

## 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 36 wind turbines in Roberts and Grant Counties, South Dakota. The Project is being developed by Apex Clean Energy, Inc. (Apex). Epsilon Associates, Inc. (Epsilon) has been retained by Apex to conduct a shadow flicker modeling study for the Project. This report presents results of the study.

Shadow flicker modeling was conservatively conducted for 45 turbines, including the 9 alternates. All wind turbines for this Project are proposed to be Vestas V136-4.2 units with serrated trailing edge blades. 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 County regulation, and the voluntary shadow flicker commitment made for Grant County.

Using the Project specific data provided by Apex, the annual expected duration of shadow flicker was modeled at all specified structures, all conservatively modeled as “sensitive receptors”. In Roberts County, the maximum expected annual flicker resulting from the operation of the proposed and alternate wind turbines is 27 hours, 13 minutes. This occurs at a participating receptor. The maximum expected annual flicker at a non-participating receptor in Roberts County is 25 hours, 00 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 and alternate wind turbines is 39 hours, 20 minutes. This receptor is a participating receptor. The maximum expected annual flicker at a non-participating receptor in Grant County is 23 hours, 32 minutes. Therefore, the Project complies with the Project’s voluntary shadow flicker commitment in Grant County.

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”).

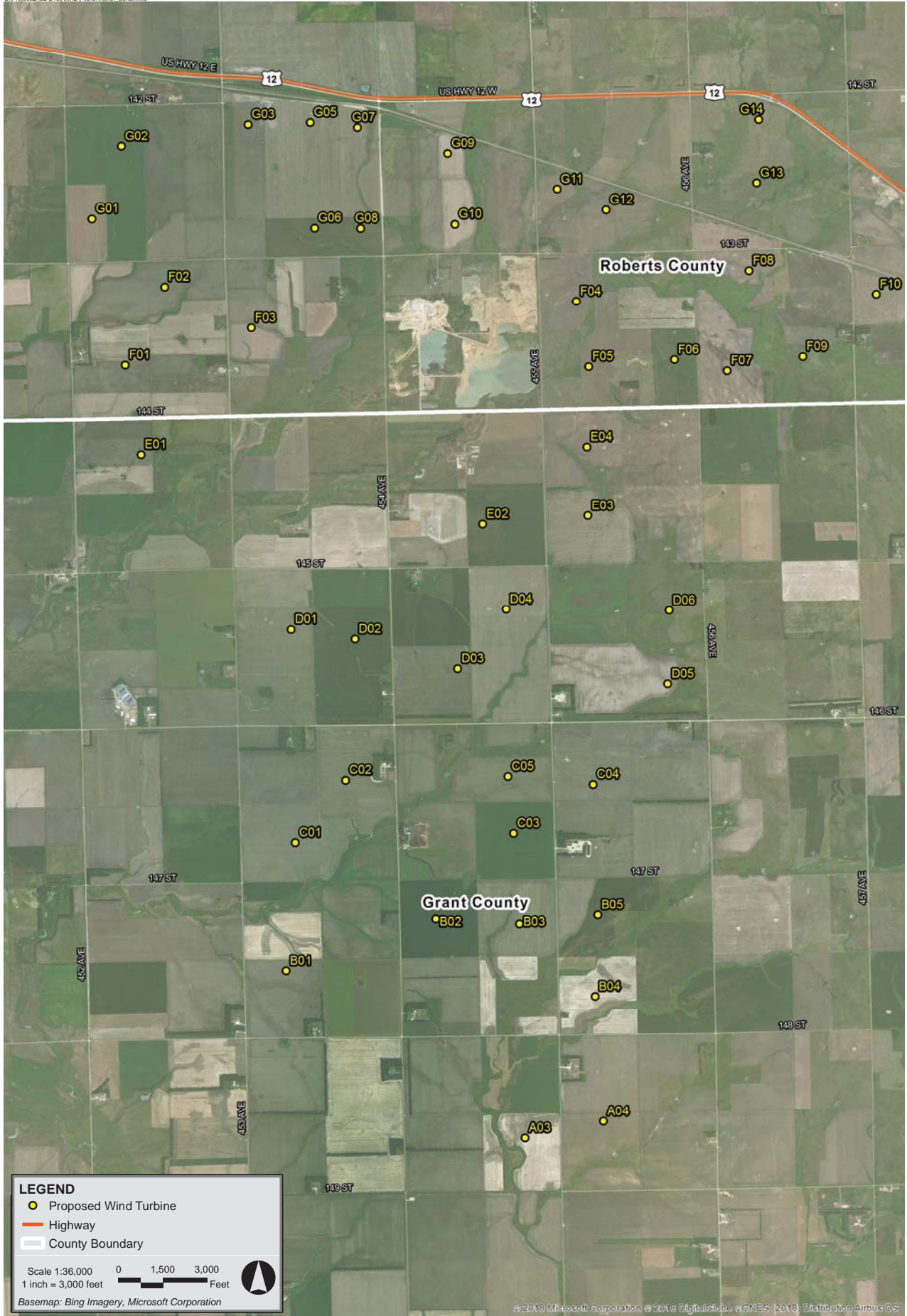
## 2.0 INTRODUCTION

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The Dakota Range III Wind Project to be located in Roberts and Grant Counties, South Dakota will consist of 36 Vestas wind turbines. A total of nine (9) alternate wind turbine locations are also proposed for the Project. The wind turbines will be Vestas V136-4.2 units with serrated trailing edge blades. The V136-4.2 wind turbines have a hub height of 105 meters and a rotor diameter of 136 meters. Figure 2-1 shows the locations of the 36 proposed and 9 alternate 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 Apex. 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.

