MUNICIPALITY OF THE COUNTY OF KINGS

Health & Safety Impacts from Large-Scale Wind Turbines (P12-01)

Final Report

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Submitted by:

Janis Rod, ALM, P.Eng.

In association with:

Wendy Heiger-Bernays, PhD

Preface

This report was issued as "final" after edits to the "interim findings" which were released on April 20, 2012 and presented at a meeting of the Planning Advisory Committee (PAC) on April 23, 2012. Questions and comments were received on the interim findings from PAC members, Municipal Councillors, Municipal staff and residents of the Municipality of the County of Kings.

Edits and refinements have been made to the draft report to ensure that the concerns of residents, staff, PAC members and the Municipal Council are appropriately addressed within the scope of this contract. There were several concerns and questions that were outside of the scope of this contract; the scope focused solely on risks to health and safety. The project team was not tasked with comparing wind energy to other forms or energy generation nor review of other social, environmental, economic or cultural considerations.

Additionally some questions cannot be addressed with more certainty than presented in the interim report. In some cases, there is a lack of data. This report presents these uncertainties in a balanced way for the review and discussion of the PAC and Council in their review of the municipal planning strategy and bylaw. Our recommendations were formed to assist the planning staff; yet they are not intended to directly form the planning approach for large-scale wind turbines as this was not a planning project.

There are many issues to consider; health and safety is but one aspect. There is a great variance in opinions, concerns and values of the residents of Kings County that spoke at the PAC meeting or provided comments to staff. It is the goal of the project team that this report provide context to these conversations in terms of risks to health and safety from large-scale wind turbines.

This work for the Municipality of the County of Kings is being completed within the regulatory framework for Nova Scotia, Canada. This work has been done under the guidance set forth by Health Canada and the approaches within the Province of Nova Scotia to assess wind energy projects under the Provincial Environmental Assessment Regulations.

While other works have been referenced by the project team, the contents herein are those of the authors and do not reflect the views of the Massachusetts Department of Environmental Protection nor the Independent Expert Review Panel of which one of the authors was a member.

Further the scope of work completed is within the constraints and guidance of the Request for Proposals (RFP) as prepared by the Municipality of the County of Kings. For clarity, this RFP is included in Appendix A.

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1 INTRODUCTION

Like many other local governments in Nova Scotia, across Canada, in the United States, and abroad, the Municipality of the County of Kings has been studying the approaches to planning large-scale wind turbines for several years. While wind turbines have become iconic symbols of our transition from fossil fuels for energy supply, they can also draw a polarized reaction from residents when a wind energy project is proposed in their community. Wind energy projects do have potential ecological impacts (such as bird strikes), yet it is the socio-economic issues that are often more challenging to address. Socio-economic concerns include, but are not limited to, property value, audible noise, low frequency vibration, shadow flicker and aesthetics[1].

After three years of review, Kings County amended their Municipal Planning Strategy (MPS) and Land Use Bylaw (LUB) in May 2011 to include large-scale wind turbines. This was based on an extensive process of review and research, as well as consultation opportunities for residents via open houses and public participation meetings. As-of-right permitting of large-scale wind turbines in certain rural districts was approved by Municipal Council based on minimum separation distance to a dwelling on a neighbouring property of 700m (2300ft). The approval of these MPS / LUB amendments was based on advice of planning staff as part of the multi-year review and feedback from residents, though a limited number of residents participated at that time.

Recent proposals for large-scale wind turbines in the Municipality have caused some residents to question the adequacy of the existing applicable regulations in the MPS and LUB. These concerns were heard by Municipal Council, the Planning Advisory Committee (PAC), and staff in December 2011 and January 2012, as well, petitions and emails were sent to the Municipality documenting residents' concerns; many included citations to research on possible health risks.

Due to the vocalization of concerns about planning for large-scale wind turbines, the PAC recommended that Municipal Council initiate a project to review the recent amendments. This broader engagement builds on the prior work in the past three years. It includes open houses, a questionnaire, PAC meetings and workshops, public participation meetings, and subsequent hearings to review draft amendments; this engagement plan and supporting documents are available to residents online[2]. This recommended review of the May 2011 MPS / LUB amendment was approved by Council on January 17, 2012.

[1] National Research Council. (2007a). Environmental impacts of wind-energy projects. Committee on Environmental Impacts of Wind Energy Projects. National Academies Press. Washington, DC. ISBN-10: 0-309-10834-9.

[2] Municipality of the County of Kings. (Website). P12-01: Large-Scale Wind Turbines. http://www.county.kings.ns.ca/residents/planning/windturbines.aspx

As many of the residents' concerns are related to possible health risks, the Municipal Council approved staff's request for an independent expert review of the potential health and safety impacts from large-scale wind turbines. As such a Request for Proposals (RFP) was subsequently issued stating the need for "objective technical advice concerning the health and safety impacts of large-scale wind turbines"[3]; the RFP is included in Appendix A. Seven proposals were received; these were evaluated by the Municipality's selection committee as per the criteria outlined in the RFP. On March 2, 2012, the Municipality awarded the contract to Janis Rod, ALM, P.Eng., an environmental consulting engineer from Nova Scotia, in association with Wendy Heiger-Bernays, Ph.D., professor of environmental health from Massachusetts. The curriculum vitae for both professionals are included in Appendix B.

It is the goal that the technical advice contained in this report aligns current, reputable research on health and safety impact of wind turbines, as well as independent reports of health effects from wind turbines, to create balanced and impartial recommendations within the specific context of Kings County, that are consistent with the guidelines on health risks set forth by Health Canada in 2000[4]. To this end, primary references include recent peer-reviewed scientific publications, and secondary references include reports prepared by or on behalf of government institutions to provide a review of this literature, such as recent studies prepared for Massachusetts and Oregon. Care was also taken to review other sources of literature, including opinion pieces, media articles, and reports prepared by or on behalf of those stakeholders who promote or oppose wind energy development, such as the Canadian Wind Energy Association and the Society for Wind Vigilance. Municipal staff also provided submissions from residents related to health and safety, as well as the results of the questionnaire; these were reviewed by the project team. This broad collection of resources reviewed is listed in the bibliography in Appendix C.

This independent report is intended to assist Municipal Council, the PAC, and staff to better understand current research on potential health and safety impacts from large-scale wind turbines. Yet this report is also equally intended to provide objective information for consideration of the residents of the Municipality of the County of Kings. This report also places the health risks from large-scale wind turbines in a framework of 'every day' health risks.

By applying the current dialogue on potential health and safety impacts to the context of the Municipality, it is the expectation that this report will inform the ongoing community discussion on planning for large-scale wind turbines in Kings County. To this end, resources for this report are annotated in Appendix D to provide perspective on the available resources.

[3] Municipality of the County of Kings. (January 2012). Request for Proposals (RFP P12-01). Health & Safety Impacts from Large-Scale Wind Turbines.
[4] Health Canada. (August 1, 2000). Decision-Making Framework for Identifying, Assessing, and Managing Health Risks. http://www.hc-sc.gc.ca/ahc-asc/alt_formats/hpfb-dgpsa/pdf/pubs/risk-risques-eng.pdf

While the scope of work involved in completing this report did not include interviews with residents of Kings County, the submissions by Kings' residents to the Municipality were reviewed and considered by the project team. While the comments from residents and concerns relayed during the PAC meeting on April 23, 2012 were all seriously considered by the project team, not all comments could be addressed within the scope of this contract. Previously the project team had direct involvement with residents, including interviews with neighbours of operating wind turbines as part of other work in the Maritimes and New England.

This report is focused solely on the potential health and safety impacts of wind turbines, yet the broader issue of perception must be considered. Social consent for a wind energy project has been shown as a key indicator of reported levels of stress and annoyance by wind farm neighbours. For example, the resident's attitude on the visual impact of the wind turbine(s) has been shown to influence their reported annoyance from noise[5]. Local involvement in the wind energy project tends to have positive effects upon residents' perceptions of the project[6].

Indeed two most recent reviews of potential health impacts prepared by state governments of Massachusetts and Oregon have cited this connection between health impacts and involvement of local residents. This local involvement may be via avenues of public participation in land use planning processes, direct compensation to communities and / or individuals, community project ownership and / or control, and public education on the role of renewable energy. Massachusetts' review suggested that measures which directly involve residents living near wind turbines in the project planning are a 'promising practice' as they may reduce the levels of annoyance[7]. Oregon's strategic health impact assessment states that long-term stress from real or perceived environmental threats can increase risks of negative health effects; this may be exacerbated by community conflict over the wind energy project. Accordingly, public participation, education and community consultation are recommended as they may decrease negative health impacts[8]

Due to the known importance of local involvement, the project team supports this additional effort by the Municipality to provide a transparent review and a community dialogue on planning for large-scale wind turbines. This report forms only one part of the work being undertaken by the Municipality on behalf of its residents to review the existing MPS / LUB for planning of large-scale wind turbines.

[5] Pedersen, E., Persson Waye, K. (2004).Perception and annoyance due to wind turbine noise: a dose-response relationship. Journal of the Acoustical Society of America. 116 (6), 3460–3470.
[6] Devine-Wright, P. (2005). Beyond NIMBYism: Towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy, 8*, 125-139.
[7] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.
[8] Oregon Health Authority. (January 3, 2012). Strategic Health Impact Assessment on Wind Energy Developments in Oregon. Public Comment Release. Prepared by Health Impact Assessment Program.

2 BACKGROUND

2.1 WIND ENERGY IN NOVA SCOTIA

Nova Scotia's Renewable Electricity Plan[9] outlines a regulated target of 25 percent renewable electricity by 2015 and has set a goal of 40 percent by 2020 which is now a legislated target. These are some of the most aggressive renewable electricity transformations in the world. Wind energy is expected to be a big part of this renewable electricity generation given wind resource and its relative low economic cost for renewable electricity generation.

It is expected that by the end of 2012, a total of 168 wind turbines will be installed in Nova Scotian communities; these have the nameplate capacity to generate over 284 megawatt (MW) of our electricity requirements[10]. As this is approximately 14 percent of our electricity requirements, the installation of many more large-scale wind turbines, in combination with other forms of renewable energy, is expected in order to meet our ambitious renewable energy targets. For context, each MW of wind energy can power about 350-400 homes.

Wind energy is included in several renewable electricity generation programs offered by the Province[11]. Under the community feed-in-tariff (ComFIT) program, wind energy is one of the eligible technologies with a guaranteed rate for approved groups, including municipalities, First Nations, co-operatives and others. For wind energy projects greater than 50 kilowatt (kW), there is a guaranteed feed-in-tariff of $0.131 per kW-hour for approved projects. The NS Department of Energy defines large-scale turbines as greater than 50kW name plate capacity; this is comparative to Ontario who also uses 50kW as a boundary to classify wind facilities, as well as the addition of a criterion of sound power level that is greater than or equal to 102 dBA[12].

At time of writing, there are twenty projects approved under the ComFIT program. Of these, all but three are identified as wind energy and five are small wind turbines, i.e., <50kW[13]. An approval under the ComFIT program does not preclude other approvals as required by municipal, provincial or federal governments; ComFIT approval only holds a place in the queue for the electricity distribution system for this guaranteed feed-in-tariff as per the process with Nova Scotia Power.

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[9] Nova Scotia Department of Energy. (April 2010.) Renewable Electricity Plan. www.gov.ns.ca/energy/resources/EM/renewable/renewable-electricity-plan.pdf

[10] Nova Scotia Power. (Website). Renewable Energy - Wind. http://www.nspower.ca/en/home/environment/renewableenergy/wind/default.aspx

[11] Nova Scotia Department of Energy. (Website) Renewable Electricity in Nova Scotia. http://nsrenewables.ca/

[12] Province of Ontario. (O.Reg. 231/11). Environmental Protection Act. Ontario Regulation 359/09. Renewable Energy Approvals under Part V.0.1 of the Act.

[13] Nova Scotia Department of Energy. (February 27, 2012). Approved ComFIT Project Status. https://nsrenewables.ca:44309/approved-comfit-projects-status

ComFIT projects are not typically large arrays of multiple large-scale wind turbines as they need to connect into the electricity distribution system (i.e., electricity generated is used locally); however, they may include a few large-scale wind turbines if capacity exists in the distribution system. The larger wind energy projects that connect to the transmission lines are selected via a competitive bidding process as organized by the provincially appointed Renewable Electricity Administrator (REA); these often consist of an array of large-scale wind turbines.

2.2 Environmental Assessment of Wind Energy Projects

In Nova Scotia, any wind energy project that has a production rating of at least 2MW must undergo a Class I environmental assessment (EA)[14]. The production rating, also referred to as "nameplate capacity", is the maximum power a turbine can output given ideal wind conditions; whereas the capacity factor is based on the turbine's output for real-world wind conditions, which is generally said to be about 30%. A Class I EA is a 50-day process overall with a 30-day review period by government experts, members of the public, and other stakeholders. This process will be triggered by the wind energy projects under the REA process, yet not all projects proposed under the ComFIT program will require an EA approval from the Minister of Nova Scotia Environment as many projects may be under the size trigger, i.e., 2MW production rating .

For projects that have a nameplate capacity of 2MW or greater, the NS EA process assesses a variety of components for all project stages (i.e., construction, operation and decommissioning). To view other wind energy project EA reports, prior EA reports for wind energy projects in Nova Scotia are available online along with the Terms and Conditions of each approval [15]. Health and safety is one such component that must be reviewed in terms of predicted changes in the environment that can affect human health. Noise is often addressed separately as its own biophysical component with emphasis on potential interaction with human health. Typically project conditions require monitoring of noise post-construction where residents have expressed concerns about noise levels.

This EA is completed by the developer but it must be done to the satisfaction of Nova Scotia Environment for approval, with consideration of expert reviews and comments of stakeholders, including residents. A guide has been prepared by the Province for proponents preparing an EA for wind energy projects[16]. This includes general requirements of baseline information and prediction of effects from the proposed wind energy project. This often includes baseline noise monitoring (i.e., existing conditions at closest dwellings) and modeling of sound pressure levels

[14] Province of Nova Scotia. (N.S. Reg. 277/2009). Environmental Assessment Regulations made under Section 49 of the Environment Act S.N.S. 1994-95, c. 1. http://www.gov.ns.ca/just/regulations/regs/envassmt.htm
[15] Nova Scotia Environment. (Website). Projects. http://novascotia.ca/nse/ea/projects.asp
[16] Nova Scotia Environment. (May 2007; Updated January 2012). Proponent's Guide to Wind Power Projects: Guide for preparing an Environmental Assessment Registration Document.

during worst case conditions for the proposed wind turbines (i.e., predicted effect considering the site specifics and details of proposed project). It is understood that the 2012 version of this guide is again under the process of revision to reflect best practice of EAs for wind energy projects, including advice of a maximum of 40 decibel A-weighted (dBA) at the outside of nearest dwellings[17].

If a wind energy project has a federal trigger under the *Canadian Environmental Assessment Act*, Health Canada would participate in the review of a federal EA as an expert department and provide advice respecting noise. While Health Canada has no jurisdiction in the provincial EA process, Nova Scotia Environment heavily relies on Health Canada for their expert advice with respect to noise. The EA registration document is reviewed by Health Canada from the perspective of human health; written comments are provided to NS Environment via the regional EA coordinator and the scientists' expertise in Ottawa. In 2010, Health Canada prepared a guide for developers and project stakeholders for environmental assessment where their advice is requested, including key resources specific to wind turbines and noise[18].

Health Canada experts' assessment of the potential effects includes review and analysis of the modeling of predicted sound pressure levels from the operating wind turbines. An example of Health Canada's response to a proposed wind energy project in Nova Scotia provides context to the extent of this review[19]; however, Health Canada's expert advice will vary by project and as scientific knowledge develops over time.

Health Canada has been in the process of developing National Guidelines for Environmental Assessment: Health Effects of Noise; this was proposed in 2004[20] and is believed that these may be released in coming months, yet no date has been provided. Health Canada is currently evaluating methods, including conducting preliminary research, to assess the potential adverse effects of wind turbines on human health. Health Canada appears to be building upon existing knowledge and to be continuing with research to provide the most up-to-date advice as part of its role to provide expert advice on human health. This approach is in line with Health Canada's revised decision making framework including issue identification, risk assessment, and risk management.

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[17] Sandford, S. (April 12, 2012). Presentation to Planning Advisory Committee on behalf of Nova Scotia Environment. Municipality of the County of Kings.
[18] Health Canada. (2010). Useful Information for Environmental Assessments. Minister of Health. http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/eval/environ_assess-eval/environ_assess-eval-eng.pdf
[19] Denning, A. (August 6, 2009). Health Canada's response to the Digby Wind Power Project Addendum, Digby, Nova Scotia. Letter from Health Canada to Nova Scotia Environment.
[20] Bly, S., Michaud, D., Keith, S., Alleyne, C., McClymont-Pearce, D. (2004). National Guidelines for Environmental Assessment: Health Impacts of Noise. Canadian Acoustics, 32(3): 38-39

2.3 Wind Energy in Kings County

Within Kings County, no large-scale wind turbines have been constructed to date. Two projects are in early proposal stages under the ComFIT program[21]. There has also been initial interest shown by a private developer of a project in Kings County via the independent power producers program as administrated by the REA[22]. While wind energy projects that are larger than 2MW in capacity will also require a provincial EA, land use control for large-scale wind turbines falls squarely within the responsibilities of Nova Scotian municipalities and towns. Accordingly, approval from the Municipality of the County of Kings is required as per its existing MPS / LUB for construction of large-scale turbines (currently defined by the Municipality as a turbine with a name plate capacity of over 100kW)[23].

Wind energy is seen as an important tool to increase energy independence, stabilize future electricity costs, and decrease our reliance on combustion of fossil fuels for electricity. Indeed the Municipality's Integrated Community Sustainability Plan includes reducing dependence on non-renewable energy as one of the goals in its action plan[24]. Yet it also recognizes that there is a need to consider the broader goal of renewable energy in context of residents' concerns.

While the benefits of energy generating systems, including wind energy, are primarily regional and global, the potential negative impacts are most often felt at the local level. This disconnect creates a tension that often underlies cited concerns about policies for planning of large-scale wind turbines. There is a need to balance the importance of renewable energy with the potential negative local impacts from large-scale wind turbines. Creating this balance is the responsibility of individual local governments in Nova Scotia; yet this is supported by the provincial EA process for projects at or above 2MW of production capacity.

Under Section 190(b) of Nova Scotia's *Municipal Government Act* [25], municipalities are enabled "to assume the primary authority for planning within their respective jurisdictions, consistent with their urban or rural character, through the adoption of municipal planning strategies and land-use by-laws consistent with interests and regulations of the Province". While this allows

[21] Nova Scotia Department of Energy. (Website). Approved ComFIT Projects Status. https://nsrenewables.ca:44309/approved-comfit-projects-status
[22] Hennessey, J. (March 27, 2012). Proposed wind project 'a marathon, not a sprint': Company official. The Kings County Register / Advertiser. http://www.kingscountynews.ca/News/2012-03-27/article-2940921/Proposed-wind-project-%26lsquo%3Ba-marathon,-not-a-sprint%26rsquo%3B%3A-Company-official/1
[23] Municipality of the County of Kings. Land Use Bylaw. Section 5.5. Siting of Large-scale Wind Turbines. http://www.county.kings.ns.ca/upload/All_Uploads/Comdev/Planning/windturbines/Regulations/MPS%20S5.5%20Siting%20of%20Large-scale%20Wind%20Turbines.pdf
[24] Institute for Planning and Design. (March 2010). Integrated Community Sustainability Plan. Phase II Report. http://www.county.kings.ns.ca/upload/All_Uploads/BulletinBoard/General/Kings%20County%20ICSP-Phase%202%20Final%20Report.pdf
[25] Province of Nova Scotia. (1998; last amended 2010). Municipal Government Act. http://nslegislature.ca/legc/statutes/muncpgov.htm

municipal units the autonomy to govern its own land use (with some provisions), it also creates a challenge when planning complex and unusual land uses, such as large-scale wind turbines.

Some guidance is available for municipalities; this includes a collection of reference material available from Department of Energy on potential impacts from wind turbines[26], including a model bylaw for Nova Scotia municipalities[27].

Also, the Union of Nova Scotia Municipalities' Sustainability Office issued a high-level document to outline the key aspects of engagement, mapping and planning policy[28]. When residents learn of a proposed large-scale wind turbine in their community, they will often seek out information to better understand the issues and provide comment to their local government and the developer. This is an important part of the public engagement process. Indeed community engagement, mapping constraints and policy development are necessary for municipal planning for large-scale wind turbines.

Impacts from construction and operation of large-scale wind turbines are broad; these are generally considered in an EA. The residents of Kings County expressed concerns about the potential impact to many of these valued components of their environment, including but not limited to:

- Ecological: impacts to birds, bats, wetlands, flora, fauna, fish, etc.;
- Financial: leases to land owners, increased tax base for municipality, construction contracts, tourism impacts, property values, etc.;
- Cultural: historical view planes, impacts to artifacts, interaction with traditional land uses, etc.;
- Social: aesthetics, recreational uses, etc.; and,
- Health and Safety: shadow flicker, ice throw, sound/vibration (i.e., both audible noise and infrasound).

Upon the relatively recent proposal of wind energy projects in the Municipality, some residents expressed concern about the proposed siting of large-scale wind turbines despite the consultation and subsequent planning policies approved in May 2011. The two ComFIT projects proposed along the South Mountain has created questions in the minds of some residents to prompt this review which was approved by Council in January 2012. Also, the initial presentation to Council about the potential wind energy project on the North Mountain by Acciona Wind Energy Canada Inc. on March 23, 2012 has appeared to increase the level of

[26] Nova Scotia Department of Energy. (Website). Wind Multimedia Library. https://nsrenewables.ca:44309/wind-multimedia-library

[27] Jacques Whitford. (January 28, 2008). Model Wind Turbine By-Laws and Best Practices for Nova Scotia Municipalities. Prepared for Union of Nova Scotia Municipalities.

[28] Rod, J. (2011.) A Primer on Wind Energy Development for Nova Scotian Municipalities. http://www.sustainability-unsm.ca/our-work.html

interest; there were many residents from the communities near this proposed site who posed questions at the PAC meetings on April 12 and April 23, 2012.

The primary issue for concern cited by residents appears to be potential health and safety impacts; accordingly, the Municipality has procured this independent review to better understand the potential of health and safety impacts as part of its current community engagement and its subsequent review of the current planning policies. Other issues, such as property values, are being addressed by Municipal staff in separate report(s); these will be considered as a whole by the PAC, staff and Municipal Council in this broader review.

2.4 Large-Scale Wind Turbines and Potential Health Impacts

The potential impact of large-scale wind turbines on health and safety is a unique challenge due to the technical complexity and the varied opinions from multiple sources. Unlike most land uses planned by local governments, there is much contradictory and highly technical information on potential health impacts from large-scale wind turbines, and historical lack of measurements accompanying siting documents and operations.

