

Shadow Flicker Study



Final Report
Three Waters Wind Farm
Shadow Flicker Study
Nobles and Jackson Counties, MN

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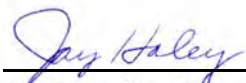

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Report Update

EAPC bears no responsibility to update this report for any changes occurring subsequent to the final issuance of this report.

Revision History

Revision No.	Revision Purpose	Date	Revised By
0	Original	7/29/2019	J. Haley
1	Incorporate Client comments	8/19/19	J. Haley
2	Updated array	9/27/2019	J. Haley

EXECUTIVE SUMMARY

EAPC was hired by Wenck Associates, Inc. (Wenck), on behalf of Three Waters Wind Farm, LLC (Three Waters), to provide estimates of the shadow flicker potential for a proposed wind turbine layout for the Three Waters Wind Energy Project (Project) in southern Minnesota.

Locations of area dwellings, a wind turbine layout and turbine technology/type were provided to EAPC by Three Waters. A windPRO model was built combining digital elevation data with the information supplied to generate a shadow flicker model for the site. The resulting model was then used to perform shadow flicker calculations for the area. Based on the shadow flicker calculation, a site-wide realistic shadow flicker map was produced and an evaluation of the shadow flicker at 343 area dwellings in Minnesota within two miles of any proposed turbine location was performed.

The 343 dwellings were represented in the model by omni-directional shadow receptors that simulate a 1 m x 1 m window 1 m above ground level. Reductions based on turbine operational time, turbine operational direction, and sunshine probabilities were used to calculate a realistic number of hours of shadow flicker to be expected at each shadow receptor. No obstacles were used so that shadow flicker reductions due to interference from trees and structures were not included, meaning that the “realistic” estimates are still conservative.

The number of occupied residences in Minnesota registering more than 30 hours per year for 114 meter hub-height turbines was 18, ranging from 30 hours to 73 hours and 33 minutes. The number of occupied residences registering more than 30 hours per year for 89 meter hub-height turbines was 13, ranging from 30 hours to 78 hours and 23 minutes. Any shadow flicker impacts over 30 hours per year will be mitigated either through curtailment of the contributing turbine(s) or by further refinement of the array.

1. INTRODUCTION

On behalf of Three Waters, Wenck hired EAPC to conduct an updated shadow flicker analysis for the potential wind turbine layout located in southern Minnesota near the town of Lake Park. The layout consists of 128-GE 2.82-127 wind turbines with either a 114 or 89 meter hub height for an up to 201 megawatt (MW) wind farm project. The hub height of 114 meters would represent worst case maximum shadow impacts. It is likely that not all turbines would be using the 114 meter hub-height towers so the results of this study based on the 114 meter hub height will be conservative. One array was analyzed (79 in Minnesota and 49 in Iowa)¹.

Coordinates for 343 dwellings in Minnesota which could potentially experience shadow flicker from the proposed wind farm were also supplied by Three Waters.

2. BACKGROUND

Shadow flicker from wind turbines occurs when rotating wind turbine blades move between the sun and the observer. Shadow flicker is generally experienced in areas near wind turbines where the distance between the observer and wind turbine blade is short enough that sunlight has not been significantly diffused by the atmosphere. When the blades rotate, this shadow creates a pulsating effect, known as shadow flicker. If the blade's shadow is passing over the window of a building, it will have the effect of increasing and decreasing the light intensity in the room at a low frequency in the range of 0.5 to 1.2 Hz, hence the term "flicker." In this case, with a maximum rotation speed of 15.7 rpm for the GE 2.82-127, the frequency would be 0.785 Hz. This flickering effect can also be experienced outdoors, but the effect is typically less intense, and becomes less intense when farther from the wind turbine causing the flicker. The moving shadow of a wind turbine blade on the ground is similar to the effect one experiences when driving on a road when there are shadows cast across the road by an adjacent row of trees.

This flickering effect is most noticeable within approximately 1,000 meters of the turbine, and becomes more and more diffused as the distance increases. There are no uniform standards defining what distance from the turbine is regarded as an acceptable limit beyond which the shadow flicker is considered to be insignificant. The same applies to the number of hours of flickering that is deemed to be acceptable.

Shadow flicker is typically greatest in the winter months when the angle of the sun is lower and casts longer shadows. The effect is also more pronounced around sunrise and sunset when the sun is near the horizon and the shadows are longer. A number of factors influence the amount of shadow flicker on the shadow receptors. One consideration is the

¹ Three Waters is seeking approval from the Minnesota Public Utilities Commission (Commission) for the entire 201 MW in Minnesota, but reserves the right to locate turbines at alternate sites within Osceola and Dickson counties, IA. This shadow flicker analysis includes review of all turbines in the Project layout in both MN (79 primary and alternate turbines) and IA (49 alternate turbines), and the impact those have on Minnesota dwellings.

environment around the shadow receptor. Obstacles such as terrain, trees or buildings between the wind turbine and the receptor can significantly reduce or eliminate shadow flicker effects. Deciduous trees may block the shadow flickering effect to some degree, depending on the tree density, species present and time of year. Deciduous trees can lead to a reduction of shadow flicker during the summer when the trees are bearing leaves. However, during the winter months, these trees are without their leaves and their impact on shadow flicker is not as significant. Coniferous trees tend to provide mitigation from shadow flicker year round. For this study, no credit was taken for any potential shading effects from any type of trees or other obstacles that would reduce the number of shadow flickering hours at the structures.

Another consideration is the time of day when shadow flicker occurs. For example, it may be more acceptable for private homes to experience the shadow flickering during daytime hours when family members may be at work or school. Likewise, a commercial property would not be significantly affected if all the shadow flicker impact occurred before or after business hours.

The climate also needs be considered when assessing shadow flicker. In areas with a significant amount of overcast weather, there would be less shadow flicker, as there are no shadows if the sun is blocked by clouds. Also, if the wind is not blowing, the turbines would not be operational and, therefore, not creating shadow flickering.

3. STUDY METHODOLOGY

This shadow flicker analysis was performed utilizing windPRO², a sophisticated wind modeling software program. windPRO has the ability to calculate detailed shadow flicker maps across an entire area of interest or at site-specific locations using shadow receptors.

Shadow maps which indicate where the shadows will be cast and for how long, are generated using windPRO, calculating the shadow flicker in varying user-defined resolutions. Standard resolution was used for this study and represents shadow flicker being calculated every three minutes of every day over the period of an entire year over a grid with a 20 m by 20 m resolution.

In addition to generating a shadow flicker map, the amount of shadow flicker that may occur at a specific point can be calculated more precisely by placing a shadow receptor at the location of interest and essentially “recording” the shadow flicker that occurs as the relative sunrise to sunset motion of the sun is simulated throughout an entire year.

The point-specific shadow flicker calculation is run at a higher resolution as compared to the shadow flicker map calculation to include the highest precision possible within windPRO. Shadow flicker at each shadow receptor location is calculated every minute of

² windPRO is the world’s leading software tool for wind farm design including shadow flicker analysis.

every day for an entire year. Shadow receptors can be configured to represent an omnidirectional window of a specific size at a specific point (greenhouse mode) or a window facing a single direction of a specific size at a specific point (single direction mode). The shadow receptors used in this analysis were configured as greenhouse-mode receptors representing a 1 m x 1 m window located 1 m above ground level. This represents more of a “worst-case” scenario and thus will produce more conservative results.

As a part of the calculation method, windPRO must determine whether or not a turbine will be visible at the receptor locations and not blocked by local topography or obstacles. It does this by performing a preliminary Zones of Visual Influence (ZVI) calculation, utilizing 10 m grid spacing. If a particular turbine is not visible within the 10 m x 10 m area that the shadow receptor is contained within, then that turbine is not included in the shadow flicker calculation for that receptor.

Any shadow flicker contributions from turbines (with no distance limit) are added to the total for each receptor. Shadow flicker is assumed to dissipate over distance assuming that no flicker is noticeable when there is less than 20% of the sun being covered by a blade. The percentage of blade coverage decreases as the distance between the turbine and the point of observation increases. For the GE 2.82-127, the shadow flicker will become imperceptible at approximately 1,700 feet from the turbine.

The inputs for the windPRO shadow flicker calculation include the following:

- Turbine Coordinates
- Turbine Specifications
- Shadow Receptor Coordinates
- Monthly Sunshine Probabilities
- Joint Wind Speed and Direction Frequency Distribution
- USGS Digital Elevation Model (DEM) (height contour data)
- Existing Turbines

A description of each input variable and how they affect the shadow flicker calculation are included below.

Turbine Coordinates: The location of a wind turbine in relation to a shadow receptor is one of the most important factors in determining shadow flicker impacts. A line-of-site is required for shadow flicker to occur. The intensity of the shadow flicker is dependent upon the distance from the wind turbine and weather conditions.

Turbine Specifications: A wind turbine’s total height and rotor diameter will be included in the windPRO shadow flicker model. The taller the wind turbine, the more likely shadow flicker could have an impact on local shadow receptors as the ability to clear obstacles (such as hills or trees) is greater, although in this analysis, no credit is taken for any such blockage from trees. The larger the rotor diameter is, the wider the area where shadows

will be cast. Also included with the turbine specifications are the cut-in and cut-out wind speeds within which the wind turbine is operational. If the wind speed is below the cut-in threshold or above the cut-out threshold, the turbine rotor will not be spinning and thus shadow flicker will not occur. The specifications for the GE 2.82-127 wind turbine model used in this study are included in Table 1 below.

Table 1: Three Waters Wind Turbine Specifications

Three Waters - Shadow Modeled Turbine Specifications					
Manufacturer	Model	Hub Heights (m)	Rotor Diameter (m)	Cut-In Wind Speed (m/s)	Cut-Out Wind Speed (m/s)
General Electric	GE 2.82-127	114 & 89	127	3	30

Shadow Receptor Coordinates: As with the wind turbine coordinates, the elevation, distance and orientation of a shadow receptor in relation to the wind turbines and the sun are the main factors in determining the impact of shadow flicker. EAPC was provided with coordinates for 343 structures found to be located within two miles of the Project Boundary in Minnesota, including the 79 wind turbine locations in MN (primary and alternate turbines) and 49 wind turbine locations in IA (alternate turbines).

Monthly Sunshine Probabilities: windPRO calculates sunrise and sunset times to determine the total annual hours of daylight for the modeled area. To further refine the shadow flicker calculations, the monthly probability of sunshine is included to account for cloud cover. The greater the probability of cloud cover, the less of an impact from shadow flicker. The monthly sunshine probabilities for many of the larger cities across the United States are available from the National Climatic Data Center (NCDC). For this study, 4 years' worth of monthly sunshine probability data were retrieved for Sioux Falls, SD, which was the closest, most representative station, to create the long-term representative monthly sunshine probabilities. The long-term representative monthly average sunshine probabilities are presented in Table 2.

