**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

**IN THE MATTER OF THE APPLICATION OF
CROWNED RIDGE, LLC FOR A FACILITIES PERMIT TO
CONSTRUCT A 300 MEGAWATT WIND FACILITY**

Docket No. EL19-003

SUPPLEMENT TESTIMONY AND EXHIBITS

OF CHRISTOPHER OLLSON

April 8, 2019

INTRODUCTION

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Christopher Ollson. My business address is 37 Hepworth Crescent, Ancaster, Ontario, Canada.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am the sole proprietor of Ollson Environmental Health Management. This is a consultancy that provides expertise on environmental health challenges related to siting of energy projects (e.g., oil and gas, pipelines, gas plants, wind turbines, solar, transmission lines, and energy-from-waste). Our clients include a mix of private sector companies and governments at all levels.

Q. WHAT ARE YOUR RESPONSIBILITIES?

A. I am a consultant to Crowned Ridge Wind, LLC ("CRW") on the scientific literature related to sound and shadow/flicker and proper siting of wind turbines to ensure the protection of health of residents.

Q. PLEASE DESCRIBE YOUR BACKGROUND AND QUALIFICATIONS.

A. My area of expertise is in the field of environmental health science. I am trained, schooled, and practiced in the evaluation of potential risks and health effects to people associated with environmental health issues. I have been consulting on environmental health issues for over 20 years. My full curriculum vitae is found in Exhibit 1. My formal education includes:

- Doctorate of Philosophy, Environmental Science, Royal Military College of Canada, Kingston, Ontario, Canada, 2003.
- Master of Science, Environmental Science, Royal Military College of Canada, Kingston, Ontario, Canada, 2000.
- Bachelor of Science (Honours), Biology, Queen's University, Kingston, Ontario, Canada, 1995.

In addition to my consulting practice, I hold an appointment of Adjunct Professor in the School of the Environment at the University of Toronto. From 2013 - 2016, I was appointed to the Governing Council, and was Vice-Chair of the Academic Affairs Committee, of the University of Toronto Scarborough. I teach a graduate course at the University of Toronto in Environmental Risk Analysis, and have supervised a number of Doctoral students and Post-Doctoral Fellows.

I was a co-recipient of the 2015 Canadian Wind Energy Association R.J. Templin Award. This award recognizes an individual or organization that has undertaken scientific, technical, engineering, or policy research and development work that has produced results that have served to significantly advance the wind energy industry in Canada.

I have been qualified to provide expert opinion evidence on wind turbines and potential health effects at a number of North American hearings, tribunals, and legal proceedings.

In addition, from 2014 to 2017, I provided expert advice on wind turbines, health and siting requirements for the Vermont Public Services Department. I have also appeared before the Indiana State Senate Energy Committee Meeting on Wind Turbine

Siting (2017), and twice before the North Dakota State Senate Energy and Natural Resources Committee (2017).

Q. HAS THIS TESTIMONY BEEN PREPARED BY YOU OR UNDER YOUR DIRECT SUPERVISION?

A. Yes.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE SOUTH DAKOTA PUBLIC UTILITIES COMMISSION?

A. No.

Q. PLEASE DESCRIBE THE PURPOSE OF YOUR SUPPLEMENTAL TESTIMONY.

A. The purpose of my supplemental testimony is to address comments made at the March 20, 2019 public input hearing on the sound and shadow/flicker.

Q. PLEASE DESCRIBE THE METHODOLOGY YOU USED TO SELECT THE LITERATURE SITED IN YOUR SUPPLEMENTAL TESTIMONY.

A. I sourced the literature from the following: 1) Scientific peer-reviewed studies published in scientific journals or on the Internet; and 2) Government agency reports. I place less, and in some cases no, weight on Internet source material, or self-published material, that has not been independently peer-reviewed or published.