While much information can be found on each of the potential interactions of large-scale wind turbines within their environmental setting, it is the issue of health and safety impacts which appears the most controversial, specifically audible noise, low frequency noise and vibration. Untangling the direct effects (noise and vibration) from indirect effects (anger, frustration and fear) is challenging. Accordingly residents become polarized as conflicting resources are easily found on websites. One end of the spectrum contains industry organizations, like Canadian Wind Energy Association (CanWEA) and the American Wind Energy Association who have commissioned reviews of impacts to health[29]. At the other end of the spectrum, there are groups dedicated to publishing news and views opposed to the wind energy industry, such as Wind Watch, who focus on significant health impacts from large-scale wind turbines, including a set of health effects characterized as "Wind Turbine Syndrome"[30].

Many resources (both peer-reviewed literature and otherwise) appear to have bias; there have been suggestions that some peer-reviewed literature on the social consent for wind power has a pro-wind energy bias by unhelpfully labeling opposition as not-in-my-backyard (NIMBY)[31]. Accordingly it is scientifically rigorous research that must form the core reference for public

[29] American Wind Energy Association; Canadian Wind Energy Association. (2009). Wind Turbine Sound and Health Effects An Expert Panel Review. http://www.canwea.ca/pdf/talkwind/Wind_Turbine_Sound_and_Health_Effects.pdf

[30] Pierpont, N. (2009). Wind Turbine Syndrome: A Report on a Natural Experiment. http://www.windturbinesyndrome.com

[31] Aitken, M. (2010). Why we still don't understand the social aspects of wind power: A critique of key assumptions within the literature. Energy Policy, 38(4), 1834-1841.

policy; this must include both causal relationships (i.e., dose-response relationship) and anecdotal evidence (i.e., self-reported) with the understanding of the limitations of each.

Indeed the recent review on health impacts of wind turbines by an independent panel of experts in Massachusetts[32] is timely and germane to this undertaking by the Municipality. The panel was composed of physicians and scientists with broad expertise in areas including acoustical noise/infrasound, public health, sleep disturbance, mechanical engineering, epidemiology, and neuroscience. This panel was charged to identify scientifically documented or potential connections between wind turbines and human health impacts, as well as offer suggestions on best practices to inform public policy decisions on siting large-scale wind turbines. The panel's charge did not include investigating or addressing reported problems at any particular turbine installation, though the panel did receive extensive public comment, including from residents who live near wind turbines. This review included both peer-reviewed and non-peer-reviewed studies.

Some of the key findings of the panel were:

- There is no evidence for a set of health effects from exposure to wind turbines that could be characterized as a "Wind Turbine Syndrome".
- Claims that infrasound from wind turbines directly impacts the vestibular system have not been demonstrated scientifically. Available evidence shows that the infrasound levels near wind turbines cannot impact the vestibular system.
- The weight of the evidence suggests no association between noise from wind turbines and measures of psychological distress or mental health problems.
- None of the limited epidemiological evidence reviewed suggests an association between noise from wind turbines and pain and stiffness, diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, and headache/migraine.
- There is limited epidemiologic evidence suggesting an association between exposure to wind turbines and annoyance. There is insufficient epidemiologic evidence to determine whether there is an association between noise from wind turbines and annoyance independent from the effects of seeing a wind turbine and vice versa.
- There is limited evidence from epidemiologic studies suggesting an association between noise from wind turbines and sleep disruption. In other words, it is possible that noise from some wind turbines can cause sleep disruption. Whether annoyance from wind turbines leads to sleep issues or stress has not been sufficiently quantified. While not based on evidence from wind turbines, there is evidence that sleep disruption can adversely affect mood, cognitive functioning, and overall sense of health and well-being.

[32] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health. http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- Scientific evidence suggests that shadow flicker does not pose a risk for eliciting seizures as a result of photic stimulation. There is limited scientific evidence of an association between annoyance from prolonged shadow flicker (exceeding 30 minutes per day) and potential transitory cognitive and physical health effects.
- There is sufficient evidence that falling ice is physically harmful and measures should be taken to ensure that the public is not likely to encounter such ice.
- Lastly, Effective public participation in and direct benefits from wind energy projects (such as receiving electricity from the neighboring wind turbines) have been shown to result in less annoyance in general and better public acceptance overall.

Across Canada and internationally, local, regional and national governments have also been reviewing the state of knowledge on potential health impacts from large-scale wind turbines. For example, a review was done in Ontario in 2010[33] to inform its *Green Energy Act* and associated regulations. This review concluded that "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. The sound level from wind turbines at common residential separation distances is not sufficient to cause hearing impairment or other direct health effects, although some people may find it annoying." (p.3).

Yet Michaud *et al* (2008) have identified annoyance as an adverse impact on human health that can be related to high levels of wind turbine noise[34]; specifically, "community noise level was associated with an increase in the percentage of the community indicating that they are highly annoyed. The relationship between noise levels and high annoyance is stronger than any other self-reported measure, including complaints. Defining high noise annoyance as an adverse health effect is certainly consistent with Health Canada's definition of what constitutes "health"." (p.16).

Health Canada's working definition of annoyance is based on ISO (2003)[35]:

> *Annoyance is "a state, or adverse reaction, that may be referred to as being annoyed, disturbed, bothered, (or dissatisfied)." In practice, "noise annoyance: a degree of annoyance measured by a subject's response to an annoyance questionnaire as part of a social survey on noise and annoyance" and "high annoyance: a degree of noise annoyance*

[33] Chief Medical Officer of Health Report. (May 2010). The Potential Health Impact of Wind Turbines. http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf

[34] Michaud, D.S., Bly, S.H.P, Keith, S.E. (2008). Using a change in percent highly annoyed with noise as a potential health effect measure for projects under the Canadian Environmental Assessment Act. Canadian Acoustics. 36(2), 13-28.

[35] ISO. (2003). Acoustics – Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedure. ISO 1996-1:2003(E). Geneva, Switzerland: International Standards Organization.

with a minimum cut-off of 7-10 on the ISO-recommended scale of 0-10 or the two categories (very or extremely) on an adjectival scale".

The World Health Organization is silent on a strict definition, although in their Guidelines for Community Noise (1999), the following statement is made: (p.50, Section 3.8)[36]:

…a feeling of displeasure associated with any agent or condition, known or believed by an individual or group to adversely affect them. However, apart from "annoyance", people may feel a variety of negative emotions when exposed to community noise, and may report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Thus, although the term annoyance does not cover all the negative reactions, it is used for convenience in this document…

Annoyance is one of the most widely studied adverse reactions to noise. While this term "annoyance" has a negative connotation to some, it is the term that captures the complex physical and psychological human responses. Pedersen and Persson Waye (2007) statistically correlated the perception of annoyance with sound pressure level from wind turbine noise[37]. These studies suffer from the fact that they are cross-sectional in design and often have too few responses for the statistical analyses required to disentangle the complex relationships between noise from turbines and annoyance independent from the effects of seeing a wind turbine and vice versa. Of the 754 respondents in their study, 31 residents said they were annoyed by wind turbine noise. Of those who were exposed to sound pressure levels under 37.5 dBA, 3 to 4 percent of respondents said they were annoyed by wind turbine noise; of those exposed to sound pressure levels between 37.5 and 40dBA, about 6 percent of respondents said they were annoyed. At greater than 40dBA, about 15 to 20 percent of respondents reported annoyance, yet this is not statistically significant because of the low numbers of respondents living with sound pressure levels above 40dBA. Beyond this correlation, it was found that increased visibility and rural areas with hilly / rocky terrain increased annoyance levels. Again, the importance of local context and residents' perception are both shown to influence reported annoyance levels.

Several peer-reviewed studies have been published since Pedersen and Persson Waye (2007), all examining the relationship between wind turbines, noise and annoyance (van den Berg, et al., (2008); Pedersen and Larsman, (2008); Petersen et al. (2009); Petersen et al., (2010); Janssen et al., (2011)). In each of these studies, researchers try to disentangle the noise generated from wind turbines, and cross-sectional survey tool-generated responses on physical health, annoyance, age, noise sensitivity, economical benefit, and visibility of the wind turbine.

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36 Berglund, B., Lindvall, T., Schwela, D.H. (1999). Guidelines for Community Noise. Geneva: World Health Organization. www.who.int/docstore/peh/noise/guidelines2.html

37 Pedersen, E., Persson Waye, K. (2007). Wind turbine noise, annoyance and self-reported health and wellbeing in different living environments. Occupational and Environmental Medicine. 64, 480–486.

There are many sources, perspectives and data that must be reviewed and analyzed to ascertain a balanced understanding of potential health effects. Review of information in a scientific and logical manner is the primary objective of this report to assist the Municipal Council, the PAC, and staff, as well as the Kings County residents, in best planning policies for wind energy in their Municipality with respect to potential risk to human health and safety.

2.5 Context of Health Risks from Wind Turbines

Assessment of human health risks is a challenging process. Governmental organizations provide guidelines and tools that allow the assessment of risk qualitatively (in words), or quantitatively (with numbers). Risk is a function of the intensity and frequency of human contact or exposure with a hazard. Hazards can be chemical, such as pesticides, biological, such as bacteria, or physical, such as noise and vibration.

Historically, human health risk from environmental hazards, such as pesticide contamination of water supplies, has been determined on a hazard-by-hazard basis. The risk assessor gathers information from the literature and from potentially impacted receptors (people) about their exposure – how much water they drink on a daily basis, the frequency with which they bathe or shower with the water and the amount of water used for such activities.

Regulatory bodies, such as Health Canada and United States Environmental Protection Agency, gather data from the literature to provide numerical estimates of the relationship between human exposure and the adverse health outcome(s). This is referred to as the dose-response relationship. There is uncertainty in the estimates of exposure and in the estimates of dose-response. Some uncertainty can be decreased with more and better data about the situation. Using guidelines provided, numerical estimates of risk provide a prediction about the numbers of people whose health might be negatively impacted due to the situation assessed.

Never is there “no risk”. Every activity in which we are engaged poses some level of risk. Often there is a level or amount of risk that we – either as individuals or societally – accept because we receive a perceived or actual benefit from the activity or the hazard. For example, we use pesticides to improve crop yield and marketability, yet we know that there are impacts of pesticides on neurological development; we can measure these pesticides in our food and water and hence, we can quantify the risk of adverse neurological development to individuals and populations. These estimates of risk contain uncertainties and some of these are truly unknown, because of the lack of science. Further some of these can be decreased with a better understanding of the situation (e.g., who is eating the food, how much pesticide is on the food, how much of this food we eat, etc).

Estimates of risk are typically provided to risk managers who must make difficult decisions about managing risks with benefits. Recently, attempts to coordinate and integrate cumulative (or many hazards at once) risks and benefits to individuals or populations have received attention – these are referred to as health impact assessments; Health Canada has developed an approach to their development[38]. One component of a health impact assessment is the risk assessment. To this end, Health Canada developed a framework in 2000 for risk assessment that attempts to incorporate issue identification, risk assessment and risk management in one decision-making framework[39]. This framework operates on the following underlying principles:

- Maintaining and improving health is the primary objective;
- Involve interested and affected parties;
- Communicate in an effective way;
- Use a broad perspective;
- Use a collaborative and integrated approach;
- Make effective use of sound science advice;
- Use a "precautionary approach";
- Tailor the process to the issue and its context;
- Clearly define roles, responsibilities, and accountabilities; and
- Strive to make the process transparent.

For wind turbine health impact assessment, this means that the decision makers must weigh the benefits and the risks. This report focuses on the risks of wind turbines on the health and safety of people and to a lesser extent to non-human organisms. The reader is reminded that the accuracy of the risk assessment is a function of the information and data available for assessment.

[38] Health Canada. (2004). The Canadian Handbook on Health Impact Assessment. http://www.hc-sc.gc.ca/fniah-spnia/pubs/promotion/_environ/handbook-guide2004/index-eng.php

[39] Health Canada. (2010). Useful Information for Environmental Assessments. Minister of Health. http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/eval/environ_assess-eval/environ_assess-eval-eng.pdf

3 Potential Health and Safety Impacts

3.1 Specific Concerns of Residents of Kings County

As part of the broad review of planning for large-scale wind turbines, Kings County prepared and broadly advertised a questionnaire to better understand perspectives of the residents. 477 responses were received. While this is not a scientific poll and cannot be relied upon to provide an accurate reflection of the opinion of Kings County as a whole, it does provide a better understanding of the types of concerns by residents about large-scale wind turbines. The results are summarized in a report prepared by Municipal staff[40]; the reader is referred here for further detail.

Respecting the focus of this report on health and safety, the following responses are noted:

- 238 of the 472 respondents noted that noise was an "extreme concern" with other responses ranging from "no concern" through to "strong concern" being relatively evenly dispersed.
- 184 of the 462 respondents noted that safety was an "extreme concern" with other responses ranging from "no concern" through to "strong concern" being somewhat evenly dispersed.
- 203 of the 461 respondents noted that shadow flicker was an "extreme concern" with other responses ranging from "no concern" through to "strong concern" being somewhat evenly dispersed.
- Specific comments on issues of concern related to health and safety generally included:
  - Audible noise;
  - Low frequency noise and vibration (or infrasound / sonic vibration);
  - Inner ear vibration (effects on vestibular system, e.g., nausea, headaches, etc.);
  - Hearing (impairment, tinnitus);
  - Heart problems, high blood pressure, etc. (i.e., cardiovascular system effects);
  - Ice throw;
  - Seizures (from shadow flicker);
  - Flight safety / navigational aids;
  - Structural failure / blade throw;
  - Stress via reduced peace; less enjoyment of property, etc. (i.e., annoyance);
  - Lightning strikes;
  - Fire;
  - Leakage of hydrocarbons (i.e., potential groundwater / soil contamination);
  - Electromagnetic fields (EMFs);
  - Stray electrical charge; and
  - Potential impact to farm animals.

[40] Municipality of the County of Kings. (April 12, 2012). Public Feedback Report. P12-01 Large-scale Wind Turbine Regulations Review. http://www.county.kings.ns.ca/upload/All_Uploads/Comdev/Planning/windturbines/Reports/2012.04.12%20Public%20Feedback%20Report.pdf

- 220 of the 357 respondents selected the more precautionary approach to balance the level of impact with expected benefits from large-scale wind turbines, as opposed to a more moderate approach (90 respondents) and an aggressive development approach (47 respondents). This reflects the concern with uncertainty in nature of the potential effects.
- Yet there were several respondents (56 of 472 for noise, 93 of 462 for safety, and 87 of 461 for shadow flicker) who identified no concerns related to health and safety.

Indeed the responses in the questionnaire dealing with health and safety issues demonstrate that the issues related to vibration – both audible noise and low frequency noise and vibration – and their potential direct and indirect health effects are of most concern to residents. Further many residents cited the importance of reviewing "not only proven risks … but those that have yet to be proven". This focus is also supported by the direct submissions by residents to the Municipality; these were reviewed as part of this study on vibration. Indeed audible noise and low frequency vibration are the focus of numerous research papers and other resources sought out as part of this review.

3.2 Scoping of Human and Animal Impacts

Based on the submissions from residents, including the results of the questionnaire, the list of sixteen potential health and safety impacts were grouped into nine categories, each of which is discussed separately in this sub-section. Three classifications of symptoms (i.e., effects on vestibular system, hearing, and cardiovascular system) and stress / annoyance as identified from the residents' submissions and the literature are discussed within the direct effects from audible noise and low frequency vibration. The four emergency or catastrophic events (i.e., structural failure / blade throw, lightning strikes, fire and leakage of hydraulic fluids) are grouped as unplanned events. In some locations, animals might be exposed to these hazards, and the potential effect on livestock is addressed separately. Further, the additional safety risk during construction of wind energy projects is also discussed below; while not specifically addressed as a safety concern, there were several concerns expressed by residents about the extent of construction activities, including transportation of concrete and turbine components. These ten are presented alphabetically below in separate subsections.

The discussion of each is generally from a perspective of evaluating potential significance of an adverse environmental effect. This is based on the typical practice of EA; in that, an effect may be considered significant where it may occur as a result of any of the following:

- Magnitude of the effect;
- Geographic extent of the effect;
- Duration of the effect;
- Frequency of the effect;

- Degree of reversibility of the effect; or
- Probability of occurrence of the effect.

Based on this high level scoping below, four potential impacts are reviewed in further detail in Section 4 to Section 7 inclusive. That is, six potential impacts are considered low concern, are relatively common to other typical development projects, or are addressed in sufficient detail via other processes.

3.2.1 Audible Noise

Indeed wind turbines do produce noise; by definition, noise is unwanted sound. Accordingly, the perception of increased sound pressure level has been shown to be affected by residents' perception of the wind energy project. The potential effects of audible noise from large-scale wind turbines have been studied in peer-reviewed literature and recent studies provide measurements of noise at distances from the turbines. The quantitative effect (i.e., increase above existing ambient noise levels) can be predicted via baseline measurements and modeling as per standard practices. There are also many scientific research articles and government or other stakeholder sponsored recommendations on defining an appropriate sound pressure level at receptors, including guidelines from the World Health Organization[41,42] (WHO).

If wind turbines are not appropriately sited, there may be a negative effect from increased sound pressure level on some receptors; yet the effect may be indirect, i.e., via annoyance. The effect to ambient sound levels from an operating turbine is ongoing; the effects are more problematic at night. The effect can increase in magnitude during certain climatic conditions, e.g., fog. Accordingly, this potential effect will further reviewed in Section 4 in context of existing research and Kings County.

3.2.2 Electromagnetic Fields

Electric and magnetic fields (EMF) are not unique to wind energy projects; EMF is part of our modern lives. Health Canada stated that while there may be health concerns associated with low levels of EMF, use of electricity and electrical appliances exposes residents constantly to EMFs at extremely low frequencies[43]. There are four sources of EMFs from wind energy projects; these are grid connection lines, wind turbine generators themselves, electrical transformers, and the underground network cables. The potential effect from EMFs is not specific to wind energy; further potential EMF from electricity transmission lines is known to be higher than the wind turbines themselves.

Due to the extremely low predicted magnitude of this effect in relation to other everyday (i.e.,

[41] World Health Organization. (2009). Night Noise Guidelines for Europe.
[42] Berglund, B., Lindvall, T., Schwela, D.H. (1999). Guidelines for Community Noise. World Health Organization.
[43] Health Canada. (January 2010). It's Your Health – Electric and Magnetic Fields at Extremely Low Frequencies. http://www.hc-sc.gc.ca/hl-vs/alt_formats/pdf/iyh-vsv/environ/magnet-eng.pdf

non-wind turbine) exposures to EMF, this potential linkage to health and safety is not further reviewed in this study. This is in line with Health Canada's position[44].

3.2.3 Flight Safety

Wind turbines can be a safety issue for aircraft in terms of potential disruption to existing flight path or navigational aids. For this reason, developers must liaise with Transport Canada and NavCanada to ensure that their proposed projects do not cause unacceptable risks in terms of flight safety.

The second largest Royal Canadian Air Force base in Canada is 14 Wing Greenwood; it is responsible for search and rescue operations, sovereignty patrols, and other ocean surveillance. Officials from 14 Wind Greenwood have expressed concern to the PAC via a presentation on April 12, 2012. They also explained that: impacts can be mitigated in many instances; there are minimal impacts from smaller wind energy projects; discussions are ongoing with many proponents; and there is a formal process of review and documentation of concerns which feeds into the EA process.

Accordingly, this potential interaction with health and safety is not included in the scope of this study; nor is this an area of expertise within the project team. This issue is well addressed through existing processes based on expertise present within the Department of National Defence and Transport Canada.

3.2.4 Ice Throw

Ice can build up on a wind turbine like any other structure during appropriate climatic conditions. When the turbine is operating, ice can also build up on the blades; the ice will be eventually shed. When these ice fragments detach from the blades, they can be thrown from the wind turbine landing either in the plane of the wind turbine blade or downwind.

There are data on the occurrence and magnitude of ice throw from operating large-scale wind turbines. Reviews have been done by positional stakeholders and governments, including Massachusetts. Accordingly, this potential effect will be further reviewed in Section 5 in context of existing research and Kings County.

3.2.5 Livestock

Several residents cited concerns with potential health impacts on animals; given the agricultural context of Kings County, potential impact to livestock is a specific concern of some residents.

[44] Health Canada. (November 8, 2008). Response Statement to Public Concerns Regarding Electric and Magnetic Fields (EMFs) from Electrical Power Transmission and Distribution Lines: Federal-Provincial-Territorial Radiation Protection Committee. http://www.hc-sc.gc.ca/ewh-semt/radiation/fpt-radprotect/emf-cem-eng.php

As part of the recent study in Massachusetts[45], the Panel searched for literature, including non-laboratory animal studies, well-documented cases of animals impacted by wind turbines, or laboratory-based animal models to evaluate biological plausibility of a cause and effect. Literature found included media articles with limited background information and peer-reviewed studies relying on the laboratory rat as a model with exposures of infrasound that are beyond expected levels of exposure from large-scale wind turbines.

Accordingly, this issue is not further reviewed separately; however, the discussions on potential interactions – predominantly low frequency vibration – may be applied to livestock, as well as domestic animals, in the absence of either laboratory studies where animals are subjected to exposures that mimic wind turbines or well-documented effects from operating large-scale wind turbines.

3.2.6 Low Frequency Noise and Vibration

Indeed wind turbines have been shown to produce vibration; this includes audible noise (i.e., dBA range which is addressed separately) and low frequency vibration[46]. Also referred to as infrasound or sonic vibration, the frequency range of interest for sounds with low frequency content is defined as under 100 Hertz (Hz) by the International Standards Organization (ISO)[47]. Very low frequencies (i.e., under 20 Hz) are in the dBG range which is weighted to accentuate low-frequency components of a sound.

There has been much scientific research and discourse in popular literature on the potential impact on health from low frequency vibration. The level of understanding regarding the health impacts of infrasound is less well understood than the impacts of sound pressure increases in the audible range. There is recent literature regarding the sensitivity of some people to infrasound and the reported relationship between some turbines and health that cannot be explained by A-weighted sound pressure levels (i.e., audible range). Accordingly, this potential effect will be further reviewed in Section 6 in context of existing research and Kings County.

3.2.7 Safety During Construction and Decommissioning

While the interaction of construction activities with human health and safety was not specifically noted by residents, concerns with extent of construction activities required for large-scale wind turbines have been cited by several residents. The key construction activities can be defined as: surveying, land clearing, construction / modification of roads, delivery of

[45] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.
[46] O'Neal, R.D, Hellweg, R.D., Jr., Lampeter, R.M. (2011, March). Low frequency noise and infrasound from wind turbines. Noise Control Engineering Journal. 59(2), 135-57.
[47] ISO. (2003). Acoustics – Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedure. ISO 1996-1:2003(E). Geneva, Switzerland: International Standards Organization.

equipment and foundation materials, temporary storage facilities, turbine component transportation to the site, and tower and turbine assembly and installation, as well as connection to distribution or transmission line operated by Nova Scotia Power, including substation construction as appropriate [48]. Similar activities occur during decommissioning.