### 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*

There are no ordinances in Grant County applicable to this Project regarding shadow flicker. Dakota Range III, has, however, voluntarily agreed to meet an annual shadow flicker commitment limit of 30 hours per year at existing non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity, unless otherwise agreed to by the landowner. Modeled shadow flicker results at receptors in Grant County are presented in this report for informational purposes only.

## 4.0 SHADOW FLICKER MODELING

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### 4.1 Modeling Methodology

Shadow flicker was modeled using a software package, WindPRO version 3.2.712. 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 October 2, 2018 (LAY-051) was provided by Apex. Of the 45 conservatively modeled wind turbines, 9 are alternative wind turbine locations. 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 Vestas V136-4.2 units with an 105 meter hub height and a 136 meter rotor diameter. Each wind turbine has the following characteristics based on the technical data provided by Apex or by WindPRO:

		<u>Vestas V136-4.2</u>
◆ Rated Power	=	4,200 kW
◆ Hub Height	=	105 meters
◆ Rotor Diameter	=	136 meters
◆ Cut-in Wind Speed	=	3 m/s
◆ Cut-out Wind Speed	=	25 m/s
◆ Maximum RPM	=	10.4 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 0.85 miles (1,360 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 Apex for occupied receptors within 1.5 miles of any proposed wind turbine in Roberts and Grant Counties on October 2, 2018. The total



203 receptors from this dataset (135 in Roberts County, 68 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 203 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 203 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>1</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 was provided by Apex. 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 due to cut-in and cut-out specifications of the proposed unit. Table 4-2 shows the distribution of operational hours for the 16 wind directions.

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<sup>1</sup> NCEI (formerly NCDC), <http://www1.ncdc.noaa.gov/pub/data/ccd-data/pctpos15.dat>. Accessed in May 2018.

**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**

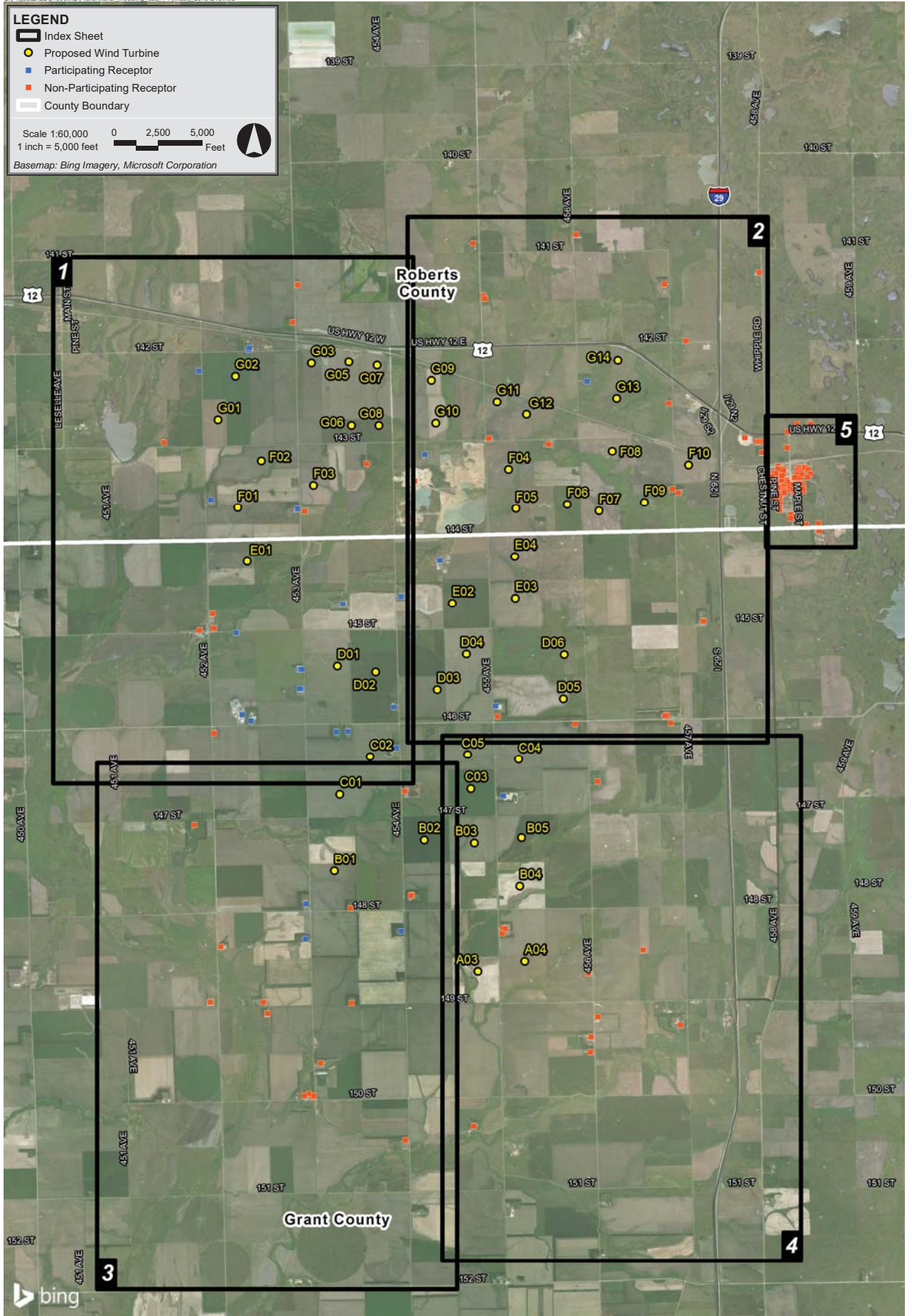
Wind Sector	Operational Hours
N	522
NNE	574
NE	364
ENE	279
E	349
ESE	428
SE	415
SSE	357
S	582
SSW	650
SW	498
WSW	498
W	520
WNW	687
NW	881
NNW	785
Annual	8,391