Table 2: Sioux Falls, SD Monthly Sunshine Probabilities

Sioux Falls, SD Monthly Sunshine Probabilities (2006-2009)												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sunshine %	53%	59%	46%	54%	55%	58%	71%	61%	59%	57%	49%	55%
retrieved from: http://www1.ncdc.noaa.gov/pub/data/ccd-data/pctpos15.dat												

Joint Wind Speed and Direction Frequency Distribution: A set of long-term corrected wind distributions generated from an on-site meteorological mast was provided by the client to represent the annual wind speed and direction distribution for the Project site. This data was used to estimate the probable number of operational hours for the wind turbines from each of the 12 wind direction sectors. During operation, the wind turbine

rotors will always be assumed to face into the wind and automatically orient themselves as the wind direction changes. Shadow flicker can only occur when the blades are turning and the wind turbine rotor is between the sun and the receptor. Shadow flicker is most significant when the rotor is facing the sun.

USGS Digital Elevation Model (DEM) (height contour data): For this study, 3-meter USGS National Elevation Database (NED) DEM's were used to construct 10-foot interval height contour lines for the windPRO shadow flicker model. The height contour information is important to the shadow flicker calculation since it allows the model to place the wind turbines and the shadow receptors at the correct elevations. The height contour lines also allow the model to include the topography of the site when calculating the zones of visual influence surrounding the wind turbine and shadow receptor locations.

The actual calculation of potential shadow flicker at a given shadow receptor is carried out by simulating the environment near the wind turbines and the shadow receptors. The position of the sun relative to the turbine rotor disk and the resulting shadow is calculated in time steps of one minute throughout an entire year. If the shadow of the rotor disk (which in the calculation is assumed solid) at any time casts a shadow on a receptor window, then this step will be registered as one minute of shadow flicker. The calculation also requires that the sun must be at least 3.0° above the horizon in order to register shadow flicker. When the sun angle is less than 3.0°, the shadow quickly becomes too diffuse to be distinguished as the amount of atmosphere that the light must pass through is 15 times greater than when the sun is directly overhead.

The sun's path with respect to each wind turbine location is calculated by the software to determine the paths of cast shadows for every minute of every day over a full year. The turbine runtime and direction are calculated from the site's long-term wind speed and direction distribution. Finally, the effects of cloud cover are calculated using long-term reference data (monthly sunshine probability) to arrive at the projected annual flicker time at each receptor.

4. SITE OVERVIEW

The area of interest is located in Nobles and Jackson Counties near the town of Lake Park in southern Minnesota. The surrounding terrain has a change in elevation across the Project site ranging from 429 meters to 477 meters (1,407 feet to 1,565 feet). The regions vegetation is comprised primarily of agricultural land. The area also has a number of existing wind energy projects currently in operation.

5. RESULTS OF ANALYSIS

The term "realistic" as used in this report means that turbine operational hours and direction as well as local sunshine probabilities have been factored in, but no blocking or shading effects due to trees or structures have been accounted for. This means that the "realistic" estimates are still inherently conservative values. Also, the realistic shadow

flicker hours predicted by windPRO assumes an availability factor of 100% which is very unlikely to be the case. Three Waters expects actual availability factors will be 95-98%, but, with a conservative approach to estimating shadow flicker totals, the realistic estimates are not discounted accordingly.

A total of 343 residential structures within the Project vicinity in Minnesota were analyzed and standard resolution realistic shadow flicker maps and individual maps were generated for each turbine array.

The 343 shadow receptors in Minnesota were then modeled as greenhouse-mode receptors and the estimated shadow flicker was calculated for the array with no distance limit. Of the 343 receptors, there were 198 receptors (57.7%) that registered zero flicker hours per year with 114 meter hub height and 201 receptors (58.6%) with a hub height of 89 meters.

Table 3 contains the shadow flicker distribution of the 343 residential structures in Minnesota within 2 miles of any turbine location along with a breakdown of how many are non-participating.

Table 3: Residential Structures Realistic Shadow Flicker Distribution

Realistic Shadow Flicker (hrs/year)	GE 2.82-127 114 m Hub Height		GE 2.82-127 89 m Hub Height	
	Total # Participating	Total # Non-Participating	Total # Participating	Total # Non-Participating
0	13	185	13	188
0 to 5	11	40	12	44
5 to 10	4	22	5	18
10 to 15	6	16	6	15
15 to 20	5	10	4	9
20 to 25	4	4	5	7
25 to 30	3	2	3	1
30+	9	9	7	6

6. CONCLUSIONS

The conservative results of this study indicate that, of the 343 receptors modeled in Minnesota, 18 measured more than 30 hours per year with 114 meter hub-height turbines and 13 with 89 meter hub-height turbines. Any shadow flicker impacts over 30 hours per year will be mitigated either through curtailment of the contributing turbine(s) or by further refinement of the array. The shadow flicker impact on the receptors was calculated from turbines within 2 miles with reductions due to turbine operational direction and sunshine probabilities included. This shadow flicker analysis is based on a number of conservative assumptions including:

- No credit was taken for the blocking effects of trees or buildings.
- The receptors were omni-directional rather than modeling specific facades of buildings.

The overall effect of using these conservative assumptions indicate that realistically, the number of hours of shadow flicker that would be observed will be less than those predicted by this study.

APPENDIX A: THREE WATERS WIND TURBINE COORDINATES

Three Waters Wind Farm
 GE 2.82-127 114 m hub height WTG Layout (Minnesota)
 UTM NAD83 Zone 15

WTG	Model	Blades	Easting (m)	Northing (m)	Elevation AMSL (m)
2	GE 2.82-127-114	Normal	313,703	4,834,648	438.0
4	GE 2.82-127-114	Normal	311,924	4,830,366	451.1
5	GE 2.82-127-114	Normal	312,052	4,831,232	445.7
6	GE 2.82-127-114	Normal	312,708	4,830,978	449.4
7	GE 2.82-127-114	Normal	313,609	4,832,347	447.0
8	GE 2.82-127-114	Normal	313,911	4,832,743	445.8
9	GE 2.82-127-114	Normal	314,397	4,832,807	444.6
11	GE 2.82-127-114	Normal	316,038	4,834,020	439.0
13	GE 2.82-127-114	Normal	317,094	4,832,503	436.4
14	GE 2.82-127-114	Normal	314,314	4,829,597	449.0
16	GE 2.82-127-114	Normal	315,416	4,829,572	446.6
17	GE 2.82-127-114	Normal	315,915	4,829,569	443.6
19	GE 2.82-127-114	Normal	318,515	4,831,182	440.8
20	GE 2.82-127-114	Normal	319,118	4,831,115	439.3
21	GE 2.82-127-114	Normal	319,853	4,830,528	437.7
24	GE 2.82-127-114	LNTE	316,685	4,828,498	444.0
27	GE 2.82-127-114	LNTE	320,691	4,827,095	434.1
28	GE 2.82-127-114	Normal	320,773	4,829,144	432.2
29	GE 2.82-127-114	Normal	321,408	4,828,797	429.4
30	GE 2.82-127-114	Normal	321,825	4,829,087	429.2
31	GE 2.82-127-114	Normal	318,267	4,826,346	432.2
32	GE 2.82-127-114	LNTE	319,347	4,826,249	433.2
33	GE 2.82-127-114	Normal	307,268	4,823,554	463.5
38	GE 2.82-127-114	Normal	310,947	4,823,211	456.0
42	GE 2.82-127-114	Normal	312,515	4,823,334	453.0
44	GE 2.82-127-114	Normal	315,129	4,825,611	444.5
45	GE 2.82-127-114	Normal	314,130	4,822,819	447.0
47	GE 2.82-127-114	Normal	316,352	4,824,237	447.0
48	GE 2.82-127-114	Normal	316,824	4,824,754	444.9
49	GE 2.82-127-114	Normal	317,470	4,824,691	441.0
51	GE 2.82-127-114	Normal	317,113	4,823,842	444.0
53	GE 2.82-127-114	Normal	318,026	4,823,314	445.7
56	GE 2.82-127-114	Normal	318,243	4,821,099	445.1
58	GE 2.82-127-114	Normal	319,804	4,821,926	444.0
59	GE 2.82-127-114	Normal	303,574	4,821,177	466.6
60	GE 2.82-127-114	Normal	305,251	4,820,697	465.0
63	GE 2.82-127-114	Normal	306,813	4,821,722	463.1
64	GE 2.82-127-114	Normal	310,034	4,819,247	458.9
65	GE 2.82-127-114	Normal	310,832	4,819,228	458.2
66	GE 2.82-127-114	Normal	321,612	4,830,813	432.0
68	GE 2.82-127-114	Normal	315,010	4,824,743	446.7

Three Waters Wind Farm
 GE 2.82-127 114 m hub height WTG Layout (Minnesota)
 UTM NAD83 Zone 15
continued

WTG	Model		Easting (m)	Northing (m)	Elevation AMSL (m)
69	GE 2.82-127-114	Normal	309,230	4,819,238	465.0
70	GE 2.82-127-114	Normal	308,360	4,819,346	465.0
72	GE 2.82-127-114	Normal	317,537	4,819,076	447.3
73	GE 2.82-127-114	Normal	318,035	4,819,062	450.0
74	GE 2.82-127-114	Normal	317,657	4,820,313	445.4
75	GE 2.82-127-114	Normal	315,086	4,827,632	444.0
76	GE 2.82-127-114	Normal	315,043	4,826,643	441.8
78	GE 2.82-127-114	Normal	319,996	4,829,584	435.0
79	GE 2.82-127-114	Normal	316,985	4,819,074	444.5
80	GE 2.82-127-114	Normal	312,793	4,831,978	444.0
81	GE 2.82-127-114	Normal	317,035	4,820,064	447.0
82	GE 2.82-127-114	Normal	321,927	4,827,502	434.0
86	GE 2.82-127-114	Normal	320,691	4,828,100	432.8
87	GE 2.82-127-114	Normal	313,527	4,831,285	442.6
88	GE 2.82-127-114	Normal	304,343	4,819,594	471.0
89	GE 2.82-127-114	Normal	306,260	4,821,682	468.0
90	GE 2.82-127-114	Normal	307,503	4,819,605	466.6
91	GE 2.82-127-114	Normal	320,008	4,825,910	435.0
92	GE 2.82-127-114	Normal	315,675	4,824,786	445.3
93	GE 2.82-127-114	Normal	315,948	4,828,687	440.5
94	GE 2.82-127-114	Normal	316,824	4,830,816	437.4
95	GE 2.82-127-114	Normal	305,739	4,821,530	459.2
96	GE 2.82-127-114	Normal	314,138	4,831,664	444.7
97	GE 2.82-127-114	Normal	308,586	4,824,871	459.8
98	GE 2.82-127-114	Normal	318,388	4,829,506	441.0
A2	GE 2.82-127-114	Normal	305,390	4,823,091	469.6
A9	GE 2.82-127-114	Normal	315,303	4,833,970	435.0
A10	GE 2.82-127-114	LNTE	315,208	4,833,245	441.0
A15	GE 2.82-127-114	LNTE	320,126	4,826,609	435.8
A36	GE 2.82-127-114	LNTE	308,884	4,824,177	456.3
A53	GE 2.82-127-114	LNTE	319,187	4,825,195	432.0
A77	GE 2.82-127-114	Normal	315,808	4,826,797	441.0
A83	GE 2.82-127-114	Normal	316,033	4,823,137	444.3
95M	GE 2.82-127-114	Normal	317,622	4,833,211	435.4
96M	GE 2.82-127-114	LNTE	319,782	4,827,905	435.0
97M	GE 2.82-127-114	Normal	313,389	4,826,857	448.8
98M	GE 2.82-127-114	Normal	315,208	4,823,518	444.0
99M	GE 2.82-127-114	Normal	309,925	4,822,098	450.0

