

# SHADOW FLICKER ANALYSIS REPORT

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## **Dakota Range III Wind Project Roberts & Grant Counties, South Dakota**

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## 1.0 EXECUTIVE SUMMARY

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The Dakota Range III Wind Project (the Project) is a proposed wind power electric generation facility expected to consist of up to 32 wind turbines in Roberts and Grant Counties, South Dakota. Epsilon Associates, Inc. (Epsilon) has been retained by Dakota Range III, LLC (DRIII) to conduct a shadow flicker modeling study for the Project. This report presents results of the study.

Shadow flicker modeling was conducted for 32 wind turbines. All wind turbines for this Project are proposed to be Nordex N149-4.8 units. The purpose of this assessment is to predict the expected annual duration of shadow flicker at modeled locations in the vicinity of the Project due to the operation of the proposed wind turbines and to evaluate the Project with respect to the shadow flicker requirements in the Roberts and Grant County regulations and the commitments set forth by the South Dakota Public Utilities Commission (Commission).

Using the Project specific data provided by DRIII, the annual expected duration of shadow flicker was modeled at occupied structures, all conservatively modeled as “sensitive receptors”. In Roberts County, the maximum expected annual shadow flicker resulting from the operation of the proposed wind turbines is 34 hours, 44 minutes. This occurs at a participating receptor. There is one (1) other receptor modeled to experience over 30 hours of annual shadow flicker, and the receptor is participating. The maximum expected annual shadow flicker at a non-participating receptor in Roberts County is 24 hours, 22 minutes. The Project complies with the shadow flicker regulation in Roberts County.

In Grant County, the maximum expected annual duration of shadow flicker at a sensitive receptor resulting from the operation of the proposed wind turbines is 45 hours, 33 minutes. This receptor is participating. There are two (2) other receptors modeled to experience over 30 hours of annual shadow flicker, and both are participating. The maximum expected annual flicker at a non-participating receptor in Grant County is 10 hours, 6 minutes. Therefore, the Project complies with the shadow flicker regulation in Grant County.

The Project additionally complies with the Settlement Stipulations set forth by the Commission in regard to shadow flicker.

The modeling results are conservative in that modeling receptors were treated as “greenhouses”, i.e. there was a window on each side of a building, and the surrounding area was assumed to be without vegetation or structures (“bare earth”).

## 2.0 INTRODUCTION

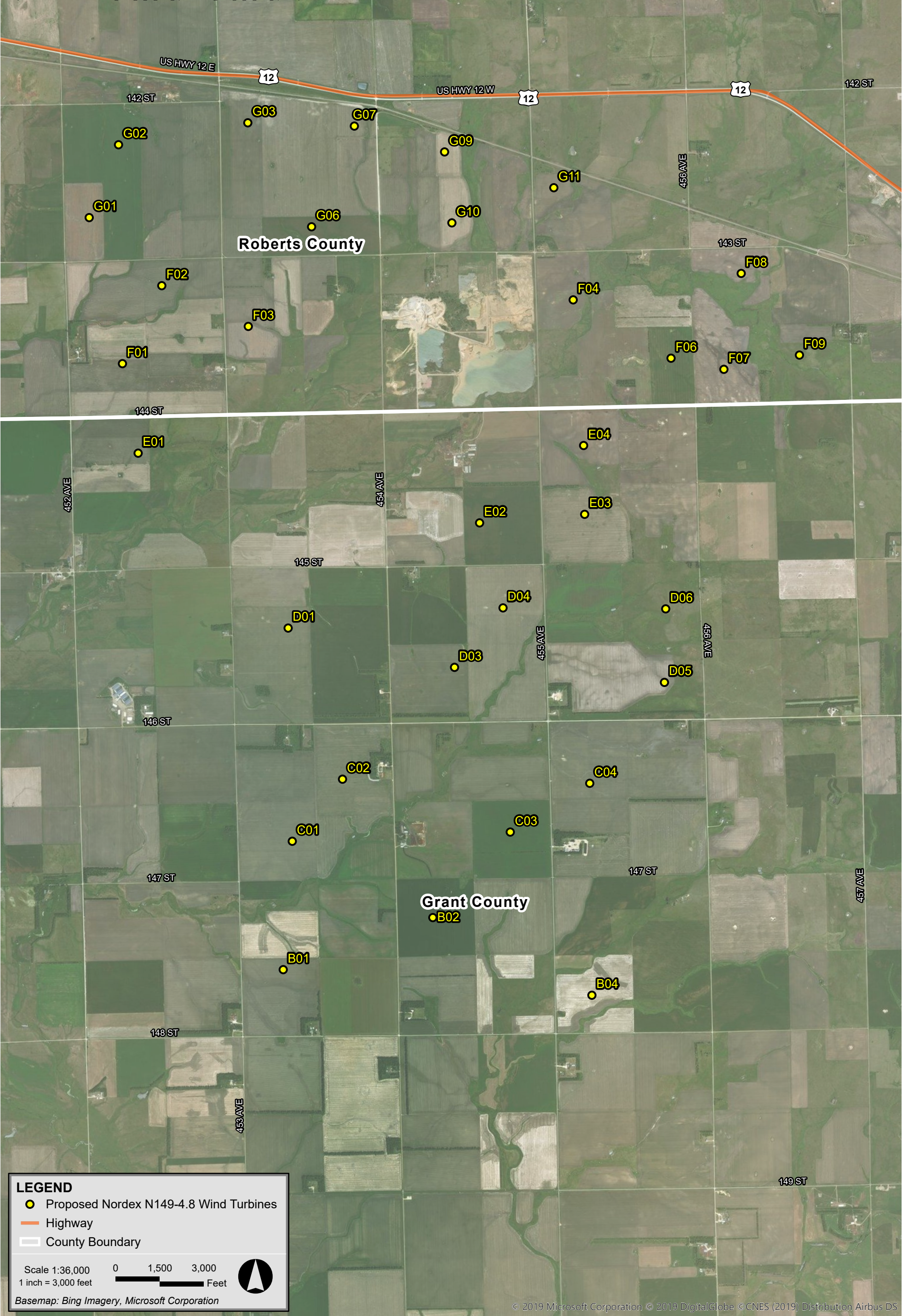
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The Dakota Range III Wind Project to be located in Roberts and Grant Counties, South Dakota will consist of 32 wind turbines. The wind turbines will be Nordex N149-4.8 units. The N149-4.8 wind turbines have a hub height of 108 meters and a rotor diameter of 149 meters. Figure 2-1 shows the locations of the 32 proposed wind turbines over aerial imagery in Roberts and Grant Counties.

