Stantec

Memo

To:	Brooke Barnes Stantec Consulting Ltd. Topsham, ME	From:	Theo Kindermans Stantec Planning and landscape Architecture PC Boston, MA
File:	Hancock Wind Project	Date:	June 20, 2014

Reference: Shadow-Flicker Modeling
Hancock Wind Project, Hancock County, Maine

Introduction

This memorandum provides a brief explanation of the shadow-flicker phenomenon, the modeling approach employed for an amendment to the Hancock Wind Project in Hancock County, ME and relevant explanations and results. The site layout was provided by Stantec Consulting Ltd. located in Topsham, ME. The layout shows a total of 17 turbine locations, one less than the original layout. For modeling purposes, all 17 turbines are presumed to be Vestas V117, with a 116.5 meter high hub and a 117 meter diameter rotor, and a total maximum height of approximately 175 meters.

Shadow-Flicker Background

Shadow-flicker from wind turbines results from brief reductions in light intensities caused by the rotating blades of the turbine casting shadows on receptors on the ground and stationary objects, such as a window at a residence. When the sun is obscured by clouds or storms, or when the turbine is not operating, no shadows will be cast.

Shadow-flicker can occur on project area receptors when the wind turbine is located near the receptor and when the turbine blades interfere with the angle of the sunlight. The most typical effect is the visibility of an intermittent light reduction on the receptor facing the wind turbine and subject to the shadow-flicker. Obstacles such as terrain, trees, or buildings between the wind turbine and a potential shadow-flicker receptor significantly reduce or eliminate shadow-flicker effects. No shadow flicker is present when the rotor of the turbine is perpendicular to the receptor.

Shadow flicker intensity is defined as the difference in brightness at a given location in the presence and absence of a shadow. Shadow flicker intensities diminish with increased distance from turbine to receptor and with lower visibility weather or atmospheric conditions such as haze or fog. Closer to a turbine the shadow will appear to be darker and wider as the rotors will block out a larger portion of sunrays. The shadow line will also be more defined. Further from the turbine the shadow will be less intense or lighter, and less distinct.

The spatial relationship between a wind turbine and a receptor, as well as wind direction are key factors related to the amount of time any location might experience shadow-flicker. Shadow-flicker time is most commonly expressed in hours per year. Shadow flicker is most pronounced at distances from the turbine of less than 1000 feet and during sunrise and sunset when the sun's angle is lower and the resulting shadows are longer. Shadow flicker is typically present at a receptor for short periods each day – rarely more than a half-hour at sunrise and at sunset. The phenomenon is more prevalent in the winter than the summer due to the sun's lower position on the horizon in winter months in North America (NAS, 2007).

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The analysis provided in this report does not evaluate the flicker intensity, but rather focuses on the total amount of time (hours and minutes per year) that shadow flicker can potentially occur at receptors regardless if the shadow flicker is barely noticeable or clearly distinct. As a result, it is likely that receptors will experience less shadow-flicker impact than modeled and reported, especially those that are further away from the turbines. It is likely that marginally affected receptors may not be able to identify shadow-flicker at all as the shadows become more diffuse with increased distance.

The speed of the rotor and the number of blades determine the frequency of the flicker of the shadow. The shadow-flicker results in this memo are based on the two turbine configurations described above. The maximum rotor speed of 16 RPM translates to a blade frequency of .8 Hz (less than 1 alternation per second, or one light interruption every 1.25 seconds).

Modeling Approach

For the shadow flicker modeling a module of the WindPRO software was used. The computer model simulates the path of the sun over the course of the year and assesses at regular intervals the potential shadow flicker across a receptor. The color coded map produced by the computer model is a conservative estimate of the number of hours per year that shadows could be cast by the rotation of the turbine blades. This report presents a flicker analysis for meteorologically adjusted conditions.

The shadow-flicker model uses the following inputs:

- Turbine locations
- Turbine hub height
- Turbine rotor diameter
- Shadow flicker receptor (residence or camp) locations (coordinates)
- USGS 1:24,000 topographic and USGS DEM (height contours)

In addition, we used data that is reflective of typical conditions at the Hancock Wind Project. The data used is local meteorological information on wind speed and direction, and cloud cover. The data came from the following sources:

- Wind speeds and direction frequency distributions were acquired from the on-site meteorological towers
- Sunshine hours, the time between sunrise and sundown for the area, was obtained from monthly reference data for the annual number of sunny or partly sunny days experienced at the airport in Portland, ME (the closest reporting station for cloudiness data for the National Oceanic and Atmospheric Administration, NOAA)

The turbine run-time and direction (seen from the receptor) are calculated from the site's long-term wind speed and direction distribution, while the actual sunshine hours add the probability of sunshine during any given period. This calculation reflects the expected shadow-flicker time.

The model calculates detailed shadow flicker results at each assessed receptor location and the amount of shadow-flicker (hours and minutes per year) everywhere surrounding the project. A

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receptor in the model is defined as a 1 square meter area that is 1 meter above ground level, approximating a window. This omni-directional approach produces shadow-flicker results at a receptor regardless of the direction of windows and provides similar results as a model with windows on various sides of the receptor.

