ordinance** shall be required to be placed on any lot in a Planned Residential District in order to protect agricultural operations or practices in the adjoining areas.

Section 3.09.02. ~~B~~ Procedure for Planned Residential District ~~Development~~.

The following shall be observed when a Planned **Residential District** ~~Development~~ proposal is submitted for consideration:

1. An applicant for consideration under the terms of this district, who must be owner, lessee, or the holder of a written purchase option of the tract of land under consideration, shall submit ~~eleven (11)~~ **three (3)** copies of a preliminary development plan to the commission for study at least seven (7) days prior to the commission meeting at which it is to be considered. The preliminary plan shall include the following information.

    a. Location map showing the relationship of the proposed district to existing roads and property lines;

    b. Proposed land uses, building locations, and housing unit densities;

    c. Proposed circulation pattern indicating the status of street ownership;

    d. Proposed open space uses;

    e. Proposed grading and drainage pattern;

    f. Proposed method of water supply and sewage disposal;

    g. Relation of the proposed development to the surrounding area and comprehensive plan.

2. Copies of the proposed water and **sanitary** sewer system ~~will~~ **may** be submitted to the South Dakota Department of Environment and Natural Resources for study and comment.

3. A list and schedule of improvements to be completed by the developer must be submitted.

4. In reviewing the plan, the Commission shall need to determine that:

    a. Resulting development will not be inconsistent with the Comprehensive Plan objectives or zoning provisions of the area.

    b. The plan can be completed within a reasonable period of time.

c. The streets are adequate to support the anticipated traffic and the development will not overload the roads outside the planned area.

d. Proposed utility and drainage facilities are adequate for the population densities proposed.

~~5. If, in the opinion of the Planning Commission, the foregoing provisions are satisfied, the proposal shall be processed according to this section. If the Commission finds to the contrary, they may recommend the application be denied or return the plan to the application for revision.~~

~~6.~~**5**. In addition to the requirements of this section, the **Planning** Commission may attach conditions it finds are necessary to carry out the purpose of this ordinance.

~~7~~**6**. Before approving a Planned **Residential** ~~Development~~ District, the Planning Commission must have copies of proposed deed restrictions, agreements for maintenance by the homeowners' association of common facilities and open spaces, guarantees (surety bonds, etc.) by the developer for the completion of the development in accordance with the approved plan, and an agreement binding successors who may take over completion of the development to conditions of the plan approval.

~~8~~**7**. The Planning Commission shall follow the procedure for considering an amendment to the Codington County Official Zoning Map before approving a Planned Residential District.

~~9~~**8**. Permits for construction in a Planned **Residential** ~~Development~~ District shall be issued only on the basis of the approved plan. Any changes in the approved plan shall be submitted to the Commission for processing as an amendment to this ordinance.

CHAPTER 3.10. TD" TOWN DISTRICT.

Section 3.10.02. ~~A~~ Permitted Uses.

1. Single-family residential usage, including Type A manufactured homes permitted; Type B manufactured homes, provided that provisions of Section 5.7 are met.

2. Public parks.

3. Agriculture and horticulture uses, excluding feedlots.

~~4. Home occupation.~~

Section 3.10.02. ~~B Special Exception~~ Conditional Uses.

1. Retail and service business.

2. Light manufacturing.

3. Bar or tavern.

4. Warehouse.

5. Multi-family housing

6. ~~Contractors' offices, shops and yards~~ **Home occupation.**

7. Manufactured home park.

8. The Board of Adjustment may permit other uses which in its opinion are not detrimental to other uses. These may include manufacturing and processing uses.

Section 3.10.03. ~~C~~ Area Regulations

1. **Residential Uses/Lots - Structures on all corner lots shall observe two (2) front yards. The depth of the front yard on each street which the lot abuts, shall be as follows.**

   a. Minimum Yard Requirements:

   Front -- Twenty-five (25) feet
   Side -- Fifteen (15) feet
   Rear -- Twenty-five (25) feet

   b. Minimum Lot Size:

   Public Water Supply/Septic Tank -- 20,000 Sq. Ft.
   Well/Septic Tank ---------- 43,560 Sq. Ft.
   Public Water Supply/Public Sewer - 9,600 Sq. Ft.

2. Commercial Uses/Lots - Lot size shall be determined by off-street parking needs; availability of water and sewage disposal systems; adjacent land uses; need for screening; and type of business. Front, side, and rear yards shall be determined by the Board of Adjustment ~~after recommendation from the Planning Commission.~~

3. **Industrial Uses/Lots**

Lot size shall be determined by off-street parking needs; impact of adjoining land use and need for screening or buffering from residential areas; availability of water and sewage disposal facilities; type of manufacturing or storage facilities; type of manufacturing or storage facilities. **Front, side, and rear yards shall be determined by the Board of Adjustment**.

CHAPTER ~~4.7~~ **3.11. FLOOD** ~~DAMAGE PREVENTION REGULATIONS~~ **PROTECTION OVERLAY DISTRICT.**

Section 3.11.01. ~~A.1.~~ **Statutory Authorization, Findings of Fact, Purpose and Methods of Reducing Flood Losses.**

1. Statutory Authorization

The Legislature of the State of South Dakota has in SDCL Chapter 11-2 delegated the responsibility to local governmental units to adopt regulations designed to promote the public health, safety, and general welfare of its citizenry. Therefore, the County Commissioners of Codington County, South Dakota, ordain as follows:

2. Findings of Fact

~~i.~~**a**. The flood hazard areas of Codington County are subject to periodic inundation which results in loss of life and property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety, and general welfare.

~~ii.~~**b** These flood losses are caused by the cumulative effect of obstructions in ~~areas of special flood hazards which increase flood heights and velocities, and when inadequately anchored, damage uses in other areas. Uses that are inadequately flood-proofed, elevated or otherwise protected from flood damage also contribute to the flood loss.~~ **floodplains which cause an increase in flood heights and velocities, and by the occupancy of flood hazards areas by uses vulnerable to floods and hazardous to other lands because they are inadequately elevated, floodproofed or otherwise protected from flood damage.**

~~3.c~~**3**. Statement of Purpose

It is the purpose of these regulations to promote the public health, safety, and general welfare, and to minimize public and private losses due to flood conditions to specific areas by provisions designed:

~~i.~~**a**. To protect human life and health;

~~ii.~~**b**.To minimize expenditure of public money for costly flood control projects;

~~iii.~~**c**. To minimize the need for rescue and relief efforts associated with flooding and generally undertaken at the expense of the general public;

~~iv.~~**d**. To minimize prolonged business interruptions;

~~v.~~**e**.To minimize damage to public facilities and utilities such as water and gas mains, electric, telephone and sewer lines, streets and bridges located in areas of special flood hazard;

~~vi.~~**f**.To help maintain a stable tax base by providing for the sound use and development of areas of special flood hazard so as to minimize future flood blight areas;

~~vii.~~**g.** To ensure that potential buyers are notified that property is in an area of special flood hazard; and

~~viii.~~**h.** To ensure that those who occupy the areas of special flood hazards assume responsibility for their actions.

~~4.~~**d4**. Methods of Reducing Flood Losses

In order to accomplish its purposes, these regulations include methods and provisions for:

~~i.~~**a**. Restricting or prohibiting uses which are dangerous to health, safety, and property due to water or erosion hazards, or which result in damaging increases in erosion or in flood heights or velocities;

~~ii.~~**b**. Requiring that uses vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction;

~~iii.~~**c**. Controlling the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel flood waters;

~~iv.~~**d**. Controlling filling, grading, dredging, and other development which may increase flood damage; and

~~v.~~**e**. Preventing or regulating the construction of flood barriers which will unnaturally divert flood waters or which may increase flood hazards in other areas.

~~B. Definitions.~~

~~Unless specifically defined below, words or phrases used in these regulations shall be interpreted so as to give them the meaning they have in common usage and to give these regulations the most reasonable application.~~

~~"Area of special flood hazard" means the land in the floodplain subject to a one percent or greater chance of flooding in any given year. The area of a special flood hazard refers top the area subject to inundation during the base (100-year flood.~~

~~"Base flood" means the flood having a once percent chance of being equaled or exceeded in any given year.~~

~~"Development" means any man-made change to improved or unimproved real estate, including but not limited to, buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations located within the area of special flood hazard.~~

~~"Flood" or "flooding" means a general and temporary condition of partial or complete inundation of normally dry land areas from:~~

~~1. The overflow of inland or tidal waters and/or~~

~~2. The unusual and rapid accumulation of runoff of surface waters from any source.~~

"Flood Insurance Rate Map (FIRM)" means an official map of a community on which the Federal Emergency Management Agency has delineated areas of special flood hazard designated as Zone A.

"Floodway" - The channel and the adjacent areas that must be reserved in order to meet the minimum requirement of the National Flood Insurance Program of providing for the discharge of the base flood without cumulatively increasing the water surface elevation more than one (1) foot. However if there are identifiable flood impacts either upstream or downstream, based upon a scientific engineering study, a more stringent definition of floodway may be justified. That definition would include the channel and the adjacent areas that must be reserved in order to provide for the discharge of the base flood without cumulatively increasing the water surface elevation to a point which may result in additional damages to upstream/downstream properties.

"Manufactured home" means a structure, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when connected to the required utilities. This term also includes park trailers, travel trailers and other similar vehicles placed on a site for greater than 180 consecutive days.

"Structure" means a walled and roofed building or manufactured home that is principally above ground.

"Substantial improvement" means any repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure either:

1. Before the improvement or repair is started, or

2. If the structure has been damaged and is being restored, before the damage occurred. For the purpose of this designation, "substantial improvement" is considered to occur when the first alteration of any wall, ceiling, floor, or other structural part of the building commences, whether or not that alteration affects the external dimensions of the structure.

   The term does not, however, include either:

   c. Any project for improvement of a structure to comply with existing State or local health, sanitary, or safety code specifications which are solely necessary to assure safe living conditions, or

   d. Any alteration of a structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

Section 3.11.02. C.2.General Provisions.

1**a1.** Lands to which this Ordinance Applies

This ordinance shall apply to all areas of special flood hazards within the jurisdiction of Codington County.

2**b2**. Basis for Establishing the Areas of Special Flood Hazard

The areas of special flood hazard identified by the Federal Emergency Management Agency in its Flood Insurance Rate Map (FIRM), **a scientific and engineering report entitled, "The Flood Insurance Study for Codington County,"** dated February 1, 1986 **January**

16, 2009, ~~is adopted by reference and declared to be part of these regulations. The FIRM is on file at the County Auditor's Office, Codington County Courthouse, Watertown, SD~~ **with accompanying Flood Insurance Rate Maps and Flood Boundary-Floodway Maps (FIRM and FBFM) and any revisions thereto are hereby adopted by reference and declared to be a part of this ordinance.**

~~3~~**c3**. Compliance

No structure or land shall hereafter be constructed, located, extended, or altered without full compliance with the terms of these regulations and other applicable regulations.

~~4~~**d4**. Abrogation and Greater Restrictions

These regulations are not intended to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where these regulations and another ordinance, easement, covenant, or deed restriction conflict or overlap, whichever imposes the more stringent restrictions shall prevail.

~~5~~**e5**.Interpretation

In the interpretation of these regulations, all provisions shall be:

a. Considered as minimum requirements;

b. Liberally construed in favor of the governing body; and

c. Deemed neither to limit nor repeal any other powers granted under State statutes.

~~6~~f**6**.Warning and Disclaimer of Liability

The degree of flood protection required by these regulations is considered reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur on rare occasions. Flood heights may be increased by man-made or natural causes. These regulations do not imply that land outside the areas of special flood hazards or uses permitted within such areas of special flood hazards or uses permitted within such areas will be free from flooding or flood damages. These regulations shall not create liability on the part of Codington County, any officer or employee thereof, or the Federal Emergency Management Agency for any flood damages that result from reliance on these regulations or any administrative decision lawfully made thereunder.

Section 3.11.03. ~~D.3.~~ Administration.

~~1~~**a1.** Establishment of Development Permit

A development permit shall be obtained before construction or development begins within any area of special flood hazard established in Section ~~C.2~~**2.b 3.11.02.2.** (BASIS FOR ESTABLISHING THE AREAS OF SPECIAL FLOOD HAZARD). Application for a development permit shall be made on forms furnished by the Zoning Officer and may include, but not be limited to: Plans in duplicate drawn to scale showing the nature, location, dimensions, and elevations of the area in questions; existing or proposed structures, fill, storage of materials, drainage facilities; and the location of the foregoing. Specifically, the following information is required:

~~i.~~**a**. Elevation in relation to mean sea level of the lowest floor (including basement) of all structures;

~~ii.~~**b**. Elevation in relation to mean sea level to which any structure has been floodproofed;

~~iii.~~**c**. Certification by a registered professional engineer or architect that the floodproofing methods for any non-residential structure meet the floodproofing criteria in ~~E.2.b.~~ **~~4.b.ii.~~ 3.11.04.2.b.** (Non-residential Construction); and

~~iv.~~**d**. Description of the extent to which any watercourse will be altered or relocated as a result of proposed development.

~~2b~~2. Designation of the Zoning Officer

The Zoning Officer is hereby appointed to administer and implement ~~these regulations by granting or denying development permit applications in accordance with their provisions~~ the provisions of this ordinance and other appropriate sections of 44 CFR (National Flood Insurance Program Regulations) pertaining to floodplain management.

~~3c~~3. Duties and Responsibilities of the Zoning Officer

Duties of the Zoning Officer shall include but not be limited to:

~~a.~~**~~i.~~a.** Permit Review

~~i.~~**~~a.~~i.** Review of all development permits to determine that the permit requirements of these regulations have been satisfied.

~~ii.~~**~~b.~~ii.** Review all development permit to determine that all necessary permits have been obtained from those Federal, State or local governmental agencies from which prior approval is required.

~~iii.~~**~~c.~~iii.** Review all development permits to determine if the proposed development adversely affects the flood carrying capacity of the area of special flood hazard. For the purposes of these regulations, “adversely affects” means damage to adjacent properties because of rises in flood stages attributed to physical changes of the channel and the adjacent overbank areas.

~~iv.~~**~~d.~~iv.** If it is determined that there is no adverse effect and the development is not a building, then the permit shall be granted without further consideration.

~~v.~~**~~e.~~v.** If it is determined that there is an adverse effect, then technical justification (i.e., a registered professional engineer’s certification) for the proposed development shall be required.

~~vi.~~**~~f.~~vi.** If the proposed development is a building, then the provisions of these regulations shall apply.

~~b.~~**~~i.~~b.** Uses of Other Base Flood Data

i. When base flood elevation data has not been provided in accordance with Section ~~C.2.~~ **~~2.b.~~ 3.11.02.2.** BASIS FOR ESTABLISHING THE AREAS OF SPECIAL FLOOD HAZARD, the zoning Officer shall obtain, review, and reasonably utilize any base flood elevation and floodway data available from a Federal, State, or other source as criteria for requiring that new construction, substantial improvements, or other development in Zone A are administered in accordance with ~~E.2.~~ **~~4.b.~~ 3.11.04.2,** SPECIFIC STANDARDS.

ii. When a regulatory floodway has not been designated, the Floodplain Administrator must require that no new construction, substantial improvements, or other development (including fill) shall be permitted within Zones A1-30 and AE on the community's FIRM, unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community.

iii. Under the provisions of 44 CFR Chapter 1, Section 65.12, of the National Flood Insurance Program regulations, a community may approve certain development in Zones A1-30, AE, AH, on the community's FIRM which increases the water surface elevation of the base flood by more than one foot, provided that the community first applies for a conditional FIRM revision through FEMA (Conditional Letter of Map Revision).

~~3.d.~~**4.** Information to be Obtained and Maintained

~~a.~~**i.a.** Obtain and record the actual elevation (in relation to mean sea level) of the lowest floor (including basement) of all new or substantially improved structures, and whether or not the structure contains a basement.

~~b.~~**ii.b.** For all new or substantially improved floodproofed structures:

~~1.~~**a.i.** Verify and record the actual elevation (in relation to mean sea level) to which the structure has been floodproofed.

~~2.~~**b.ii.** Maintain the floodproofing certification required in Section ~~D.1.c.~~ **3.a.iii. 3.11.03.1.c.**

~~c.~~**iii.c.** Maintain for public inspection all records pertaining to the provisions of these regulations.

~~4.~~**e.5.** Alteration of Watercourses

a. Assure that the flood carrying capacity within the altered or relocated portion of any watercourse is maintained.

~~a.~~**i.b.** Notify adjacent communities and State Coordinating Agency prior to any alteration or relocation of a watercourse, and submit evidence of such notification to the Federal Emergency Management Agency.

~~b.~~**2.c.** Require that maintenance be provided within the altered or relocated portion of said watercourse so that the flood carrying capacity is not diminished.

~~5.~~**f.6.** Interpretation of FIRM Boundaries

Make interpretations, where needed, as to the exact location of the boundaries of the areas of special flood hazards (for example, where there appears to be conflict between a mapped boundary and actual field conditions).

7. VARIANCE PROCEDURES

a. The appeal Board as established by the community shall hear and render judgment on requests for variances from the requirements of this ordinance.

b. The Appeal Board shall hear and render judgment on an appeal only when it is alleged there is an error in any requirement, decision, or determination made by the Floodplain Administrator in the enforcement or administration of this ordinance.

c. Any person or persons aggrieved by the decision of the Appeal Board may appeal such decision in the courts of competent jurisdiction.

d. The Floodplain Administrator shall maintain a record of all actions involving an appeal and shall report variances to the Federal Emergency Management Agency upon request.

e. Variances may be issued for the reconstruction, rehabilitation or restoration of structures listed on the National Register of Historic Places or the State Inventory of Historic Places, without regard to the procedures set forth in the remainder of this ordinance.

f. Variances may be issued for new construction and substantial improvements to be erected on a lot of one-half acre or less in size contiguous to and surrounded by lots with existing structures constructed below the base flood level, providing the relevant factors in 3.11.03 (4) (b) (i) have been fully considered. As the lot size increases beyond the one-half acre, the technical justification required for issuing the variance increases.

g. Upon consideration of the factors noted above and the intent of this ordinance, the Appeal Board may attach such conditions to the granting of variances as it deems necessary to further the purpose and objectives of this ordinance (3.11.01 (3)).

h. Variances shall not be issued within any designated floodway if any increase in flood levels during the base flood discharge would result.

i. Variances may be issued for the repair or rehabilitation of historic structures upon a determination that the proposed repair or rehabilitation will not preclude the structure's continued designation as a historic structure and the variance is the minimum necessary to preserve the historic character and design of the structure.

j. Prerequisites for granting variances:

i. Variances shall only be issued upon a determination that the variance is the minimum necessary, considering the flood hazard, to afford relief.

ii. Variances shall only be issued upon:
- **a. showing a good and sufficient cause;**
- **b. a determination that failure to grant the variance would result in exceptional hardship to the applicant, and**
- **c. a determination that the granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, create nuisances, cause fraud on or victimization of the public, or conflict with existing local laws or ordinances.**

iii. Any application to whom a variance is granted shall be given written notice that the structure will be permitted to be built with the lowest floor elevation below the base flood elevation, and that the cost of flood insurance will be commensurate with the increased risk resulting from the reduced lowest floor elevation.

k. Variances may be issued by a community for new construction and substantial improvements and for other development necessary for the conduct of a functionally dependent use provided that:

i. the criteria outlined in 3.11.03 (7) (a-j) are met, and
ii. the structure or other development is protected by methods that minimize flood

iii. damages during the base flood and create no additional threats to public safety.

Section 3.11.04. ~~E.4.~~ Provisions for Flood Hazard Reduction

~~1~~**~~a.~~** ~~General Standards~~

~~In all areas of special flood hazards, the following standards are required:~~

~~a~~**~~i.~~** ~~Anchoring~~

~~i.~~**~~a.~~**~~All new construction and substantial improvements shall be anchored to prevent flotation, collapse, or lateral movement of the structure and capable of resisting the hydrostatic and hydrodynamic loads.~~

~~ii.~~**~~b.~~**~~All manufactured homes must be elevated and anchored to resist flotation, collapse or lateral movement and capable of resisting the hydrostatic and hydrodynamic loads. Methods of anchoring may include, but are not limited to use of over-the-top or frame ties to ground anchors. This requirement is in addition to applicable State and local anchoring requirements for resisting wind forces. Specific requirements may be:~~

~~a.~~**~~1.~~**~~Over-the-top ties be provided at each of the four corners of the manufactured home, with two additional ties per side at intermediate locations, with manufactured homes less than~~ **~~fifty~~** ~~(50) feet long requiring one additional tie per side.~~

b.**2.**Frame ties be provided at each corner of the home with five additional ties per side at intermediate points, with manufactured homes less than **fifty** (50) feet long requiring four additional ties per side.

c.**3.**All components of the anchoring system be capable of carrying a force of **four thousand eight hundred** (4,800) pounds; and

d.**4.**Any additions to the manufactured home be similarly anchored.

b.**ii.** Construction Materials and Methods

i.**a.**All new construction and substantial improvements shall be constructed with materials and utility equipment resistant to flood damage.

ii.**b.**All new construction and substantial improvements shall be constructed using methods and practices that minimize flood damage.

iii.**c.**All new construction and substantial improvements shall be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding.

c.**iii.**Utilities

i.**a.**All new and replacement water supply systems shall be designed to minimize or eliminate infiltration of flood waters into the system;

ii.**b.**New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of flood waters into the systems and discharge from the systems into flood waters; and

iii.**c.**On-site waste disposal systems shall be located to avoid impairment to them or contamination from them during flooding.

d.**iv.**Subdivision Proposals

i.**a.**All subdivision proposals shall be consistent with the need to minimize flood damage;

ii.**b.**All subdivision proposals shall have public utilities and facilities such as sewer, gas, electrical, and water systems located and constructed to minimize flood damage;

iii.**c.**All subdivision proposals shall have adequate drainage provided to reduce exposure to flood damage; and

iv.**d.**Base flood elevation data shall be provided for subdivision proposals and other proposed development which contain at least **fifty** (50) lots or five (5) acres (whichever is less).

e.**v.**Encroachments

~~Encroachments, including fill, new construction, substantial improvements, and other development shall be prohibited in any **floodplain or** floodway unless a technical evaluation demonstrates that the encroachments will not result in any increase in flood levels during the occurrence of the base flood discharge.~~

~~2.**b.**Specific Standards~~

~~In all areas of special flood hazards where base flood elevation data has been provided as set forth in Section D.3.b. **3.c.ii** USE OF OTHER BASE FLOOD DATA, the following standards are required:~~
~~a.**i.** Residential Construction~~

~~New construction and substantial improvement of any residential structure shall have the lowest floor (including basement) elevated to one **(1)** foot above the flood elevation.~~

~~b.**ii.** Nonresidential Construction~~

~~New Construction and substantial improvement of any commercial, industrial or other nonresidential structure shall either have the lowest floor (including basement) elevated to one **(1)** foot above the level of the base flood elevation; or, together with attendant utility and sanitary facilities, shall:~~

~~i.**a.**Be floodproofed so that below the base flood elevation the structure is watertight with walls substantially impermeable to the passage of water;~~

~~ii.**b.**Have structural components capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy; and~~

~~iii.**c.**Be certified by a registered professional engineer or architect that the design and methods of construction are in accordance with accepted standards of practice for meeting the provisions of this paragraph. Such certifications shall be provided to the official as set forth in Section D**3. Administration.**~~

In all areas of special flood hazards the following provisions are required for all new construction and substantial improvements:

a. **All new construction or substantial improvements shall be designed (or modified) and adequately anchored to prevent flotation, collapse or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy;**

b. **All new construction or substantial improvements shall be constructed by methods and practices that minimize flood damage;**

c. **All new construction or substantial improvements shall be constructed with materials resistant to flood damage;**

d. **All new construction or substantial improvements shall be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located so as to prevent water**

from entering or accumulating within the components during conditions of flooding.

e. All new and replacement water supply systems shall be designed to minimize or eliminate infiltration of flood waters into the system;

f. New and replacement sanitary sewage systems shall be designed to minimize or eliminate infiltration of flood waters into the system and discharge from the systems into flood waters; and,

g. On-site waste disposal systems shall be located to avoid impairment to them or contamination from them during flooding.

1. Specific Standards

a. In all areas of special flood hazards where base flood elevation data has been provided as set forth in (i) 3.11.02 (2), (ii) 3.11.03 (3) (b), or 3.11.04 (3) (c), the following provisions are required:

b. Residential Construction -new construction and substantial improvement of any residential structure shall have the lowest floor (including basement), elevated to or above the base flood elevation. A registered professional engineer, architect, or land surveyor shall submit a certification to the Floodplain Administrator that the standard of this subsection as proposed in 3.11.03 (4) (a), is satisfied.

c. Nonresidential Construction - new construction and substantial improvements of any commercial, industrial or other nonresidential structure shall either have the lowest floor (including basement) elevated to or above the base flood level or together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. A registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify that the design and methods of construction are in accordance with accepted standards of practice as outlined in this subsection. A record of such certification which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained by the Floodplain Administrator.

d. Enclosures - new construction and substantial improvements, with fully enclosed areas below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are subject to flooding shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria:
   i. A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding shall be provided.
   ii. The bottom of all openings shall be no higher than one foot above grade.

iii. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.

e. Manufactured Homes

i. Require that all manufactured homes to be placed within Zone A on a community's FHBM or FIRM shall be installed using methods and practices which minimize flood damage. For the purposes of this requirement, manufactured homes must be elevated and anchored to resist flotation, collapse, or lateral movement. Methods of anchoring may include, but are not limited to, use of over-the-top or frame ties to ground anchors. This requirement is in addition to applicable State and local anchoring requirements for resisting wind forces.

ii. Require that manufactured homes that are placed or substantially improved within Zones A1-30, AH, and AE on the community's FIRM on sites

a. outside of a manufactured home park or subdivision,
b. in a new manufactured home park or subdivision,
c. in an expansion to an existing manufactured home park or subdivision, or
d. in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as a result of a flood, be elevated on a permanent foundation such that the lowest floor of the manufactured home is elevated to or above the base flood elevation and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

iii. Require that manufactured homes be placed or substantially improved on sites in an existing manufactured home park or subdivision with Zones A1-30, AH and AE on the community's FIRM that are not subject to the provisions of paragraph (4) of this section be elevated so that either:

a. the lowest floor of the manufactured home is at or above the base flood elevation, or
b. the manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than 36 inches in height above grade and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

f. Recreational Vehicles - Require that recreational vehicles placed on sites within Zones A1-30, AH, and AE on the community's FIRM either:

i. be on the site for fewer than 180 consecutive days,
ii. be fully licensed and ready for highway use, or
iii. meet the permit requirements of 3.11.03 (4) (a), and the elevation and anchoring requirements for "manufactured homes" in this section. A recreational vehicle is ready for highway use if it is on its wheels or jacking system, is attached to the site only by quick disconnect type utilities and security devices, and has no permanently attached additions.