These construction activities are typical of a large construction project with exception of turbine component transport and assembly. All activities are subject to the Nova Scotia Occupational Health and Safety Act[49]. An approval from Nova Scotia Transportation and Infrastructure Renewal is required for wind turbine component transport to occur, while standard requirements exist for transport of gravels, etc. which are under their control jurisdiction as well. Accordingly, this potential interaction with health and safety is not further reviewed in this study; it is well addressed through existing legislation as most of the construction practices do not differ dramatically from other construction projects.

3.2.8 Shadow Flicker

When wind turbine blades rotate in front of a low-level sun, shadows may be created which alter with flickering light. The impact depends on specifics of the site, including location of receptors (distance and direction) relative to turbine(s) and the height and angle relationship (i.e., geometric). This is primarily a concern in terms of annoyance and distraction, yet there are concerns of physical effects, including light sensitive seizures, dizziness, nausea, etc.

There has been scientific research and some discourse by stakeholders on the potential impact on health from shadow flicker given relative frequencies (e.g., Epilepsy Foundation[50]), as well as information on suitable approaches to mitigation impacts. Accordingly, this potential effect will further reviewed in Section 7 in context of existing research and Kings County.

3.2.9 Stray Electrical Charge

Stray voltage is a low level electric shock to humans or animals caused by improperly grounded electrical components; it is not unique to large-scale wind turbines and is a potential risk from any electrical distribution component that it not properly grounded, i.e., causing a “tingle”. These issues are addressed via electrical code enforcement. Agriculture in general can be an

[48] Pembina Institute and Ecology Acion Centre. (April 2011). Wind Energy in Nova Scotia: A guide for landowners and communities. Prepared for Nova Scotia Department of Energy. https://nsrenewables.ca:44309/sites/default/files/pdfs/wind_energy_guide.pdf
[49] Province of Nova Scotia. (1996). Occupational Health and Safety Act. c. 7, s. 1.
[50] Erba, G. (ND). Shedding Light on Photosensitivity, One of Epilepsy’s Most Complex Conditions. Epilepsy Foundation. http://www.epilepsyfoundation.org/aboutepilepsy/seizures/photosensitivity/gerba.cfm

issue for stray electrical charge due to improper wiring or problems with the utility distribution systems[51].

Accordingly, this potential interaction with health and safety is not further reviewed in this study; it is well addressed through existing codes and is not specific to large-scale wind turbines.

3.2.10 Unplanned Events During Operation

As with any activity, various unplanned events can occur during the operation of large-scale wind turbines that may cause an adverse effect to health and safety. Four potential occurrences are described briefly below:

- Fire: Due to their height, responding to fires at the hub of a wind turbine can be a challenge for the local fire department. Fires may occur due to lightning strikes or sparks from mechanical or electrical failure in the nacelle (i.e., within the hub at the top of the tower). As part of the emergency response planning process, developers often engage and train the local fire department to respond in the event of a fire. According to the Ontario Office of the Fire Marshall[52], fire does not appear to pose a significant threat to human health and safety due to the low frequency of occurrence and low magnitude of effect. Accordingly, this hazard is not further reviewed.

- Lightning strikes: Due to their height and conductivity, lightning strikes can be a persistent threat to wind turbines. Insurers and owners of wind turbines have financial cost to address damage from lightning strikes, so it is in their best interest financially for modern turbines have lightning protection systems; if properly installed, these systems can protect the structure and its components by conveying the charge to the ground[53]. Accordingly, this hazard is not further reviewed.

- Release of hydrocarbons: The mechanical aspect of large-scale wind turbines typically includes lubricating oils; it is understood that these may be present in volumes up to 600 litres. This is above the spill reporting level in Nova Scotia of 100 litres[54]. There is a relatively low potential for hydrocarbons to contaminate soil and groundwater; therefore, at these quantities and low frequency of occurrence, the potential interaction of a spill and human health (e.g., via a pathway groundwater

[51] BDR North America Inc. (March 31, 2008). Regulatory Approaches to Addressing the Impact of Stray Voltage on Farm Operations. Submitted to Ontario Energy Board. http://www.ontarioenergyboard.ca/OEB/_Documents/EB-2007-0709/report_BDR_20080530.pdf

[52] Ng, M. (2010). In detail – Fire hazards involving renewable energy technology. Fire Protection Engineer. Ontario Fire Service Messenger. 19(4).

[53] Canadian Standards Association. (2007). Wind Turbine Generator Systems - Part 24: Lightning Protection (Adopted IEC/TR 61400-24:2002, first edition, 2002-07, with Canadian deviations). CAN/CSA-C61400-24-07.

[54] Province of Nova Scotia. (N.S. Reg. 59/95). Emergency Spill Regulations. made under Sections 74, 136, and 171 of the Environment Act. S.N.S. 1994-95, c. 1.

contamination) is low. Further, it is addressed under distinct legislation and the hazard is not specific to wind turbines. Accordingly, this hazard is not further reviewed in this report.

- Structural failure / blade throw: Based on analysis of information of two large databases of wind turbines in Denmark and Germany covering turbine operation from the 1980s until 2001, the authors of Dutch Handbook suggested the following risk values for blade failure rates (as summarized by Garrad Hassan[55]); these probabilities are only for failure and do not include the very low probability of contact with a structure or living thing:
  - Full blade failure at nominal rotor speed – 1 in 2,400 turbines per year;
  - Full blade failure at mechanical breaking – 1 in 2,400-20,000 turbines per year;
  - Failure of tip or piece of blade – 1 in 4,000 turbines per year.

  Further, distances were also reported in the same handbook with the maximum distance reported for an entire blade as 150 m and for a blade fragment 500 m. In the rare event of complete structural failure (i.e., a tower falling over), impacted area is limited to height to blade tip. Incidences of failure have reported to been decreasing over time with improved safety mechanisms. Blade failure is most often caused by a human interference with a control system leading to an over-speed situation, a lightning strike or a manufacturing defect in the blade. As the latter have both decreased with improved systems for lightning protection and quality assurance in manufacturing, human interference is likely the primary cause. There is a low probability of occurrence and limited geographic area of impact. Accordingly, this hazard is not further reviewed.

In summary, these potential interactions of unplanned events with health and safety are not further reviewed in this study; as noted above, the probability is considered low, the event is not specific to large-scale wind turbines, or there are monitoring/management plans in place to address the infrequent event.

3.3 Practices to Address Risks via Land Use Planning

Balanced planning policy for large-scale wind turbines incorporates adequate protection for the residents from socio-economic impacts and for the ecosystem from environmental impacts while providing opportunity for feasible development. Indeed this is not a simple matter due to the complexity of information on potential effects – especially related to health and safety. Also in Nova Scotia, the presence of both homes and environmental sensitivities – like bird migration corridors – are often near locations with higher wind regime; Kings County is no exception.

[55] Garrad Hassan. (May 31, 2007). Recommendations for Risk Assessments of Ice Throw and Blade Failure in Ontario. Prepared for the Canadian Wind Energy Association http://www.canwea.ca/images/uploads/File/GH-RiskAssessment-38079or01a(1).pdf

In terms of health and safety, protective measures can be developed in terms of: separation distances to a property line or dwelling; zoning of areas where large-scale wind turbine development is acceptable; use of effect-based criteria (such as sound pressure level); or combinations of any of these. In Nova Scotia, wind energy projects with a nameplate capacity of 2MW or greater will also undergo an EA; this will provide an additional measure of protection as discussed in Section 2.2, including a project-specific assessment of audible noise.

There are challenges with the use of a blanket separation distance for projects of any size in Kings County. This is true especially related to impacts from vibration – both low frequency and audible range – as well as shadow flicker as these effects are often specific to the proposed project. As per the June 2011 review in Australia[56]:

> *A difficulty with a prescribed setback distance is that, in terms of noise and shadow flicker, the distance may either be too great or too little. If the setback is too great then this could limit the industry and possibly affect the amount of renewable power generation in Australia. If the distance were too little, residents affected adversely would not have any redress. The Committee considers that the application of scientific measurements for sound and for shadow flicker to alleviate problems for wind farm neighbours may be preferable to prescribed setbacks. Prescribed setbacks are arbitrary and may be too great or too small.* (p.20)

In terms of sound pressure effects specifically, the level of impact is partially a function of the type of wind turbine itself. For example, the noise rating and turbine technology both vary across types of turbines with the same generation capacity; this will affect sound pressure level at different distances from the turbine. Often, the specifics of the site proposed can influence residual impacts. For example, humidity / fog, wind direction and speed, ground cover and topography can greatly affect the observed sound pressure level at various separation distances from the operating wind turbines. The size of the project, i.e., number and nameplate capacity of large-scale wind turbines, will influence the potential impact.

Notwithstanding the above, the challenges associated with limited technical resources of any municipality to address these issues on a case-by-case basis is noted; this is the primary reason that many municipalities use separation distances to plan for siting large-scale wind turbines. In Nova Scotia, a listing of wind turbine planning approaches was compiled in 2010 by the Union of Nova Scotia Municipalities[57]. Only six municipalities / towns used sound pressure as a development constraint for wind turbines. This includes the Municipality of the County of

[56] Commonwealth of Australia. (2011, June). The Social and Economic Impact of Rural Wind Farms. Community Affairs References Committee. Senate Printing Unit. Parliament House. Canberra.

[57] Union of Nova Scotia Municipalities. (2010). Wind Turbine Bylaws. A spreadsheet compilation of responses to 2010 wind bylaws questionnaire. www.sustainability-unsm.ca/index.php?option=com_docman&task=doc_download&gid=154&Itemid=57

Antigonish which states both a separation distance for utility scale wind turbines (600m or 1000m if an EA is required) and a “mean value of sound pressure level from a wind turbine shall not exceed 40 dBA or above the existing background noise, whichever is greater, at the nearest residence” (p.12)[58].

Ontario has prescribed separation distances from large-scale turbines (i.e., over 50kW) based on number of turbines and sound pressure level of the turbines. The separation distances were developed based on generic modeling to achieve 40dBA outside of the nearest residence except when ambient noise is greater than 40dBA due to road traffic[59]. The 40dBA is based on 10 minute L_{eq} given the specific assumptions (e.g., wind speed, etc.)[60].

These Ontario regulations define noise receptor (Part 1: 1(4)); however, it is intended to be the centre of a dwelling or a building used for institutional purposes, including school, place of worship, health care facility. Further the definition includes land which has been zoned to construct any of the above. The separation distances are not based on property boundary, but the location of the structure used as a dwelling or institution.

The following table shows this matrix showing distance from noise receptors. Developers have the option to conduct a noise study to demonstrate ability to lower the separation distances identified in the matrix while maintaining 40dBA (to a minimum separation distance of 550m).

Table 1 Ontario Separation Distances (O. Reg. 521/10 s.33(7).)

Number of wind turbines[1]	Sound power level of wind turbine (dBA)	Distance to noise receptor[2]
1 to 5	102	550
	103 – 104	600
	105	850
	106 – 107	950
6 to 10	102	650
	103 – 104	700
	105	1000
	106 – 107	1200
11 to 25	102	750
	103 – 104	850
	105	1250
	106 – 107	1500

[1] As per Section 55(2) which is generally an aggregate within 3km radius
[2] As per Section 55(2.1) which is generally from base of turbine to noise receptor

[58] Municipality of the County of Antigonish. (June 2009). Land Use By-law for the County of Antigonish. Concerning the Regulations of Wind Turbine Development.
[59] Ontario Government. (2010). Renewable Energy Approvals. Technical Bulletin Six – Required Setbacks for Wind Turbines as part of an application under O.Reg.359/09.
[60] Ontario Ministry of the Environment. (2008). Compliance Protocol for Wind Turbine Noise. Guideline for Acoustic Assessment and Measurement. www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_088931.pdf

For projects that propose more than 25 turbines within a 3km radius of a dwelling or using wind turbines with sound power level above 107dBA, a noise study would automatically be required for review. Further the conditions of approval would have requirements of developers post-construction, including monitoring and addressing perceptible low frequency vibration.

As part of the review completed in Massachusetts, the Panel recommended that the State develop guidelines for noise and shadow flicker based on best practices in jurisdictions with more experience with wind energy projects and protective policies for human health and safety; Germany and Denmark were specifically referenced. The onus would then be on the developer to demonstrate compliance with these guidelines based on project specific modeling for noise and shadow flicker as part of wind energy project feasibility studies.

As noted, attitude toward the wind turbines also greatly influences perception of impacts and can lead to annoyance. Attitude can be influenced by local involvement in the planning of the land use regulations and the project itself. Increased opposition will result from projects that are poorly planned and not communicated well to the public. Further lack of transparency in earlier projects will set the stage for future distrust and adversarial conditions[61,62].

This connection of public participation and expressed annoyance of affected individuals is well rooted in peer-reviewed academic literature. The Massachusetts Panel[63] stated that “measures taken to directly involve residents who live in close proximity to a wind turbine project may also serve to reduce the levels of annoyance” (p.62).

Further the Oregon Strategic Health Impact Assessment[64] recommended the following based on their findings on community conflict; this text (without the citations) is represented here in full due to its relevance in context of the rural character and sense of community in Kings County, especially the third key finding.

Community Conflict:

Key Findings and Conclusions

1. *Community conflicts over wind energy developments have many similarities to conflicts over other controversial siting or natural resource decisions in rural*

[61] Breukers, S., & Wolsink, M. (2007). Wind power implementation in changing institutional landscapes: An international comparison. *Energy Policy*, 35(5), 2737-2750.
[62] Stevenson, R. (2009). Discourse, power, and energy conflicts: Understanding Welsh renewable energy planning policy. *Environment and Planning C: Government and Policy*, 27, 512-526.
[63] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.
[64] Oregon Health Authority. (January 3, 2012). Strategic Health Impact Assessment on Wind Energy Developments in Oregon. Public Comment Release. Prepared by Health Impact Assessment Program.

communities. These similarities include: tensions between local risks vs. global benefits, mistrust of developers or owners, and limited opportunities for community members to influence the decision making process.

2. *Long-term stress from real or perceived environmental threats can increase risks for cardiovascular disease, endocrine disorders, reduced immune functions, mental illness, and other negative health effects. Community conflict over controversial siting or environmental decisions may contribute to or exacerbate this stress, and thus increase risks of these negative health effects.*
3. *Rural communities may be disproportionately impacted by community level conflicts because these conflicts may erode traditional sources of social and interactional support that community members rely on.*
4. *Based on experiences from other controversial environmental and siting decisions, public participation that is inclusive, collaborative, and transparent is an effective strategy to improve the quality, legitimacy, and acceptance of environmental and siting decisions.*

Recommendations

1. *Planners, developers, decision-makers, and government agencies involved in wind facility siting decisions should consider and use strategies to anticipate, understand, and manage conflict and stress in communities near proposed developments. If done well, public participation and community consultation are strategies that can minimize negative and maximize positive impacts (health and otherwise) for local communities, decision-makers, developers, and other stakeholders.*

The connection between residents' involvement in planning and their self-reported health effects from operation of wind turbines is well accepted. Ontario's Renewable Energy Approval Regulations do prescribe consultation requirements. Some Nova Scotian municipalities have included community consultation in the bylaws for siting large-scale wind turbines. The Municipality may wish to pursue mechanisms within its MPS / LUB to require community consultation as part of developer proposed large-scale wind turbine(s). Indeed the community participation as part of the re-review of the 2012 MPS / LUB for large-scale wind turbines in response to residents' concerns demonstrates the understanding of the Municipality of the benefits of public participation.

4 AUDIBLE NOISE

4.1 NATURE OF IMPACT

Noise (or unwanted sound) is perceived by hearing organs via vibrations transferred in the air or another medium. It is characterized by both frequency and amplitude. Human hearing can perceive sounds in a frequency range of about 20 Hz to 20,000 Hz. Sound with a limited frequency is tonal while sound spread over varying frequencies is broadband. Amplitude is the pressure created by the sound. It is represented in decibels (dB) which is a logarithmic scale of the sound pressure level (SPL). Both the frequency and amplitude affect how humans perceive sound. Sound at lower frequencies must have higher SPLs to be heard. For example, the median hearing threshold at 8 Hz is 100 dB, at 20 Hz is 80 dB, and at 200 Hz is 14 dB[65]. Recent evidence demonstrates that there are some people who are able to hear sound at higher and lower SPLs. As we age, our ability to hear sounds of higher levels decreases.

In general, SPLs will decrease with distance from source; however, this attenuation is a function of many factors; these include:

- climatic conditions, such as humidity, wind speed and direction, temperature;
- frequency, where lower frequency sounds have less attenuation over distance;
- building materials which reduce interior SPLs, though this attenuation is less for lower frequency sounds;
- ground characteristics, where hard ground reflects sound and ground cover may absorb sound; and,
- terrain, where features may obstruct sound.

Further, perception of sound by a receptor is a function of many factors, including attitude toward to source of the sound. Sound can be but one common sources of annoyance in our environment. If a sound is a reminder of an unwanted activity or development, the perception of that sound will be influenced accordingly. The existing ambient conditions, that is, background sound levels, will also influence impact; in general, there is less masking in rural areas and at nighttime from existing ambient sounds.

In terms of how people typically perceive changes in SPLs:

- a change in the SPL of 1-3 dB is the minimum perceived change in similar sounds, yet an increase in about 5 dB will likely result in a noticeable community response; and

[65] Oregon Health Authority. (January 3, 2012). Strategic Health Impact Assessment on Wind Energy Developments in Oregon. Public Comment Release. Prepared by Health Impact Assessment Program.

- doubling the magnitude of the sound pressure results in a 6dB increase due to logarithmic scale of SPLs, whereas a 10 dB increase in SPL is perceived as a doubling in loudness.

Sound is often measured and reported as a frequency-weighted decibel; dBA (i.e., A-weighted) correlates to human hearing and is representative of loud broadband sounds, dBC is representative of relatively loud sounds, impulsive sounds and low frequency sounds, and dBG is typically used to represent very low frequency sounds. The A-weighted decibel scale is the focus of this section on audible sounds; low frequency sound is discussed in Section 6.

Sound pressure, like other environmental hazard measurements, is often weighted over time. The purpose of which is to allow comparison with regulatory criteria. Common representations include:

- L_{eq} – SPL averaged over a period of time, e.g., one day which is shown as $L_{eq,24}$;
- L_{night} – SPL averaged over nighttime period, e.g., 11pm to 7am;
- L_{dn}/L_{den} – similar to $L_{eq,24}$ but with penalties to account for increased sensitivity in evening and at night of 5 dB and 10 dB, respectively; and,
- L_{max} – maximum SPL during a measurement period.

As per the World Health Organization (p.v) [66]:

> *Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic, industries, construction and public work, and the neighbourhood. Main indoor sources of noise are ventilation systems, office machines, home appliances and neighbours. Typical neighbourhood noise comes from installations related to the catering event (restaurants, cafeterias, discotheques, etc.); from live or recorded music; sport events including motor sports; playgrounds; car parks; and domestic animals such as barking dogs.*

Indeed large-scale wind turbines create a sound emission that can be defined as community noise. In general anthropogenic sound is typically higher in urban areas, near transportation corridors, and in industrial and commercial areas; whereas rural, wilderness and residential areas are expected to have lower sound levels.

It is helpful to appreciate the sources of community noise – both indoor and outdoor spaces. Table 2 depicts typical community noises expressed as weighted averages using the dBA scale.

[66] Berglund, B., Lindvall, T., Schwela, D.H. (1999). Guidelines for Community Noise. Geneva: World Health Organization.

It is based on a graphic[67] used in Oregon's Strategic Health Impact Assessment. The potential public reactions to changes in community noise levels are shown in Table 2 for increases at intervals of 10 dBA. This also shows the perceived change to increase or decrease in SPL by about 10dBA; that is, a 10dBA increase in SPL is perceived as a doubling of loudness.

Table 2 Noise Sources and Effects on People

Public Reaction	Perceived Degree of Change	Noise Level (dBA, Leq)	Common indoor noises (typical)	Common outdoor noises (typical)
		110	Rock band	Jet flyover at 1000ft
		100	Inside NYC subway	Gas lawn mower at 1m
Strong opposition	[4x as Loud]	90	Food blender at 1m	Diesel truck at 15m
Complaints likely	[Twice as Loud]	80	Shouting at 1m	Noisy urban daytime
Complaints possible	[Reference]	70	Vacuum cleaner at 1m	Gas lawn mower at 30m
Complaints rare	[Half as Loud]	60	Large office	Commercial area
Acceptance	[Quarter as Loud]	50	Dishwasher next room	Quiet urban daytime
		40	Conference room (background)	Quiet urban nighttime
		30	Library	Quiet suburban nighttime
		20	Concert hall (background)	Quiet rural nighttime
		10	Recording studio	
		0	Threshold of hearing	

In terms of the degree of sound emitted from large-scale wind turbines, the SPL increases with increasing wind speed; that is, noise from turbines is primarily a function of the blade tip speed. Yet background noise is often quieter during lower wind speeds; accordingly evidence typically shows a higher annoyance during light-moderate wind speeds.

Indeed ambient noise – both level and character – can affect how residents perceive additional noise. Recognizing that existing environmental noise may either mask or adjust the perception of the contribution of noise from wind farms, Pedersen et al., (2010) explored whether road traffic sound could mask wind turbine sound or, in contrast, increase annoyance due to wind

67 California Public Utilities Commission. (ND). http://www.cpuc.ca.gov/environment/info/esa/divest-pge-one/newfigs/pge10_1.gif

turbine noise. This work relied on a similar survey tool as used in prior studies, yet with additional questions probing responses such as feeling tense or stressed, feeling irritable, having mood changes, being depressed, suffering from undue tiredness and having concentration problems. Relying on modeled sound pressure levels at dwellings and roadways, the authors conclude that: "the presence of road traffic sound did not, in general decrease annoyance with wind turbine noise except when levels of wind turbine sound were moderate (35-40 dB(A)) and road traffic sound level exceeded that level with at least 20 dB(A). Annoyance with both noises was intercorrelated but this correlation was probably due to the influence of individual factors. Furthermore, visibility and attitude towards wind turbines were significantly related to noise annoyance of modern wind turbines." (p.2520)[68].