Q. PLEASE EXPLAIN WHAT IS MEANT BY "PEER-REVIEWED" AND WHY THIS TERMINOLOGY IS IMPORTANT?

A. "Peer-reviewed" means that prior to publication the study was evaluated by scientific, academic, or professionals working in the field of health effects and wind turbines. The peer review process is considered a fundamental tenet of quality control in scientific publishing. As with any scientific undertaking it is important that evidence be critically evaluated and reviewed when forming an opinion in a transparent, systematic manner (Knopper and Ollson, 2011 at Exhibit 2).

To that end, I place a higher degree of weight on research that has been published in credible scientific peer-reviewed journals. This is but the first step in the evaluation. Although a paper may have been published, that does not mean that it should not be critically reviewed, especially when considering what the entire body of the scientific field reveals.

The second tier or level of evidence that I consider is government agency reports, consulting reports, and primary research. Often these reports are not published in the scientific literature, but can nonetheless be very informative.

SOUND

Q. DO THE GRANT COUNTY AND CODINGTON COUNTY ZONING ORDINANCES PLACE RESTRICTIONS ON ALLOWABLE SOUND LEVELS FROM CRW?

A. Yes. Both counties have sound limits in their ordinances.

Grant County:

Noise level shall not exceed 45 dBA, average A-weighted Sound pressure including constructive interference effects measured twenty-five (25) feet ("ft") from the perimeter of the existing non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity.

Noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects measured twenty-five (25) ft from the perimeter of participating residences, businesses, and buildings owned and/or maintained by a governmental entity.

Codington County:

> Noise level shall not exceed 50 dBA, average A-weighted Sound pressure including constructive interference effects at the property line of existing non participating residences, businesses, and buildings owned and/or maintained by a governmental entity.

Although Codington County's standard is to measure noise at the property line for all receptors, CRW applied a more stringent design goal of no greater than 45 dBA at the exterior of all non-participating residents, regardless of which county the turbines are located.

Q. AT THE PUBLIC INPUT HEARING THERE WERE COMMENTS EXPRESSED THAT CRW'S ADHERENCE TO SOUND METHODOLOGY AND DBA THRESHOLDS IN GRANT AND CODINGTON COUNTIES IS NOT SUFFICIENT TO PROTECT THE HEALTH OF RESIDENTS. DOES THE SCIENTIFIC LITERATURE SUPPORT THIS CONCERN?

A. No. First, I will provide an overview of the scientific literature, and then apply the findings to the Grant and Codington counties' sound ordinance.

Sleep

The critical effect from a health perspective in setting any nighttime sound source standard is to ensure that it is protective of sleep. Quality of sleep and sleep perception can be challenging to establish causation through self-reported surveys alone.

For a general context, in 2006, the Institute of Medicine of the National Academies released the book Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem (IOM, 2006). In that book, it was reported that: "It is estimated that 50 to 70 million Americans suffer from a chronic disorder of sleep and wakefulness, hindering daily functioning and adversely affecting health."

In the context of wind turbines, there are a number of wind turbine specific sleep studies in relation to nighttime noise levels at exterior of homes. See, e.g., Michaud et al., 2016. Effects of Wind Turbine Noise on Self-Reported and Objective Measures of Sleep, Sleep, Vol. 39, No. 1 (Health Canada) (Exhibit 3). This study presents the peer-reviewed published findings of the Health Canada Wind Turbine Noise ("WTN") and Health Study with respect to sleep. This is most comprehensive study of its kind to date and its results will be referenced a number of times in this testimony. This study, initiated in 2012, was a partnership between Health Canada and Statistics Canada to understand the potential impacts of wind turbine noise on health and well-being of communities in Southern Ontario and Prince Edward Island. A total of 1238 households participated in the study, with an almost 80% response rate of all households within 6 miles of projects investigated, making it the largest and most comprehensive study ever undertaken. Households that were studied were located between 820 feet and 6 miles from operational wind turbines. The A-weighted ("dBA") sound levels (audible sound/noise) were grouped into 5 dBA increments with the loudest level in the study at the exterior of a home being 46 dBA Leq (highest nighttime level).