**LEGEND**

- Index Sheet
- Proposed Wind Turbine
- Participating Receptor
- Non-Participating Receptor
- County Boundary

Scale 1:60,000  
1 inch = 5,000 feet

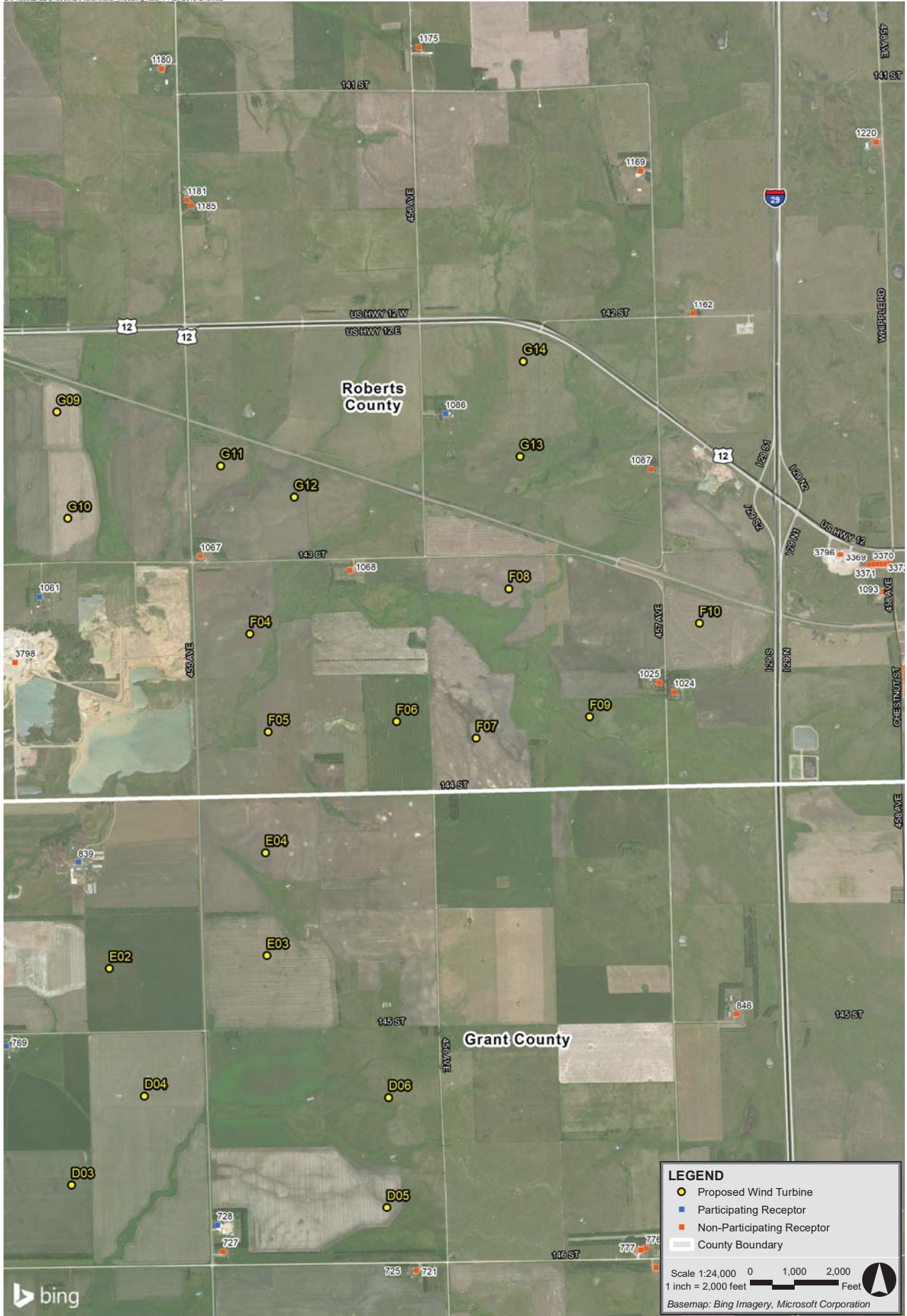
Basemap: Bing Imagery, Microsoft Corporation



