

# Shadow Flicker Impact Analysis for the Wilton IV Wind Energy Center

*Prepared for*  
**Wilton Wind IV, LLC**

*Prepared by*



**160 Federal Street  
Boston, MA 02110**

**June 2012  
Revised October 2012**

**TABLE OF CONTENTS**

**EXECUTIVE SUMMARY** ..... 1

**1.0 OVERVIEW** ..... 1

**2.0 WINDPRO SHADOW FLICKER ANALYSIS** ..... 3

**3.0 WINDPRO SHADOW FLICKER ANALYSIS RESULTS**..... 4

**4.0 CONCLUSION** ..... 6

**5.0 REFERENCES**..... 7

**TABLES**

Table 1A. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts - Turbine Scenario A (Wilton IV Turbines Only).....5

Table 1B. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts - Turbine Scenario B (Wilton IV Turbines plus Existing Turbines) .....5

Table 2A. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Sensitive Receptor Locations - Turbine Scenario A (Wilton IV Turbines Only) .....6

Table 2B. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Sensitive Receptor Locations - Turbine Scenario B - (Wilton IV Turbines plus Existing Turbines) .....6

**FIGURES**

Figure 1. Residential Receptors Modeled with WindPro to Predict Expected Shadow Flicker Impacts .....8

Figure 2A. WindPro Predicted Expected Shadow Flicker Impact Areas –Scenario A: Wilton IV Turbines Only .....9

Figure 2B. WindPro Predicted Expected Shadow Flicker Impact Areas –Scenario B: Wilton IV Turbines Plus Existing Projects Turbines .....9

**ATTACHMENT**

Attachment A Detailed Summary of WindPro Shadow Flicker Analysis Results

## ***Executive Summary***

A shadow flicker impact analysis was originally conducted for the Wilton IV Wind Energy Center (Project) in October 2011. That analysis was based on the GE 1.6 xle-82.5 wind turbine model, which included an 82.5-meter rotor diameter and an 80-meter hub height. The wind turbine model for the current Project design has been revised to a new model, the GE 1.6 xle-100, which has a 100-meter rotor diameter and an 80-meter hub height. Since larger rotors can result in greater shadow flicker impacts, the shadow flicker analysis was updated to account for the wind turbine design change. The wind turbine model for the current Project design is based on the same wind turbine model (GE 1.6 xle-100, 80-meter hub height), but locations for several of the turbines have been microsited. The updated shadow flicker analysis results indicate that shadow flicker impacts increase slightly from those predicted for the original Project design, but not enough to change any of the original conclusions. Two occupied receptors are anticipated to have more than 30 hours of shadow flicker per year from the proposed Project; when the existing adjacent projects were included in the analysis to account for cumulative effects, an additional two receptors are anticipated to have more than 30 hours of shadow flicker per year. All of the receptors anticipated to have more than 30 hours of shadow flicker per year are Project participants.

## **1.0 OVERVIEW**

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 phenomena experienced by people at nearby residences or public gathering places. The impact area depends on the time of year and day (which determines 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 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), the light has to pass 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.

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 1,500 meters is very low and generally considered imperceptible. Shadow flicker intensity for receptor-to-turbine distances between 1,000 and 1,500 meters (between 3,281 and 4,921 feet) is also low and considered barely noticeable. At this distance shadow flicker intensity would only tend to be noticed under conditions that would enhance the intensity difference, such as observing from a dark room with a single window directly facing the turbine casting the shadow. At distances less than 1,000 meters (3,281 feet), shadow flicker may be more noticeable. In

general, the largest number of shadow flicker hours, along with greatest shadow flicker intensity, occurs nearest the wind turbines.

Wilton Wind IV, LLC (Wilton IV) is proposing to install 62 wind turbines as part of the Wilton IV Wind Energy Center (Project) in Ghylin and Crofte Townships in Burleigh County, North Dakota. Since the Project is using a minimum turbine siting setback requirement to occupied residences<sup>1</sup>, sensitive receptors (occupied residences) are generally not located in the worst case potential shadow flicker impact zones, which ensures that shadow flicker impacts are minimized.

The wind turbine being considered for the Project, and evaluated for potential shadow flicker impacts, has the following characteristics:

- **GE Wind Energy GE 1.6 MW xle** – 3-blade 100-meter-diameter rotor, with a hub height of 80 meters. The GE 1.6 MW xle has a nominal rotor speed of 16.8 rpm; however a conservative rotor speed of 18 rpm was utilized for the purpose of the analysis, which translates to a blade pass frequency of 0.9 Hz (less than 1 alternation per second) to account for the different turbine models in the cumulative analysis.

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, such low frequencies are harmless. For comparison, strobe lights used in discotheques have frequencies which range from about 3 Hertz (Hz) to 10 Hz (1 Hz = 1 flash per second). As a result, public concerns that flickering light from wind turbines can have negative health effects, such as triggering seizures in people with epilepsy are unfounded. The 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. Since the proposed Project's wind turbine blade pass frequency is approximately 0.9 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 trigger with regard to hours per year of anticipated impacts to a receptor from a wind energy project. Due to the significant growth of the wind energy industry in recent years, some states have published model bylaws for local governments to adopt or modify at their own discretion which sometimes includes guidance and recommendations for shadow flicker levels

---

<sup>1</sup> Ghylin Township does not have established setbacks for wind turbines. Based on experience with other wind farms, Wilton IV has utilized setbacks of 1,400 feet from occupied residences in designing the turbine layout in Ghylin Township, consistent with their policy at other wind energy facilities. Crofte Township has established setbacks of 1,400 feet from occupied residences on participating properties and 1,750 feet from occupied residences on non-participating properties. Wilton IV has utilized the Crofte Township setbacks in designing the turbine layout in Crofte Township.

and mitigation. However, a general precedent has been established in the industry both abroad and in the United States that fewer than 30 hours per year of shadow flicker impacts is acceptable to receptors in terms of nuisance and well below health hazard thresholds. In German court case for example, a judge found 30 hours of actual shadow flicker per year at a certain neighbor's property to be tolerable (WindPower 2003).