Three Waters Wind Farm
 GE 2.82-127 114 m hub height WTG Layout (Iowa)
 UTM NAD83 Zone 15
continued

WTG	Model		Easting (m)	Northing (m)	Elevation AMSL (m)
1	GE 2.82-127-114	Normal	303,000	4,818,475	473.9
3	GE 2.82-127-114	Normal	304,352	4,818,472	469.1
4	GE 2.82-127-114	Normal	305,167	4,818,859	470.5
5	GE 2.82-127-114	Normal	306,000	4,818,834	469.5
6	GE 2.82-127-114	Normal	306,740	4,818,019	469.6
7	GE 2.82-127-114	Normal	307,940	4,818,421	465.0
9	GE 2.82-127-114	Normal	310,292	4,818,090	466.4
10	GE 2.82-127-114	Normal	310,820	4,818,075	459.0
11	GE 2.82-127-114	Normal	311,881	4,818,093	457.9
12	GE 2.82-127-114	Normal	313,529	4,818,766	447.0
13	GE 2.82-127-114	Normal	314,301	4,818,745	453.0
14	GE 2.82-127-114	Normal	315,066	4,818,724	447.0
18	GE 2.82-127-114	Normal	319,008	4,818,104	450.0
19	GE 2.82-127-114	Normal	319,825	4,818,394	447.0
20	GE 2.82-127-114	Normal	320,513	4,818,376	435.9
21	GE 2.82-127-114	Normal	303,926	4,817,752	467.9
22	GE 2.82-127-114	Normal	305,004	4,816,976	471.0
23	GE 2.82-127-114	Normal	305,676	4,816,957	471.0
24	GE 2.82-127-114	Normal	307,737	4,817,079	459.0
25	GE 2.82-127-114	Normal	309,540	4,816,847	456.2
26	GE 2.82-127-114	Normal	310,001	4,817,025	460.1
27	GE 2.82-127-114	Normal	310,953	4,816,998	459.0
28	GE 2.82-127-114	Normal	315,475	4,816,865	447.0
29	GE 2.82-127-114	Normal	316,245	4,816,665	446.2
31	GE 2.82-127-114	Normal	318,732	4,816,757	447.3
32	GE 2.82-127-114	Normal	306,332	4,817,221	467.0
33	GE 2.82-127-114	Normal	308,305	4,817,063	459.0
34	GE 2.82-127-114	Normal	311,485	4,816,970	456.0
35	GE 2.82-127-114	Normal	313,384	4,816,922	454.1
36	GE 2.82-127-114	Normal	314,056	4,816,904	453.0
37	GE 2.82-127-114	Normal	314,710	4,816,886	453.0
A5	GE 2.82-127-114	Normal	312,682	4,816,942	453.0
A9	GE 2.82-127-114	Normal	318,204	4,816,771	449.3
A10	GE 2.82-127-114	Normal	319,263	4,816,864	447.0
A11	GE 2.82-127-114	Normal	307,323	4,815,615	455.7
A12	GE 2.82-127-114	Normal	308,043	4,815,594	462.0
A13	GE 2.82-127-114	Normal	317,476	4,815,290	451.6
A14	GE 2.82-127-114	Normal	317,277	4,813,852	435.7
A15	GE 2.82-127-114	Normal	318,888	4,813,412	429.3
A16	GE 2.82-127-114	Normal	318,630	4,815,565	444.3
A17	GE 2.82-127-114	Normal	319,384	4,815,222	447.0

Three Waters Wind Farm
 GE 2.82-127 114 m hub height WTG Layout (Iowa)
 UTM NAD83 Zone 15
continued

APPENDIX B: SHADOW RECEPTOR COORDINATES & REALISTIC SHADOW HOURS

B-1 Three Waters Wind Farm

Real case shadow flicker results at dwellings within two miles of Project WTGs

Results using GE 2.82-127 89 m hub height WTGs

UTM NAD83 Zone 15 (meters)

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J187	Not Participating	319710.49	4826519.13	438.0	78:23
J141	Participating	316550.57	4825056.69	444.4	57:20
J145	Participating	316064.72	4825090.48	444.0	50:23
J264	Participating	313158.82	4830865.51	448.2	43:47
J40	Not Participating	304845.90	4819436.38	468.9	38:39
J300	Not Participating	313199.32	4832558.72	450.0	38:22
J309	Not Participating	318136.57	4833013.30	438.0	37:10
J190	Not Participating	313930.27	4826635.52	448.6	36:33
J120	Participating	314800.15	4823852.93	450.7	35:37
J107	Participating	316425.57	4823507.99	447.0	34:45
J196	Not Participating	320493.85	4826806.49	435.0	31:45
J262	Participating	313270.58	4830793.37	447.6	30:40
J129	Participating	309353.14	4824075.55	456.0	30:06
J331	Participating	314806.01	4834060.61	435.2	27:35
J96	Not Participating	304957.13	4823068.36	469.8	27:24
J133	Participating	307944.44	4824640.29	462.0	25:12
J310	Participating	313379.17	4833148.99	446.3	25:05
J253	Participating	316263.58	4829942.25	447.0	24:18
J206	Not Participating	321205.60	4827062.74	433.0	24:03
J53	Not Participating	316646.90	4820486.11	451.9	23:51
J204	Participating	313897.99	4827084.54	447.1	23:48
J104	Not Participating	310519.59	4823405.36	454.0	23:33
J89	Not Participating	313581.06	4822598.68	450.7	22:44
J271	Not Participating	319616.67	4831494.63	439.2	22:34
J100	Participating	313833.92	4823221.98	448.9	22:14
J323	Not Participating	317325.52	4833613.63	436.6	21:58
J45	Participating	317717.92	4819771.10	450.0	21:41
J165	Not Participating	316003.40	4825448.45	446.9	21:34
J130	Participating	317793.42	4824243.71	442.4	20:59
J269	Not Participating	311522.58	4831331.34	449.9	19:31
J308	Not Participating	318040.87	4832960.65	436.8	19:29
J259	Not Participating	311355.12	4830342.20	451.0	19:09
J247	Participating	314651.21	4829254.23	450.0	18:15
J123	Participating	311807.97	4823908.91	454.4	18:12
J84	Not Participating	309387.00	4822455.22	456.0	17:07
J272	Participating	314729.45	4831576.06	442.8	16:48
J207	Not Participating	316420.17	4827287.86	439.1	16:24
J246	Not Participating	316667.54	4829100.69	435.9	16:23
J313	Not Participating	313223.39	4833319.93	445.4	15:59

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J50	Participating	318224.31	4820294.13	447.0	15:46
J65	Not Participating	304449.08	4821051.93	464.5	15:15
J103	Not Participating	306594.78	4823386.49	463.8	15:11
J305	Not Participating	314938.08	4832879.04	443.4	14:38
J93	Not Participating	316821.65	4822694.42	444.0	14:30
J124	Not Participating	308112.17	4823965.74	462.0	14:15
J95	Not Participating	316962.30	4822867.91	444.0	13:54
J63	Participating	317730.56	4820843.98	443.9	13:43
J138	Not Participating	318150.31	4824874.90	439.6	13:29
J317	Participating	316260.84	4833446.79	441.0	13:09
J125	Not Participating	308507.40	4823967.98	460.3	12:40
J117	Not Participating	315804.22	4823802.37	447.0	12:37
J252	Not Participating	319241.32	4829867.40	438.0	12:26
J229	Participating	320043.75	4828440.03	436.0	12:26
J74	Not Participating	319345.88	4821677.76	443.2	12:20
J275	Not Participating	319827.30	4831583.05	438.7	12:08
J254	Participating	320975.19	4829903.70	438.0	11:41
J203	Not Participating	312773.43	4827094.74	450.0	11:23
J119	Not Participating	315852.45	4823809.24	447.0	11:08
J316	Not Participating	318299.25	4833418.15	435.0	11:00
J199	Not Participating	321497.84	4826844.25	432.4	10:29
J64	Participating	317806.91	4820864.02	444.0	10:27
J233	Not Participating	322238.48	4828550.89	433.0	10:12
J198	Participating	319284.53	4826836.35	435.8	10:00
J256	Participating	313535.96	4830149.53	453.0	9:55
J128	Not Participating	306493.66	4824104.99	459.0	9:22
J90	Not Participating	318959.30	4822608.74	445.3	9:08
J169	Not Participating	316152.90	4825519.98	447.0	9:05
J209	Not Participating	316106.97	4827442.08	441.0	8:37
J298	Participating	314809.08	4832480.60	444.0	8:36
J102	Not Participating	308081.71	4823328.10	459.4	8:28
J109	Not Participating	316119.63	4823693.84	447.0	7:51
J110	Not Participating	316092.05	4823697.02	447.0	7:49
J201	Not Participating	318601.33	4826949.96	438.0	7:05
J54	Participating	306283.67	4820615.75	466.1	7:05
J212	Not Participating	319474.11	4827565.51	438.0	6:59
J85	Not Participating	304224.00	4822588.12	465.0	6:48
J42	Not Participating	311652.42	4819556.45	451.3	6:38

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J46	Not Participating	303525.17	4819945.46	468.0	6:36
J251	Not Participating	317504.03	4829872.50	435.0	6:32
J97	Not Participating	319025.33	4822914.48	444.0	6:27
J279	Participating	318216.83	4831747.62	441.0	6:18
J231	Not Participating	318898.28	4828514.76	438.5	6:10
J345	Not Participating	314779.43	4835078.89	438.0	5:53
J245	Not Participating	313188.03	4829125.22	449.8	5:52
J306	Participating	317194.43	4832960.52	438.0	5:16
J222	Not Participating	314163.03	4828243.22	446.0	5:15
J47	Participating	306478.95	4819922.74	469.2	4:56
J322	Not Participating	312775.42	4833661.07	444.0	4:51
J239	Not Participating	322992.11	4828630.54	432.0	4:36
J180	Not Participating	316378.14	4826065.88	443.3	4:32
J66	Not Participating	308020.55	4821013.63	460.6	4:26
J213	Not Participating	319373.32	4827570.45	438.0	4:25
J295	Not Participating	319626.48	4831998.05	441.0	4:11
J115	Participating	318982.93	4823741.14	438.0	4:02
J116	Not Participating	318103.60	4823765.66	443.7	3:54
J343	Not Participating	312728.61	4835004.74	444.0	3:53
J359	Not Participating	314850.52	4835504.33	436.1	3:46
J76	Not Participating	320829.28	4821884.29	436.1	3:42
J49	Not Participating	307963.04	4820227.24	465.2	3:37
J179	Not Participating	316470.76	4826037.16	443.0	3:32
J111	Not Participating	313604.32	4823778.00	451.0	3:30
J108	Not Participating	313628.86	4823710.89	450.0	3:29
J178	Not Participating	316503.66	4825953.34	443.2	3:29
J348	Not Participating	314691.57	4835088.49	438.0	3:28
J312	Participating	314202.27	4833288.99	443.2	3:27
J122	Not Participating	313604.57	4823885.37	452.6	3:25
J182	Not Participating	312329.20	4826289.74	450.0	3:17
J39	Participating	312340.73	4819053.50	456.0	3:10
J181	Not Participating	316486.53	4826138.30	442.3	3:09
J230	Not Participating	321717.14	4828426.12	432.7	3:08
J121	Not Participating	314079.06	4823865.91	456.0	3:06
J227	Participating	322595.59	4828401.45	430.4	3:05
J114	Not Participating	313774.69	4823796.40	448.5	3:04
J263	Participating	311612.63	4830867.35	452.4	2:59
J184	Not Participating	316487.10	4826322.99	441.2	2:57

