

Shadow Flicker Impact Analysis
for the
Brady II Wind Energy Center
Hettinger and Stark Counties, North Dakota

Prepared for

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Acronyms and Abbreviations

Brady Wind	Brady Wind II, LLC
GE	General Electric
Hz	Hertz
NCDC	National Climatic Data Center
Project	Brady II Wind Energy Center Project
rpm	rotations per minute
UTM	Universal Transverse Mercator

OVERVIEW

Brady Wind II, LLC (Brady II), a wholly owned, indirect subsidiary of NextEra Energy Resources, LLC (NEER), is proposing to develop the Brady II Wind Energy Center (the Project) in Hettinger County, North Dakota. The Project includes up to 72 wind turbines with a maximum nameplate capacity of approximately 150 megawatts. Tetra Tech has conducted the following shadow flicker analysis for the Project to support Brady Wind's application for a Certificate of Site Compatibility under the North Dakota Public Service Commission.

PROJECT COMPONENTS

2.0 The Project will consist of up to 72 wind turbines. Seven (7) of the turbines will be the GE 1.79-100 turbine model and the rest of turbines will be the General Electric (GE) 2.1-116 turbine model. The two wind turbine models being considered for the Project, and evaluated for potential shadow flicker impacts, have the following characteristics:

- **GE 1.79 100** – 3-blade 100-meter diameter rotor, with a hub height of 80 meters and generating capacity of 1.79 MW. The GE 1.79-100 has a normal high rotor speed of 17.5 rotations per minute (rpm) which translates to a blade pass frequency of 0.87 hertz (Hz) (less than 1 alternation per second). The Project will include up to 7 GE 1.79-100 turbines.
- **GE 2.1-116** – 3-blade 116-meter diameter rotor, with a hub height of 80 meters and generating capacity of 2.1 MW. The GE 2.1-116 has a normal high rotor speed of 15.7 rpm which translates to a blade pass frequency of 0.79 Hz (less than 1 alternation per second). The Project will include up to 65 GE 1.715-100 turbines.

3.0

SHADOW FLICKER BACKGROUND

A wind turbine's moving blades can cast a moving shadow on locations within a certain distance of a turbine. These moving shadows are called shadow flicker, and can be a temporary phenomenon experienced at nearby residences or public gathering places. The impact area depends on the time of year and day (which determine the sun's azimuth and altitude angles) and the wind turbine's physical characteristics (height, rotor diameter, blade width, and orientation of the rotor blades). Shadow flicker impact to surrounding properties generally occurs during low angle sunlight conditions, typically during sunrise and sunset times of the day. However, when the sun angle gets very low (less than 3 degrees), sunlight passes through more atmosphere and becomes too diffused to form a coherent shadow. Shadow flicker will not occur when the sun is obscured by clouds or fog, at night, or when the source turbine(s) are not operating. In addition, shadow flicker is only an issue when at least 20 percent of the sun's disc is covered by the turbine blades.

Shadow flicker intensity is defined as the difference in brightness at a given location in the presence and absence of a shadow. Shadow flicker intensity diminishes with greater receptor-to-turbine separation distance. Shadow flicker intensity for receptor-to-turbine distances beyond 2,500 meters (8,202 feet) is very low and generally considered imperceptible. In general, increasing proximity to turbines may make shadow flicker more noticeable, with the largest number of shadow flicker hours, along with greatest shadow flicker intensity, occurring nearest the wind turbines.

Shadow flicker frequency is related to the wind turbine's rotor blade speed and the number of blades on the rotor. From a health standpoint, the low flicker frequencies associated with wind turbines, are harmless, and public concerns that flickering light from wind turbines can have negative health effects, such as triggering seizures in people with epilepsy are unfounded. Epilepsy Action (working name for the British Epilepsy Foundation) states that there is no evidence that wind turbines can cause seizures (Epilepsy Action 2008). However, they recommend that wind turbine flicker frequency be limited to 3 Hz. (For comparison, strobe lights used in discotheques have frequencies which range from about 3 Hz to 10 Hz (1 Hz = 1 flash per second). Since the proposed Project's wind turbine blade pass frequency is approximately 0.87 Hz (less than 1 alternation per second), no negative health effects to individuals with photosensitive epilepsy are anticipated.

Shadow flicker impacts are not regulated in applicable state or federal law, and there is no permitting threshold with regard to hours per year of anticipated impacts to a receptor from a wind energy project.

4.0

WINDPRO SHADOW FLICKER ANALYSIS

An analysis of potential shadow flicker impacts from the Project was conducted using the WindPro software package. As described above, the Project will install up to 72 wind turbines (7 GE 1.79-100 and the rest GE 2.1-116 model turbines). While only 72 turbines will be constructed, 77 turbines have been evaluated with WindPro so that the analysis includes assessment of up to 5 alternative turbine locations (layout dated April 22, 2016).

In addition to the assessment of the Brady II Wind Energy Center Project, a cumulative impact assessment with the Brady Wind Energy Center was also conducted. The Brady Wind Energy Center is proposed to be constructed starting in May immediately to the north of Brady II in Stark County, ND and will consist of up to 87 wind turbines (80 GE 1.715 MW and 7 GE 1.79 MW). The GE 1.715 MW turbine has a hub height of 80 meters and a rotor diameter of 103 meters.

The analysis evaluated the following three turbine layout scenarios:

- Scenario A – 72 wind turbines (Brady II primary turbines only)
- Scenario B – 77 wind turbines (Brady II primary plus alternate turbines)
- Scenario C – 159 wind turbines (Brady II plus Brady – primary turbines only)

The WindPro analysis was conducted to determine shadow flicker impacts under realistic impact conditions (actual expected shadow). This analysis calculated the total amount of time (hours and minutes per year) that shadow flicker could occur at receptors surrounding the Project. The realistic impact condition scenario is based on the following assumptions:

- The elevation and position geometries of the wind turbines and surrounding receptors (inhabited residences). Elevations were determined using U.S. Geological Survey digital elevation model data. Positions geometries were determined using geographic information system and referenced to Universal Transverse Mercator (UTM) Zone 13 (NAD83).
- The position of the sun and the incident sunlight relative to the wind turbine and receptors on a minute-by-minute basis over the course of a year.
- Historical sunshine availability (percent of total hours available). Historical sunshine rates for the area (as summarized by the National Climatic Data Center [NOAA 2012] for nearby Bismarck, North Dakota) used in this analysis are as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
53%	53%	58%	58%	61%	64%	73%	72%	65%	58%	43%	47%

- Estimated wind turbine operations and orientation (based on approximately 5 years of wind data (6/15/2006–10/19/2011), including wind speed/wind direction frequency distribution, measured at a meteorological tower located approximately 50 miles northeast of the Project).
- Receptor viewpoints (i.e., house windows) are assumed to always be directly facing turbine to sun line of sight (“greenhouse mode”).