## 2.0 WINDPRO SHADOW FLICKER ANALYSIS

An analysis of potential shadow flicker impacts from the Project was conducted using the WindPro software package. The Wilton IV turbine array dated September 20, 2012, which includes 62 turbines and 2 alternate locations, was included in the analysis. The analysis evaluated both the Project only and cumulative (Project plus existing) wind turbine scenarios:

- Scenario A (Wilton IV turbines only) – 64 turbines (62 primary and 2 alternate locations)
- Scenario B (Wilton IV plus existing turbines) – 194 turbines (64 Wilton IV turbine locations and 130 existing turbines from the Wilton I, Wilton II, and Baldwin Wind Energy Centers located adjacent to the north and east of the Wilton IV Project Area). For the purpose of the shadow flicker analysis, turbines from all projects were modeled using the GE 1.6 MW xle model turbine with a conservative rotor speed of 18 rpm.

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 out to 1,500 meters (4,921.3 feet). The realistic impact condition scenario is based on the following assumptions:

- The elevation and position geometries of the wind turbines and surrounding receptors (houses). Elevations were determined using USGS digital elevation model (DEM) data. Positions geometries were determined using GIS and referenced to UTM Zone 14 (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 hours availability (percent of total available). Historical sunshine rates for the area (as summarized by the National Climatic Data Center (NCDC, 2008) for nearby Bismarck, ND) 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 7 years of wind data from July 1, 2002 to October 31, 2009 [wind speed / wind direction frequency distribution] measured at meteorological tower approximately 47 miles east of the proposed project site). The WindPro calculated wind direction frequency distribution for operating hour winds is as follows:

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
7.1%	4.9%	5.4%	7.0%	9.1%	10.1%	8.3%	5.6%	6.2%	9.9%	13.9%	12.5%

- 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 this section.

A total of 84 sensitive receptor locations were identified within approximately one mile of the proposed turbine locations for Wilton IV. These receptors are based on the GIS data provided by Wilton IV dated September 6, 2011 that included receptors within Ghylin Township (Farmstead Report dated August 4, 2011) and Crofte Township (Farmstead Report dated February 25 2010) and supplementary input from the client based on local knowledge. An additional 110 receptors previously identified for the Wilton I, II, and Baldwin Wind Energy Centers were utilized for the cumulative impacts analysis, for a total of 194 receptors. These locations correspond to houses or other structures in the Project Area. In addition, non-residential structures (such as barns) were considered.

A receptor in the model is defined as a 1 m<sup>2</sup> area (approximate size of a typical window), 1 meter (3.28 feet) aboveground level. Approximate eye level is set at 1.5 meters (4.94 feet). Figure 1 shows the sensitive receptor locations considered.

### 3.0 WINDPRO SHADOW FLICKER ANALYSIS RESULTS

WindPro predicts that shadow flicker impacts will primarily occur near the wind turbines. Figures 2A and 2B describe the WindPro predicted expected shadow flicker impact areas for turbine scenarios A and B, respectively. A detailed WindPro shadow flicker analysis results summary, for each of the modeling receptor locations, is provided in Attachment A. Tables 1A and 1B present the WindPro predicted expected shadow flicker impacts for the top ten worst case receptors for turbine scenarios A and B, respectively. For scenario A, only 4 of the 194 receptors modeled had expected shadow flicker impacts predicted for more than 30 hours per year. However, only two of those receptors are occupied structures. For scenario B, only 8 of the 194 receptors modeled had expected shadow flicker impacts predicted for more than 30 hours per year. However, only four of those receptors are occupied structures.

Four of the top ten impact receptors are actively occupied residential structures for turbine scenario A. Four of the top ten impact receptors are actively occupied residential structures for turbine scenario B. The maximum predicted shadow flicker impact at any active residential receptor (#60062) is 36 hours, 23 minutes per year, which is approximately 0.8 percent of the potential available daylight hours. Receptor #60062 is the only receptor with predicted shadow flicker greater than 30 hours per year that is not a participant in the Project.

**Table 1A. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts - Turbine Scenario A (Wilton IV Turbines Only)**

Receptor ID	Receptor Description / Status	Shadow Hours per Year (expected) [hh:mm / year]
60005	Unoccupied	59:33
60010a	Unoccupied	47:18
60062	Occupied	36:23
530173	Occupied	31:08
530170	Unoccupied	29:25
530167	Unoccupied	25:05
530070	Unoccupied	24:55
60066	Occupied	23:58
530106	Unoccupied	23:35
530133	Occupied	23:16

**Table 1B. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts - Turbine Scenario B (Wilton IV Turbines plus Existing Turbines)**

Receptor ID	Receptor Description / Status	Shadow Hours per Year (expected) [hh:mm / year]
2027	Unoccupied	94:29
60005	Unoccupied	59:33
60010a	Unoccupied	47:18
60062	Occupied	36:23
40074a	Unoccupied	33:21
40039	Occupied	32:57
2018	Occupied	31:47
530173	Occupied	31:08
530170	Unoccupied	29:25
2025a	Unoccupied	27:44

Approximately 96 percent, or 186 of the 194 receptor locations evaluated (for turbine scenario B), have less than 30 hours per year of predicted shadow flicker impact. The shadow flicker impact prediction statistics are as summarized in Tables 2A and 2B, for turbine scenarios A and B, respectively.

**Table 2A. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Sensitive Receptor Locations - Turbine Scenario A (Wilton IV Turbines Only)**

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	194
= 0 Hours	132
> 0 Hours < 10 hours	31
≥ 10 Hours < 20 hours	12
≥ 20 Hours < 30 hours	15
≥ 30 hours	4

**Table 2B. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Sensitive Receptor Locations - Turbine Scenario B - (Wilton IV Turbines plus Existing Turbines)**

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	194
= 0 Hours	77
> 0 Hours < 10 hours	51
≥ 10 Hours < 20 hours	33
≥ 20 Hours < 30 hours	25
≥ 30 hours	8

#### 4.0 CONCLUSION

The analysis of potential shadow flicker impacts from the Project on nearby houses (receptors) shows that shadow flicker impacts within the area of study are expected to be minor. The analysis assumes that the houses 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 to be affected by the key shadow flicker impact times. In addition, potential shadow flicker impacts for wind turbines up to 1,500 meters (4,921 feet) away were determined. In reality, the shadow flicker impacts for turbines beyond 1,000 meters (3,281 feet) will be very low intensity. For these reasons, shadow flicker impacts are expected to be less than estimated with the conservative analysis, and shadow flicker is not expected to be a significant environmental impact.