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J248	Not Participating	322957.59	4829389.03	435.0	2:56
J112	Not Participating	313894.52	4823776.28	451.8	2:50
J249	Not Participating	310533.03	4829647.30	451.5	2:49
J352	Not Participating	312587.76	4835160.51	444.0	2:45
J88	Not Participating	320947.26	4822492.95	432.0	2:41
J43	Not Participating	313768.28	4819658.41	450.0	2:22
J58	Not Participating	304082.64	4820722.94	465.0	2:22
J304	Participating	311543.28	4832835.96	447.0	2:17
J92	Not Participating	319493.17	4822649.04	441.0	2:15
J244	Participating	317912.75	4828977.38	436.0	2:08
J333	Not Participating	312401.98	4834357.27	441.5	1:56
J289	Participating	317203.22	4831893.14	438.0	1:52
J77	Not Participating	321122.05	4821901.22	435.9	1:48
J243	Not Participating	313101.50	4828924.80	448.2	1:39
J220	Participating	316388.25	4828178.18	441.0	1:39
J105	Not Participating	303989.02	4823577.00	465.0	1:36
J75	Not Participating	308132.76	4821899.43	465.0	1:24
J132	Not Participating	307099.88	4824519.86	462.0	1:18
J228	Not Participating	318166.60	4828458.95	437.1	1:14
J267	Not Participating	322996.83	4830922.44	435.4	1:14
J139	Participating	318884.23	4824900.27	438.0	1:13
J326	Not Participating	319061.52	4833718.98	435.0	1:10
J255	Not Participating	321816.24	4830016.70	432.0	1:01
J134	Not Participating	310375.94	4824760.15	459.0	0:59
J152	Not Participating	320764.76	4825175.03	432.0	0:54
J341	Participating	315255.46	4834964.05	438.0	0:50
J171	Not Participating	317560.87	4825517.46	434.7	0:46
J41	Not Participating	319831.08	4819437.86	448.8	0:00
J44	Not Participating	320770.77	4819581.90	441.0	0:00
J48	Not Participating	322539.66	4820027.18	432.0	0:00
J51	Not Participating	323158.09	4820303.38	436.7	0:00
J52	Not Participating	312005.56	4820535.48	459.0	0:00
J55	Not Participating	314928.46	4820521.75	447.0	0:00
J56	Not Participating	303192.85	4820673.50	468.0	0:00
J57	Not Participating	309536.02	4820641.68	462.4	0:00
J59	Not Participating	309769.67	4820719.85	460.7	0:00
J60	Not Participating	319886.46	4820710.38	441.6	0:00
J61	Not Participating	309068.17	4820890.72	462.7	0:00

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J62	Not Participating	309105.72	4820933.24	463.2	0:00
J67	Not Participating	322997.15	4820847.53	437.6	0:00
J68	Not Participating	315404.96	4821078.84	448.5	0:00
J69	Not Participating	320955.27	4821066.22	435.4	0:00
J70	Not Participating	316191.64	4821187.87	443.7	0:00
J71	Not Participating	316267.29	4821514.77	447.0	0:00
J72	Not Participating	323132.73	4821435.04	432.0	0:00
J73	Not Participating	313725.26	4821714.16	444.0	0:00
J78	Not Participating	312217.31	4822006.98	445.0	0:00
J80	Not Participating	313907.96	4822234.93	450.0	0:00
J81	Not Participating	302838.30	4822419.30	466.6	0:00
J82	Not Participating	302104.59	4822437.98	471.5	0:00
J86	Not Participating	303466.86	4822618.72	468.0	0:00
J87	Not Participating	307194.46	4822577.19	468.0	0:00
J91	Not Participating	317884.75	4822625.87	445.1	0:00
J94	Not Participating	317791.72	4822840.19	444.0	0:00
J98	Not Participating	322632.57	4822881.56	434.3	0:00
J99	Not Participating	320725.17	4822934.14	432.0	0:00
J101	Not Participating	308966.90	4823316.24	462.0	0:00
J106	Not Participating	319823.23	4823427.80	435.0	0:00
J126	Not Participating	305493.98	4824032.87	459.0	0:00
J127	Not Participating	322666.55	4823904.74	432.0	0:00
J135	Not Participating	312453.08	4824763.34	456.0	0:00
J136	Not Participating	312132.15	4824783.46	456.0	0:00
J137	Not Participating	324484.98	4824652.48	432.2	0:00
J140	Not Participating	324041.18	4824939.98	438.0	0:00
J142	Not Participating	304329.27	4825201.75	465.3	0:00
J143	Not Participating	305070.05	4825199.02	465.0	0:00
J144	Not Participating	304354.09	4825224.97	466.3	0:00
J146	Not Participating	304366.44	4825249.59	466.5	0:00
J147	Not Participating	304410.22	4825302.44	467.5	0:00
J148	Not Participating	304426.74	4825321.51	467.4	0:00
J149	Not Participating	304437.39	4825327.11	467.6	0:00
J150	Not Participating	304465.89	4825357.48	466.6	0:00
J151	Not Participating	302387.20	4825386.53	466.5	0:00
J153	Not Participating	304470.33	4825375.63	466.3	0:00
J155	Not Participating	304486.96	4825386.24	466.1	0:00
J156	Not Participating	304519.63	4825429.89	465.0	0:00

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J157	Not Participating	302388.39	4825455.00	465.7	0:00
J158	Not Participating	304531.15	4825456.22	465.0	0:00
J159	Not Participating	304537.81	4825464.62	465.0	0:00
J160	Not Participating	306444.36	4825451.73	462.1	0:00
J161	Not Participating	304544.74	4825478.30	465.0	0:00
J162	Not Participating	321846.16	4825286.55	430.1	0:00
J163	Not Participating	304551.89	4825492.61	465.0	0:00
J164	Not Participating	323994.07	4825329.10	441.0	0:00
J166	Not Participating	324019.35	4825361.50	441.0	0:00
J167	Not Participating	324019.35	4825361.50	441.0	0:00
J168	Not Participating	310705.16	4825557.36	453.0	0:00
J170	Not Participating	305905.07	4825651.69	466.8	0:00
J172	Not Participating	307859.43	4825639.24	464.4	0:00
J381	Not Participating	304724.19	4825701.12	465.0	0:00
J173	Not Participating	309090.34	4825738.40	461.3	0:00
J174	Not Participating	306786.88	4825804.35	459.6	0:00
J175	Not Participating	302087.79	4825862.93	469.7	0:00
J176	Not Participating	323749.87	4825642.64	438.0	0:00
J177	Not Participating	309451.49	4825939.15	459.0	0:00
J185	Not Participating	305057.13	4826523.92	468.0	0:00
J186	Not Participating	308145.88	4826569.47	462.0	0:00
J188	Not Participating	303093.21	4826726.57	465.4	0:00
J384	Not Participating	302870.34	4826749.48	469.0	0:00
J189	Not Participating	303313.33	4826755.13	469.7	0:00
J383	Not Participating	302935.97	4826761.43	468.6	0:00
J382	Not Participating	302963.38	4826763.50	468.3	0:00
J191	Not Participating	324783.70	4826508.21	441.0	0:00
J192	Not Participating	303268.79	4826769.13	470.0	0:00
J193	Not Participating	303148.11	4826799.62	468.5	0:00
J194	Not Participating	309699.94	4826762.89	452.2	0:00
J195	Not Participating	308726.42	4826830.64	459.0	0:00
J197	Not Participating	322361.41	4826798.44	429.9	0:00
J200	Not Participating	310374.32	4827046.53	450.0	0:00
J202	Not Participating	304977.34	4827134.68	465.0	0:00
J205	Not Participating	307207.92	4827219.06	465.0	0:00
J208	Not Participating	325115.37	4827301.62	447.0	0:00
J210	Not Participating	307874.75	4827561.02	456.0	0:00
J211	Not Participating	310117.22	4827570.16	450.3	0:00

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J214	Not Participating	325540.66	4827722.48	447.0	0:00
J215	Not Participating	311982.58	4827964.28	450.0	0:00
J216	Not Participating	305298.67	4828075.19	465.0	0:00
J217	Not Participating	306172.71	4828109.03	462.0	0:00
J218	Not Participating	308339.44	4828148.16	459.0	0:00
J219	Not Participating	309915.37	4828245.53	452.4	0:00
J221	Not Participating	309678.19	4828280.93	453.5	0:00
J223	Not Participating	308096.12	4828333.62	459.0	0:00
J224	Not Participating	312353.26	4828345.51	450.0	0:00
J225	Not Participating	324827.97	4828263.84	450.0	0:00
J226	Not Participating	324221.87	4828329.10	438.0	0:00
J232	Not Participating	313396.69	4828603.21	449.9	0:00
J234	Not Participating	305902.15	4828758.28	456.0	0:00
J235	Not Participating	311089.36	4828714.13	450.0	0:00
J236	Not Participating	314144.75	4828703.64	447.0	0:00
J237	Not Participating	314124.97	4828706.54	447.3	0:00
J240	Not Participating	319046.52	4828691.44	439.3	0:00
J241	Not Participating	306273.97	4828907.49	458.7	0:00
J242	Not Participating	308917.53	4828944.09	456.0	0:00
J250	Not Participating	309869.41	4829744.11	454.4	0:00
J257	Not Participating	308123.13	4830213.97	457.2	0:00
J258	Not Participating	321605.15	4830172.43	432.0	0:00
J260	Not Participating	305908.39	4830473.59	459.2	0:00
J261	Not Participating	306738.56	4830465.10	459.0	0:00
J265	Not Participating	308286.40	4830992.12	455.2	0:00
J266	Not Participating	306671.16	4831033.74	457.1	0:00
J268	Not Participating	306681.12	4831171.22	456.6	0:00
J270	Not Participating	324096.31	4831388.12	444.0	0:00
J273	Not Participating	308610.62	4831697.59	453.0	0:00
J274	Not Participating	316405.71	4831613.04	444.0	0:00
J276	Not Participating	308386.22	4831779.06	452.0	0:00
J277	Not Participating	321157.98	4831672.99	435.0	0:00
J278	Not Participating	306677.46	4831873.50	455.7	0:00
J280	Not Participating	322480.25	4831725.84	444.0	0:00
J281	Not Participating	310013.38	4831886.25	453.0	0:00
J282	Not Participating	308402.24	4831915.46	451.7	0:00
J283	Not Participating	308534.26	4831916.45	452.3	0:00
J284	Not Participating	322503.29	4831755.25	444.0	0:00

