Shadow Flicker Assessment

For the

West Bay Wind Project



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1.0 Introduction

The proposed West Bay Wind Project is located approximately 7 km northwest of Parrsboro and 2 km west of Lake Road Corner in Cumberland County, Nova Scotia. The proposed project will consist of 25 turbines with a proposed hub height of 125 m and a rotor diameter of 163 m.

The rotating blades of a wind turbine create moving shadows known as shadow flicker that are noticeable in close proximity to the turbine. The potential impact depends on the time of year, the physical characteristics of the wind turbine, the orientation of the blades relative to the sun, the presence of wind and of course, the presence of sunlight.

The following report summarizes the results of a shadow flicker assessment which will be incorporated into the Nova Scotia Environmental Assessment Registration document for the project.

2.0 Methodology

2.1 Shadow Flicker Analysis

The shadow flicker analysis was completed using WindPRO 4.2.316 which provides a comprehensive suite of wind farm design and modeling software. The locations of the 25 proposed turbines are summarized in Table 1 and the turbine specific parameters in Table 2.

The shadow flicker analysis was based on developing a theoretical or worst-case, scenario and a realistic scenario that provides an understanding of the extent of shadow flicker as a result of the existing and proposed turbines.

2.2 Digital Elevation Model

A digital elevation model (DEM) that was derived from aerial Light Detection and Ranging (LiDAR) data was used to model the sound and attenuation in this analysis. The original DEM was resampled from 1 m to 4 m resolution to minimize the file size for the project and adjacent areas.

Table 1: Proposed Turbine Locations.

Id	Model	Easting (m)*	Northing (m)*
1	N163 5.X 5900	389,824	5,037,439
2	N163 5.X 5900	390,254	5,035,657
3	N163 5.X 5900	388,993	5,036,838
4	N163 5.X 5900	390,963	5,037,972
5	N163 5.X 5900	389,662	5,034,023
6	N163 5.X 5900	389,389	5,036,227
7	N163 5.X 5900	392,444	5,035,837
8	N163 5.X 5900	388,858	5,035,623
9	N163 5.X 5900	390,944	5,037,197
10	N163 5.X 5900	392,159	5,034,855
11	N163 5.X 5900	391,124	5,033,995
12	N163 5.X 5900	388,533	5,038,014
13	N163 5.X 5900	391,164	5,035,579
14	N163 5.X 5900	393,488	5,036,134
15	N163 5.X 5900	389,608	5,038,173
16	N163 5.X 5900	391,326	5,036,567
17	N163 5.X 5900	392,709	5,036,995
18	N163 5.X 5900	388,173	5,039,418
19	N163 5.X 5900	388,782	5,037,441
20	N163 5.X 5900	389,709	5,034,998
21	N163 5.X 5900	392,028	5,037,758
22	N163 5.X 5900	388,040	5,038,589
23	N163 5.X 5900	390,944	5,034,653
24	N163 5.X 5900	387,824	5,037,976
25	N163 5.X 5900	388,134	5,036,353

* UTM, NAD83(CSRS), Zone 20

Table 2: Proposed Turbine Specifications

Item	Specification
Manufacturer	Nordex
Model	N163 6.X 5900
Hub Height	125 m
Rotor Diameter	163 m
Operation Mode	Full Power
Rated Power Output	5,900 kW

2.3 Theoretical (Worst) Case

In this highly conservative scenario, existing shadowing objects such as forests, trees and out buildings were not included in the analysis. This scenario provides an understanding of the maximum amount of shadow flicker that could theoretically be experienced at the modeled receptors under the following conditions:

- The sun shines 100% of the time when it is above the horizon;
- The turbine rotor is always perpendicular to the sun;
- Shadow flicker starts as the sun moves above 3 degrees from the horizon;
- The shadows dissipate at a maximum distance from the blade as a result of atmospheric conditions and light diffusion, and;
- The rotor blades are always spinning.