WindPro incorporates terrain elevation contour information and the analysis accounts for terrain elevation differences. The sun’s path with respect to each turbine location is calculated by the software to determine the cast shadow paths every minute over a full year. Sun angles less than 3 degrees above the horizon were excluded, for the reasons identified earlier in Section 3. Since shadow flicker is only an issue when at least 20 percent of the sun disc is covered by the blades, WindPro uses blade width dimension data to calculate the maximum distance from the turbine where shadow flicker must be calculated. Beyond this distance, the turbine will not contribute to the shadow flicker impact. It should be noted however, that WindPro provides a conservative estimate of shadow flicker as obstacles such as trees, haze, and visual obstructions (window facing, coverings) are not accounted for despite the likelihood of their reducing or eliminating shadow flicker impacts to some receptors.

A total of 175 structures were identified within and near the Project Area; of these, 114 were determined to be inhabited or potentially inhabited residences and are considered potential shadow-flicker receptors for the purpose of this analysis. A receptor in the model is defined as a

1 meter squared area (approximate size of a typical window), 3.28 feet (1 meter) above ground level. Approximate eye level is set at 4.94 feet (1.5 meters). Figure 1 shows the locations of all identified structures and the 114 shadow flicker receptors (inhabited residences), along with the 77 potential turbine locations considered. A detailed description of the turbine and receptor locations is shown on topographic sheet maps provided in Attachment A.

SHADOW FLICKER ANALYSIS RESULTS

As expected, WindPro predicts that shadow flicker impacts will be greatest at locations nearer to the wind turbines. Figures 2 illustrates the WindPro predicted shadow flicker impact areas for the 72 planned Brady II turbines (Scenario A). Figure 3 illustrates the WindPro predicted shadow flicker impacts for the 72 planned and 5 alternate turbine locations (Scenario B). Figure 4 illustrates the WindPro predicted shadow flicker impacts for the 72 planned Brady II turbines as well as the 87 planned Brady turbine locations (Scenario C). A detailed WindPro shadow flicker analysis summary, for each of the modeled receptor location, is provided in Attachment B.

Tables 1, 2, and 3 present the WindPro predicted shadow flicker impacts for the top ten worst case impacts for the 114 identified receptors (inhabited residences), for the turbine scenarios A, B, and C, respectively. The predicted shadow flicker for all 114 inhabited residential receptors is presented in Appendix A. Because the Project is using a minimum turbine siting setback requirement of 2,000 feet (609.6 meters) to inhabited residences, the most sensitive receptors are generally not located in the high potential shadow flicker impact zones. The maximum predicted shadow flicker impact at any inhabited residence receptor is 13 hours and 9 minutes per year (Receptor 610149) if only the 72 planned turbines are constructed, and 13 hours 49 minutes per year (Receptor 501118), if the alternate turbines are also included in the analysis.

In the cumulative analysis, the maximum predicted cumulative shadow flicker impact at any inhabited residence receptor is 44 hours and 55 minutes per year (Receptor 880001) if the 159 planned turbines for both Brady and Brady II are constructed. The highest predicted shadow flicker impacts, 44 hours and 55 minutes, is approximately 1.0 percent of the potential available daylight hours. There are two occupied residences with shadow flicker impacts greater than 30 hours per year (Scenario C). These are the same residences identified in the Brady Wind shadow flicker report as being expected to have shadow flicker impacts over 30 hours per year, meaning that between the Brady I and Brady II project there are only two occupied residences that are expected to experience shadow flicker impacts greater than 30 hours per year. As referenced in the Brady shadow flicker report, both of these residences are owned by landowners that are participating in the Brady Project.

Table 1. WindPro Predicted Shadow Flicker Impacts for Inhabited Receptors – Scenario A

Receptor ID	Shadow Hours per Year (expected) [hh:mm / year]	Receptor Type	Project Participation Status	Distance to Nearest Turbine (meters)
610149	13:09:00	house	Not Participating	1050
501138	10:53:00	house	Participating	690
501118	10:39:00	house	Not Participating	1123
500028	9:29:00	house	Not Participating	870
800311	9:07:00	FEMA trailer	Participating	903
800308	9:05:00	FEMA trailer	Participating	861
500022	7:10:00	house	Not Participating	924
501156	5:00:00	house	Participating	717
610084	2:56:00	trailer home	Not Participating *	1197
501085	2:15:00	trailer house	Not Participating	901

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowner at these receptor are participants of the Project on property located elsewhere in the Project Area.

Table 2. WindPro Predicted Shadow Flicker Impacts for Inhabited Receptors – Scenario B

Receptor ID	Shadow Hours per Year (expected) [hh:mm / year]	Receptor Type	Project Participation Status	Distance to Nearest Turbine (meters)
501118	13:49:00	house	Not Participating	1123
610149	13:09:00	house	Not Participating	1050
501138	10:53:00	house	Participating	690
500028	9:29:00	house	Not Participating	870
800311	9:07:00	FEMA trailer	Participating	903
800308	9:05:00	FEMA trailer	Participating	861
500022	7:10:00	house	Not Participating	924
900019	7:10:00	house	Not Participating	1361
900015	6:49:00	house & garage	Not Participating	1388
501156	5:00:00	house	Participating	717

Table 3. WindPro Predicted Shadow Flicker Impacts for Inhabited Receptors – Scenario C

Receptor ID	Shadow Hours per Year (expected) [hh:mm / year]	Receptor Type	Project Participation Status	Distance to Nearest Turbine (meters)
880001 *	44:55:00	new house	Not Participating	649
610121	35:08:00	house	Participating	672
610053	27:40:00	house	Not Participating	671
610181	23:24:00	house	Participating	729
610057	22:25:00	future trailer home	Not Participating	671
501068	21:59:00	house	Not Participating	630
610049	19:59:00	house	Not Participating	648
610185	19:02:00	house	Participating	696
420119	16:49:00	future trailer home	Not Participating	712
501059	16:28:00	portable home	Not Participating	730

Note: The cumulative shadow flicker assessment was analyzed using Brady Wind Energy Center and Brady II Wind Energy Center site layouts dated November 6, 2015, and April 22, 2016, respectively. If either facility site layout is modified, potential shadow flicker impacts will be reanalyzed to ensure consistency with the PSC's shadow flicker requirements.

* Receptor 880001 is participating in the Brady Wind project which are the turbines impacting the residence.

The shadow flicker impact prediction statistics are summarized in Tables 4, 5 and 6 below.

Table 4. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Receptor Locations – Scenario A

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	114
= 0 Hours	99
> 0 Hours < 10 Hours	12
≥ 10 Hours < 20 Hours	3
≥ 20 Hours < 30 Hours	0
≥ 30 Hours	0

Table 5. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Receptor Locations – Scenario B

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	114
= 0 Hours	97
> 0 Hours < 10 Hours	14
≥ 10 Hours < 20 Hours	3
≥ 20 Hours < 30 Hours	0
≥ 30 Hours	0

Table 6. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Receptor Locations – Scenario C

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	114
= 0 Hours	71
> 0 Hours < 10 Hours	24
≥ 10 Hours < 20 Hours	13
≥ 20 Hours < 30 Hours	4
≥ 30 Hours	2

CONCLUSION

6.0

The analysis of potential shadow flicker impacts from the Project on nearby receptors shows that shadow flicker impacts within the area of study are expected to be minor and well within acceptable ranges for avoiding nuisance conditions. Shadow flicker is not expected to be a significant environmental impact.