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J285	Not Participating	308556.00	4831936.46	451.9	0:00
J286	Not Participating	306775.42	4831961.92	455.1	0:00
J287	Not Participating	306813.52	4831961.70	454.7	0:00
J288	Not Participating	306874.52	4831964.81	454.3	0:00
J290	Not Participating	310421.51	4832003.30	450.7	0:00
J291	Not Participating	320676.40	4831888.76	435.8	0:00
J292	Not Participating	306813.60	4832054.77	455.1	0:00
J293	Not Participating	306853.13	4832058.08	454.8	0:00
J294	Not Participating	306763.72	4832061.06	455.5	0:00
J296	Not Participating	310137.36	4832353.95	446.8	0:00
J297	Not Participating	309932.84	4832393.66	445.7	0:00
J299	Not Participating	306784.24	4832621.72	453.4	0:00
J302	Not Participating	306805.66	4832763.15	453.0	0:00
J303	Not Participating	306805.66	4832763.15	453.0	0:00
J307	Not Participating	324761.39	4832871.57	444.0	0:00
J311	Not Participating	321245.05	4833082.69	435.0	0:00
J314	Not Participating	319310.86	4833335.97	435.0	0:00
J315	Not Participating	310440.63	4833492.27	447.4	0:00
J319	Not Participating	306749.35	4833659.64	453.0	0:00
J320	Not Participating	307114.44	4833659.39	451.1	0:00
J321	Not Participating	308732.53	4833641.72	450.0	0:00
J324	Not Participating	323020.28	4833549.74	444.0	0:00
J325	Not Participating	323007.88	4833567.21	444.0	0:00
J327	Not Participating	322470.47	4833685.98	442.4	0:00
J328	Not Participating	306748.18	4833874.93	453.0	0:00
J329	Not Participating	321260.13	4833740.25	436.6	0:00
J332	Not Participating	311682.18	4834109.88	444.1	0:00
J334	Not Participating	308126.10	4834553.99	447.0	0:00
J336	Not Participating	306846.10	4834907.56	447.4	0:00
J337	Not Participating	308675.53	4834899.47	444.7	0:00
J338	Not Participating	322074.64	4834869.13	438.0	0:00
J339	Not Participating	318729.75	4834910.41	435.7	0:00
J340	Not Participating	317029.61	4834931.51	438.0	0:00
J342	Not Participating	320592.73	4834911.50	438.4	0:00
J344	Not Participating	317584.57	4835035.67	438.0	0:00
J346	Not Participating	315573.84	4835072.93	438.0	0:00
J350	Not Participating	311773.49	4835158.34	445.6	0:00
J351	Not Participating	311808.79	4835167.46	445.7	0:00

B-1 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 89 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J353	Not Participating	308690.64	4835228.47	444.0	0:00
J354	Not Participating	309327.07	4835223.59	444.0	0:00
J355	Not Participating	307336.85	4835322.43	448.3	0:00
J356	Not Participating	307903.84	4835369.56	447.0	0:00
J357	Not Participating	319778.24	4835289.55	438.0	0:00
J358	Not Participating	310071.63	4835520.90	444.0	0:00
J360	Not Participating	319630.40	4835462.56	437.7	0:00
J361	Not Participating	318307.46	4835550.62	437.4	0:00
J362	Not Participating	318195.00	4835834.55	438.0	0:00
J363	Not Participating	317055.63	4835888.94	439.5	0:00
J364	Not Participating	317022.66	4835894.46	439.6	0:00
J365	Not Participating	318199.19	4835969.17	437.7	0:00
J366	Not Participating	314890.78	4836066.81	435.0	0:00
J367	Not Participating	319005.62	4836529.82	438.0	0:00
J368	Not Participating	315383.14	4836604.61	435.0	0:00
J369	Not Participating	313403.54	4836629.87	439.3	0:00
J370	Not Participating	308190.73	4836697.84	444.8	0:00
J371	Not Participating	309547.47	4836728.32	444.0	0:00
J372	Not Participating	315807.12	4836672.94	437.9	0:00
J374	Not Participating	309275.92	4836860.48	444.0	0:00
J375	Not Participating	313573.26	4836873.96	438.4	0:00
J376	Not Participating	318132.36	4836825.35	435.9	0:00
J377	Not Participating	313158.17	4837445.57	438.0	0:00
J378	Not Participating	313193.16	4837451.52	438.0	0:00
J388	Not Participating	322636.53	4834649.55	441.5	0:00
J79	Participating	317880.99	4822028.07	444.0	0:00
J131	Participating	319582.01	4824351.61	432.0	0:00
J183	Participating	313244.95	4826338.41	450.0	0:00
J238	Participating	312287.65	4828756.30	447.0	0:00
J318	Participating	309644.88	4833608.14	448.6	0:00
J330	Participating	313356.51	4833857.86	441.9	0:00
J349	Participating	313446.94	4835109.98	441.0	0:00
J373	Participating	316885.43	4836669.17	434.5	0:00
N380	Not Participating	300147.39	4821969.44	471.0	0:00
N379	Not Participating	301377.75	4822432.27	470.6	0:00
N385	Not Participating	300915.52	4823298.21	471.0	0:00
N386	Not Participating	300927.31	4823625.02	469.9	0:00
N387	Not Participating	300891.12	4824175.78	474.0	0:00

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)**

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J187	Not Participating	319710.49	4826519.13	438.0	73:33
J141	Participating	316550.57	4825056.69	444.4	66:08
J145	Participating	316064.72	4825090.48	444.0	51:19
J264	Participating	313158.82	4830865.51	448.2	50:44
J300	Not Participating	313199.32	4832558.72	450.0	43:42
J40	Not Participating	304845.90	4819436.38	468.9	41:18
J129	Participating	309353.14	4824075.55	456.0	38:55
J120	Participating	314800.15	4823852.93	450.7	38:32
J190	Not Participating	313930.27	4826635.52	448.6	38:03
J309	Not Participating	318136.57	4833013.30	438.0	37:18
J107	Participating	316425.57	4823507.99	447.0	36:53
J262	Participating	313270.58	4830793.37	447.6	36:32
J100	Participating	313833.92	4823221.98	448.9	32:30
J323	Not Participating	317325.52	4833613.63	436.6	31:44
J196	Not Participating	320493.85	4826806.49	435.0	31:08
J53	Not Participating	316646.90	4820486.11	451.9	30:46
J96	Not Participating	304957.13	4823068.36	469.8	30:26
J331	Participating	314806.01	4834060.61	435.2	30:23
J253	Participating	316263.58	4829942.25	447.0	29:04
J165	Not Participating	316003.40	4825448.45	446.9	27:17
J206	Not Participating	321205.60	4827062.74	433.0	26:25
J45	Participating	317717.92	4819771.10	450.0	26:11
J133	Participating	307944.44	4824640.29	462.0	25:56
J204	Participating	313897.99	4827084.54	447.1	24:29
J310	Participating	313379.17	4833148.99	446.3	23:58
J104	Not Participating	310519.59	4823405.36	454.0	22:50
J271	Not Participating	319616.67	4831494.63	439.2	22:47
J269	Not Participating	311522.58	4831331.34	449.9	22:26
J130	Participating	317793.42	4824243.71	442.4	22:22
J123	Participating	311807.97	4823908.91	454.4	22:13
J259	Not Participating	311355.12	4830342.20	451.0	21:26
J247	Participating	314651.21	4829254.23	450.0	19:56
J89	Not Participating	313581.06	4822598.68	450.7	19:38
J313	Not Participating	313223.39	4833319.93	445.4	19:10
J272	Participating	314729.45	4831576.06	442.8	18:59
J65	Not Participating	304449.08	4821051.93	464.5	18:41
J207	Not Participating	316420.17	4827287.86	439.1	18:40
J103	Not Participating	306594.78	4823386.49	463.8	18:32
J50	Participating	318224.31	4820294.13	447.0	17:30

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J95	Not Participating	316962.30	4822867.91	444.0	17:20
J124	Not Participating	308112.17	4823965.74	462.0	17:20
J84	Not Participating	309387.00	4822455.22	456.0	17:19
J305	Not Participating	314938.08	4832879.04	443.4	16:52
J254	Participating	320975.19	4829903.70	438.0	16:48
J317	Participating	316260.84	4833446.79	441.0	15:51
J138	Not Participating	318150.31	4824874.90	439.6	15:44
J93	Not Participating	316821.65	4822694.42	444.0	14:59
J246	Not Participating	316667.54	4829100.69	435.9	14:40
J229	Participating	320043.75	4828440.03	436.0	14:15
J233	Not Participating	322238.48	4828550.89	433.0	14:07
J252	Not Participating	319241.32	4829867.40	438.0	13:55
J117	Not Participating	315804.22	4823802.37	447.0	13:17
J199	Not Participating	321497.84	4826844.25	432.4	13:16
J316	Not Participating	318299.25	4833418.15	435.0	12:17
J198	Participating	319284.53	4826836.35	435.8	12:11
J119	Not Participating	315852.45	4823809.24	447.0	12:04
J263	Participating	311612.63	4830867.35	452.4	12:00
J169	Not Participating	316152.90	4825519.98	447.0	11:53
J203	Not Participating	312773.43	4827094.74	450.0	11:53
J275	Not Participating	319827.30	4831583.05	438.7	11:41
J90	Not Participating	318959.30	4822608.74	445.3	11:26
J256	Participating	313535.96	4830149.53	453.0	11:19
J298	Participating	314809.08	4832480.60	444.0	11:00
J209	Not Participating	316106.97	4827442.08	441.0	10:52
J201	Not Participating	318601.33	4826949.96	438.0	10:42
J102	Not Participating	308081.71	4823328.10	459.4	10:15
J212	Not Participating	319474.11	4827565.51	438.0	10:11
J349	Participating	313446.94	4835109.98	441.0	10:08
J308	Not Participating	318040.87	4832960.65	436.8	9:46
J54	Participating	306283.67	4820615.75	466.1	9:46
J128	Not Participating	306493.66	4824104.99	459.0	9:42
J109	Not Participating	316119.63	4823693.84	447.0	9:41
J110	Not Participating	316092.05	4823697.02	447.0	9:38
J97	Not Participating	319025.33	4822914.48	444.0	8:58
J245	Not Participating	313188.03	4829125.22	449.8	8:31
J85	Not Participating	304224.00	4822588.12	465.0	8:12
J345	Not Participating	314779.43	4835078.89	438.0	8:12