3. Standards for Subdivision Proposals

a. All subdivision proposals including the placement of manufactured home parks and subdivisions shall be consistent with 3.11.01 (2), (3), and (4) of this ordinance.
b. All proposals for the development of subdivisions including the placement of manufactured home parks and subdivisions shall meet Development Permit requirements of 3.11.03 (1), 3.11.03 (3); and the provisions of 3.11.04 of this ordinance.
c. Base flood elevation data shall be generated for subdivision proposals and other proposed development including the placement of manufactured home parks and subdivisions which is greater than 50 lots or 5 acres, whichever is lesser, if not otherwise provided pursuant to 3.11.02 (2) or 3.11.03 (3) (b) of this ordinance.
d. All subdivision proposals including the placement of manufactured home parks and subdivisions shall have adequate drainage provided to reduce exposure to flood hazards.
e. All subdivision proposals including the placement of manufactured home parks and subdivisions shall have public utilities and facilities such as sewer, gas, electrical and water systems located and constructed to minimize or eliminate flood damage.

4. Standards for Areas of Shallow Flooding (AO/AH Zones)

Located within the areas of special flood hazard established 3.11.02 (2) are areas designated as shallow flooding. These areas have special flood hazards associated with base flood depths of 1 to 3 feet where a clearly defined channel does not exist and where the path of flooding is unpredictable and where velocity flow may be evident. Such flooding is characterized by ponding or sheet flow; therefore, the following provisions apply:

a. All new construction and substantial improvements of residential structures have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified).

b. All new construction and substantial improvements of non-residential structures;
   i. have the lowest floor (including basement) elevated above the highest adjacent grade at least as high as the depth number specified in feet on the community's FIRM (at least two feet if no depth number is specified), or;
   ii. together with attendant utility and sanitary facilities be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads of effects of buoyancy.

c. A registered professional engineer or architect shall submit a certification to the Floodplain Administrator that the standards of this Section, as proposed in 3.11.03 (4) (a), are satisfied.

d. Require within Zones AH or AO adequate drainage paths around structures on slopes, to guide flood waters around and away from proposed structures.

5. Floodways

Floodways - located within areas of special flood hazard established in 3.11.02 (2), are areas designated as floodways. Since the floodway is an extremely hazardous area due to the velocity of flood waters which carry debris, potential projectiles and erosion potential, the following provisions shall apply:

a. **Encroachments are prohibited, including fill, new construction, substantial improvements and other development within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge.**

b. **If 3.11.04 (5) (a) above is satisfied, all new construction and substantial improvements shall comply with all applicable flood hazard reduction provisions of 3.11.04**

c. **Under the provisions of 44 CFR Chapter 1, Section 65.12, of the National Flood Insurance Regulations, a community may permit encroachments within the adopted regulatory floodway that would result in an increase in base flood elevations, provided that the community first applies for a conditional FIRM and floodway revision through FEMA.**

CHAPTER ~~4.10~~ 3.12 "AP" AQUIFER PROTECTION OVERLAY DISTRICT.

Section 3.12.01. Purpose and Intent.

The Codington County Planning Commission and Board of County Commissioners recognize (1) that residents of Codington County rely on ground water for a safe drinking water supply and (2) that certain land uses in Codington County can contaminate ground water particularly in shallow aquifers.

The purpose of the Aquifer Protection Overlay District is to protect public health and safety by minimizing contamination of the shallow aquifers of Codington County.

It is the intent to accomplish aquifer protection, as much as possible, by public education and securing public cooperation. Appropriate land use regulations will be imposed, however, which are in addition to those imposed in the underlying zoning districts or in other county regulations.

Section 3.12.02. Establishment/Delineation/Regulation of Aquifer Protection Overlay Zones.

Boundaries for the aquifer protection zones for the Aquifer Protection Overlay District are shown on the Official Zoning map~~s~~ **based upon data** prepared by Banner Associates, Brookings, South Dakota. ~~Said maps are hereby adopted by reference as part of these regulations as if the maps were fully described herein~~. **In addition to the Official Zoning Map, the South Dakota Department of Environment and Natural Resources, Division of Financial and Technical Assistance, Geological Survey created a map entitled First Occurrence of Aquifer Materials Map" dated February 13, 2003. This map will be used to further identify aquifer boundaries. In the event of a conflict between such maps as to the area covered by the aquifer at a given location, then the map showing the larger aquifer area shall be followed.**

The Aquifer Protection Overlay District is divided into three zones. The zone of contribution for Zones A and B was mapped by Banner Associates using techniques outlined in the U.S. Environmental Protection Agency publication "Guidelines for Delineation of Wellhead Protection Areas", June, 2000. The shallow/surficial aquifer boundary for Zone C was mapped by the South Dakota Geological Survey.

Section 3.12.03. Zone A – Aquifer Critical Impact Zones.

Zone A, the wellhead protection area, is the mapped zone of contribution around all public water supply wells or wellfields in shallow/surficial aquifers and includes land upgradient from the well or wellfield to the five (5) year time of travel boundary plus any delineated adjacent lands not underlain by the aquifer with sufficient slope that contaminated surface water could flow directly onto Zone A.

Section 3.12.03.01. Permitted Uses in Zone A:

The following uses are permitted provided they meet appropriate performance standards outlined for aquifer protection overlay zones:

1. Agriculture, excluding all classes of new Concentrated Animal Feeding Operations.

2. Horticulture.

3. Parks, greenways or publicly owned recreational areas.
4. Necessary public utilities/facilities designed so as to prevent contamination of groundwater.

5. All uses permitted in the underlying district which do not pose a potential risk to groundwater resources and are not a prohibited use.

Section 3.12.03.02. ~~Special Exception~~ Conditional Use in Zone A.

The following uses are permitted only under the terms of a ~~Special Exception~~ **Conditional Use Permit** and must conform to provisions of the underlying zoning district and meet Performance Standards outlined for Aquifer Protection Overlay Zones.

1. Expansion, **modification, alteration, or relocation** of existing **permitted or conditional** uses to the extent they remain or become nonconforming and to the extent allowed by the underlying district. The Board of Adjustment shall not grant approval unless it finds the proposed expansion does not pose greater potential for groundwater contamination than the existing use.

2. ~~All uses not permitted or not prohibited in Zone A may be approved by the Board of Adjustment provided they can meet Performance Standards outlined for the Aquifer Protection Overlay Zones.~~ **Expansion of existing Concentrated Animal Feeding Operations (Existing as of June 30, 1997) not to exceed a cumulative total of three hundred (300) animal units.**

3. All uses permitted by conditional use in the underlying district which do not pose a potential risk to groundwater resources and are not a prohibited use.

Section 3.12.03.03. Prohibited Uses in Zone A.

The following uses are expressly prohibited in Zone A:

1. PR Planned Residential District.

2. New concentrated animal feeding operations of all classes **after July 31, 2001.**

3. Disposal of solid waste except spreading of manure.

4. Outside unenclosed storage of road salt.

5. Disposal of snow containing de-icing chemicals.

6. Processing and storage of PCB contaminated oil.

7. Car washes.

8. Auto service, repair or painting facilities and junk or salvage yards.

9. Disposal of radioactive waste.

10. Graveyards or animal burial sites.

11. Detonation sites, except blasting of rock for farming purposes.
12. Open burning except ditches, fields and non-hazardous yard and household wastes such as paper, wood and leaves.

13. Public sewer systems and wastewater lagoons.

14. Fall application of nitrogen fertilizer except spreading of manure.

15. Land spreading of petroleum contaminated soil.

16. Land spreading or dumping of waste oil.

17. Industrial process water and waste disposal wells--5W20 type Class V injection wells.

18. Automobile service station disposal wells--5X28 type Class V injection wells.

19. All other facilities, **not existing at the time of the adoption of this chapter**, involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste having a potentially harmful impact on groundwater quality.

~~20. New Concentrated Animal Feeding Operations after the adoption of these regulations.~~

~~21.~~**20.** Expansion of existing Concentrated Animal Feeding Operations **(Existing as of June 30, 1997)** beyond a **cumulative** total of **three hundred** (300) animal units.

~~22.~~**21.** Earthen storage basins and lagoons.

~~23.~~**22**. Stockpiling of solid waste.

Section 3.12.04. Zone B - Aquifer Secondary Impact Zones

Zone B, the secondary wellhead protection area, is the mapped zone of contribution around all public water supply wells or wellfields in shallow/surficial aquifers and includes land upgradient from the well or wellfield in the five (5) to ten (10) year time of travel boundary plus any delineated adjacent lands not underlain by the aquifer with sufficient slope that contaminated surface water could flow directly onto Zone B.

Section 3.12.04.01. Permitted Uses in Zone B.

The following uses are permitted provided they meet appropriate performance standards outlined for aquifer protection overlay zones:

1. Agriculture, excluding all new Concentrated Animal Feeding Operations ~~which require a special exception permit (New Class 4, and the expansion of existing Class 4 to Class 3).~~

2. Horticulture.

3. Parks, greenways or publicly owned recreational areas.

4. Necessary public utilities/facilities designed so as to prevent contamination of groundwater.

5. All uses permitted in the underlying district which do not pose a potential risk to groundwater resources and are not a prohibited use.

Section 3.12.04.02. ~~Special Exception~~ Conditional Uses in Zone B:

The following uses are permitted only under the terms of a ~~Special Exception~~ **Conditional Use Permit** and must conform to provisions of the underlying zoning district and meet Performance Standards outlined for Aquifer Protection Overlay Zones.

1. Expansion, **modification, alteration, or relocation** of existing **permitted or conditional** uses to the extent they remain or become nonconforming and to the extent allowed by the underlying district. The Board of Adjustment shall not grant approval unless it finds the proposed expansion does not pose greater potential for groundwater contamination than the existing use.

2. ~~New Class 4 and expansion of existing Class 4 up to 999 animal units (Class 3). The County shall require soil borings to determine impermeable material between land surface and the aquifer~~ **Expansion of existing Concentrated Animal Feeding Operations (Existing as of June 30, 1997) not to exceed cumulative total of three hundred (300) animal units.**

3. ~~All other facilities involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste having a potentially harmful impact on groundwater quality~~**All uses permitted by conditional use in the underlying district which do not pose a potential risk to groundwater resources and are not a prohibited use**.

4. Earthen storage basins and lagoons.

5. Stockpiling of solid waste.

6. ~~All uses not permitted by Special Exception or prohibited in Zone B~~ **All uses permitted by conditional use in the underlying district which do not pose a potential risk to groundwater resources and are not a prohibited use** may be approved by the Board of Adjustment provided they can meet Performance Standards outlined for the Aquifer Protection Overlay Zones.

Section 3.12.04.03. Prohibited Uses in Zone B.

The following uses are expressly prohibited in Zone B:

1. PR Planned Residential District.

2. New concentrated ~~Class 1, 2, and 3~~ animal feeding operations of all classes **after June 30, 1997**.

3. Disposal of solid waste except spreading of manure.

4. Outside unenclosed storage of road salt.

5. Disposal of snow containing de-icing chemicals;

6. Processing and storage of PCB contaminated oil;

7. Car washes.

8. Auto service, repair or painting facilities and junk or salvage yards.

9. Disposal of radioactive waste.

10. Graveyards or animal burial sites.

11. Detonation sites, except blasting of rock for farming purposes.

12. Open burning except ditches, fields and non-hazardous yard and household wastes such as paper, wood and leaves.

13. Public sewer systems and wastewater lagoons.

14. Fall application of nitrogen fertilizer except spreading of manure.

15. Land spreading of petroleum contaminated soil.

16. Land spreading or dumping of waste oil.

17. Industrial process water and waste disposal wells--5W20 type Class V injection wells.

18. Automobile service station disposal wells--5X28 type Class V injection wells.

19. ~~New Class 4 or expansions existing Class 4 to Class 3 CAFO's which cannot meet performance standards.~~ **Expansion of existing Concentrated Animal Feeding Operations (Existing as of June 30, 1997) beyond a cumulative total of three hundred (300) animal units.**

20. All other facilities, not existing at the time of the adoption of this chapter, involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste having a potentially harmful impact on groundwater quality.

Section 3.12.05. Zone C -- Aquifer Tertiary Impact Zones.

Zone C is the remainder of the mapped shallow/surficial aquifer in the County not included in Zone A or Zone B. Zone C is being protected because (1) the aquifer is a valuable natural resource for future development, (2) the aquifer provides drinking water supply for individual domestic users, (3) contamination is not justified just because this area is not currently used for public water supply, and (4) contaminants from this area could eventually enter Zone A or Zone B.

Section 3.12.05.01 Permitted Uses in Zone C.

1. All uses permitted in the underlying zoning districts, with the exception of those prohibited, provided that they can meet the Performance Standards as outlined for the Aquifer Protection Overlay Zones.

Section 3.12.05.02 ~~Special Exception~~ Conditional Use in Zone C.

1. All ~~Special Exception~~ **Conditional Use** allowed in underlying districts, with the exception of those prohibited, may be approved by the Board of Adjustment provided they can meet Performance Standards outlined for the Aquifer Protection Overlay Zones.

2. New Class 4 and expansion of existing Class 4 up to **nine hundred ninety-nine** (999) animal units (Class 3). The County shall require soil borings to determine impermeable material between land surface and the aquifer.

3. Earthen storage basins and lagoons.

Section 3.12.05.03 Prohibited Uses in Zone C.

The following uses are expressly prohibited in Zone C:

1. Fall application of nitrogen fertilizer on lands before October 20th.

2. Land spreading of petroleum contaminated soil.

3. Land spreading or dumping of waste oil.

4. Automobile service station disposal wells--5X28 type Class V injection wells.

5. New Concentrated Animal Feeding Operations of Class 1, Class 2, and Class 3 or expansions **of existing Class 4 concentrated animal feeding operations** which cannot meet performance standards.

Section 3.12.06 Performance Standards for Aquifer Protection Overlay Zones.

The following standards shall apply to land uses in Zones A, B, and C of the Aquifer Protection Overlay Districts:

1. New or replacement septic tanks and associated drain fields for containment of human or animal wastes must conform with regulations established by the South Dakota Department of Environment and Natural Resources.

2. Open liquid waste ponds containing any solid or liquid material or waste will not be permitted without a secondary containment system except for community wastewater lagoons.

3. Storage of petroleum products in quantities exceeding one hundred (100) gallons at one (1) locality in one (1) tank or series of tanks must be in elevated tanks; such tanks larger than eleven hundred (1,100) gallons must have a secondary containment system where it is deemed necessary by the ~~County Zoning Office~~ **Board of Adjustment**.

4. Any commercial or industrial facility, not addressed by #2 or #3 above, involving the collection, handling, manufacture, use, storage, transfer or disposal of any solid or liquid material or waste, except for spreading of manure, in excess of **one thousand** (1,000) pounds and/or **one hundred** (100) gallons which has the potential to contaminate groundwater must have a secondary containment system which is easily inspected and whose purpose is to intercept any leak or discharge from the primary containment vessel or

structure. Underground tanks or buried pipes carrying such materials must have double walls and accessible sumps.

5. Discharge of industrial processed water on site is prohibited without ~~County Zoning Office~~ **Board of Adjustment** approval.

6. Commercial auto service, repair or painting facilities and junk or salvage yards shall meet all State and Federal standards for storage, handling and disposal of all other potentially hazardous waste materials.

7. Any facility involving collection, handling, manufacture, use, storage, transfer or disposal of hazardous materials must prepare and have on file in the County Zoning Office an acceptable contingency plan for preventing hazardous materials from contaminating the shallow/surficial aquifer should floods, fire, other natural catastrophes or equipment failure occur:

   a. For flood control, all underground facilities shall include a monitoring system and a secondary standpipe above the **one hundred** (100)-year frequency flood level. For above ground facilities, an impervious dike, above the **one hundred** (100)-year year flood level and capable of containing **one hundred twenty** percent (120%) of the largest storage volume, will be provided with an overflow recovery catchment area (sump).

   b. For fire control, plans shall include but not be limited to a safe fire fighting procedure, a fire retardant system and provision for dealing safely with both health and technical hazards that may be encountered by disaster control personnel in combating fire. Hazards to be considered are overhead and buried electrical lines, pipes, other buried objects and other hazardous liquids, chemicals or open flames in the immediate vicinity.

   c. For equipment failures, plans shall include but not be limited to:

      i. Below ground level, provision for removal and replacement of leaking parts, a leak detection system with monitoring and an overfill protection system.

      ii. Above ground level, provisions for monitoring, replacement, repair and cleanup of primary containment systems

   d. For other natural or man-caused disasters, the owner and/or operator shall report all incidents involving liquid or chemical material which may endanger health and/or safety of disaster personnel and/or the general public.

   e. Agricultural operations are exempted from performance standard #7 unless chemicals are stored which are on the Superfund Amendments and Reauthorization Act of 1986 (SARA Title III) extremely hazardous substance list in the quantities exceeding the threshold planning quantity at any one time.

   d. The County Zoning Office and DENR shall be informed within **twenty-four** (24) hours of all leaks and spills of materials that might potentially contaminate groundwater.

8. Since it is known that improperly abandoned wells can become a direct conduit for contamination of groundwater by surface water, all abandoned wells should be plugged in conformance with South Dakota Well Construction Standards, Chapter 74:02:04:67-70.

Section 3.12.07 Grant of Permit, Alteration of Use.

Before a permit is granted, the County Zoning Officer must examine an application and determine that the proposed use, activity or development meets the provisions of this ordinance.

When securing a use permit, the owner/developer agrees to make future improvements which may become necessary to prevent contamination of shallow/surficial aquifers and the owner/developer must allow County personnel to inspect any improvements to verify they meet the performance standards.

Whenever any person has an existing use, activity or development and thereafter desires alteration or expansion of the authorized use, such persons shall apply for a permit. The owner may appeal a County Zoning Officer's decision to modify or deny a requested permit to the ~~County~~ Board of Adjustment.

Any lawful use in existence on the effective date of this ordinance shall be permitted to continue provided it can be shown such use does not threaten public health and safety by potential contamination of water in the shallow/surficial aquifer.

Section 3.12.07.01. Exceptions.

1. Storage of liquids, chemicals and fertilizers used in agricultural operations during planting and crop cultivation are exempt from the requirements of this ordinance March 1 to October 1. However, Best Management Practices are encouraged, particularly in Zone A and Zone B.

2. Tanks used for chemigation are exempt from secondary containment regulations but secondary containment is encouraged.

3. Storage of liquid or dry fertilizer in amounts equal to or less than **one thousand** (1,000) pounds or **one hundred** (100) gallons, stored indoors by each farm operator is exempt from the requirements of this ordinance.

Section 3.12.08. Limitation Of County Liability.

Nothing in this ordinance shall be construed to imply that Codington County, by issuing a permit, has accepted any of an owner's/developer's liability if a permitted development contaminates water in shallow/surficial aquifers.

Section 3.12.09. Underlying Zones.

Underlying zoning restrictions apply along with restrictions set forth in the Aquifer Protection Overlay District.

Section 3.12.10. Saving Clause.

Should any section or provision of this ordinance be declared invalid, such decision shall not affect the validity of the ordinance as a whole or any other part thereof.

CHAPTER 3.13. "RR" RURAL RESIDENTIAL DISTRICT.

Section 3.13.01 Purpose

The purpose of this district is to protect a vigorous agricultural industry by limiting the areas in which the "RR" Rural Residential District can be used. The "RR" Rural Residential District is intended to allow the continuation of residential uses which developed with residential density of four or more residences per quarter-quarter section prior to October 22, 2012. The "RR" Rural Residential District is a closed zoning district, therefore the existing platted/legally described lots shall not be subdivided unless and until said property is annexed into the corporate limits of a municipality or appropriately zoned for the proposed subdivision.

Section 3.13.02. Permitted Uses.

1. Site-built single-family non-farm dwelling, including modular homes, and Type A manufactured homes.
2. Public building
3. Farm buildings.
4. Public park and recreation areas.
5. Field crops and grasslands.
6. Orchards, tree farms, botanical gardens (nurseries and greenhouses) – without retail sales.
7. Animal Units on Small Acreages. (See Chapter 5.09)
8. Type 5 Concentrated Animal Feeding Operations (See Chapter 5.21)

Section 3.13.03 Permitted Accessory Uses

The following accessory uses and structures shall be permitted in the "RR" Rural Residential District:

1. Accessory uses and structures customarily incidental to permitted uses and structures when established within the space limit of this district.
2. Home occupation.
3. On-premise signs.

Section 3.13.04. Conditional Uses.

1. Private Wind Energy Conversion Systems. (See Chapter 5.31)

2. Kennels.

3. Religious Institutions and Cemeteries.

4. Assisted living facility

5. Group home

6. Public utility facility

7. Public utility and public service structure including transmission lines, substations, gas regulator stations, pipelines, community equipment buildings, pumping stations, and reservoirs.

8. Bed and breakfast.

9. Wireless Telecommunications Towers and Facilities.

10. Extended home occupation (See Section 5.12).

11. Type B manufactured home

Section 3.13.05 Area Regulations/Easement/Waivers

Minimum lot area, maximum building height, maximum lot coverage and minimum yard requirements shall be regulated in accordance with the following tables:

1.

[redacted]	Minimum Lot Area	Maximum Lot Coverage	Maximum Height (A)	Minimum Lot Width
Permitted Uses (lots less than 35 acres on October 22, 2012)	No minimum (B)(C)(D)	25%	35'	125'
Permitted Uses (lots greater than 35 acres on October 22, 2012)	35 Acres	25%	35'	125'
Other Conditional Uses	To be determined by the Board of Adjustment			

A. *[Exception to maximum height]* The administrative official may allow heights to exceed thirty-five (35) feet for the following:

i. Agricultural buildings.
ii. Water tanks.
iii. Private Wind Energy Conversion Systems (PWECS).
iv. Wireless Telecommunications Towers and Facilities.
v. Others as determined b the Board of Adjustment.

B. No lot shall be decreased in size after October 22, 2012.

C. Any lot created prior to October 26, 1976 shall be considered a single lot, regardless of ownership, for the purposes of this ordinance.

D. Any lot created after October 26, 1976, with less than thirty-five (35) acres as of October 22, 2012 in single ownership with a contiguous lot, shall be considered to be an undivided parcel for the purposes of this ordinance, and no portion of said parcel shall be used or sold in a manner which diminishes compliance with lot width and area requirements established by this ordinance, nor shall any division of any parcel be made which creates a lot with width or area below the total area of the two or more lots on October 22, 2012.

2.

[redacted]	Minimum Front Yard	Minimum Rear Yard	Minimum Side Yard	Minimum Side or Rear Yard Adjacent to A – Agricultural Zoning District
Permitted Uses (A)(B)	50'	25'	15'	25'
Conditional Uses	To be determined by the Board of Adjustment			

A. *[Exception to Setbacks for Nonconforming Structures]*

i. Existing nonconforming residential structures, constructed prior to (Date of Adoption) are eligible to be expanded or added onto, without Board of Adjustment Approval, as long as the existing front, side or rear yard setback(s) is not further encroached upon.

ii.

B. *[Increased Front Yard Setback on Arterial and Township/Section line roads]*

i. The front yard setback on all arterial streets or township maintained section line roads shall be sixty-five (65) feet.

C. Any accessory uses shall be required to comply with the height, front, rear and side yard requirements of the principal building.

3. Agriculture Easement/Waiver:

a. All new residential development (farm and non-farm) shall be required to file an "Agricultural Easement" with the Register of Deeds before the issuance of a building permit. (See Chapter 5.27)

b. Applicants for residential development (farm and non-farm) are required to obtain a written waiver from the owner/operator of any existing concentrated animal feeding operation which is closer than one-half (1/2) mile from the proposed residential building site. If the applicant is unable to obtain the written waiver, he/she shall be required to file a waiver with the Register of Deeds waiving any or all common law challenges to future expansions of the said existing concentrated

animal feeding operation. The waiver is to be filed with the Register of Deeds. (See Chapter 5.29)

4. Access

a. The drive-way serving the parcel shall be separated from adjacent driveways on the same side of the road by the following distances depending upon road types:

v. Local road: 100 feet.

vi. Collector road: 300 feet.

vii. Arterial road: 500 feet.

viii. Minimum distance from intersection of two (2) or more of the above: 100 feet.

b. For all proposed uses and structures adjacent to a State highway, an access permit from the State of South Dakota Department of Transportation shall be required prior to the filing of a plat or the issuance of a building/use permit

ARTICLE IV
ADMINISTRATION

CHAPTER 4.01. GENERAL.

Section 4.01.01. Permits Required.

1. No building or other structure shall be erected, moved, added to, or structurally altered without a permit issued by the Zoning Officer. The Zoning Officer except in conformity with the provisions of this ordinance shall issue no permit, unless he received a written order from the Board of Adjustment in the form of an administrative review, under conditional use, or variance as provided by this ordinance.

2. It shall be unlawful to commence the excavation for the construction of any building or any accessory building without a permit. A permit is also required for any filling, grading, lagooning, or dredging which is related to site preparation for future construction.

Section 4.01.02. Applications.

1. All applications for permits shall be accompanied by a site plan drawn to scale, showing the actual dimensions and shape of the lot to be built upon; the exact sizes and locations on the lot of the buildings already existing, if any; and the location and dimensions of the proposed building or alteration. The application shall include such other information as lawfully may be required by the Zoning Officer, including legal description, existing or proposed buildings or alterations; existing or proposed uses of the building and land; the number of families, housekeeping units, or rental units the building is designed to accommodate; conditions existing on the lot; existing or proposed water, sewer, electrical facilities; and such other matters as may be necessary to determine conformity with, and provide for the enforcement of, this ordinance. Such plans and data accompanying the permit shall be final and conclusive. Deviations shall be deemed a violation of this Ordinance, and punishable as provided in 1.02.03.

Section 4.01.03. Building/Use Permit.

1. Issuance of a Building/Use Permit. If the proposed excavation or construction as set forth in the application are in conformity with the provisions of this Ordinance, and other regulations of the County then in force, the Zoning Officer shall issue a building/use permit for such excavation or construction. If a building/use permit is refused, the Zoning Officer shall provide the applicant notice, verbally or by mail, of such refusal with the cause for denial. The Zoning Officer shall grant or deny the permit within a reasonable time from the date the application is submitted.

2. The issuance of a building/use permit shall, in no case, be construed as waiving any provisions of this Ordinance. If the work described in any building permit has not been substantially completed within six (6) months of the date of issuance thereof, said permit shall expire and be cancelled by the Zoning Officer and written notice thereof shall be given to the persons affected, together with notice that further work as described in the canceled permit shall not proceed unless and until a new building/use permit has been issued. If substantial progress has been made within

six (6) months from the issuance of the permit but has not been completed, the Zoning Officer may extend the building/use permit and additional six (6) months.

Section 4.01.04. Permits Displayed.

1. Permits Displayed. It shall be unlawful to commence work until the building permit is displayed in a conspicuous place visible from public right-of-way. The permit shall be placed upon the premises at all times from the beginning until the completion of such construction, alteration, repair, occupancy or change of use.

Section 4.01.05. Fees.

1. The Board of County Commissioners shall, by resolution, establish a schedule of fees, charges, and expenses and a collection procedure for building permits, certificates of zoning compliance, appeals, and other matters pertaining to this Ordinance, The schedule of fees shall be posted in the office of the Zoning Officer and may be altered or amended only by the Board of County Commissioners.

2. Until all applicable fees, charges, and expenses have been paid in full, no action shall be taken on any application or appeal.

CHAPTER 4.02. ZONING OFFICER.

Section 4.02.01. Zoning Officer.

1. The provisions of this Ordinance shall be administered and enforced by a County Zoning Officer appointed by the Board of County Commissioners, who shall have the power to make inspection of buildings or premises necessary to carry out his duties in the enforcement of this Ordinance.

Section 4.02.02. Duties.