Finally, there is no state or federal regulatory threshold for shadow flicker hours per year at a given receptor; therefore, the Project does not violate state or federal permitting requirements or conditions according to the results of this shadow flicker impact analysis.

## 5.0 REFERENCES

Epilepsy Action. 2008. British Epilepsy Association.

[http://www.epilepsy.org.uk/info/photo\\_other.html](http://www.epilepsy.org.uk/info/photo_other.html). Accessed 3/1/10.

WindPower 2003. Danish Wind industry Association. Shadow Casting From Wind Turbines.

<http://guidedtour.windpower.org/en/tour/env/shadow/index.htm>, Accessed 4/28/10

National Climatic Data Center. 2008. – Sunshine Average Percent of Possible.

<http://www.ncdc.noaa.gov/oa/climate/online/ccd/pctpos.txt> . Accessed 3/1/10

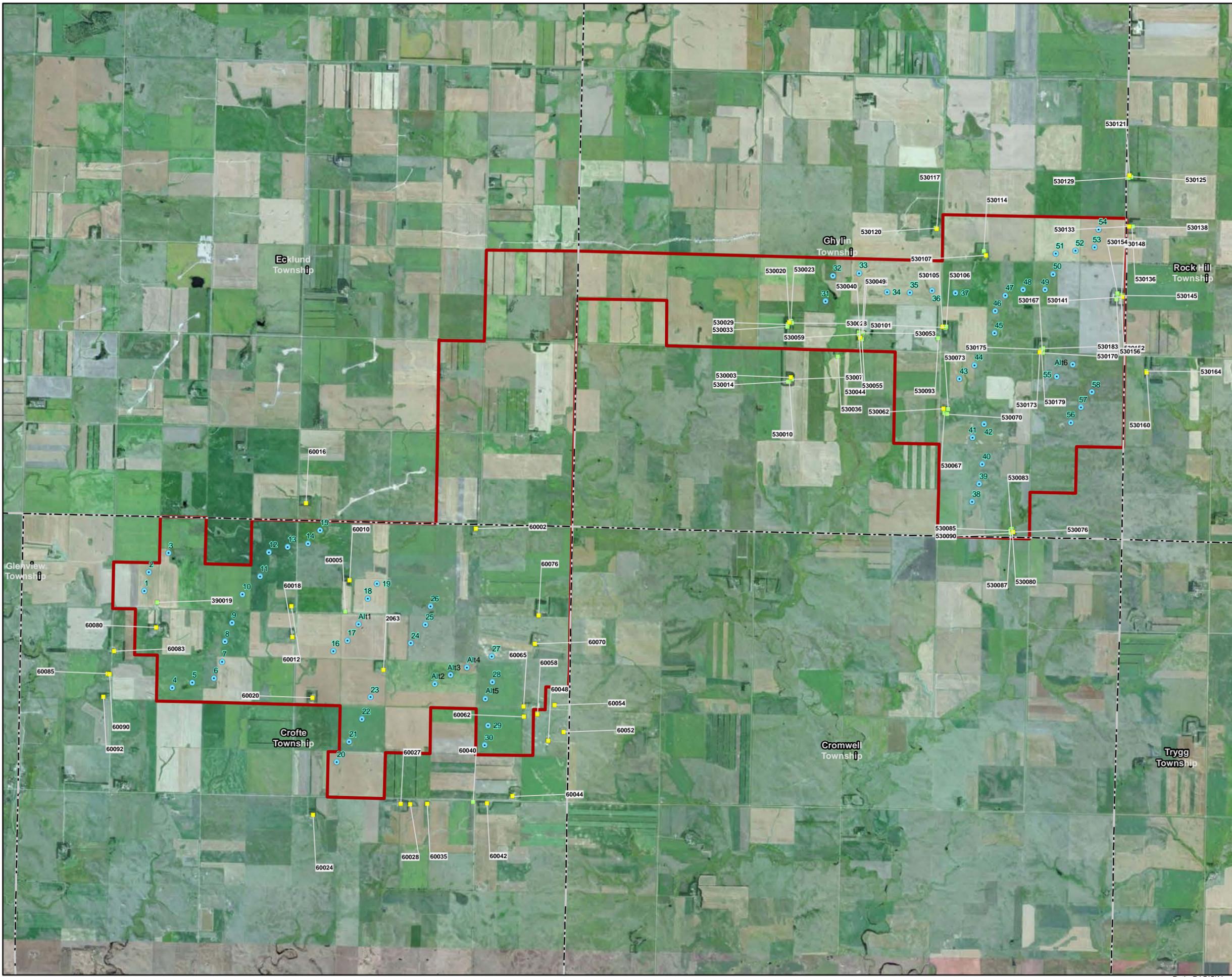
**WILTON WIND IV, LLC**  
**WILTON IV WIND ENERGY CENTER**  
 Burleigh County, North Dakota

**FIGURE 1**  
**RESIDENTIAL RECEPTORS MODELED**  
**WITH WINDPRO TO PREDICT**  
**EXPECTED SHADOW FLICKER IMPACTS**

October, 2012

**Legend**

- Wilton IV WTG (9/20/12)
- Receptor - Occupied
- Receptor - Unoccupied
- Project Boundary
- Civil Township