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J63	Participating	317730.56	4820843.98	443.9	7:38
J251	Not Participating	317504.03	4829872.50	435.0	7:35
J231	Not Participating	318898.28	4828514.76	438.5	7:28
J46	Not Participating	303525.17	4819945.46	468.0	7:24
J279	Participating	318216.83	4831747.62	441.0	7:21
J42	Not Participating	311652.42	4819556.45	451.3	7:15
J239	Not Participating	322992.11	4828630.54	432.0	6:45
J322	Not Participating	312775.42	4833661.07	444.0	6:39
J180	Not Participating	316378.14	4826065.88	443.3	6:32
J213	Not Participating	319373.32	4827570.45	438.0	6:31
J222	Not Participating	314163.03	4828243.22	446.0	6:28
J47	Participating	306478.95	4819922.74	469.2	6:07
J178	Not Participating	316503.66	4825953.34	443.2	5:21
J179	Not Participating	316470.76	4826037.16	443.0	5:17
J295	Not Participating	319626.48	4831998.05	441.0	5:17
J66	Not Participating	308020.55	4821013.63	460.6	5:16
J49	Not Participating	307963.04	4820227.24	465.2	5:07
J116	Not Participating	318103.60	4823765.66	443.7	4:57
J343	Not Participating	312728.61	4835004.74	444.0	4:57
J359	Not Participating	314850.52	4835504.33	436.1	4:52
J74	Not Participating	319345.88	4821677.76	443.2	4:43
J312	Participating	314202.27	4833288.99	443.2	4:38
J111	Not Participating	313604.32	4823778.00	451.0	4:35
J108	Not Participating	313628.86	4823710.89	450.0	4:32
J181	Not Participating	316486.53	4826138.30	442.3	4:32
J122	Not Participating	313604.57	4823885.37	452.6	4:31
J115	Participating	318982.93	4823741.14	438.0	4:31
J121	Not Participating	314079.06	4823865.91	456.0	4:30
J39	Participating	312340.73	4819053.50	456.0	4:29
J76	Not Participating	320829.28	4821884.29	436.1	4:27
J227	Participating	322595.59	4828401.45	430.4	4:21
J114	Not Participating	313774.69	4823796.40	448.5	4:12
J348	Not Participating	314691.57	4835088.49	438.0	4:10
J184	Not Participating	316487.10	4826322.99	441.2	4:09
J112	Not Participating	313894.52	4823776.28	451.8	4:02
J248	Not Participating	322957.59	4829389.03	435.0	4:02
J230	Not Participating	321717.14	4828426.12	432.7	3:48
J352	Not Participating	312587.76	4835160.51	444.0	3:46

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J92	Not Participating	319493.17	4822649.04	441.0	3:34
J43	Not Participating	313768.28	4819658.41	450.0	3:27
J304	Participating	311543.28	4832835.96	447.0	3:18
J182	Not Participating	312329.20	4826289.74	450.0	3:17
J249	Not Participating	310533.03	4829647.30	451.5	3:15
J58	Not Participating	304082.64	4820722.94	465.0	3:10
J88	Not Participating	320947.26	4822492.95	432.0	3:10
J172	Not Participating	307859.43	4825639.24	464.4	2:56
J255	Not Participating	321816.24	4830016.70	432.0	2:46
J333	Not Participating	312401.98	4834357.27	441.5	2:41
J244	Participating	317912.75	4828977.38	436.0	2:41
J289	Participating	317203.22	4831893.14	438.0	2:40
J125	Not Participating	308507.40	4823967.98	460.3	2:32
J77	Not Participating	321122.05	4821901.22	435.9	2:24
J105	Not Participating	303989.02	4823577.00	465.0	2:14
J220	Participating	316388.25	4828178.18	441.0	2:11
J75	Not Participating	308132.76	4821899.43	465.0	1:58
J132	Not Participating	307099.88	4824519.86	462.0	1:53
J228	Not Participating	318166.60	4828458.95	437.1	1:45
J267	Not Participating	322996.83	4830922.44	435.4	1:45
J139	Participating	318884.23	4824900.27	438.0	1:42
J326	Not Participating	319061.52	4833718.98	435.0	1:40
J240	Not Participating	319046.52	4828691.44	439.3	1:38
J243	Not Participating	313101.50	4828924.80	448.2	1:36
J134	Not Participating	310375.94	4824760.15	459.0	1:25
J152	Not Participating	320764.76	4825175.03	432.0	1:21
J64	Participating	317806.91	4820864.02	444.0	1:17
J341	Participating	315255.46	4834964.05	438.0	1:14
J171	Not Participating	317560.87	4825517.46	434.7	1:13
J56	Not Participating	303192.85	4820673.50	468.0	1:05
J41	Not Participating	319831.08	4819437.86	448.8	0:00
J44	Not Participating	320770.77	4819581.90	441.0	0:00
J48	Not Participating	322539.66	4820027.18	432.0	0:00
J51	Not Participating	323158.09	4820303.38	436.7	0:00
J52	Not Participating	312005.56	4820535.48	459.0	0:00
J55	Not Participating	314928.46	4820521.75	447.0	0:00
J57	Not Participating	309536.02	4820641.68	462.4	0:00
J59	Not Participating	309769.67	4820719.85	460.7	0:00

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J60	Not Participating	319886.46	4820710.38	441.6	0:00
J61	Not Participating	309068.17	4820890.72	462.7	0:00
J62	Not Participating	309105.72	4820933.24	463.2	0:00
J67	Not Participating	322997.15	4820847.53	437.6	0:00
J68	Not Participating	315404.96	4821078.84	448.5	0:00
J69	Not Participating	320955.27	4821066.22	435.4	0:00
J70	Not Participating	316191.64	4821187.87	443.7	0:00
J71	Not Participating	316267.29	4821514.77	447.0	0:00
J72	Not Participating	323132.73	4821435.04	432.0	0:00
J73	Not Participating	313725.26	4821714.16	444.0	0:00
J78	Not Participating	312217.31	4822006.98	445.0	0:00
J80	Not Participating	313907.96	4822234.93	450.0	0:00
J81	Not Participating	302838.30	4822419.30	466.6	0:00
J82	Not Participating	302104.59	4822437.98	471.5	0:00
J86	Not Participating	303466.86	4822618.72	468.0	0:00
J87	Not Participating	307194.46	4822577.19	468.0	0:00
J91	Not Participating	317884.75	4822625.87	445.1	0:00
J94	Not Participating	317791.72	4822840.19	444.0	0:00
J98	Not Participating	322632.57	4822881.56	434.3	0:00
J99	Not Participating	320725.17	4822934.14	432.0	0:00
J101	Not Participating	308966.90	4823316.24	462.0	0:00
J106	Not Participating	319823.23	4823427.80	435.0	0:00
J126	Not Participating	305493.98	4824032.87	459.0	0:00
J127	Not Participating	322666.55	4823904.74	432.0	0:00
J135	Not Participating	312453.08	4824763.34	456.0	0:00
J136	Not Participating	312132.15	4824783.46	456.0	0:00
J137	Not Participating	324484.98	4824652.48	432.2	0:00
J140	Not Participating	324041.18	4824939.98	438.0	0:00
J142	Not Participating	304329.27	4825201.75	465.3	0:00
J143	Not Participating	305070.05	4825199.02	465.0	0:00
J144	Not Participating	304354.09	4825224.97	466.3	0:00
J146	Not Participating	304366.44	4825249.59	466.5	0:00
J147	Not Participating	304410.22	4825302.44	467.5	0:00
J148	Not Participating	304426.74	4825321.51	467.4	0:00
J149	Not Participating	304437.39	4825327.11	467.6	0:00
J150	Not Participating	304465.89	4825357.48	466.6	0:00
J151	Not Participating	302387.20	4825386.53	466.5	0:00
J153	Not Participating	304470.33	4825375.63	466.3	0:00

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J155	Not Participating	304486.96	4825386.24	466.1	0:00
J156	Not Participating	304519.63	4825429.89	465.0	0:00
J157	Not Participating	302388.39	4825455.00	465.7	0:00
J158	Not Participating	304531.15	4825456.22	465.0	0:00
J159	Not Participating	304537.81	4825464.62	465.0	0:00
J160	Not Participating	306444.36	4825451.73	462.1	0:00
J161	Not Participating	304544.74	4825478.30	465.0	0:00
J162	Not Participating	321846.16	4825286.55	430.1	0:00
J163	Not Participating	304551.89	4825492.61	465.0	0:00
J164	Not Participating	323994.07	4825329.10	441.0	0:00
J166	Not Participating	324019.35	4825361.50	441.0	0:00
J167	Not Participating	324019.35	4825361.50	441.0	0:00
J168	Not Participating	310705.16	4825557.36	453.0	0:00
J170	Not Participating	305905.07	4825651.69	466.8	0:00
J381	Not Participating	304724.19	4825701.12	465.0	0:00
J173	Not Participating	309090.34	4825738.40	461.3	0:00
J174	Not Participating	306786.88	4825804.35	459.6	0:00
J175	Not Participating	302087.79	4825862.93	469.7	0:00
J176	Not Participating	323749.87	4825642.64	438.0	0:00
J177	Not Participating	309451.49	4825939.15	459.0	0:00
J185	Not Participating	305057.13	4826523.92	468.0	0:00
J186	Not Participating	308145.88	4826569.47	462.0	0:00
J188	Not Participating	303093.21	4826726.57	465.4	0:00
J384	Not Participating	302870.34	4826749.48	469.0	0:00
J189	Not Participating	303313.33	4826755.13	469.7	0:00
J383	Not Participating	302935.97	4826761.43	468.6	0:00
J382	Not Participating	302963.38	4826763.50	468.3	0:00
J191	Not Participating	324783.70	4826508.21	441.0	0:00
J192	Not Participating	303268.79	4826769.13	470.0	0:00
J193	Not Participating	303148.11	4826799.62	468.5	0:00
J194	Not Participating	309699.94	4826762.89	452.2	0:00
J195	Not Participating	308726.42	4826830.64	459.0	0:00
J197	Not Participating	322361.41	4826798.44	429.9	0:00
J200	Not Participating	310374.32	4827046.53	450.0	0:00
J202	Not Participating	304977.34	4827134.68	465.0	0:00
J205	Not Participating	307207.92	4827219.06	465.0	0:00
J208	Not Participating	325115.37	4827301.62	447.0	0:00
J210	Not Participating	307874.75	4827561.02	456.0	0:00