The powers and duties of the Zoning Officer shall be as follows:

1. Issue all building/use permits and make and maintain records thereof.

2. Conduct inspections of buildings, structures, and the use of land to determine compliance with this Ordinance.

3. Notify in writing persons responsible for violations, indicating the nature of the violation and ordering action necessary to correct.

4. Order discontinuance of illegal use of land, buildings, or structures; removal of illegal buildings or structures or of illegal additions; alterations or structural changes; discontinuance of any illegal work being done; or shall take any other action authorized by this Ordinance to ensure compliance with or to prevent violation of its provisions.

5. Revoke any permit, which was unlawfully issued, or any permit wherein defective work has been performed, and when such work has not been corrected within ninety (90) days of notification.

6. Maintain permanent and current records of this regulation, including, but not limited to, all maps, amendments, variances, appeals, and applications.

7. Prepare documents, easements, letters of assurance, waivers, etc. as required by this Ordinance, or at the direction of the Codington County Planning Commission and/or the Codington County Board of Adjustment and/or Codington County Commissioners.

8. Provide public information relative to all matters arising out of this Ordinance.

9. Forward to the Planning Commission all plats and/or applications for amendments to this Ordinance.

10. Forward to the Board of Adjustment, applications for appeals, conditional uses, variances, or other matters on which the Board of Adjustment is required to pass under this ordinance.

11. Initiate, direct, and review, from time to time, a study of the provisions of this ordinance, and to make such reports available to the Planning Commission.

12. The Zoning Officer shall receive applications required under this ordinance, specifically but not limited to Building Permits, Conditional Uses, Variances, and Zoning Amendments.

    a. For building permits, the Zoning Officer shall approve the application only in accordance with the provisions of the County's Zoning Ordinance.

    b. For Conditional Uses and Variances, the Zoning Officer shall review the application, and shall make recommendations regarding said application to the Board of Adjustment.

    c. For Zoning Amendments, the Zoning Officer shall review the application, and shall make recommendations regarding said application to the Planning Commission and Board of County Commissioners.

Section 4.02.03. Right of Entry.

Whenever necessary to make an inspection to enforce any of the provisions of this regulation, or whenever the Zoning Officer or an authorized representative has reasonable cause to believe that there exists in any building or upon any premises a regulation violation, the Zoning Officer or an authorized representative may enter such building or premises at all reasonable times to inspect the same or to perform any duty imposed upon the Zoning Officer by this ordinance, provided that if such building or premises be occupied, they shall first present proper credentials and request entry; and if such building or premises be unoccupied, they shall first make a reasonable effort to locate the owner or other persons having charge or control of the building or premises and request entry. If such entry is refused, the Zoning Officer or an authorized representative shall have recourse to every remedy provided by law to secure entry.

When the Zoning Officer or an authorized representative shall have first obtained a proper inspection warrant or other remedy provided by law to secure entry, no owner or occupant or any other persons having charge, care or control of any building or

premises shall fail or neglect, after proper request is made as herein provided, to promptly permit entry therein by the Zoning Officer or an authorized representative for the purpose of inspection and examination pursuant to this regulation.

Section 4.02.04. Stop Order

Whenever any work is being done contrary to the provisions of this ordinance, the Zoning Officer may order the work stopped by notice in writing served on any persons engaged in the doing or causing such work to be done, and any such persons shall forthwith stop such work until authorized by the Zoning Officer to proceed with the work.

Section 4.02.05. Occupancy Violation.

Whenever any building or structure regulated by this ordinance is being used contrary to the provisions of this ordinance, the Zoning Officer may order such use discontinued and the structure, or portion thereof, vacated by notice served on any person causing such use to be continued. Such persons shall discontinue the use within the time prescribed after receipt of such notice to make the structure, or portion thereof, comply with the requirements of this ordinance.

CHAPTER 4.03. PLANNING COMMISSION.

Section 4.03.01. Establishment.

1. The Board of County Commissioners shall appoint a Planning Commission of seven (7) members, at least one (1) member of which shall be a member of the Board of County Commissioners.

Section 4.03.02. Term of Office.

1. The term of each of the appointed members of the County Planning Commission shall be for four (4) years. The terms shall be varied so no more than one-third of terms shall expire in the same year. Any appointed member of the county Planning Commission may be removed for cause, after hearing prior to the expiration of the term by a majority vote of the elected members of the Board of County Commissioners. Zoning Officers of the County may be appointed as ex-officio members of the Commission.

Section 4.03.03. Meetings of the Planning Commission

1. The Planning Commission shall meet at such times as may be necessary to accomplish the purposes of their duties, but in no event shall they meet less than once every three (3) months.

Section 4.03.04. PerDiem and Expenses of Commission

1. Per diem and expenses of the County Planning Commission shall be established by the Board of County Commissioners and paid by the County.

CHAPTER 4.04. BOARD OF ADJUSTMENT.

Section 4.04.01 Establishment

Within Codington County outside of incorporated municipalities, the power and jurisdiction related to this article shall be executed by the Board of Adjustment.

1. The Board of Codington County Commissioners shall appoint the Codington County Planning Commission and two (2) alternates to act as the Board of Adjustment. If a Planning Commissioner acting as a Board of Adjustment member is unable to attend a meeting, the first alternate, or second alternate, in turn, shall serve in the member's place. Alternates may be appointed for a term of three (3) years.

Section 4.04.02. Procedures for Meetings.

1. The Board of Adjustment shall adopt rules necessary to the conduct of its affairs and in keeping with the provisions of this Ordinance. Meetings shall be held at the call of the chairman and at such other times as the Board of Adjustment may determine. The chairman, or in his absence the acting chairman, may administer oaths and compel the attendance of witnesses. All meetings shall be open to the public.

2. The Board of Adjustment shall keep minutes of its proceedings and shall keep records of its examinations and other official actions, all of which shall be immediately filed in the office of the Zoning Officer and shall be public record. The Board of Adjustment shall keep record in the minutes showing the vote of each member upon each question or if absent or failing to vote, indicating that fact.

Section 4.04.03. Powers and Duties of the Board.

1. The Board of Adjustment shall have the following powers and duties:

   a. Administrative Review. To hear and decide where it is alleged by the appellant that there is error in any order, requirement, permit decision, determination or refusal made by the Zoning Officer or other administrative officers in the carrying out or enforcement of any provision of this Ordinance, and for interpretation of the Zoning Map.

   b. Conditional Uses. To hear and decide applications for conditional uses that are specified in this Ordinance and for decisions on any special questions upon which the Board of Adjustment is specifically authorized to pass.

   c. Variance. To hear and decide applications for variance from the terms of this Ordinance because of unnecessary hardship and to authorize upon appeal in specific cases such variance from the terms of this Ordinance as which will not be contrary to the public interest where, owing to special conditions, a literal enforcement of the provisions of this Ordinance would result in unnecessary hardship.

Section 4.04.04. Power and Jurisdiction Relating to Administrative Review.

The Board of Adjustment shall have the power to hear and decide appeals where it is alleged there is error in any order, requirement, decision or determination made by an Zoning Officer or agency based on or made in the enforcement of any zoning regulation or any regulation relating to the location of structures or to interpret any map.

Section 4.04.05. Board of Adjustment has Powers of Administrative Officer on Appeals: Reversing Decision of Zoning Officer.

1. **In exercising the above-mentioned powers, the Board of Adjustment may reverse or affirm, wholly or partly, or may modify the order, requirement, decision or determination appeal from, and may make such order, requirement, decision or determination as ought to be made, and to that end shall have all the powers of the Zoning Officer from whom the appeal is taken.**

2. **The concurring vote of two-thirds (2/3) of all members of the Board of Adjustment (five (5) votes) shall be necessary to reverse any order, requirement, decision, or determination of the Zoning Officer, or to decide in favor of the applicant on any matter upon which it is required to pass under this ordinance, or to effect any variation in the application of this ordinance.**

Section 4.04.06. Appeals, Record of Appeal, Hearing and Stays

1. **It is the intent of this Ordinance that all questions of interpretation and enforcement shall be first presented to the Zoning Officer, and that such questions shall be presented to the Board of Adjustment only on appeal from the decision of the Zoning Officer.**

2. **Appeals to the Board of Adjustment may be taken by any person aggrieved or by an officer, department, board or bureau of the County affected by any decision of the zoning officer. The applicant shall file with the Zoning Officer a notice of appeal specifying the grounds thereof. The Zoning Officer shall forthwith transmit to the Board of Adjustment all papers constituting the record upon which the action appealed from was taken. Such appeal shall be taken within thirty (30) days.**

3. **An appeal stays all proceedings in furtherance of the action appealed from, unless the Zoning Officer from whom the appeal is taken certifies to the Board of Adjustment after the notice of appeal shall have been filed with him, that by reason of facts stated in the certificate a stay would, in his opinion, cause imminent peril to life or property.**

4. **In such case, proceedings shall not be stayed otherwise than by a restraining order which may be granted by the Board of Adjustment or by a court of record on application on notice to the office from whom the appeal is taken and on due cause shown.**

5. **The Board of Adjustment shall hear and decide, on not less than ten (10) days public notice prior to an affixed time and place for hearing appeals where it is alleged by the appellant that there is error in any order, requirement, permit decision, determination or refusal made by the Zoning Officer or other administrative officers in carrying out**

the enforcement of any provision of this Ordinance, and for interpretation of the Zoning Map. At the hearing, any party may appear in person or by agent or attorney.

Section 4.04.07. Duties Of Zoning Officer, Board Of County Commissioners, and Courts On Matters Of Appeal.

It is the intent of this Ordinance that all questions of interpretation and enforcement shall be first presented to the Zoning Officer, and that such questions shall be presented to the Board of Adjustment only on appeal from the decision of the Zoning Officer, and that recourse from the decision of the Board of Adjustment shall be to the courts as provided by the laws of the State of South Dakota.

Section 4.04.08. Appeals to a Court of Record.

Any person or persons, jointly or severally, aggrieved by any decision of the board of adjustment, or any taxpayer, or any officer, department, board, or bureau of the county, may present to a court of record a petition duly verified, setting forth that the decision is illegal, in whole or in part, specifying the grounds of the illegality. The petition shall be presented to the court within thirty (30) days after the filing of the decision in the office of the Board of Adjustment.

CHAPTER 4.05. PROCEDURES FOR CONDITIONAL USES, VARIANCES, AND ZONING AMENDMENTS.

Section 4.05.01. Powers and Jurisdiction Relating to Conditional Uses.

The Board of Adjustment shall have the power to hear and decide, in accordance with the provisions of this Ordinance, requests for conditional uses or for decisions upon other special questions upon which the Board of Adjustment is authorized by this Ordinance to pass; to decide such questions as are involved in determining whether special conditions and safeguards as are appropriate under this Ordinance, or to deny conditional uses when not in harmony with the purpose and intent of this Ordinance. A conditional use shall not be granted by the Board of Adjustment unless and until:

1. A written application for a conditional use is submitted, indicating the section of this Ordinance under which the conditional use is sought and stating the grounds on which it is requested.

2. The Zoning Officer shall require the applicant for a conditional use permit to notify adjacent property owners by certified or registered mail, at the cost of the applicant, of the conditional use permit or in lieu of this, at the discretion of the Zoning Officer, obtain written consent from adjacent landowners.

3. Notice of hearing shall be published once, ten (10) days prior to the Board of Adjustment public hearing, in a paper of general circulation in the area affected.

4. The public hearing shall be held. Any party may appear in person, or by agent or attorney.

5. The Board of Adjustment shall make a finding that it is empowered under the section of this Ordinance described in the application to grant the conditional use, and that the granting of the conditional use will not adversely affect the public interest.

6. Before granting any conditional use, the Board of Adjustment shall make written findings certifying compliance with the specific rules governing individual conditional uses and that satisfactory provision and arrangements have been made concerning the following, where applicable:

   a. Entrance and exit to property and proposed structures thereon with particular reference to automotive and pedestrian safety and convenience, traffic flow and control, and access in case of fire or catastrophe.

   b. Off-street parking and loading areas where required, with particular attention to the items in (a) above and the economic, noise, glare or other effects of the conditional use on adjoining properties and properties generally in the district.

   c. Utilities refuse and service areas, with reference to locations, availability, and compatibility.

   d. Screening and buffering with reference to type, dimensions and character.

   e. Signs, if any, and proposed exterior lighting with reference to glare, traffic safety, economic effect and compatibility and harmony with properties in the district.

   f. Required yards and other open space.

   g. General compatibility with adjacent properties and other property in the district.

7. In granting any conditional use, the Board of Adjustment may prescribe appropriate conditions and safeguards in conformity with this regulation. Violation of such conditions and safeguards, when made a part of the terms under which the variance is granted, shall be deemed a violation of this regulation and punishable under the terms of this regulation

8. The concurring vote of five (5) members of the Board of Adjustment is required to pass any application for a Conditional Use.

9. A conditional use permit shall expire one (1) year from the date upon which it becomes effective if no work has commenced. Upon written request to the Board of Adjustment and prior to the conditional use permit expiration date, a one (1) year time extension for the conditional use may be granted by the Board of Adjustment.

Section 4.05.02. Powers and Jurisdiction Relating to Variances.

The Board of Adjustment shall have the power, where, by reason of exception, narrowness, shallowness or shape of a specific piece of property at the time of the enactment of this Ordinance, or by reason of exceptional topographic conditions or other extraordinary and exceptional situation or condition of such piece of property, the strict application of any regulation under this Ordinance would result in peculiar and exceptional practical difficulties to, or exceptional and undue hardships upon, the owner of such property, to authorize, upon an appeal relating to the property, a variance from such strict application so as to relieve such difficulties or hardship, if such relief may be granted without substantially impairing the intent and purpose of this Ordinance. A variance shall not be granted by the Board of Adjustment unless and until:

1. A written application for a variance is submitted, indicating the section of this Ordinance under which the variance is sought and stating the grounds on which it is requested.

2. The Zoning Officer may require the applicant for a variance to notify adjacent property owners by certified or registered mail, at the expense of the applicant, of the variance request or in lieu of this, at the discretion of the Zoning Officer, obtain written consent from adjacent landowners.

3. Notice of hearing shall be published once, ten (10) days prior to the Board of Adjustment public hearing, in a paper of general circulation in the area affected.

4. The public hearing shall be held. Any party may appear in person, or by agent or attorney.

5. The Board of Adjustment shall make a finding that it is empowered under the section of this Ordinance described in the application to grant the variance, and that the granting of the variance will not adversely affect the public interest. A variance from the terms of this ordinance shall not be granted if the following occur:

   a. There are no special conditions and circumstances exist which are peculiar to the land, structure or building involved, and which are applicable to other land, structures, or buildings in the same district;

   b. The literal interpretation of the provisions of this ordinance would not deprive the applicant of rights commonly enjoyed by other properties in the same district under the terms of this ordinance;

   c. The special conditions and circumstances do result from the actions of the applicant;

   d. Financial disadvantage of the property owner shall not constitute conclusive proof of unnecessary hardship within the purposes of zoning.

   e. The granting the variance request would confer on the applicant any special privilege that is denied by this ordinance to other lands, structures, or buildings in the same district.

   f. No nonconforming use of neighboring lands, structures, or buildings in the same district, and no permitted or nonconforming use of lands, structures, or buildings in other districts shall be considered grounds for the issuance of a variance.

6. In granting any variance, the Board of Adjustment may prescribe appropriate conditions and safeguards in conformity with this regulation. Violation of such conditions and safeguards, when made a part of the terms under which the variance is granted, shall be deemed a violation of this regulation and punishable under the terms of this regulation.

7. Under no circumstances shall the Board of Adjustment grant a variance to allow a use not permissible under the terms of this regulation in the district involved, or any use expressly or by implication prohibited by the terms of this regulation in said district.

8. The concurring vote of five (5) members of the Board of Adjustment is required to pass any application for a variance.

Section 4.05.03. Zoning Amendments.

Whenever the public necessity, safety, and general welfare or good zoning practices justifies such action, and after consideration and recommendation by the Planning Commission, as provided herein, the Board of County Commissioners may change zoning district boundaries, use groups, or the regulations established by this ordinance. A proposed change of zoning district boundaries or regulations may be initiated by the Board of County Commissioners, the Planning Commission, or by application of one (1) or more of the owners of property within the area requested to be rezoned. Initiated petitions which create amendments to this ordinance are required to submit signatures of thirty (30) percent of the landowners in the zoning district or districts requesting change. Unless otherwise provided for in these regulations, any change in these regulations, shall require Board of County Commissioners approval of an ordinance describing said changes. The Board of County Commissioners may not consider said ordinance until the Planning Commission has delivered a recommendation to either approve or not approve said ordinance amendment.

The following procedure for requesting a Zoning Amendment or Zoning District Boundary Change shall be followed:

4. The landowner or other person(s) requesting the Amendment/Boundary change shall complete an application, available from the Zoning Officer. Completed applications shall be returned to the Zoning Officer for review. To be considered by the Planning Commission and Board of County Commissioners, the application form shall be completed and shall be accompanied by the following items:

   a. Any required attachments and fees, including Registered or Certified Mail.

   b. Any additional information, as requested by the Zoning Officer, as lawfully may be required to determine conformance with and provide for enforcement of this ordinance.

   c. The Zoning Officer shall review the application, and shall forward a summary of the application, and his/her comments regarding said application, to the Planning Commission for their review.

   d. The Zoning Officer shall set the date, time, and place for public hearings to be held by the Planning Commission and Board of County Commissioners. The Zoning Officer shall publish notice of the public hearing in a newspaper of general circulation in the area affected by the proposed amendment; such notice shall be published not less than ten (10) days prior to each board's (Planning and Zoning, Board of County Commissioners) public hearing. If the proposed amendment will change the boundaries of a zoning district, the Zoning Officer shall notify all owners of property within two hundred fifty (250) feet of the proposed boundary change, by Registered or Certified Mail at the expense of the applicant, at least one (1) week before the public hearing.

e. The public hearing shall be held. Any person may appear in person, or by agent or attorney. Minutes of the public hearing shall be recorded and kept in the records of the Planning Commission.

f. The Planning Commission shall either recommend or denial of the amendment to the Board of County Commissioners.

g. Adoption. Amendments to the zoning ordinance may be adopted by a majority vote unless the amendment has been denied by the Planning Commission in which case a two-thirds (2/3) vote of the Board of Codington County Commissioners is required.

h. When the Board of County Commissioners approves a proposed amendment affecting the zoning classification of property, affected property owners may file a written protest to stop such an amendment from taking effect. If the protest meets the following standard, such amendment shall not become effective unless the amendment is approved by two-thirds (4 votes) of the Board of County Commissioners.

   i. Protest Standard: The protest shall be signed by at least 40% of the owners of equity in the parcels in the area affected by the amendment, and the parcels or parts of parcels within 250 feet of the area affected by the amendment.

i. After passage the Ordinance Amendment shall take effect on the 20th day after its publication in an official newspaper of the County.

Section 4.05.04. Reapplication.

No application requesting a variance, conditional use, or zoning ordinance amendment or district classification change on any property whose application includes any such property either entirely or substantially the same as that which has been denied by the Board of Adjustment (variances, conditional uses) or Board of County Commissioners (Zoning Amendments, Zoning District Boundary Changes), shall again be considered by the Planning Commission, Board of Adjustment or Board of County Commissioners before the expiration of six (6) months from the date of the final action of the Planning Commission, Board of Adjustment, or Board of County Commissioners.

~~SECTION~~ ARTICLE V
GENERAL REQUIREMENTS

Pursuant to the purpose of this Regulation are certain general requirements that are not provided for under ~~Section IV~~ **Article III** District ~~Requirements~~ **Regulations**. These requirements are set forth under this Section.

~~5.1 RESERVED~~ CHAPTER 5. 0~~2~~1. VISION CLEARANCE ON CORNER LOTS.

On any corner **lot in any zoning district**, no **planting,** ~~no fence, building, other~~ structure, ~~shelterbelt, hedge, tree, bush~~, or ~~other object~~ **obstruction to vision between the range of three (3) and eight (8) feet in height measured from the center line of the road shall be placed or maintained within the triangular area formed by the intersection road right-of-way lines and a straight line connecting points on said road right-of-way line each of which is one hundred (100) feet distance from the point of intersection (Clear View Triangle). Exception: In the Lake Park District, Town District, and Planned Residential District, the Clear View Triangle shall be formed by the intersection road right-of-way lines and a straight line connecting points on said road right-of-way line each of which is fifty (50) feet distance from the point of intersection.**

CHAPTER 5.0~~3~~2. REFUSE.

In all Zoning Districts, refuse (rubbish, garbage, trash, waste or debris) shall be kept within a completely enclosed building or specially designed closed container made for such purpose. Owners of vacant lots shall be responsible for keeping their property free of trash. Normal farming operations excluded.

CHAPTER 5.043. UNLICENSED VEHICLES.

Vehicles not in use and without a current license may not be kept in any uncovered area other than a designated junk or salvage yard **or designated collection site**.

CHAPTER 5.0~~5~~4. SALE OF PARKING AREAS.

Off-street parking areas required under ~~Section IV~~ **Article III** District ~~Requirements~~ **Regulations**, as part of lot requirements may not be separated from the property of which it was an original part.

~~5.6 NON-CONFORMING USE~~

~~A. Any non-conforming building or land existing at the time of the passage of this Regulation may be continued even though such building, structure, or land use does not conform with the provisions of this Regulation for the District in which it is located. Any such existing non-conforming use may hereafter be extended throughout any part or parts of a building which were manifestly arranged or designed for such use at the time of passage of this Regulation. Any such existing non-conforming land use may be expanded throughout any contiguous land area under the same ownership at the time of the adoption of this Regulation except when such non-conforming land use by its expansion enters into an area with a different zoning classification.~~

~~B. No non-conforming use, building, structure, or premises, if once changed to conform to the requirements of this Regulation for the District in which it is located, shall ever be changed back so as to be non-conforming. No non-conforming use which shall have been discontinued for a period exceeding twelve (12) months shall be resumed or replaced by any other non-conforming use.~~

~~C. Nothing in this Regulation shall prevent the restoration of any wall or other portion of a building declared unsafe by an authorized public official.~~

~~D. Whenever any building existing in any of the districts as a non-conformity is condemned by an authorized public official, it cannot be rebuilt for a non-conforming use. If any non-conforming building is destroyed or damaged by any casualty, such building may be repaired or replaced and use continued providing said reconstruction shall not add to the non conformity or add to the cubic contents of said building as the same existed at the time of such casualty; and provided further than such repair or reconstruction of such building shall be begun within six (6) months after such casualty and completed within a reasonable time thereafter; however, if the damage caused by such casualty is such as to cause a loss in value exceeding sixty percent (60%) of the value immediately prior to such casualty, then it cannot be rebuilt for a non-conforming use. The loss in value shall be computed as the difference between the actual cash value of the structure immediately before and after the casualty. Cash value shall be the same as that used for insurance purposes as approved by the State of South Dakota Insurance Code.~~

~~E. The foregoing provision of this Section shall apply to buildings, structures, land or uses, except those buildings, land or uses which are agricultural in nature which may hereafter become non-conforming by reason for the rezoning of the area in which the same may be situated.~~

~~F. Nothing contained in this Section shall be so construed as to abridge or curtail the powers of the County Planning Commission as set forth elsewhere in this Regulation.~~

~~G. Any area proposed or being developed for residential use in the "A" Agricultural Land District must provide for a minimum of thirty five (35) acres per lot, unless platted prior to the adoption of this Regulation. Exception to the lot size may be made according to Section IV (4.1)(C) 6 of this Regulation.~~

~~H. All structures used for human habitation or commercial use must be connected to a sewage disposal system approved by the zoning commission. If a public sewer is available, all such structures must be connected.~~

CHAPTER 5.05. SCREENING.

Where any commercial or industrial use is adjacent to any residential use, that use (building, parking or storage) shall be appropriately screened from the residential use by a fence or planting, approved by the Board of Adjustment, except where such fence or planting may be in conflict with vision clearance.

CHAPTER 5.~~7~~06. MOVED IN BUILDINGS

1. ~~Any building, except those covered under Section 8.1 moved into any use district must secure a special permit from the Zoning Officer.~~ **It shall be unlawful to move any house or other building onto any lot or to any new location within the County unless and until a permit to do so has been obtained from the Zoning Officer. No permit shall be issued until the following requirements are met.**

   a. The fee for said permit as prescribed in Section 4.01.05, shall have been paid.

   b. That the work is to be completed within six (6) months after the permit has been issued by the Zoning Officer.

   c. Must have signatures, by petition, of ~~one hundred~~ ~~(100%)~~ **sixty-six percent (66%)** of the adjoining landowners, including land directly across a road or highway, and ~~one hundred~~ ~~(100%)~~ **fifty percent (50%**) of landowners within two hundred (200) feet. EXCEPTION: A new residence to be used for first occupancy, constructed off the property and moved to location, shall not require adjoining landowners' approval.

~~C. Type A manufactured homes are exempt from the requirements of 5.7 B; Type B and Type C must meet the requirements of 5.7 B, except that a manufactured home located on adjoining property shall be considered consent.~~

~~D. Nothing contained in this Regulation shall prevent a single permanent manufactured home from being placed on an established farmstead, to be used as a secondary residence, so long as it is immediately connected to the existing farm operation and its occupant is also engaged in that farming operation.~~

CHAPTER 5.~~8~~07. MINIMUM WATER AND SEWER REQUIREMENTS.

A water and sewer system cannot be approved until it meets the following standards:

1. All subsurface absorption systems shall be at least one hundred (100) feet from any water supply well, eighty (80) feet from any lake, stream, or water course, and twenty-five (25) feet from property lines.

2. The bottom of the drain area or tile field should be at least four (4) feet above the maximum high ground water level and five (5) feet above rock or impervious soil strata and not more than five (5) feet below ground surface.

3. All structures used for human habitation or commercial or industrial use must be connected to a sewage disposal system which meets South Dakota Department of Environment and Natural Resources Administrative Rules and be approved by the Zoning Officer. If a public sewer is available, all such structures must be connected to said public sewer.

CHAPTER 5.~~9~~ 08. SHELTERBELT SETBACK REQUIREMENTS.

1. A shelterbelt, consisting of one (1) or more rows, shall not be established within one hundred fifty (150) feet of a public road right-of-way ~~line~~ on the north and west sides of roads and not within one hundred (100) feet of a public road right-of-way ~~line~~ on the south and east sides of roads. **Exception: A shelterbelt, consisting of one (1) or more rows, may be established on the north and west sides of a road with the north or west windward row to be located at least one hundred fifty (150) feet from a public road right-of-way and the north or west non-windward row to be located no closer than seventy-five (75) feet from a public road right-of-way; or a shelterbelt, consisting of one (1) or more rows, may be established on the south and east sides of a road with the south and east windward row to be located at least one hundred (100) feet from a public road right-of-way and the south and east non-windward row to be located no closer than fifty (50) feet from a public road right-of-way if there is an existing shelterbelt within one-half (1/2) mile and parallel to the north or west of the proposed shelterbelt. The exception(s) is also subject to 5.08.4. The windward row of trees shall consist of shrubbery or tree species, as determined by the State Urban Forester, which aid in the containment of snow.** Shelterbelts at right angles to roads shall have a minimum turnaround of fifty (50) feet measured from the road right-of-way. Shelterbelts shall not be established within one hundred fifty (150) feet of adjoining property lines without written permission of adjoining property owners.