The total length of the shadow influence in the atmosphere is calculated from the physical dimensions of the turbine blade. In this analysis, the maximum shadow distance for the N163 6.X 5900 kW was calculated to be 1,788 m. This scenario represents conditions that will not be experienced in the real world with continuous sunshine, constant operation of the turbines, no obstacles or trees and turbine rotors are always located between the sun and the receptor window.

2.4 Realistic Case

The realistic case was modeled by incorporating local monthly sunshine probabilities into the analysis. As with the theoretical case, shadowing objects were not included in the model; therefore there still is some conservatism with this case as the model does not provide an accurate representation of the forests and outbuildings within the study area.

Statistical climate data in the form of average sunshine probabilities per month were obtained from the closest, representative weather station (that records sunshine data).

2.5 Climate Data

Monthly sunshine data were used to provide a realistic condition for calculating shadow flicker. The realistic scenario was modeled using site specific wind conditions and monthly sunshine probabilities obtained from the closest observatory at Kentville, Nova Scotia. The monthly daily sunshine hours used in the analysis are shown in Table 3.

Table 3: Monthly Average Sunshine Hours for Kentville, Nova Scotia.

Month	Jan	Feb	Mar	Aproil	May	June	July	Aug	Sept	Oct	Nov	Dec
Average Daily Sunshine Hours	2.53	3.50	4.28	4.96	6.33	7.24	7.51	7.27	5.85	4.44	2.81	1.86

2.6 Shadow Receptors

The spatial location of all the permanent and seasonal receptors located within 2.0 km of the proposed turbines were extracted from the Nova Scotia Topographic database. Recent satellite imagery and Aerial LiDAR point cloud data were manually reviewed and additional potential receptors were identified and included in the analysis. There are a number of buildings located within the wind farm which are situated on properties where the landowners have entered into agreements with West Bay Wind Inc. for the development and operation of the wind project. These buildings are considered to be participating receptors and therefore have been excluded from this analysis. Accordingly, the assessment results presented below focus on non-participating receptors and their compliance with applicable shadow flicker criteria.

Each non participating receptor was assumed to have windows facing in all directions. This modeling approach is referred to as ‘greenhouse mode’ and ensures that the orientation of individual receptor windows are not a factor in estimating shadow flicker. These parameters ensure that the modeling results are based on the best available data. Table 4 shows the locations of the 41 receptors used in the analysis.

Table 4: Shadow Flicker Receptor Locations

Receptor ID	Easting (m)*	Northing (m)*	Elevation (m)
A	387,585	5,032,038	140
B	387,703	5,033,184	176
C	387,584	5,033,074	173
D	391,967	5,032,848	155
E	395,320	5,036,534	23
F	394,941	5,036,606	24
G	395,067	5,035,188	42
H	387,212	5,034,114	126
I	386,490	5,037,010	133
J	387,190	5,034,126	125
K	394,803	5,037,103	26
L	395,007	5,035,356	39
M	394,813	5,037,161	27
N	395,186	5,036,144	38
O	387,049	5,036,245	112
P	395,102	5,036,262	51
Q	392,142	5,033,437	90
R	386,694	5,033,467	67
S	395,023	5,034,763	46
T	393,932	5,034,795	135
U	395,033	5,035,905	40
V	395,140	5,035,919	36
W	395,319	5,035,968	32
X	395,426	5,035,969	34
Y	395,082	5,036,451	33
Z	394,129	5,034,919	101
AA	387,333	5,034,936	149
AB	395,377	5,036,522	23
AC	395,011	5,036,530	29
AD	386,734	5,033,680	88
AE	386,745	5,033,703	89
AF	395,428	5,036,083	25
AG	393,960	5,038,450	87
AH	393,849	5,038,502	99
AI	394,257	5,037,930	31
AJ	394,278	5,037,953	30
AK	395,269	5,035,946	42
AL	395,172	5,036,102	36
AM	395,132	5,035,859	37
AN	391,409	5,032,720	177
AO	387,598	5,033,124	176

* UTM, NAD83(CSRS), Zone 20

3.0 Shadow Flicker Analysis Results and Discussion

A generally accepted guideline that originates from Europe is that shadow flicker exposure be limited to a maximum of 30 hours per year. In Nova Scotia, developers are required to demonstrate that no receptor will receive more than 30 hours per year or more than 30 minutes per day of shadow flicker.