For this sleep study, all 1,238 participants self-reported sleep quality over 30 days using the Pittsburgh Sleep Quality Index ("PSQI") and additional questions assessing the prevalence of diagnosed sleep disorders and the magnitude of sleep disturbance over the previous year. Also, for the first time, objective measures for sleep latency, sleep efficiency, total sleep time, rate of awakening bouts, and wake duration after sleep were recorded using the wrist worn Actiwatch2® for 654 participants, over a total of 3,772 sleep nights. This is currently the largest and most comprehensive sleep study of its kind ever undertaken for wind turbine noise. The study presented the following conclusions:

> The potential association between WTN levels and sleep quality was assessed over the previous 30 days using the PSQI, the previous year using percentage highly sleep disturbed, together with an assessment of diagnosed sleep disorders. These self-reported measures were considered in addition to several objective measures including total sleep time, sleep onset latency, awakenings, and sleep efficiency. In all cases, in the final analysis there was no consistent pattern observed between any of the self-reported or actigraphy-measured endpoints and WTN levels up to 46 dB(A) [820 ft]. Given the lack of an association between WTN levels and sleep, it should be considered that the study design may not have been sensitive enough to reveal effects on sleep. However, in the current study it was demonstrated that the factors that influence sleep quality (e.g. age, body mass index, caffeine, health conditions) were related to one or more self-reported and objective measures of sleep. This demonstrated sensitivity, together with the observation that there was consistency between multiple measures of self-reported sleep disturbance and among some of the self reported and actigraphy measures, lends strength to the robustness of the conclusion that WTN levels up to 46 dB(A) [820 ft] had no statistically significant effect on any measure of sleep quality.

The conclusion in the Michaud et al. sleep study supports the position that the sound requirements in the Grant and Codington County ordinances will ensure that residents do not experience sleep disturbance from the wind turbine sound, because for non-participants in both counties the sound from wind turbine operation is below 45 dBA at the residence in which they sleep.

Further, the Michaud et al. study findings are consistent with previously published peer-reviewed literature in the field. See, Bakker et al. 2012. Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. Science of The Total Environment, Volume 425, 15 May 2012, Pages 42-51(Exhibit 4). The Bakker et al. study completed the most compelling research, prior to the Michaud et al. sleep study, into wind sound awakenings. This research reported the number or percentage of awakenings with those living in proximity to wind turbines in a rural setting. As can be seen in Table 7 (below) from the Bakker paper, more people in rural environments are awakened by people/animal sound and traffic/mechanical sounds, than by the proximate wind turbines. In this study, people living in close proximity to wind turbines reported being awoken more by people/animal noise (11.7%) and rural traffic/mechanical noise (12.5%), than by turbine noise (6.0%). Sound levels in this study were as high as 54 dBA from wind turbines at the exterior of neighboring homes.

Table 7
Sound sources of sleep disturbance in rural and urban area types, only respondents who did not benefit economically from wind turbines.

Sound source of sleep disturbance	Rural		Urban		Total	
	n	%	n	%	n	%
Not disturbed	196	69.8	288	64.9	484	66.8
Disturbed by people/ animals	33	11.7	64	14.4	97	13.4
Disturbed by traffic/ mechanical sounds	35	12.5	75	16.9	110	15.2
Disturbed by wind turbines	17	6.0	17	3.8	34	4.7
Total	281	100	444	100	725	100

The Baker Study was recognized in the Michaud Study:

> Study results concur with those of Bakker et al. (2002), with outdoor WTN levels up to 54 dB(A), wherein it was concluded that there was no association between the levels of WTN and sleep disturbance when noise annoyance was taken into account.

These results also support the Grant and Codington allowance of sound above 45 dBA for participating landowners, as even levels at 54 dBa for wind turbines have not been found to result in sleep disturbance.

Also, the first study to be published on before-after operation effect of wind turbine noise on objectively measured sleep was conducted with respect to 16 participants living within 1.25 miles of a five-wind turbine project in Ontario, Canada. Jalali et al. 2016. Before–after field study of effects of wind turbine noise on polysomnographic sleep parameters, Noise Health; 18:194-205. (Exhibit 5). This study used portable polysomnography for the first time, which is a comprehensive system that objectively monitors people's sleep in their homes. The study concluded:

> The result of this study based on advanced sleep recording methodology together with extensive noise measurements in an ecologically valid setting cautiously suggests that there are no major changes in the sleep of participants who host new industrial WTs in their community.