Using data previously gathered from the Netherlands and from Sweden, and modeled sound pressure levels Janssen et al., (2011) derived an exposure-response relationship for annoyance indoors and outdoors at the dwellings. The study concludes that annoyance due to wind turbines was reported at lower noise levels than annoyance due to other sources of environmental noise. As in the study by van den Berg et al., (2008), annoyance was lower among residents who benefitted economically from the turbines, further, there appeared to be virtually no annoyance regardless of whether those people could see or hear a turbine. Based on their analyses, Janssen et al., (2011) propose as an example that locations with an SPL of 45 dB(A) could expect less than 14% of the exposed population to be highly annoyed indoors by wind turbines and less than 29% to be highly annoyed outdoors.

For context, the resulting SPL at the hub of the turbine has been measured from 93dBA to 104dBA based on measurements of a wind energy project in Germany[69]; yet the resulting SPLs from seventeen large-scale wind turbines at a distance of about 400m ranged from about 30dBA to 45dBA. These results were a function of the noise from the specific turbines and the cumulative noise from multiple turbines, i.e., seventeen, as well as specifics of the site.

For the perspective of a smaller wind energy project, the Town of Falmouth in Massachusetts erected two large-scale wind turbines in 2010. Noise has been studied by consultants hired by the Town of Falmouth due to reports of difficulty sleeping, headaches, loss of cognition and stress by some residents who are located within 330-400m of the turbines. Near the closest receptors, background SPLs were found to be about 29 dBA in the early morning hours and range from 41 to 46 dBA during the day. Operation of turbines increased SPL over background by about 1 dBA during the day, yet the increase was found to be 4 to 8 dBA at night. During worst case conditions of lower wind speeds (i.e., 5 to 6 m/s at turbine hub height) of the early

[68] Pedersen, E., van den Berg, F., Bakker, R., Bouma, J. (2010). Can road traffic mask sound from wind turbines? Response to wind turbine sound at different levels of road traffic sound. Energy Policy. 38, 2520-2527.
[69] van der Burg, G.P. (2004). Effects of .the wind profile at night on wind turbine sound. Journal of Sound and Vibration. 277, 955-970.

morning hours when background SPLs are lowest, additional sound from the wind turbines may increase SPLs to almost 10 dBA over background; this is key as a 10-decibel increase over background is the Massachusetts guideline for maximum impact[70]. Yet during higher winds, the background noises increase such that the operation of the wind turbines is within the Massachusetts guideline for increase of SPLs over background[71].

Recently, the Massachusetts Department of Environmental Protection (MassDEP) released its own sound measurements that were taken from outside the homes[72]. The results demonstrate that the MassDEP threshold for sound is exceeded as the noise limits are greater than 10 dBA over background sound levels during nighttime hours. MassDEP considers this level of noise to be a nuisance under the State noise control regulation, as such there is a need to complete additional measurements and limit the operation of the turbines until measures are taken to become compliant with MassDEP's nighttime sound level requirements; this includes cumulative effects of two turbines.

Because of the logarithmic scale of SPLs, the level does not increase linearly when an additional turbine is added. Indeed Appendix E of the report prepared by the Massachusetts Panel provides simplified equations describing SPL estimates and noise propagation. Based on a German study, distances from turbine(s) to achieve SPLs are modeled. In summary, the following tabulates the distances to achieve SPLs for a single turbine versus seven turbines. Again this is a simplification (e.g., assumption of flat land, etc.); however, this shows the implications to distances to achieve these levels of noise. This also demonstrates how one separation distance may be too small for larger projects while being overly protective for single turbines installations.

Table 3 Example of Sound Propagation from Single or Multiple Large-Scale Wind Turbines

	Distance (m)	
SPL (dBA)	Single Turbine (103 dBA at hub)	Seven Turbines (each 103 dBA at hub)
35	620	1100
40	410	740
45	280	440

[70] The Commonwealth of Massachusetts. Department of Environmental Protection. (ND). Noise Control Regulation 310 CMR 7.10.
[71] Harris Miller Miller & Hanson Inc. (September 2010). Falmouth Wind Turbine Noise Study. Falmouth, Massachusetts. HMMH Report No. 304390. Prepared for Weston & Sampson Engineers, Inc. http://www.hmmh.com/cmsdocuments/falmouthwind_noisereport_20sep2010_fnl.pdf
[72] Massachusetts Department of Environmental Protection. (May 2012). Attended Sampling of Sound from Wind Turbine #1. Falmouth, MA. Prepared by MassDEP - Southeast Regional Office.

According to the Massachusetts Panel, the most persistent and often strongest source of sound from large-scale wind turbines is the trailing edge noise; this is often reported as a “swish” sound. This trailing edge noise is created as a turbine blade rotates through a changing wind stream; the change in aerodynamics leads to differences in the trailing edge noise[73]. Also the directivity of the noise from the trailing edge will vary as the direction of the blade changes as it rotates.

The amplitude modulation of this noise source is due to the presence of atmospheric effects leading to the “thumping” sound often reported. The sound produced by the amplitude modulation is in the audible range; the modulation effect means that the sound is quiet and then loud and then quiet again at a rate related to the blade passing frequency. The level of amplitude modulation is often greater at night because the difference between the wind speed at the top and bottom of the rotor disc can be much larger at night when there is a stable atmosphere. It is further argued by the Massachusetts Panel that in a stable atmosphere there is little wind near the ground so wind noise does not mask the turbine noise.

There is evidence that amplitude modulated sound is more annoying than sound with constant frequency and sound intensity[74]. Indeed ISO 1996-1 notes that an adjustment, in dBA, should be added to the A-weighted equivalent continuous sound exposure to estimate the long-term annoyance response of a community to sounds with tonality, impulsiveness or strong low frequency content[75].

Health Canada does not yet have noise guidelines or enforceable thresholds or standards[76]; yet they have a proposed criteria for predicting sound level produced by wind turbine operation of 45 dBA L_{dn} at the outside of a dwelling or institution, i.e., noise sensitive receptor[77]. As noted above, the L_{dn} includes an adjustment of 10dBA as an adjustment for nighttime hours. As a federal department with expertise in health impacts, Health Canada provides advice as explained in Section 2.2. Health Canada specifies that the prediction is to be determined using the wind speed yielding the maximum sound power from the wind turbine, site specific considerations and use of worst case scenarios for propagation of noise to sensitive receptors.

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[73] Oerlemansa,S., Sijtsmaa, P., Méndez López, B. (2007). Location and quantification of noise sources on a wind turbine. Journal of Sound and Vibration, 299, 869–883.

[74] Oregon Health Authority. (January 3, 2012). Strategic Health Impact Assessment on Wind Energy Developments in Oregon. Public Comment Release. Prepared by Health Impact Assessment Program.

[75] ISO. (2003). Acoustics – Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedure. ISO 1996-1:2003(E). Geneva, Switzerland: International Standards Organization.

[76] Health Canada. (2010). Useful Information for Environmental Assessments. Minister of Health. http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/eval/environ_assess-eval/environ_assess-eval-eng.pdf

[77] Keith, S.E., Michaud, D.S., Bly, S.H.P. (2008). A proposal for evaluating the potential health effects of wind turbines noise for projects under the Canadian Environmental Assessment Act. Journal of Low Frequency Noise, Vibration and Active Control. 27(4), 253-265.

Health Canada's 45 dBA L_{dn} recommendation at the outside of dwellings is consistent with WHO's recommendation of equivalent sound level indoors to not exceed 30 dBA to maintain sleep[78] as noise attenuation within homes ranges from 15 dBA (windows slightly open) to 20 dBA (windows closed). While some other jurisdictions recommend 40 dBA outside of residences in quiet rural areas, Health Canada suggests that a "conclusive quantitative comparison can only be made with complete modeling of the sound level because of its dependence on prediction model, sound power as a function of wind speed, the limit period (day or night), and implied area type." (p.255)[79].

Further, Health Canada recommends adjustments as per the ISO 1996-1 standard. This includes a pre-cautionary adjustment to be applied to proposed project noise in a rural setting compared to industrial sources in urbanized settings; based on ISO 1996-1, research has shown that there is a greater expectation for and value placed on "peace and quiet" in rural settings that may equate up to 10 dB. In terms of the potential tonal quality of the sound emissions from the proposed wind turbine (which should be available in the manufacturer's specifications if they conform to International Electrotechnical Commission standard[80]), Health Canada recommends adding a 5 dB adjustment due to annoyance should a tonal quality be present.

As previously stated, Health Canada will provide comment at the request of the NSE for projects undergoing a provincial EA or those projects triggered under the Canadian Environmental Assessment Act. Health Canada is preparing guidance on evaluating noise and associated health effects in the context of environmental assessments; this is underway and is expected to be released in coming months. It is expected that these would support the Municipality in terms of the dialogue with developers.

In terms of the predictive modeling, the climatic and topographical conditions must be included in the model to ensure a cautious approach to modeling. The prevailing wind direction, proximity to water and mountain/valley topography all must be considered. Predicted noise models are typically based on ISO 9613-2 for propagation; while ISO 9613-2 has a standard uncertainty of ±3 dB, i.e., a level of change in SPL that is typically below perception of many people, ISO 9613-2 is intended to be used for sources up to 30m high and up to 1km from source. Some wind energy projects have resulted in complaints when operating in certain climatic conditions; this may have been because the predictive model may not have accounted

[78] Berglund, B., Lindvall, T., Schwela, D.H. (1999). Guidelines for Community Noise. Geneva: World Health Organization.

[79] Keith, S.E., Michaud, D.S., Bly, S.H.P. (2008). A proposal for evaluating the potential health effects of wind turbines noise for projects under the Canadian Environmental Assessment Act. Journal of Low Frequency Noise, Vibration and Active Control. 27(4), 253-265.

[80] International Electrotechnical Commission. (2006). Standard on wind turbine generator systems – Part II: Acoustic noise measurement techniques. IEC 61400-11.

for unanticipated or site specific conditions. This can also create larger uncertainties than specified by the model (±3 dB).

As a local example, the wind energy project at Pubnico Point, Nova Scotia, was the subject of complaints by a nearby resident; though the extent of impacts remains a controversy in the community. In 2006, a study was commissioned by the federal government to measure the levels of noise at the residence of concern about one year after the seventeen turbines were commissioned[81]. The resident lived some 330m from the closest turbine. The study included predictive modeling and field measurements. Results confirmed the resident's observations that there is a higher than acceptable level of audible noise impact during worst case conditions when the residence was directly downwind and humidity was high[82]. The consultant noted that the ISO 9613-2 standard does not necessarily consider propagation of sound under worst case environmental conditions. A different predictive modeling approach was used to better correlate results to measured impacts during specific climatic conditions. Best practices for predictive modeling of SPL propagation are constantly evolving.

To accommodate for the possibility that measured values of an operating wind turbine may be higher than predicted, Health Canada scientists recommend that developers "prepare mitigation measures if it is reasonable to expect, within plausible uncertainties, proposed criterion levels to be measurably exceeded during operation" (pp.261-262)[83]. A two wind turbine installation in Falmouth, Massachusetts has been a source of public complaints such that the Town of Falmouth commissioned a study of mitigative measures[84]. However, mitigative measures after construction are not ideal; planning wind energy projects to achieve protective audible noise levels is the best approach.

Indeed of the seventeen wind energy projects that have been approved under the Environmental Assessment Regulations in Nova Scotia since 2004, only two have required intervention post-construction from NS Environment[85]. These projects, located in Pubnico and Lingan, were both approved in 2005; the separation distances were under 400m. The two wind turbines installed in Falmouth, Massachusetts also have residences within 400m.

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[81] HGC Engineering. (August 23, 2006). Environmental Noise Assessment. Pubnico Point Wind Farm, Nova Scotia. Natural Resources Canada Contract NRCAN-06-00046.

[82] The consultant took measurements in the audible range and in the infrasonic range. The dominant audible characteristic is the "swish" sound which is broadband, with no clear tonal characteristics and is amplitude modulated. The consultant stated that sound at infrasonic frequencies is not present at perceptible levels.

[83] Keith, S.E., Michaud, D.S., Bly, S.H.P. (2008). A proposal for evaluating the potential health effects of wind turbines noise for projects under the Canadian Environmental Assessment Act. Journal of Low Frequency Noise, Vibration and Active Control. 27(4), 253-265.

[84] Weston & Sampson. (December 2011). Wind energy facility mitigation alterative analysis. Town of Falmouth, Massachusetts. http://www.falmouthmass.us/selectmen/falmouth%20turbine%20mitigation%20study.pdf

[85] Sanford, S. (April 12, 2012). Presentation to Planning Advisory Committee on behalf of Nova Scotia Environment. Municipality of the County of Kings

4.2 Context of Kings County

The setting of the proposed project should be considered in the predictive noise modelling parameters; further adjustments should be made to the predicted SPL as appropriate. The Municipality is predominantly a rural area; indeed value of "peace and quiet" is held highly by many residents. Health Canada recommends that an adjustment of up to 10 dB be used in the prediction of impacts to quiet rural areas. This adjustment may vary depending on location; for example, Highway 101 bisects the Municipality; highway noise must be considered in determining the SPL equivalent value of relative "peace and quiet".

Site specific review of baseline noise conditions is an important aspect of determining potential impact from audible noise of the large-scale wind turbines. This is an important consideration in Kings County, especially at nighttime. Indeed some guidelines for community noise include an increase of SPL by no more than 10 dBA above ambient (e.g., Massachusetts) while others have maximum increases of 3dBA to 5 dBA (Ontario and Alberta, respectively). Indeed the World Health Organization has shown that 10 dBA increase in baseline can result in sleep disturbance[86].

The climatic and topographical setting is also of important consideration in the prediction of noise impacts. An area with flat terrain with little obstruction will propagate noise quite differently than a forested area with hills and valleys. Further the presence of the Bay of Fundy and the Minas Basin will have an effect on the propagation of sound. The prevailing winds, range of wind speeds and humidity range must be considered when assessing the worst case scenarios for modeling.

Much of the evidence reviewed is based on data from larger wind turbines, such as greater than 800kW. The definition of large-scale wind turbines in Kings County is greater than 100kW. Yet the SPL from these moderately-sized wind turbines is anecdotally as high as or perhaps higher than the larger wind turbines. Accordingly, the following discussions on current research, risks and uncertainties, and best practices do not distinguish in terms of size. Indeed other jurisdictions address turbines based on size and / or noise emission. For example, Ontario's separation distances are for turbines larger than 50kW with a SPL greater than 102 dBA[87].

4.3 Current Research

There is a vast amount of literature on the plausible link between audible sound and health impacts – from wind turbines and otherwise. This literature has been reviewed by the project

[86] Berglund, B., Lindvall, T., Schwela, D.H. (1999). Guidelines for Community Noise. Geneva: World Health Organization.
[87] Province of Ontario. (O.Reg. 231/11). Environmental Protection Act. Ontario Regulation 359/09. Renewable Energy Approvals under Part V.0.1 of the Act.

team as outlined in the bibliography. Some of the primary sources are directly referenced in this report.

Two bodies of work released in January 2012 – a study by the Massachusetts Panel[88] and Oregon's Strategic Health Impact Assessment[89] – have thoroughly reviewed the peer-reviewed literature, case studies and cross-sectional studies, evidence reviews, white papers and other health impact assessments. While the scope and approach varied, the basic conclusions are comparable. Accordingly, the results relating to effect of audible noise on health are summarized below as interpreted from these two sources:

- As noise is defined as unwanted sound, noise can then be perceived as annoying, and as such has the potential to increase health risks. Environmental noise in general has been linked to sleep disturbance, annoyance, stress and decline in cognitive performance. This indirect connection to health risks stemming from annoyance and stress is not specific to wind turbines; indeed many epidemiological studies look at health risks from noise, but at exposures much higher than those from large-scale wind turbines.

- Residents closer to turbines are more likely to be impacted by sound than those farther away. Yet the extent of the impacts in dBA and the perception of the sound as noise are a function of many variables; these include but are not limited to turbine technology, topography, presence of water bodies, climatic conditions, direction of wind, background sound levels, characteristics of the sound, and involvement in the project. Typically SPLs from wind turbines at distances over 400m are under 40 dBA on average; yet unique circumstances may result in SPLs approaching or exceeding 45 dBA, certainly during certain worst case weather conditions.

- When compared to other community or industrial sounds, there is some evidence that sound from wind turbines could be perceived as more annoying. This may be due to the combination of the "swish" and the amplitude modulation sound components, i.e., "thumping", which can be reported as more annoying than steady sounds. Also noise from wind turbines does not decrease at night as with some other noises. Noise from wind turbines has been shown to be more noticeable at night; this could result in stress and sleep disturbance which has been indicated via limited epidemiological evidence obtained through self-reported responses on survey tools. Yet there is not sufficient

[88] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.
[89] Oregon Health Authority. (January 3, 2012). Strategic Health Impact Assessment on Wind Energy Developments in Oregon. Public Comment Release. Prepared by Health Impact Assessment Program.

evidence that noise from wind turbines directly causes disease. The connection to increased adverse health is via sleep disturbance or annoyance.

- If chronic stress and sleep disturbance result from annoyance with the wind turbine, this could increase risks for cardiovascular disease, decreased immune function, endocrine disorders, mental illnesses and other effects. A small number of epidemiological studies have linked wind turbine noise to reports of increased annoyance, feelings of stress and irritation, sleep disturbance and decreased quality of life. Self-reports of annoyance from wind turbine noise was more likely when levels exceeded the 35-40dBA range.

While literature is constantly being published and much recent literature (i.e., since January 2012) has been reviewed as part of this work, it is the project team's opinion that the general conclusions stated above hold true. Indirect impacts can exist via annoyance or stress as a mediator when the planning and approvals for large-scale wind turbine have not been suitably protective. An indirect effect on sleep disturbance that is correlated by reported annoyance has been shown to significantly increase at SPLs above 45 dBA[90]. This supports Health Canada's proposed criterion level of 45 dBA.

4.4 Risks and Uncertainties

It is undisputed that large-scale wind turbines produce audible noise that will decrease with distance from the turbine. The SPL at the hub of different turbines is indicated by the manufacturer in accordance with industry standards. This sound emission is primarily a function of wind speed. The sound will attenuate over space; this is site-specific depending on many factors, including climate. Modeling is used to predict environmental effect, i.e., resulting SPL over existing conditions. Yet there has been some variation shown between predicted values and measured results; like any other environmental change, prediction is never completely accurate.

While there are widely accepted standards for community noise levels, evidence has shown that annoyance increases more rapidly with increasing SPLs from wind turbines than from many other sources of community noise. Annoyance has been shown to be the major linkage to health effects, yet there is accumulating evidence showing sleep disturbance from large-scale wind turbines. High levels of annoyance have also been linked to negative attitudes associated with the wind turbines. There is a subset of the population that is more sensitive and affected by noise and sleep disruption as evidenced by the reports of individual, yet not all, members of families reporting ill-health. Exact estimates of population responses are unavailable.

[90] Bakker, R.H., Pedersen, E., van den Berg, G.P., Stewart, R.E., Lok, W., Bouma, J. (2012). Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. Science of the Total Environment. Article in press.

There are limitations in the available data; yet current data generally suggest that noise at a distance of 400m or less from the wind turbine is associated with annoyance in most cases. Though other studies have reported reduced quality of life at a distance as great as 2km; this particular New Zealand study is based on a limited sample of residents in fifty-six homes within 2km distance of a sixty-two turbine wind energy project where measured SPLs were reported to range from 24 to 54 dBA[91]. Accordingly, protective separation distances in terms of audible noise lies within this range; the ideal distance will vary by project depending on factors already listed such as number and type of turbines and specifics of the site.

4.5 Best Practices

As discussed in the prior sub-sections, there is indeed potential for adverse health impacts from audible noise from large-scale wind turbines that may be constructed in Kings County. Unacceptable noise impacts will only exist when the proposed wind energy project is sited too close to residences. The appropriate distance is a function of the size of the wind energy project, type of turbines and specifics of the site.

Due to the influence of project and site specifics, it is most appropriate to site turbines based on predicted noise impacts at nearby dwellings rather than determine set separation distance common to all sizes of projects. While setting a noise criterion is a more applied and science-based approach, many municipalities prefer separation distances for their ease of application. So the recommendations on best practices take the best available knowledge to frame up both noise criteria and possible approaches on separation distances should the Municipality decide on this approach in addition to or in lieu of noise criteria. These recommendations are based on the available data, are suitably conservative to address the reality that some people are more sensitive to the effects of noise; yet the resulting recommendations are not considered prohibitive to development.

While the scope of this report is health and safety impacts, the importance of community engagement has been entwined in the discussion of health and safety impacts. Indeed evidence has demonstrated a link to health and safety via annoyance where annoyance from audible noise is increased when the resident did not feel engaged in the process to plan the project. This is true for all developments, but perhaps given the high visibility of large-scale wind turbines, it appears to be even more crucial. These recommended best practices to minimize health risk taking into account the effects of levels of involvement in the project on perception.

Accordingly, the best practices for audible noise are presented within three headings: sound pressure level criteria, range of separation distances, and stakeholder engagement – residents, developers and other levels of government.

[91] Shepherd, D., McBride, D., Welch, D., Dirks, K.N., Hill, E.M. (2011). Evaluating the impact of wind turbine noise on health-related quality of life. Noise & Health. 13(54), 333-339.

4.5.1 SOUND PRESSURE LEVEL

As discussed, a sound pressure criterion is a more science-based approach for protection of human health from audible noise than application of a standard separation distance. Use of a noise criterion accounts for specifics of both the project and the site, and it also incorporates the evidence on the impact to human health from audible sound. Accordingly, it is recommended that developers of large-scale turbines be required to demonstrate to the Municipality a protective criterion for resulting SPLs at the outside of nearby dwellings.

A predicted value of 40 dBA SPL at dwellings should be considered as a Kings County criterion for planning large-scale wind turbines. This value is in line with Nova Scotia Environment's recommendations. This is also comparable to Health Canada's criterion of 45 dBA with their stated adjustments for nighttime and other considerations, e.g., tonality. Epidemiological studies have also shown that noise emissions below 40 dBA outside a dwelling is generally protective of sleep and results in relatively low reports of annoyance and stress. Yet consideration of baseline noise level, specifically at nighttime, is also important as is later discussed.

This predicted SPL can be demonstrated with modeling. While predictive modeling is never completely accurate, it should be completed using extreme condition inputs to represent reasonable worst case conditions. Proactive assessment of impacts allows for best planning of development; it is typical EA methodology. These acoustical assessments must be completed by professional and properly trained consultants using methods that are recognized as the industry standard. Current, up-to-date modeling methodology, data and standards should be used[92]. The predictive noise modeling should be accompanied by clear explanation of assumptions and model sensitivities for review by local stakeholders. The level of effort for predictive modeling and background measurements should be dependent on size of proposed project and site sensitivity. In certain circumstances, limited modeling and baseline data may be needed; in part, this will depend on distance to receptors, for example, where there are no noise receptors in a 2km radius, it could be argued that no noise studies should be required.