**REFERENCE MAP**





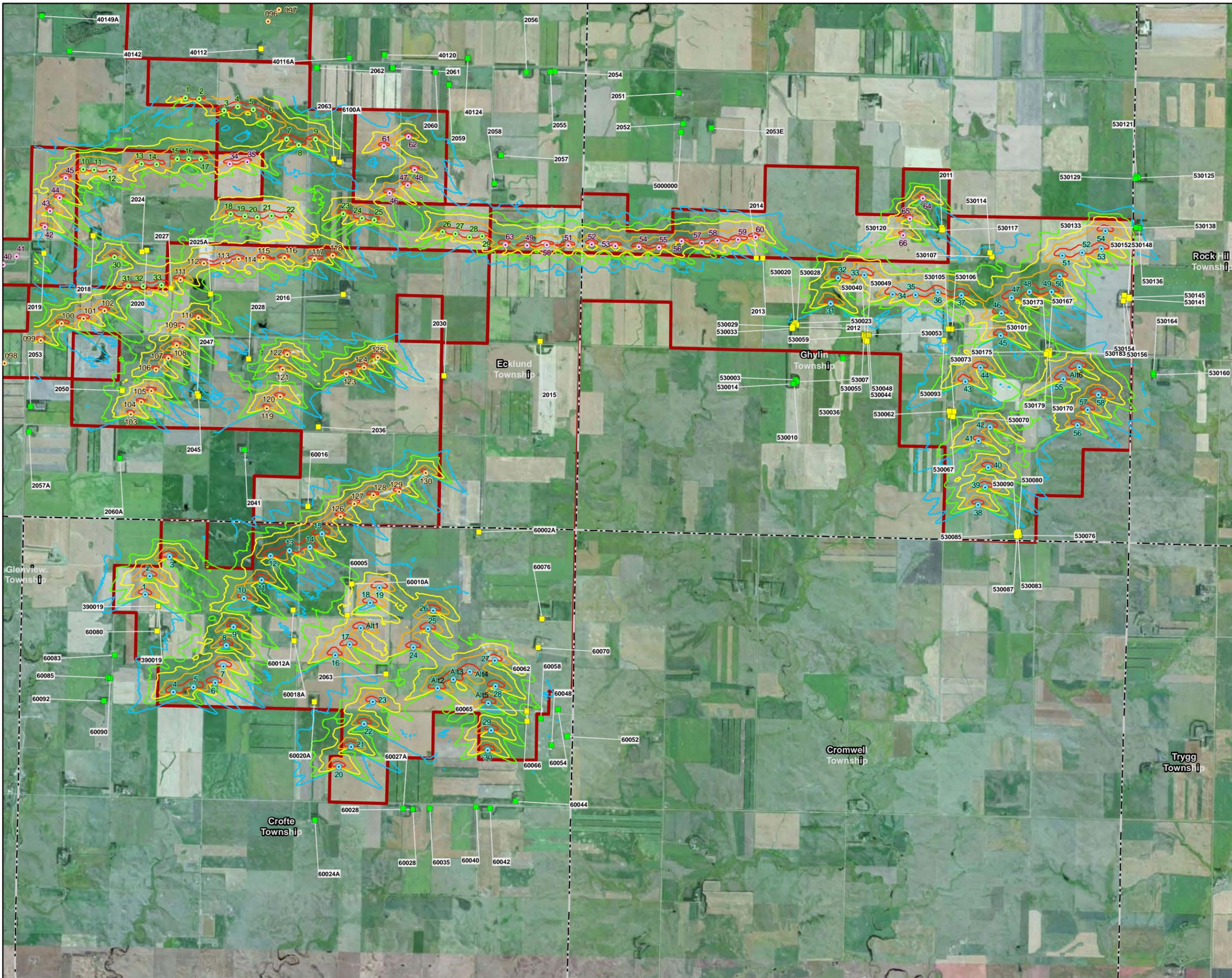
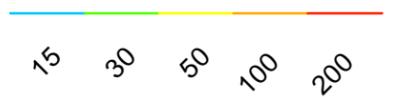
**WILTON WIND IV, LLC**  
**WILTON IV WIND ENERGY CENTER**  
 Burleigh County, North Dakota

**FIGURE 2**  
**WINDPRO PREDICTED EXPECTED**  
**SHADOW FLICKER IMPACT AREAS**  
**SCENARIO B**  
**WILTON IV TURBINES PLUS**  
**EXISTING PROJECTS TURBINES**  
 October, 2012

**Legend**

- Wilton IV WTG (9/20/12)
- Wilton I WTG
- Wilton II WTG
- Baldwin WTG
- Receptor - Occupied
- Receptor - Unoccupied
- Civil Township
- Project Boundary

**Shadow Flicker Iso Line (hrs/yr)**



**REFERENCE MAP**



## **ATTACHMENT A**

### **Detailed Summary of WindPro Shadow Flicker Analysis Results**

**Wilton IV Wind Energy Center  
WindPro Shadow Flicker Analysis Results Summary  
Turbine Scenario A (Wilton IV Turbines Only)**