The analysis was deliberately conservative and actual shadow flicker is expected to occur for less than the modeled durations. The analysis assumes that the receptors all have a direct in-line view of the incoming shadow flicker sunlight and does not account for trees or other obstructions which may block sunlight. In reality, the windows of many houses will not face the sun directly for the key shadow flicker impact times. Adding to the analysis' conservatism, Brady II will only construct up to 72 turbines, which is fewer wind turbines than were included in the Scenario B (77 turbines including alternates) modeled results.

REFERENCES

- Epilepsy Action. 2008. Information Web Page on Photosensitive Epilepsy. British Epilepsy Association. http://www.epilepsy.org.uk/info/photo_other.html. Accessed November 2015.
- National Oceanic and Atmospheric Administration (NOAA). 2012. Comparative Climatic Data for the United States through 2012.

Figures

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 NORTH DAKOTA

FIGURE 1
 TURBINE AND RECEPTOR
 LOCATIONS

MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

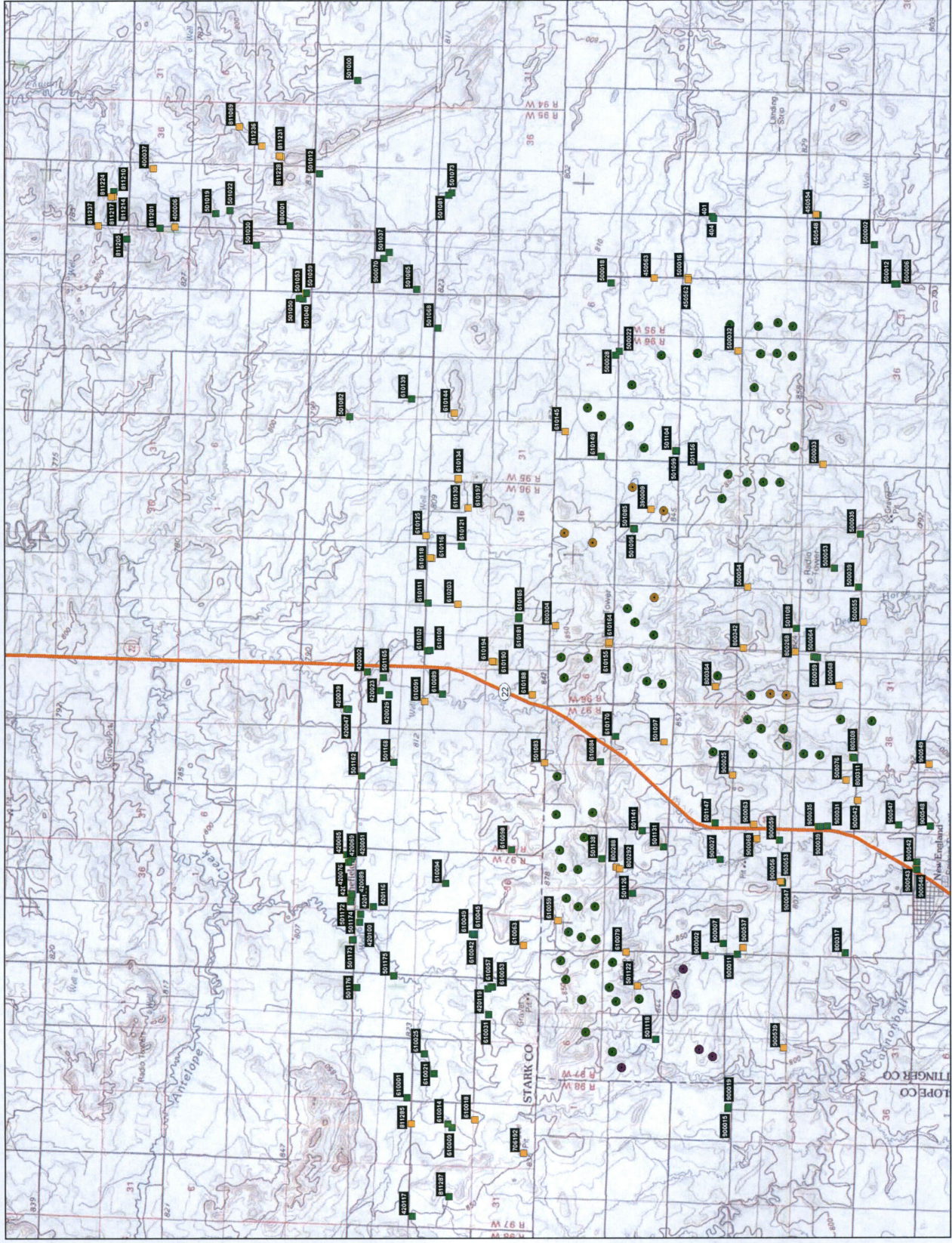
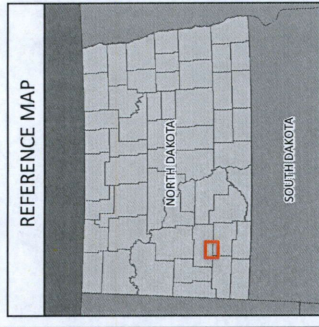
- GE Xle 2.1-116 Turbine
- GE Xle 2.1-116 Turbine (Alt)
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied
- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES



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FIGURE 2
 EXPECTED SHADOW FLICKER
 IMPACT AREAS (SCENARIO A –
 PRIMARY TURBINES ONLY)