With respect to wind turbines, shadow flicker can be defined as an intermittent change in the intensity of light in a given area resulting from the operation of a wind turbine due to its interaction with the sun. While indoors, an observer experiences repeated changes in the brightness of the room as shadows cast from the wind turbine blades briefly pass by windows as the blades rotate. In order for this to occur, the wind turbine must be operating, the sun must be shining, and the window must be within the shadow region of the wind turbine, otherwise there is no shadow flicker. A stationary wind turbine only generates a stationary shadow similar to any other structure.

This report presents the findings of a shadow flicker modeling analysis for the Project. The wind turbines were modeled with the WindPRO software package using information provided by DRIII. The expected annual duration of shadow flicker was calculated at discrete receptor points and shadow flicker isolines for the area surrounding the Project were generated. The results of this analysis are found within this report.





Dakota Range III    Roberts County/Grant County, South Dakota



## **3.0 REGULATIONS**

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### **3.1 Federal Regulations**

There are no federal shadow flicker regulations applicable to this Project.

### **3.2 State Regulations**

There are no state shadow flicker regulations applicable to this Project. However, as a result of the DRIII permit application to the South Dakota Public Utilities Commission (Commission), a Settlement Stipulation has been adopted which provides the following commitments in regard to shadow flicker from the Project under Condition 29(c):

*[A] shadow flicker analysis showing the anticipated shadow flicker levels will not exceed 30 hours per year at any residence, absent a waiver agreement executed by the residence owner(s);*

### **3.3 Local Regulations**

#### **3.3.1 Roberts County**

The section of the proposed Dakota Range III Wind Project within Roberts County, SD is subject to the following shadow flicker requirements in Section 1603.03(10) of Ordinance #20 of Roberts County, Flicker Analysis subsection of General Provisions for Wind Energy System (WES) Requirements:

*A Flicker Analysis shall include the duration and location of flicker potential for all schools, churches, businesses and occupied dwellings within a one (1) mile radius of each turbine within a project. The applicant shall provide a site map identifying the locations of shadow flicker that may be caused by the project and the expected durations of the flicker at these locations from sun-rise to sun-set over the course of a year. The analysis shall account for topography but not for obstacles such as accessory structures and trees. Flicker at any receptor shall not exceed thirty (30) hours per year within the analysis area.*

Subsection (a) of the Flicker Analysis section provides exceptions to the county limit:

*The Board of Adjustment may allow for a greater amount of flicker than identified above if the participating or non-participating landowners agree to said amount of flicker. If approved, such agreement is to be recorded and filed with the Roberts County Zoning Officer. Said agreement shall be binding upon the heirs, successors, and assigns of the title holder and shall pass with the land.*

Therefore, the schools, churches, businesses and occupied dwellings within a one (1) mile radius of each turbine within the Project in Roberts County were evaluated in this analysis against the 30 hours per year limit.

### **3.3.2 Grant County**

The section of the proposed Dakota Range III Wind Project within Grant County, SD is subject to the following shadow flicker requirements in Section 1211.04(9) of the Grant County Compiled Zoning Ordinances, Flicker Analysis subsection of General Provisions for Wind Energy System (WES) Requirements:

*A Flicker Analysis shall include the duration and location of flicker potential for all schools, churches, businesses and occupied dwellings within a one (1) mile radius of each turbine within a project. The applicant shall provide a site map identifying the locations of shadow flicker that may be caused by the project and the expected durations of the flicker at these locations from sun-rise to sun-set over the course of a year. The analysis shall account for topography but not for obstacles such as accessory structures and trees. Flicker at any receptor shall not exceed thirty (30) hours per year within the analysis area.*

Subsection (a) of the Flicker Analysis section provides exceptions to the county limit:

*The Board of Adjustment may allow for a greater amount of flicker than identified above if the participating or non-participating landowners agree to said amount of flicker. If approved, such agreement is to be recorded and filed with the Grant County Register of Deeds. Said agreement shall be binding upon the heirs, successors, and assigns of the title holder and shall pass with the land.*

Therefore, the schools, churches, businesses and occupied dwellings within a one (1) mile radius of each turbine within the Project in Grant County were evaluated in this analysis against the 30 hours per year limit.

## 4.0 SHADOW FLICKER MODELING

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### 4.1 Modeling Methodology

Shadow flicker was modeled using a software package, WindPRO version 3.3. WindPRO is a software suite developed by EMD International A/S and is used for assessing potential environmental impacts from wind turbines. Using the Shadow module within WindPRO, worst-case shadow flicker in the area surrounding the wind turbines was calculated based on data inputs including: location of the wind turbines, location of discrete receptor points, wind turbine dimensions, flicker calculation limits, and terrain data. Based on these data, the model was able to incorporate the appropriate sun angle and maximum daily sunlight for this latitude into the calculations. The resulting worst-case calculations assume that the sun is always shining during daylight hours and that the wind turbine is always operating. The WindPRO Shadow module can be further refined by incorporating sunshine probabilities and wind turbine operational estimates by wind direction over the course of a year. The values produced by this further refinement, also known as the “expected” shadow flicker, are presented in this report.