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
1	53007	380,694	5,216,793	0:00:00	Unoccupied
2	60005	372,824	5,212,708	59:33:00	Unoccupied
3	390019	369,513	5,212,867	3:32:00	Unoccupied
4	530010	380,647	5,216,753	0:00:00	Unoccupied
5	530014	380,625	5,216,754	0:00:00	Unoccupied
6	530023	380,673	5,217,814	6:52:00	Unoccupied
7	530028	380,693	5,217,783	0:00:00	Unoccupied
8	530029	380,626	5,217,756	1:44:00	Unoccupied
9	530033	380,615	5,217,720	0:00:00	Unoccupied
10	530044	381,925	5,217,498	0:00:00	Unoccupied
11	530048	381,950	5,217,604	0:41:00	Unoccupied
12	530049	381,924	5,217,605	1:21:00	Unoccupied
13	530053	381,904	5,217,608	1:59:00	Unoccupied
14	530055	381,873	5,217,610	2:50:00	Unoccupied
15	530059	381,871	5,217,584	0:00:00	Unoccupied
16	530067	383,380	5,216,196	19:57:00	Unoccupied
17	530070	383,428	5,216,176	24:55:00	Unoccupied
18	530073	383,446	5,216,269	20:03:00	Unoccupied
19	530080	384,574	5,214,158	0:00:00	Unoccupied
20	530083	384,560	5,214,155	0:00:00	Unoccupied
21	530085	384,542	5,214,136	0:00:00	Unoccupied
22	530087	384,543	5,214,100	0:00:00	Unoccupied
23	530090	384,543	5,214,091	0:00:00	Unoccupied
24	530101	383,401	5,217,704	22:04:00	Unoccupied
25	530106	383,413	5,217,713	23:35:00	Unoccupied
26	530114	384,071	5,219,042	19:05:00	Unoccupied
27	530120	383,225	5,219,446	0:00:00	Unoccupied
28	530125	386,672	5,220,354	0:00:00	Unoccupied
29	530129	386,624	5,220,336	0:00:00	Unoccupied
30	530136	386,682	5,219,476	20:01:00	Unoccupied
31	530138	386,699	5,219,476	18:58:00	Unoccupied
32	530145	386,513	5,218,265	7:57:00	Unoccupied
33	530148	386,500	5,218,264	7:37:00	Unoccupied
34	530152	386,487	5,218,266	7:26:00	Unoccupied
35	530164	386,937	5,216,938	6:48:00	Unoccupied
36	530167	385,105	5,217,281	25:05:00	Unoccupied
37	530170	385,112	5,217,255	29:25:00	Unoccupied
38	530175	385,078	5,217,318	21:43:00	Unoccupied
39	530179	385,089	5,217,313	22:05:00	Unoccupied
40	530183	385,122	5,217,332	22:08:00	Unoccupied
41	2063	373,499	5,211,684	13:05:00	Occupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
42	60002a	375,123	5,214,163	0:00:00	Occupied
43	60010a	372,900	5,213,255	47:18:00	Occupied
44	60012a	371,877	5,212,797	13:48:00	Occupied
45	60016	372,129	5,214,610	2:56:00	Occupied
46	60018a	371,895	5,212,263	21:34:00	Occupied
47	60020a	372,243	5,211,194	7:04:00	Occupied
48	60024a	372,255	5,209,130	0:00:00	Occupied
49	60027a	373,800	5,209,328	2:05:00	Occupied
50	60028	373,971	5,209,320	4:36:00	Occupied
51	60035	374,268	5,209,331	0:00:00	Occupied
52	60042	375,320	5,209,336	0:00:00	Occupied
53	60044	375,770	5,209,460	0:00:00	Occupied
54	60048	376,397	5,210,435	7:37:00	Occupied
55	60052	376,671	5,210,591	5:32:00	Occupied
56	60054	376,515	5,211,062	10:21:00	Occupied
57	60058	376,209	5,210,903	14:15:00	Occupied
58	60062	375,973	5,210,859	36:23:00	Occupied
59	60065	375,966	5,211,041	22:54:00	Occupied
60	60070	376,164	5,212,140	11:39:00	Occupied
61	60076	376,229	5,212,642	4:30:00	Occupied
62	60080	369,491	5,212,432	10:42:00	Occupied
63	60083	368,754	5,212,014	4:04:00	Occupied
64	60085	368,637	5,211,618	4:04:00	Occupied
65	60090	368,671	5,211,608	4:23:00	Occupied
66	60092	368,562	5,211,213	2:37:00	Occupied
67	530003	380,670	5,216,823	0:00:00	Occupied
68	530020	380,646	5,217,791	5:39:00	Occupied
69	530040	381,894	5,217,518	0:00:00	Occupied
70	530062	383,364	5,216,276	19:38:00	Occupied
71	530076	384,588	5,214,106	0:00:00	Occupied
72	530105	383,345	5,217,711	18:00:00	Occupied
73	530107	384,110	5,218,969	20:58:00	Occupied
74	530117	383,241	5,219,439	0:00:00	Occupied
75	530121	386,637	5,220,374	0:00:00	Occupied
76	530133	386,633	5,219,482	23:16:00	Occupied
77	530141	386,513	5,218,238	6:34:00	Occupied
78	530160	386,944	5,216,909	6:49:00	Occupied
79	530173	385,063	5,217,268	31:08:00	Occupied
80	530036	381,502	5,217,191	0:00:00	Unoccupied
81	530093	383,270	5,217,511	17:18:00	Unoccupied
82	530154	386,429	5,218,300	7:54:00	Unoccupied
83	530156	386,411	5,218,203	6:21:00	Unoccupied
84	60040	375,079	5,209,360	0:00:00	Unoccupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
85	2013	380,100	5,218,948	2:05:00	Unoccupied
86	2014	379,983	5,218,952	0:45:00	Unoccupied
87	2061	373,618	5,222,266	0:00:00	Unoccupied
88	40011a	375,671	5,223,949	0:00:00	Unoccupied
89	40028a	375,368	5,229,059	0:00:00	Unoccupied
90	40049	373,825	5,224,083	0:00:00	Unoccupied
91	40074a	370,668	5,225,623	0:00:00	Unoccupied
92	40076a	370,151	5,225,694	0:00:00	Unoccupied
93	40125a	372,393	5,227,947	0:00:00	Unoccupied
94	40128	372,293	5,228,874	0:00:00	Unoccupied
95	40139a	369,726	5,224,097	0:00:00	Unoccupied
96	40142	367,963	5,222,567	0:00:00	Unoccupied