The time weighted average (TWA) to define the SPL is as important as the SPL itself. These vary as the World Health Organization uses an annual average for L_{night} whereas Ontario uses $L_{eq,hr}$ and Health Canada uses L_{dn}. It is challenging as academic research, practice and policies do not always identify the TWA of the measurements that were correlated with direct and indirect health effects. While 40 dBA $L_{eq,24}$ has been suggested, a daily average could allow shorter periods of relatively high SPL that when averaged with lower SPLs could average out to remain in compliance.

[92] Current standards (or the equivalent of) include but are not limited to ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General Method of Calculation, and IEC 61400-11, Wind turbine generator systems – Part II: Acoustic noise measurement techniques.

Predictive modeling is also quite dependent on wind speed. It is often the lower wind speeds (e.g., around 6 to 8 m/s) that are responsible for the complaints; this is believed to be due to less masking of sound from the wind turbine from the wind itself. The Massachusetts Panel compiled promising practices for nighttime SPLs based on land use, and in the case of Denmark, wind speed. Denmark's noise limits are calculated over a ten minute period (as opposed to values for $L_{eq,24}$, L_{dn}, etc.). The Massachusetts Panel supported these criteria as they are in line with noise levels that the epidemiological studies connect with insignificant reports of annoyance. Interestingly, the Danish criteria allow for higher SPLs in rural areas, yet the evidence suggests that there is more annoyance recorded in rural areas due, in part, to low background SPLs. These Danish criteria are reproduced below.

Table 4 Denmark's Nighttime SPL Criteria by Wind Speed and Land Use[93]

Land Use	Wind Speed	SPL Nighttime (10-minute period)
Residential	6 m/s	37
	8 m/s	39
Sparsely populated areas	6 m/s	42
	8 m/s	44

It is the nighttime SPLs that are most critical; this is to protect sleep but also to minimize annoyance and stress as most reports are due to nighttime audible noise. The amplitude modulation (i.e., the "thump") has been shown to be more prominent during nighttime hours. Accordingly, it is recommended that developers be required to address nighttime noise as this is of the most concern from a health perspective.

A maximum predicted increase of the nighttime baseline, i.e., L_{night}, of not more than 10 dBA above background levels is suggested; this is seen in other jurisdictions. Yet an increase of 10 dBA above baseline may create unacceptable impacts such as sleep disturbance. In other Canadian jurisdictions, 3 dBA to 5 dBA increase over background is legislated; the latter is cumulative increase, i.e., impacts from other project developments that may increase the ambient noise levels, including but not limited to other wind energy projects.

While there is some variance in research outcomes and existing practice, the consideration of both nighttime SPLs from the operating turbines and the ambient existing noise levels are key.

[93] [93] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.

Indeed existing developments should be considered in the planning of large-scale wind turbines, (e.g., proximity to highways, etc.).

4.5.2 Separation Distances

While SPL criteria are the recommended approach from both science- and practice-based perspectives, there are challenges associated with Municipal staff resources and expertise. Accordingly, many local governments opt for separation distances – in Nova Scotia, in North America and abroad. The project team only suggests the use of separation distances rather than SPL-based criteria with understanding of the influence of the site- and project-specific parameters on perceived noise that may result in stated distances as either too restrictive for development to occur or not sufficiently protective of the residents. Indeed separation distances can be used in concert with SPL criterion.

The following advice is offered based on review of evidence by the project team:

- Under 400m has been shown to cause a high level of annoyance and limited evidence of health impact, yet it may be acceptable in certain circumstances, e.g., where the resident within 400m is directly involved in the project by investing or leasing land;
- Distances between 400m and 700m may be acceptable in some circumstances, e.g., smaller projects with one to two wind turbines, yet predictive modeling is strongly recommended to verify that SPLs are protective;
- Existing 700m separation distance is protective in most cases, yet noise impacts at distances of 700m to 1000m will very much depend on size of the wind energy project, the SPL at the turbine hub, and specifics of the proposed site, as well as level of social consent of the nearby residents – accordingly, predictive modeling is recommended for arrays of turbines; and
- Distances of 1000m to upwards of 2000m are considered conservative as a prescribed separation distance, yet predictive modeling is recommended for large wind energy projects, such as greater than 25 turbines.

The separation distance intervals reflect best estimates based on available literature and recognize that there are some people who are more sensitive to effects of sound than others. The largest distance is least science-based, yet will likely address most of the complaints or concerns, though these may still exist; for many projects, this distance is unnecessarily large and may prohibit development without a marked benefit of reducing annoyance. Indeed for most projects, it is unlikely that annoyance will reach zero in the host community; this is true of most developments and is not specific to large-scale wind turbines.

4.5.3 Stakeholder Engagement

The evidence links social consent to level of annoyance; yet social consent can be developed only where residents feel engaged in the planning process. Accordingly, community engagement is recommended. While indirect, this can affect health outcomes via annoyance.

The project team strongly recommends that the Municipality of the County of Kings review mechanisms to address residents' perception of the planning process for wind energy projects; this includes requiring community engagement opportunities, such as forming a community liaison committee (CLC) at the earliest project planning stages. This acknowledges the evidence that suggests a correlation of perception of large-scale wind turbines with annoyance.

It is suggested that the Municipality review Nova Scotia Environment's *Guidelines for the Formation of a Community Liaison Committee*. A Terms of Reference could be developed for a CLC as part of the ongoing MPS / bylaw review. Further developers could be required to form a project-specific CLC as part of early project planning. This is an ongoing process by which residents and developer will engage in transparent dialogue that includes municipal officials; this process should include the suite of issues (economic, ecological and social) rather than health alone since evidence shows that health can be the endpoint, but is inextricably tied to the other issues.

While engagement of the host community is key, it is recommended that the Municipality also engage with project developers, NS Environment and Health Canada to determine a project-specific approach to planning wind energy projects which typically includes predictive noise modeling and baseline noise measurements. While health-specific guidance has been provided in this report, the Municipal planning staff must engage the other levels of government and the developer community – as well as the residents – in their review of existing MPS and LUB.

As part of working with the upper levels of government, the Municipal staff should review opportunities to integrate planning policies with the Provincial EA process for wind energy projects with nameplate capacity of 2MW or more. In these cases, the NS Environment staff will review noise as part of the developer's EA submission as supported by Health Canada's expert advice. The Municipality should engage in this process in a supportive manner without duplication.

Once projects are constructed, engagement should not end. Indeed ongoing communication is key. It is recommended that the Municipality define a complaints procedure such that residents living near large-scale wind turbines who have complaints on audible noise will know how to communicate concerns. A complaints response protocol is often a requirement of the terms and conditions of approval when a wind energy project is released from the NS EA process; this is something that the Municipality should consider for all projects.

Indeed involvement and education regarding measurements of audible noise emissions from operating wind turbines and their interpretation are key. Involving the host community with the regulators and developers on an ongoing basis will assist in future planning of wind energy projects. The term “citizen scientists” has been used to describe the role that interested residents should be able to take in local wind energy projects. A CLC can function in this way.

Overall, the Municipality and other stakeholders must recognize that both the science associated with human health risks from noise of wind turbines and the technology of wind turbines is improving over time. Many turbine manufacturers are attempting to design models to reduce the SPL resulting from their operation. As such, the Municipality should incorporate a review period for its planning policies with reliance on the expertise of federal and provincial governments, as well as its own experience as large-scale wind turbines are built in the Municipality.

5 Ice Throw

5.1 Nature of Impact

Ice may form on the wind turbine structure during certain climatic conditions. Glaze may form during an ice storm and rime ice may form from frozen fog at high elevations. Typically, wind turbines have controls to shut down when there is sufficient ice formed on the blades; this can be determined via sensors – ice or vibrational.

Ice buildup will most often fall from the turbine when it is stationary. During an extreme weather event with very high winds, the turbine blades will be shut off. In this event, the ice shed could be blown downwind. Ice could also be thrown from an operational blade – this would typically occur during start up when rotational speeds are low or if a failure of the control system occurs.

5.2 Context of Kings County

Ice formation on large-scale wind turbines – or any large structure – will occur during certain climatic conditions, i.e., low temperature and high humidity. In Kings County, as in the rest of Maritime Canada, it is probable to have extreme events conducive to icing in winter months. According to Environment Canada[94], the average daily temperature in December through to March is below zero in Kentville with a mixture of rainfall and snowfall over these months. There is a safety risk from ice throw from large-scale wind turbines that may be constructed in Kings County under certain climatic conditions.

5.3 Current Research

The Massachusetts Panel[95] did a thorough review of risk from ice throw; this includes analysis of the physics of ice throw to ascertain probable distance and comparison with a European study[96]. Since the writing of the Massachusetts report, no additional data have been published on ice throw. The European study included a database review of recorded ice throw from wind turbines; recorded distances are typically less than 125m from the base of the turbine.

In summary, the Panel determined that (p.AC-5):

[94] Environment Canada. (Website). Canadian Climate Normals 1971-2000. National Climate Data and Information Archive. Kentville CDA. Climate ID: 8202800. www.climate.weatheroffice.gc.ca.

[95] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.

[96] Seifert, H., Westerhellweg, A., & Kröning, J. (2003). Risk analysis of ice throw from wind turbines. Proceedings of Boreas VI, Pyhätunturi, Finland.

…there are two plausible scenarios in which ice may fall from a wind turbine and may land at some distance from the tower. In the first scenario, ice that falls from a stationary turbine is blown some distance from the tower. In the second scenario, ice is thrown from the blade of an operating turbine during a failure of the control system. In the first case, ice may land 100 m or more from the tower in high winds, depending on the wind speed, the height from which the ice falls, and the dimensions of the ice. In the second case, the ice could land even further from the turbine. Just how far would depend on the actual speed of the rotor when the ice was shed, the height of the tower, the length of the blade, the angular position of the blade when the ice was released, and the size and shape of the ice. In general, it appears that ice is unlikely to land farther from the turbine than its maximum vertical extent (tower height plus the radius).

The Massachusetts Panel identified the following simplified formula for maximum ice throw from an operating turbine without ice control measures (p.62):

$$x_{max,\ throw} = 1.5\ (2R + H)$$

where $x_{max,\ throw}$ is probable maximum distance in meters, R is rotor (blade) radius in meters, and H is hub height in meters. Where a typical turbine may have a hub height of 80m and blade radius of 40m, the maximum distance of ice throw is 240m.

In 2007, Garrad Hassan was commissioned by the Canadian Wind Energy Association to develop a risk assessment for ice throw from an operating turbine from perspective of public safety[97]. The model used a large-scale wind turbine with a hub height of 80m and rotor diameter of 80m; that is, 120m from base to blade tip. The model result was a distance of 220m for critical ice shed; that is, beyond 220m, there is negligible risk of injury from ice throw. For ice to shed from a non-operational turbine, distance is typically under 50m from turbine base. The model also demonstrated three scenarios for example calculations of risk based on sample conditions:

- Fixed dwelling 300m from wind turbine: 1 strike of dwelling every 62,500 years;
- Rural road setting 200m from wind turbine: 1 vehicle strike per 100,000 years; and
- Individual ever present within 300m radius but not 50m radius: 1 strike in 500 years.

5.4 Risks and Uncertainties

There is a risk of injury or even death from ice throw under certain conditions; these are:

- Weather conditions suitable to develop icing on the turbine blades;
- Ice shed from the turbine blade;

[97] Garrad Hassan. (May 31, 2007). Recommendations for Risk Assessments of Ice Throw and Blade Failure in Ontario. Prepared for the Canadian Wind Energy Association http://www.canwea.ca/images/uploads/File/GH-RiskAssessment-38079or01a(1).pdf

- Pieces of ice large enough to remain intact once shed from the blade;
- Ice traveling along the necessary path and trajectory of the individual;
- Presence of the individual.

Yet the sources reviewed – one independent panel for government, another review of recorded data, and another a risk analysis for industry organization – arrive at similar conclusions on safe distances. Risk is only present in relatively close proximity to the turbine during icing conditions.

5.5 Best Practices

Since there is potential for icing of large-scale wind turbines that may be constructed in Kings County, the following recommendations are based on best practices to minimize risk:

1. Post warning signs and/or installation of gates in the proximity of the wind turbines to warn individuals of risk of ice shed during an icing event.
2. Restrict operational activities in the vicinity of the wind turbine during and immediately following an icing event.
3. Train operational staff of risks associated with ice throw during certain conditions.
4. Determine safe distance based upon the formula: $x_{max,\ throw} = 1.5\ (2R + H)$ where R = rotor (blade) radius and H = hub height.
5. Use ice detection systems and management of turbine operation during icing conditions; however, the above distances are pre-cautionary based on failure or absence of these systems.

6 LOW FREQUENCY NOISE AND VIBRATION

6.1 NATURE OF IMPACT

Sounds with a frequency under 100Hz are considered low frequency vibration. Infrasound is defined specifically as that with a frequency under 20Hz. Infrasound is generally not audible by humans although infrasound has been reported to be sensed as pressure or sensation. For this report, the definition of under 100 Hz for low frequency noise and vibration is based on ISO[98]; however, other definitions exist (e.g., under 200 Hz, etc.).

Perceptions and effects of sounds with strong low frequency content can differ from sounds in middle or higher frequency ranges; this is primarily due to the human perception of sound. These unique perceptions of low frequency noise and vibration may include:

- Interpreting as pulsations and fluctuations, i.e., not constant;
- More rapid increase in loudness and annoyance with increased SPLs;
- Increased complaints about feelings of ear pressure; and
- Less attenuation by structures and over distances.

Sound representing the range of human audibility is typically reported in dBA as discussed in Section 4; however, to represent the very low frequency vibration of infrasound, a G-weighted measurement of the SPL is preferred[99]. The unweighted decibel measurements include the entire sound frequency. This is shown graphically in Figure 1 where the dBL is shown as the dashed line at 0 dB. So at a frequency of about 10Hz, the dBA measurement will be much lower than dBC and dBG. The G-weighting focuses on the 10-20 Hz frequency range[100]; as the sound frequency approaches 100 Hz, it matches the A-weighting before dropping off.

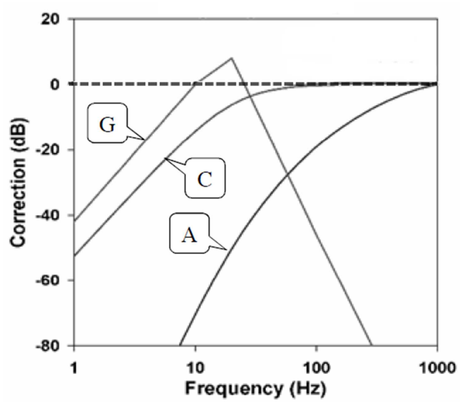

Figure 1 Sound Pressure Weighting (Source: Ambrose & Rand, 2011)

[98] ISO. (2003). Acoustics – Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedure. ISO 1996-1:2003(E). Geneva, Switzerland: International Standards Organization.

[99] ISO. (1995). Acoustics – Frequency-weighting characteristic for infrasound measurements. ISO 7196:1995€. Geneva, Switzerland: International Standards Organization.

[100] Ambrose, S.E. & Rand, R.W. (December 14, 2011). The Bruce McPherson Infrasound and Low Frequency Noise Study: Adverse Health Effects Produced By Large Industrial Wind Turbines Confirmed. 51p. www.acousticecology.org/wind/winddocs/health/Ambrose%20Rand_Bruce%20McPherson%20Infrasound%20and%20Low%20Frequency%20Noise%20Study.pdf

Low frequency noise and vibration is emitted from sources including: equipment, such as pumps, fans, and boilers; industrial activities such as blasting, quarrying; transportation, such as road, rail and air traffic; and electrical installations, including operating wind turbines. Natural sources of low frequency noise and vibration include ocean surf and thunder.

Large-scale wind turbines have been shown to emit infrasound and low frequency noise (ILFN)[101]. This effect is primarily due to rotation of the blades and the associated lifting surface as they rotate. The Massachusetts Panel has explained that this “thickness noise” would have an associated frequency equal to blade passing frequency; an example is a turbine with a 3-bladed rotor turning at 20 rotations per minute which might generate sound at a frequency of about 1 Hz, i.e., infrasonic.

In contrast to ILFN, the impulsive noises that are described anecdotally as the “swish” and “thump” sounds are broadband sounds. As described in Section 4, these are in the audible range and are not infrasound by definition. The receptor receives both the higher and lower frequency vibrations as a spectrum within the noise. In practice, it has not possible to separate the perception of ILFN from audible noise.

A summary of ILFN data from peer-reviewed literature is provided in the Massachusetts Panel study; it is difficult to find reliable and comparable ILFN data as their compilation explains. Indeed the potential effects are more difficult to ascertain. In a report by independent consultants contracted by a few residents of Falmouth, Massachusetts, pressure measurements were taken inside and outside of a home in the spring of 2011 (Ambrose and Rand, 2011) in response to concerns about infrasound and the residents’ ill health[102]. A robust review of this report is presented in the Massachusetts Panel study (pp.49-51), but in summary, the methods used for measurement and interpretation are not transparent, and not fully described, yet do show a difference in A and C weighted outdoor sound levels of around 15 dB at the high wind speeds, a simultaneous indoor and outdoor measurements indicate that at very low frequencies (2-6 Hz) the indoor pressure levels are greater than those outdoors, and the presence of a 22.9 Hz tone that was amplitude modulated at approximately the blade passage frequency. The source of the tone was not identified, and no indication as to whether the tone varied with wind speed was provided. Finally, the measurements shown in the report are atypical within the wind turbine measurement literature and suggest the presence of a site/turbine-specific situation.

[101] O'Neal, R.D, Hellweg, R.D., Jr., Lampeter, R.M. (2011, March). Low frequency noise and infrasound from wind turbines. Noise Control Engineering Journal. 59(2), 135-57.
[102] Ambrose, S. E. & Rand R. W., (2011, December). The Bruce McPherson Infrasound and Low Frequency Noise Study: Adverse Health Effects Produced By Large Industrial Wind Turbines Confirmed. Retrieved from: http://www.wind-watch.org/documents/brucemcpherson-infrasound-and-low-frequency-noise-study/

As the Panel states (pp.12-13)[103]:

> *When these recorded levels are taken at face value, one might conclude that the infrasonic regime levels are well below the audible threshold. In contrast, the low frequency regime becomes audible around 30 Hz. Such data have led many researchers to conclude that the infrasound and low frequency noise from wind turbines is not an issue (Leventhal, 2009; O'Neal, 2011; Bowdler, 2009). Others who have sought explanations for complaints from those living near wind turbines have pointed to ILFN as a problem (Pierpont, 2009; Branco & Alves (Pereira, 2004). Some have declared the low frequency range to be of greatest concern (Kamperman et al., 2008; Jung, 2008).*

This report has separated audible noise from low frequency noise and vibration; this is primarily due to the differences in the state of research, measurement approaches (i.e., weighting), and specific concerns cited on effect of ILFN. Yet again, it is difficult to untie components of sound based on frequency – both in terms perception and guidelines to best manage impacts for protection of human health.

As explained in Section 4.1, Health Canada recommends 45 dBA at the outside of dwellings. While this is based on audible sound and is represented as an A-weighted SPL, it is also considered protective by Health Canada in terms of low frequency noise and vibration[104]. This is based on Health Canada's comparison of sound levels from large-scale wind turbines (as per 2006 International Electrotechnical Commission[105]) to the 1995 American National Standards Institute (ANSI) recommendations; this comparison was completed at a level of 63 Hz. At present, Health Canada does not specifically address concerns associated with inaudible frequencies, i.e., typically below about 20 Hz.

6.2 Context of Kings County

Like audible noise, low frequency noise and vibration from a large-scale wind turbine will attenuate over space as a function of the site-specific characteristics and time-specific climatic conditions. Yet one of the properties of infrasound is its ability to travel at distances far from its source. Further the baseline levels – both within the audible range and within the infrasound range – may impact reported observation of ILFN from any large-scale wind turbine(s) that may be constructed in Kings County. Indeed should a complaint be reported due to a future large-

[103] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.

[104] Keith, S.E., Michaud, D.S., Bly, S.H.P. (2008). A proposal for evaluating the potential health effects of wind turbines noise for projects under the Canadian Environmental Assessment Act. Journal of Low Frequency Noise, Vibration and Active Control. 27(4), 253-265.

[105] International Electrotechnical Commission. (2006). Standard on wind turbine generator systems – Part II: Acoustic noise measurement techniques. IEC 61400-11.

scale wind turbine, it will be difficult to ascertain if the perceived effect is due to low frequency noise and vibration or broadband sound – even if the complaint mentions low frequency noise. In practice, humans cannot easily separate the two – nor can attitudes on the wind turbine be separated from the perception of effects of ILFN.

6.3 Current Research

There are limited but growing numbers of peer-reviewed articles based on field studies of low frequency noise and vibration. In addition, there are numerous case reports documenting the health effects of large-scale wind turbines; often with specific focus on ILFN. While the latter are not typically peer-reviewed and many have been self-published by community groups, medical professionals and individuals, these reports have been cited in some journal articles, including a double 2011 issue of the Bulletin of Science, Technology & Society. This literature has been reviewed by the project team as outlined in the bibliography. Some of the primary sources are referenced in this report.

As with the discussion on current research on audible noise effects from wind turbines, this report does not contain a detailed literature review; rather the results of the two works in Massachusetts and Oregon are summarized for discussion in context of this report. Both of these bodies of work included review and consideration of peer-reviewed and non-peer-reviewed resources. Accordingly, the effects of low frequency noise and vibration on health are summarized below as interpreted from these two sources which were both released in January 2012[106,107]:

- Low frequency sound from wind turbines may be near or within levels of human hearing, yet there is insufficient evidence to determine if low frequency sound from wind turbines is specifically associated with annoyance or other health effects;
- Infrasound from wind turbines is below levels that can be directly heard or felt outdoors, although it may couple to structures and be felt indoors;
- Evidence does not demonstrate the influence of infrasound generated by wind turbines on the brain via vestibular mediated effects;
- Significant uncertainty exists on the subjective nature of sound and its interaction with humans – especially with a strong sound component in lower frequencies though some individuals do appear to be more responsive than others to ILFN; and

[106] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.
[107] Oregon Health Authority. (January 3, 2012). Strategic Health Impact Assessment on Wind Energy Developments in Oregon. Public Comment Release. Prepared by Health Impact Assessment Program.

- Additional uncertainty exists due to limited evidence from epidemiological studies on effects of indoor levels of ILFN, as well as potential for infrasound to couple into structure.

Indeed the specific effect of low frequency sound on a human receptor is not well understood. While there is a relatively recent proposal of a possible coupling mechanism between infrasound and the vestibular system (via the outer hair cells in the inner ear), it is not yet fully understood or sufficiently explained. Yet if these mechanisms are demonstrated in evidence, the levels of infrasound near wind turbines could be high enough to be sensed by the inner ear's outer hair cells, i.e., via a SPL as low as 40 dB[108,109].