Conclusion on WTN and Sleep

The published findings reveal that there is no association between exterior wind turbine sound levels of up to 46 dBA at homes and impact on sleep. The maximum sound level for non-participants was 45 dBA, and, therefore residents should not experience sleep disturbance from the wind turbine sound. Similarly, even levels at 54 dBa for wind turbines have not been found to result in sleep disturbance that support Grant County holding sound levels for participants to 50 dBA and Codington County not having a specific threshold for participants. Also, importantly, CRW's modeling presented by witness Jay Haley shows that there will be no non-participant that experience more than 45 dBA at their residence, and no participant that experiences more than 50 dBA at their residences.

Q. AT THE PUBLIC HEARING, THERE WERE COMMENTS ABOUT INFRASOUND AND LOW FREQUENCY NOISE. CAN YOU EXPLAIN WHAT THESE ARE AND IF THERE IS A CONCERN FOR HEALTH?

A. Infrasound is a term used to describe sounds that are produced at frequencies too low to be heard by the human ear at frequencies of 0 to 20 Hz, at common everyday levels. Infrasound is typically measured and reported on the G-weighted scale ("dBG"). Low frequency noise ("LFN"), at frequencies between 20 to 200 Hz, can be audible.

Infrasource is typically measured and reported on the C-weighted scale ("dBC") to account for higher-level measurements and peak sound pressure levels.

Universally, wind turbine sound standard are set using audible dBA levels, as they are in Grant and Codington Counties, and approved based on modeling. Over the past couple of years there have been a limited number of researchers that have speculated that wind turbine infrasound and LFN could be the potential cause of potential health impacts or sleep disturbance. The mere presence of measured LFN and infrasound does not indicate a potential threat to health or an inability for people to sleep. The fact that one can measure infrasound and LFN from wind turbines at either the exterior or interior of a home does mean that infrasound is at a level that poses a potential health threat. In addition, just because there may be a distinct acoustical signature that allows sound engineers to distinguish between low levels of infrasound or LFN from turbines does not mean that these sounds result in health impacts.

Although wind turbines are a source of LFN and infrasound during operation, these sound pressure levels are not unique to wind turbines. Common natural sources of LFN and infrasound include ocean waves, thunder, and even the wind itself. Anthropogenic sources include road traffic, refrigerators, air conditioners, machinery, and airplanes.

In the context of wind turbines, a study was conducted to investigate whether typical audible noise-based guidelines for wind turbines account for the protection of human health given the levels of infrasound and LFN typically produced by wind turbines. Berger et al., 2015. Health-based Audible Noise Guidelines Account for Infrasound and Low Frequency Noise Produced by Wind Turbines in the journal

Frontiers in Public Health Vol 3, Art. 31 (Exhibit 6). In this study, new field measurements of indoor infrasound and outdoor LFN at locations between 1,312 ft and 2,952 ft from the nearest turbine, which were previously underrepresented in the scientific literature, were reported and put into context with existing published works. The analysis showed that indoor infrasound levels were below auditory threshold levels while LFN levels at generally accepted setback distances were similar to background LFN levels.

The study also discussed two guidelines for exposure to infrasound, dBG, although neither is specific to wind turbine noise. The first was The Queensland Department of Environment and Resource Management's Draft ECOACCESS Guideline- Assessment of Low Frequency Noise. The authors of this study proposed an interior infrasound limit of 85 dBG. This value was derived based on a 10 dB protection level from the average 95 dBG hearing threshold and previous Danish recommendations for infrasound limits. The second was The Japanese Handbook on Low Frequency Noise, which provides an infrasound reference value of 92 dBG at 10 Hz and 1/3 octave bands up to 80 Hz. These values were derived from investigations that monitored complaints of mental and physical discomfort from healthy adults exposed to low frequency sounds in a room. The application of these guidelines for infrasound to CRW shows that that they would not be reached in homes situated in the CRW Project. These homes are located too far back from the turbines based on audible sound criteria to have the accompanying infrasound levels exceed these guidelines. In fact, these levels of infrasound are not reached even in close proximity to the wind turbines themselves.