Dakota Range III Roberts County/Grant County, South Dakota



Dakota Range III Roberts County/Grant County, South Dakota



Dakota Range III Roberts County/Grant County, South Dakota







Dakota Range III Roberts County/Grant County, South Dakota

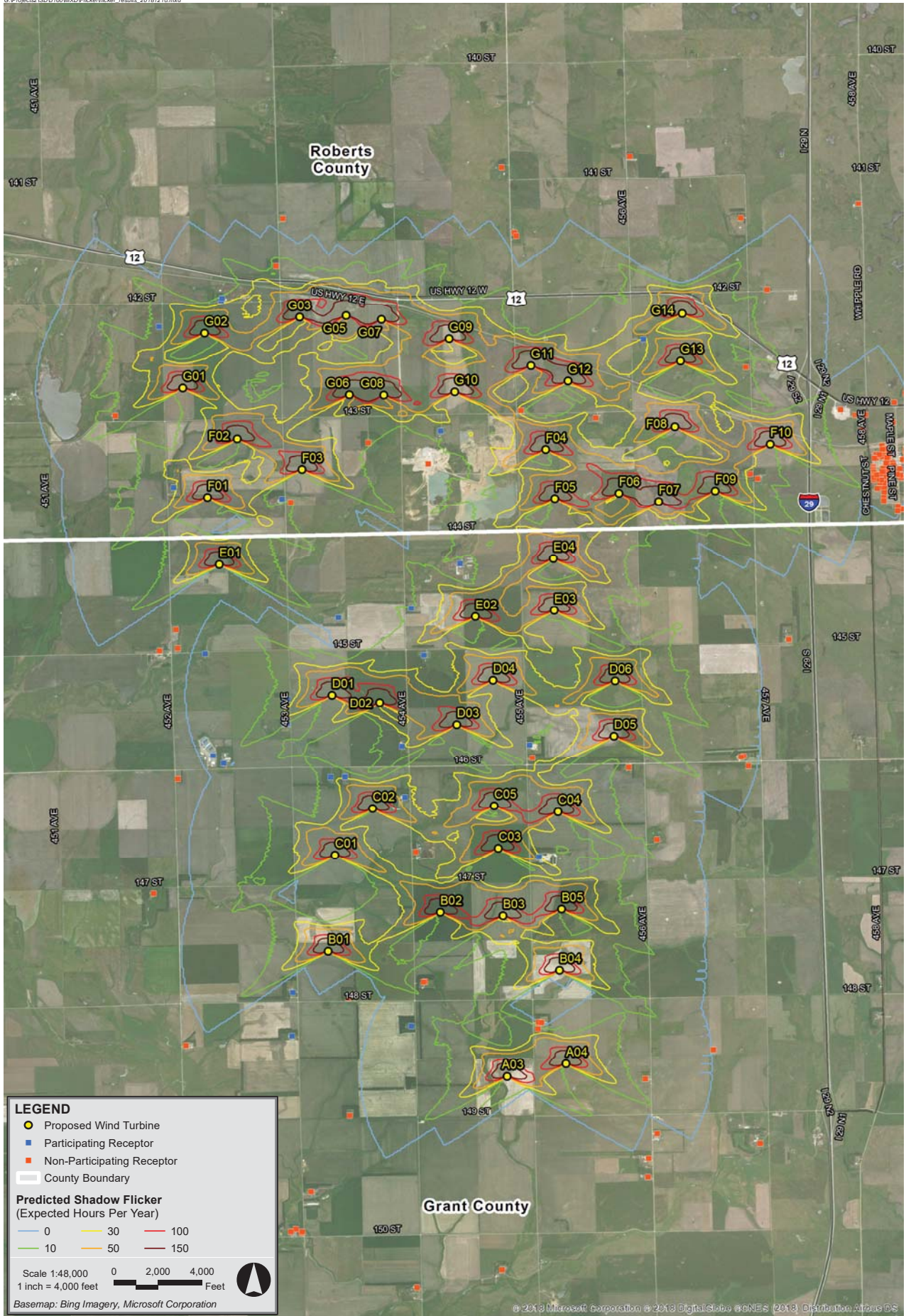


## 4.2 Results

Following the modeling methodology outlined in Section 4.1, WindPRO was used to calculate shadow flicker at the 203 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 135 receptors in Roberts County. The predicted expected annual shadow flicker duration ranged from 0 hours, 0 minutes per year to 27 hours, 13 minutes per year. Many of the receptors in Roberts County (16) were predicted to experience no annual shadow flicker. 104 locations were predicted to experience some shadow flicker but less than 10 hours per year. The modeling results showed that 15 locations would be expected to have 10 to 30 hours of shadow flicker per year, while zero locations would be expected to have over 30 hours of shadow flicker per year. 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 68 receptors in Grant County. The predicted expected annual shadow flicker duration ranged from 0 hours, 0 minutes per year to 39 hours, 20 minutes per year. The majority of the receptors (33) in Grant County were predicted to experience no annual shadow flicker. 17 locations were predicted to experience some shadow flicker but less than 10 hours per year. The modeling results showed that 16 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 (#689 & #2305) are participating receptors. The maximum annual duration of shadow flicker at a non-participating sensitive receptor (#727) is 23 hours, 32 minutes in Grant County. Figure 4-2 displays the modeled flicker isolines over aerial imagery in relation to modeled wind turbines and receptors.



Dakota Range III Roberts County/Grant County, South Dakota

## 5.0 EVALUATION

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### 5.1 Roberts County

Zero out of 135 modeling receptors in Roberts County were predicted to experience over 30 hours per year of shadow flicker from the proposed wind turbine layout. The maximum annual duration of shadow flicker at a sensitive receptor in Roberts County is 27 hours, 13 minutes. This receptor (#1086) is a participating structure. The maximum annual duration at a non-participating sensitive receptor (#1025) is 25 hours, 00 minutes in Roberts County. The Project meets the regulatory limit of 30 hours per year of shadow flicker in Roberts County.