97	40324	365,832	5,226,445	0:00:00	Unoccupied
98	40326	365,834	5,226,625	0:00:00	Unoccupied
99	40342	370,909	5,226,405	0:00:00	Unoccupied
100	41013a	368,951	5,226,825	0:00:00	Unoccupied
101	41014a	368,950	5,226,845	0:00:00	Unoccupied
102	390002	372,431	5,226,918	0:00:00	Unoccupied
103	390019	369,513	5,212,867	3:32:00	Unoccupied
104	5000000	378,668	5,221,147	0:00:00	Unoccupied
105	2011	383,232	5,219,483	0:00:00	Occupied
106	2015	376,198	5,217,497	0:00:00	Occupied
107	2016	372,755	5,218,312	0:00:00	Occupied
108	2018	368,373	5,219,341	0:00:00	Occupied
109	2019	367,510	5,219,031	0:00:00	Occupied
110	2020w	365,973	5,217,765	0:00:00	Occupied
111	2020	369,311	5,219,083	0:00:00	Occupied
112	2024	369,232	5,219,059	0:00:00	Occupied
113	2028	371,097	5,217,187	0:00:00	Occupied
114	2030	374,516	5,216,892	0:00:00	Occupied
115	2036	372,317	5,216,000	0:00:00	Occupied
116	2041	371,025	5,215,602	0:00:00	Occupied
117	2045	370,218	5,216,534	0:00:00	Occupied
118	2047	370,195	5,216,578	0:00:00	Occupied
119	2050	368,883	5,216,631	0:00:00	Occupied
120	2051	378,621	5,221,835	0:00:00	Occupied
121	2053e	379,196	5,221,219	0:00:00	Occupied
122	2053	367,280	5,216,355	0:00:00	Occupied
123	2054	376,457	5,222,208	0:00:00	Occupied
124	2055	376,380	5,222,202	0:00:00	Occupied
125	2056	375,960	5,222,198	0:00:00	Occupied
126	2057a	367,248	5,215,913	0:00:00	Occupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
127	2057	375,513	5,220,742	0:00:00	Occupied
128	2058	375,404	5,220,251	0:00:00	Occupied
129	2059	374,606	5,221,973	0:00:00	Occupied
130	2060a	368,839	5,215,450	0:00:00	Occupied
131	2060	374,367	5,222,200	0:00:00	Occupied
132	2062	372,289	5,222,275	0:00:00	Occupied
133	2063	372,584	5,220,687	0:00:00	Occupied
134	2065	366,333	5,220,865	0:00:00	Occupied
135	2066a	365,765	5,216,992	0:00:00	Occupied
136	2066	366,175	5,220,821	0:00:00	Occupied
137	2067	366,079	5,220,821	0:00:00	Occupied
138	2068	364,110	5,219,367	0:00:00	Occupied
139	6096	366,619	5,217,768	0:00:00	Occupied
140	6099	366,688	5,218,078	0:00:00	Occupied
141	6100a	372,687	5,220,626	0:00:00	Occupied
142	40001a	376,933	5,223,953	0:00:00	Occupied
143	40018a	375,524	5,224,880	0:00:00	Occupied
144	40021a	376,428	5,227,682	0:00:00	Occupied
145	40025	375,732	5,229,916	0:00:00	Occupied
146	40031	375,434	5,226,226	0:00:00	Occupied
147	40033	373,882	5,225,842	0:00:00	Occupied
148	40037a	373,984	5,228,148	0:00:00	Occupied
149	40039	373,837	5,227,612	0:00:00	Occupied
150	40044	375,953	5,224,137	0:00:00	Occupied
151	40051	373,899	5,223,692	0:00:00	Occupied
152	40055a	372,334	5,224,178	0:00:00	Occupied
153	40066	372,315	5,225,695	0:00:00	Occupied
154	40077	370,102	5,225,602	0:00:00	Occupied
155	40081	369,701	5,225,578	0:00:00	Occupied
156	40086	368,967	5,226,144	0:00:00	Occupied
157	40089	367,924	5,226,018	0:00:00	Occupied
158	40093a	367,907	5,226,008	0:00:00	Occupied
159	40097	368,972	5,227,351	0:00:00	Occupied
160	40099	367,401	5,228,151	0:00:00	Occupied
161	40100	367,556	5,227,926	0:00:00	Occupied
162	40105a	367,270	5,227,370	0:00:00	Occupied
163	40107a	365,871	5,224,958	0:00:00	Occupied
164	40110b	366,065	5,224,523	0:00:00	Occupied
165	40112	371,312	5,222,602	0:00:00	Occupied
166	40116a	372,859	5,222,443	0:00:00	Occupied
167	40120	373,474	5,222,500	0:00:00	Occupied
168	40124	374,934	5,222,439	0:00:00	Occupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
169	40134a	371,186	5,223,960	0:00:00	Occupied
170	40135	371,067	5,223,960	0:00:00	Occupied
171	40149a	367,475	5,223,178	0:00:00	Occupied
172	40155a	366,297	5,223,595	0:00:00	Occupied
173	40196	365,654	5,221,719	0:00:00	Occupied
174	40198	365,596	5,221,731	0:00:00	Occupied
175	40323	365,791	5,225,833	0:00:00	Occupied
176	40329	364,837	5,227,355	0:00:00	Occupied
177	40333a	365,619	5,228,487	0:00:00	Occupied
178	60028	373,971	5,209,320	4:36:00	Occupied
179	60066	375,965	5,211,018	23:58:00	Occupied
180	2012	380,630	5,217,738	0:00:00	Unoccupied
181	2025a	370,431	5,218,318	0:00:00	Unoccupied
182	2027	369,737	5,218,420	0:00:00	Unoccupied
183	2052	378,705	5,221,297	0:00:00	Unoccupied
184	2064	366,589	5,221,003	0:00:00	Unoccupied
185	40060	372,120	5,223,886	0:00:00	Unoccupied
186	40063a	372,312	5,224,843	0:00:00	Unoccupied
187	40069	372,228	5,226,802	0:00:00	Unoccupied
188	40070a	372,259	5,227,439	0:00:00	Unoccupied
189	40130a	375,933	5,228,266	0:00:00	Unoccupied
190	40140a	368,909	5,223,606	0:00:00	Unoccupied
191	40152a	365,746	5,223,799	0:00:00	Unoccupied
192	40193	365,836	5,222,282	0:00:00	Unoccupied
193	40336a	373,387	5,228,862	0:00:00	Unoccupied
194	40343	370,818	5,228,021	0:00:00	Unoccupied