2. **Shade Trees, ornamental trees or shrubs generally used in front yards for landscaping and spaced further than fifteen (15) feet apart and further do not extend lineally for a distance of over one hundred fifty (150), are not considered shelterbelts and are allowed in a controlled area. The controlled area is defined as the area within one hundred (100) feet of homes or farm buildings, but not closer to the right-of-way than fifty (50) feet. Except for the following, plantings within the controlled area are exempt from this regulation. Four (4) or more trees planted in a row are not allowed with the controlled area. Deciduous trees which are spotted or staggered within the controlled area can be no closer than twenty (20) feet. Conifer trees which are spotted or staggered within the controlled area can be no closer than twenty-five (25) feet. The distance between trees shall be determined by measuring distance between tree trunks.**

3. **The shelterbelts setback requirements (paragraph 1) also apply to volunteer trees that the landowner allows to grow.**

4. **A recommendation from the County Highway Superintendent, Township and/or State Department of Transportation is required prior to the issuance of any variance of the shelterbelt setback from any respective County, Township or State/Federal public right-of-way.**

CHAPTER 5.~~1~~09. ANIMAL UNITS ON SMALL ACREAGES.

On parcels of land of ten (10) acres or less, a maximum of one (1) animal unit per acre will be allowed. Designated ~~commercial feedlots~~ **concentrated animal feeding operations** excluded.

CHAPTER 5.1~~1~~0. MANUFACTURED HOME PARKS.

It shall be unlawful for any person to place or maintain a manufactured home park in the unincorporated area of Codington County unless said court is connected to an approved public water and sewer system. **Exception, A manufactured home park existing prior to June 18, 1974 may be allowed in a commercial zoning district subject to meeting the following requirements:**

Section 5.10.01 Manufactured Home Parks Minimum Standards.

1. The existing manufactured home park shall provide a map showing:

- **a. Location and topography of the manufactured home park, including adjacent proximity to Federal and State highways, and County, Township, and City roads/streets.**
- **b. Property lines and square footage of the proposed park.**
- **c. Location and dimension of all manufactured home rental lots.**
- **d. Location of all structures on said manufactured home rental lots with special attention to setback from streets and other structures.**
- **e. Age of all manufactured homes on said manufactured home rental lots.**
- **f. Location and dimensions of all easements and rights-of-way.**
- **g. Proposed general layout, including parking and recreation areas.**
- **h. General street and pedestrian walkway plan.**
- **i. General utility, water, and sewer plan.**

2. The existing manufactured home park shall provide a mitigation plan addressing the following:

- **a. Streets - Each manufactured home lot shall abut or face a public or private roadway or street. The street shall be in good repair and the manufactured home park owner shall present a plan on how and when the roads are to be maintained.**
- **b. Lot area - Each lot provided for the occupancy of a single manufactured home unit shall be not less than fifty (50) feet in width and have an area of not less than five thousand five hundred (5,500) square feet, and the same shall be defined by markers at each corner.**
- **c. Density – No existing manufactured home park shall be permitted to increase the density of manufactured home lots existing at the time of issuance of conditional use permit.**
- **d. Spacing and Yard Requirements - All subsequent manufactured housing units positioned on defined rental lots will comply with the following:**
  - **i. Front Yard - All manufactured homes shall be located at least twenty (20) feet from any road or street. The distance will be measured from the wall of the structure to the street or roadway at the closest point.**
  - **ii. Side and Rear Yards - All manufactured homes shall have minimum side yards of seven (7) feet and a minimum rear yard of ten (10) feet.**
  - **iii. Exceptions to Minimum Yard Requirements - A garage, canopy, or carport may project into a required side or rear yard provided it is located no closer than ten (10) feet to another manufactured home, garage, canopy, carport, or addition thereto, and provided further that the maximum depth be twenty-four (24) feet.**

A deck may project into a required side or rear yard provided it is located no closer than four (4) feet to any other structures.
An enclosed vestibule containing not more than forty (40) square feet in area may project into a required yard for a distance not to exceed four (4) feet, but in no event closer than ten (10) feet to another manufactured home, garage, canopy, carport, or addition thereto.
Detached accessory buildings with a projected room area of not more than one hundred and twenty (120) square feet may project into a required side or rear yard provided it is located no closer than four (4) feet to another structure or right-of-way.

e. Parking -Two (2) off-street automobile parking spaces shall be provided for each manufactured home. Such off-street parking spaces shall be set-aside in a location convenient to the occupants.
f. Refuse Collection - One refuse collection station shall be provided, with a minimum of one (1) two-yard dumpster situated on a concrete pad, for each twelve (12) families or fractions thereof, conveniently located to serve tenants, not less than one hundred (100) feet from any manufactured home unit served, and to be conveniently located for collection.
g. On-Site Management - Each manufactured home park shall provide management by the owner or his representative at all times to supervise the management, repairs, maintenance and janitorial work connected therewith and to see that all provisions of this Chapter are complied with.
h. Tie Down Requirements - All manufactured homes placed after the adoption of this ordinance, regardless of location, unless such manufactured homes are securely anchored to a permanent foundation approved by the Zoning Officer, shall be anchored to the ground, in accordance with the manufacturer's specifications or as prescribed by the TR-75, issued June 1972 by the U.S. Department of Defense.
i. Maximum Age Limitation - No manufactured home placed within a manufactured home park may exceed fifteen (15) years from the date of manufacture. The Board of Adjustment may grant a variance from the maximum age requirement subject to the applicant meeting the following requirements:

   i. The applicant shall provide a photograph of the manufactured home's exterior and interior.
   ii. That it shall have been shown to the satisfaction of the Zoning Officer that the said manufactured home complies with the recognized gas, plumbing, electrical, and construction standards.
   iii. A majority of adjoining residences (excluding streets) do no object to the placement of the manufactured home.

j. Skirting - All manufactured homes, regardless of location, unless such manufactured homes are securely anchored to a permanent foundation, approved by the Zoning Officer, shall be skirted within thirty (30) days of placement.
k. Expansion - Existing manufactured home parks may not be extended or expanded into adjoining property.
l. Building/Moved-in Building Permit Required. A building permit is required whenever a manufactured home is moved into or removed from the manufactured home park, or if when an accessory structure is to be constructed.

m. Addresses – Each manufactured home shall have an address number affixed to the manufactured home. Required signage shall consist of a green reflective sign with four (4) inch silver or white reflective numbers.

n. Street Lighting – On all private streets, street light will be provided per approved site plan.

o. Septic Tank/Sanitary Sewer – Existing manufactured home park shall meet the requirements of South Dakota Codified Law and associated administrative rules regarding on-site septic tanks and drainage systems. Existing manufactured home parks shall provide documentation, as requested, from the South Dakota Department of Environment and Natural Resources that the septic system identified in the approved site plan meets minimum standards. If said system fails to meet minimum State standards, said system will be abandoned and replaced with connection to a public sanitary sewerage system or redesigned to meet State standards only after receiving a conditional use permit from the Board of Adjustment. In the event a public central sanitary sewerage system is within two hundred fifty (250) feet of the perimeter of the manufactured home park, said manufactured home park shall request connection to said public central sanitary sewerage system.

CHAPTER 5.11. MANUFACTURED HOME REGULATIONS.

1. A manufactured home is an industrialized building unit constructed on a chassis for towing to the point of use and designed to be used for continuous year-round occupancy as a single dwelling. For the purpose of this Ordinance, manufactured homes will be regulated by types. Two (2) types of homes are defined under these regulations.

a. Type A manufactured home shall:

i. Have more than 1,100 square feet of occupied space in a double-section or larger multi-section unit.

ii. Be anchored to a permanent foundation (permanent perimeter enclosure) and permanent footing.

iii. The age of the manufactured house may not exceed five (5) years from the date of manufacture.

iv. Have a gabled roof with a pitch of at least 2/12 feet.

v. Have siding material of a type customarily used on site-constructed residences.

vi. Have roofing material of a type customarily used on site-constructed residences.

b. Type B manufactured home shall:

i. Have more than 700 square feet of occupied space in a single, double, expando or multi-section unit. Minimum width for a Type B mobile home is fourteen (14) feet.

ii. Utilize a perimeter enclosure of metal, vinyl, wood or styrofoam in accordance with manufacturer's specifications.

iii. The age of the manufactured house may not exceed fifteen (15) years from the date of manufacture.

iv. Be anchored to the ground, in accordance with manufacturer's specifications, or as prescribed by the ANSI/NFPA 501A Standards.

v. Have siding material of a type customarily used on site-constructed residences.

vi. Have roofing material of a type customarily used on site-constructed residences.

vii. Be placed onto a support system, in accordance with approved installation standards, as specified in subsection (2), Installation Standards.

2. Installation Standards.

a. Support System.

i. All HUD-Code manufactured homes of the Type A classification shall be installed with load bearing foundations in conformance with the manufacturer's installation specifications.

ii. Type B manufactured homes not placed on a permanent foundation shall be installed on a support system in conformance with the manufacturer's installation specifications or with the support systems regulations in the ANSI/NFPA 501A installation standards.

b. Foundation/Skirting

i. Those manufactured homes designated in this Ordinance (Type A), as requiring a permanent foundation and permanent perimeter enclosure must have footings and crawl space or basement walls.

a. A crawl space must be constructed of concrete or masonry block grouted solid with one (1) number four or (1/2") horizontal rebar, continuous tied to number four or (1/2") rebar verticals placed in the footing four feet (4') on center.

b. The foundation shall be (a) an approved wood basement constructed of 2 x 6 frame work and treated with water resistant materials; or (b) a foundation shall be constructed with eight inches poured concrete or concrete block.

c. The footing to be a minimum of eight (8) inches thick by sixteen (16) inches wide poured concrete with top of footing to be sixteen (16) inches below grade and the bottom of the footing to be below the frost line.

d. The space between the floor joints of the home shall be completely enclosed with the permanent perimeter enclosure (except for required openings).

ii. All manufactured homes without a permanent perimeter enclosure shall have an approved foundation/siding/skirting enclosing the entire perimeter of the home.

3. Nonconforming Homes.

A manufactured or mobile home placed and maintained on a tract of land and deemed to be a legal nonconforming use prior to the adoption of this Ordinance, shall continue to be a legal nonconforming use. If the nonconforming use is discontinued, the land thereafter must be used in conformity with all provisions of this Ordinance.

4. Replacement of Nonconforming Homes.

Thereafter, upon application to the Zoning Officer and subsequent approval thereof, a manufactured home, deemed a legal nonconforming use, may be replaced by a manufactured home, provided the replacement is of an equal or higher type. Equal or higher type means a Type B manufactured home could be replaced with a Type A or B manufactured home; a Type A manufactured home could be replaced with another Type A manufactured home.

5. Structural Alteration.

Due to its integral design, any structural alteration or modification of a manufactured or mobile home after it is placed on the site must be approved by the Zoning Officer.

6. Variance from Maximum Age Requirement

Type A and B manufactured homes may receive a variance from the maximum age requirement. The Board of Adjustment may grant a variance if the manufactured home meets the following requirements:

a. The applicant shall provide a photograph of the manufactured home's exterior and interior.

b. That it shall have been shown to the satisfaction of the Zoning Officer that the said manufactured home complies with the gas, plumbing, electrical, and construction requirements of Codington County.

c. That the applicant shall obtain the written consent of all property owners owning property immediately adjacent (excluding streets and alleys) to the proposed building site and the consent of sixty-six (66) percent of the property owners within one hundred fifty (150) feet (excluding streets and alleys) of said proposed location has been received.

5.12 TIE DOWN REQUIREMENTS

All manufactured homes, including permanent manufactured homes and regardless of location, shall be tied down as prescribed by the Defense Civil Preparedness Agency, publication TR-75, issued June, 1972, by the U.S. Department of Defense.

CHAPTER 5.132. EXTENDED HOME OCCUPATION.

There are significant differences between home occupations **conducted in residential dwellings** on small tracts and agricultural**-based extended** home occupations. The nature of resources available for use, the benefits and disadvantages created by home occupations, and the problems generated necessitate a distinction between home occupations **conducted in residential dwellings** on small tracts and ~~farm~~ **agricultural-based extended** home occupations.

1. For the purposes of this section, provided all requirements are met, the following shall be considered extended home occupations:

    a. Welding repair conducted in a safe manner.

    b. Veterinarian's office.

    c. Blacksmith.

    d. Service office.

    e. Others which, in the opinion of the Board of Adjustment would not conflict with adjoining land uses.

2. Performance Standards

a. Individuals engaged in such occupation shall consist of family members residing on the premises and up to three (3) non-family employees.

b. There shall be no change in the outside appearance of the buildings or premises, or other visible evidence of the conduct of such home occupation other than one on-premise sign, not to exceed sixteen (16) square feet in area, non-illuminated.

c. Off premise signage for extended home occupations shall be limited to South Dakota Department of Transportation (SDDOT) commercial, directional signs, also known as "Blue Signs". These signs, with SDDOT approval, may be located adjacent to State and Federal Highways.

d. The only retail sales allowed shall consist of the sale of commodities/products prepared on the premises in connection with such occupation or activity. Exception: Seed Sales.

e. There shall be no outdoor storage of materials, vehicles, etc. related to the extended home occupation.

f. Extended home occupations should be agriculturally related and be conducted in an accessory building.

g. No traffic shall be generated by such extended home occupation in greater volumes than would normally be expected in a residential neighborhood, and any need of parking generated by the conduct of such extended home occupation shall be provided off the street and other than in a required front yard.

h. No equipment or process shall be used in such extended home occupation which creates noise, vibration, glare, fumes, odors, or electrical interference detectable to the normal senses off the lot. In the case of electrical interference, no equipment or process shall be used which creates visual or audible interference in any radio or television receivers off the premises, or causes fluctuations in line voltage off the premises.

CHAPTER 5.13. FENCES.

Section 5.13.01. Purpose.

The regulation of fences is intended to protect the public safety and welfare, provide privacy, buffer noise, and allow adequate air, light and vision.

Section 5.13.02. Permit required.

1. Except for the Agricultural District, all fences, walls and hedges shall require a building permit. Customary farm and animal fencing is exempt from this Chapter.

Section 5.13.03. Location/Construction Requirements.

1. Notwithstanding other provisions of this Ordinance, fences, walls, and hedges may be permitted in any required yard. Except fences, walls, and hedges which are more than thirty (30) percent solid shall not be located within fifty (50) feet of an intersection, measuring along the property lines and connecting these two points by a straight line. Further, the fence, wall, or hedge shall not be constructed within twenty-five (25) feet of a public right-of-way or private road. Fences, walls and hedges shall be set back twenty (20) feet from high water mark.
2. Fences, with a maximum height of not more than eighty inches (80) inches, may be erected on any part of a lot other than in the required front yard which shall be limited to a height of forty-eight (48) inches.

3. The County does not provide surveying services. The property owner is responsible for locating property lines.

4. Fences may be built no closer than one (1) foot up to the property line, not to include the public right-of-way. Fences constructed within an identified easement face the potential of removal in the event of necessary work to be conducted within the easement. Replacement of the removed fence is the responsibility of the owner of said fence.

5. The “finished side” of the fence shall face neighboring properties or the road.

6. Approved fencing materials include stone, brick, wood, vinyl, and chain link. No

barbed wire fences shall be allowed in the Lake Park and Planned Residential Districts.

7. Hedges or other plantings which create a fence effect are subject to the same regulations as fences.

8. Fences can be built on the property line when the fence is shared between property owners.

CHAPTER 5.14. ACCESSORY BUILDINGS.

1. Only specifically authorized accessory uses allowed; accessory uses must be subordinate to principal use.

2. No accessory use shall be permitted in any district unless such use is specifically authorized by this Ordinance. No accessory use shall be deemed to be authorized by this Ordinance unless such use is in fact subordinate to and on the same zoning lot with the principal use in conjunction with which it is maintained.

3. No accessory building shall be erected in any required yard, and no separate accessory building shall be erected within five (5) feet of any other building.

4. No accessory building may be used for residential dwelling purposes at any time.

5. Agricultural District.

   In any Agricultural district, any accessory use customarily incident to the principal permitted use or conditional use shall be permitted, except those uses specifically prohibited in the district.

6. Commercial and Industrial Districts.

   In any Commercial or Industrial district, any accessory use customarily incident to the principal permitted use or conditional use shall be permitted, except those uses specifically prohibited in the district.

7. Lake Park and Planned Residential Districts.

   Accessory uses shall be permitted for the principal permitted uses and conditional uses of the Lake Park and Planned Residential Districts only in accordance with the provisions of the following table hereby adopted by reference and declared to be part of this Ordinance.

8. In the TD – Town District certain separate accessory building may be erected within the required side or rear yards provided the following conditions are met:

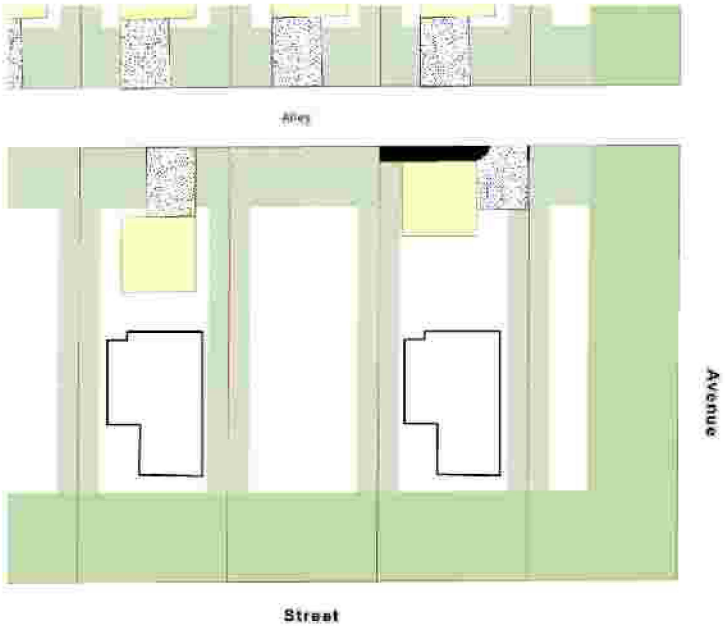
   a. The accessory structure(s) may not exceed two hundred (200) square feet.
   b. In no case shall an accessory structure be placed less than five (5) feet from any side or rear lot line shared by another property in the TD – Town District
   c. Accessory structures located less than the minimum required side or rear yard (see Section 3.10.03.1.a) shall not be constructed upon a permanent foundation.

d. Exception: when garage doors are entered directly from an alley the accessory structure shall not be located closer than twenty (20) feet to the alley line. (See Figure 5.14.8).

Permitted Accessory Uses: LP and PR Districts

Principal Use	Permitted Accessory Uses
Single-family dwellings; duplexes; townhouses and multiple-family dwellings; nursery schools and Day care centers	1. Private garages. a. Attached and unattached garages shall be limited to maximum dimensions per 3.04.07.3.g and conform to the design of the house. b. Attached garages shall be limited to maximum sidewalls of ten (10) feet; and a maximum of 4/12 roof pitch or to conform to the design of the house. c. Unattached garages shall be limited to maximum sidewalls of twelve and one-half (12 ½) feet; and a maximum of 4/12 roof pitch or to conform to the design of the house.
	a. Buildings or structures for customary residential storage purposes not over ten (10) feet in height and not exceeding one hundred fifty (150) square feet in gross floor area. b. Readily moveable sports, recreation, or outdoor cooking equipment. c. Permanent sports or recreational structures or facilities, such as tennis courts, swimming pools, barbeque pits, and similar improvements provided a site plan for such facility is approved d. Home occupations but only as defined herein. e. Non-commercial greenhouses provided that greenhouses over one hundred (100) square feet in floor area must have an approved site plan. f. Off-street parking and storage of vehicles.
Principal Use	Permitted Accessory Uses
Churches, Convents and Monasteries	1. All customarily incidental uses reasonably necessary to allow the free exercise of religion, but not to include commercial use.
All conditional uses	1. All customarily incidental uses reasonably necessary to promote the primary purposes of the principal use, provided that such use must be specifically authorized by the Board of Adjustment for the principal use.
All other items	1. No accessory uses permitted.

Figure 5.14.8



Symbol	Structure
	House
	Garage
	Driveway

Symbol	Required Yard	Setback*
	Front Yard	25'
	Rear Yard	20'
	Side Yard	15'
	Parallel Accessory Building Setback	5'

*Applicable setbacks for TD – Town District.

CHAPTER 5.15 SIGNS.

Section 5.15.01 On-premise and Off-premise Signs

1. Prohibited signs:

a. No sign shall be erected or maintained which creates a hazard due to collapse, fire, collision, decay, or abandonment; or creates traffic hazards, by either:

i. Confusing or distracting motorists; or

ii. Impairing the driver's ability to see pedestrians, obstacles or other vehicles, or

iii. Impairing the driver's ability to see and interpret any official traffic sign, signal or device; or

iv. Creates a nuisance to persons using a public right-of-way; or

v. Constitutes a nuisance to occupancy of adjacent and contiguous property by its brightness, size, height, or movement

b. Any vehicle or trailer parking on public right-of-way, public property or private property so as to be visible from the public right-of-way and which displays an advertising message, unless said vehicle is used in the regular course of a business.

2. Signs shall be permitted in zoning districts per Article III, subject to the following provisions:

   a. Wall signs may be located anywhere on the wall of a building.

   b. Signs shall not project over public property.

   c. Signs shall not be erected adjacent to a corner of two (2) intersecting streets, unless such signs are constructed to not obstruct the view of said intersection. See Chapter 5.01.

   d. Each sign – size, lighting, and location - in the County shall at least meet the standards established by the South Dakota Department of Transportation.

   e. Other than utility fixtures or holiday decorations, no signs, awnings, or display shall be suspended, hanged, or placed so that the same shall hang over any part of a street or sidewalk, used for vehicular or pedestrian travel unless a written application for a permit is made to the Zoning Officer and the said Official grants a permit therefore.

   f. The Zoning Officer shall take into consideration factors that would make the proposed structure likely to endanger the property or personal safety of passerby traveling the streets or sidewalks in question, and whether or not such structure complies with codes relating to outdoor advertising.

3. On-premise Signs: Each sign erected as an on-premise sign in those zoning districts where permitted shall, unless specified elsewhere in this ordinance, conform to the following requirements:

   a. Unless otherwise specified herein, each sign shall have a maximum surface area of eighty (80) square feet and shall observe all yard and height requirements of the district in which it is located.
   b. No on-premise sign may be converted to an off-premise sign.

4. Off-premise Signs: Off-premise signs erected in those zoning districts where permitted shall, unless specified elsewhere in this ordinance, conform to the following requirements:

   a. Maximum off-premise sign area:
      i. Signs primarily visible from Interstate 29: The maximum surface area of any off-premise sign facing any one direction shall be twelve hundred (1,200) square feet.

      ii. Signs primarily visible from all other roadways: ~~Each sign shall have a~~ The maximum surface area of any off-premise sign facing any one direction shall be ~~of~~ three hundred (300) square feet. Stacked signs (two or more signs stacked vertically on a single sign structure) are prohibited.

   b. The sign structure or sign shall have a maximum height of thirty (30) feet. Height of sign is the vertical distance from the top of the sign or sign structure, whichever is greater, to the ground in a straight line directly below, measured

from a point equidistant from the sides or edges of the sign.

c. **Off-premise signs shall comply with all applicable state and federal requirements.** ~~Stacked signs (two or more signs stacked vertically on a single sign structure are prohibited.~~

d. Each sign shall not be closer than three hundred (300) feet from any street intersection and five hundred (500) feet from another permitted Off-premise sign on the same side of the street or road.

e. Each sign shall not be closer than ten (10) feet from any street right-of-way.

f. Each sign shall not be closer than two hundred fifty (250) feet from adjoining property lines.

CHAPTER 5.16. STRUCTURES TO HAVE ACCESS.

Every building hereafter erected or moved shall be on a lot adjacent to a public street, or with access to private streets approved by the Board of Adjustment, and all structures shall be so located on lots as to provide safe and convenient access for services, fire protection and required off-street parking.

CHAPTER 5.17. YARDS.

No part of a yard or other open space, or off-street parking or loading space required about or in connection with any building for the purpose of complying with this ordinance, shall be included as part of a yard, open space, or off-street parking or loading space similarly required for any other building.

Section 5.17.01. Yards, Reduction in Size.

No yard or lot existing at the time of passage of this ordinance shall be reduced in dimension or area below the minimum requirements set forth herein. Yards and lots created after the effective date of this ordinance shall meet at least the minimum requirements established by this ordinance.

Section 5.17.02. Additional Yard Requirements.

The following yard requirements must be observed in addition to the yard requirements of the various districts:

1. A corner lot must have a front yard on both streets

2. On developed property, in the LP-Lake Park District and PR-Planned Residential District, fronting on one side of the street between two streets where one or more residences already exist, no building shall hereafter be erected and no existing building shall be reconstructed or altered in such a way that any portion thereof shall be closer to the street line than the average improved building front on that street in that block, but in no case shall the set-back line be less than twelve (12) feet from the front lot line..

3. In the LP and PR Districts, on through lots and reversed frontage lots, a front yard must be provided on both streets.

4. In the LP and PR Districts, required front yards shall be devoted entirely to landscaped area except for the necessary paving or driveways and sidewalks to reach parking or loading areas in the side or rear yard.

Section 5.17.03. Exceptions to Yard Requirements.

The following exceptions may be made to the yard requirements in the LP and PRL Districts:

1. Air conditioning units, sills, chimneys, cornices, and ornamental features may project into a required yard a distance not to exceed twenty-four (24) inches.

2. In commercial and industrial districts, filling station pumps and pump islands may occupy required yards, provided, however, that they are not less than fifteen (15) feet from all lot lines.

3. An accessory building may be located in a rear yard but not occupy more than 30 percent of a rear yard.

4. Any accessory buildings closer than ten (10) feet to a main building shall be considered as part of the main building and shall be provided with the same side and rear yard requirements as the main building.

CHAPTER 5.18. PERMANENT FOUNDATIONS REQUIRED FOR DWELLINGS.

No dwelling shall be constructed, installed, or moved into the area under the jurisdiction of these regulations, unless said dwelling is constructed upon, installed on or moved onto a permanent foundation, as defined in these regulations. Exempted from this requirement are manufactured homes as defined herein.

CHAPTER 5.19. UTILITY EASEMENTS.

No building or addition thereto shall be erected over or across any existing public utility or upon any platted easement.

CHAPTER 5.20. ERECTION OF MORE THAN ONE PRINCIPAL STRUCTURE ON A LOT.

In any district, only one (1) structure housing a permitted or permissible principal use may be erected on single lot, provided that yard and other requirements are met.

CHAPTER 5.~~14~~21. CONCENTRATED ANIMAL FEEDING OPERATION REGULATIONS.

Section 5.21.01 Intent

An adequate supply of healthy livestock, poultry and other animals is essential to the well-being of county citizens and the State of South Dakota. However, livestock, poultry, and other animals produce manure which may, where improperly stored, transported, or disposed, negatively affect the County' environment. Animal manure must be controlled where it may add to air, surface water, ground water, or land pollution. The following regulations have been adopted to provide protection against pollution caused by manure from domesticated animals. All new and proposed expansions of Concentrated Animal Feeding Operations shall comply with the regulations as outlined herein.

It is the intention of the Board of Adjustment in the enforcement of this ordinance that when an operator of an existing Concentrated Animal Feeding Operation applies for a permit to expand to another class level, the standards that apply to the expansion will not be applied to existing structures that were built in compliance with accepted industry standards in existence at the time of the construction of such facilities.