### 5.2 Grant County

Two out of 68 modeling receptors in Grant County were predicted to experience over 30 hours per year of shadow flicker from the proposed wind turbine layout. Both of these receptors (#689 & #2305) are participating receptors. The maximum annual duration of shadow flicker at a sensitive receptor (#689) in Grant County is 39 hours, 20 minutes. The maximum annual duration at a non-participating sensitive receptor (#727) is 23 hours, 32 minutes in Grant County. As described in Section 3.3.2, in Grant County, the Project has voluntarily applied an annual shadow flicker limit of 30 hours at existing non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity, unless otherwise agreed to by the landowner. The Project meets this voluntary commitment.

## 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 and alternate wind turbine locations was calculated at 203 sensitive receptors, and isolines were generated from a grid encompassing the area surrounding the wind turbines.

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

Zero modeling receptors in Roberts County were predicted to experience over 30 hours per year of shadow flicker from the operation of the proposed and alternate wind turbines. The maximum annual duration of shadow flicker at a sensitive receptor (#1086) in Roberts County is 27 hours, 13 minutes. This receptor is a participating occupied structure. The maximum annual duration at a non-participating occupied sensitive receptor (#1025) is 25 hours, 00 minutes in Roberts County; therefore, the Project complies with the shadow flicker regulation in Roberts County.

Two modeling receptors in Grant County were predicted to experience over 30 hours per year of shadow flicker from the operation of the proposed and alternate wind turbines. Both of these receptors (#689 & #2305) are participating receptors. The maximum annual duration at a non-participating occupied sensitive receptor (#727) is 23 hours, 32 minutes in Grant County; therefore, the Project meets the voluntarily applied limit of 30 hours per year of shadow flicker at existing non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity in Grant County.