MAY 2016

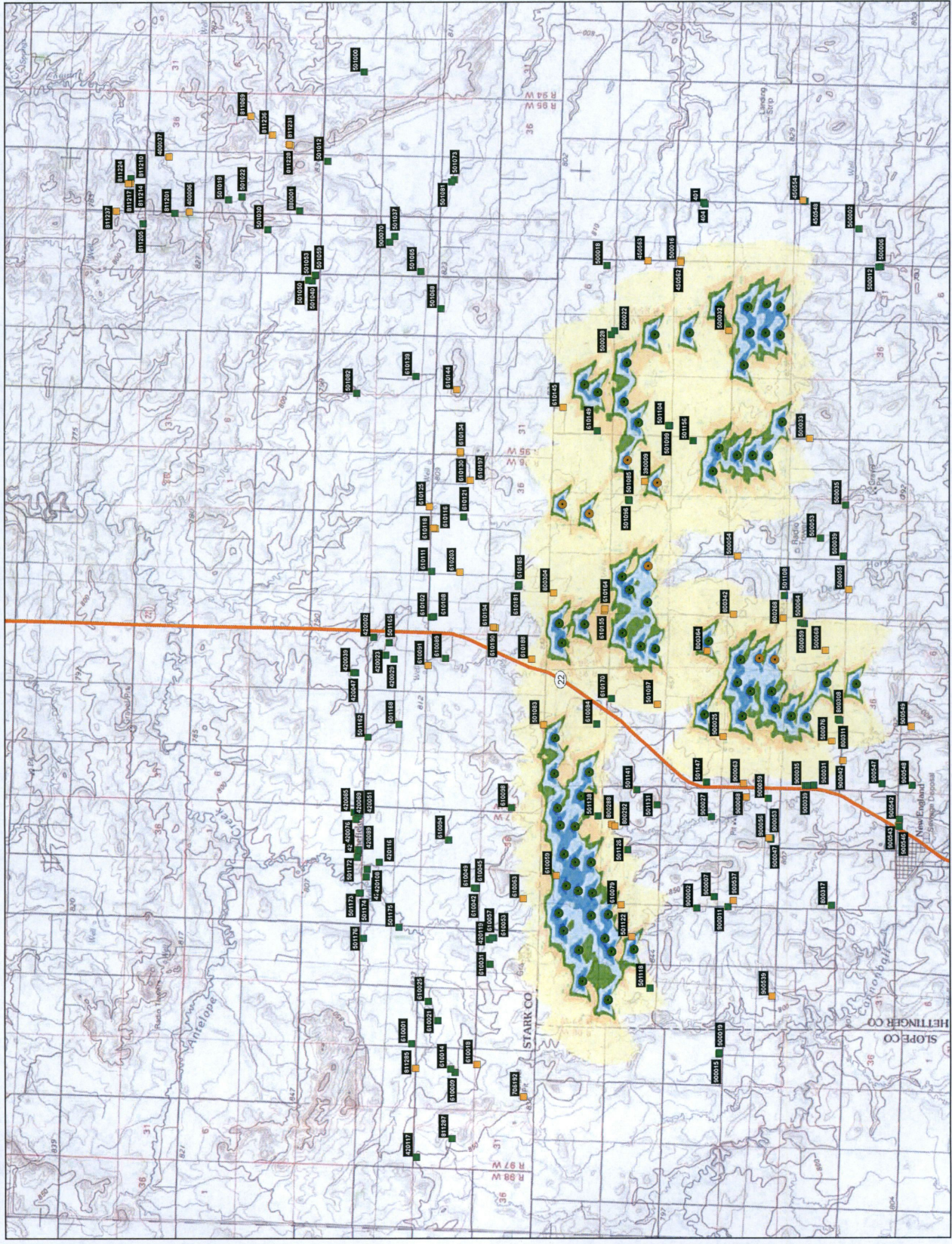
Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 1.75-100 Turbine
- Receptors
 - Occupied
 - Not Occupied
- Shadow Flicker (hours per year)
 - 0 - 15
 - >15 - 30
 - >30 - 50
 - >50 - 100
 - >100 - 200
 - >200
- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



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FIGURE 3
 EXPECTED SHADOW FLICKER
 IMPACT AREAS (SCENARIO B –
 PRIMARY PLUS ALTERNATE
 TURBINES)

MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 2.1-116 Turbine (Alt)
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied

Shadow Flicker (hours per year)

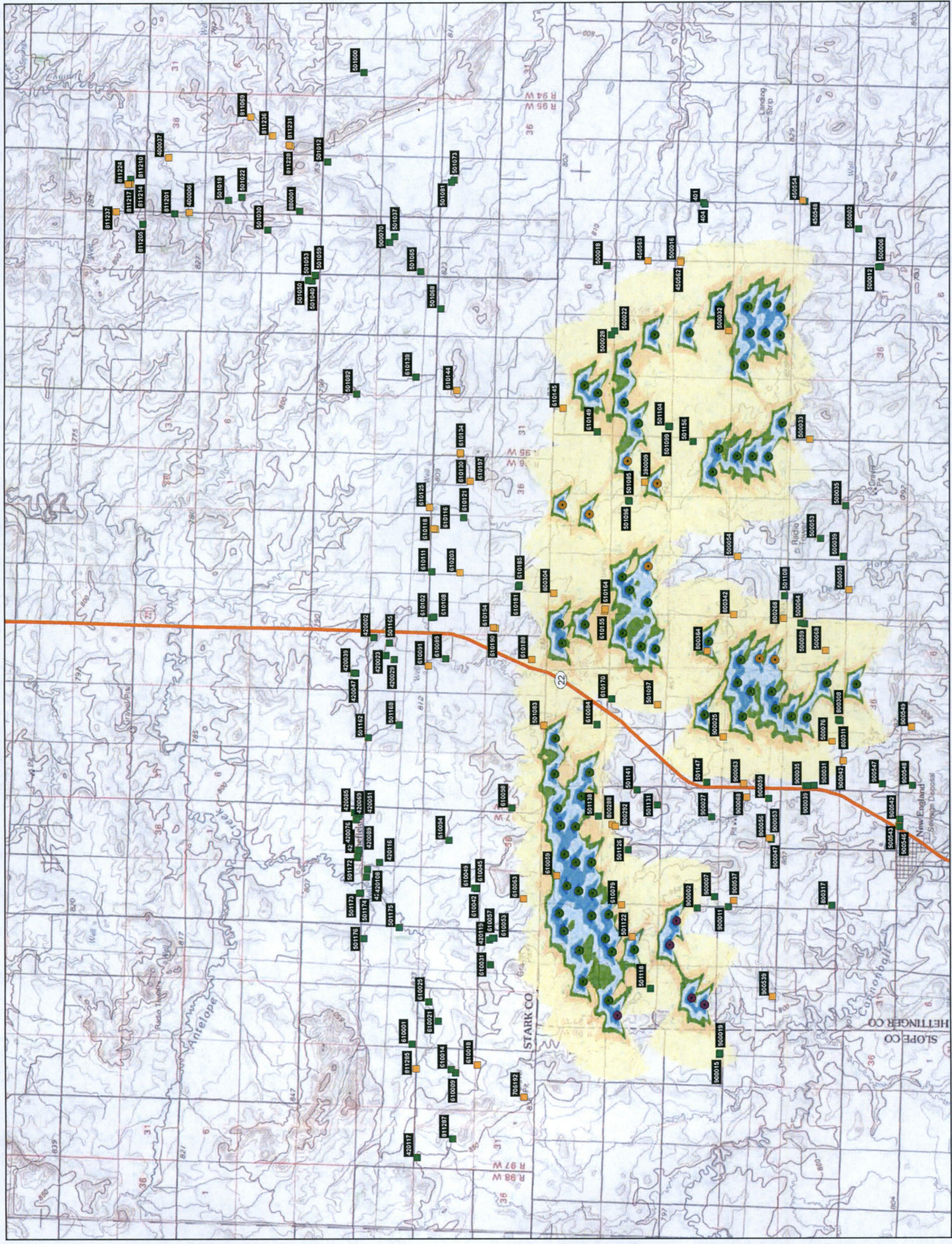
- 0 - 15
- >15 - 30
- >30 - 50
- >50 - 100
- >100 - 200
- >200

- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



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 HETTINGER AND STARK COUNTIES
 NORTH DAKOTA

FIGURE 4
 EXPECTED SHADOW FLICKER
 IMPACT AREAS (SCENARIO C –
 BRADY AND BRADY II
 PRIMARY TURBINES ONLY)

MAY 2016

Brady Proposed Turbine Array (11/6/2015)

- GE Xle 1.715-103 Turbine
- GE Xle 1.79-100 Turbine
- GE Xle 2.1-116 Turbine
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied

Shadow Flicker (hours per year)