~~**Definitions**~~

~~**Animal Manure**: Poultry, livestock, or other animal excreta or mixture of excreta with feed, bedding or other materials.~~

~~**Animal Unit**: See page 56.~~

~~***Applicant*:** An individual, a corporation, a group of individuals, partnership, joint venture, owners, or any other business entity having charge or control of one or more concentrated animal feeding operations.~~

~~**Change in Operation**: "Change in operation" means a cumulative increase of more than 300 animal units, or change in animal species, after July 1, 1997, which are confined at an unpermitted concentrated animal feeding operation.~~

~~**Farm Dwelling***: Any dwelling farmer owned or occupied by the farm owners, operators, tenants, or seasonal or year-around hired workers.~~

~~**Non-Farm Dwelling***: Any occupied dwelling which is not a farm dwelling.~~

~~**Permit***: A permit required by these regulations unless stated otherwise.~~

~~**Potential Pollution Hazard***: A Concentrated Animal Feeding Operation of 50 to 499 Animal Units may be classified as a Class 4 Operation by the County Zoning Officer when a Potential Pollution Hazard exists. Factors to be considered by the Zoning Officer in determining a Potential Pollution Hazard include the following:~~

~~1. The Concentrated Animal Feeding Operation does not meet the minimum setback and separation distances of these regulations.~~

~~2. A Potential Water Pollution Hazard exists due to siting over a shallow aquifer or drainage which contributes to the waters of the State.~~

Process Generated Wastewater: Water directly or indirectly used in the operation of an animal feeding operation. The term includes spillage or overflow from watering systems; water and manure collected while washing, cleaning or flushing pens, barns, manure pits or other areas; water and manure collected during direct contact swimming, washing or spray cooling of animals; and water used in dust control.

Process Wastewater: "Process wastewater" means any process generated wastewater and any precipitation (rain or snow) that comes into contact with the animals, manure, litter or bedding, feed, or other portions of the animal feeding operation. The term includes runoff from an open lot.

Shall means that the condition is an enforceable requirement of this permit.

Shallow Aquifer: An aquifer vulnerable to contamination because the permeable material making up the aquifer (a) extends to the land surface so percolation water can easily transport contaminants from land surface to the aquifer, or (b) extends to near the land surface and lacks a sufficiently thick layer of impermeable material on the land or near the land surface to limit percolation water from transporting contaminants from the land surface to the aquifer.

Shallow Well: A well which is located in a shallow aquifer.

Should means that the condition is a recommendation. If violations of the permit occur, the County will evaluate whether the producer implemented the recommendations contained in this permit that may have helped the producer to avoid the violation.

Significant Contributor of Pollution: To determine if a concentrated animal feeding operation meets this definition, the following factors are considered:

1. Size of feeding operation and amount of manure reaching waters of the state;

2. Location of the feeding operation in relation to waters of the state;

3. Means of conveyance of manure and process wastewater into waters of the state; and

4. The slope, vegetation, rainfall and other factors affecting the likelihood or frequency of discharge of animal wastes and process wastewater into waters of the state.

Waters of the State means all waters within the jurisdiction of this state, including all streams, lakes, ponds, impounding reservoirs, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, situated wholly or partly within or bordering upon the state.

Section 5.21.02. Animal Units.

Table 5.21.1 shows Animal species and number of a species required to equal 500, 1,000 and 2,000 animal units. Note that these figures relate to inventory rather than annual production. Other animal species equivalents which are not listed will be based on species' waste production.

TABLE 5.21.1
EQUIVALENT NUMBER OF A SPECIES TO EQUAL:

ANIMAL SPECIES	500 AU	1,000 AU	2,000 AU	ANIMAL UNIT EQUIVALENT SPECIES/AU
Feeder or Slaughter Cattle	500 hd	1,000 hd	2,000 hd	1.0
Mature Dairy Cattle	350 hd	700 hd	1,400 hd	1.43
Calves (up to 400 pounds)	**1250 hd**	**2,500 hd**	**5,000 hd**	**0.4**
Finisher Swine (over 55 lbs)	1,250 hd	2,500 hd	5,000 hd	0.4
Nursery Swine (less than 55 lbs)	5,000 hd	10,000 hd	20,000 hd	0.1
Farrow-to-Finish (sows)	135 hd	270 hd	540 hd	3.7
Swine Production Unit (Sows Breeding, Gestating & Farrowing)	1,060 hd	2,130 hd	4,260 hd	0.47
Horses	250 hd	500 hd	1,000 hd	2.0
Sheep	5,000 hd	10,000 hd	20,000 hd	0.1
Turkeys	27,750 hd	55,000 hd	110,000 hd	0.018
Laying Hens and Broilers (continuous overflow watering in facility)	50,000 hd	100,000 hd	200,000 hd	0.01
Laying Hens and Broilers (liquid handling system in confinement facility)	15,150 hd	30,000 hd	60,000 hd	0.033
Ducks	2,500 hd	5,000 hd	10,000 hd	0.2

Section 5.21.03 Classes of Concentrated Animal Feeding Operations

A Concentrated Animal Feeding Operation is defined as a lot, yard, corral, building or other area where animals have been, are, or will be stabled or confined for a total of **forty-five** (45) days or more during any **twelve** (12)-month period, and where crops, vegetation, forage growth, or post harvest residues are not sustained over any portion of the lot or facility. Two or more animal feeding operations under common ownership are single animal operation if they adjoin each other, or if they use a common area, or if they use a common area or system for disposal of manure.

For the purpose of these regulations, Concentrated Animal Feeding Operations are divided into the following classes:

	ANIMAL UNITS	
Class 1	2,000 or more	
Class 2	1,000 to 1,999	
Class 3	500 to 999	
Class 4	50 to 499	(Potential water pollution hazard)
Class 5	50 to 499	(No pollution hazard)

Section 5.21.04. Concentrated Animal Feeding Operation Permit Requirements.

Owners of Class 1, Class 2, Class 3, and Class 4 Concentrated Animal Feeding Operations are required to complete a permit application whenever any of the following occur:

1. A new Concentrated Animal Feeding Operation is proposed where one does not exist.

2. An expansion is proposed beyond what a current permit allows.

3. A cumulative expansion by three hundred (300) animal units, after July 1, 1997, of existing concentrated animal feeding operation that does not have a permit.

4. A change in ownership or transfer of control.

5. An existing concentrated animal feeding operation is to be restocked after being idle for five (5) or more years.

6. A signed complaint has been received **and/or documented** ~~or made~~ by the County Zoning Officer or South Dakota Department of Environment and Natural Resources and after inspection reveals that the Concentrated Animal Feeding Operation is in violation of County or State regulations.

Section 5.21.05. Concentrated Animal Feeding Operation Control Requirements.

1. No Significant Contribution of Pollution

In general, no Concentrated Animal Feeding Operation shall be constructed, located, or operated so as to create a significant contribution of pollution.

2. State General Permit

Classes 1 and 2 Concentrated Animal Feeding Operations shall obtain a State General Permit pertaining to the animal species of the Concentrated Animal Feeding Operation. A County permit may be approved conditioned on receiving a State permit.

Classes 3 and 4 Concentrated Animal Feeding Operations will be required to obtain a State General Permit if the following occur:

a. If an earthen storage basin or lagoon is used for manure storage, excluding existing operations that are improving waste handling facilities according to Natural Resource Conservation Service standards.

b. The Board of Adjustment decides conditions require a State permit.

3. Nutrient Management Plan.

a. Class 1, 2, 3, and 4 Concentrated Animal Feeding Operations **are required to have a nutrient management plan** ~~shall submit a Nutrient Management Plan~~. The applicant shall develop, maintain, and follow a nutrient management plan to ensure safe disposal of manure and protection of surface and ground water. The South Dakota Department of Environment & Natural Resources must approve the plan prior to land application of any wastes. Due to crop rotation, site changes, and other operational

changes, the producer should update the plan annually to reflect the current operation and crops grown on the application sites. The applicant shall collect, store, and dispose of liquid and solid manure according to recognized practices of good agricultural management. The economic benefits derived from agricultural operations carried out at the land disposal site are secondary to the proper and safe disposal of the manure.

b. **The Nutrient Management Plan is a conservation system for an animal feeding operation. It describes practices and management activities on how best to utilize manure as a fertilizer resource while protecting surface and ground water. The plan deals specifically with managing the amount, source, placement, and timing of the application of manure nutrients to the land. The use of other nutrient sources (i.e. commercial fertilizer) also must be taken into account when planning manure applications. All nutrient management plans developed must meet the current Natural Resources Conservation Service (NRCS) South Dakota Technical Nutrient Management Standard (590) and all applicable DENR and Codington County Zoning Standards.**

~~A generic nutrient management plan that the applicant may use in developing a nutrient management plan is available from the South Dakota Department of Environment & Natural Resources. The generic nutrient management plan is based on application of nitrogen. The applicant may use other plans, provided the alternate plan contains all the information necessary to determine compliance with conditions of this general permit. Nitrogen, in addition to that allowed in the nutrient management plan, may be applied up to the amounts as indicated by soil or crop nitrogen test results that are necessary to obtain the realistic crop yield.~~

~~The South Dakota Department of Environment & Natural Resources recommends and encourages producers to develop nutrient management plans for other nutrients such as phosphorous and potassium. Over application of these nutrients may lead to water quality problems in area lakes and streams and result in potential damage to the producer's land and crop~~.

c. The applicant must maintain records to show compliance with the plan.

d. The plan must comply with County Manure Application Setbacks.

e. Land spreading agreements shall be provided if applicant does not have minimum acreage to apply animal manure.

4. Manure Management and Operation Plan

Classes 1, 2, 3, and 4 Concentrated Animal Feeding Operations shall submit a Manure Management and Operation Plan.

~~A~~a. Plan must include:

~~1.~~i. The location and specifics of proposed animal manure facilities.

~~2.~~ii. The operation procedures and maintenance of manure facilities.

~~3.~~iii.Plans and specifications must be prepared or approved by a registered professional engineer, or a Natural Resource Conservation Service (NRCS)

engineer. Waste treatment facilities will require inspection by an engineer and as-built plans to be submitted to the County Zoning Officer.

~~4.~~**iv**.Animal manure shall not be stored longer than two years.

~~5.~~**v**. Manure containment structures shall provide for a minimum design volume of three hundred sixty-five (365) days of storage for 1,000 animal units or more and **two hundred forty** (240) days of storage for less than **one thousand** 1,000 animal units. The Board of Adjustment may reduce the number of days of storage if deemed appropriate.

~~6.~~**vi**.Producers shall keep records on manure applications on individual fields which document acceptable manure and nutrient management practices have been followed. These records shall include soils test results for surface two feet of soil, actual and projected crop yields, nutrient analysis of manure, and information about date, rate and method of manure applications for individual fields.

~~B~~**b**. As a condition of the permit, the County Board of Adjustment may require the producer to participate in environmental training programs and become a certified livestock manager.

5. Management Plan for Fly and Odor Control

Classes 1, 2, 3, and 4 Concentrated Animal Feeding Operations shall dispose of dead animals, manure and wastewater in such a manner as to control odors or flies. A management plan is required for submission of a permit. The County Board of Adjustment will review the need for control measures on a site-specific basis, taking into consideration prevailing wind direction and topography. The following procedures to control flies and odors should be considered in a management control plan.

~~A~~**a**. Operational plans for manure collection, storage treatment and use must be kept updated and implemented.

~~B~~**b**. Methods to be utilized to dispose of dead animals should be included in the management plan.

~~C~~**c**. Plant trees and shrubs to reduce wind movement of odors away from buildings, manure storage ponds and/or lagoons.

~~D~~**d**. Provide adequate slope and drainage to remove surface water from pens and keep pen area dry so odor production is minimized.

~~E~~**e**.Store solid manure in containment areas having good drainage to minimize odor production.

~~f~~**a**. Remove manure from open pens as frequently as possible to minimize odor production.

~~G~~**g**.Consider use of covers on open storage systems for liquid manure systems to reduce odor production.

~~H~~**h**.Avoid spreading manure on weekends, holidays and evenings during warm season when neighbors may be involved in outdoor recreation activities.

~~i~~. Avoid spreading during calm and humid days, since these conditions restrict the dispersion and dilution of odors.

6. Suggested Setbacks and Separation Distance for New Concentrated Animal Feeding Operations and those Expanding by 300 or More Animal Units after July 1, 1997.

SUGGESTED MINIMUMS

	CLASS 1	CLASS 2	CLASS 3	CLASS 4 & 5
Established Residences	2,640 feet	1,760 feet	1,320 feet	1,320 feet
Churches, Businesses and Commercially Zoned Areas, Town Districts	2,640 feet	2,640 feet	1,320 feet	1,320 feet
Incorporated Municipality Limits	5,280 feet plus 440 feet for each additional 1,000 AU over 2,000	5,280 feet	2,640 feet	1,320 feet
Private Wells other than the operator	2,640 feet	1,760 feet	1,320 feet	1,320 feet
Lakes and Streams classified as Fisheries as identified by the State	500 feet	500 feet	200 feet	200 feet
Federal, State & County Road ROW				
Confinement	300 feet	300 feet	200 feet	200 feet
Open Lot	150 feet	150 feet	150 feet	150 feet
Township Road ROW				
Confinement	150 feet	150 feet	150 feet	150 feet
Open Lot	150 feet	150 feet	150 feet	150 feet

~~Proposals for new Concentrated Animal Feeding Operations, on a site-by-site basis, shall be set back from adjoining property lines as determined by the County Board of Adjustment.~~

Each application for a new or expanded Concentrated Animal Feeding Operation (CAFO) will be reviewed by the Board of Adjustment on a site-specific basis. The Board of Adjustment reserves the right to increase or decrease suggested required setbacks and separation distance on a site specific review, based on one **(1)** or more of the following considerations.

a. Considerations To Decrease Suggested Setbacks And Separation Distances

i. An existing Concentrated Animal Feeding Operation proposes to expand but does not meet suggested setback or separation distances, the Board of Adjustment may reduce suggested setbacks and separation distances after review of past management practices and proposed improvements to waste handling facilities.

ii. A new Concentrated Animal Feeding Operation is proposed which, because of the waste handling facilities, would not require conformance with suggested setback and separation distances as outlined herein.

b. Considerations To Increase Suggested Setbacks And Separation Distances

~~A.~~**i.** A concentration of CAFOs in the area exists or would occur which may pose an air or water quality concern.

~~B.~~**ii.** Due to topography and prevailing wind direction, additional setback and separation distance is appropriate to safeguard air or water quality.

~~C.~~**iii.** A Concentrated Animal Feeding Operation is in excess of 5,000 animal units.

7. Manure Application Setbacks

The following manure application setbacks apply to all classes of Concentrated Animal Feeding Operations.

~~B.~~**a**. The County Board of Adjustment may require liquid manure to be incorporated or injected in order to minimize air and water quality impacts.

~~C.~~**b**. Requests for application of liquid manure by means of irrigation will be reviewed by the Board of Adjustment on a site-specific basis. Impact on air and water quality will be taken into consideration.

~~A.~~**c**. The following manure application setbacks apply to all classes of Concentrated Animal Feeding Operations.

COUNTY MANURE APPLICATION SETBACKS

CATEGORY	**SURFACE IRRIGATION APPLIED**	**INCORPORATED OR INJECTED**
Lake, Rivers and Streams Classified as Fisheries	300 feet	100 feet (lake) 50 feet (river & stream)
Streams and Lakes Classified as Drinking Water Supplies	1000 feet	300 feet
Public Roads	25 feet (surface) from right-of-way 300 feet (irrigation)	10 feet from right-of-way
Area of 10 or more Residences	300 feet (surface) 1,000 feet (irrigation)	300 feet
Public Wells	1000 feet	1000 feet
Private Shallow Wells	250 feet	250 feet
A Residence other than the Operator	300 feet (surface) 1,000 feet (irrigation)	300 feet

Natural or Manmade Drainage	200 feet	50 feet

8. Standards for ~~Special Exceptions~~ Conditional Uses

a. The County Board of Adjustment may request information relating to a Concentrated Animal Feeding Operation not contained in these regulations.

b. The County Board of Adjustment may impose, in addition to the standards and requirements set forth in these regulations additional conditions which the Board of Adjustment considers necessary to protect the public health, safety and welfare.

c. ~~Special Exceptions~~ **Conditional Uses** shall be in effect only as long as sufficient land specified for spreading purposes is available for such purposes and other provisions of the permit are being adhered to.

d. When considering an application, the County Board of Adjustment will take into consideration current and past violations relating to Concentrated Animal Feeding Operations that the applicant has an interest in.

e. Permit applicants will be required to file a letter of assurances as required by the Board of Adjustment. The letter of assurances will be prepared by the zoning officer and signed by both the applicant and the zoning officer. The permit for the concentrated animal feeding operation is based upon compliance with the regulations herein, and letter of assurances. Any violation of the regulations or non compliance with the letter of assurances shall be cause for revoking a permit. Permit applicants will be notified by registered mail and a hearing before the board of adjustment will be held concerning status of the permit. The Board of Adjustment shall either revoke the permit or set a time line for compliance. If compliance is not met, the permit shall be revoked and the permit holder ordered to cease operations.

9. Information Required for Class 1 and 2 Concentrated Animal Feeding Operation Permit.

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

b. Legal descriptions of site and site plan.

c. Number and type of animals.

d. Nutrient management plan.

e. Manure management and operation plan.

f. Management plan for fly and odor control.

g. Information on ability to meet suggested setbacks and separation distance including site plan to scale.

h. General permit from South Dakota Department of Environment & Natural Resources if available for animal species.

i. Review of plans and specifications and nutrient management plan by the South Dakota Department of Environment & Natural Resources.

j. Information on soils, shallow aquifers, designated wellhead protection areas, and 100-year floodplain designation.

k. Notification of whomever maintains the access road (township, county and state). Notification of public water supply officials.

l. Any other information as contained in the application and requested by the County Zoning Officer.

10. Information Required for Class 3 and 4 Concentrated Animal Feeding Operation Permit.

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

b. Legal descriptions of site and site plan.

c. Number and type of animals.

d. Nutrient management plan.

e. Manure management and operation plan.

f. Management plan for fly and odor control.

g. Information on ability to meet suggested setbacks and separation distance, including site plan to scale.

h. Review of plans and specifications and nutrient management plan by the South Dakota Department of Environment & Natural Resources if using lagoon or earthen storage basin.

i. Information on soils, shallow aquifers, designated wellhead protection areas, and 100-year floodplain designation.

j. Notification of whomever maintains the access road (township, county and state). Notification of public water supply officials.

k. Any other information as contained in the application and requested by the County Zoning Officer.

CHAPTER 5.~~15~~22. WIND ENERGY SYSTEM (WES) REQUIREMENTS.

Section 5.~~15~~22.01.A Applicability.

~~A.~~**1.** The requirements of these regulations shall apply to all WES facilities except private facilities with a single tower height of less than seventy-five (75) feet and used primarily for on-site consumption of power.

Section 5.~~15~~22.02.~~B~~ Federal And State Requirements.

~~A.~~**1.** All WESs shall meet or exceed standards and regulations of the Federal Aviation and South Dakota State Statutes and any other agency of federal or state government with the authority to regulate WESs.

Section 5.~~15~~22.03.~~C~~ General Provisions.

~~A.~~**1.** Mitigation Measures

a. Site Clearance. The permittees shall disturb or clear the site only to the extent necessary to assure suitable access for construction, safe operation and maintenance of the WES.

b. Topsoil Protection. The permittees shall implement measures to protect and segregate topsoil from subsoil in cultivated lands unless otherwise negotiated with the affected landowner.

c. Compaction. The permittees shall implement measures to minimize compaction of all lands during all phases of the project's life and shall confine compaction to as small an area as practicable.

d. Livestock Protection. The permittees shall take precautions to protect livestock during all phases of the project life.

e. Fences. The permittees shall promtply replace or repair all fences and gates removed or damaged during all phases of the project's life unless otherwise negotiated with the affected landowner.

f. Roads

i. Public Roads. Prior to commencement of construction, the permittees shall identify all state, county or township "haul roads" that will be used for the WES project and shall notify the state, county or township governing body having jurisdiction over the roads to determine if the haul roads identified are acceptable. The governmental body shall be given adequate time to inspect the haul roads prior to use of these haul roads. Where practical, existing roadways shall be used for all activities associated with the WES. Where practical, all-weather roads shall be used to deliver cement, turbines, towers, assemble nacelles and all other heavy components to and from the turbine sites.

ii. The permittees shall, prior to the use of approved haul roads, make satisfactory arrangements with the appropriate state, county or township governmental body having jurisdiction over approved haul roads for construction of the WES for the maintenance and repair of the haul roads that will be subject to extra wear and tear due to transportation of equipment and WES components. The permittees shall notify the County of such arrangements upon request of the County.

iii. Turbine Access Roads. Construction of turbine access roads shall be minimized. Access roads shall be low profile roads so that farming equipment can cross them and shall be covered with Class 5 gravel or similar material. When access roads are constructed across streams and drainageways, the access roads shall be designed

in a manner so runoff from the upper portions of the watershed can readily flow to the lower portion of the watershed.

iv. Private Roads. The permittees shall promptly repair private roads or lanes damaged when moving equipment or when obtaining access to the site, unless otherwise negotiated with the affected landowner.

v. Control of Dust. The permittees shall utilize all reasonable measures and practices of construction to control dust.

g. Soil Erosion and Sediment control Plan. The permittees shall develop a Soil Erosion and Sediment Control Plan prior to construction and submit the plan to the County. The Soil Erosion and Sediment Control Plan shall address the erosion control measures for each project phase, and shall at a minimum identify plans for grading, construction and drainage of roads and turbine pads; necessary soil information; detailed design features to maintain downstream water quality; a comprehensive revegetation plan to maintain and ensure adequate erosion control and slop stability and to restore the site after temporary project activities; and measures to minimize the area of surface disturbance. Other practices shall include containing excavated material, protecting exposed soil, stabilizing restored material and removal of silt fences or barriers when the area is stabilized. The plan shall identify methods for disposal or storage of excavated material.

d. Setbacks. Wind turbines shall meet the following minimum spacing requirements.

a. Distance from existing off-site residences, business**es, churches,** and ~~public~~ buildings **owned and/or maintained by a governmental entity** shall be **at least** one thousand (1,000) feet. Distance from on-site or lessor's residence shall be **at least** five hundred (500) feet.

b. Distance from centerline of public roads shall be **at least** ~~two (2) times~~ **one hundred ten percent (110%)** the height of the wind turbines, measured from the ground surface to the tip of the blade when in a fully vertical position.

c. Distance from any property line shall be **at least** ~~two (2) times~~ **one hundred ten percent (110%)** the height of the wind turbine, measured from the ground surface to the tip of the blade when in a fully vertical position unless wind easement has been obtained from adjoining property owner.

e. Electromagnetic Interference. The permittees shall not operate the WES so as to cause microwave, television, radio, or navigation interference contrary to Federal Communications Commission (FCC) regulations or other law. In the event such interference is caused by the WES or its operation, the permittees shall take the measures necessary to correct the problem.

f. Lighting. Towers shall be marked as required by the Federal Aviation Administration (FAA). There shall be no lights on the towers other than what is required by the FAA. This restriction shall not apply to infrared heating devices used to protect the monitoring equipment.

g. Turbine Spacing. The turbines shall be spaced **no closer** than three (3) rotor diameters (RD) **(measurement of blades tip to tip)** within a string ~~and 10 RDs between strings~~. If required during final micro siting of the turbines to account for topographic conditions, up to

ten (10**)** percent of the towers may be sited closer than the above spacing but the permittees shall minimize the need to site the turbines closer.

h. Footprint Minimization. The permittees shall design and construct the WES so as to minimize the amount of land that is impacted by the WES. Associated facilities in the vicinity of turbines such as electrical/electronic boxes, transformers and monitoring systems shall ~~to the greatest extent feasible~~ be mounted on the foundations used for turbine towers or inside the towers unless otherwise negotiated with the affected landowner.

i. ~~Electrical Cables~~ **Collector Lines**. **When located on private property, t**~~T~~he permittees shall place electrical lines, known as collectors, and communication cables underground **between the WES and the feeder lines** ~~when located on private property~~. **The exception to this requirement is when the total distance of the collectors from the substation require an overhead installation due to line loss of current from an underground installation.** Collectors and cables shall also be placed within or immediately adjacent to the land necessary for turbine access roads unless otherwise negotiated with the affected landowner. This paragraph does not apply to feeder lines.

j. Feeder Lines. The permittees shall place overhead electric lines, known as feeders, on public rights-of-way if a public right-of-way exists. Changes in routes may be made as long as feeders remain on ~~pubic~~ **public** rights-of-way and approval has been obtained from the governmental unit responsible for the affected right-of-way. If no public right-of-way exists, the permittees may place feeders on private property. When placing feeders on private property, the permittees shall place the feeder in accordance with the easement negotiated with the affected landowner. The permittees shall submit the site plan and engineering drawings for the feeder lines before commencing construction.

k. Decommissioning/Restoration/Abandonment

a. Decommissioning Plan. Within 120 days of completion of construction, the permittees shall submit to the County a decommissioning plan describing the manner in which the permittees anticipate decommissioning the project in accordance with the requirements of paragraph (b) below. The plan shall include a description of the manner in which the permittees will ensure that it has the financial capability to carry out these restoration requirements when they go into effect. The permittees shall ensure that it carries out its obligation to provide for the resources necessary to fulfill these requirements. The County may at any time request the permittees to file a report with the County describing how the permittees are fulfilling this obligation.

b. Site Restoration. Upon expiration of this permit, or upon earlier termination of operation of the WES, the permittees shall have the obligation to dismantle and remove from the site all towers, turbine generators, transformers, **overhead collector and feeder lines,** ~~overhead and underground cables,~~ foundations, buildings and ancillary equipment to a depth of four **(4)** feet. To the extent possible the permittees shall restore and reclaim the site to its pre-project topography and topsoil quality. All access roads shall be removed unless written approval is given by the affected landowner requesting that one or more roads, or portions thereof, be retained. Any agreement for removal to a lesser depth or for no removal shall be recorded with the County and shall show the locations of all such foundations. All such agreements between the permittees and the affected landowner shall be submitted to the County prior to completion of restoration activities. The site shall be restored in accordance with the requirements of this condition within eighteen **(18)** months after expiration.

c. Abandoned Turbines. The permittees shall advise the County of any turbines that are abandoned prior to termination of operation of the WES. The County may require the permittees to decommission any abandoned turbine.

10. Height from Ground Surface. The minimum height of blade tips, measured from ground surface when a blade is in fully vertical position, shall be twenty-five (25) feet.

11. Towers.

a. Color and Finish. The finish of the exterior surface shall be non-reflective and non-glass.

b. All towers shall be singular tubular design.

12. Noise. Noise level shall not exceed 50 dBA, **average A-weighted Sound pressure** including constructive interference effects at the property line of existing off-site residences, businesses, and ~~public~~ buildings **owned and/or maintained by a governmental entity.**

13. Permit Expiration. The permit shall become void if no substantial construction has been completed within three (3) years of issuance.

14. Required Information for Permit.

a. Boundaries of the site proposed for WES and associated facilities on United States Geological Survey Map or other map as appropriate.

b. Map of easements for WES.

c. Map of occupied residential structures, businesses, **churches,** and ~~public~~ buildings **owned and/or maintained by a governmental entity**.

d. Map of sites for WES, access roads and utility lines.

e. Location of other WES in general area.

f. Project schedule.

g. Mitigation measures.

h. Haul road agreements

i. Haul road agreements will state that collector and feeder lines will not be trenched across public roads or public road right-of-ways.