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 (LAY-051)**

Wind Turbine ID	Coordinates NAD83 UTM Zone 14N (meters)	
	X (Easting)	Y (Northing)
G01	644069.37	5019682.13
G02	644372.97	5020436.04
F01	644413.60	5018170.33
F02	644820.83	5018977.35
G03	645684.00	5020660.46
F03	645716.57	5018555.79
D01	646129.26	5015433.54
C01	646172.00	5013227.00
G05	646326.44	5020682.18
C02	646692.12	5013869.38
D02	646789.72	5015334.55
G07	646814.64	5020629.19
G08	646847.63	5019583.70
G09	647748.85	5020361.86
G10	647824.65	5019627.47
D03	647852.00	5015027.00
E02	648111.37	5016522.39
D04	648354.10	5015642.49
C03	648428.99	5013322.19
G11	648880.05	5019991.34
F04	649080.58	5018830.64
E04	649188.49	5017323.04
E03	649199.33	5016610.85
F05	649206.60	5018155.00
C04	649252.00	5013827.00
B04	649274.15	5011633.29
B05	649302.08	5012478.13
D06	650038.45	5015632.43
D05	650025.44	5014871.27
F06	650093.66	5018226.66
F08	650866.95	5019143.94
F07	650640.88	5018111.76
G13	650943.57	5020055.05
G14	650965.75	5020710.65
F09	651423.03	5018259.05
F10	652182.12	5018903.20
E01	644576.16	5017243.74
B01	646078.29	5011898.34
C05	648372.00	5013907.00
G06	646372.00	5019587.00
B02	647627.16	5012437.01
B03	648491.74	5012385.54
A03	648550.55	5010167.89
A04	649361.55	5010341.75
G12	649388.59	5019776.99

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	Participation Status	Coordinates NAD83 UTM Zone 14N (meters)		Annual Expected Shadow Flicker
		X (Easting)	Y (Northing)	(HH:MM/year)
669	Non-Participating	654426.49	5017892.36	0:00
670	Non-Participating	654209.18	5017869.34	0:00
956	Non-Participating	654009.01	5018003.84	0:00
957	Non-Participating	653947.62	5018047.23	2:14
958	Non-Participating	653727.49	5018884.37	1:36
959	Non-Participating	653644.94	5018764.78	2:06
960	Non-Participating	653647.06	5018716.10	2:12
961	Non-Participating	653686.22	5018751.02	1:55
962	Non-Participating	653727.49	5018733.03	1:46
963	Non-Participating	653732.78	5018803.94	1:37
964	Non-Participating	653775.12	5018820.87	1:31
965	Non-Participating	653779.35	5018775.37	1:32
966	Non-Participating	653796.28	5018756.32	1:30
967	Non-Participating	653812.16	5018729.86	1:28
968	Non-Participating	653789.93	5018684.35	1:35
969	Non-Participating	653801.57	5018650.48	1:36
970	Non-Participating	653830.15	5018654.72	1:30
971	Non-Participating	653872.48	5018648.37	1:20
972	Non-Participating	653824.86	5018766.90	1:24
973	Non-Participating	653821.68	5018837.81	1:21
974	Non-Participating	653773.00	5018844.16	1:29
975	Non-Participating	653729.61	5018837.81	1:38
976	Non-Participating	654082.03	5018861.09	0:45
977	Non-Participating	654097.91	5018818.76	0:44
978	Non-Participating	654051.34	5018819.82	0:48
979	Non-Participating	654060.87	5018781.72	0:47
980	Non-Participating	654100.02	5018783.83	0:44
981	Non-Participating	654098.97	5018738.32	0:41
982	Non-Participating	654058.75	5018740.44	0:49
983	Non-Participating	654134.95	5018784.89	0:38
984	Non-Participating	654136.01	5018744.67	0:41
985	Non-Participating	654104.26	5018656.83	0:46
986	Non-Participating	654054.52	5018682.23	0:48
987	Non-Participating	654011.12	5018692.82	0:53
988	Non-Participating	654193.16	5018864.27	0:35
989	Non-Participating	654247.13	5018830.40	0:00
990	Non-Participating	654284.17	5018758.43	0:00
991	Non-Participating	654237.61	5018695.99	0:00
992	Non-Participating	654160.35	5018557.35	0:44
993	Non-Participating	654118.02	5018592.27	0:48
994	Non-Participating	654088.38	5018585.92	0:49