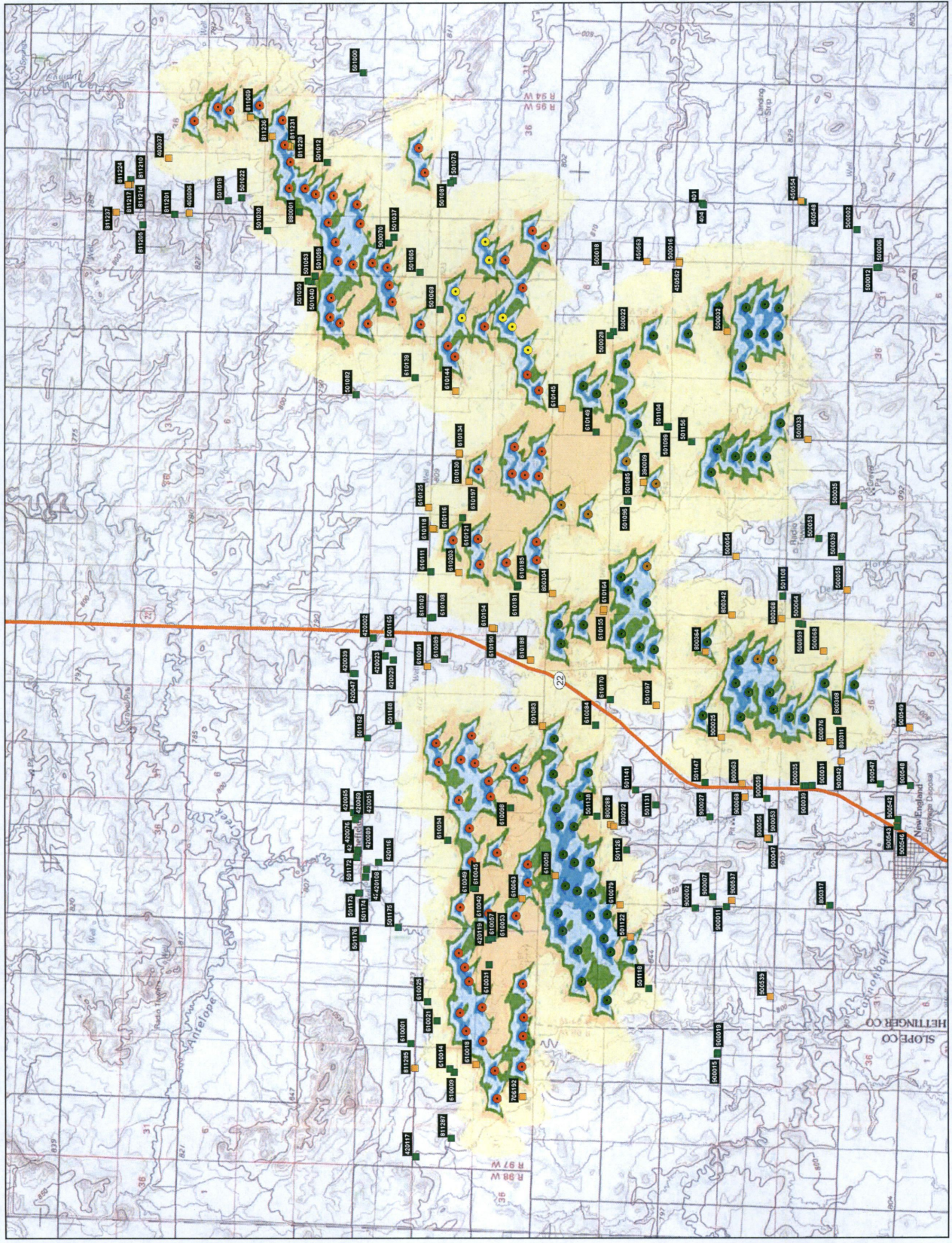
- 0 - 15
- >15 - 30
- >30 - 50
- >50 - 100
- >100 - 200
- >200

- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



**Attachment A:
Detailed Summary of WindPro Shadow Flicker Analysis Results**

Detailed Summary of WindPro Shadow Flicker Analysis Results – Scenario A

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status	Distance to Nearest Turbine (m)
401 *	681,106	5,162,818	0:00:00	Not Participating	2819
404 *	681,064	5,162,775	0:00:00	Not Participating	2768
420002	668,875	5,171,095	0:00:00	Not Participating	5033
420023	668,410	5,170,735	0:00:00	Not Participating	4764
420029	668,316	5,170,507	0:00:00	Not Participating	4557
420039	667,891	5,171,580	0:00:00	Not Participating	5689
420047	667,886	5,171,532	0:00:00	Not Participating	5642
420051	664,044	5,171,213	0:00:00	Not Participating	5361
420065	664,088	5,171,360	0:00:00	Not Participating	5505
420069	663,975	5,171,244	0:00:00	Not Participating	5398
420076	663,894	5,171,299	0:00:00	Not Participating	5462
420089	663,065	5,171,180	0:00:00	Not Participating	5492
420090	662,974	5,171,187	0:00:00	Not Participating	5516
420100	662,342	5,170,932	0:00:00	Not Participating	5299
420108	662,543	5,170,920	0:00:00	Not Participating	5316
420116	662,765	5,170,601	0:00:00	Not Participating	4992
420117	654,920	5,169,153	0:00:00	Not Participating	6501
420119	660,825	5,167,514	0:00:00	Not Participating	2013
450548	681,287	5,160,073	0:00:00	Not Participating	2935
500002	680,617	5,158,589	0:00:00	Not Participating	2988
500006	679,633	5,157,936	0:00:00	Not Participating	2927
500012	679,628	5,157,991	0:00:00	Not Participating	2875
500018	679,256	5,165,366	0:00:00	Not Participating	2275
500022	677,510	5,165,047	7:10:00	Not Participating	924
500028	677,401	5,165,136	9:29:00	Not Participating	870
500035*	673,147	5,158,516	0:00:00	Not Participating	2489
500039	671,766	5,158,494	0:00:00	Not Participating	3356
500053	672,221	5,159,146	0:00:00	Not Participating	2638
500059*	669,892	5,159,454	0:35:00	Not Participating	1261
500064*	669,899	5,159,550	0:00:00	Not Participating	1213
501000	684,105	5,172,245	0:00:00	Not Participating	10357
501012	681,646	5,173,097	0:00:00	Not Participating	9231
501019	680,468	5,175,745	0:00:00	Not Participating	10909
501022	680,563	5,175,382	0:00:00	Not Participating	10620
501030	679,723	5,174,632	0:00:00	Not Participating	9592
501037	679,731	5,171,167	0:00:00	Not Participating	6541
501040	678,406	5,173,332	0:00:00	Not Participating	7915
501050	678,419	5,173,433	0:00:00	Not Participating	8015