The proposed wind turbine layout for the Project dated November 1, 2019 was provided by DRIII. Locations of the turbines are shown in Figure 4-1 and the coordinates are provided in Appendix A. All wind turbines are proposed to be Nordex N149-4.8 units with a 108-meter hub height and a 149-meter rotor diameter. Each wind turbine has the following characteristics based on the technical data provided by DRIII:

<u>Nordex N149-4.8</u>		
◆ Rated Power	=	4,800 kW
◆ Hub Height	=	108 meters
◆ Rotor Diameter	=	149 meters
◆ Cut-in Wind Speed	=	3 m/s
◆ Cut-out Wind Speed	=	26 m/s
◆ Maximum RPM	=	12.3 rpm

To-date, there are no federal, state, or local regulations regarding the maximum radial distance from a wind turbine to which shadow flicker should be analyzed applicable to this Project. In the United States, shadow flicker is commonly evaluated out to a distance of ten times the rotor diameter because this is the generally accepted distance beyond which shadow flicker impacts are minimal. For this Project, ten times the rotor diameter of the proposed wind turbine corresponds to a distance of 0.93 miles (1,490 m). Conservatively, this analysis includes shadow flicker calculations out to 1.25 miles (2,012 m) from each wind turbine in the model for the proposed layout.

A modeling receptor dataset was provided by DRIII on March 21, 2019. This dataset included 206 occupied structures.<sup>1</sup> These receptors (137 in Roberts County, 69 in Grant County) were input into the model. These were all conservatively treated as sensitive receptors and modeled as discrete points and are shown on Figure 4-1. Each modeling point was assumed to have a window facing all directions (“greenhouse” mode) which yields conservative results. Participation status for each of the 206 modeling receptors was assigned based on information provided in the dataset. The receptors are indicated as either participating or non-participating on Figure 4-1. The model was set to limit calculations to 2,012 meters from a wind turbine, the equivalent of 1.25 miles. Consequently, shadow flicker at any of the 206 modeling receptors greater than the corresponding limitation distance from a wind turbine was zero. In addition to modeling discrete receptors, shadow flicker was calculated at grid points in the area surrounding the modeled wind turbines to generate flicker isolines. A 20-meter spacing was used for this grid.

The terrain height contour elevations for the modeling domain were generated from elevation information derived from the National Elevation Dataset (NED) developed by the U.S. Geological Survey. Conservatively, obstacles, i.e. buildings and vegetation, were excluded from the analysis. This is effectively a “bare earth” scenario which is conservative. When accounted for in the shadow flicker calculations, such obstacles may significantly mitigate or eliminate the flicker effect depending on their size, type, and location. In addition, shadow flicker durations were calculated only when the angle of the sun was at least 3° above the horizon.

Monthly sunshine probability values were input for each month from January to December. These numbers were obtained from a publicly available historical dataset for Huron, South Dakota from the National Oceanic and Atmospheric Administration’s (NOAA) National Centers for Environmental Information (NCEI).<sup>2</sup> Table 4-1 shows the percentage of sunshine hours by month used in the shadow flicker modeling. These values are the percentages that the sun is expected to be shining during daylight hours.

The number of hours the wind turbines are expected to operate for the 16 cardinal wind directions was input into the model. The number of operational hours per wind direction sector for a hub height of 105 meters was provided by DRIII. Wind conditions at a hub height of 108 meters are expected to be comparable. These hours per wind direction sector are used by WindPRO to estimate the “wind direction” and “operation time” reduction factors. Based on this dataset, the wind turbines would operate 96% of the year. Table 4-2 shows the distribution of operational hours for the 16 wind directions.

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<sup>1</sup> Epsilon was informed on December 12, 2019 that two receptors (#725 and 1031) were recently confirmed to be occupied which differed from the indication in the dataset.

<sup>2</sup> NCEI (formerly NCDC), <http://www1.ncdc.noaa.gov/pub/data/ccd-data/pctpos15.dat>. Accessed in August 2019.

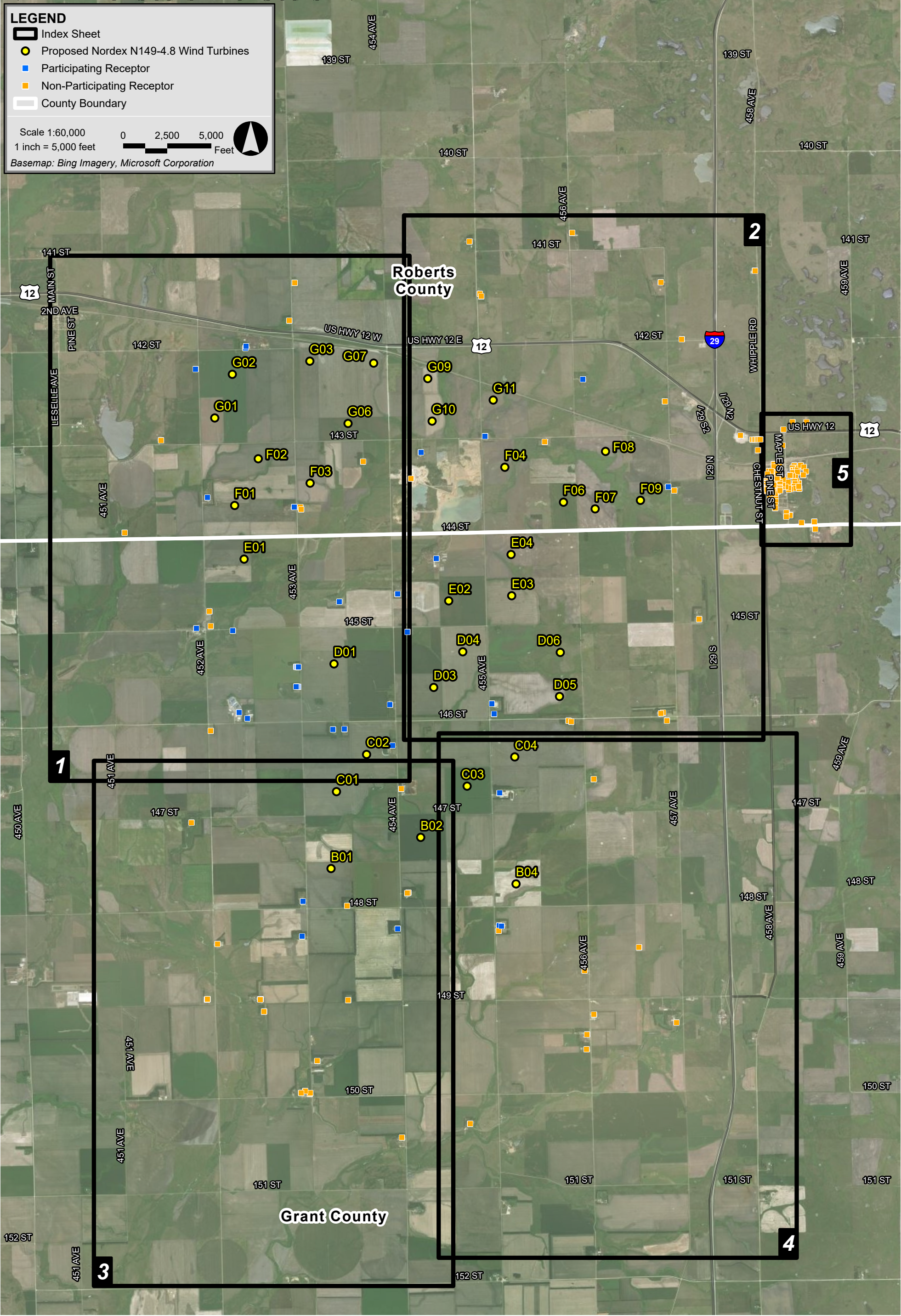
**Table 4-1 Monthly Percent of Possible Sunshine**