Furthermore, studies support that that levels of infrasound and LFN are not sufficient to induce adverse health effects, and, thus, health-based audible noise guidelines are suitable for the protection of human health. Simply put, the sound level for the CRW Project on the A-weighted scale, and the setback to homes, act as surrogates to ensure that levels of LFN and infrasound will not impact health or sleep. See, Turnbull C, Turner J, Walsh D. 2012. Measurement and level of infrasound from wind farms and other sources, Acoust Aust 40:45-50. (Exhibit 7).

In 2012, the Turnbull et al. peer-reviewed paper presented a study conducted in Australia around wind turbines and other common sources of infrasound and included the Clements Gap Wind Farm and the Cape Bridgewater Wind Farm. The Clements Gap Wind Farm is comprised of 27 Suzlon S88 2.1 MW wind turbines and the Cape Bridgewater Wind Farm is comprised of 29 Repower MM82 2.0 MW wind turbines. The authors of this paper determined that infrasound from wind turbines reached ambient (background) levels within 656 ft (200 m) to 1,180 ft (360 m) (Table 5). The levels were found to be lower than those measured around beaches, gas fired plants and major roadways. Indeed, humans are regularly exposed to infrasound from several natural and engineered sources at levels that exceed those produced by wind turbines.

Noise Source	Measured Level (dB(G))
Clements Gap Wind Farm at 85m	72
Clements Gap Wind Farm at 185m	67
Clements Gap Wind Farm at 360m	61
Cape Bridgewater Wind Farm at 100m	66
Cape Bridgewater Wind Farm at 200m	63
Cape Bridgewater Wind Farm ambient	62
Beach at 25m from high water line	75
250m from coastal cliff face	69
8km inland from coast	57
Gas fired power station at 350m	74
Adelaide CBD at least 70m from any major road	76

In addition, with respect to LFN and infrasound the Michaud et al. 2016 (Exhibit 3) sound study also included the following conclusion:

> In the current study, low-frequency noise was estimated by calculating C-weighted sound pressure levels. No additional benefit was observed in assessing low frequency noise because C- and A-weighted levels were so highly correlated. Depending on how dB(C) was calculated and what range of data was assessed, the correlation between dB(C) and dB(A) ranged from r = 0.84 to r = 0.97.

Because LFN (dBC) and A-weighted (dBA) levels were so highly correlated, these Health Canada conclusions on the absence of direct or indirect health effects for audible wind turbine noise <46 dBA are true also for the noise in the LFN (dBC) range around the wind turbines they studied. In other words, one does not have to conduct additional studies on LFN to determine potential noise health related impacts or sleep disturbance from wind turbines. Therefore, exposure to these frequencies are inherently included in the findings that no sleep disturbance was found in people living with up to 46 dBA audible sound. These conclusions are supported by other peer-revised studies. McCunney et al. (2014), published a study entitled <u>Wind Turbines and Health: A Critical</u>

Review of the Scientific Literature in the Journal of Environmental and Occupational Medicine (Exhibit 8) and The Ministry for the Environment, Climate and Energy of the Federal State of Bade Wuerttemberg in Germany reported on their study Low-frequency noise including infrasound from wind turbines and other sources (MECE, 2016; Exhibit 9).

Conclusion on Low Frequency Noise and Infrasound

The hypothesis that low frequency noise or infrasound from wind turbines is a causative agent in health effects or sleep disturbance is not supported by the scientific and medical literature. Although infrasound and low frequency noise are emitted from wind turbines and their contribution above background sources can be measured close to wind turbines, noise levels are typically within background levels at homes and are well below levels that could induce health impacts. Measurements at other wind farms are similar, if not lower, than natural and anthropogenic sources of infrasound that we are exposed to, and are below international guidelines on infrasound. Given the setback distances to participant and non-participants residences and CRW's modeled sound levels, the international research indicates that the CRW Project will not impact the health or sleep of local residents.