Output from the model includes the following information:

- Calculated shadow-flicker time at selected receptors,
- Tabulated and plotted time of day with shadow flicker at receptors,
- Tabulated time of impact from each turbine at a receptor, and
- Map showing turbine locations, selected shadow-flicker receptors and color-coded contour lines indicating projected shadow-flicker time (hours per year).

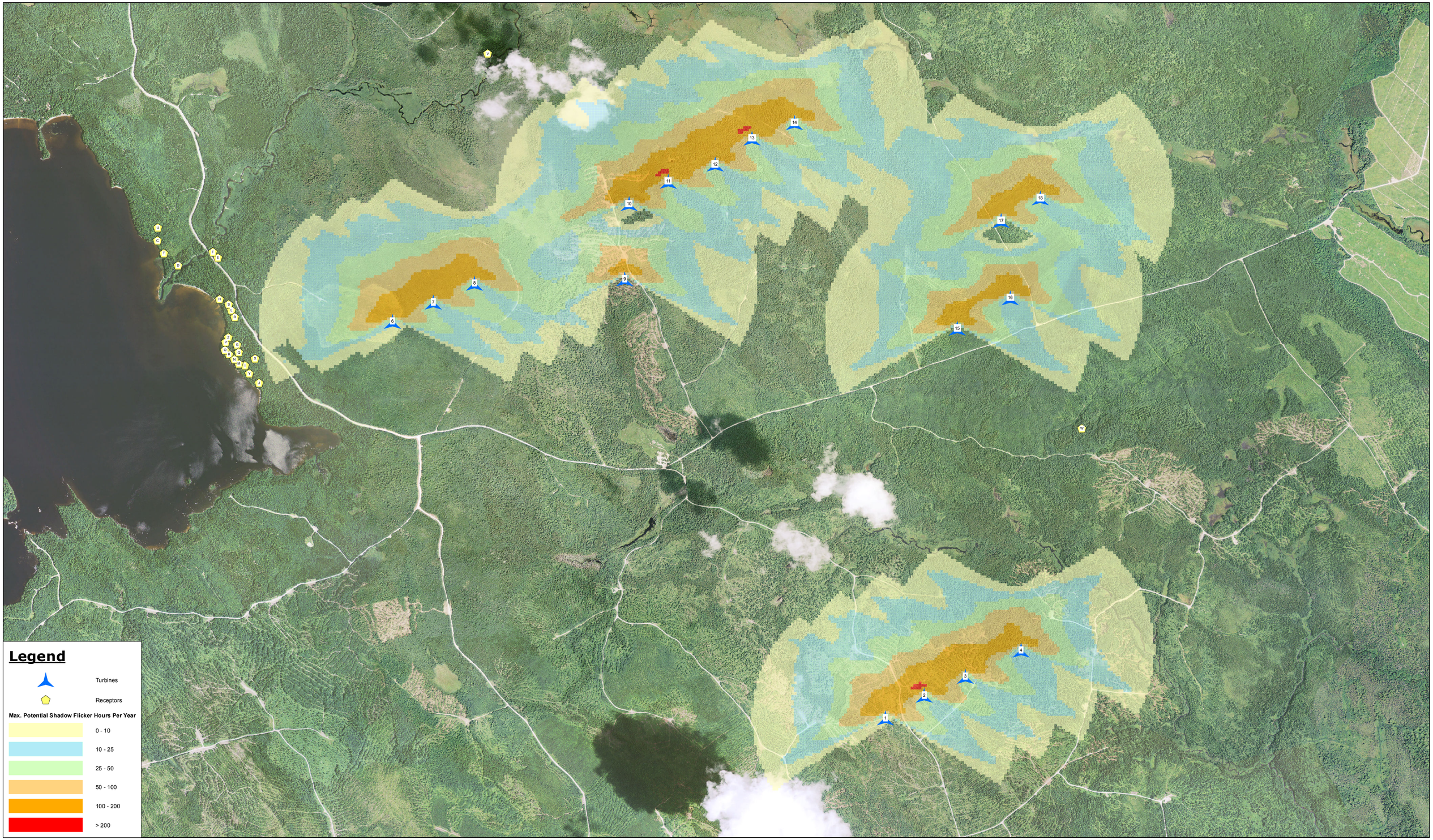
The analysis assumes that windows are situated in direct alignment with the turbine-to-sun line of sight. Even when windows are so aligned, the analysis does not account for the difference between windows in rooms with primary use and enjoyment (e.g. living rooms) and other less frequently occupied or un-occupied rooms or garages.

Analysis and Conclusion

As previously stated, the shadow-flicker model assumptions applied to this project are very conservative and as such results are expected to over-predict the impacts. Additionally, many of the modeled shadow flicker hours are expected to be of very low intensity. The modeling demonstrated that the number of receptors potentially impacted by shadow flicker would be reduced to zero under the amended configuration.

Furthermore, the area between the receptor sites and the turbines is heavily wooded. It is my opinion that shadow flicker will not pose an adverse impact on the receptors identified in this report. For clarifications and more detailed analysis of expected influence at selected receptors, please do not hesitate to contact me.

Attachment: Shadow Flicker Maps



Hancock Wind Project - Vestas V117 3.3 MW
Hancock County, Maine

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Stantec
Planning and Landscape Architecture, PC
226 Causeway Street
Boston, MA 02114

Meteorological Adjusted Shadow Flicker Study

June 2014

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