Figure 1 shows the results of the modeling and the spatial extent of the threshold 30 shadow hours per year. Receptor specific results are provided in Table 5.

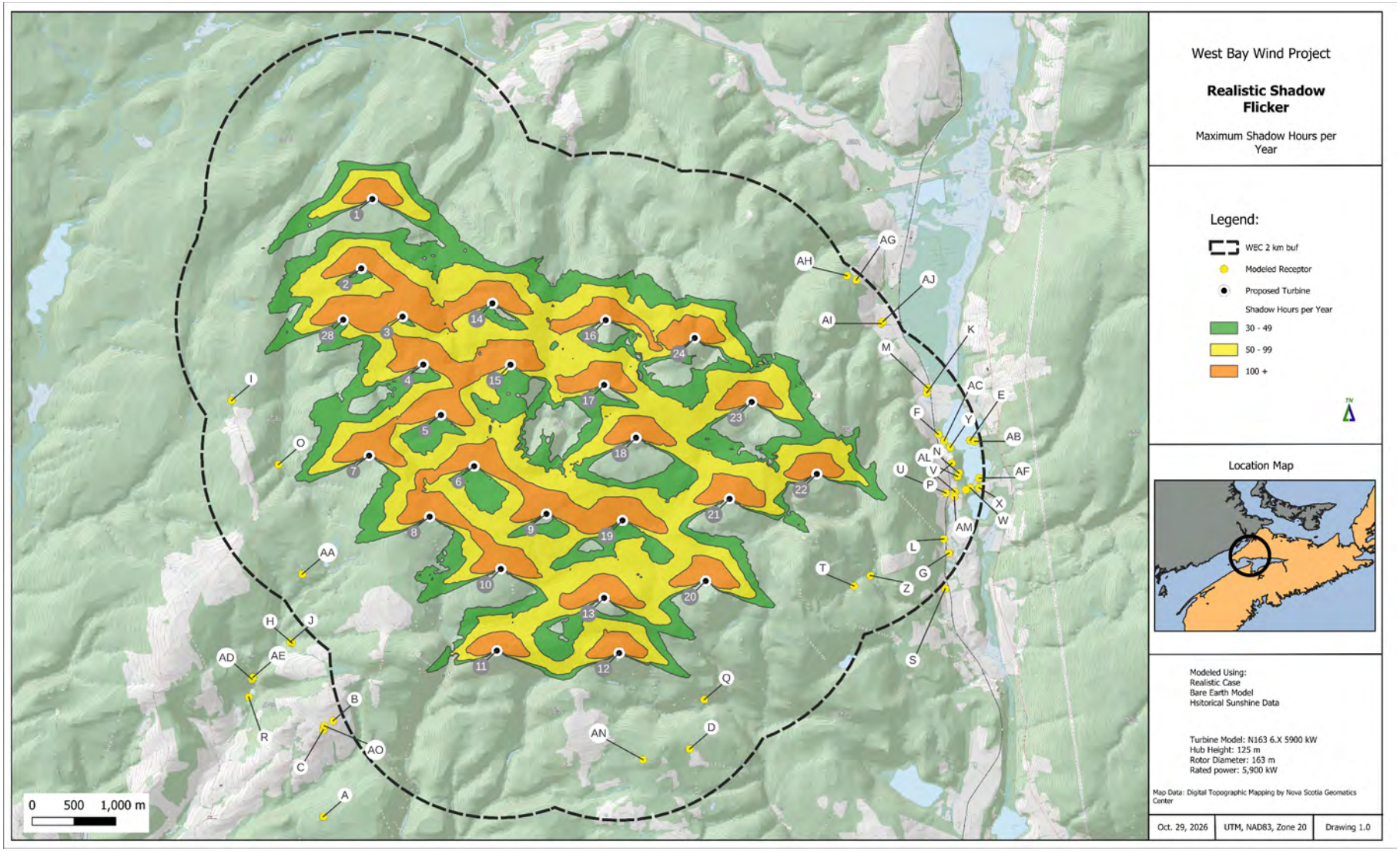


Figure 1: Shadow Flicker per Year Based on Realistic Scenario for the Proposed West Bay Wind Project.