Q. AT THE HEARING THERE WERE GENERAL COMMENTS ON HEALTH CONCERNS THAT THEY BELIEVED WOULD OCCUR WHEN CRW IS OPERATIONAL. ARE THESE HEALTH CONCERNS LIKELY TO MANIFEST?

A. No. There are numerous peer-reviewed studies that have explicitly examined the relationship between levels of wind turbine noise and various self-reported indicators of human health and well-being. These are summarized in the Knopper et al 2015 (Exhibit

10) and McCunney et al. 2014 (Exhibit 8) literature reviews. These studies have included a wide range of wind turbine models, manufacturers, heights, and noise levels. They were conducted over several years, in some cases over 10 years, after wind turbines became operational. The study of wind turbine health concerns began in Europe in the early 2000s and most recently conducted examined in Canada.

In general, the peer-reviewed studies do not support a correlation between wind turbine noise exposure and any other response other than some annoyance. For example, various studies based on the results of two surveys performed in Sweden and one in the Netherlands (1755 respondents overall), found that no measured variable (e.g., self-reported evaluations of high blood pressure, cardiovascular disease, tinnitus, headache, sleep interruption, diabetes, tiredness, and reports of feeling tense, stressed, or irritable), other than annoyance that was directly related to wind turbine noise for all three datasets.

Michaud et al. 2016a. Exposure to wind turbine noise: Perceptual responses and reported health effects. (Exhibit 11). The Michaud et al. study provides the results of Health Canada's investigation into perceptual responses (annoyance and quality of life) and those of self-reported health effects by participants from the WTN and Health Study. Only the self-reported health effects results are discussed here. Health Canada developed a final questionnaire that consistent of socio-demographics, modules on community noise and annoyance, self-reported health effects, lifestyle behaviors, and prevalent chronic illness.

Health Canada reported that:

> The results from the current study did not show any statistically significant increase in the self-reported prevalence of chronic pain, asthma, arthritis, high blood pressure, bronchitis, emphysema, chronic obstructive pulmonary disease (COPD), diabetes, heart disease, migraines/headaches,

> dizziness, or tinnitus in relation to WTN exposure up to 46 dB. In other words, individuals with these conditions were equally distributed among WTN exposure categories.

This resulted in the overall conclusion of the paper that "Beyond annoyance, results do not support an association between exposure to WTN up to 46 dBA and the evaluated health-related endpoints."

Conclusions on Other Potential Health Impacts

This research studies indicates that given that the maximum sound level at the exterior of non-participating residences (i.e., occupied structures) is less than 45 dBA at non-participants and 50 dBA at participates that CRW Project should not result in these residences experiencing any health effects when the wind turbines become operational.

Q. SO ARE THE GRANT AND CODINGTON COUNTY ORDINANCES ON SOUND PROTECTIVE OF HEALTH?

A. Yes. As described above the counties' ordinances and the overall CRW design goal of no more than 45 dBA at the exterior of non-participating occupied structures. Also, CRW's conservative modeling shows that no non-participant will experience over 45 dBA at their residence and no participant over 50 dBA at their resident, which will protect the health of local residents.

Q. DO THE GRANT AND CODINGTON COUNTY ORDINANCES ON SOUND REQUIRE THAT CRW SETBACK A CERTAIN DISTANCE TO COMPLY WITH THE ORDINANCES?

A. Yes. Although both counties ordinances require a 1,500 foot setback from the wind turbines to non-participating occupied structures, the 45 dBA sound level requirement effectively requires typically a 2,000 foot setback to achieve sound compliance. Similarly, both counties ordinances require a 1,000 foot setback from the wind turbines to participating occupied structure, while the 50 dBA sound level requirement effective requires typically a 1,500 foot setback to achieve sound compliance.