Month	Possible Sunshine
January	62%
February	62%
March	62%
April	59%
May	66%
June	69%
July	76%
August	74%
September	69%
October	59%
November	51%
December	51%

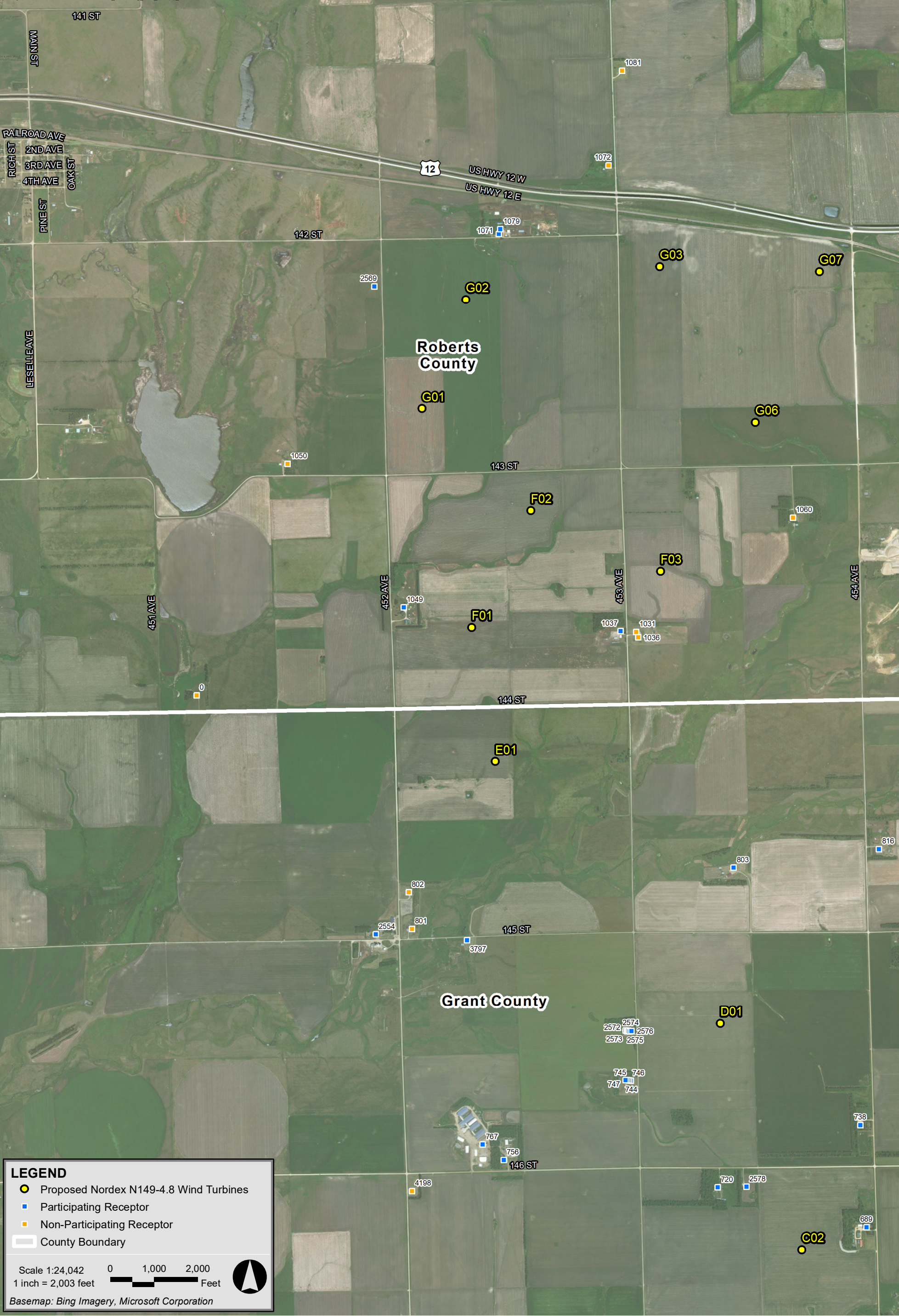
**Table 4-2 Operational Hours per Wind Direction Sector**

Wind Sector	Operational Hours
N	522
NNE	574
NE	364
ENE	279
E	349
ESE	428
SE	415
SSE	357
S	582
SSW	650
SW	498
WSW	498
W	520
WNW	687
NW	881
NNW	785
Annual	8,391