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J211	Not Participating	310117.22	4827570.16	450.3	0:00
J214	Not Participating	325540.66	4827722.48	447.0	0:00
J215	Not Participating	311982.58	4827964.28	450.0	0:00
J216	Not Participating	305298.67	4828075.19	465.0	0:00
J217	Not Participating	306172.71	4828109.03	462.0	0:00
J218	Not Participating	308339.44	4828148.16	459.0	0:00
J219	Not Participating	309915.37	4828245.53	452.4	0:00
J221	Not Participating	309678.19	4828280.93	453.5	0:00
J223	Not Participating	308096.12	4828333.62	459.0	0:00
J224	Not Participating	312353.26	4828345.51	450.0	0:00
J225	Not Participating	324827.97	4828263.84	450.0	0:00
J226	Not Participating	324221.87	4828329.10	438.0	0:00
J232	Not Participating	313396.69	4828603.21	449.9	0:00
J234	Not Participating	305902.15	4828758.28	456.0	0:00
J235	Not Participating	311089.36	4828714.13	450.0	0:00
J236	Not Participating	314144.75	4828703.64	447.0	0:00
J237	Not Participating	314124.97	4828706.54	447.3	0:00
J241	Not Participating	306273.97	4828907.49	458.7	0:00
J242	Not Participating	308917.53	4828944.09	456.0	0:00
J250	Not Participating	309869.41	4829744.11	454.4	0:00
J257	Not Participating	308123.13	4830213.97	457.2	0:00
J258	Not Participating	321605.15	4830172.43	432.0	0:00
J260	Not Participating	305908.39	4830473.59	459.2	0:00
J261	Not Participating	306738.56	4830465.10	459.0	0:00
J265	Not Participating	308286.40	4830992.12	455.2	0:00
J266	Not Participating	306671.16	4831033.74	457.1	0:00
J268	Not Participating	306681.12	4831171.22	456.6	0:00
J270	Not Participating	324096.31	4831388.12	444.0	0:00
J273	Not Participating	308610.62	4831697.59	453.0	0:00
J274	Not Participating	316405.71	4831613.04	444.0	0:00
J276	Not Participating	308386.22	4831779.06	452.0	0:00
J277	Not Participating	321157.98	4831672.99	435.0	0:00
J278	Not Participating	306677.46	4831873.50	455.7	0:00
J280	Not Participating	322480.25	4831725.84	444.0	0:00
J281	Not Participating	310013.38	4831886.25	453.0	0:00
J282	Not Participating	308402.24	4831915.46	451.7	0:00
J283	Not Participating	308534.26	4831916.45	452.3	0:00
J284	Not Participating	322503.29	4831755.25	444.0	0:00

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J285	Not Participating	308556.00	4831936.46	451.9	0:00
J286	Not Participating	306775.42	4831961.92	455.1	0:00
J287	Not Participating	306813.52	4831961.70	454.7	0:00
J288	Not Participating	306874.52	4831964.81	454.3	0:00
J290	Not Participating	310421.51	4832003.30	450.7	0:00
J291	Not Participating	320676.40	4831888.76	435.8	0:00
J292	Not Participating	306813.60	4832054.77	455.1	0:00
J293	Not Participating	306853.13	4832058.08	454.8	0:00
J294	Not Participating	306763.72	4832061.06	455.5	0:00
J296	Not Participating	310137.36	4832353.95	446.8	0:00
J297	Not Participating	309932.84	4832393.66	445.7	0:00
J299	Not Participating	306784.24	4832621.72	453.4	0:00
J302	Not Participating	306805.66	4832763.15	453.0	0:00
J303	Not Participating	306805.66	4832763.15	453.0	0:00
J307	Not Participating	324761.39	4832871.57	444.0	0:00
J311	Not Participating	321245.05	4833082.69	435.0	0:00
J314	Not Participating	319310.86	4833335.97	435.0	0:00
J315	Not Participating	310440.63	4833492.27	447.4	0:00
J319	Not Participating	306749.35	4833659.64	453.0	0:00
J320	Not Participating	307114.44	4833659.39	451.1	0:00
J321	Not Participating	308732.53	4833641.72	450.0	0:00
J324	Not Participating	323020.28	4833549.74	444.0	0:00
J325	Not Participating	323007.88	4833567.21	444.0	0:00
J327	Not Participating	322470.47	4833685.98	442.4	0:00
J328	Not Participating	306748.18	4833874.93	453.0	0:00
J329	Not Participating	321260.13	4833740.25	436.6	0:00
J332	Not Participating	311682.18	4834109.88	444.1	0:00
J334	Not Participating	308126.10	4834553.99	447.0	0:00
J336	Not Participating	306846.10	4834907.56	447.4	0:00
J337	Not Participating	308675.53	4834899.47	444.7	0:00
J338	Not Participating	322074.64	4834869.13	438.0	0:00
J339	Not Participating	318729.75	4834910.41	435.7	0:00
J340	Not Participating	317029.61	4834931.51	438.0	0:00
J342	Not Participating	320592.73	4834911.50	438.4	0:00
J344	Not Participating	317584.57	4835035.67	438.0	0:00
J346	Not Participating	315573.84	4835072.93	438.0	0:00
J350	Not Participating	311773.49	4835158.34	445.6	0:00
J351	Not Participating	311808.79	4835167.46	445.7	0:00

B-2 Three Waters Wind Farm**Real case shadow flicker results at dwellings within two miles of Project WTGs****Results using GE 2.82-127 114 m hub height WTGs****UTM NAD83 Zone 15 (meters)***continued*

Shadow Receptor #	Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)
J353	Not Participating	308690.64	4835228.47	444.0	0:00
J354	Not Participating	309327.07	4835223.59	444.0	0:00
J355	Not Participating	307336.85	4835322.43	448.3	0:00
J356	Not Participating	307903.84	4835369.56	447.0	0:00
J357	Not Participating	319778.24	4835289.55	438.0	0:00
J358	Not Participating	310071.63	4835520.90	444.0	0:00
J360	Not Participating	319630.40	4835462.56	437.7	0:00
J361	Not Participating	318307.46	4835550.62	437.4	0:00
J362	Not Participating	318195.00	4835834.55	438.0	0:00
J363	Not Participating	317055.63	4835888.94	439.5	0:00
J364	Not Participating	317022.66	4835894.46	439.6	0:00
J365	Not Participating	318199.19	4835969.17	437.7	0:00
J366	Not Participating	314890.78	4836066.81	435.0	0:00
J367	Not Participating	319005.62	4836529.82	438.0	0:00
J368	Not Participating	315383.14	4836604.61	435.0	0:00
J369	Not Participating	313403.54	4836629.87	439.3	0:00
J370	Not Participating	308190.73	4836697.84	444.8	0:00
J371	Not Participating	309547.47	4836728.32	444.0	0:00
J372	Not Participating	315807.12	4836672.94	437.9	0:00
J374	Not Participating	309275.92	4836860.48	444.0	0:00
J375	Not Participating	313573.26	4836873.96	438.4	0:00
J376	Not Participating	318132.36	4836825.35	435.9	0:00
J377	Not Participating	313158.17	4837445.57	438.0	0:00
J378	Not Participating	313193.16	4837451.52	438.0	0:00
J388	Not Participating	322636.53	4834649.55	441.5	0:00
J79	Participating	317880.99	4822028.07	444.0	0:00
J131	Participating	319582.01	4824351.61	432.0	0:00
J183	Participating	313244.95	4826338.41	450.0	0:00
J238	Participating	312287.65	4828756.30	447.0	0:00
J306	Participating	317194.43	4832960.52	438.0	0:00
J318	Participating	309644.88	4833608.14	448.6	0:00
J330	Participating	313356.51	4833857.86	441.9	0:00
J373	Participating	316885.43	4836669.17	434.5	0:00
N380	Not Participating	300147.39	4821969.44	471.0	0:00
N379	Not Participating	301377.75	4822432.27	470.6	0:00
N385	Not Participating	300915.52	4823298.21	471.0	0:00
N386	Not Participating	300927.31	4823625.02	469.9	0:00
N387	Not Participating	300891.12	4824175.78	474.0	0:00

APPENDIX C: THREE WATERS WIND ENERGY PROJECT SITE OVERVIEW



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Three Waters Wind Farm Overview Map

Client
Wenck Associates

Project Description
128-GE 2.82-127 wind turbines with 114 meter hub height and occupied residences within 2 miles of turbines.

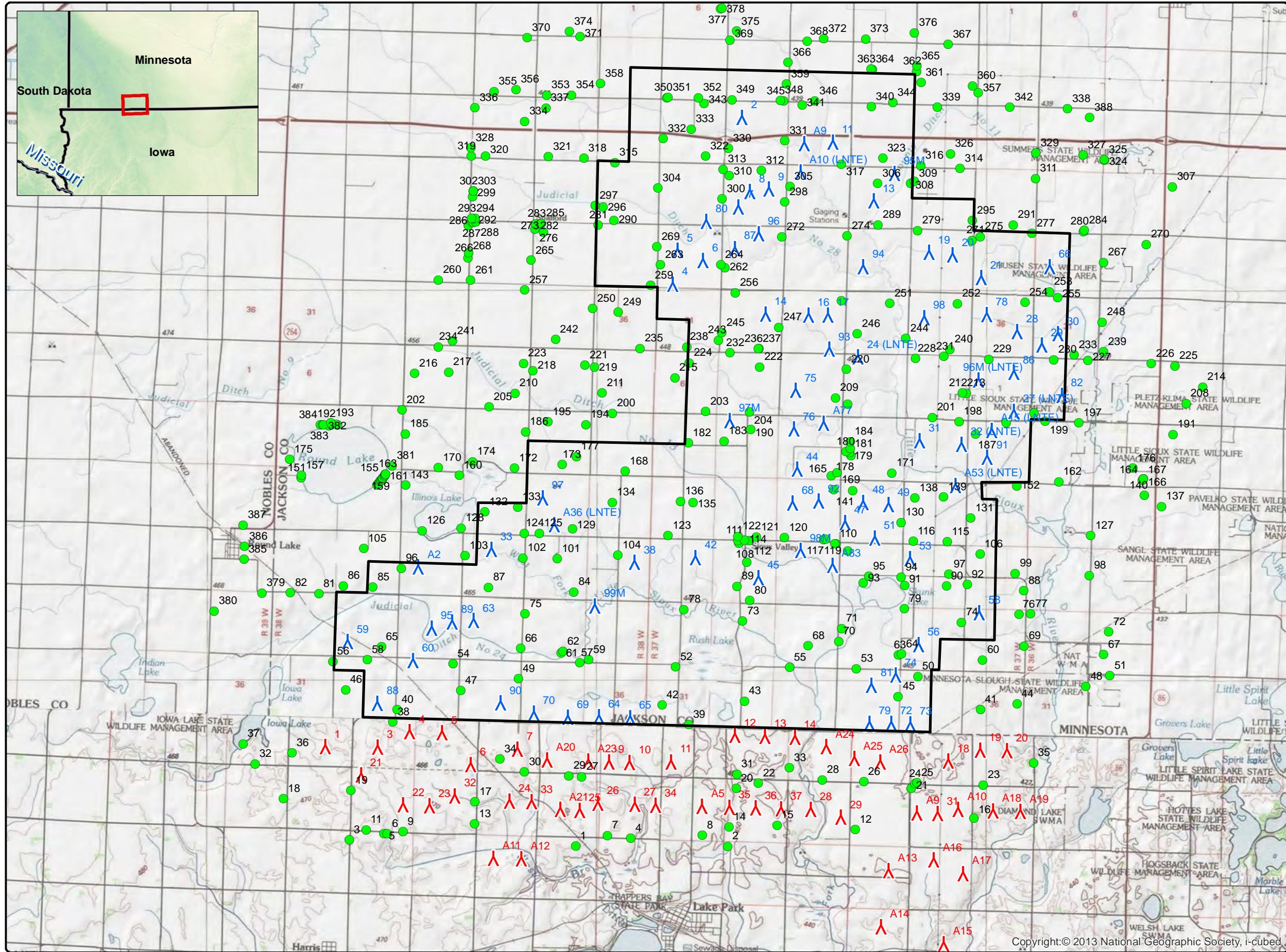
Location: Jackson and Nobles Countys, MN
Project #: 20193770

Issue Dates

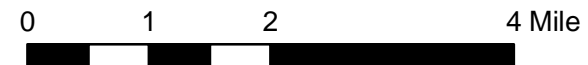
#	Description	Date
1	Original	2019.09.29

Drawn By: AS **Checked By:** JH

- Legend**
- Project Boundary
 - ▲ Minnesota Turbines
 - ▲ Iowa Turbines
 - Occupied Residences



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APPENDIX D: STANDARD RESOLUTION SHADOW FLICKER MAPS



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Three Waters Wind Farm Shadow Flicker Iso-Lines

Client

Wenck Associates

Project Description

Shadow Flicker for GE 2.82-127 WTG's with 89 m hub height.