**Wilton IV Wind Energy Center  
WindPro Shadow Flicker Analysis Results Summary  
Turbine Scenario B (Wilton IV plus Existing Turbines)**

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
1	53007	380,694	5,216,793	0:00:00	Unoccupied
2	60005	372,824	5,212,708	59:33:00	Unoccupied
3	390019	369,513	5,212,867	3:32:00	Unoccupied
4	530010	380,647	5,216,753	0:00:00	Unoccupied
5	530014	380,625	5,216,754	0:00:00	Unoccupied
6	530023	380,673	5,217,814	6:52:00	Unoccupied
7	530028	380,693	5,217,783	0:00:00	Unoccupied
8	530029	380,626	5,217,756	1:44:00	Unoccupied
9	530033	380,615	5,217,720	0:00:00	Unoccupied
10	530044	381,925	5,217,498	0:00:00	Unoccupied
11	530048	381,950	5,217,604	0:41:00	Unoccupied
12	530049	381,924	5,217,605	1:21:00	Unoccupied
13	530053	381,904	5,217,608	1:59:00	Unoccupied
14	530055	381,873	5,217,610	2:50:00	Unoccupied
15	530059	381,871	5,217,584	0:00:00	Unoccupied
16	530067	383,380	5,216,196	19:57:00	Unoccupied
17	530070	383,428	5,216,176	24:55:00	Unoccupied
18	530073	383,446	5,216,269	20:03:00	Unoccupied
19	530080	384,574	5,214,158	0:00:00	Unoccupied
20	530083	384,560	5,214,155	0:00:00	Unoccupied
21	530085	384,542	5,214,136	0:00:00	Unoccupied
22	530087	384,543	5,214,100	0:00:00	Unoccupied
23	530090	384,543	5,214,091	0:00:00	Unoccupied
24	530101	383,401	5,217,704	22:04:00	Unoccupied
25	530106	383,413	5,217,713	23:35:00	Unoccupied
26	530114	384,071	5,219,042	19:05:00	Unoccupied
27	530120	383,225	5,219,446	0:00:00	Unoccupied
28	530125	386,672	5,220,354	0:00:00	Unoccupied
29	530129	386,624	5,220,336	0:00:00	Unoccupied
30	530136	386,682	5,219,476	20:01:00	Unoccupied
31	530138	386,699	5,219,476	18:58:00	Unoccupied
32	530145	386,513	5,218,265	7:57:00	Unoccupied
33	530148	386,500	5,218,264	7:37:00	Unoccupied
34	530152	386,487	5,218,266	7:26:00	Unoccupied
35	530164	386,937	5,216,938	6:48:00	Unoccupied
36	530167	385,105	5,217,281	25:05:00	Unoccupied
37	530170	385,112	5,217,255	29:25:00	Unoccupied
38	530175	385,078	5,217,318	21:43:00	Unoccupied
39	530179	385,089	5,217,313	22:05:00	Unoccupied
40	530183	385,122	5,217,332	22:08:00	Unoccupied
41	2063	373,499	5,211,684	13:05:00	Occupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
42	60002a	375,123	5,214,163	0:00:00	Occupied
43	60010a	372,900	5,213,255	47:18:00	Occupied
44	60012a	371,877	5,212,797	13:48:00	Occupied
45	60016	372,129	5,214,610	2:56:00	Occupied
46	60018a	371,895	5,212,263	21:34:00	Occupied
47	60020a	372,243	5,211,194	7:04:00	Occupied
48	60024a	372,255	5,209,130	0:00:00	Occupied
49	60027a	373,800	5,209,328	2:05:00	Occupied
50	60028	373,971	5,209,320	4:36:00	Occupied
51	60035	374,268	5,209,331	0:00:00	Occupied
52	60042	375,320	5,209,336	0:00:00	Occupied
53	60044	375,770	5,209,460	0:00:00	Occupied
54	60048	376,397	5,210,435	7:37:00	Occupied
55	60052	376,671	5,210,591	5:32:00	Occupied
56	60054	376,515	5,211,062	10:21:00	Occupied
57	60058	376,209	5,210,903	14:15:00	Occupied
58	60062	375,973	5,210,859	36:23:00	Occupied
59	60065	375,966	5,211,041	22:54:00	Occupied
60	60070	376,164	5,212,140	11:39:00	Occupied
61	60076	376,229	5,212,642	4:30:00	Occupied
62	60080	369,491	5,212,432	10:42:00	Occupied
63	60083	368,754	5,212,014	4:04:00	Occupied
64	60085	368,637	5,211,618	4:04:00	Occupied
65	60090	368,671	5,211,608	4:23:00	Occupied
66	60092	368,562	5,211,213	2:37:00	Occupied
67	530003	380,670	5,216,823	0:00:00	Occupied
68	530020	380,646	5,217,791	5:39:00	Occupied
69	530040	381,894	5,217,518	0:00:00	Occupied
70	530062	383,364	5,216,276	19:38:00	Occupied
71	530076	384,588	5,214,106	0:00:00	Occupied
72	530105	383,345	5,217,711	18:00:00	Occupied
73	530107	384,110	5,218,969	20:58:00	Occupied
74	530117	383,241	5,219,439	0:00:00	Occupied
75	530121	386,637	5,220,374	0:00:00	Occupied
76	530133	386,633	5,219,482	23:16:00	Occupied
77	530141	386,513	5,218,238	6:34:00	Occupied
78	530160	386,944	5,216,909	6:49:00	Occupied
79	530173	385,063	5,217,268	31:08:00	Occupied
80	530036	381,502	5,217,191	0:00:00	Unoccupied
81	530093	383,270	5,217,511	17:18:00	Unoccupied
82	530154	386,429	5,218,300	7:54:00	Unoccupied
83	530156	386,411	5,218,203	6:21:00	Unoccupied
84	60040	375,079	5,209,360	0:00:00	Unoccupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
85	2013	380,100	5,218,948	2:05:00	Unoccupied
86	2014	379,983	5,218,952	0:45:00	Unoccupied
87	2061	373,618	5,222,266	0:00:00	Unoccupied
88	40011a	375,671	5,223,949	0:00:00	Unoccupied
89	40028a	375,368	5,229,059	0:00:00	Unoccupied
90	40049	373,825	5,224,083	0:00:00	Unoccupied
91	40074a	370,668	5,225,623	0:00:00	Unoccupied
92	40076a	370,151	5,225,694	0:00:00	Unoccupied
93	40125a	372,393	5,227,947	0:00:00	Unoccupied
94	40128	372,293	5,228,874	0:00:00	Unoccupied
95	40139a	369,726	5,224,097	0:00:00	Unoccupied
96	40142	367,963	5,222,567	0:00:00	Unoccupied
97	40324	365,832	5,226,445	0:00:00	Unoccupied
98	40326	365,834	5,226,625	0:00:00	Unoccupied
99	40342	370,909	5,226,405	0:00:00	Unoccupied
100	41013a	368,951	5,226,825	0:00:00	Unoccupied
101	41014a	368,950	5,226,845	0:00:00	Unoccupied
102	390002	372,431	5,226,918	0:00:00	Unoccupied
103	390019	369,513	5,212,867	3:32:00	Unoccupied
104	5000000	378,668	5,221,147	0:00:00	Unoccupied
105	2011	383,232	5,219,483	0:00:00	Occupied
106	2015	376,198	5,217,497	0:00:00	Occupied
107	2016	372,755	5,218,312	0:00:00	Occupied
108	2018	368,373	5,219,341	0:00:00	Occupied
109	2019	367,510	5,219,031	0:00:00	Occupied
110	2020w	365,973	5,217,765	0:00:00	Occupied
111	2020	369,311	5,219,083	0:00:00	Occupied
112	2024	369,232	5,219,059	0:00:00	Occupied
113	2028	371,097	5,217,187	0:00:00	Occupied
114	2030	374,516	5,216,892	0:00:00	Occupied
115	2036	372,317	5,216,000	0:00:00	Occupied
116	2041	371,025	5,215,602	0:00:00	Occupied
117	2045	370,218	5,216,534	0:00:00	Occupied
118	2047	370,195	5,216,578	0:00:00	Occupied
119	2050	368,883	5,216,631	0:00:00	Occupied
120	2051	378,621	5,221,835	0:00:00	Occupied
121	2053e	379,196	5,221,219	0:00:00	Occupied
122	2053	367,280	5,216,355	0:00:00	Occupied
123	2054	376,457	5,222,208	0:00:00	Occupied
124	2055	376,380	5,222,202	0:00:00	Occupied
125	2056	375,960	5,222,198	0:00:00	Occupied
126	2057a	367,248	5,215,913	0:00:00	Occupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
127	2057	375,513	5,220,742	0:00:00	Occupied
128	2058	375,404	5,220,251	0:00:00	Occupied
129	2059	374,606	5,221,973	0:00:00	Occupied
130	2060a	368,839	5,215,450	0:00:00	Occupied
131	2060	374,367	5,222,200	0:00:00	Occupied
132	2062	372,289	5,222,275	0:00:00	Occupied
133	2063	372,584	5,220,687	0:00:00	Occupied
134	2065	366,333	5,220,865	0:00:00	Occupied
135	2066a	365,765	5,216,992	0:00:00	Occupied
136	2066	366,175	5,220,821	0:00:00	Occupied
137	2067	366,079	5,220,821	0:00:00	Occupied
138	2068	364,110	5,219,367	0:00:00	Occupied
139	6096	366,619	5,217,768	0:00:00	Occupied
140	6099	366,688	5,218,078	0:00:00	Occupied
141	6100a	372,687	5,220,626	0:00:00	Occupied
142	40001a	376,933	5,223,953	0:00:00	Occupied
143	40018a	375,524	5,224,880	0:00:00	Occupied
144	40021a	376,428	5,227,682	0:00:00	Occupied
145	40025	375,732	5,229,916	0:00:00	Occupied
146	40031	375,434	5,226,226	0:00:00	Occupied
147	40033	373,882	5,225,842	0:00:00	Occupied
148	40037a	373,984	5,228,148	0:00:00	Occupied
149	40039	373,837	5,227,612	0:00:00	Occupied
150	40044	375,953	5,224,137	0:00:00	Occupied
151	40051	373,899	5,223,692	0:00:00	Occupied
152	40055a	372,334	5,224,178	0:00:00	Occupied
153	40066	372,315	5,225,695	0:00:00	Occupied
154	40077	370,102	5,225,602	0:00:00	Occupied
155	40081	369,701	5,225,578	0:00:00	Occupied
156	40086	368,967	5,226,144	0:00:00	Occupied
157	40089	367,924	5,226,018	0:00:00	Occupied
158	40093a	367,907	5,226,008	0:00:00	Occupied
159	40097	368,972	5,227,351	0:00:00	Occupied
160	40099	367,401	5,228,151	0:00:00	Occupied
161	40100	367,556	5,227,926	0:00:00	Occupied
162	40105a	367,270	5,227,370	0:00:00	Occupied
163	40107a	365,871	5,224,958	0:00:00	Occupied
164	40110b	366,065	5,224,523	0:00:00	Occupied
165	40112	371,312	5,222,602	0:00:00	Occupied
166	40116a	372,859	5,222,443	0:00:00	Occupied
167	40120	373,474	5,222,500	0:00:00	Occupied
168	40124	374,934	5,222,439	0:00:00	Occupied