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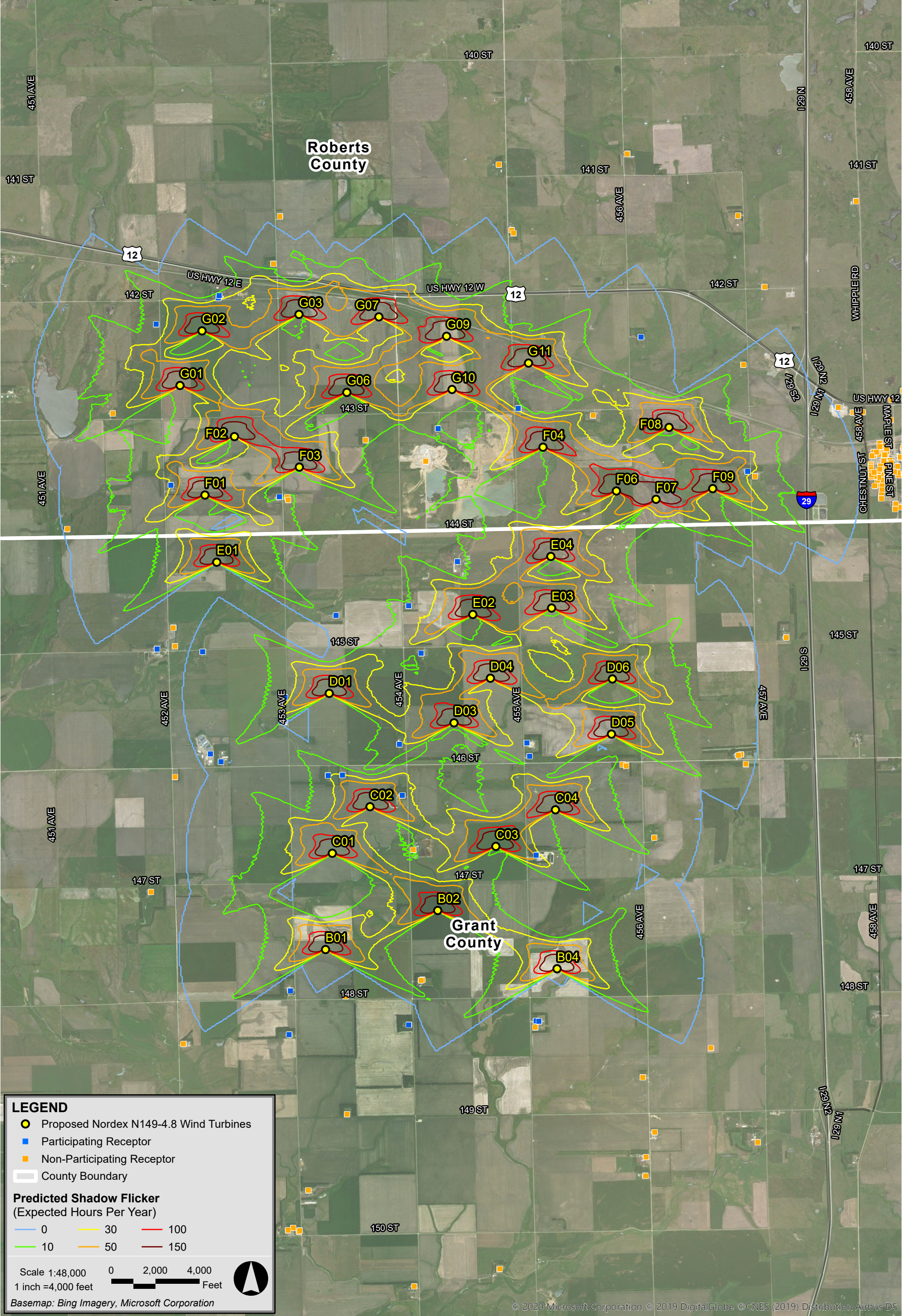
## 4.2 Results

Following the modeling methodology outlined in Section 4.1, WindPRO was used to calculate shadow flicker at the 206 discrete receptor points in Roberts and Grant Counties and generate shadow flicker isolines based on the grid calculations.

Table B-1 in Appendix B presents the shadow flicker modeling results for the 137 receptors in Roberts County. The predicted expected annual shadow flicker duration at the occupied receptors ranged from 0 hours, 0 minutes per year to 34 hours, 44 minutes per year. The majority of the receptors in Roberts County (118) were predicted to experience no annual shadow flicker. Six (6) locations were predicted to experience some shadow flicker but less than 10 hours per year. The modeling results showed that 11 locations would be expected to have 10 to 30 hours of shadow flicker per year, while 2 locations would be expected to have over 30 hours of shadow flicker per year. Both of these receptors are participating. The maximum annual duration of shadow flicker at a non-participating sensitive receptor in Roberts County (#1024) is 24 hours, 22 minutes. Figure 4-2 displays the modeled flicker isolines over aerial imagery in relation to modeled wind turbines and receptors.

Table B-2 in Appendix B presents the shadow flicker modeling results for the 69 receptors in Grant County. The predicted expected annual shadow flicker duration at the occupied receptors ranged from 0 hours, 0 minutes per year to 45 hours, 33 minutes per year. Many of the receptors (37) in Grant County were predicted to experience no annual shadow flicker. Sixteen (16) locations were predicted to experience some shadow flicker but less than 10 hours per year. The modeling results showed that 13 locations would be expected to have 10 to 30 hours of shadow flicker per year while 3 locations would be expected to have over 30 hours of shadow flicker per year. All of these receptors are participating. The maximum annual duration of shadow flicker at a non-participating sensitive receptor in Grant County (#2306) is 10 hours, 6 minutes. Figure 4-2 displays the modeled flicker isolines over aerial imagery in relation to modeled wind turbines and receptors.