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status	Distance to Nearest Turbine (m)
501059	678,568	5,173,250	0:00:00	Not Participating	7888
501065	678,822	5,170,399	0:00:00	Not Participating	5401
501068	677,851	5,169,797	0:00:00	Not Participating	4411
501073	681,345	5,169,634	0:00:00	Not Participating	6580
501081	681,279	5,169,706	0:00:00	Not Participating	6568
501082	675,433	5,171,946	0:00:00	Not Participating	6182
501085	672,965	5,164,410	2:15:00	Not Participating	901
501096	672,947	5,164,396	2:07:00	Not Participating	899
501099	675,017	5,163,411	1:08:00	Participating	856
501104	675,027	5,163,439	1:07:00	Participating	828
501108	670,613	5,160,034	0:00:00	Not Participating	1742
501118	659,777	5,163,091	10:39:00	Not Participating	1123
501126	663,477	5,163,902	0:00:00	Not Participating	1049
501131	664,747	5,163,175	0:00:00	Not Participating	2051
501138	664,349	5,164,755	10:53:00	Participating	690
501141	665,127	5,163,747	0:00:00	Not Participating	1382
501147	665,442	5,161,863	0:00:00	Not Participating	1855
501156	674,657	5,162,748	5:00:00	Participating	717
501162	666,164	5,171,091	0:00:00	Not Participating	5054
501165	668,751	5,170,669	0:00:00	Not Participating	4630
501168	666,562	5,170,280	0:00:00	Not Participating	4237
501172	662,856	5,171,199	0:00:00	Not Participating	5552
501173	661,884	5,171,096	0:00:00	Not Participating	5422
501174	661,893	5,171,077	0:00:00	Not Participating	5404
501175	661,018	5,169,979	0:00:00	Not Participating	4347
501176	660,668	5,170,916	0:00:00	Not Participating	5329
610001	657,943	5,169,457	0:00:00	Not Participating	4918
610009	657,243	5,168,249	0:00:00	Not Participating	4229
610014	657,329	5,168,365	0:00:00	Not Participating	4270
610021	658,588	5,168,791	0:00:00	Not Participating	4068
610025	659,083	5,169,071	0:00:00	Not Participating	4125
610031	660,171	5,167,459	0:00:00	Not Participating	2186
610042	662,190	5,167,946	0:00:00	Not Participating	2330
610045	662,204	5,167,951	0:00:00	Not Participating	2338
610049	662,204	5,167,996	0:00:00	Not Participating	2382
610053	660,882	5,167,398	0:00:00	Not Participating	1884
610057	660,875	5,167,437	0:00:00	Not Participating	1922
610084 *	666,867	5,164,930	2:56:00	Not Participating	1197
610089*	668,413	5,169,125	0:00:00	Not Participating	3179
610094	663,473	5,168,761	0:00:00	Not Participating	3040
610098	664,446	5,167,109	0:00:00	Not Participating	1239

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status	Distance to Nearest Turbine (m)
610102*	669,505	5,169,577	0:00:00	Not Participating	3472
610108*	669,518	5,169,514	0:00:00	Not Participating	3409
610111	670,742	5,169,632	0:00:00	Not Participating	3729
610121*	672,258	5,168,851	0:00:00	Participating	2694
610139	675,979	5,170,362	0:00:00	Not Participating	4572
610149	674,773	5,165,354	13:09:00	Not Participating	1050
610170	667,574	5,164,565	1:12:00	Participating	1627
610181	670,466	5,167,264	0:00:00	Participating	1490
610185	670,516	5,167,245	0:00:00	Participating	1507
800308	667,354	5,158,391	9:05:00	Participating	861
800311	667,332	5,158,349	9:07:00	Participating	903
800317	662,260	5,158,285	0:00:00	Not Participating	5195
811201	680,019	5,177,169	0:00:00	Not Participating	12066
811205	679,691	5,178,020	0:00:00	Not Participating	12773
811210	680,887	5,178,421	0:00:00	Not Participating	13541
811287	655,467	5,168,218	0:00:00	Not Participating	5489
811290	650,090	5,167,200	0:00:00	Not Participating	9782
880001**	680,270	5,173,773	0:00:00	Not Participating	9051
900002	661,988	5,161,930	0:00:00	Participating	2051
900007	662,323	5,161,469	0:00:00	Participating	2621
900011	662,065	5,161,089	0:00:00	Not Participating	2810
900015	658,130	5,161,120	0:00:00	Not Participating	3339
900019	658,166	5,161,105	0:00:00	Not Participating	3340
900027	664,500	5,161,670	0:00:00	Not Participating	2813
900031	665,522	5,158,935	0:00:00	Not Participating	1869
900035*	665,494	5,159,171	0:00:00	Not Participating	1872
900039*	665,496	5,159,110	0:00:00	Not Participating	1873
900047	663,971	5,160,025	0:00:00	Not Participating	3418
900053	664,011	5,160,036	0:00:00	Not Participating	3379
900059	665,090	5,160,153	0:00:00	Not Participating	2331
900070	679,567	5,171,280	0:00:00	Not Participating	6543
900542	664,710	5,156,553	0:00:00	Not Participating	3785
900546	664,516	5,156,546	0:00:00	Not Participating	3929
900547	665,655	5,157,082	0:00:00	Not Participating	2762
900548	665,667	5,156,254	0:00:00	Not Participating	3165

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

** Receptor 880001 is participating in the Brady Wind project which are the turbines impacting the residence.

Detailed Summary of WindPro Shadow Flicker Analysis Results – Scenario B

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status	Distance to Nearest Turbine (m)
401 *	681,106	5,162,818	0:00:00	Not Participating	2819
404 *	681,064	5,162,775	0:00:00	Not Participating	2768
420002	668,875	5,171,095	0:00:00	Not Participating	5033
420023	668,410	5,170,735	0:00:00	Not Participating	4764
420029	668,316	5,170,507	0:00:00	Not Participating	4557
420039	667,891	5,171,580	0:00:00	Not Participating	5689
420047	667,886	5,171,532	0:00:00	Not Participating	5642
420051	664,044	5,171,213	0:00:00	Not Participating	5361
420065	664,088	5,171,360	0:00:00	Not Participating	5505
420069	663,975	5,171,244	0:00:00	Not Participating	5398
420076	663,894	5,171,299	0:00:00	Not Participating	5462
420089	663,065	5,171,180	0:00:00	Not Participating	5492
420090	662,974	5,171,187	0:00:00	Not Participating	5516
420100	662,342	5,170,932	0:00:00	Not Participating	5299
420108	662,543	5,170,920	0:00:00	Not Participating	5316
420116	662,765	5,170,601	0:00:00	Not Participating	4992
420117	654,920	5,169,153	0:00:00	Not Participating	6501
420119	660,825	5,167,514	0:00:00	Not Participating	2013
450548	681,287	5,160,073	0:00:00	Not Participating	2935
500002	680,617	5,158,589	0:00:00	Not Participating	2988
500006	679,633	5,157,936	0:00:00	Not Participating	2927
500012	679,628	5,157,991	0:00:00	Not Participating	2875
500018	679,256	5,165,366	0:00:00	Not Participating	2275
500022	677,510	5,165,047	7:10:00	Not Participating	924
500028	677,401	5,165,136	9:29:00	Not Participating	870
500035*	673,147	5,158,516	0:00:00	Not Participating	2489
500039	671,766	5,158,494	0:00:00	Not Participating	3356
500053	672,221	5,159,146	0:00:00	Not Participating	2638
500059*	669,892	5,159,454	0:35:00	Not Participating	1261
500064*	669,899	5,159,550	0:00:00	Not Participating	1213
501000	684,105	5,172,245	0:00:00	Not Participating	10357
501012	681,646	5,173,097	0:00:00	Not Participating	9231
501019	680,468	5,175,745	0:00:00	Not Participating	10909
501022	680,563	5,175,382	0:00:00	Not Participating	10620
501030	679,723	5,174,632	0:00:00	Not Participating	9592
501037	679,731	5,171,167	0:00:00	Not Participating	6541
501040	678,406	5,173,332	0:00:00	Not Participating	7915
501050	678,419	5,173,433	0:00:00	Not Participating	8015