SHADOW/FLICKER STUDY

Q. DO THE GRANT COUNTY AND CODINGTON COUNTY ZONING ORDINANCES PLACE RESTRICTIONS ON ALLOWABLE SHADOW/ FLICKER LEVELS FROM CRW?

A. Yes. Both counties have the same requirement in their ordinances.

> Flicker at any receptor shall not exceed thirty (30) hours per year within the analysis area.

The level of no more than 30 hours a year maybe exceeded by obtaining a written waiver from the landowner.

Q. ARE THE 30 HOURS OF SHADOW/FLICKER STANDARD IN THE COUNTY ORDINANCES CONSISTENT WITH THE LITERATURE ON THE THRESHOLD FOR SHADOW/FLICKER?

A. Yes. Two of the most comprehensive and widely cited published scientific review articles on this topic are Knopper & Ollson (2011; Exhibit 2) and McCunney et al. (2014; Exhibit 8). Both papers review the potential health impacts of shadow/flicker and concluded that there are no health effects associated with this issue living in proximity to wind turbines. Knopper & Ollson (2011) concluded:

> Although shadow flicker from wind turbines is unlikely lead to a risk of photo-induced epilepsy there has been little if any study conducted on how it could heighten the annoyance factor of those living in proximity to turbines. It may however be included in the notion of visual cues. In Ontario it has been common practice to attempt to ensure no more than 30 hours of shadow flicker per annum at any one residence.

Since 2011, there has only been one study conducted that examined the potential for shadow/flicker to lead to increased annoyance for those living near wind turbines. Health

Canada recently completed the most comprehensive study of wind turbine health and annoyance issues of its kind in the world (Health Canada, 2014). (Voicescu et al., 2016; Exhibit 12). By using questionnaires of over 1200 people living as close as 800 ft from a turbine they attempted to determine if they could predict the percentage of people that were highly annoyed by varying levels of hours of shadow/flicker a year or number of minutes on a given day. However, although annoyance did tend to increase with increasing minutes a day they could not find a statistical relationship:

> For reasons mentioned above, when used alone, modeled SF_m results represent an inadequate model for estimating the prevalence of HAWTSF as its predictive strength is only about 10%. This research domain is still in its infancy and there are enough sources of uncertainty in the model and the current annoyance question to expect that refinements in future research would yield improved estimates of SF annoyance.

In light of this study, a no more than 30 hours of shadow/flicker modeled on a residence has almost become the universally adopted standard. To put this in perspective it represents less than 0.5% of the daylight hours a year.

Q. ARE THE 30 HOURS OF SHADOW/FLICKER STANDARD IN THE COUNTY ORDINANCES CONSISTENT WITH THE HOW OTHER JURISDICTIONS APPLY THE THRESHOLD FOR SHADOW FLICKER?

A. Yes. For context, the origins of the 30 hour shadow/flicker threshold standard can be traced to Germany in 2002. The German Territorial Committee for Emissions control released the document "Hinweise zur Ermittlung und Beurteilung der optischen Immissionen von Windenergieanlagen, Länderausschuss für Immissionsschutz [Notes on the identification and evaluation of optical emissions from wind turbines], (in German; Exhibit 13)." The standard was based on limiting the nuisance of local residents. This level is often cited as being below one that would result in nuisance of local residents.

They subsequently codified this formal shadow/flicker guideline as part of the Federal Emission Control Act (Haugen, 2011).

Also, across the United States many jurisdictions have successfully adopted shadow/ flicker restrictions based on the "Realistic/Expected" scenario of no more than 30 hours a year. The following are examples of state-wide legislation.

North Dakota

The North Dakota Public Service Commission ("NDPSC") from the impact upon light-sensitive land uses to be managed and maintained at an acceptable minimum (N.D. Admin. Code §69-06-08-01(5)(c)(3)). The NDPSC has recognized the 30-hour per year standard and evaluates shadow/flicker impacts pursuant to this standard. Justification, similar to what is contained in this report, for continued use of this standard has been provided to the ND PSC during several recent wind project applications and hearings.