CHAPTER 5.~~16~~23 WILLOW CREEK FLOOD DAMAGE PREVENTION.

The Codington County Planning Commission and County Commissioners shall require an applicant who requests a use permit or plat in the geographic area identified within the scientific and engineering report entitled “Willow Creek Floodplain Study” to follow the requirements found within the City of Watertown’s Willow Creek Flood Damage Prevention Ordinance (Adopted by the City of Watertown on April 2, 2001),

CHAPTER 5.~~17~~24 WIRELESS TELECOMMUNICATIONS TOWERS AND FACILITIES.

Section 5.~~17~~24.01. Purposes.

1. The general purpose of this Section is to regulate the placement, construction, and modification of Towers and Telecommunications Facilities in order to protect the health, safety, and welfare of the public, while at the same time not unreasonably interfering with the development of the competitive wireless telecommunications marketplace in the County. Specifically, the purposes of this Ordinance are:

    a. To regulate the location of Towers and Telecommunications Facilities in the County;

    b. To protect residential areas and land uses from potential adverse impact of Towers and Telecommunications Facilities;

    c. To minimize adverse visual impact of Towers and Telecommunications Facilities through careful design, siting, landscaping, and innovative camouflaging techniques;

    d. To promote and encourage shared use/collocation of Towers and Antenna Support Structures as a primary option rather than construction of additional single-use Towers;

    e. To promote and encourage utilization of technological designs that will either eliminate or reduce the need for erection of new Tower structures to support antenna and Telecommunications Facilities;

    f. To avoid potential damage to property caused by Towers and Telecommunications Facilities by ensuring such structures are soundly and carefully designed, constructed, modified, maintained, and removed when no longer used or are determined to be structurally unsound; and

    g. To ensure that Towers and Telecommunications Facilities are compatible with surrounding land uses.

~~**Section 5.17.1. Definitions.**~~

~~The following words, terms, and phrases, when used in this Section, shall have the meanings ascribed to them in this Section, except where the context clearly indicates a different meaning:~~

~~A. Antenna Support Structure means any building or structure other than a Tower which can be used for location of Telecommunications Facilities.~~

~~B. Applicant means any Person that applies for a Tower development permit.~~

~~C. Application means the process by which the Owner of a parcel of land within the County submits a request to develop, construct, build, modify, or erect a Tower upon such parcel of land. Application includes all written documentation, verbal statements, and representations, in whatever form or forum, made by an Applicant to the County concerning such a request.~~

~~D. Engineer means any engineer licensed by the State of South Dakota.~~

~~E. Owner means any Person with fee title or a long-term (exceeding ten (10) years) leasehold~~

~~to any parcel of land within the County who desires to develop, or construct, build, modify, or erect a Tower upon such parcel of land.~~

~~F. Person is any natural person, firm, partnership, association, corporation, company, or other legal entity, private or public, whether for profit or not for profit.~~

~~G. Stealth means any Tower or Telecommunications Facility which is designed to enhance compatibility with adjacent land uses, including, but not limited to, architecturally screened roof-mounted antennas, antennas integrated into architectural elements, and Towers designed to look other than like a Tower such as light poles, power poles, and trees. The term Stealth does not necessarily exclude the use of uncamouflaged lattice, guyed, or monopole Tower designs.~~

~~H. Telecommunications Facilities means any cables, wires, lines, wave guides, antennas, and any other equipment or facilities associated with the transmission or reception of communications which a Person seeks to locate or has installed upon or near a Tower or Antenna Support Structure. However, Telecommunications Facilities shall not include:~~

~~3. Any satellite earth station antenna two (2) meters in diameter or less which is located in an area zoned industrial or commercial; or~~

~~4. Any satellite earth station antenna one (1) meter or less in diameter, regardless of zoning category.~~

~~I. Tower means a self-supporting lattice, guyed, or monopole structure constructed from grade which supports Telecommunications Facilities. The term Tower shall not include amateur radio operators' equipment, as licensed by the FCC.~~

Section 5.~~17~~24.02. Development of Towers.

~~A.~~**1.** Towers are exempt from the maximum height restrictions of the districts where located. Towers shall be permitted to a height of one hundred and fifty (150) feet. Towers may be permitted in excess of one hundred and fifty (150) feet in accordance with "Criteria for Site Plan Development Modifications."

~~B.~~**2.** No new Tower shall be built, constructed, or erected in the County unless the Tower is capable of supporting three other Persons' operating Tele-communications Facilities comparable in weight, size, and surface area to the Telecommunications Facilities installed by the Applicant on the Tower within six (6) months of the completion of the Tower construction. No tower shall charge co-location fees in excess of commercially reasonable industry amounts. Each tower constructed shall upon the request of Codington County mount law-enforcement or public safety communications apparatus.

~~C.~~**3.** An application to develop a Tower shall include:

~~1.~~**a.** The name, address, and telephone number of the Owner and lessee of the parcel of land upon which the Tower is situated. If the Applicant is not the Owner of the parcel of land upon which the Tower is situated, the written consent of the Owner shall be evidenced in the Application.

~~2.~~**b.** The legal description, folio number, and address of the parcel of land upon which the Tower is situated.

~~3.~~**c.** The names, addresses, and telephone numbers of all owners of other Towers or usable Antenna Support Structures within a one-half (½) mile radius of the proposed new Tower site, including County-owned property.

~~4.~~**d.** A description of the design plan proposed by the Applicant. Applicant must identify its utilization of the most recent technological design, including microcell design, as part of the design plan. The Applicant must demonstrate the need for Towers and why design alternatives, such as the use of microcell, cannot be utilized to accomplish the provision of the Applicant's telecommunications services.

~~5.~~**e.** An affidavit attesting to the fact that the Applicant made diligent, but unsuccessful, efforts to install or collocate the Applicant's Telecommunications Facilities on Towers or usable Antenna Support Structures owned by other Persons located within a one-half (½) mile radius of the proposed Tower site. In the event that one reason for the unsuccessful efforts to install or collocate is that fees to be charged are not commercially reasonable, an explanation shall be provided why said charges are commercially reasonable.

~~6.~~**f.** Written technical evidence from an Engineer(s) that the proposed Tower or Telecommunications Facilities cannot be installed or collocated on another person's Tower or usable Antenna Support Structures owned by other Persons located within one-half (½) mile radius of the proposed Tower site.

~~7.~~**g.** A written statement from an Engineer(s) that the construction and placement of the Tower will not interfere with public safety communications and the usual and customary transmission or reception of radio, television, or other communications services enjoyed by adjacent residential and non-residential properties.

~~8.~~**h** Written, technical evidence from an Engineer(s) that the proposed structure meets the standards set forth in, "Structural Requirements," of this Ordinance.

~~9.~~**i.** Written, technical evidence from a qualified Engineer(s) acceptable to the Fire Marshall and the building official that the proposed site of the Tower or Telecommunications Facilities does not pose a risk of explosion, fire, or other danger to life or property due to its proximity to volatile, flammable, explosive, or hazardous materials such as LP gas, propane, gasoline, natural gas, or corrosive or other dangerous chemicals.

~~10.~~**j.** The Act gives the FCC sole jurisdiction of the field of regulation of RF emissions and does not allow the County to condition or deny on the basis of RF impacts the approval of any Telecommunications Facilities (whether mounted on Towers or Antenna Support Structures) which meet FCC standards. In order to provide information to its citizens, the County shall make available upon request copies of ongoing FCC information and RF emission standards for Telecommunications Facilities transmitting from Towers or Antenna Support Structures. Applicants shall be required to submit information on the proposed power density of their proposed Telecommunications Facilities and demonstrate how this meets FCC standards.

~~10.~~**j.** No application shall be accepted from landowners or on property on which there are current or past unresolved violations outstanding.

~~11.~~**k.** The Board of Adjustment may require an Applicant to supplement any information that the Board considers inadequate or that the Applicant has failed to supply. The Board of

Adjustment may deny an Application on the basis that the Applicant has not satisfactorily supplied the information required in this subsection. Applications shall be reviewed by the Board in a prompt manner and all decisions shall be supported in writing setting forth the reasons for approval or denial.

Section 5. ~~17~~24.03. Setbacks.

~~A.~~**1.** All Towers up to one-hundred (100) feet in height shall be set back on all sides a distance equal to the underlying setback requirement in the applicable zoning district.

~~B.~~**2.** Towers in excess of one hundred (100) feet in height shall ~~be set back one (1) additional foot per each foot of Tower height in excess of one hundred (100) feet~~ **meet the following**.

a. Distance from existing off-site residences, business and public buildings shall be one thousand (1,000) feet. Distance from on-site or lessor's residence shall be five hundred (500) feet.

b. Distance from public right-of-way shall be the height of the tower.

c. Distance from any property line shall be the height of the tower.

~~C.~~**3.** Setback requirements for Towers shall be measured from the base of the Tower to the property line of the parcel of land on which it is located.

~~D.~~**4.** Setback requirements may be modified, as provided herein, when placement of a Tower in a location which will reduce the visual impact can be accomplished. For example, adjacent to trees which may visually hide the Tower.

Section 5. ~~17~~24.04. Structural Requirements.

~~A.~~**1.** All Towers must be designed and certified by an Engineer to be structurally sound and, at minimum, in conformance with the Building Code, and any other standards outlined in this Ordinance. All Towers in operation shall be fixed to land.

Section 5. ~~17~~24.05. Separation of Buffer Requirements.

For the purpose of this Section, the separation distances between Towers shall be measured by drawing or following a straight line between the base of the existing or approved structure and the proposed base, pursuant to a site plan of the proposed Tower.

Proposed Towers must meet the following minimum separation requirements from existing Towers or Towers which have a development permit but are not yet constructed at the time a development permit is granted pursuant to this Ordinance:

1. Monopole Tower structures shall be separated from all other Towers, whether monopole, self-supporting lattice, or guyed, by a minimum of seven hundred and fifty (750) feet.

2. Self-supporting lattice or guyed Tower structures shall be separated from all other self-supporting or guyed Towers by a minimum of fifteen hundred (1,500) feet.

3. Self-supporting lattice or guyed Tower structures shall be separated from all monopole Towers by a minimum of seven hundred and fifty (750) feet.

4. The separation requirements contained in 5.24.05 shall not be required of existing Towers or Towers which have a development permit but are not yet constructed at the time a development permit is granted pursuant to this Ordinance.

Section 5.~~17~~24.06. Method Of Determining Tower Height.

1.Measurement of Tower height for the purpose of determining compliance with all requirements of this Section shall include the Tower structure itself, the base pad, and any other Telecommunications Facilities attached thereto which extend more than twenty (20) feet over the top of the Tower structure itself. Tower height shall be measured from grade.

Section 5.~~17~~24.07. Illumination.

1. Towers shall not be artificially lighted except as required by the Federal Aviation Administration (FAA). Upon commencement of construction of a Tower, in cases where there are residential uses located within a distance which is three hundred (300) percent of the height of the Tower from the Tower and when required by federal law, dual mode lighting shall be requested from the FAA.

Section 5.~~17~~24.08. Exterior Finish.

1.Towers not requiring FAA painting or marking shall have an exterior finish which enhances compatibility with adjacent land uses, as approved by the appropriate reviewing body.

Section 5.~~17~~24.09. Modification Of Towers.

~~A.~~**1.**A Tower existing prior to the effective date of this Ordinance, which was in compliance with the Count's zoning regulations immediately prior to the effective date of this Ordinance, may continue in existence as a nonconforming structure. Such nonconforming structures may be modified or demolished and rebuilt without complying with any of the additional requirements of this Section, except for Sections "Separation or Buffer Requirements", "Certification and Inspections", and "Maintenance," provided:

~~1.~~**a**.The Tower is being modified or demolished and rebuilt for the sole purpose of accommodating, within six (6) months of the completion of the modification or rebuild, additional Telecommunications Facilities comparable in weight, size, and surface area to the discrete operating Telecommunications Facilities of any Person currently installed on the Tower.

~~2.~~**b** An Application for a development permit is made to the Board of Adjustment which shall have the authority to issue a development permit without further approval. The grant of a development permit pursuant to this Section allowing the modification or demolition and rebuild of an existing nonconforming Tower shall not be considered a determination that the modified or demolished and rebuilt Tower is conforming.

~~3.~~**c** The height of the modified or rebuilt Tower and Telecommunications Facilities attached thereto do not exceed the maximum height allowed under this Ordinance.

~~B.~~**2.**A Except as provided in this Section, a nonconforming structure or use may not be enlarged, increased in size, or discontinued in use for a period of more than one hundred eighty (180) days. This Ordinance shall not be interpreted to legalize any structure or use

existing at the time this Ordinance is adopted which structure or use is in violation of the Code prior to enactment of this Ordinance.

Section 5. ~~17~~24.10. Certifications And Inspections.

~~A.~~**1.** All Towers shall be certified by an Engineer to be structurally sound and in conformance with the requirements of this ordinance and all other construction standards set forth by federal and state law. For new monopole Towers, such certification shall be submitted with an Application pursuant to of this Ordinance and every five (5) years thereafter. For existing monopole Towers, certification shall be submitted within sixty (60) days of the effective date of this Ordinance and then every five (5) years thereafter. For new lattice or guyed Towers, such certification shall be submitted with an Application pursuant to of this Ordinance and every two (2) years thereafter. For existing lattice or guyed Towers, certification shall be submitted within sixty (60) days of the effective date of this Ordinance and then every two (2) years thereafter. The Tower owner may be required by the County to submit more frequent certifications should there be reason to believe that the structural and electrical integrity of the Tower is jeopardized.

~~B.~~**2.** The County or its agents shall have authority to enter onto the property upon which a Tower is located, between the inspections and certifications required above, to inspect the Tower for the purpose of determining whether it complies with this ordinance and all other construction standards provided by federal and state law.

~~C.~~**3.** The County reserves the right to conduct such inspections at any time, upon reasonable notice to the Tower owner. All expenses related to such inspections by the County shall be borne by the Tower owner.

Section 5. ~~17~~24.11. Maintenance.

~~A.~~**1.** Tower owners shall at all times employ ordinary and reasonable care and shall install and maintain in use nothing less than commonly accepted methods and devices for preventing failures and accidents which are likely to cause damage, injuries, or nuisances to the public.

~~B.~~**2.** Tower owners shall install and maintain Towers, Telecommunications Facilities, wires, cables, fixtures, and other equipment in substantial compliance with the requirements of the National Electric Safety Code and all FCC, state, and local regulations, and in such manner that will not interfere with the use of other property.

~~C.~~**3.** All Towers, Telecommunications Facilities, and Antenna Support Structures shall at all times be kept and maintained in good condition, order, and repair so that the same shall not menace or endanger the life or property of any Person.

~~D.~~**4.** All maintenance or construction of Towers, Telecommunications Facilities, or Antenna Support Structures shall be performed by licensed maintenance and construction personnel.

~~E.~~**5.** All Towers shall maintain compliance with current RF emission standards of the FCC.

~~F.~~**6.** In the event that the use of a Tower is discontinued by the Tower owner, the Tower owner shall provide written notice to the County of its intent to discontinue use and the date when the use shall be discontinued.

Section 5. ~~17.~~24.12. Criteria For Site Plan Development Modifications.

~~A.~~**1.** Notwithstanding the Tower requirements provided in this Ordinance, a modification to the requirements may be approved by the Board of Adjustment as a ~~Special Exception~~ **Conditional use** in accordance with the following:

~~1.~~**a.** In addition to the requirement for a Tower Application, the Application for modification shall include the following:

~~a.~~**i.** A description of how the plan addresses any adverse impact that might occur as a result of approving the modification.

~~b.~~**ii.** A description of off-site or on-site factors which mitigate any adverse impacts which might occur as a result of the modification.

~~c.~~ii**i.** A technical study that documents and supports the criteria submitted by the Applicant upon which the request for modification is based. The technical study shall be certified by an Engineer and shall document the existence of the facts related to the proposed modifications and its relationship to surrounding rights-of-way and properties.

~~d.~~**iv.** For a modification of the setback requirement, the Application shall identify all parcels of land where the proposed Tower could be located, attempts by the Applicant to contract and negotiate an agreement for collocation, and the result of such attempts.

~~e.~~**v.** The Board of Adjustment may require the Application to be reviewed by an independent Engineer under contract to the County to determine whether the antenna study supports the basis for the modification requested. The cost of review by the County's Engineer shall be reimbursed to the County by the Applicant.

b. The Board of Adjustment shall consider the Application for modification based on the following criteria:

~~a.~~**i.** That the Tower as modified will be compatible with and not adversely impact the character and integrity of surrounding properties.

~~b.~~**ii.** Off-site or on-site conditions exist which mitigate the adverse impacts, if any, created by the modification.

~~c.~~ii**i.** In addition, the board may include conditions on the site where the Tower is to be located if such conditions are necessary to preserve the character and integrity of the neighborhoods affected by the proposed Tower and mitigate any adverse impacts which arise in connection with the approval of the modification.

~~B.~~**2.** In addition to the requirements of subparagraph (A) of this Section, in the following cases, the Applicant must also demonstrate, with written evidence, the following:

~~1.~~**a.** In the case of a requested modification to the setback requirement, that the setback requirement cannot be met on the parcel of land upon which the Tower is proposed to be located and the alternative for the Person is to locate the Tower at another site which is closer in proximity to a residentially zoned land.

~~2.b.~~**b.** In the case of a request for modification of the separation and buffer requirements from residential use of land of , if the Person provides written technical evidence from an Engineer(s) that the proposed Tower and Telecommunications Facilities must be located at the proposed site in order to meet the coverage requirements of the Applicant's wireless communications system and if the Person is willing to create approved landscaping and other buffers to screen the Tower from being visible to residentially used property.

~~3.c.~~**c.** In the case of a request for modification of the height limit for Towers and Telecommunications Facilities or to the minimum height requirements for Antenna Support Structures, that the modification is necessary to:

~~a.~~**i.** facilitate collocation of Telecommunications Facilities in order to avoid construction of a new Tower; or

~~b.~~**ii.** To meet the coverage requirements of the Applicant's wireless communications system, which requirements must be documented with written, technical evidence from an Engineer(s) that demonstrates that the height of the proposed Tower is the minimum height required to function satisfactorily, and no Tower that is taller than such minimum height shall be approved.

Section 5. ~~17.20~~**24.13. Abandonment.**

~~A.~~**1.** If any Tower shall cease to be used for a period of **three hundred sixty-five** (365) consecutive days, the Codington County Planning Commission shall notify the Owner, with a copy to the Applicant, that the site will be subject to a determination by the Codington County Planning Commission that such site has been abandoned. The Owner shall have thirty (30) days from receipt of said notice to show, by a preponderance of the evidence, that the Tower has been in use or under repair during the period. If the Owner fails to show that the Tower has been in use or under repair during the period, the Codington County Planning Commission shall issue a final determination of abandonment for the site. Upon issuance of the final determination of abandonment, the Owner shall, within seventy-five (75) days, dismantle and remove the Tower.

~~B.2.~~ To secure the obligation set forth in this Section, the Applicant [and/or Owner] may be required to post a bond.

CHAPTER 5.25. SOIL EROSION AND SEDIMENTATION CONTROL.

1. **Before issuing a building permit, the Zoning Officer may require a filing of a certificate of intent to adhere to the county soil loss standards developed by the Codington County Conservation District. The Zoning Officer shall consult the Codington County Soil Erosion and Sedimentation Control Ordinance that was developed pursuant to SDCL 38-8A before determining if the proposed activity requires such a certificate of intent.**

2. **If a complaint is received regarding a violation of the county soil loss standards caused by non-agricultural activity, the Zoning Officer shall undertake those actions outlined herein in order to bring about compliance.**

CHAPTER 5.26. MINERAL EXPLORATION AND DEVELOPMENT.

Separate permits are required for mineral extraction and milling. The applicant for a permit must meet the following minimal conditions as they pertain to the permit for which application is made.

1. The applicant shall provide:

   a. A description of the mineral or minerals which are the subject of the mining or milling.

   b. Maps showing the general area within which the mining or milling operation will be conducted.

   c. A detailed description of the regional environmental conditions, to include surface land use and vegetation as well as a detailed description of the area's geologic formations and hydrology from the best available scientific sources are required for mining or milling permits.

   d. An environmental assessment which establishes base line conditions for radioactive and toxic material in air, ground and surface water, soil, vegetation and animals is required for mining or milling permits.

   e. The applicant shall provide maps indicating the location of the affected sites to the nearest section of land, a technical description of the mining or milling process, the types of equipment to be used, and the estimated timetable for each phase of work and for final completion of the program.

   f. A description of the major environmental impacts upon air quality, water quality and quantity, and land use modification presented by the proposed mining or milling.

   g. A description of the proposed plan to address the identified environmental impacts to include all measures to be taken to prevent soil erosion, water contamination, air contamination, disruption of the area's ecological balance and any other related hazard to public health and safety.

2. The applicant shall provide for a plan for land reclamation of the land after mining is completed. Measures to be taken for surface reclamation shall take into account the impact on adjacent land uses and natural resources, and the proposed future use of the lands mined and adjacent lands. The reclamation plan shall include:

   a. A reclamation schedule.

   b. Methods of plugging drill holes.

   c. Methods of severing and returning topsoil and subsoil.

   d. Methods of grading, backfilling and contouring of exploration sites, access roads, and mining sites.

   e. Methods of waste management and disposal, including liquid and solid wastes.

f. Method of revegetation.

The applicant may be required to post a surety performance bond in an amount to be determined by the County Commission to assure that sufficient funds will be available to carry out required reclamation and, if necessary, decontamination of affected ground and surface waters. The amount shall be set by the County Commission based on an estimate of the cost of reclamation and decontamination. The bond shall be released five (5) years after mining and milling has ceased unless the Commissioners find, for good cause shown, that the water quality of the affected area has not been restored or the reclamation plan has not been completed. The amount of the surety bond may be reduced by the Commissioners if a bond is held by the State of South Dakota for the same purpose, by the same amount of the latter bond.

3. **The applicant shall identify specific phases when monitoring and inspection of the mining and milling activities shall be conducted by County, State, or Federal personnel or their representatives to assure compliance with all applicable rules and regulations. If the special use permit is granted, the permit shall identify such inspection and it shall be the responsibility of the applicant to notify said agency when monitoring or inspection is required. The applicant shall bear the burden of the cost of the monitoring and inspection program as determined by the Planning and Zoning Commission.**

4. **A conditional use permit shall be issued only after all conditions specified herein have been met. Evidence of violation of the regulations, including but not limited to air and water contamination, shall be cause for an immediate cessation of mining and milling activities.**

CHAPTER 5.27 AGRICULTURAL EASEMENT.

The following easement is to be utilized as required for farm and non-farm residential development within the Agricultural, Lake Park and Planned Residential Districts. **(See 3.04.03.9.a)**

Prepared by:
Codington County Zoning Officer (or by Grantor or Grantor's Attorney)
1910 West Kemp Avenue (or Grantor's or Grantor's Attorney's address)
Watertown, SD 57201 (or Grantor's or Grantor's Attorney's city)

~~MODEL~~ AGRICULTURAL EASEMENT

1. Purpose. This easement is required in the Agricultural District.

2. Easement.

   ("Grantors") are the owners of real property described as follows:

   _____

   _____

In accordance with the conditions set forth in the decision of Codington County, dated _____ 20____, approving a permit for a dwelling on the above described property, and in consideration of such approval, Grantors grant to the owners of all property adjacent to the above described property, a perpetual nonexclusive easement as follows:

a. The Grantors, their heirs, successors, and assigns acknowledge by the granting of this easement that the above described property is situated in an agricultural area and may be subjected to conditions resulting from commercial agricultural operations on adjacent lands. Such operations include the cultivation, harvesting, and storage of crops and livestock raising and the application of chemicals, operation of machinery, application of irrigation water, and other accepted and customary agricultural activities conducted in accordance with Federal and State laws. These activities ordinarily and necessarily produce noise, dust, smoke, and other conditions that may conflict with Grantors' use of Grantors' property for residential purposes. Grantors hereby waive all common law rights to object to normal and necessary agricultural management activities legally conducted on adjacent lands which may conflict with Grantors' use of Grantors' property for residential purposes, and Grantors hereby grant an easement to adjacent property owners for such activities.

b. Nothing in this easement shall grant a right to adjacent property owners for ingress or egress upon or across the described property. Nothing in this easement shall prohibit or otherwise restrict the Grantors from enforcing or seeking enforcement of statutes or regulations of governmental agencies for activities conducted on adjacent properties.

This easement is appurtenant to all property adjacent to the above described property and shall bind to the heirs, successors and assigns of Grantors and shall endure for the benefit of the adjoining landowners, their heirs, successors, and assigns. The adjacent landowners, their heirs, successors, and assigns are hereby expressly granted the right of third party enforcement of this easement.

IN WITNESS WHEREOF, the Grantors have executed this easement on _____, 20____.

_____
Signature, Grantor

STATE OF SOUTH DAKOTA
SS:
COUNTY OF CODINGTON

This instrument was acknowledged before me on _____, 20____ by _____ (Grantors).

_____Notary Public

My Commission Expires: _____

CHAPTER 5.~~19~~28. Range Requirements.

~~5.19.1 Definitions.~~

~~1. Archery Ranges are included as Ranges.~~

~~2. Firearm means a gun that discharges shot, bullet or other projectile by means of an explosive, gas, compressed air, or other propellant.~~

~~3. Range Officer means the person designated to be responsible at a Range at any given time during any activity.~~

~~4. A Range shall be defined as an area for the discharge of weapons for sport under controlled conditions where the object of the shooting is an inanimate object such as, but not limited to, paper, metal or wooden targets. A Range Officer shall be present on site at any Range when the range is in use.~~

Section 5.~~19~~28.0~~2~~1. Conditional Use Permits.(Added by Ord. #18, moved by Ord. #30)

No Range shall be established within the Codington County without first obtaining a ~~Special Exception~~ Conditional Use Permit.

Section 5.~~19~~28.0~~3~~2 General Regulations for All Ranges.

No ~~Special Exception~~ Conditional Use Permit shall be approved for any Range unless all of the following conditions are met (unless specifically waived by the Board of Adjustment):

1. A safety plan shall be submitted along with the application. The plan, once approved, shall be posted in a prominent place at the site. Any changes to the safety plan shall be submitted to the County Board of Adjustment for approval. At a minimum the safety plan must state:

    a. A method of identifying the Range Officer when the Range Officer is present at the site. Additionally, a permanent log identifying the Range Officer who is present when required at the facility must be maintained and available for inspection by the County or local law enforcement officers.

    b. The authority of Range Officers to carry out the rules and regulations on the site and to enforce penalties.

    c. The policy for the site for the use of alcohol.

    d. Controlled substances are prohibited on the site.

    e. Rules for the safe handling of weapons.

    f. A building and grounds maintenance plan.

    g. Administrative Rules to include regulations that normally govern range schedules, parking, guest policies, member/user responsibilities, hours of operation, security, program development, range supervision and other items such as sign-in procedures.

    h. Regulations on the type of weapon, shooting activity, caliber, shot size or type of target to ensure safety for range users and others.

i. The penalties that are in force for violations of the safety plan.

j. The method used to control trespass or unauthorized access to the range or preserve.