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

BRADY II WIND ENERGY CENTER

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status	Distance to Nearest Turbine (m)
501059	678,568	5,173,250	0:00:00	Not Participating	7888
501065	678,822	5,170,399	0:00:00	Not Participating	5401
501068	677,851	5,169,797	0:00:00	Not Participating	4411
501073	681,345	5,169,634	0:00:00	Not Participating	6580
501081	681,279	5,169,706	0:00:00	Not Participating	6568
501082	675,433	5,171,946	0:00:00	Not Participating	6182
501085	672,965	5,164,410	2:15:00	Not Participating	901
501096	672,947	5,164,396	2:07:00	Not Participating	899
501099	675,017	5,163,411	1:08:00	Participating	856
501104	675,027	5,163,439	1:07:00	Participating	828
501108	670,613	5,160,034	0:00:00	Not Participating	1742
501118	659,777	5,163,091	13:49:00	Not Participating	1123
501126	663,477	5,163,902	0:00:00	Not Participating	1049
501131	664,747	5,163,175	0:00:00	Not Participating	2051
501138	664,349	5,164,755	10:53:00	Participating	690
501141	665,127	5,163,747	0:00:00	Not Participating	1382
501147	665,442	5,161,863	0:00:00	Not Participating	1855
501156	674,657	5,162,748	5:00:00	Participating	717
501162	666,164	5,171,091	0:00:00	Not Participating	5054
501165	668,751	5,170,669	0:00:00	Not Participating	4630
501168	666,562	5,170,280	0:00:00	Not Participating	4237
501172	662,856	5,171,199	0:00:00	Not Participating	5552
501173	661,884	5,171,096	0:00:00	Not Participating	5422
501174	661,893	5,171,077	0:00:00	Not Participating	5404
501175	661,018	5,169,979	0:00:00	Not Participating	4347
501176	660,668	5,170,916	0:00:00	Not Participating	5329
610001	657,943	5,169,457	0:00:00	Not Participating	4918
610009	657,243	5,168,249	0:00:00	Not Participating	4229
610014	657,329	5,168,365	0:00:00	Not Participating	4270
610021	658,588	5,168,791	0:00:00	Not Participating	4068
610025	659,083	5,169,071	0:00:00	Not Participating	4125
610031	660,171	5,167,459	0:00:00	Not Participating	2186
610042	662,190	5,167,946	0:00:00	Not Participating	2330
610045	662,204	5,167,951	0:00:00	Not Participating	2338
610049	662,204	5,167,996	0:00:00	Not Participating	2382
610053	660,882	5,167,398	0:00:00	Not Participating	1884
610057	660,875	5,167,437	0:00:00	Not Participating	1922
610084*	666,867	5,164,930	2:56:00	Not Participating	1197
610089*	668,413	5,169,125	0:00:00	Not Participating	3179
610094	663,473	5,168,761	0:00:00	Not Participating	3040
610098	664,446	5,167,109	0:00:00	Not Participating	1239

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

BRADY II WIND ENERGY CENTER

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status	Distance to Nearest Turbine (m)
610102*	669,505	5,169,577	0:00:00	Not Participating	3472
610108*	669,518	5,169,514	0:00:00	Not Participating	3409
610111	670,742	5,169,632	0:00:00	Not Participating	3729
610121*	672,258	5,168,851	0:00:00	Participating	2694
610139	675,979	5,170,362	0:00:00	Not Participating	4572
610149	674,773	5,165,354	13:09:00	Not Participating	1050
610170	667,574	5,164,565	1:12:00	Participating	1627
610181	670,466	5,167,264	0:00:00	Participating	1490
610185	670,516	5,167,245	0:00:00	Participating	1507
800308	667,354	5,158,391	9:05:00	Participating	861
800311	667,332	5,158,349	9:07:00	Participating	903
800317	662,260	5,158,285	0:00:00	Not Participating	4253
811201	680,019	5,177,169	0:00:00	Not Participating	12066
811205	679,691	5,178,020	0:00:00	Not Participating	12773
811210	680,887	5,178,421	0:00:00	Not Participating	13541
811287	655,467	5,168,218	0:00:00	Not Participating	5489
811290	650,090	5,167,200	0:00:00	Not Participating	9500
880001	680,270	5,173,773	0:00:00	Not Participating	9051
900002	661,988	5,161,930	0:00:00	Participating	670
900007	662,323	5,161,469	0:00:00	Participating	1240
900011	662,065	5,161,089	0:00:00	Not Participating	1469
900015	658,130	5,161,120	6:49:00	Not Participating	1388
900019	658,166	5,161,105	7:10:00	Not Participating	1361
900027	664,500	5,161,670	0:00:00	Not Participating	2813
900031	665,522	5,158,935	0:00:00	Not Participating	1869
900035*	665,494	5,159,171	0:00:00	Not Participating	1872
900039*	665,496	5,159,110	0:00:00	Not Participating	1873
900047	663,971	5,160,025	0:00:00	Not Participating	3407
900053	664,011	5,160,036	0:00:00	Not Participating	3379
900059	665,090	5,160,153	0:00:00	Not Participating	2331
900070	679,567	5,171,280	0:00:00	Not Participating	6543
900542	664,710	5,156,553	0:00:00	Not Participating	3785
900546	664,516	5,156,546	0:00:00	Not Participating	3929
900547	665,655	5,157,082	0:00:00	Not Participating	2762
900548	665,667	5,156,254	0:00:00	Not Participating	3165