6.4 Risks and Uncertainties

Of the potential hazards of large-scale wind turbines that may be a risk to human health, low frequency noise and vibration is the most controversial. As explained above, some researchers dismiss potential effects while others see the potential interaction as a great concern. Indeed peer-reviewed literature is published regularly; while case studies and self-published reports, often reinterpreting the science, are available through internet sources at an even higher rate.

The Society for Wind Vigilance, an advocacy group, completed a literature review on adverse health effects from low frequency noise and infrasound from wind turbines[110]. It is the opinion of the project team that many of their conclusions indeed support the conclusions of the Massachusetts and Oregon reports.

Indeed wind turbines emit sounds which are both audible and inaudible. Data are needed to demonstrate that infrasound generated from turbines disrupts sleep and causes other adverse health outcomes. Further research would allow stronger conclusions to be drawn about the levels at which this occurs and the numbers of people affected. Yet it is possible such conclusions will not be able to be drawn in the near future.

6.5 Best Practices

The evidence regarding the mechanism by which low frequency noise and vibration is sensed by humans is inconclusive and there remains uncertainty about health risks associated with low frequency noise and vibration from large-scale wind turbines that may be constructed in Kings County. Yet the recommended 40 dBA (or a corresponding assumed separation distance based

[108] Salt, A.N., Hullar, T.E. (2010). Responses of the ear to low frequency sounds, infrasound and wind turbines. Hearing Research. 268, 12-21.
[109] Salt, A.N. & Kaltenbach, J.A. (2011). Infrasound from Wind Turbines Could Affect Humans. Bulletin of Science, Technology and Society, 31 (4), 296-302.
[110] The Society for Wind Vigilance. (Website). Low Frequency Noise, Infrasound and Wind Turbines. http://www.windvigilance.com/about-adverse-health-effects/low-frequency-noise-infrasound-and-wind-turbines

on conservative yet practical assumptions) that is protective of human health in terms of audible noise is also suggestive of protection in terms of ILFN based on current knowledge. Yet uncertainties exist, including the ability and prevalence of coupling with structures and its mechanism to affect people indoors. Based on the current level of understanding, the best practices suggested in Section 4.5 in terms of SPL criteria and/or separation distances also apply for low frequency noise and vibration.

7 Shadow Flicker

7.1 Nature of Impact

Shadow flicker is an effect created when wind turbine blades rotate in front of a low-level sun (i.e., about 30 minutes after dawn or before dusk at certain times of year). When the rotating blades are between the observer and the direct sunlight, shadows may be created which alter with light, hence a flickering effect.

The impact depends on specifics of the site, including location of receptors (distance and direction) relative to turbine(s) and the height, elevation and angle relationship (i.e., geometric with respect to the sun's position). Further the frequencies of shadow flicker created by the turbines is proportional to the rotational speed of the rotor times the number of blades; the frequency is known to be between 0.5 and 1.1 Hz for typical large-scale wind turbines[111]. Shadow flicker is a concern in terms of annoyance and distraction and indirectly on sleep and cognition; some have raised questions about its direct health impact, e.g., nausea, dizziness, and seizures.

7.2 Context of Kings County

The phenomenon of shadow flicker itself is physical; it is partially a function of the angle of the sun. In higher latitudes, the angle of the sun is lower; accordingly, there are fewer issues with shadow flicker in the Unites States than in Europe. The latitude of Kings County is about 45^{o} which is comparable to southern Europe; effects are expected to be less than those seen in the United Kingdom and northern Europe, yet shadow flicker may still be an issue in Kings County depending on the project and orientation of receptors. Further, open land, i.e., agricultural areas rather than forested areas, may be more susceptible to shadow flicker as less buffer of the flickering shadows will occur.

7.3 Current Research

The physical impacts from shadow flicker are known to decrease at distances away from the turbine; the Massachusetts Panel determined that shadow flicker is present until about 1400m from the turbine, yet the effect is most pronounced up to about 400m from the turbine. However, the distance of impact is related to the project and the site, including ground cover, topography and presence of receptors. The presence (times of year, minutes per day) of flicker effects can be modeled using software commonly used by developers; computer software, like

[111] Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.

WindPro, has a maximum default value of 2000m where flicker will not be an issue; this distance does not include atmospheric effects which limit the distance to about 1400m.

There may be potential cumulative effects where several turbines are closely sited depending on orientation of the turbines and receptor; a combination of flicker effects from various turbines may occur. This could happen at same time to worsen the intensity of the flicker effect or it could extend the effect such that the receptor experiences flicker at different times of day or year from different turbines. Again, this could only happen where the geometry allows the shadow flicker effect to be produced, and when the sun is not obscured by cloud or fog.

Health concerns have been raised about shadow flicker. Approximately 1.3 percent of Canadians are affected by epilepsy; of these, about 5 percent of those with epilepsy are light sensitive. This sensitivity does not exist for all flashing light effects; it is restricted to frequencies around 16 to 26 Hz, occurring occasionally as low as 10Hz[112]. As stated above, a wind turbine producing shadow flicker would do so in a frequency range of about 0.5 to 1 Hz; this is well below the sensitivity level of photosensitive people. Therefore, seizures will not be triggered from shadow flicker of an operating wind turbine for people have a photosensitivity.

From a perspective of potential health effects in the general population from shadow flicker, a German government sponsored study was reviewed by the Massachusetts Panel. This study showed that prolonged shadow flicker, more than 30 minutes continuously, can results in transient effects on cognition and nervous system functioning. Again these effects were only shown at durations longer than 30 minutes. Yet it is clear that effects of shadow flicker can be a source of significant annoyance to some individuals depending on their perception – regardless of level of effect. There is not sufficient evidence – other than anecdotal – to evaluate the concern of dizziness, nausea, or disorientation from shadow flicker exposure.

7.4 Risks and Uncertainties

The Massachusetts Panel provided a general estimate for modeling the flicker zone of ten times the rotor diameter; for example, a blade length of 40m (i.e., diameter of 80m) would then have a potential flicker area that is outwards of 800m from the base of the turbine. Yet only portions of this zone may experience flicker, and this may only occur for relatively small portions of time. This potential impact on receptors can be estimated fairly accurately via modeling software as it is a geometric calculation. Minimizing effect from shadow flicker should be a key consideration in siting large-scale wind turbines.

In terms of acceptable limits for shadow flicker, Germany has identified 30 hours per year as maximum duration of flicker for one receptor based on clear sky assumptions, including 30

[112] Sierra Club. (May 2011). The Real Truth About Wind Energy – An Analysis of the Potential Impacts of Wind Turbine Development in Ontario. 37p.

minutes maximum in one day. Denmark has developed guidance of a maximum of 10 hours per year based on actual conditions, i.e., not worse-case clear sky scenario. These two approaches are fairly consistent; there is general consensus on appropriate level of impact to minimize annoyance.

Given the frequencies of shadow flicker created by an operating large-scale wind turbine, it is clear that shadow flicker from an operating wind turbine is not connected to seizures. Yet there are indirect health impacts related to annoyance, as well as direct physical and cognitive effects for exposures greater than recommended maximum of 30 minutes per day.

As well, distraction of drivers from shadow flicker caused by turbines is also a potential safety issue should it occur. Yet this flicker effect can also occur while driving during conditions where an obstruction, such as trees is positioned between a low-level sun and the driver. Nonetheless, this potential effect must be considered when planning for large-scale turbines.

7.5 Best Practices

Since there is potential for shadow flicker to cause annoyance / distraction of residents at certain times and locations, the following recommendations are best practices to minimize risk:

1. Calculate the estimated flicker zone based upon distance from turbine given the formula: $x_{max, flicker} = 2R * 10$ where R = rotor (blade) radius; consideration must also be made to the orientation of the rising and setting sun to determine if impacts may exist.
2. Where receptors are present within this area (residences, schools, roadways, etc.), ensure that the duration of shadow flicker is within a maximum of 30 hours per year and 30 minutes maximum in any one day based on clear sky assumptions.
3. Minimize extent of shadow flicker effects on receptors where possible via decision rated to siting of wind turbines.

8 CLOSURE

The objective of this independent report was to assist Municipal Council, the PAC, Municipal staff and Kings County residents to better understand current research on potential health and safety impacts from large-scale wind turbines. While Kings County had developed its MPS and LUB for wind energy in May 2011, recently proposed projects on the North Mountain and South Mountain raised concerns for many residents. The scope of this report was defined based on the Request for Proposals.

The selected project team consisted of an environmental consulting engineer from Nova Scotia in association with a professor of environmental health from Massachusetts. Building on experience of the project team, there are many sources, perspectives and data that were reviewed and analyzed to ascertain a balanced understanding of potential health effects.

Review of information in a scientific and logical manner was key to assisting in best planning policies for wind energy in their Municipality with respect to potential risk to human health and safety. While there are many considerations in planning for large-scale wind turbines (i.e., economic, ecologic and social), health and safety was raised as a significant issue of concern by many residents.

Ten potential impacts were identified by the project team with consideration of concerns identified by residents. Of these, six impacts were not further reviewed in this study as the probability is considered low, the event is not specific to large-scale wind turbines, the issue is addressed through existing legislation, or there should be monitoring / management plans in place to address the infrequent event.

The remaining four potential impacts were reviewed in greater detail; these were audible noise, ice throw, low frequency noise and vibration, and shadow flicker. Each impact was explained in content of large-scale wind turbines in Kings County; the current evidence was provided to support recommendations of best practices for planning of large-scale wind turbines. This was also supplemented with a discussion on risks and uncertainties for each of these four impacts.

While separation distances are a common tool for planning, these are generally not science-based from the perspective of health impacts. With the exception of ice throw, the protective distance from a health and safety perspective is specific to the site and the project. In terms of shadow flicker, it is more straightforward as it is a function of the orientation of the sun over the seasons. Yet in terms of audible noise and low frequency vibration, the specifics of the site and the project greatly influence its potential impact; this includes number and type of turbine, site topography, ground cover, prevailing winds, proximity to water, humidity, and other factors all influence the propagation of vibration from the source.

Accordingly, the recommendations include reference to these complexities. For audible sound, a protective SPL is proposed that is in line with the Provincial approach. Based on available evidence, it is believed that protection then exists for low frequency noise and vibration when the protective SPL for audible noise is achieved. It is the SPL that effectively sets the separation distance; this allows the specifics to be incorporated into the planning. Yet the Municipality may wish to incorporate ranges of distances into its planning tools where increased levels of risk require additional protection. To this end, recommendations are made which state the likely risk at intervals of separation to the nearest dwellings. It is believed that this is protective for audible sound and low frequency noise and vibration based on available data.

Assessment of human health risks is a challenging process. Governmental organizations provide guidelines and tools that allow the assessment of risk qualitatively or quantitatively. Risk is a function of the intensity and frequency of human contact or exposure with a hazard. There is uncertainty in the estimates of exposure and in the estimates of the dose-response relationship. This is true for chemical, biological and physical hazards; hazards from large-scale wind turbines are primarily physical – these include audible noise, ice throw, low frequency noise and vibration, and shadow flicker.

As there is never "no risk", the project team has identified uncertainties in the existing data and the current understanding. It has been identified where the data are fairly robust and where additional data are needed. The key uncertainty primarily revolves around the subset of the population that is more sensitive and affected by vibration and sleep disruption. It is the opinion of the project team that the recommendations are suitably conservative to address the reality that some people are more sensitive to the effects of noise and vibration; this reality is especially uncertain for low frequency noise and vibration. Yet the resulting recommendations are not considered prohibitive to development.

While some of the health impacts are direct, many of the reported health impacts are indirect via annoyance. While this term, *annoyance*, may be a cause for controversy for some, it is widely used in the literature and regulatory bodies, including Health Canada. As degree of annoyance is highly influenced by perception of the resident on the wind energy project, the importance of stakeholder engagement cannot be over emphasized. It is recommended that the Municipality review planning mechanisms to further engage residents in the planning and operational monitoring of large-scale wind turbines.

The project team hopes that this report on health and safety impacts of large-scale wind turbines is supportive of the ongoing MPS / LUB review process planning tools for the Municipality of the County of Kings.

APPENDIX A – REQUEST FOR PROPOSALS

Request for Proposals

RFP P12-01

Health & Safety Impacts from Large-Scale Wind Turbines

1. The Project

The Municipality of Kings is seeking a qualified professional or group to provide objective technical advice concerning the health and safety impacts of large-scale wind turbines. The advice is intended to inform an impartial review of the Municipality's large-scale wind turbines land use policies and bylaws. Ideally, the qualified proponent would have credentials/ experience that demonstrate a thorough understanding of wind-turbine technologies, the health and environmental sciences, and public policy. The successful proponent will possess the ability to critically comment on the quality and rigor of the available research literature in terms of methodologies, hypotheses, analyses, statistical confidence levels, general and specific theories and other elements.

2. Background

On May 3rd, 2011 Council approved amendments to the Municipal Planning Strategy (MPS) and Land Use Bylaw (LUB) to permit the development of large-scale wind turbines in Kings County. This concluded a three year process to develop large-scale wind turbine policies. The process included extensive background research; Open Houses and Public Participation Meetings to gather public input; and a visit to the Digby Wind Park by members of Council. Ultimately, Council chose as-of-right permitting for large-scale wind turbines in select rural districts, as well as a 2300 ft (700m) minimum separation distance between turbines and dwellings.

In December, 2011 and January 2012, Council and the Planning Advisory Committee (PAC) heard concerns from residents about the adequacy of Council's current large-scale wind turbine policy. The residents' concerns were in response to the erection of a wind monitoring tower in the Greenfield area, and the possibility that a large-scale turbine would be developed in the area in the future. The residents have submitted petitions, containing hundreds of signatures, in opposition to two separate wind-turbine proposals in Kings County. Many emails, with web links to research and expert opinion concerning health risks have also be submitted to staff and Council.

In response to these concerns, Council directed Municipal staff to initiate a project to review large-scale wind turbine policies. The multi-step review process will include open houses, questionnaire, public meetings and multiple meetings of the Planning Advisory Committee (PAC) and Council.

As part of the review, Council also authorized staff to hire an outside expert to provide technical advice concerning health and safety risks at a cost not to exceed $25,000, HST included. The Municipality intends to use this technical advice to inform the review of Municipal regulations that will ultimately need to balance health concerns with other practical considerations, such as cultural landscape issues, infrastructure, areas of suitable wind and sustainability goals.

The following table, next page, outlines the tentative schedule for the project, subject to change by PAC, Council or other circumstances.

Step	Target Date (2012)	Description
1	February	Open House(s) & Questionnaire to inform and gather feedback from the public. Intended to inform the development of policy options (i.e should Council take a conservative, middle of the road, or permissive approach etc)
2	April	PAC meeting/workshop to review results of the open house and provide direction on broad policy options. * Expert advice concerning health and safety impacts intended to inform discussions here
3	May	PAC review of draft amendments
4	June	Public Participation Meeting
5	June	PAC recommendation to Council
6	July	Council: First Reading
7	July	Public Hearing
8	August	Council: Second Reading
9	August to September	Provincial review of any MPS amendments

3. Terms of Reference

The Municipality is seeking a qualified professional or group to provide objective technical advice concerning the human and animal health impacts of large-scale wind turbines. Specifically, the successful proponent is expected to conduct the following work.

a. Prepare a report that:
   i. Uses one or more reputable reference reports to describe in general terms the health risks associated with large-scale wind turbines, including, but not limited to, noise, infra-sound, shadow flicker and ice throw.
   ii. Reviews and responds to public submissions compiled into themes by Municipal Staff.
   iii. Discusses the human and animal health risk concerns submitted by the public. The discussion should explore whether concerns are proven by the health sciences community, probable, possible or unfounded, based on the quality or the research. Where are the areas of uncertainly and the areas of consensus? Why are the conclusions from the research found on the CanWAE website different from the research submitted by some members of public that

call for much greater setbacks? Which research should the Municipality pay the most attention to?

iv. Evaluates health and safety risks in the context of everyday realities. How do the risks compare to the risks associated with highways, industry and other land use, or even personal travel and lifestyle choices?

v. Makes recommendations, from a health and safety perspective, concerning separation distances between large-scale wind turbines and residential dwellings, livestock farms, and commercial establishments, situating the recommendations at three points along a continuum of vigilance, as described below:
   - A vigilant approach that mitigates not only proven risks, but those which may be compelling, if not necessarily proven
   - A cautious approach that mitigates only well-established, scientifically proven health risks
   - An permissive, but conscientious approach that reduces possible or probable health risks to well-established tolerable levels.

vi. Is written in plain language so that an average member of the public could read and understand the report. Technical terms required for the report should be defined.

b. Make a presentation to the Planning Advisory Committee (PAC) in person or via a video conference technology. At this meeting, the proponent is expected to answer any questions by committee members, staff and members of the public.

c. If needed, the proponent is expected to be available to answer further questions, at future PAC and Council meetings either in person or via video conference technology.

4. Municipal Support

The Municipality will provide the following information and support to the successful proponent.

a. Copies of Municipal regulations concerning large-scale wind turbines and the associated staff reports.
b. Copies of maps, produced by the Municipality, including a variety of separation distance mapping
c. Copies of all public submissions, including a summary of the submissions according to general themes.

5. Deliverables

a. A draft report as outlined in section 3(a).
b. A final report as outlined in section 3(a).
c. A presentation, in person of via video conference, to the Planning Advisory Committee.

All deliverables, including images contained in reports, shall be submitted in a digital format.

Schedule

Deliverable	Date
Start up meeting	Late February, 2012
Draft Report	March, 30th, 2012
Final Report	April, 12th, 2012
Presentation to the Planning Advisory Committee	April, 24th, 2012

6. Evaluation Criteria

All proposals received prior to the RFP closing will be ranked according to the following criteria.

Qualifications and Experience
The proponent shall explain how their qualifications and experience make them a good candidate for this RFP, including the demonstrated knowledge of wind-turbine health impacts and the ability to critically examine research methodologies. The proponent shall provide curriculum vitae for themselves and each member of their team. Knowledge of municipal planning is not required.

The proponent shall also describe any previous work that may be perceived by Council or the public as showing bias.

Methodology
The proponent shall provide a detailed work plan that demonstrates the proposed project methodology. The work plan is the proponent's opportunity to present their understanding of, and approach to, the Terms of Reference for this project, including their awareness of issues that may pose challenges or barriers to completing the work. While the Terms of Reference set out the minimum level of effort, the proponent may describe an alternative methodology provided its benefits are clearly explained compared to the approach set out in the terms of reference.

Costs
The proponent is responsible for any and all costs and expenses incurred in the performance of the work. The proposal should specify a firm price, including total fees, expenses and HST, in order to complete the requirements described in Section 3. This should be broken down by:

- Hours, hourly rate and total charge for each individual that is part of the proponent's team
- Expenses by major category (time, travel, accommodation, photocopying, long distance telephone etc.)

Scoring for costs will be assigned on a sliding scale proportional to the difference in cost between the proposals.

(Note: Respondents should also provide separate pricing on 4c, regarding the potential for the Municipality to request the proponent to be available to answer further questions at a future Council or PAC meeting. This potential item, however, will not be used for scoring purposes.)

The weighting of criteria for the evaluation of proposals will be as shown in the following table.

Criteria	Weight
Qualifications and Experience	40
Methodology	40
Costs	20
Total	**100**

The client reserves the right to re-issue the project in the event that no satisfactory proposals are received either because costs exceed budgeted amounts or because the technical scores, excluding costs, are lower than 50 points for each proposal.

Once a conditional award is made, any concerns with the proposal which have been brought out by the evaluation may be negotiated with the selected proponent. Final award will be subject to entering into a contractual agreement.

8. General Terms and Conditions

a. Agreement

By submitting a proposal in response to the RFP, the Consultant agrees to abide by the terms and conditions outlined in the RFP.

b. Privilege

The Municipality reserves the right to:

- Suspend or cancel the RFP at any time for any reason without penalty.
- Reject any and all bids or accept any bid or part thereof and may award all or a portion of the work to one or more Bidders.
- Waive any informalities, formalities, technicalities or to reject any or all proposals based on the Bidder's lack of proven experience, performance on similar projects or the suitability of proceeding with the execution of the work.
- In the event that a number of proponents submit bids in substantially the same amount or score, the Municipality may, at its discretion, call upon those Bidders to submit further bids, information or to participate in an interview.
- No term or condition shall be implied, based upon any industry or trade practice or custom, any practice or policy of the Municipality or otherwise, which are inconsistent with the provisions contained herein.
- Reject any or all proposals and discontinue the RFP process without obligation or liability to any potential Consultant.

c. Confidentiality

RFP documents (including all attachments and appendices) may not be used for any purpose other than the submission of a proposal.

By submitting a Form of Proposal, the Consultant agrees to public disclosure of its contents subject to the provisions of Part XX of the Municipal Government Act relating to Freedom of Information and Protection of Privacy. Anything submitted in the Form of Proposal that the proponent considers to be "personal information" or "confidential information" of a proprietary nature should be marked as such and will be subject to appropriate consideration under Part XX of the Municipal Government Act as noted above.

The work described in the RFP is being conducted with public funds, and the fees and expenses proposed in the Consultant's submission will be made public.

d. Law

The law applicable to the RFP and any subsequent agreements shall be the law in force in the Province of Nova Scotia.

In responding to the RFP, Consultants warrant their compliance with all appropriate Municipal, Provincial and Federal regulations, laws and orders.

Respondents must agree to indemnify the Municipality and its employees if they fail to comply, and the Municipality reserves the right to cancel any agreement arising from the RFP if the proponent fails to comply with the above.

The successful Consultant shall indemnify the Municipality, its officers and employees against any damage caused to the Municipality as a result of any negligence or unlawful acts of the successful Consultant or its employees. Similarly, the successful Consultant shall agree to indemnify the Municipality, its officers and employees against any claims or costs initiated by third parties as a result of any negligence or wrongful acts of the successful Consultant or its employees.

10. Submission and Award

a. Submission instructions

One digital copy of the proposal shall be submitted by **2:00 pm February 21st, 2012.**

By email at planning@county.kings.ns.ca

Or on a CD or DVD

By Mail to:
Planning Services, Municipality of the County of Kings, 87 Cornwallis St. PO Box 100, Kentville, Nova Scotia, B4N 3W3.