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## 5.0 EVALUATION

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### 5.1 Roberts County

Two (2) out of 137 modeling receptors in Roberts County were predicted to experience over 30 hours per year of shadow flicker from the proposed wind turbine layout. Both of these receptors are participating. The maximum annual duration of shadow flicker at a receptor in Roberts County (#1025) is 34 hours, 44 minutes. The maximum annual duration of shadow flicker at a non-participating receptor in Roberts County (#1024) is 24 hours, 22 minutes. The Project meets the regulatory limit of 30 hours per year of shadow flicker in Roberts County as well as the shadow flicker commitment in the Commission Settlement Stipulations.<sup>3</sup>

### 5.2 Grant County

Three (3) out of 69 modeling receptors in Grant County were predicted to experience over 30 hours per year of shadow flicker from the proposed wind turbine layout. All of these receptors are participating. The maximum annual duration of shadow flicker at a receptor in Grant County (#2305) is 45 hours, 33 minutes. The maximum annual duration at a non-participating receptor in Grant County (#2306) is 10 hours, 6 minutes. The Project meets the regulatory limit of 30 hours per year of shadow flicker in Grant County as well as the shadow flicker commitment in the Commission Settlement Stipulations.<sup>4</sup>

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<sup>3</sup> It is Epsilon's understanding that a waiver agreement has been made with those participants that are predicted to receive over 30 hours of annual shadow flicker.

<sup>4</sup> It is Epsilon's understanding that a waiver agreement has been made with those participants that are predicted to receive over 30 hours of annual shadow flicker.

## 6.0 CONCLUSIONS

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A shadow flicker analysis was conducted to determine the duration of shadow flicker in the vicinity of the proposed Dakota Range III Wind Project within Roberts and Grant Counties, SD. Shadow flicker resulting from the operation of the proposed wind turbine layout was calculated at 206 sensitive receptors, and isolines were generated from a grid encompassing the area surrounding the wind turbines.

In Roberts and Grant Counties shadow flicker from a wind energy system is limited to 30 hours per year at schools, churches, businesses and occupied dwellings.

Two (2) out of 137 modeling receptors in Roberts County were predicted to experience over 30 hours per year of shadow flicker from the proposed wind turbine layout. Both of these receptors are participating. The maximum annual duration of shadow flicker at a non-participating receptor in Roberts County (#1024) is 24 hours, 22 minutes; therefore, the Project complies with the shadow flicker regulation in Roberts County.

Three (3) out of 69 modeling receptors in Grant County were predicted to experience over 30 hours per year of shadow flicker from the proposed wind turbine layout. All of these receptors are participating. The maximum annual duration at a non-participating receptor in Grant County (#2306) is 10 hours, 6 minutes; therefore, the Project complies with the shadow flicker regulation in Grant County.

The Project additionally complies with the Settlement Stipulations set forth by the Commission.

The modeling results are conservative in that modeling receptors were treated as “greenhouses” and the surrounding area was assumed to be without vegetation or structures (“bare earth”).



## **Appendix A**

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### **Wind Turbine Coordinates**

**Table A-1: Wind Turbine Coordinates (Layout Date: November 1, 2019)**

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
B01	646,078.29	5,011,898.34
B02	647,627.16	5,012,437.01
B04	649,274.15	5,011,633.29
C01	646,172.00	5,013,227.00
C02	646,692.12	5,013,869.38
C03	648,428.99	5,013,322.19
C04	649,252.00	5,013,827.00
D01	646,129.26	5,015,433.54
D03	647,852.00	5,015,027.00
D04	648,354.10	5,015,642.49
D05	650,025.44	5,014,871.27
D06	650,038.45	5,015,632.43
E01	644,576.16	5,017,243.74
E02	648,111.37	5,016,522.39
E03	649,199.33	5,016,610.85
E04	649,188.49	5,017,323.04
F01	644,413.60	5,018,170.33
F02	644,820.83	5,018,977.35
F03	645,716.57	5,018,555.79
F04	649,080.58	5,018,830.64
F06	650,093.66	5,018,226.66
F07	650,640.88	5,018,111.76
F08	650,820.16	5,019,104.17
F09	651,423.03	5,018,259.05
G01	644,069.37	5,019,682.13
G02	644,372.97	5,020,436.04
G03	645,711.50	5,020,663.11
G06	646,372.00	5,019,587.00
G07	646,814.64	5,020,629.19
G09	647,748.85	5,020,361.86
G10	647,824.65	5,019,627.47
G11	648,880.05	5,019,991.34

## **Appendix B**

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### **Shadow Flicker Modeling Results: Sensitive Receptors**

**Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors in Roberts County**

Modeling ID	Coordinates NAD83 UTM Zone 14N (meters)		Participation Status	Expected Shadow Flicker Hours per Year
	X (Easting)	Y (Northing)		(HH:MM/year)
0	642512.13	5017700.01	Non-Participating	1:36
669	654426.49	5017892.36	Non-Participating	0:00
670	654209.18	5017869.34	Non-Participating	0:00
956	654009.01	5018003.84	Non-Participating	0:00
957	653947.62	5018047.23	Non-Participating	0:00
958	653727.49	5018884.37	Non-Participating	0:00
959	653644.94	5018764.78	Non-Participating	0:00
960	653647.06	5018716.10	Non-Participating	0:00
961	653686.22	5018751.02	Non-Participating	0:00
962	653727.49	5018733.03	Non-Participating	0:00
963	653732.78	5018803.94	Non-Participating	0:00
964	653775.12	5018820.87	Non-Participating	0:00
965	653779.35	5018775.37	Non-Participating	0:00
966	653796.28	5018756.32	Non-Participating	0:00
967	653812.16	5018729.86	Non-Participating	0:00
968	653789.93	5018684.35	Non-Participating	0:00
969	653801.57	5018650.48	Non-Participating	0:00
970	653830.15	5018654.72	Non-Participating	0:00
971	653872.48	5018648.37	Non-Participating	0:00
972	653824.86	5018766.90	Non-Participating	0:00
973	653821.68	5018837.81	Non-Participating	0:00
974	653773.00	5018844.16	Non-Participating	0:00
975	653729.61	5018837.81	Non-Participating	0:00
976	654082.03	5018861.09	Non-Participating	0:00
977	654097.91	5018818.76	Non-Participating	0:00
978	654051.34	5018819.82	Non-Participating	0:00
979	654060.87	5018781.72	Non-Participating	0:00
980	654100.02	5018783.83	Non-Participating	0:00
981	654098.97	5018738.32	Non-Participating	0:00
982	654058.75	5018740.44	Non-Participating	0:00
983	654134.95	5018784.89	Non-Participating	0:00
984	654136.01	5018744.67	Non-Participating	0:00
985	654104.26	5018656.83	Non-Participating	0:00
986	654054.52	5018682.23	Non-Participating	0:00
987	654011.12	5018692.82	Non-Participating	0:00
988	654193.16	5018864.27	Non-Participating	0:00
989	654247.13	5018830.40	Non-Participating	0:00
990	654284.17	5018758.43	Non-Participating	0:00
991	654237.61	5018695.99	Non-Participating	0:00
992	654160.35	5018557.35	Non-Participating	0:00
993	654118.02	5018592.27	Non-Participating	0:00
994	654088.38	5018585.92	Non-Participating	0:00
995	654096.85	5018546.77	Non-Participating	0:00
996	654075.68	5018498.08	Non-Participating	0:00
997	654075.68	5018466.33	Non-Participating	0:00
998	654167.76	5018458.92	Non-Participating	0:00
999	654156.12	5018498.08	Non-Participating	0:00
1000	654013.24	5018454.69	Non-Participating	0:00
1001	653986.78	5018446.22	Non-Participating	0:00
1002	653980.43	5018480.09	Non-Participating	0:00

**Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors in Roberts County**

Modeling ID	Coordinates NAD83 UTM Zone 14N (meters)		Participation Status	Expected Shadow Flicker Hours per Year
	X (Easting)	Y (Northing)		(HH:MM/year)
1003	653975.14	5018568.99	Non-Participating	0:00
1004	653933.87	5018491.73	Non-Participating	0:00
1005	653876.72	5018492.79	Non-Participating	0:00
1006	653880.95	5018543.59	Non-Participating	0:00
1007	653833.32	5018607.09	Non-Participating	0:00
1008	653789.93	5018604.97	Non-Participating	0:00
1009	653789.93	5018572.17	Non-Participating	0:00
1010	653785.70	5018529.83	Non-Participating	0:00
1011	653792.05	5018446.22	Non-Participating	0:00
1012	653793.11	5018411.30	Non-Participating	0:00
1013	653755.01	5018415.53	Non-Participating	0:00
1014	653746.54	5018463.16	Non-Participating	0:00
1015	653702.09	5018464.22	Non-Participating	0:00
1016	653707.38	5018314.99	Non-Participating	0:00
1017	653758.18	5018316.05	Non-Participating	0:00
1018	653751.83	5018374.26	Non-Participating	0:00
1019	653660.82	5018297.00	Non-Participating	0:00
1020	653758.18	5018239.85	Non-Participating	0:00
1021	653751.83	5018171.06	Non-Participating	0:00
1022	653750.77	5018124.49	Non-Participating	0:00
1023	653942.33	5017978.44	Non-Participating	0:00
1024	652007.10	5018428.62	Non-Participating	24:22
1025	651904.31	5018493.71	Participating	34:44
1031	645549.34	5018139.28	Non-Participating	11:09
1036	645562.04	5018101.98	Non-Participating	12:26
1037	645441.78	5018144.84	Participating	8:48
1049	643942.45	5018308.02	Participating	31:47
1050	643141.20	5019297.31	Non-Participating	23:00
1060	646631.14	5018927.53	Non-Participating	16:00
1061	647630.61	5019088.92	Participating	11:54
1067	648739.88	5019368.72	Participating	21:42
1068	649770.43	5019268.18	Non-Participating	21:24
1071	644598.95	5020889.63	Participating	25:48
1072	645356.99	5021362.71	Non-Participating	7:33
1079	644610.06	5020920.59	Participating	20:29
1081	645450.73	5022016.36	Non-Participating	0:00
1086	650430.29	5020350.23	Participating	1:42
1087	651845.75	5019968.54	Non-Participating	6:53
1093	653454.27	5019124.78	Non-Participating	0:00
1095	653878.92	5019204.82	Non-Participating	0:00
1096	653892.81	5019481.31	Non-Participating	0:00
1097	654050.90	5019609.63	Non-Participating	0:00
1098	654293.66	5019607.65	Non-Participating	0:00
1162	652138.05	5021042.12	Non-Participating	0:00
1169	651774.25	5022027.04	Non-Participating	0:00
1175	650244.29	5022880.98	Non-Participating	0:00
1180	648470.34	5022730.04	Non-Participating	0:00
1181	648648.67	5021826.75	Non-Participating	0:00
1185	648673.54	5021782.83	Non-Participating	0:00
1220	653401.72	5022226.38	Non-Participating	0:00