Realistic shadow flicker map and receptors within 2 miles of turbines.

Assumes statistical reduction due to sunshine probability, turbine orientation and operation probability. Sensors in "greenhouse" mode. No obstacles.

Location: Jackson and Nobles Countys, MN
Project #: 20193770

Issue Dates

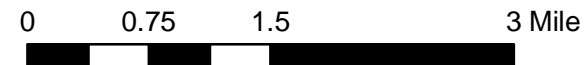
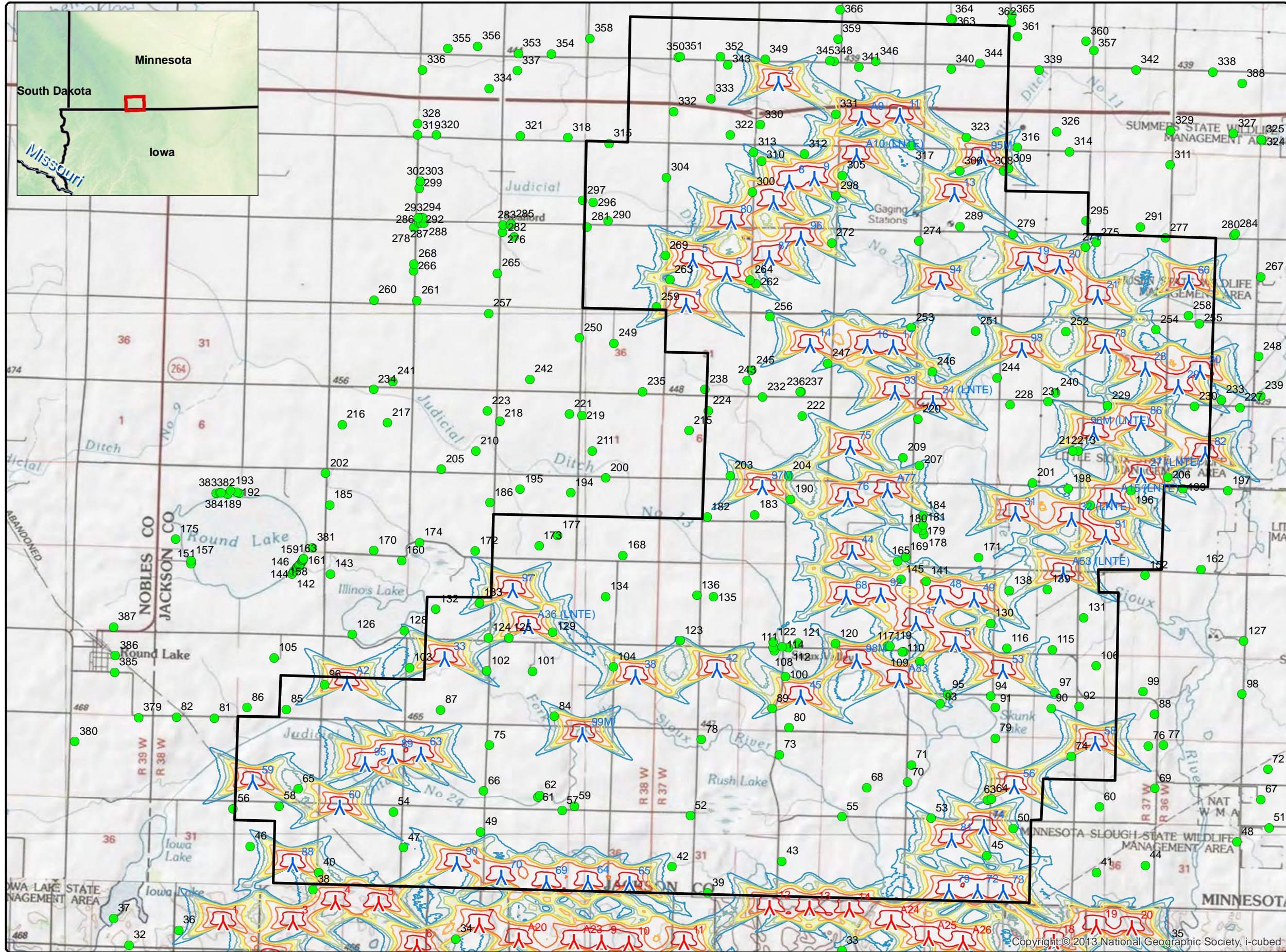
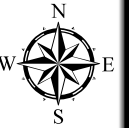
#	Description	Date
1	Original	2019.09.29

Drawn By: AS Checked By: JH

Legend

- Project Boundary
 - Minnesota Turbines
 - Iowa Turbines
 - Occupied Residences
- Shadow Flicker (hr/yr)**
- 10
 - 15
 - 20
 - 25
 - 30
 - 50
 - 100

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Three Waters Wind Farm Shadow Flicker Iso-Lines

Client

Wenck Associates

Project Description

Shadow Flicker for GE 2.82-127 WTG's with 114 m hub height.

Realistic shadow flicker map and receptors within 2 miles of turbines.

Assumes statistical reduction due to sunshine probability, turbine orientation and operation probability. Sensors in "greenhouse" mode. No obstacles.

Location: Jackson and Nobles Countys, MN
Project #: 20193770

Issue Dates

#	Description	Date
1	Original	2019.09.29

Drawn By: AS Checked By: JH

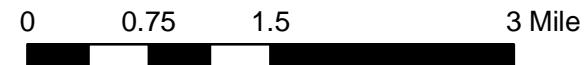
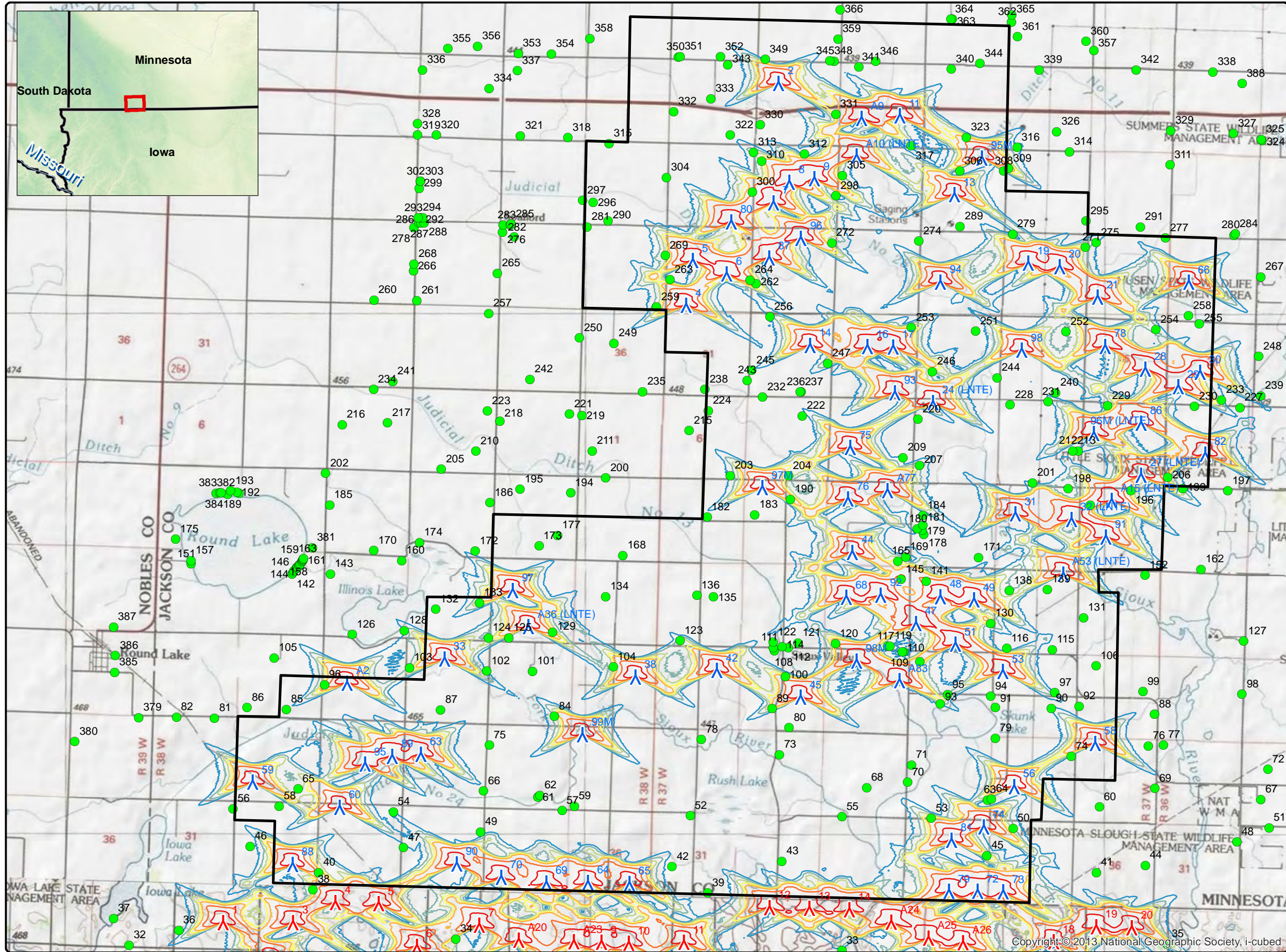
Legend

- Project Boundary
- Minnesota Turbines
- Iowa Turbines
- Occupied Residences

Shadow Flicker (hr/yr)

- 10
- 15
- 20
- 25
- 30
- 50
- 100

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