If delivered by hand, deliver to:
The Financial Services reception area at the Municipal Offices; 87 Cornwallis Street, Kentville, Nova Scotia for deposit in the tender box until the RFP closing.

b. Proposal Preparation

All expenses incurred in the preparation and presentation of the response to the RFP are entirely the responsibility of the Consultant. This includes but is not limited to labour, materials and the cost of site visits if applicable.

c. Completeness

It is the Consultant's responsibility to ensure that their proposal is complete and is delivered to the Municipality by the date and time indicated. ***Proposals submitted after the noted time will not be opened or evaluated***.

d. Changes to Submission

Changes in a submission will only be considered if submitted by same method(s) prescribed for the original proposal, and providing such change is received by the Municipality prior to the established closing date and time. Changes to a submission will not be accepted after the established closing date and time.

e. Evaluation Process

The evaluation procedures outlined in the RFP do not reflect any policy or resolution of Municipal Council. The CAO and Municipal Council reserve the right to award for reasons not stated in the evaluation process described herein.

f. Contact

Any attempt by the Proponent or any of its employees, agents, contractors, or representatives to contact members of Municipal Council or Municipal staff not identified in the RFP may lead to disqualification.

g. Changes to RFP

Any changes to this RFP shall be stated in writing by Addenda. Verbal statements made by Municipal staff or their representatives shall not be binding. All potential proponents who download the RFP documents from the Municipality's website or a third party website are advised that they should periodically check those websites for any addendums that may be issued. Those websites do not record or otherwise track information on persons downloading tender documents.

h. Payment

Reimbursement will be on a lump sum basis, which may be invoiced on a percentage basis throughout the project.

i. Data and Documents

All data and information collected and work products created (i.e. drawings, calculations, reports) either directly for, or in support of the work outlined in the RFP are the property of the Municipality of the County of Kings.

j. Contract Award

During the RFP review period, submissions will be assessed and proponents may be contacted to answer questions or to present their proposal. The successful respondent will be notified of the conditional award. The unsuccessful proponents will be informed in writing.

The award of this RFP is conditional upon the successful respondent entering into an agreement to perform the services and other obligations as required by this RFP. (See Appendix A for an example of a Agreement)

k. Inquiries/Contact

All inquiries concerning the questions regarding the RFP must be directed to the client prior to the submission date. Depending upon the inquiries, a written submission may be required.

Ben Sivak, Manager of Planning Services
Municipality of the County of Kings
PO Box 100
87 Cornwallis Street
Kentville, NS B4N 3W3
(902) 690-6102
bsivak@county.kings.ns.ca

APPENDIX B – CURRICULUM VITAE

Janis Rod, ALM, P.Eng.

Wendy Heiger-Bernays, Ph.D.

Janis Rod, ALM, P.Eng.

Office (902)431-1077
Mobile (902)225-4436
Fax (902)453-4670
Email janis@janisrod.ca
Web www.janisrod.ca

SUMMARY

As an environmental consultant for fifteen years, Janis Rod has broad experience spanning project management, environmental management and permitting, policy development and review, stakeholder consultation, sustainability planning, and environmental impact assessments. She has foundational experience as an environmental engineer, direct experience in a wide range of industries and levels of government, and varied experiences engaging with stakeholders; this allows her to assess strategy issues holistically from social, cultural, economic and environmental perspectives.

Janis' experience in the private sector spans several industries, including renewable energy, natural gas distribution, food and beverage processing, metal and mineral mining, petroleum product storage, petrochemical manufacturing, and commercial land development. Her work for the public sector has included environmental training, planning and studies for all levels of government. Through this broad base of experience, she has a solid understanding of government policy and regulatory tools from varied perspectives.

EDUCATION

2008 - 2011	Master of Liberal Arts (Sustainability and Environmental Management), Harvard University; Thesis – Social Consent for Large Onshore Wind Energy Projects
1993 - 1997	Bachelor of Science (Environmental Engineering), University of Guelph
1991 - 1993	Diploma of Engineering, Dalhousie University

EMPLOYMENT

2005 - present	Instructor, Dalhousie University, Nova Scotia
2002 – present	Independent Environmental Consultant, Sole proprietorship, Nova Scotia
2000 - 2002	Environmental Engineer, Vaughan Engineering Limited, Nova Scotia
1997 - 2000	Environmental Engineer-in-Training, Dillon Consulting Limited, Nova Scotia

PROFESSIONAL AFFILIATIONS / APPOINTMENTS

1997– present	Member – Association of Professional Engineers of Nova Scotia
2003 – 2006	Appointment – Halifax Regional Watershed Advisory Board
2002 – 2004	Appointment – Shubenacadie Canal Commission

PROFILE OF PROFESSIONAL PROJECT EXPERIENCE

Environmental Management

- Design of best practices for municipalities to plan for wind energy projects in their communities for the Union of Nova Scotia Municipalities including associated research and review of two pilot projects and consultation with identified municipalities.
- Development of a toolkit to build capacity for Nova Scotia Department of Energy's Community Feed-in-Tariff (COMFIT) program, including liaison with stakeholders and presentations in five communities around Nova Scotia as a pilot of the toolkit.
- Development of an environmental protection plan and a post-construction community consultation plan for a wind energy project on the eastern shore of Nova Scotia.
- Management of post-construction commitments of a wind energy project on the northern shore of Nova Scotia, including bird and bat studies, moose studies, and other regulatory commitments.
- Analysis of four renewable energy development scenarios from an environmental perspective as part of the Stakeholder Consultation Process for: A New Renewable Strategy for Nova Scotia that was conducted by Dr. David Wheeler and the Faculty of Management, Dalhousie University for Nova Scotia Department of Energy.
- Advice and support to Nova Scotia Environment in the preparation of the Nova Scotia Water Resource Strategy, including review and analysis of public comments, member of facilitation team for the provincial regulator workshop, and preparation of documentation to assist in next steps of strategy.
- Developing a corporate plan for sustainability including greenhouse gas accounting and management relating to development of natural gas distribution lines in Nova Scotia.
- Provision of direction and advice on environmental issues associated with development of natural gas distribution lines in Nova Scotia, including existing policies/specifications, field inspections, and advice regarding environmental liabilities and permitting requirements.
- Development of an Integrated Sustainability Plan for the Town of Middleton including preparing a visioning statement, public consultation and development of a detailed action plan.
- Team member for preparing a visioning statement, design and implementation of a public consultation program, and preparing a go forward plan for the Municipality of the County of Kings' Integrated Community Sustainability Plan.
- Creation and instruction of a new undergraduate course under the Environmental Science Program at Dalhousie University, Enterprise Sustainability, ENVS 3301.
- Team member for pollution prevention assessments and workshops for the winery and brewery industry in Nova Scotia.
- Presentation to the Canadian Pollution Prevention Roundtable in Halifax, Nova Scotia, entitled "Selling Sustainability: A Business Case Roadmap".
- Development of key issues paper with specialists in the fields of public consultation, oceanography and fisheries for potential offshore drilling near Cape Breton, Nova Scotia.
- Facilitation and management of a group of public and private sector partners in the development of an environmental effects monitoring research project using autonomous underwater vehicle and sensor technology.
- Assessment of treated sewage effluent options in an innovative manner to protect sensitive freshwater receiving environment.

- Environmental team member in a study assessing best management practices for small-scale marine projects for Environment Canada.
- Environmental team member in the policy assessment for environmental impact assessments for air quality for highway projects.
- Environmental consultant for a pollution prevention assessment of poultry processing / packaging plants in Kentville, Nova Scotia.
- Environmental planning for the golf community development in Timberlea, Nova Scotia, including environmental permitting and approvals, stormwater management planning, environmental construction planning, and long term monitoring plan.
- Project manager in the evaluation of municipal servicing and groundwater protection in the Town of Nackawic, New Brunswick.
- Team member in the feasibility assessment of an industrial waste management facility in India.
- Project team member in the facility siting of the Cobequid Multi-Service Centre including review of environmental sensitivities, socio-economic issues, and site development options.
- Engineer for a water supply study to evaluate options for a water supply for a First Nations Reserve in Nova Scotia, including conceptual design of possible options, costing estimates and recommendation.
- Team member assisting in the preparation of air quality impact assessment (including climate change implications) to the environmental impact assessment for a proposed natural gas transmission pipeline.
- Engineer responsible for the calculation of the environmental impact of replacement of traditional fossil fuels with natural gas using emission factors as part of the economic analysis of a proposed natural gas transmission pipeline.

Environmental Assessments and Associated Approvals

- Project management and lead assessor of an environmental assessment for a wind energy project for the eastern shore of Nova Scotia.
- Instruction of a fourth year course, ENVS 4001 / ENVE 4772, Environmental Assessment and Management, at Dalhousie University to sixty environmental science and engineering students.
- Environmental assessor of the exploration stage for a coal mine in Donkin, Cape Breton, including consultation with regulators, preparing the project description and developing mitigative measures in partnership with the client.
- Coordination of environmental planning and federal-provincial environmental impact assessment for a proposed large wind farm in Cumberland County, Nova Scotia.
- Advising on key issues on environmental assessment of a wind farm, such as impact on radar, in Point Tupper, Nova Scotia.
- Provision of advice on both provincial and federal level environmental impact assessments and associated follow up for a petrochemical facility in eastern Nova Scotia.
- Management of environmental permitting and stakeholder consultation associated with a proposed wharf expansion project within the Strait of Canso.
- Review and recommendations on draft Strategic Environmental Assessment of management options in Rustico Harbour / Bay, Prince Edward Island.
- Regulator liaison and coordination of environmental operating approvals for a lead and zinc mine in central Nova Scotia.

- Preparation of project description, including valued ecological components identification, for the future environmental impact assessment of a proposed gypsum quarry expansion.
- Preparation of project description and analysis of environmental impacts as part of an environmental impact assessment of a wastewater treatment plant in Saint John, New Brunswick.
- Update of an environmental assessment of seismic activity in Sydney Bight, Nova Scotia with a team of environmental scientists.
- Amendment an environmental assessment for drilling activity, including assessing project against Species at Risk Act and reviewing other changes since review by Canada Nova Scotia Offshore Petroleum Board.
- Coordination of an environmental impact assessment, including stakeholder consultation, for a surface coal mine extension in Stellarton, Nova Scotia.
- Coordination of the environmental impact assessment of the taxiway extension and associated development at the Halifax International Airport.
- Project team member working with Sempra Atlantic Gas team in preparation of award of the provincial natural gas distribution franchise and subsequent environmental analysis and impact assessment.

Contaminated Sites Management

- Review and recommendations for Transportation Infrastructure Renewal's highway base and garage site management program.
- Review of Phase I and II Environmental Site Assessments on behalf of a client reviewing properties for purchase and subsequent recommendations.
- Management of several Phase I and II Environmental Site Assessments of four bases for Nova Scotia Transportation and Infrastructure Renewal.
- Project manager for the development of a compliance promotion training package to be used by Environment Canada staff for proposed regulations on petroleum products handling and storage.
- Instruction of third year undergraduate course on contaminated sites management for four years at Dalhousie University, ENVS 3300.
- Environmental review of contaminated site management process completed by other consultants for Defence Construction Canada at various sites in the Atlantic Region.
- Project manager of a hazardous material assessment of a building in Willow Park to identify the presence and quantity of hazardous materials.
- Project manager of a contaminated sites audit of various sites owned by the Department of National Defence to verify that the federal Contaminated Sites Remediation Framework was followed.
- Project manager of a long term monitoring program at a hazardous waste transfer facility in Debert, Nova Scotia.
- Coordinator of historical review and field survey and qualitative risk assessment at Wright's Cove for the Department of National Defence.
- Project engineer for Statia Terminals' Waste Disposal Area Remedial Action Plan which included excavation, transport and treatment of various contaminants.
- Team member for environmental baseline studies at Halifax International and St. John's Airports. Duties included data interpretation, organization and presentation, and assisting in report and presentation preparation.

Wendy J. Heiger-Bernays, PhD
Department of Environmental Health
Boston University School of Public Health (BU SPH)
715 Albany St. T4W Boston, MA 02118
whb@bu.edu (617) 638.4620

Education

1981 BS	Biology, University of Connecticut
1987 PhD	Biochemistry, University of Nebraska Medical Center. Thesis title: Effect of tobacco smoke on the gene expression of P450c (CYP1A1) & its activity in human tissue.

Academic Appointments

2009-present	Director, MPH Program, Environmental Health, Boston University School of Public Health (BU SPH)
2008-present	Associate Professor of Environmental Health, BU SPH
2000-2008	Assistant Professor of Environmental Health, BU SPH
1992-1999	Instructor, Department of Environmental Health, BU SPH
1988-1990	Postdoctoral Fellow, MIT, Program in Toxicology (Sponsor: John Essigmann)
1987-1988	Postdoctoral Fellow, Cold Spring Harbor Laboratory (Sponsor: Bruce Stillman)

Research and practice interests center on understanding how environmental toxicants adversely affect people's health and how risks associated with these exposures can be quantified.

Non-Academic Appointments

1990-1999	Senior Scientist, Menzie-Cura and Associates, Inc.

Provided project management of toxicological issues on risk assessment and non-risk assessment related projects. Conducted and reviewed human health risk assessments for hazardous waste sites and other facilities with emphasis on the evaluation of exposure and chemical toxicity. Developed risk assessment guidance for state and federal agencies.

On-going Research

Indoor exposures to PCBs, PBDEs and other flame retardant chemicals. 2008-present.

Wind turbine health impacts; measurement focused siting and community involvement. 2011 – present.

Indoor Air American Recovery and Reinvestment Act NIH Administrative Supplement
Assessment of Vapor Intrusion Exposures and Risks 2009-present

Characterization of municipal compost towards sustainable solutions for urban gardens. 2005-present.

BU Superfund Research Grant. Research Translation. 2006 – 2011
P42 ES007381 Ozonoff (PI) 4/01/05- 3/31/11
Superfund Basic Research Program at BU
Research Translation Core: Governmental Agency Liason

Characterization of uptake and assessment of metals and PAHs in Boston Urban Community Gardens. The results of this investigation are being used to provide recommendations for soil clean-up and healthy gardening practices. Partnership with Boston Natural Areas Network, City of Boston and USEPA. 2004 – 2009.

Teaching Experience
BUSPH. Water and Health (EH750). Graduate level course with field component on water testing,interpretation of water quality testing data and development of criteria. 2011-present

BUSPH. Introduction to Environmental Health (EH708). Graduate level core environmental health for non-EH students. Fall 2011

School for Field Study (Summer 2009). Field Practicum in Public Health and Environment in Kenya. Responsible for teaching and coordinating a community-based survey of a local community (water, hygiene, health and pesticide use).

BUSPH. Survey of Environmental Health (EH765). Core course for EH concentrators. 1997 - present. Co-taught in 1998 & 1999.

BU SPH. Introduction to Toxicology (EH768). Required course for EH concentrators. 1993 - present (co-taught in 1993)

BU SPH. Risk Assessment Methods (EH866). This course teaches the practical application of risk assessment methods to various environmental problems. 2000 - present (co-taught 2003, 2005).

BU SPH. Intermediate Toxicology (EH840). This advanced-level course is an extension in detail and content of EH768. Major topics include cellular mechanisms of toxicants as they relate to oncogenesis, neurotoxicology, and immunotoxicology, and the use of these data in regulatory toxicology. Developed & co-taught course, 2000-2010.

BU SPH. Introduction to Public Health (PH510). Undergraduate course in public health. Lecturer, 2006-2010.

Doctoral Student Thesis Advisor:
Kerry Diskin – Completion of degree – 2007
Meghan Keaney Lynch – Completion of degree – 2008
John Minnery – 2008-present
Courtney Walker – 2009- present

Teaching Tool Development An interdisciplinary, case-based learning module for assessment, clean-up and redevelopment of a contaminated site (Romano, M., LaMorte,W., Clapp, R., Heiger-Bernays, W. McClean, M., Schadt, R.) BUSPH. (2007).

Awards
BU SPH Scotch Award for Excellence in Teaching, 2010
BU SPH Teaching Award, 1998, 1999, 2006.
ASPH [CFDA Grant No. 93.283] "This is Public Health" Campaign Challenge. Faculty Sponsor (competitive award). 2008.

Selected Recent Risk Assessment and Toxicological Work

Technical review of document entitled: "Health Risk Literature Review and Dose-Response Assessment for Dichloromethane (Methylene Chloride)." Abt Associates, Inc. 2011

Risk Assessment support for Framingham Board of Health. Indoor Air Risk Characterization for Home Impacted by General Chemical Hazardous Waste Transfer Facility. 2010-present.

Toxicology & Excellence in Risk Assessment Peer Review: Health Canada Screening Level Assessments of Common Chemicals. TERA, 2008, 2009.

USEPA External Peer Review: Estimating Perchlorate Intakes from Food and Drinking Water Using the NHANES Biomonitoring Data and UCMR 1 Occurrence Data. Office of Drinking Water. October, 2008.

Review of the Human Health Risk Assessment for the Kiln-Related Emissions at the Holcim Trident Cement Plant at Trident, MT (Montanans Against Toxic Burning; 2006).

Exposure sources, measurement and classification & risk communication for residents to arsenic in and around Prairie Grove, AK. (J Snow Inst. 2005-2006).

Support for the Toxicological and Exposure Assessments of PCBs from fish consumption; Rest of River, GE Housatonic Risk Assessment (H. Strauss/USEPA, 2004).

Derivation of a acute "RfDs" for arsenic and hexavalent chromium at the Henry Woods and Sons Former Paint Factory Site (Menzie-Cura & Assoc., 2000).

Post-remediation Risk Assessment of Lead and Chromium Pigments at the Henry Woods and Sons Former Paint Factory Site (Menzie-Cura & Assoc., 2000-2004).

Development of Guideline for Protecting Residents from Inhalation Exposure to Petroleum Vapors: Prepared for the State of Maine Department of Environmental Protection (1999).

Service

BU SPH

Faculty Senate Ad-hoc Member, 2009-present
Educational (Curriculum) Committee Member, 2000-2011
Environmental Health Departmental Representative for MPH Practicum, 2005 – present
Gender Equity Task Force member, 2007-2009
Director, MPH Program Department of Environmental Health, 2009-present

Local Public Health Practice

Lexington Board of Health, member 2002 – 2004.
Lexington Board of Health, Chair, 2005 – present.

Governmental & Advisory Panels & Workgroups

Waste Site Cleanup Advisory Committee Member, Massachusetts Department of Environmental Protection (MassDEP), 2005-present.

Indoor Air Workgroup member, MassDEP. 2010-present.

National Toxicology Program (NTP) Technical Report Peer Group Panelist (2011). Review of NTP Toxicological Reports Evaluating Carcinogenicity. April, 2011.

USEPA FIFRA SAP Participant, 2010. Review of EPA/ORD/NERL's SHEDS-Multimedia Model Aggregate version 3.

USEPA FIFRA SAP Participant, 2010. Comparative Adult and Juvenile Sensitivity Toxicity Protocols for Pyrethroids.

USEPA FIFRA SAP Panelist, 2008. The Agency's Evaluation of the Toxicity Profile of Chlorpyrifos. http://www.epa.gov/scipoly/sap/meetings/2008/september/sap0908report.pdf

USEPA FIFRA SAP Participant, 2007. Assessing Approaches for the Development of PBPK Models of Pyrethroid Pesticides.
http://www.epa.gov/scipoly/sap/meetings/2007/august/aug_16.pdf

USEPA FIFRA SAP Participant, 2007. Review of EPA/ORD/NERL's SHEDS-Multimedia Model Aggregate version 3.
http://www.epa.gov/scipoly/sap/meetings/2007/august/sap_minutes_aug_14_15_2007.pdf

USEPA Contaminant Candidate List (CCL) Workgroup, 2002-2005. This group is charged with defining the process used by USEPA to list contaminants for regulation in drinking water.

USEPA STAR Fellowship Study Section: Public Health Subsection, 2000, 2002, 2010, 2012

Peer-Reviewer
Environmental Health Perspectives (2008-present)
NewSolutions Journal (2009)
Journal of Environmental Science (2006-2008)
Journal of Exposure Science and Environmental Epidemiology (2009-present)

Professional Affiliations
Society of Toxicology – since 1990
Society for Risk Analysis – New England Chapter – since 1992

Full-Length Peer-Reviewed Publications

Strauss, H. and **Heiger-Bernays, W.** (2012). Investigation of the Mode of Action Underlying the Tumorigenic Response in Rodent Bioassays to PCBs. Tox Path J. Accepted for publication.

Pennell, K. Kangsen Scammell, M., McClean, M., Ames, J., Weldon, B., Friguglietti, L., Suuberg, E., Shen, R., **Heiger-Bernays, W**. (2012). Sewer Gas: An Indoor Air Source of VOCs to Consider During Vapor Intrusion Investigations. Manuscript submitted for publication.

Lynch, MK, **Heiger-Bernays, WJ,** and Ozonoff, A. (2011). Quantification and Correction of the Bias in the Estimated Geometric Standard Deviation. Manuscript submitted for publication.

Minnery JG, Jacangelo JG, Boden LI, Vorhees DJ, **Heiger-Bernays W.** (2009). Sensitivity analysis of the pressure-based direct integrity test for membranes used in drinking water treatment. .Environ Sci Technol. 43(24):9419-24.PMID: 20000538

Heiger-Bernays, W., Fraser, A., Burns, V., Diskin, K., Pierotti, D., Merchant-Borna, K., McClean, M., Brabander, D., and Hynes, H. P. (2009). Characterization and Low-Cost Remediation of Soils Contaminated by Timbers in Community Gardens. Int J Soil Sediment Water. 2009 Jan 1;2(3). PMID: 21804925.

Heiger-Bernays, W., C. Menzie, C. Montgomery, D. Edwards, and S. Pauwels. 1997. A Framework for Biological and Chemical Testing for Society. In Environmentally Acceptable Endpoints in Soil. D.G. Linz and D.V. Nakles (Eds.) American Academy of Environmental Engineers.

Burstyn JN, **Heiger-Bernays WJ**, Cohen SM, Lippard SJ. (2000). Formation of cis-diamminedichloroplatinum(II) 1,2-intrastrand cross-links on DNA is flanking-sequence independent. Nucleic Acids Res. 28(21):4237-43. PMID: 11058123

Hollis, L.S., W.I. Sundquist, J.N. Burstyn, **W. Heiger-Bernays,** A.R. Amundsen, S.F. Bellon, K. Ahmed, E.W. Stern and S.J. Lippard. 1991. Mechanistic studies of a novel class of trisubstituted platinum (II) antitumor agents. Cancer Research 51: 1866-1875. PMID: 2004370

Heiger-Bernays, W., J.M. Essigmann, and S.J. Lippard. 1990. The effect of platinum complexes on eukaryotic DNA replication. Biochemistry 29: 8461-8466. PMID: 2174701

Hollis, L.S., A.V. Miller, A.R. Amundsen, E.W. Stern, W.I. Sundquist, J. Toney, J.N. Burstyn, **W. Heiger-Bernays** and S.J. Lippard. 1989. Chemical and biological studies of new platinum antitumor agents. J. Inorg. Biochem. 36: 153-167.

Iversen, P.L., **W. Heiger**, E. Bresnick and R. Hines. 1987. Isolation and expression of the human cytochrome P-450c gene. Arch. Biochem. Biophys. 256: 397-401.