Connecticut

Similarly, the Regulations of Connecticut State Agencies Section 16-50j-95, part (c) requires:

> Shadow flicker shall not occur more than 30 total annual hours cumulative at any off-site occupied structure location from each of the proposed wind turbine locations and any alternative wind turbine locations at the proposed site and any alternative sites.

Q. AT THE PUBLIC INPUT HEARING THERE WERE CONCERNS EXPRESSED THAT CRW'S ADHERENCE TO SHADOW/FLICKER THRESHOLD OF 30 HOURS IN GRANT AND CODINGTON COUNTIES IS NOT SUFFICIENT AND POSES A HEALTH CONCERN. DOES THE SCIENTIFIC LITERATURE SUPPORT THEIR CONCERN?

A. No. First, I will provide an overview of the scientific literature, and then apply the findings to the Grant and Codington counties' shadow/flicker ordinance threshold of 30 hours. The main health concern that has been raised with shadow/flicker is the potential risk of seizures in those people with photosensitive epilepsy. Photosensitive epilepsy affects approximately 5% of people with epilepsy where their seizures can be triggered by flashing light. The Epilepsy Society first investigated this issue in the United Kingdom in the late 2000s. They polled their members and determined that no one had experienced an epileptic seizure living or being in proximity to a wind farm from shadow/flicker (Epilepsy Society, 2012; Exhibit 14).

Following on from this informal polling, two of the United Kingdom's academic experts in epilepsy published scientific research articles in the area. Harding et al. (2008; Exhibit 15) and Smedley et al. (2010; Exhibit 16) have published the seminal studies dealing with this concern. Both authors investigated the relationship between photo-induced seizures (i.e., photosensitive epilepsy) and wind turbine shadow/flicker. Both studies indicate that flicker from turbines that interrupt or reflect sunlight at frequencies greater than 3 Hz pose a potential risk of inducing photosensitive seizures in 1.7 people per 100,000 of the photosensitive population. For turbines with three blades, this translates to a maximum speed of rotation of 60 revolutions per minute (rpm). Large, modern, utility scale wind turbines spin at rates well below this threshold and are typically below 20 rpm. For example, the General Electric turbines being proposed for the CRW Farm have a maximum rotational speed of 15.6 rpm (0.78 Hz). Therefore, shadow/flicker from these wind turbines is not at a flash frequency that could trigger seizures and not a concern supported in the peer-review scientific literature.

Further, in 2011, the Department of Energy and Climate Change (United Kingdom) released a consultant's report entitled "Update of UK Shadow Flicker Evidence Base" (Exhibit 17). The report concluded that:

> On health effects and nuisance of the shadow flicker effect, it is considered that the frequency of the flickering caused by the wind turbine rotation is such that it should not cause a significant risk to health.

Therefore, there is nothing in the scientific literature that suggests that shadow/flicker should be limited to protect health.

Q. DO THE GRANT AND CODINGTON COUNTY ORDINANCES ON SHADOW/ FLICKER REQUIRE THAT CRW SETBACK A CERTAIN DISTANCE FROM THE OCCUPIED STRUCTURE TO BE UNDER THE 30 HOUR THRESHOLD?

A. Yes. Although both counties ordinances require a 1,500 foot setback from the wind turbine to non-participating occupied structures, the 30 hour shadow/flicker level requirement effectively requires at least a 1,600 foot setback to achieve compliance. Given that participants in the CRW Project will also not experience more than 30 hours of shadow/ flicker, this setback is also applicable to those residents.

Q. DOES THIS CONCLUDE YOUR SUPPLEMENTAL TESTIMONY?

A. Yes, it does.

State of South Dakota)
) ss
County of Grant)

I, Chris Ollson, being duly sworn on oath, depose and state that I am the witness identified in the foregoing prepared testimony and I am familiar with its contents, and that the facts set forth are true to the best of my knowledge, information and belief.

Chris Ollson

MILES F. SCHUMACHER
SEAL NOTARY PUBLIC SOUTH DAKOTA SEAL
My Commission Expires 4-1-22

SEAL

Subscribed and sworn to before me this 8th day of April, 2019.

Notary Public

My Commission Expires ________