2. On an annual basis, applicants must provide proof of insurance.

3. Applicants shall continuously keep the City informed as to the current names and telephone numbers of the officers of any organization having an interest in the Range. Any changes to the names or telephone numbers of the officers shall be reported to the County within thirty (30) days of the change.

4. All Ranges must control entrance to their sites.

5. No alcohol licenses shall be granted to any site which has a Range.

6. Parking space for all members, owners or guests must be on-site and is not allowed on public streets or roads.

Section 5.~~19~~28.043 Special Regulations for Ranges. Applications for all Ranges, in addition to any other requirements of this Ordinance, must also show:

1. A survey delineating the layout of all individual Ranges.
2. Setbacks to all property lines.

3. Method of containing projectiles within each individual range (such as earthen berms or other method).

4. Methods to be employed to reduce noise, including impulse noise.

a. The maximum noise that may escape the range into areas not controlled by the owner is 125 dB.

5. All Ranges shall be designed using the NRA Range Source Book as a guideline.

Section 5.~~19~~28.05~~4~~ Application Requirements. Each application for a Range shall, at a minimum, include the following:

1. A description of specific activities to be conducted on-site.

2. The hours and days of operation.

3. The maximum number of people using the facility at any one time.

4. A plan, if applicable, for collecting and recycling used shot.

5. A delineation of any special events, if any.

6. A sewage, water and solid waste management plan.

Section 5.~~19~~28.06~~5~~ Area Regulations.

1. Minimum Lot Size: Ten (10) acres

2. Minimum Front Yard: One hundred fifty (150) feet

3. Minimum Side Yard: Three hundred (300) feet

4. Back of the Range Setback: A minimum of one thousand (1000) feet from any buildings and/or roads.

5. Setback from Residences: One-quarter (1/4) mile to be measured from the firing line to the nearest residential dwelling.

6. Setback from Commercial Uses: One-quarter (1/4) mile to be measured from the firing line to the nearest commercial structure.

7. Setback from Churches and Schools: One-quarter (1/4) mile to be measured from the firing line to the nearest church or school.

8. Setback from Municipalities: Three (3) miles to be measured from the firing line to the corporate limits of the municipality.

Section 5.~~19~~28.0~~7~~6. Miscellaneous Regulations.

1. In the event that any provision of this Ordinance or the ~~Special Exception~~ Conditional Use Permit is violated, or the County otherwise reasonably believes that the health, safety or general welfare of the public is endangered by the use, or if the County reasonably believes that a public nuisance has been created, then, upon ten (10) days written notice, the County may originate action to either modify or cancel any ~~Special Exception~~ Conditional Use Permit.

~~Chapter 5.29. Waiver of Setback from Existing Concentrated Animal Feeding Operation~~ (Chapter 5.29 Amended by Ord. #64)

CHAPTER 5.29. SINGLE FAMILY DWELLING (FARM OR NON-FARM) CONSTRUCTED LESS THAN ONE-HALF (1/2) MILE FROM AN EXISTING CONCENTRATED ANIMAL FEEDING OPERATION

Section 5.29.01. Single family dwelling (farm or non-farm) Constructed Less than One-Half (1/2) Mile from an existing Concentrated Animal Feeding Operation as a Conditional Use.

Applicants for a Single family dwelling (farm or non-farm) proposed to be constructed less than one-half (1/2) mile from an existing concentrated animal feeding operation may obtain a conditional use permit provided one of the following conditions is met:

1. Applicant obtains a written waiver from the owner/operator of any existing concentrated animal feeding operation which is closer than one-half (1/2) mile from the proposed residential building site.

2. Applicant files a document consistent with Section 5.29.02 with the Register of Deeds acknowledging the existence of a concentrated animal feeding operation less than

one-half mile from the proposed building site at the time of application for a building permit. Exception: This requirement does not apply to lots of record with existing residential development that are destroyed by an act of God (wind, fire, flood) and subsequently are rebuilt.

Section 5.29.02. Acknowledgement of Existing Concentrated Animal Feeding Operation

The following ~~waiver~~ acknowledgement is to be utilized as required for a conditional use permit in Section 5.29.01 for farm and non-farm residential development in the Agricultural District which is located within one-half (1/2) mile of an existing concentrated animal feeding operation.

Prepared by:
Codington County Zoning Officer (or by Grantor or Grantor's Attorney)
1910 West Kemp Avenue (or Grantor's or Grantor's Attorney's address)
Watertown, SD 57201 (or Grantor's or Grantor's Attorney's city)

ACKNOWLEDGEMENT OF ~~WAIVER OF SETBACK FROM~~
EXISTING CONCENTRATED ANIMAL FEEDING OPERATION

The following ~~waiver~~ acknowledgement is to be used when a dwelling (Farm or Non-Farm) is proposed to be constructed within one-half (1/2) mile of an existing Concentrated Animal Feeding Operation. The ~~waiver~~ acknowledgement shall be filed with the Register of Deeds. Grantors are the owner(s) of property applying for the proposed residential development. (See ~~3.04.03.9.b~~ 3.04.02.41 and 5.29.01.2)

1. Purpose. This ~~waiver~~ acknowledgement is required for any dwelling to be constructed within one-half (1/2) mile of an existing concentrated animal feeding operation as defined by the Codington County Zoning Ordinance.

2. Waiver:

("Grantors") are the owners of real property described as follows:
_____
In accordance with the conditions set forth in the decision of Codington County, dated _____ 20____, approving a plat with a residential dwelling development right or by the issuance of a permit for a residential dwelling either to be located within one-half (1/2) mile of the existing concentrated animal feeding operation located at the following property,
_____
and in consideration of such approval, Grantors ~~agree to the perpetual non-exclusive easement as follows~~ acknowledge the following:

1. The Grantors, their heirs, successors, and assigns acknowledge that the location of a residential development/dwelling on (legal description) is within one-half (1/2) mile of an existing concentrated animal feeding operation. ~~This easement waives the Grantors, their heirs, successors, and assigns common law rights to object to the existing concentrated animal feeding operation's, located at the above legal description, potential need for a variance from the setback requirements of the Codington County Zoning Ordinance.~~

2. ~~Further, t~~The grantors hereby ~~waive all common law rights to appeal any decision of Codington County Board of Adjustment relating to the issuance of a variance regarding separation setbacks from the existing concentrated animal feeding operation located at above legal description.~~ acknowledge that the construction of this residence will not result in the existing concentrated animal feeding operation becoming a nonconforming use as defined by the Codington County Zoning Ordinance.

IN WITNESS WHEREOF, _____, 20__

Grantors (Print) _____

Grantors (Signature) _____

STATE OF SOUTH DAKOTA
_____ SS:
COUNTY OF CODINGTON

This instrument was acknowledged before me on _____, 20____ by _____ (Grantors).

_____ Notary Public

My Commission Expires: _____

CHAPTER 5.30. ADULT USE REGULATIONS.

In the development and execution of these regulations, it is recognized that there are some uses which because of their very nature, are recognized as having serious objectionable operational characteristics, particularly when several of them are concentrated under certain circumstances thereby having a deleterious effect upon the adjacent areas. Special regulation of these uses is necessary to ensure that these adverse effects will not contribute to the blighting or downgrading of the surrounding neighborhood. These special regulations are itemized in this section. The primary control or regulation is for the purpose of preventing a concentration of these uses in any one area.

Section 5.30.01 Setbacks.

1. None of the following uses may be established, operated or maintained within one thousand (1,000) feet of a residence, a church, a school meeting all the requirements of the Compulsory Education Laws of the State of South Dakota, or a public park.

   a. Adult bookstore.

   b. Adult motion picture theater.

   c. Adult photo studio.

   d. Adult Entertainment Facility.

e. Any use which has as a part of its operation an adult use component including but not limited to, a restaurant or eating place, a bar, lounge or tavern.

f. Any use intended to provide adult amusement or entertainment.

2. Not more than two of the following uses may be established, operated or maintained within one thousand (1,000) feet of each other:

a. Adult bookstore.

b. Adult motion picture theater.

c. Adult photo studio.

d. Adult entertainment facility.

e. Any use which has as a part of its operation an adult use component including but not limited to, a restaurant or eating place, a bar, lounge or tavern.

f. Any use intended to provide adult amusement or entertainment.

g. A bar.

h. A liquor store.

3. The 1,000-foot restriction provided for in 5.30.01.2 above may be waived and a conditional use permit issued upon proper application if the Board of Adjustment finds:

a. That the proposed use will not be contrary to the public interest or injurious to nearby properties and that the spirit and intent of these regulations will be observed.

b. That the proposed use will not enlarge or encourage the development of a 'skid row' area.

c. That all applicable regulations will be observed.

Section 5.30.02. Required License.

It shall be unlawful for any person to engage in the business of operating an adult use in Codington County without first having obtained a license from the Codington County Commissioners.

Section 5.30.03 Application; Standards for Issuance.

1. Application for an adult use license shall be made in writing and shall state the following:

a. The name, address, telephone number and age of the applicant and the registered agent of the applicant if the applicant is a corporation.

b. The location of the adult use business.

c. The exact nature of the adult use to be conducted and of the proposed place of business and the facilities related thereto.

d. A statement by the applicant that he is familiar with the provisions of this article and is in compliance with them.

e. A statement of whether the business will be conducted by a manager and, if so, the name, address, telephone number, and age of each such manager.

f. A statement that no manager or principal operating the business has been convicted of any offense of prostitution, soliciting for prostitution, or obscenity or public indecency as defined in the South Dakota Compiled Statutes within the last two (2) years, and that the applicant has not had any license for an adult use in any other community revoked within the last two (2) years.

2. Within fifteen (15) days after receipt of an application for an adult use license, the Codington County Commissioners shall investigate the information contained in the application and shall determine the following:

a. That the premises designated by the applicant as the location of the business are in full compliance with all applicable ordinances of Codington County, including zoning ordinances.

b. That the premises and each manager and employee comply with the provisions of Section 5.30.03.1 as such provisions apply to them.

c. That the applicant, each manager and each employee are over twenty-one (21) years of age.

d. That no manager or principal operator of the business has been convicted of any offense of prostitution, solicitation for prostitution, or obscenity or public indecency, as defined in the South Dakota Compiled Statutes within the last two (2) years, and that the applicant has not had any license for an adult use revoked within the last two (2) years.

3. If the investigation shows the compliance of the applicant for an adult use license, the premises upon which the business is to be conducted and each manager and employee, if applicable, with each of the requirements established in subsections (1) and (2) of this section, and with the conditions and regulations set forth in Section 5.30.03 within fifteen (15) days after completion of such investigation, the Codington County Commissioners shall issue a license, and upon payment by the applicant of the license fee required under this article, the license shall be issued.

4. If the investigation shows that the applicant for an adult use license, the premises on which the business is to be conducted, or the managers and employees, if applicable, do not comply with each of the requirements established in subsection (1) of this section, and with the conditions and regulations set forth in Section 5.30.03 within fifteen (15) days after completion of such investigation, the Codington County Commissioners shall notify the applicant in writing that the license has been denied. Such denial shall be the final administrative action of the County with respect to the

license application, and shall be subject to the immediate appeal by the applicant to the circuit court.

Section 5.30.04. Conditions & Regulations Governing Operation; Violation; Penalty.

1. The following regulations shall govern and control the business of operating an adult use in Codington County:

   a. No person under twenty-one (21) years of age shall be allowed on the licensed premises.

   b. At all times during the hours of operation there shall be present a manager or other employee of the licensee who shall be not less than twenty-one (21) years of age.

   c. Upon a change of any manager conducting business for the licensee, the licensee shall, within ten regular business days, give the County Commissioners written notice of such change by actual delivery or by registered or certified mail. The licensee shall, thereafter, as promptly as practicable, but in any event within five (5) regular business days, provide the information concerning the new manager which is required in Section 5.30.03.

   d. No adult use shall be located on-premises for which a license to sell alcoholic liquor has been issued, and no alcoholic liquor shall be permitted on such premises.

   e. No adult use shall be permitted unless the premises on which such business is located complies with the requirements of the zoning ordinance.

   f. No licensee or manager under the provisions of this article shall knowingly permit any person to remain in or upon licensed premises who commits any act of public indecency or obscenity as defined in the South Dakota Compiled Statutes.

   g. No licensee or manager under the provisions of this article shall permit any act of prostitution, solicitation for prostitution or patronization of a prostitute on the licensed premises.

   h. No sign shall be posted on the licensed premises which depicts, displays or refers to specified anatomical areas or specified sexual activities, as defined in this article.

2. In addition to the requirements established in Section 5.30.04.1, the following regulations shall govern and control the operation of an adult bookstore which offers any films or videotapes for viewing on-premises by use of motion picture devices or other such operations means:

   a. All viewing areas, which shall be defined as the area where a patron or customer would ordinarily be positioned while watching a film or viewing device, shall be visible from a continuous main aisle or public room and shall not be obscured by any curtain, door, wall or other enclosure.

b. There shall be no aperture whatsoever in any wall or partition between viewing areas.

c. Each viewing area shall be lighted at a minimum level of ten (10) foot candles in all parts thereof.

3. In addition to the requirements established in Section (1) of this section, the following regulations shall govern and control the operation of an adult entertainment cabaret:

a. All performers shall be at least twenty-one (21) years of age.

b. All performances, exhibitions or displays shall take place on a platform raised at least two feet from the level of the floor, and located at least ten (10) feet from any patron.

c. No performer shall fondle or caress any patron or other performer and no patron shall fondle or caress any performer.

d. No patron shall be permitted to pay or give any gratuity to any performer, and no performer shall solicit any pay or gratuity from any patron.

4. It shall be unlawful for any person licensed to engage in the business of operating an adult use within the County to fail to comply with the conditions and regulations set forth in subsections 5.30.03 and 5.30.04 of this section as they are applicable to the licensed business, or to suffer or permit noncompliance with such conditions and regulations on or within the licensed premises. In this regard, any act or omission of an employee shall be deemed the act or omission of the owner if such act or omission occurred either with the authorization, knowledge or approval of the owner or as a result of the owner's negligent failure to supervise the employee's conduct. All conduct occurring while on the premises shall be presumed to be the responsibility of the owner.

5. Any person convicted of a violation of this section shall be subject to a fine pursuant to Section 1.02.03 of this Ordinance.

Section 5.30.05 Suspension or Revocation.

Nothing in the terms of this article shall preclude the right of the Codington County Commissioners to suspend or revoke the license of the licensee, as follows:

1. The Codington County Commissioners may temporarily suspend any license issued under the terms of this article when he has reason to believe that the continued operation of a particular licensed premises will immediately threaten the welfare of the community or create an imminent danger of violation of applicable law. In such case, he may, upon the issuance of a written order stating the reason for such determination, and without notice or hearing, order the licensed premises closed for not more than seven (7) days; provided, that the licensee shall be given an opportunity to be heard in a public hearing during the seven (7)-day period, and further provided that if such licensee shall also be engaged in the conduct of other business on the licensed premises, such order shall not be applicable to such other businesses.

2. The Codington County Commissioners may suspend or revoke any license issued under the terms of this article upon ten (10) days notice to the licensee of the time and place of a public hearing, and a public hearing at which the licensee may appear and present evidence, if the Codington County Commissioners determines upon such hearing that the licensee has failed or refused to comply with the terms of this article, has failed or refused to comply with other law applicable to the business of operating an adult use, has knowingly permitted the failure of any manager or employee on the premises to comply with the terms of this article or with other law applicable to the business of operating an adult use, has knowingly furnished false or misleading information on any application required for any license under this section or has suffered or caused another to furnish or withhold such information on his behalf, or has been convicted by a court of competent jurisdiction of a violation of any provision of this section.

5.30.06 Exception.

1. The above language of 5.30 "Adult Use Regulations" adopted April 25, 2006, hereby does not apply to the following legal description: OL 2 SE 1/4 less H-1 E 1/2 SE 1/4 less S 105' W 110' Section 6-116-52 and/or business currently known as "The South Fork Lounge".

Chapter 5.31. PRIVATE WIND ENERGY CONVERSION SYSTEMS (PWECS). The regulations regarding Private Wind Energy Conversion Systems (hereafter referred to as PWECS) shall be as follows:

1. Limited Use. No PWECS installed in accordance with the requirements of these regulations shall generate power as a commercial enterprise as defined by the Public Utility Commission.

2. Setback Requirements. The minimum distance between the property line, overhead utility lines or another wind turban, and any tower support base of a PWECS shall be equal to the proposed tower height (plus the radius of the rotor for the horizontal access machines).

3. Contiguous property owners and planned developments may construct a PWECS for their use in common. If property held by more than one (1) single owner is used to meet the setback requirements, a site plan establishing easements or reserved areas must be submitted to the Board of Adjustment for their approval.

4. Tower Access. Climbing access to the PWECS tower shall be limited either by means of a fence six (6) feet high around the tower base with a locking portal, or by limiting tower climbing apparatus so there is access to it no lower than twelve (12) feet from the ground.

5. Electromagnetic Interference. If a PWECS is installed in any location along or within the major access of an existing microwave communications link, the person desiring to install the PWECS shall be required to provide a letter from the business whose link they are within or adjacent to stating that the business whose link is affected would have no objection to the installation of the PWECS.

6. Air Space. A PWECS shall be located or installed in compliance with the guidelines of the Federal Aviation Administration Regulations with regard to Airport Approach Zones and clearance around VOR stations.

7. Interconnect. The PWECS, if interconnected to an electric utility distribution system, shall meet the interconnect requirements of the electric utility company.

Chapter 5.32 Religious Conference Facility Standards.

Section 5.32.01. Requirements

1. Religious Conference Facilities shall comply with the following conditions:

   a. Religious Conference Facility's buildings and activities shall be set back no less than 300) feet from any off-site residential use.

   b. A Religious Conference Facility shall contain a minimum lot area of twenty-five (25) acres.

   c. A Religious Conference Facility shall be owned and operated by a 501(c) 3 non-profit organization.

   d. Religious Conference Facilities shall be designed in a manner which will minimize the impact of traffic, noise and glare on the surrounding uses.

   e. Religious Conference Facilities must have access to a concrete or bituminous-asphalt street. Further all interior streets constructed within the Religious Conference Facility shall be either concrete or asphalt with the design to be approved by the County Highway Superintendent.

   f. Religious Conference Facilities are not allowed over the shallow aquifer or wellhead protection areas. EXCEPTION: A Religious Conference Facility may be allowed over a shallow aquifer if the proposed Religious Conference Facility utilizes a Board of Adjustment approved central sanitary sewer collection system, which may consist of holding tanks, trunk lines, lift stations, and/or treatment facilities.

   g. Easements per 3.04.03.9 of this ordinance shall be required to be placed on a Religious Conference Facility in order to protect agricultural operations or practices in the adjoining areas.

   h. A site plan shall be submitted including the interior layout of the building and exterior design of the premises.

   i. On-premise signage: The number, size and illumination standards shall be determined by the Board of Adjustment.

   j. Sleeping and dining facilities shall be registered with the South Dakota Department of Health and provide a smoke detector in each sleeping room.

   k. The length of stay of any registered guest shall not exceed thirty (30) days during any 120-day consecutive period.

l. Campgrounds associated with Religious Conference Facilities shall comply with the following conditions:

i. Each campsite shall contain at least two thousand (2,000) square feet.

ii. The campground(s) shall be supplied with a water supply and sewage disposal facilities, including washing, toilets, and similar facilities, and all of which shall meet all applicable State and County codes and regulations.

iii. Access roads shall be provided to each campsite and all access roads shall have a minimum unobstructed width of fourteen (14) feet for all one-way roads, and twenty (20) feet for all two-way roads.

iv. Campsites shall be used by the same persons as temporary/seasonal stays only.

v. No manufactured homes shall be located in any campground.

vi. Religious Conference Facilities shall keep accurate records as to the length of time a person stays in the campground, and shall make said records available to the Zoning Officer upon request.

2. In addition to the following information, plans shall be drawn to scale and shall be of sufficient clarity to indicate the location, nature, and extent of the work proposed and show in detail that it will conform to the provisions of this chapter and all other relevant laws, ordinances, rules and regulations. The Zoning Officer may waive the submission of plans if the nature of the work applied for is such that reviewing of plans is not necessary to obtain compliance with this chapter. The site plan shall contain the following:

a. The address of the property and the legal description.

b. The name of the project and/or business.

c. The scale and north arrow.

d. All existing and proposed buildings or additions.

e. Dimensions of all buildings.

f. Distance from all building lines to the property lines at the closest points.

g. Building height and number of stories.

h. Dimensions of all property lines.

i. Parking lots or spaces; designate each space, give dimensions of the lot, stalls and aisles.

j. Screening; show height, location and type of material to be used.

k. The landscaped setback and trees; indicate species of trees and material to be used for landscaping.

l. Name and location of all adjacent streets, alleys, waterways and other public places.

m. Proposed grading and drainage pattern.

n. Proposed interior circulation pattern indicating the status of street ownership.

o. **Proposed open space uses;**

p. **Utility (water, sewer, electricity, etc.) plans.**

q. **Relation of the proposed development to the surrounding area and comprehensive plan.**

r. **Phasing plan for development.**

3. **Approved plans shall not be changed, modified, or altered without authorization from the Board of Adjustment giving final approval, and all work shall be done in accordance with the approved plans.**

~~SECTION VI~~
~~GENERAL PROVISIONS AND ENFORCEMENT~~

~~6.1 REQUIREMENTS FOR CHANGE~~

~~Whenever the public necessity, safety, and general welfare or good zoning practices justify such action, and after consideration and recommendation by the County Planning Commission as provided herein, the Board of County Commissioners may change zone district boundaries or the regulations established by this Ordinance.~~

~~6.2 ZONING AMENDMENTS~~

~~Whenever the public necessity, safety, and general welfare or good zoning practices justifies such action, and after consideration and recommendation by the County Planning and Zoning Commission, as provided herein, the Board of County Commissioners may change zoning district boundaries, use groups, or the regulations established by this ordinance. A proposed change of zoning district boundaries or regulations may be initiated by the Board of County Commissioners, the Codington County Planning and Zoning Commission, or by application of one or more of the owners of property within the area requested to be changed. However, no such action may be taken until after a public hearing in relation thereto, at which parties in interest and citizens shall have an opportunity to be heard. Notice of the time and place of such hearing shall be published once ten (10) days prior to the date of the meetings as provided in South Dakota Compiled Laws Chapter 11-2, and its and Amendments. Unless otherwise provided for in these regulations, any change in these regulations, shall require Board of County Commissioners approval of an ordinance describing said changes. The Board of County Commissioners may not consider said ordinance until the Planning and Zoning Commission has delivered a recommendation to either approve or not approve said ordinance amendment.~~

~~The following procedure for requesting a Zoning Amendment or Zoning District Boundary Change shall be followed:~~

~~1. The landowner or other person(s) requesting the Amendment/Boundary change shall complete an application, available from the Zoning Officer. Completed applications shall be returned to the Zoning Officer for review. To be considered by the Planning and Zoning Commission and Board of County Commissioners, the application form shall be completed and shall be accompanied by the following items:~~

~~A. Any required attachments and fees, including Registered or Certified Mail costs in~~

Section 6.6; and

B. Any additional information, as requested by the Zoning Officer, as lawfully may be required to determine conformance with and provide for enforcement of this ordinance.

C. The Zoning Officer shall review the application, and shall forward a summary of the application, and his/her comments regarding said application, to the Planning and Zoning Commission for their review.

D. The Zoning Officer shall set the date, time, and place for a joint public hearing to be held by the Planning and Zoning Commission and Board of County Commissioners. The Zoning Officer shall publish notice of the public hearing in a newspaper of general circulation in the area affected by the proposed amendment; such notice shall be published not less than ten (10) days prior to the public hearing. If the proposed amendment will change the boundaries of a zoning district, the Zoning Officer shall notify all owners of property within 250 feet of the proposed boundary change, by Registered or Certified Mail at the expense of the applicant, at least one week before the public hearing.

E. The public hearing shall be held. Any person may appear in person, or by agent or attorney. Minutes of the public hearing shall be recorded and kept in the records of the Planning and Zoning Commission.

F. The Planning and Zoning Commission shall either recommend or not recommend approval of the amendment to the Board of County Commissioners.

G. The Board of County Commissioners shall either approve or not approve the ordinance describing the proposed changes to these zoning regulations, in accordance with standard procedures for reading, approval, publication, and effective date.

H. When the Board of County Commissioners approves a proposed amendment affecting the zoning classification of property, affected property owners may file a written protest to stop such an amendment from taking effect. If the protest meets the following standard, such amendment shall not become effective unless the amendment is approved by two-thirds (4 votes) of the Board of County Commissioners.

Protest Standard: The protest shall be signed by at least 40% of the owners of equity in the parcels in the area affected by the amendment, and the parcels or parts of parcels within 250 feet of the area affected by the amendment.

6.3 OFFICIAL ZONING MAP

Section 6.3.1 Official Zoning Map.

The County is hereby divided into zones, or districts, as shown on the Official Zoning Map which, together with all explanatory matter thereon, is hereby adopted by reference and declared to be a part of this Ordinance.
The Official Zoning Map shall be identified by the signature of the Chairperson of the Board of County Commissioners attested by the County Auditor and bearing the seal of the County under the following words: "This is to certify that this is the Official Zoning Map referred to in Chapter 6.3 of Ordinance Number 15 of Codington County, State of South Dakota," together with the

date of the adoption of this Ordinance. The Official Zoning Map shall be on file at the office of the County Auditor.

Regardless of the existence of purported copies of the Official Zoning Map which may from time to time be made or published, the Official Zoning Map, which shall be located in the office of the County Auditor Offices, shall be the final authority as to the current zoning status of land and water areas, buildings, and other structures in the County.

Section 6.3.2 Amendment of the Official Zoning Map

If, in accordance with the provisions of this Ordinance changes are made in district boundaries or other matter portrayed on the Official Zoning Map, such changes shall be entered on the Official Zoning Map promptly after the amendment has been approved by the Board of County Commissioners, and has become law according to the statutes of the State of South Dakota. No amendment of this Ordinance which involves matter portrayed on the Official Zoning Map shall become effective until after such change and entry has been made on the Official Zoning Map.

No changes of any nature shall be made on the Official Zoning Map or matter shown thereon except with conformity with the procedure set forth in this Ordinance. Any unauthorized change of whatever kind by any person or persons shall be considered a violation of this Ordinance and punishable as provided by this Ordinance.

6.4 FEE SCHEDULE

The Board of County Commissioners shall establish a schedule of fees, charges, and expenses and a collection procedure for building permits, re-zonings, and other matters pertaining to this ordinance. The schedule of fees shall be posted in the office of the Zoning Administrator, and may be altered or amended only by the Board of County Commissioners.

SECTION VII
ADMINISTRATION

7.1 ENFORCEMENT

The Board of County Commissioners shall appoint a Zoning Officer to enforce the provisions of Ordinance. It shall be his duties to enforce all applications for permits, issue permits only for construction and uses which are in accordance with the requirements of this Ordinance, record and file all applications for permits with an accompanying plan and documents, and make such reports as the Commissioners may require. Permits for construction or uses which are a special exception or variance to requirements of this Ordinance shall be issued by the Board of Adjustment.

7.2 CONSTRUCTION UNDERWAYS

Nothing herein contained shall require any change in plans or construction of a lawful use, the construction of which is started before the effective date of this Ordinance and which is completed within one (1) year of the effective date of this Ordinance.