Table 5: Predicted Shadow Flicker for Local Receptors Based on Theoretical (Worst) and Realistic Case Scenarios.

Receptor ID	Theoretical Case		Realistic Case
	Shadow Hrs/Yr	Max. Shadow Minutes per Day	Shadow Hours per Year
A	0:00	0:00	0:00
B	0:00	0:00	0:00
C	0:00	0:00	0:00
D	0:00	0:00	0:00
E	0:00	0:00	0:00
F	0:00	0:00	0:00
G	0:00	0:00	0:00
H	0:00	0:00	0:00
I	8:05	0:22	2:59
J	0:00	0:00	0:00
K	1:27	0:06	0:27
L	0:00	0:00	0:00
M	2:55	0:12	0:53
N	1:53	0:09	0:47
O	0:00	0:00	0:00
P	2:40	0:12	1:06
Q	0:00	0:00	0:00
R	0:00	0:00	0:00
S	0:00	0:00	0:00
T	0:00	0:00	0:00
U	0:00	0:00	0:00
V	0:00	0:00	0:00
W	0:00	0:00	0:00
X	0:00	0:00	0:00
Y	1:22	0:07	0:33
Z	0:00	0:00	0:00
AA	0:00	0:00	0:00
AB	0:00	0:00	0:00
AC	0:00	0:00	0:00
AD	0:00	0:00	0:00
AE	0:00	0:00	0:00
AF	0:00	0:00	0:00
AG	0:00	0:00	0:00
AH	0:00	0:00	0:00
AI	0:00	0:00	0:00
AJ	0:00	0:00	0:00
AK	0:00	0:00	0:00
AL	1:04	0:07	0:26
AM	0:00	0:00	0:00
AN	0:00	0:00	0:00
AO	0:00	0:00	0:00

* UTM, NAD83(CSRS), Zone 20

The results of the theoretical (Worst) case indicate that all of the 41 receptors are not expected to experience greater than 30 hours of shadow flicker per year or more than 30 minutes per day. The maximum shadow hours per year in the worst-case occur at receptor I which will experience 8:05 (hrs:min) per year of shadow flicker with a maximum of 22 minutes per day. This analysis is completed to obtain a baseline understanding of project impact on receptors.

The realistic case scenario provides a more comprehensive analysis as the assumptions in the theoretical case are very conservative in nature and do not represent conditions which would occur in the real world. By introducing monthly sunshine probabilities into the model, more precise annual results can be generated, however the maximum shadow flicker per day cannot be calculated. This is a result of using monthly sunshine probabilities which cannot be scaled to minute time steps. The realistic case scenario, which includes the sunshine probabilities shows that all the receptors are expected to receive less than 30 hour per year of shadow flicker (Table 5). In the realistic case, receptor I mentioned above is expected to receive 2:59 (hrs:min) of shadow flicker per year. It should be noted that the realistic case is also conservative as it does not include any obstacles or trees, assumes turbines are always operating and that receptor windows are always facing the turbine.

4.0 Conclusion

The shadow flicker analysis based on the realistic case indicate that the modeled non-participating receptors are expected to receive less than 30 hours per year of shadow flicker. The realistic values range from 0 to 2:59 (hrs:min) per year which are well below the 30 hour per year threshold value.

These modeled results indicate that the proposed wind project meets the current guidelines as defined by the Nova Scotia Department of Environment and Climate Change.

5.0 References

Nova Scotia Department of Environment and Climate Change. Environmental Assessment Supplemental Checklist: Wind Energy Projects, https://novascotia.ca/nse/ea/docs/environmental-assessment-supplemental-checklist-wind-energy-projects-en.pdf

Nova Scotia Topographic Database, https://nsgi.novascotia.ca/datalocator/indexing.html

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