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

Detailed Summary of WindPro Shadow Flicker Analysis Results – Scenario C

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Distance to Nearest Turbine (m)	Participation Status
401 *	681,106	5,162,818	0:00:00	2819	Not Participating
404 *	681,064	5,162,775	0:00:00	2768	Not Participating
420002	668,875	5,171,095	0:00:00	3314	Not Participating
420023	668,410	5,170,735	0:00:00	2728	Not Participating
420029	668,316	5,170,507	0:00:00	2528	Not Participating
420039	667,891	5,171,580	0:00:00	2927	Not Participating
420047	667,886	5,171,532	0:00:00	2885	Not Participating
420051	664,044	5,171,213	0:00:00	2595	Not Participating
420065	664,088	5,171,360	0:00:00	2690	Not Participating
420069	663,975	5,171,244	0:00:00	2661	Not Participating
420076	663,894	5,171,299	0:00:00	2755	Not Participating
420089	663,065	5,171,180	0:00:00	3050	Not Participating
420090	662,974	5,171,187	0:00:00	3096	Not Participating
420100	662,342	5,170,932	0:00:00	2690	Not Participating
420108	662,543	5,170,920	0:00:00	2737	Not Participating
420116	662,765	5,170,601	0:00:00	2516	Not Participating
420117	654,920	5,169,153	0:00:00	2694	Not Participating
420119	660,825	5,167,514	16:49:00	712	Not Participating
450548	681,287	5,160,073	0:00:00	2935	Not Participating
500002	680,617	5,158,589	0:00:00	2988	Not Participating
500006	679,633	5,157,936	0:00:00	2927	Not Participating
500012	679,628	5,157,991	0:00:00	2875	Not Participating
500018	679,256	5,165,366	0:00:00	1742	Not Participating
500022	677,510	5,165,047	7:10:00	924	Not Participating
500028	677,401	5,165,136	9:29:00	870	Not Participating
500035*	673,147	5,158,516	0:00:00	2489	Not Participating
500039	671,766	5,158,494	0:00:00	3356	Not Participating
500053	672,221	5,159,146	0:00:00	2638	Not Participating
500059*	669,892	5,159,454	0:35:00	1261	Not Participating
500064*	669,899	5,159,550	0:00:00	1213	Not Participating
501000	684,105	5,172,245	0:00:00	2509	Not Participating
501012	681,646	5,173,097	13:08:00	907	Not Participating
501019	680,468	5,175,745	0:00:00	1699	Not Participating
501022	680,563	5,175,382	0:00:00	1324	Not Participating
501030	679,723	5,174,632	5:19:00	1290	Not Participating
501037	679,731	5,171,167	9:57:00	838	Not Participating
501040	678,406	5,173,332	12:00:00	676	Not Participating
501050	678,419	5,173,433	7:50:00	766	Not Participating

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

BRADY II WIND ENERGY CENTER

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Distance to Nearest Turbine (m)	Participation Status
501059	678,568	5,173,250	16:28:00	730	Not Participating
501065	678,822	5,170,399	0:59:00	909	Not Participating
501068	677,851	5,169,797	21:59:00	630	Not Participating
501073	681,345	5,169,634	0:00:00	820	Not Participating
501081	681,279	5,169,706	0:00:00	769	Not Participating
501082	675,433	5,171,946	0:00:00	1933	Not Participating
501085	672,965	5,164,410	2:15:00	901	Not Participating
501096	672,947	5,164,396	2:07:00	899	Not Participating
501099	675,017	5,163,411	1:08:00	856	Participating
501104	675,027	5,163,439	1:07:00	828	Participating
501108	670,613	5,160,034	0:00:00	1742	Not Participating
501118	659,777	5,163,091	10:39:00	1123	Not Participating
501126	663,477	5,163,902	0:00:00	1049	Not Participating
501131	664,747	5,163,175	0:00:00	2051	Not Participating
501138	664,349	5,164,755	10:53:00	690	Participating
501141	665,127	5,163,747	0:00:00	1382	Not Participating
501147	665,442	5,161,863	0:00:00	1855	Not Participating
501156	674,657	5,162,748	5:00:00	717	Participating
501162	666,164	5,171,091	0:00:00	1846	Not Participating
501165	668,751	5,170,669	0:00:00	2987	Not Participating
501168	666,562	5,170,280	0:00:00	1123	Not Participating
501172	662,856	5,171,199	0:00:00	3109	Not Participating
501173	661,884	5,171,096	0:00:00	2774	Not Participating
501174	661,893	5,171,077	0:00:00	2756	Not Participating
501175	661,018	5,169,979	0:00:00	1764	Not Participating
501176	660,668	5,170,916	0:00:00	2621	Not Participating
610001	657,943	5,169,457	0:00:00	1524	Not Participating
610009	657,243	5,168,249	9:51:00	1099	Not Participating
610014	657,329	5,168,365	3:56:00	1097	Not Participating
610021	658,588	5,168,791	3:55:00	657	Not Participating
610025	659,083	5,169,071	1:20:00	922	Not Participating
610031	660,171	5,167,459	9:06:00	667	Not Participating
610042	662,190	5,167,946	16:07:00	664	Not Participating
610045	662,204	5,167,951	16:20:00	673	Not Participating
610049	662,204	5,167,996	19:59:00	648	Not Participating
610053	660,882	5,167,398	27:40:00	671	Not Participating
610057	660,875	5,167,437	22:25:00	671	Not Participating
610084 *	666,867	5,164,930	2:56:00	1197	Not Participating
610089*	668,413	5,169,125	0:00:00	2185	Not Participating
610094	663,473	5,168,761	3:26:00	660	Not Participating

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

Brady Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Distance to Nearest Turbine (m)	Participation Status
610098	664,446	5,167,109	10:38:00	637	Not Participating
610102*	669,505	5,169,577	0:00:00	1970	Not Participating
610108*	669,518	5,169,514	0:00:00	1920	Not Participating
610111	670,742	5,169,632	4:13:00	1040	Not Participating
610121*	672,258	5,168,851	35:08:00	672	Participating
610139	675,979	5,170,362	3:33:00	1214	Not Participating
610149	674,773	5,165,354	13:09:00	1050	Not Participating
610170	667,574	5,164,565	1:12:00	1627	Participating
610181	670,466	5,167,264	23:24:00	729	Participating
610185	670,516	5,167,245	19:02:00	696	Participating
800308	667,354	5,158,391	9:05:00	861	Participating
800311	667,332	5,158,349	9:07:00	903	Participating
800317	662,260	5,158,285	0:00:00	5195	Not Participating
811201	680,019	5,177,169	0:00:00	2577	Not Participating
811205	679,691	5,178,020	0:00:00	3127	Not Participating
811210	680,887	5,178,421	0:00:00	2338	Not Participating
811287	655,467	5,168,218	0:00:00	1630	Not Participating
811290	650,090	5,167,200	0:00:00	6518	Not Participating
880001**	680,270	5,173,773	44:53:00	649	Not Participating
900002	661,988	5,161,930	0:00:00	2051	Participating
900007	662,323	5,161,469	0:00:00	2621	Participating
900011	662,065	5,161,089	0:00:00	2810	Not Participating
900015	658,130	5,161,120	0:00:00	3339	Not Participating
900019	658,166	5,161,105	0:00:00	3340	Not Participating
900027	664,500	5,161,670	0:00:00	2813	Not Participating
900031	665,522	5,158,935	0:00:00	1869	Not Participating
900035*	665,494	5,159,171	0:00:00	1872	Not Participating
900039*	665,496	5,159,110	0:00:00	1873	Not Participating
900047	663,971	5,160,025	0:00:00	3418	Not Participating
900053	664,011	5,160,036	0:00:00	3379	Not Participating
900059	665,090	5,160,153	0:00:00	2331	Not Participating
900070	679,567	5,171,280	13:22:00	663	Not Participating
900542	664,710	5,156,553	0:00:00	3785	Not Participating
900546	664,516	5,156,546	0:00:00	3929	Not Participating
900547	665,655	5,157,082	0:00:00	2762	Not Participating
900548	665,667	5,156,254	0:00:00	3165	Not Participating

Note: The cumulative shadow flicker assessment was analyzed using Brady Wind Energy Center and Brady II Wind Energy Center site layouts dated November 6, 2015, and April 22, 2016, respectively. If either facility site layout is modified, potential shadow flicker impacts will be reanalyzed to ensure consistency with the PSC's shadow flicker requirements.

* Denotes receptor categorized as Not Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

** Receptor 880001 is participating in the Brady Wind project which are the turbines impacting the residence.