7.3 PENALTIES

Any person who owns, rents, occupies, or maintains any building or premises or uses any land in violation of this Ordinance, for each and every violation hereof shall be imprisoned for a period not exceeding thirty (30) days or be fined in an amount not exceeding one two hundred dollars ($200) or both. Each and every day that a violation continues shall constitute a separate offense punishable by a like penalty.

SECTION VIII
PERMITS

8.1 BUILDING PERMIT REQUIRED

It shall be unlawful to commence the excavation for or the construction of any building or any accessory buildings, or to commence the moving or alteration of any buildings, including accessory buildings, or the change in use of any building until the Zoning Officer has issued a building permit for such work or change.

8.2 ISSUANCE OF A BUILDING PERMIT

In applying to the Zoning Officer for a building permit, the applicant shall submit a dimensioned sketch or a scale plan indicating the shape, size and height and location of all buildings to be erected, altered, or moved and of any building already on the lot. The applicant shall also state the existing and intended use of all such buildings and location of existing or proposed water and sewer facilities. In the case of a change of use, the applicant shall, in writing, state that intended change plus any other information as may be required by the Zoning Officer for determining whether the provisions of this Ordinance are being observed. If the propose excavation, alteration, construction, or change of use, as set forth in the application, are in conformity with the provisions of this Ordinance and other regulations of the County then in force, the Zoning Officer shall issue a building permit for such excavation, construction, alteration, or change of use. If a building permit is refused, the Zoning Officer shall state such refusal in writing, with the cause, and shall immediately thereupon mail notice of such refusal to the applicant at the address indicated upon the application. The Zoning Officer shall grant or deny the permit within a reasonable time from the date the application is submitted.

The issuance of a building permit shall, in no case, be construed as waiving any provisions of this Ordinance. A building permit shall become void six (6) months from the date of issuance unless substantial progress has been made by that date on the project described therein.

8.3 REMEDIES

In case any building or structure is erected, constructed, reconstructed, altered, required, converted, or maintained or any building, structure, or land is used in violation of Chapter 11-2 of the South Dakota Codified Laws, as the same now exists or may hereafter be amended or this Ordinance, the Board of County Commissioners may institute any appropriate action or proceedings to prevent such unlawful erection, construction, reconstruction, alteration, repair, conversion, maintenance or use, to retrain, correct, or abate such violation to prevent the occupancy of said building, structure, or land or to prevent any illegal act, conduct, business or use in or about such premises.

8.4 PERMITS POSTED

Such permits shall be posted in a conspicuous place upon the premises at all times from the beginning until the completion of such construction, alteration, repair, occupancy or change of use.

SECTION IX
BOARD OF ADJUSTMENT

9.1 ESTABLISMENT

The Board of Codington County Commissioners shall appoint the Codington County Planning Commission and two (2) alternates to act as the Board of Adjustment. If a Planning Commissioner acting as a Board of Adjustment member is unable to attend a meeting, the first alternate, or second alternate, in turn, shall serve in the member's place. Alternates may be appointed for a term of three years.

9.2 POWERS AND DUTIES OF THE BOARD

The Board of Adjustment shall have the following powers and duties:

A. Administrative Review

To hear and decide where it is alleged by the appellant that there is error in any order, requirement, permit decision, determination or refusal made by the Zoning Officer or other administrative officers in the carrying out or enforcement of any provision of this Ordinance, and for interpretation of the Zoning Map.

B. Special Exceptions

To hear and decide applications for special exceptions that are specified in this Ordinance and for decisions on any special questions upon which the Board of Adjustment is specifically authorized to pass.

C. Variance

To hear and decide applications for variance from the terms of this Ordinance because of unnecessary hardship and to authorize upon appeal in specific cases such variance from the terms of this Ordinance as which will not be contrary to the public interest where, owing to special conditions, a literal enforcement of the provisions of this Ordinance would result in unnecessary hardship.

Before any variance is granted, all of the following conditions must be shown to be present.

1. Conditions and circumstances are peculiar to the land, structure, or building and do not apply to neighboring lands, structures, or buildings in the same district.

2. Strict application of the provisions of this Ordinance would not deprive the applicant of reasonable use of the land, structure or building equivalent to the use made of neighboring lands, structures or buildings in the same district and permitted under the terms of the Ordinance.

3. The peculiar conditions and circumstances are not the result of actions of the applicant taken subsequent to the adoption of this Ordinance.

4. Financial disadvantage of the property owner shall not constitute conclusive proof of unnecessary hardship within the purposes of zoning.

5. The Board does not possess the powers to permit a use not generally or by special exception, permitted in the district involved.

6. In granting a variance, the Board may attach thereto any conditions and safeguards it deems necessary to desirable in furthering the purposes of this Regulation Ordinance. Violation of any of these conditions or safeguards shall be deemed a violation of this Ordinance.

9.3 PROCEDURES FOR MEETINGS.

The Board of Adjustment shall adopt rules necessary to the conduct of its affairs and in keeping with the provisions of this Ordinance. Meetings shall be held at the call of the chairman and at such other times as the Board of Adjustment may determine. The chairman, or in his absence the acting chairman, may administer oaths and compel the attendance of witnesses. All meetings shall be open to the public.

The Board of Adjustment shall keep minutes of its meetings and proceedings, showing the vote of each member upon each question, or if absent or failing to vote indicating such fact, and shall keep records of its examinations and other official action, all of which shall be filed in the office of the Zoning Officer of Codington County, South Dakota and shall be a public record.

9.4 HEARINGS; APPEALS; NOTICE:

Appeals from the decision of the Zoning Officer concerning interpretation or administration of this Ordinance may be taken by any person aggrieved. The applicant shall file with the Zoning Officer and the Board of Adjustment a notice of appeal specifying the grounds thereof. The Zoning Officer shall forthwith transmit to the Board of Adjustment all papers constituting the record upon which the action appealed from was taken. Such appeal shall be taken within thirty (30) days.

The Board of Adjustment shall hear and decide, on not less than ten (10) days public notice prior to an affixed time and place for hearing appeals where it is alleged by the appellant that there is error in any order, requirement, permit decision, determination or refusal made by the Zoning Officer or other administrative officers in carrying out the enforcement of any provision of this Ordinance, and for interpretation of the Zoning Map. At the hearing, any party may appear in person or by agent or attorney.

9.5 STAY OF PROCEEDINGS

An appeal stays all proceedings in furtherance of the action appealed from unless the Zoning Officer from whom the appeal is taken certifies to the Board of Adjustment after the notice of appeal is filed with him, that by reason of facts stated in the certificate, a stay would, in his opinion, cause an imminent peril to life and property. In such case proceedings shall not be stayed other than by a restraining order which may be granted by the Board of Adjustment or by

a court of record on application, on notice to the Zoning Officer from whom the appeal is taken and on due cause shown.

9.6 PROCEDURES FOR SPECIAL EXCEPTIONS AND VARIANCES

9.6.1 Special Exceptions

The following procedure for requesting a Special Exception Permit shall be followed:

A. The Board of Adjustment shall follow the following procedure in considering the recommendation of the Zoning Officer. A Special Exception Permit from the terms of this ordinance shall not be granted by the Board of Adjustment unless and until:

1. An application for a Special Exception Permit, available from the Zoning Officer, shall be completed by the landowner requesting the Special Exception Permit. Any required attachments and fees as in 6.4 shall further accompany the application. The written application for a special exception shall indicate the section of this Ordinance under which the special exception is sought and stating the grounds on which it is requested; Completed applications shall be returned to the Zoning Officer for review. To be considered by the Board of Adjustment, the application form shall be completed. If any of the information required by Section VIII has changed since the original Building Permit application, the revised, update or corrected information shall accompany the application for a Special Exception Permit.

2. The Zoning Officer shall review the application, and shall make a recommendation to the Board of Adjustment to either approve or not approve said application. The Zoning Officer's recommendation shall include a summary of the application, and reasons and justification for either approval of or disapproval of the application.

3. The Zoning Officer shall set the date, time and place for a public hearing to be held by the Board of Adjustment. The Zoning Officer shall notify the adjacent landowners (excluding public right-of-ways) by mail at the expense of the applicant, at least one week before the public hearing. The Zoning Officer shall publish notice of the public hearing, with all costs to be paid by the applicant, not less than ten (10) days prior to the public hearing in a newspaper of general circulation in the area affected by the proposed Special Exception Permit.

4. A public hearing shall be held. Any party may appear in person, or by agent or attorney;

5. The Board of Adjustment shall rule that it is empowered under the section of this ordinance described in the application to grant the Special Exception, and that the granting of the Special Exception will not adversely affect the public interest; and

6. Before any Special Exception shall be issued, the Board of Adjustment shall make a written finding certifying compliance with the specific rules governing individual Special Exceptions and that satisfactory provision and arrangement has been made concerning the following, where applicable:

   a. Utilities, refuse, and service areas, with reference to locations, availability, and compatibility;

   b. Screening and buffering with reference to type, dimensions, and character;

c. Required yards and other open space; and
d. General compatibility with adjacent properties and other property in the zoning district.

e. Entrance and exit to property and proposed and proposed structures thereon with particular reference to automotive and pedestrian safety and convenience, traffic flow and control, and access in case of fire or catastrophe;

f. Signs, if any, and proposed exterior lighting with reference to glare, traffic safety, economic effect, and compatibility and harmony with properties.

g. Off-street parking and loading areas where required, with particular attention on effects of the special exception on adjoining properties and properties generally within the district.

B. In order to preserve the intent of these zoning regulations and to protect the public interest, the Board of Adjustment may attach conditions to a Special Exception Permit. A Special Exception Permit shall remain valid only as long as the original applicant complies with any terms and conditions of the Special Exception Permit, as attached by the Board of Adjustment.

C. Approval of any application for a Special Exception permit shall be by a two-thirds (2/3) majority (five of seven) of all members of the Board of Adjustment.

9.6.2 Variances.

Variances are designed to allow some flexibility in the zoning regulations, in cases where the exceptional shape of a parcel of land, in cases where use of a property is overwhelmingly effected by exceptional topographic conditions, or any other extraordinary situation or condition of such a parcel of land. Variances are to be approved only when a property owner demonstrates that the provisions of all or part of these zoning regulations present an undue hardship on such property owner's use of such parcel land. A variance shall include a description of the specific regulatory item or items in these zoning regulations, which are found to produce, said undue hardship. Variances shall only be granted when the Board of Adjustments finds that such relief from these zoning regulations will be neither detrimental to the public good nor in conflict with the intent of these zoning regulations.

The following procedure for requesting a Variance shall be followed:

A. The Board of Adjustment shall follow the following procedure in considering the recommendation of the Zoning Officer. A variance from the terms of this ordinance shall not be granted by the Board of Adjustment unless and until:

1. An application for Variance, available from the Zoning Officer, shall be completed by the landowner requesting the variance and shall be accompanied by any required attachments and fees as in 6.4. The written application for a variance shall indicate the section of this Ordinance under which the variance is sought and stating the grounds for which it is requested. Completed applications shall be returned to the Zoning Officer for review. To be considered by the Board of Adjustment, the application form shall be completed. If any of the information required by Section VIII has changed since the original Building Permit application, the revised, updated or corrected information shall

accompany the application for a variance.

2. The Zoning Officer shall review the application, and shall make a recommendation to the Board of Adjustment to either approve or not approve said application. The Zoning Officer's recommendation shall include a summary of the application, and reasons and justification for either approval or disapproval of the application.

3. The Zoning Officer shall set the date, time and place for a public hearing to be held by the Board of Adjustment. The Zoning Officer shall notify the adjacent landowners (excluding public right-of-ways) by mail at the expense of the applicant, at least one week before the public hearing. The Zoning Officer shall publish notice of the public hearing, with all costs to be paid by the applicant, no less than (10) days prior to the public hearing in a newspaper of general circulation in the area affected by the proposed variance.

4. A public hearing shall be held. Any party may appear in person, or by agent or attorney;

5. The Board of Adjustment shall follow the following procedure in considering the recommendation of the Zoning Officer. A variance from the terms of this ordinance shall not be granted by the Board of Adjustments unless and until a written application for a variance is submitted demonstrating:

   a. That special conditions and circumstances exist which are peculiar to the land, structure or building involved, and which are not applicable to other land, structures, or buildings in the same district;

   b. That literal interpretation of the provisions of this ordinance would deprive the applicant of rights commonly enjoyed by other properties in the same district under the terms of this ordinance;

   c. That the special conditions and circumstance do not result from the actions of the applicant;

   d. Financial disadvantage of the property owner shall not constitute conclusive proof of unnecessary hardship within the purposes of zoning.

   e. That granting the variance request will not confer on the applicant any special privilege that is denied by this ordinance to other lands, structures, or buildings in the same district.

   f. No non-conforming use of neighboring lands, structures, or buildings in the same district, and no permitted or non-conforming use of lands, structures, or buildings in other districts shall be considered grounds for the issuance of a variance.

   g. The Board of Adjustment shall make findings that the requirements of 9.6.2 above have been met by the applicant for a variance;

   h. The Board of Adjustment shall further make a finding that the reasons set forth in the application justify the granting of the variance, and that the variance is the minimum variance that will make possible the reasonable use of land, building, or structure; and

i. The Board of Adjustment shall further make a finding that the granting of the variance will be in harmony with the general purpose and intent of this ordinance, and will not be injurious to the neighborhood, or otherwise detrimental to the public welfare.

B. Approval of any variance shall be by a two-thirds (2/3) majority (five of seven votes) of all members of the Board of Adjustment.

C. In granting any variance, the Board of Adjustment may prescribe appropriate conditions and safeguards in conformity with this ordinance. Violations of such conditions and safeguards, when made a part of the terms under which the variance is granted, shall be deemed a violation of this ordinance and punishable under 7.3 of this Ordinance.

Under no circumstances shall the Board of Adjustment grant a variance to allow a use not permissible under the terms of this ordinance in the district involved, or any use expressly or by implication prohibited by the terms of this ordinance in said district.

9.7 Board of Adjustment has Powers of Zoning Officer on Appeals; Reversing Decision of Zoning Officer:

A. It is the intent of this Ordinance that all questions of interpretation and enforcement shall be first presented to the Zoning Officer, and that such questions shall be presented to the Board of Adjustment only on appeal from the decision of the Zoning Officer.

B. In exercising the above-mentioned powers, the Board of Adjustment may, so long as such action is in conformity with the terms of this ordinance, reverse or affirm, wholly or partly, or may modify the order, requirement, decision, or determination appealed from and may make such order, requirement, decision, or determination as ought to be made, and to that end shall have the powers of the Zoning Officer from whom the appeal is taken.

C. The concurring vote of two-thirds (2/3) of all members of the Board of Adjustment shall be necessary to reverse any order, requirement, decision, or determination of the Zoning Officer, or to decide in favor of the applicant on any matter upon which it is required to pass under this ordinance, or to effect any variation in the application of this ordinance.

9.8 Appeals:

Any persons, or any board, taxpayer department, board, or bureau of the County aggrieved by any decision of the Board of Adjustment may seek review by a court of record of such decision, in the manner provided by the laws of the State of South Dakota.

SECTION X

COUNTY PLANNING COMMISSION

10.1 APPOINTMENT OF COUNTY PLANNING COMMISSION

The Board of County Commissioners shall appoint a Planning Commission of seven members, at least one member of which shall be a member of the Board of County Commissioners. The Planning Commission shall also be the County Zoning Commission.

10.2 TERM OF OFFICE

The term of each of the appointed members of the County Planning Commission shall be for four years. The terms shall be varied so no more than one-third of terms shall expire in the same year. Any appointed member of the county Planning Commission may be removed for cause, after hearing prior to the expiration of the term by a majority vote of the elected members of the Board of County Commissioners. Zoning Officers of the County may be appointed as ex-officio members of the Commission.

10.3 MEETINGS OF THE PLANNING COMMISSION

The Planning Commission shall meet at such times as may be necessary to accomplish the purposes of their duties, but in no event shall they meet less than once every three months.

10.4 PER DIEM AND EXPENSES OF COMMISSION

Per diem and expenses of the County Planning Commission shall be established by the Board of County Commissioners and paid by the County.

ATTACHMENT 1

WIND TURBINE SAFETY CONSIDERATIONS

Vestas is one of the leading wind turbine manufacturers, with approximately 70% market share worldwide. Based on its prominence in the world market, the Vestas Safety Manual (32 pages) is a credible source of safety information. Nordex is another well know manufacturer of wind turbines. Its Safety Manual (130 pages) likewise is considered a credible source of information on the subject of safety.

On page 3 of the Vestas Safety Regulations for Operators and Technicians Manual, point # 2. – Stay and Traffic by the Turbine, Vestas personnel are instructed to stay away from a turbine by 400 m (1312 ft) unless it is necessary. Taken in context, this distance would apply to normal operating conditions. (See Exhibit 1)

Under abnormal operating conditions, Vestas expands this distance in consideration of the safety of its employees. This is evidenced by the Vestas Confidential Health and Safety Instruction manual for a Falmouth MA wind farm. Page 10 of this manual addresses the situation of a free spinning "runaway turbine". In that manual, instructions are for no one to be allowed within a 1640 feet (500 m) radius. (See Exhibit 2)

The Nordex Safety Manual also addresses safety in the context of a fire. On page 52, under section 9.3 Fire, it states:

DANGER ***FALLING TURBINE PARTS*** *In case of a fire in the nacelle or on the rotor, parts may fall off the wind turbine. In case of a fire, nobody is permitted within a radius of 500 m from the turbine.* (See Exhibit 3)

Given that these standards apply to employees who are familiar with the safety implications of wind turbines and are equipped to deal with abnormal conditions, it is indefensible, from a safety perspective alone, to specify in a wind ordinance designed to protect the public health, safety and welfare a setback that is less than 1640 feet.

1. Introduction

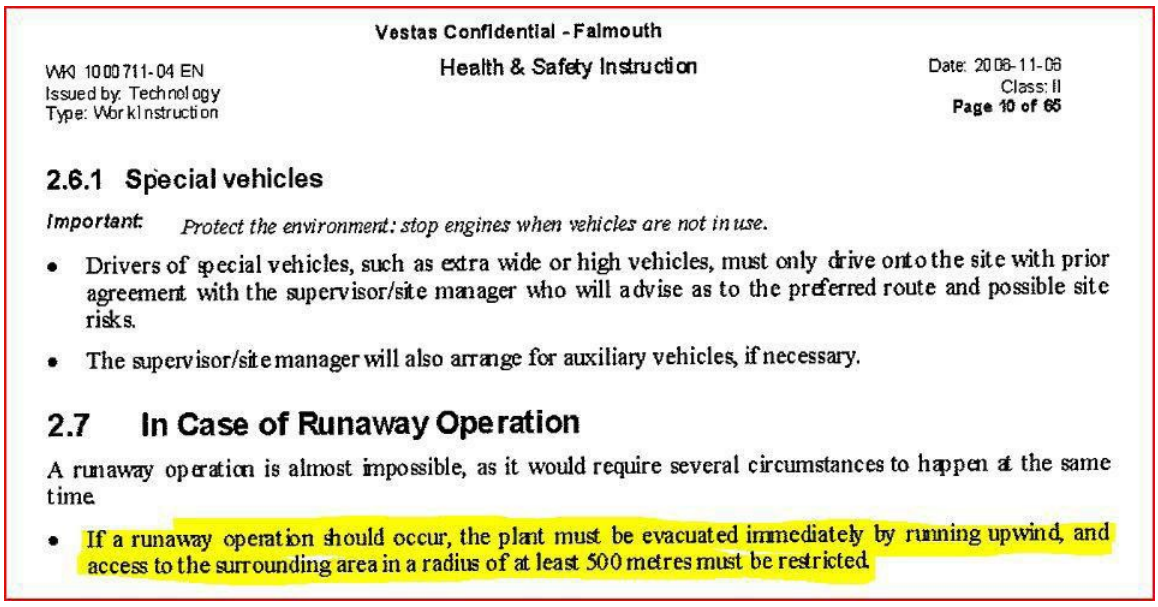
A turbine connected to the grid implies certain elements of danger if it is handled without exercising proper caution.
For safety reasons, at least two persons have to be present during a work procedure.
The work must be properly carried out in accordance with this manual and other related manuals. This implies, among other things that personnel must be instructed in and familiar with relevant partsof this manual.
Furthermore, personnel must be familiar with the contents of the “Substances and Materials” regulations.
Caution must especially be exerted in situations where measurement and work is done in junction boxes that can be connected to power.
Consequently the following safety regulations must be observed.

2. Stay and Traffic by the Turbine

Do not stay within a radius of 400m (1300ft) from the turbine unless it is necessary. If you have to inspect an operating turbine from the ground, do not stay under the rotor plane but observe the rotor from the front.
Make sure that children do not stay by or play nearby the turbine. If necessary, fence the foundation. The access door to the turbine must be locked in order to prevent unauthorized persons from stopping or damaging the turbine due to mal-operation of the controller.

3. Address and Phone Number of the Turbine

Note the address and the access road of the turbine in case an emergency situation should arise. The
address of the turbine can often be found in the service reports in the ring binders next to the ground
controller. Find the phone number of the local life-saving service.



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2.6.1 Special vehicles

Important: *Protect the environment: stop engines when vehicles are not in use.*

- Drivers of special vehicles, such as extra wide or high vehicles, must only drive onto the site with prior agreement with the supervisor/site manager who will advise as to the preferred route and possible site risks.
- The supervisor/site manager will also arrange for auxiliary vehicles, if necessary.

2.7 In Case of Runaway Operation

A runaway operation is almost impossible, as it would require several circumstances to happen at the same time.

- If a runaway operation should occur, the plant must be evacuated immediately by running upwind, and access to the surrounding area in a radius of at least 500 metres must be restricted.

Vestas advises to *"evacuate by running upwind …access to the surrounding area in a radius of at least 500 meters [1640 ft.] must be restricted."*

The WT itself is adequately protected against damage by comprehensive lightning protection measures. However, persons inside or in the proximity of a WT are still at risk. ■ Initially, proceed as in a grid failure ■ Leave and lock the WT ■ Wait at a safe distance from the WT until the thunderstorm has passed Do not re-enter the WT until the thunderstorm has passed.

9.3Fire

DANGER

FALLING TURBINE PARTS

In case of a fire in the nacelle or on the rotor, parts may fall off the wind turbine. ***In case of a fire, nobody is permitted within a radius of 500 m from the turbine****.*

NOTE The WT is equipped with ABC powder fire extinguishers for fighting incipient fires. At least one fire extinguisher is located in the tower base near the door and another in the nacelle near the Topbox. This makes it possible to extinguish burning solids and liquids, as well as fires in electrical systems of up to 1,000 V. These fire extinguishers are not suitable for extinguishing a fire on the high-voltage elements, see Chapter 9.3.2 "Fire in medium-voltage switchgear or transformer".

9.3.1 Fire in the WT

■ Remove any persons from the danger area ■ If possible, disconnect the burning object from the grid ■ Fight the fire with available means if there is any chance of success ■ If the fire cannot be extinguished or if there is no chance of success, call the fire department ■ Inform the responsible Remote Monitoring

ATTACHMENT 1

WIND TURBINE SAFETY CONSIDERATIONS

Vestas is one of the leading wind turbine manufacturers, with approximately 70% market share worldwide. Based on its prominence in the world market, the Vestas Safety Manual (32 pages) is a credible source of safety information. Nordex is another well know manufacturer of wind turbines. Its Safety Manual (130 pages) likewise is considered a credible source of information on the subject of safety.

On page 3 of the Vestas Safety Regulations for Operators and Technicians Manual, point # 2. – Stay and Traffic by the Turbine, Vestas personnel are instructed to stay away from a turbine by 400 m (1312 ft) unless it is necessary. Taken in context, this distance would apply to normal operating conditions. (See Exhibit 1)

Under abnormal operating conditions, Vestas expands this distance in consideration of the safety of its employees. This is evidenced by the Vestas Confidential Health and Safety Instruction manual for a Falmouth MA wind farm. Page 10 of this manual addresses the situation of a free spinning "runaway turbine". In that manual, instructions are for no one to be allowed within a 1640 feet (500 m) radius. (See Exhibit 2)

The Nordex Safety Manual also addresses safety in the context of a fire. On page 52, under section 9.3 Fire, it states:

DANGER ***FALLING TURBINE PARTS*** *In case of a fire in the nacelle or on the rotor, parts may fall off the wind turbine. In case of a fire, nobody is permitted within a radius of 500 m from the turbine.* (See Exhibit 3)

Given that these standards apply to employees who are familiar with the safety implications of wind turbines and are equipped to deal with abnormal conditions, it is indefensible, from a safety perspective alone, to specify in a wind ordinance designed to protect the public health, safety and welfare a setback that is less than 1640 feet.

1. Introduction

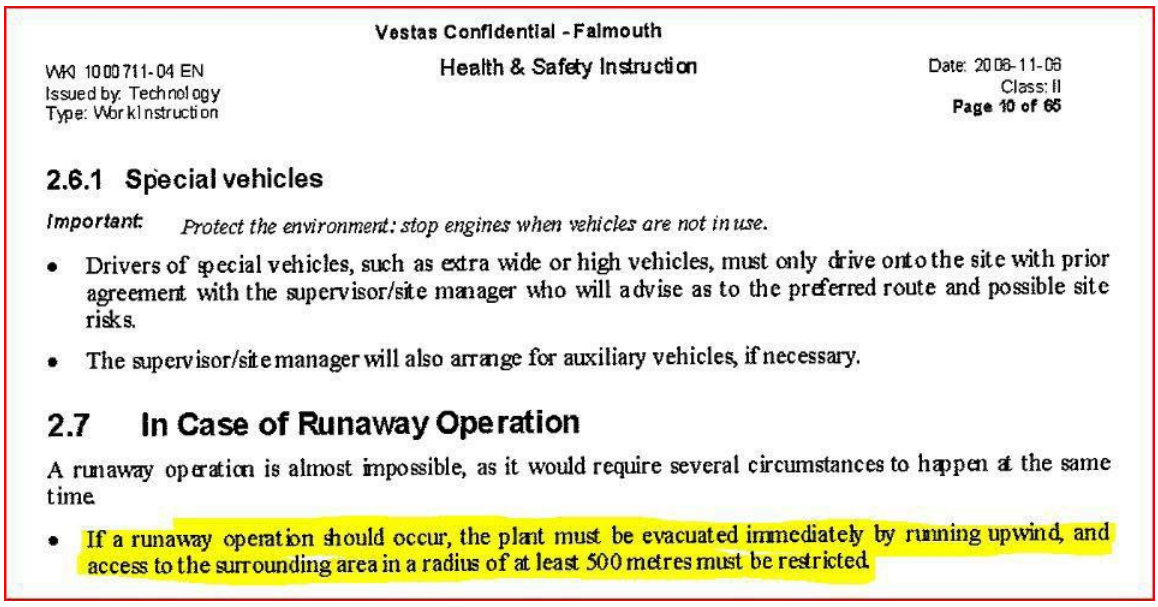
A turbine connected to the grid implies certain elements of danger if it is handled without exercising proper caution.
For safety reasons, at least two persons have to be present during a work procedure.
The work must be properly carried out in accordance with this manual and other related manuals. This implies, among other things that personnel must be instructed in and familiar with relevant partsof this manual.
Furthermore, personnel must be familiar with the contents of the “Substances and Materials” regulations.
Caution must especially be exerted in situations where measurement and work is done in junction boxes that can be connected to power.
Consequently the following safety regulations must be observed.

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