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

Modeling ID	Participation Status	Coordinates NAD83 UTM Zone 14N (meters)		Annual Expected Shadow Flicker
		X (Easting)	Y (Northing)	(HH:MM/year)
995	Non-Participating	654096.85	5018546.77	0:51
996	Non-Participating	654075.68	5018498.08	0:52
997	Non-Participating	654075.68	5018466.33	0:52
998	Non-Participating	654167.76	5018458.92	0:00
999	Non-Participating	654156.12	5018498.08	0:00
1000	Non-Participating	654013.24	5018454.69	1:01
1001	Non-Participating	653986.78	5018446.22	1:05
1002	Non-Participating	653980.43	5018480.09	1:06
1003	Non-Participating	653975.14	5018568.99	1:06
1004	Non-Participating	653933.87	5018491.73	1:14
1005	Non-Participating	653876.72	5018492.79	1:27
1006	Non-Participating	653880.95	5018543.59	1:22
1007	Non-Participating	653833.32	5018607.09	1:31
1008	Non-Participating	653789.93	5018604.97	1:40
1009	Non-Participating	653789.93	5018572.17	1:43
1010	Non-Participating	653785.70	5018529.83	1:48
1011	Non-Participating	653792.05	5018446.22	1:56
1012	Non-Participating	653793.11	5018411.30	2:00
1013	Non-Participating	653755.01	5018415.53	2:10
1014	Non-Participating	653746.54	5018463.16	2:08
1015	Non-Participating	653702.09	5018464.22	2:25
1016	Non-Participating	653707.38	5018314.99	2:51
1017	Non-Participating	653758.18	5018316.05	2:25
1018	Non-Participating	653751.83	5018374.26	2:19
1019	Non-Participating	653660.82	5018297.00	3:29
1020	Non-Participating	653758.18	5018239.85	2:46
1021	Non-Participating	653751.83	5018171.06	3:42
1022	Non-Participating	653750.77	5018124.49	5:22
1023	Non-Participating	653942.33	5017978.44	3:11
1024	Non-Participating	652007.10	5018428.62	17:30
1025	Non-Participating	651904.31	5018493.71	25:00
1036	Non-Participating	645562.04	5018101.98	10:37
1037	Participating	645441.78	5018144.84	6:36
1049	Participating	643942.45	5018308.02	26:31
1050	Non-Participating	643141.20	5019297.31	18:22
1060	Non-Participating	646631.14	5018927.53	13:57
1061	Participating	647630.61	5019088.92	13:16
1067	Non-Participating	648739.88	5019368.72	22:53
1068	Non-Participating	649770.43	5019268.18	18:21
1071	Participating	644598.95	5020889.63	21:59
1072	Non-Participating	645356.99	5021362.71	14:38

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

Modeling ID	Participation Status	Coordinates NAD83 UTM Zone 14N (meters)		Annual Expected Shadow Flicker
		X (Easting)	Y (Northing)	(HH:MM/year)
1079	Participating	644610.06	5020920.59	17:05
1081	Non-Participating	645450.73	5022016.36	0:00
1086	Participating	650430.29	5020350.23	27:13
1087	Non-Participating	651845.75	5019968.54	14:32
1093	Non-Participating	653454.27	5019124.78	2:48
1095	Non-Participating	653878.92	5019204.82	1:04
1096	Non-Participating	653892.81	5019481.31	0:53
1097	Non-Participating	654050.90	5019609.63	0:38
1098	Non-Participating	654293.66	5019607.65	0:00
1162	Non-Participating	652138.05	5021042.12	7:11
1169	Non-Participating	651774.25	5022027.04	0:00
1175	Non-Participating	650244.29	5022880.98	0:00
1180	Non-Participating	648470.34	5022730.04	0:00
1181	Non-Participating	648648.67	5021826.75	0:00
1185	Non-Participating	648673.54	5021782.83	0:00
1220	Non-Participating	653401.72	5022226.38	0:00
2464	Non-Participating	653885.69	5018617.60	1:19
2569	Participating	643740.41	5020526.47	16:03
3369	Non-Participating	653357.06	5019308.47	2:56
3370	Non-Participating	653386.66	5019309.46	2:44
3371	Non-Participating	653412.09	5019310.84	2:36
3372	Non-Participating	653442.11	5019311.42	2:25
3373	Non-Participating	653467.54	5019311.97	2:17
3374	Non-Participating	653494.22	5019312.94	2:09
3769	Non-Participating	653603.40	5018596.29	2:41
3770	Non-Participating	653604.82	5018578.43	2:44
3771	Non-Participating	653605.25	5018559.25	2:45
3772	Non-Participating	653606.32	5018544.38	2:52
3773	Non-Participating	653606.78	5018519.91	2:57
3774	Non-Participating	653738.12	5018572.85	1:57
3775	Non-Participating	653833.37	5018573.34	1:32
3776	Non-Participating	653746.30	5018527.91	1:58
3777	Non-Participating	653783.39	5018643.52	1:41
3778	Non-Participating	653830.24	5018539.59	1:36
3779	Non-Participating	653824.23	5018486.98	1:42
3780	Non-Participating	653711.74	5018495.32	2:15
3781	Non-Participating	653836.59	5018462.57	1:40
3782	Non-Participating	653835.10	5018431.80	1:43
3783	Non-Participating	653698.14	5018375.86	2:44
3784	Non-Participating	653712.83	5018413.97	2:30
3785	Non-Participating	653654.57	5018423.59	2:54

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

Modeling ID	Participation Status	Coordinates NAD83 UTM Zone 14N (meters)		Annual Expected Shadow Flicker (HH:MM/year)
		X (Easting)	Y (Northing)	
3786	Non-Participating	653610.61	5018419.39	3:19
3787	Non-Participating	653608.95	5018483.21	3:04
3788	Non-Participating	653609.72	5018462.71	3:08
3789	Non-Participating	653612.12	5018445.52	3:10
3790	Non-Participating	653731.26	5018526.38	2:04
3791	Non-Participating	653653.83	5018482.45	2:42
3792	Non-Participating	653684.55	5018762.40	1:52
3793	Non-Participating	653822.23	5018807.10	1:21
3794	Non-Participating	653619.64	5018711.28	2:23
3795	Non-Participating	653796.87	5018723.96	1:30
3796	Non-Participating	653153.96	5019379.44	4:57
3798	Non-Participating	647460.57	5018633.20	4:30