White Papers

Massachusetts Department of Environmental Protection (2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. http://www.mass.gov/dep/energy/wind/panel.htm

Porter, J. and Heiger-Bernays, W. (2011). Risk Assessment: Vapor Intrusion in a Home Down-Gradient to a Hazardous Waste Transfer Station. Submitted to Framingham Board of Health. April 2. 2011.

Bax, D. and Heiger-Bernays, W. (2011). Trend Analysis of Lead in Municipal Compost and Recommendations for Annual Compost Sampling. Submitted to Boston Natural Areas Network and City of Boston, Department of Public Works. April, 2011.

Heiger-Bernays, Vorhees, D., and C. Long. 1999. Indoor Air Guidance for Petroleum-Contaminated Residences. Maine Department of Environmental Protection.

Vorhees, D.J., W.J. Heiger-Bernays, D. Murray, and R.E. Dodson. 1998. Trial Guideline for Protecting Residents from Inhalation Exposure to Petroleum Vapors: Trial Period Findings. Prepared for the State of Maine Department of Environmental Protection.

Vorhees, J.D., W.J. Heiger-Bernays, M.D. McClean. 1997. Human Health Risk Associated with Cigarette Smoke: the Link Between Smoke Constituents and Additives. Prepared for the Medical Foundation, Boston, MA.

Menzie, C.A., W. Heiger-Bernays, C.R. Montgomery, D.G. Linz, and D.V. Nakles. 1996. Development of an ecological risk assessment framework based on contaminant availability. "Ecotalks - Environmental Contaminants through the Macroscope." Wuerz Publishing Ltd., Winnipeg, MB, Canada.

Cura, J.J., W. Heiger-Bernays, and K.W. Buchholz. 1995. Draft Guidance on Managing Dredged Material Contaminated with Dioxins and Furans. Submitted to USEPA Oceans and Coastal Protection Division, Washington, DC.

Invited Talks

Manwell, J., Grace, S., and Heiger-Bernays, W. (2012). Report from the Expert Panel on Wind Turbines and Health. Massachusetts Wind Working Group. Waltham, MA.

Heiger-Bernays. W. (2011). Human Health Risks to Urban Garden Soils. Pilot Urban Agriculture Project on four City-owned Properties in South Dorchester. The Boston Redevelopment Authority (BRA) and Department of Neighborhood Development (DND). Boston, MA. 4/14/11.

Heiger-Bernays, W. (2011). Decreasing Exposures is the "Root" to Decreasing Risk. SRA-NE/LSPA Joint Meeting. Waltham, MA. 4/7/11.

Heiger-Bernays, W. (2011). Gardening in Urban Soils. Waste Site Advisory Committee meeting. Massachusetts Department of Environmental Protection. Boston, MA. www.mass.gov/dep/cleanup/laws/111food.ppt

Heiger-Bernays, W. (2010). Risk and Regulation Beyond Bis Phenol. The Science and Policy of BPA. AEI Center for Regulatory Studies. Washington DC. June, 2010.

Selected Recent Abstracts

Heiger-Bernays, W., Chambless, D., Tabony, J., Burns, V., Dick, J., Estes, E., Fitzstevens, M., Chien, J., Brabander, D. Municipal Compost: Towards Designing Best Practices for Managing Facilities and Application. AEHS, 2012.

Ames, J., Pennell, K. Kangsen Scammell, M., McClean, M., Ames, J., Weldon, B., Friguglietti, L., Suuberg, E., Shen, R., **Heiger-Bernays, W** Sewer Gas: An Indoor Air Source of VOCs to Consider During Vapor Intrusion Investigations. AEHS, 2012.

Vorhees, D., Strauss, H., **Heiger-Bernays, W.,** Gopinathan, B., Oruchin, E., Stirret t-Wood, G., Igbara, J., Cowell, W. Chien, J. Dong, J. Health Risk Assessment of Exposures Associated with Nigerian Oil Fields. Society for Risk Analysis, 2011.

Carignan, Courtney, Abdallah, Mohamed A., Wu, Nerissa, **Heiger-Bernays, Wendy**, McClean, Michael D., Harrad, Stuart, and Thomas F. Webster. Predictors of HBCDs and TBBPA in Milk from Boston Mothers. Brominated Flame Retardants, 2011. Poster.

Krajewski, A.K., Cody, G., **Heiger-Bernays, W.** Food Safety and Emergency Planning for Retail Food Establishments. National Environmental Health Association Annual Meeting, 2011. Poster.

Heiger-Bernays, W., Fraser, A., Burns, V., Diskin, Maxfield, R., Boudreau, D., Brabander, D., and Hynes, H. P. A Practical Approach to Addressing Urban Garden Soil Contamination. . 24th Annual International Conference on Soils, Sediments and Water, 2008.

Heiger-Bernays, W. and Stepenuck, L. Unintended conversion of private drinking water wells to PWS. New England Private Well Symposium, RI, 2007.

Keaney-Lynch and **Heiger-Bernays**. Protection of obese and diabetic members of the population through refinement of the reference dose. APHA, 2006.

Diskin, K., **Heiger-Bernays, W**., Price, P. Comparison of model predictions of absorbed pesticide dose to biomonitoring data. Society for Risk Assessment, 2006.

Romano, M., LaMorte,W., Clapp, R., **Heiger-Bernays, W**. McClean, M., Schadt, R. "An interdisciplinary, case-based learning module for assessment, clean-up and redevelopment of a contaminated site" APHA, 2006.

APPENDIX C – Bibliography

The listings below represent the resources reviewed by the project team specific to this contract. These are listed under four categories:

- *A – Peer-Reviewed Literature*
- *B – Policy, Reviews, Legislation and Guidelines written by (or on behalf of) Governmental Organizations*
- *C – Non-peer reviewed literature written by (or on behalf of) Non-Governmental Organizations and Individuals*
- *D – Project Specific Reports*

A – Peer-Reviewed Literature

Aitken, M. (2010). Why we still don't understand the social aspects of wind power: A critique of key assumptions within the literature. *Energy Policy*, 38(4), 1834-1841.

Bakker, R.H., Pedersen, E., van den Berg, G.P., Stewart, R.E., Lok, W., Bouma, J. (2012). Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. *Science of the Total Environment*. Article in press.

Bly, S., Michaud, D., Keith, S., Alleyne, C., McClymont-Peace, D. (2004). National Guidelines for Environmental Assessment: Health Impacts of Noise. *Canadian Acoustics - Acoustique Canadienne*. 32(3): 38-39

Breukers, S., & Wolsink, M. (2007). Wind power implementation in changing institutional landscapes: An international comparison. *Energy Policy*, 35(5), 2737-2750.

Devine-Wright, P. (2005). Beyond NIMBYism: Towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy*, 8, 125-139.

Harrison, J.P. (2011). Wind Turbine Noise. *Bulletin of Science, Technology and Society*, 31 (4), 256-261.

Havas, M., Colling, D. (2011). Wind Turbines Make Waves: Why Some Residents Near Wind Turbines Become Ill. *Bulletin of Science, Technology and Society*, 31 (5), 414-426.

Horner, B., Jeffrey, R.D., and Krough, C. (2011). Literature Reviews on Wind Turbines and Health: Are They Enough? *Bulletin of Science, Technology and Society*, 31 (5), 399-413.

Janssen, Vos, Eisses, Pedersen, (2011). Exposure-response for wind turbine noise *Journal of Acoustic Society of America*. 130 (6): 3746-3753.

Keith, S.E., Michaud, D.S., Bly, S.H.P. (2008). A proposal for evaluating the potential health effects of wind turbines noise for projects under the Canadian Environmental Assessment Act. *Journal of Low Frequency Noise, Vibration and Active Control*. 27(4), 253-265.

Knopper, L.D. & Ollson, C.A. (2011). Health effects and wind turbines: a review of the literature. *Environmental Health*. 10(78), 1-10.

McMurty, R.Y. (2011). Toward a Case Definition of Adverse Health Effects in the Environs of Industrial Wind Turbines: Facilitating a Clinical Diagnosis. *Bulletin of Science, Technology and Society*, 31 (4), 316-320.

Michaud, D.S., Bly, S.H.P, Keith, S.E. (2008). Using a change in percent highly annoyed with noise as a potential health effect measure for projects under the Canadian Environmental Assessment Act. *Canadian Acoustics*. 36(2), 13-28.

Michaud, D.S., Keith, S.E., McMurchy, D. (2005). Noise annoyance in Canada. Noise & Health. 7(27), 39-47.

Oerlemansa,S., Sijtsmaa, P., Méndez López, B. (2007). Location and quantification of noise sources on a wind turbine. *Journal of Sound and Vibration*, 299, 869–883.

O'Neal, R.D, Hellweg, R.D., Jr., Lampeter, R.M. (2011, March). Low frequency noise and infrasound from wind turbines. *Noise Control Engineering Journal*. 59(2), 135-57.

Pedersen, E., Persson Waye, K. (2004).Perception and annoyance due to wind turbine noise: a dose-response relationship. *Journal of the Acoustical Society of America*. 116 (6), 3460–3470.

Pedersen, E., Persson Waye, K. (2007). Wind turbine noise, annoyance and self-reported health and wellbeing in different living environments. *Occupational and Environmental Medicine*. 64, 480–486.

Pedersen, E., van den Berg, F., Bakker, R., Bouma,J. (2009). Response to noise from modern wind farms in the Netherlands. *Journal of the Acoustical Society of America*. 126 (2), 634–643.

Pedersen, E., van den Berg, F., Bakker, R., Bouma, J. (2010). Can road traffic mask sound from wind turbines? Response to wind turbine sound at different levels of road traffic sound. *Energy Policy*. 38, 2520-2527.

Phillips, C. (2011). Properly Interpreting the Epidemiological Evidence about the Health Effects of Industrial Wind Turbines on Nearby Residents. *Bulletin of Science, Technology and Society*, 31 (4), 303-315.

Rand, R.W., Ambrose, S.E., Krogh, C. (2011). Occupational Health and Industrial Wind Turbines: A Case Study. *Bulletin of Science, Technology and Society*, 31 (5), 359-362.

Salt, A.N., Hullar, T.E. (2010). Responses of the ear to low frequency sounds, infrasound and wind turbines. *Hearing Research*. 268, 12-21.

Salt, A.N. & Kaltenbach, J.A. (2011). Infrasound from Wind Turbines Could Affect Humans. *Bulletin of Science, Technology and Society*, 31 (4), 296-302.

Shepard, D. & Billington, R. (2011). Mitigating the Acoustic Impacts of Modern Technologies: Acoustics, Health and Psychosocial Factors Influencing Wind Farm Placement. *Bulletin of Science, Technology and Society*, 31 (5), 389-398.

Shepherd, D., McBride, D., Welch, D., Dirks, K.N., Hill, E.M. (2011). Evaluating the impact of wind turbine noise on health-related quality of life. *Noise & Health*. 13(54), 333-339.

Smedley, ARD., Webb, A.R. & Wilkins, A.J. (2010). Potential of wind turbines to elicit seizures under various meteorological conditions. *Epilepsia*. 51 (7), 1146–1151.

Stevenson, R. (2009). Discourse, power, and energy conflicts: Understanding Welsh renewable energy planning policy. *Environment and Planning C: Government and Policy*. 27, 512-526.

van der Burg, G.P. (2004). Effects of .the wind profile at night on wind turbine sound. *Journal of Sound and Vibration*. 277, 955-970.

Verheijen E, Jabben J, Schreurs E, Smith KB. Impact of wind turbine noise in The Netherlands. (2011). *Noise & Health*. 13:459-463

B – Policy, Reviews, Legislation and Guidelines written by (or on behalf of) Governmental Organizations

Provincial (Nova Scotia, Ontario and Alberta)

Chief Medical Officer of Health. (May 2010). The Potential Health Impact of Wind Turbines. Province of Ontario.

Energy Resources Conservation Board. (February 16, 2007). Directive 038: Noise Control. Alberta Energy and Utilities Board.

HGC Engineering. (December 10, 2010). Low Frequency Noise and Infrasound Associated with Wind Turbines Generator Systems: A Literature Review. Ontario Ministry of the Environment RFP No. OSS-078696.

Jacques Whitford. (January 28, 2008). Model Wind Turbine By-Laws and Best Practices for Nova Scotia Municipalities. Prepared for Union of Nova Scotia Municipalities.

Nova Scotia Environment. (May 2007; Updated January 2012). Proponent's Guide to Wind Power Projects: Guide for preparing an Environmental Assessment Registration Document.

Nova Scotia Department of Energy. (March 11, 2009). Renewable Energy – Wind Turbine Noise. Accessed on April 5, 2012 from http://www.gov.ns.ca/energy/renewables/publiceducation/wind/turbine-noise.asp

Nova Scotia Department of Energy. (August 2011). Nova Scotia Community Feed-in-Tariff Guide.

Nova Scotia Department of Energy. (February 27, 2012). Approved ComFIT Project Status. https://nsrenewables.ca:44309/approved-comfit-projects-status

Nova Scotia Environment and Labour. (April 1990). Guidelines for Environmental Noise Measurement and Assessment. Currently Under Review.

Ontario Ministry of the Environment. (2008). Compliance Protocol for Wind Turbine Noise. Guideline for Acoustic Assessment and Measurement. www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_088931.pdf

Ontario Government. (June 9, 2009). Backgrounder: Wind Turbines – Proposed Requirements and Setbacks. Accessed on April 5, 2012 from http://news.ontario.ca/ene/en/2009/06/backgrounder-wind-turbines---proposed-requirements-and-setbacks.html

Ontario Government. (2010). Renewable Energy Approvals. Technical Bulletin Six – Required Setbacks for Wind Turbines as part of an application under O.Reg.359/09. http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2010/Bulletin6.pdf

Pembina Institute and Ecology Acion Centre. (April 2011). Wind Energy in Nova Scotia: A guide for landowners and communities. Prepared for Nova Scotia Department of Energy. https://nsrenewables.ca:44309/sites/default/files/pdfs/wind_energy_guide.pdf

Province of Nova Scotia. (N.S. Reg. 277/2009). Environmental Assessment Regulations made under Section 49 of the Environment Act S.N.S. 1994-95, c. 1.

Province of Nova Scotia. (1998; last amended 2010). Municipal Government Act. http://nslegislature.ca/legc/statutes/muncpgov.htm

Province of Nova Scotia. (1996). Occupational Health and Safety Act. c. 7, s. 1.

Province of Nova Scotia. (N.S. Reg. 59/95). Emergency Spill Regulations. made under Sections 74, 136, and 171 of the Environment Act. S.N.S. 1994-95, c. 1.

Province of Ontario. (O.Reg. 231/11). Environmental Protection Act. Ontario Regulation 359/09. Renewable Energy Approvals under Part V.0.1 of the Act.

Sandford, S. (April 12, 2012). Presentation to Planning Advisory Committee on behalf of Nova Scotia Environment. Municipality of the County of Kings.

Stantec Consulting. (May 2011).Health Effects and Wind Turbines: A Review for Renewable Energy Approval (REA) Applications submitted Under Ontario Regulation 359/09

Health Canada

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Other Jurisdictions

Alberts, J. (October 2006). Primer for Addressing Wind Turbine Noise. Lawrence Technical University.

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

California Public Utilities Commission. (ND). http://www.cpuc.ca.gov/environment/info/esa/divest-pge-one/newfigs/pge10_1.gif

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Ellenbogen, J.M., Grace, S., Heiger-Bernays, W. J., Manwell, J.F., Mills, D. A., Sullivan, K.A., Weisskopf, M.G. (January 2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.

McFadden, J.D. (May 17, 2010). Wind Turbines: A Brief Health Overview. Presentation to Wisconsin Wind Siting Council.

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Oregon Health Authority. (January 3, 2012). Strategic Health Impact Assessment on Wind Energy Developments in Oregon. Public Comment Release. Prepared by Health Impact Assessment Program.

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Nova Scotian Municipalities

Institute for Planning and Design. (March 2010). Integrated Community Sustainability Plan. Phase II Report. http://www.county.kings.ns.ca/upload/All_Uploads/BulletinBoard/General/Kings%20County%20ICSP-Phase%202%20Final%20Report.pdf

Municipality of the County of Antigonish. (June 2009). Municipal Planning Strategy for the County of Antigonish. Concerning the Regulations of Wind Turbine Development.

Municipality of the County of Antigonish. (June 2009). Land Use By-law for the County of Antigonish. Concerning the Regulations of Wind Turbine Development.

Municipality of the County of Kings. (Website). P12-01: Large-Scale Wind Turbines. http://www.county.kings.ns.ca/residents/planning/windturbines.aspx

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APPENDIX D – Annotated Resources

There are numerous resources available on potential health and safety impacts of large-scale wind turbines ranging from peer-reviewed scientific papers to self-published reports. Indeed the project team reviewed well over a hundred resources as part of this project; these are listed in the bibliography and many were directly referenced in the report. These include all material provided by Municipal staff from concerned residents, as well as research of the project team.

Primary references include recent peer-reviewed scientific publications, and secondary references include reports prepared by or on behalf of government institutions to provide a review of this literature, such as recent studies prepared for US States of Massachusetts and Oregon. Care was also taken to review other sources of literature, including opinion pieces, media articles, and reports prepared by or on behalf of those stakeholders who promote or oppose wind energy development.

No source is without bias in some form; considerations that must be made include the author(s), publisher (if applicable), funding source (if applicable), extent of evidence used, bias in evidence (e.g., self-reporting), and applicability of the case study to context of Kings County.

To assist the PAC members, Municipal Council, staff and interested residents, as well as to increase transparency in this work, the project team has prepared an overview of the resources available and a brief discussion of how evidence was considered in this work for Kings County. These annotated resources are grouped under the headings used in the bibliography (Appendix C).

A – Peer-Reviewed Literature

Over two dozen peer-reviewed papers were reviewed with publishing dates ranging from 2004 to 2012 though many were published in 2011. While research is ongoing, there are good data on many aspects of potential impacts to health and safety; especially related to audible noise. Three of these papers were authored by Health Canada scientists (Bly et al, 2004; Keith et al, 2008; Michaud et al, 2008); these informed the scientific basis for the expert advice provided by Health Canada with respect to noise. The most cited author is Eja Pedersen, a Swedish researcher who completed numerous studies with her team in the past decade on audible noise from wind turbines including dose-response relationships with annoyance, as well as influence of perception, comparison with other noise sources and masking of noise from wind turbines. Papers were also cited on infrasound (e.g., Salt et al, 2010 and 2011) and shadow flicker (Smedley et al, 2010); there were no peer-reviewed articles found on ice throw or structural failure. There are several other papers that are individual reports; many are based on self-reporting or a limited data set or review a case study that has numerous large-scale wind turbines sited very close to residences; published in the Bulletin of Science, Technology & Society, yet these papers also informed our report and recommendations.

B – Policy, Reviews, Legislation and Guidelines written by (or on behalf of) Governmental Organizations

Provincial (Nova Scotia, Ontario and Alberta)

The noise and/or wind turbine regulations were reviewed in Ontario and Alberta as these two provinces were known for robust legislative frameworks. Ontario in particular has commissioned several studies which were reviewed, as well as government produced technical information to support understanding of the setback approach included in their regulations. Alberta's Directive 038 was also reviewed for context of its approach to approvals from a consideration of audible noise.

Though Nova Scotia does not have noise regulations, there are guidelines for environmental noise that are under review. Further other regulatory aspects of Nova Scotia were reviewed to support the broad scoping of possible health and safety risks in Chapter 3. In addition, some of the wind energy background documents produced by the Nova Scotia Department of Energy and Nova Scotia Environment were reviewed for context.

Health Canada

Several Health Canada publications were reviewed and cited in the report. Health Canada's framework for assessing health risks formed the foundational approach of this work. As the two key government reviews cited were from the United States (Massachusetts and Oregon), it was important that the review of health risks be placed in context of Canada, including the definition of health and annoyance. These official publications were also augmented by the peer-reviewed articles by Health Canada's scientists.

Other Jurisdictions

Ten resources from other governmental jurisdictions were reviewed ranging from US states to Australia. The Health Impact Assessment on Wind Energy Developments in Oregon and the Wind Turbine Health Impact Study Report of Independent Expert Panel as prepared for Massachusetts were both published in January 2012. These were recent and robust reviews of existing research on health impacts from large-scale turbines; accordingly, the results were cited in this report yet they were augmented to form recommendations suitable to the context of Kings County.

Nova Scotian Municipalities

Reports and planning documents of the Municipality of the County of Kings were reviewed within the scope of this project only (i.e., health effects). For a Nova Scotian context outside of Kings County, other bylaws and municipal planning strategies were reviewed (e.g., the compilation completed by Union of Nova Scotia Municipalities), especially Antigonish County which has a 40dBA requirement or not above baseline and a minimum separation distance of 1000km for large-scale wind turbines; while this project's scope was not a planning exercise, the project team did want to place our recommendations in context of other municipal planning in Nova Scotia for large-scale wind turbines.

C – Non-peer reviewed literature written by (or on behalf of) Non-Governmental Organizations and Individuals

Over fifty non-peer-reviewed references were reviewed as part of this project. These include reports prepared by wind industry organizations to those reports prepared by opponents of wind energy; however, many are prepared with an intention of balance. For all sources, many of these reports remain valuable when the data are reviewed independently from an objective perspective; this was the attempt of the project team.

Of specific interest in this category are the document cited by the World Health Organization (WHO), i.e., Nighttime Noise Guidelines in Europe (2009) and Guidelines for Community Noise (1999). Also standards by the Canadian Standards Association, International Standards Organization, and the International Electrical Commission are listed; these are often cited to guide the use of predictive modeling for audible noise from a proposed wind energy project.

Letters, concerns and complaints submitted to the Municipality of Kings by residents and others on behalf of the residents were compiled and reviewed. These, coupled with the comments and concerns heard by the project team at the PAC meeting on April 23, 2012 were seriously considered with the body of evidence in the project team's recommendations.

D – Project Specific Reports

To place some of the research in context, two projects with large-scale turbines were referenced in the report. While some project documents were reviewed, the report did not attempt to present a case study for each project but rather to cite projects where we have a greater understanding of the impacts. Both of these projects have separation distances smaller than recommended in this report and very different characteristics than Kings County; yet they provide helpful context as to when and why negative impacts have occurred on some past wind energy projects.

Falmouth, MA

The Town of Falmouth, Massachusetts commissioned two large-scale turbines in recent years; these have been reviewed in detail with limited noise measurements (taken at a nearby home) and a review of mitigation options due to complaints from nearby residents, especially two residences within 400m of one turbine, as well as recent measurements by the State that confirmed non-compliance at nearby residences for nighttime noise levels greater than 10dBA over baseline.

Pubnico, NS

For a local context, there is a larger wind energy project in Pubnico, NS (seventeen turbines) which was approved by Nova Scotia Environment in 2003. This project was further studied and monitored for sound and vibration due to complaints of a nearby resident who was within 400m of the nearest turbine.