**Table B-1: Shadow Flicker Modeling Results at Sensitive Receptors in Roberts County**

Modeling ID	Coordinates NAD83 UTM Zone 14N (meters)		Participation Status	Expected Shadow Flicker Hours per Year
	X (Easting)	Y (Northing)		(HH:MM/year)
2464	653885.69	5018617.60	Non-Participating	0:00
2569	643740.41	5020526.47	Participating	19:16
3369	653357.06	5019308.47	Non-Participating	0:00
3370	653386.66	5019309.46	Non-Participating	0:00
3371	653412.09	5019310.84	Non-Participating	0:00
3372	653442.11	5019311.42	Non-Participating	0:00
3373	653467.54	5019311.97	Non-Participating	0:00
3374	653494.22	5019312.94	Non-Participating	0:00
3769	653603.40	5018596.29	Non-Participating	0:00
3770	653604.82	5018578.43	Non-Participating	0:00
3771	653605.25	5018559.25	Non-Participating	0:00
3772	653606.32	5018544.38	Non-Participating	0:00
3773	653606.78	5018519.91	Non-Participating	0:00
3774	653738.12	5018572.85	Non-Participating	0:00
3775	653833.37	5018573.34	Non-Participating	0:00
3776	653746.30	5018527.91	Non-Participating	0:00
3777	653783.39	5018643.52	Non-Participating	0:00
3778	653830.24	5018539.59	Non-Participating	0:00
3779	653824.23	5018486.98	Non-Participating	0:00
3780	653711.74	5018495.32	Non-Participating	0:00
3781	653836.59	5018462.57	Non-Participating	0:00
3782	653835.10	5018431.80	Non-Participating	0:00
3783	653698.14	5018375.86	Non-Participating	0:00
3784	653712.83	5018413.97	Non-Participating	0:00
3785	653654.57	5018423.59	Non-Participating	0:00
3786	653610.61	5018419.39	Non-Participating	0:00
3787	653608.95	5018483.21	Non-Participating	0:00
3788	653609.72	5018462.71	Non-Participating	0:00
3789	653612.12	5018445.52	Non-Participating	0:00
3790	653731.26	5018526.38	Non-Participating	0:00
3791	653653.83	5018482.45	Non-Participating	0:00
3792	653684.55	5018762.40	Non-Participating	0:00
3793	653822.23	5018807.10	Non-Participating	0:00
3794	653619.64	5018711.28	Non-Participating	0:00
3795	653796.87	5018723.96	Non-Participating	0:00
3796	653153.96	5019379.44	Non-Participating	0:00
3798	647460.57	5018633.20	Non-Participating	3:51

**Table B-2: Shadow Flicker Modeling Results at Sensitive Receptors in Grant County**

Modeling ID	Coordinates NAD83 UTM Zone 14N (meters)		Participation Status	Expected Shadow Flicker Hours per Year
	X (Easting)	Y (Northing)		(HH:MM/year)
671	654440.66	5017764.63	Non-Participating	0:00
689	647139.01	5014024.33	Participating	42:30
720	646111.96	5014301.87	Participating	28:02
721	650227.89	5014434.71	Non-Participating	5:31
725	650180.49	5014452.90	Non-Participating	6:31
727	648895.05	5014567.56	Participating	22:39
728	648857.57	5014749.46	Participating	14:56
738	647097.54	5014730.16	Participating	26:33
744	645511.35	5015039.18	Participating	5:48
745	645500.11	5015039.51	Participating	7:28
746	645488.20	5015041.82	Participating	9:29
747	645475.97	5015042.48	Participating	11:04
756	644633.40	5014490.63	Participating	4:31
767	644488.94	5014596.46	Participating	4:04
769	647399.27	5015986.51	Participating	12:31
776	651813.15	5014591.35	Non-Participating	1:05
777	651778.23	5014579.18	Non-Participating	1:10
778	651881.15	5014455.09	Non-Participating	0:56
801	643999.49	5016084.40	Non-Participating	0:00
802	643977.66	5016340.39	Non-Participating	0:00
803	646221.99	5016509.06	Participating	5:22
816	647225.43	5016639.23	Participating	14:26
839	647898.23	5017253.63	Participating	7:53
846	652438.65	5016205.55	Non-Participating	0:00
1976	647303.97	5007251.04	Non-Participating	0:00
1985	648480.56	5007489.68	Non-Participating	0:00
2193	652045.23	5009239.11	Non-Participating	0:00
2195	650621.29	5009376.36	Non-Participating	0:00
2205	650503.26	5009033.74	Non-Participating	0:00
2212	650493.66	5008776.86	Non-Participating	0:00
2214	645840.98	5008574.90	Non-Participating	0:00
2217	645708.61	5008004.25	Non-Participating	0:00
2218	645720.53	5008021.46	Non-Participating	0:00
2219	645631.03	5008056.63	Non-Participating	0:00
2220	645560.46	5008023.00	Non-Participating	0:00
2230	644920.93	5009426.30	Non-Participating	0:00
2236	646374.72	5009624.58	Non-Participating	0:00
2239	647229.03	5010859.63	Participating	0:00
2240	648982.24	5010914.63	Participating	0:00
2242	648974.09	5010822.91	Non-Participating	0:00
2243	650458.09	5010135.55	Non-Participating	0:00
2244	651399.84	5010537.19	Non-Participating	0:00
2270	645591.52	5011330.52	Participating	0:00
2271	646356.26	5011253.61	Non-Participating	0:00
2277	647415.35	5011482.18	Non-Participating	6:02
2293	650616.12	5013442.16	Non-Participating	3:54
2305	648987.99	5013202.15	Participating	45:33
2306	647290.87	5013273.96	Non-Participating	10:06
2423	643933.96	5009635.42	Non-Participating	0:00
2424	643946.39	5009641.33	Non-Participating	0:00

**Table B-2: Shadow Flicker Modeling Results at Sensitive Receptors in Grant County**

Modeling ID	Coordinates NAD83 UTM Zone 14N (meters)		Participation Status	Expected Shadow Flicker Hours per Year
	X (Easting)	Y (Northing)		(HH:MM/year)
2426	644853.33	5009638.98	Non-Participating	0:00
2427	644862.14	5009641.30	Non-Participating	0:00
2496	643667.62	5012693.36	Non-Participating	0:00
2521	644116.25	5010595.94	Non-Participating	0:00
2528	645577.99	5010725.78	Participating	0:00
2554	643750.44	5016047.80	Participating	0:00
2572	645476.01	5015383.27	Participating	19:18
2573	645485.86	5015380.02	Participating	20:03
2574	645493.52	5015381.73	Participating	20:33
2575	645504.71	5015378.12	Participating	21:27
2576	645515.66	5015380.47	Participating	22:18
2578	646310.24	5014306.02	Participating	31:55
2972	644922.56	5009429.71	Non-Participating	0:00
2973	649025.05	5010906.20	Participating	0:00
2974	647394.85	5011472.38	Non-Participating	6:21
2975	643939.34	5009639.68	Non-Participating	0:00
2976	644856.17	5009637.68	Non-Participating	0:00
3797	644380.38	5016007.67	Participating	1:43
4198	644000.03	5014277.21	Non-Participating	0:00