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

Modeling ID	Participation Status	Coordinates NAD83 UTM Zone 14N (meters)		Annual Expected Shadow Flicker
		X (Easting)	Y (Northing)	(HH:MM/year)
671	Non-Participating	654440.66	5017764.63	0:00
689	Participating	647139.01	5014024.33	39:20
720	Participating	646111.96	5014301.87	24:19
721	Non-Participating	650227.89	5014434.71	5:17
727	Non-Participating	648895.05	5014567.56	23:32
728	Participating	648857.57	5014749.46	12:26
738	Participating	647097.54	5014730.16	26:13
744	Participating	645511.35	5015039.18	7:48
745	Participating	645500.11	5015039.51	9:19
746	Participating	645488.20	5015041.82	11:08
747	Participating	645475.97	5015042.48	12:41
756	Participating	644633.40	5014490.63	3:29
767	Participating	644488.94	5014596.46	3:12
769	Participating	647399.27	5015986.51	19:48
776	Non-Participating	651813.15	5014591.35	0:48
777	Non-Participating	651778.23	5014579.18	0:55
778	Non-Participating	651881.15	5014455.09	0:42
801	Non-Participating	643999.49	5016084.40	0:00
802	Non-Participating	643977.66	5016340.39	0:00
803	Participating	646221.99	5016509.06	4:12
816	Participating	647225.43	5016639.23	11:41
839	Participating	647898.23	5017253.63	6:37
846	Non-Participating	652438.65	5016205.55	0:00
1976	Non-Participating	647303.97	5007251.04	0:00
1985	Non-Participating	648480.56	5007489.68	0:00
2193	Non-Participating	652045.23	5009239.11	0:00
2195	Non-Participating	650621.29	5009376.36	0:00
2205	Non-Participating	650503.26	5009033.74	0:00
2212	Non-Participating	650493.66	5008776.86	0:00
2214	Non-Participating	645840.98	5008574.90	0:00
2217	Non-Participating	645708.61	5008004.25	0:00
2218	Non-Participating	645720.53	5008021.46	0:00
2219	Non-Participating	645631.03	5008056.63	0:00
2220	Non-Participating	645560.46	5008023.00	0:00
2230	Non-Participating	644920.93	5009426.30	0:00
2236	Non-Participating	646374.72	5009624.58	0:00
2239	Participating	647229.03	5010859.63	2:23
2240	Non-Participating	648982.24	5010914.63	0:03
2242	Non-Participating	648974.09	5010822.91	15:51
2243	Non-Participating	650458.09	5010135.55	5:48
2244	Non-Participating	651399.84	5010537.19	0:00

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

Modeling ID	Participation Status	Coordinates NAD83 UTM Zone 14N (meters)		Annual Expected Shadow Flicker
		X (Easting)	Y (Northing)	(HH:MM/year)
2270	Participating	645591.52	5011330.52	0:00
2271	Non-Participating	646356.26	5011253.61	0:00
2277	Non-Participating	647415.35	5011482.18	4:58
2293	Non-Participating	650616.12	5013442.16	5:22
2305	Participating	648987.99	5013202.15	35:00
2306	Non-Participating	647290.87	5013273.96	21:22
2423	Non-Participating	643933.96	5009635.42	0:00
2424	Non-Participating	643946.39	5009641.33	0:00
2426	Non-Participating	644853.33	5009638.98	0:00
2427	Non-Participating	644862.14	5009641.30	0:00
2496	Non-Participating	643667.62	5012693.36	0:00
2521	Non-Participating	644116.25	5010595.94	0:00
2528	Participating	645577.99	5010725.78	0:00
2554	Non-Participating	643750.44	5016047.80	0:00
2572	Participating	645476.01	5015383.27	18:55
2573	Participating	645485.86	5015380.02	19:42
2574	Participating	645493.52	5015381.73	20:04
2575	Participating	645504.71	5015378.12	21:01
2576	Participating	645515.66	5015380.47	21:43
2578	Participating	646310.24	5014306.02	26:43
2972	Non-Participating	644922.56	5009429.71	0:00
2973	Non-Participating	649025.05	5010906.20	0:00
2974	Non-Participating	647394.85	5011472.38	5:11
2975	Non-Participating	643939.34	5009639.68	0:00
2976	Non-Participating	644856.17	5009637.68	0:00
3797	Participating	644380.38	5016007.67	1:24
4198	Non-Participating	644000.03	5014277.21	0:00