WindPro Receptor ID	Wilton IV Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Receptor Type
169	40134a	371,186	5,223,960	0:00:00	Occupied
170	40135	371,067	5,223,960	0:00:00	Occupied
171	40149a	367,475	5,223,178	0:00:00	Occupied
172	40155a	366,297	5,223,595	0:00:00	Occupied
173	40196	365,654	5,221,719	0:00:00	Occupied
174	40198	365,596	5,221,731	0:00:00	Occupied
175	40323	365,791	5,225,833	0:00:00	Occupied
176	40329	364,837	5,227,355	0:00:00	Occupied
177	40333a	365,619	5,228,487	0:00:00	Occupied
178	60028	373,971	5,209,320	4:36:00	Occupied
179	60066	375,965	5,211,018	23:58:00	Occupied
180	2012	380,630	5,217,738	0:00:00	Unoccupied
181	2025a	370,431	5,218,318	0:00:00	Unoccupied
182	2027	369,737	5,218,420	0:00:00	Unoccupied
183	2052	378,705	5,221,297	0:00:00	Unoccupied
184	2064	366,589	5,221,003	0:00:00	Unoccupied
185	40060	372,120	5,223,886	0:00:00	Unoccupied
186	40063a	372,312	5,224,843	0:00:00	Unoccupied
187	40069	372,228	5,226,802	0:00:00	Unoccupied
188	40070a	372,259	5,227,439	0:00:00	Unoccupied
189	40130a	375,933	5,228,266	0:00:00	Unoccupied
190	40140a	368,909	5,223,606	0:00:00	Unoccupied
191	40152a	365,746	5,223,799	0:00:00	Unoccupied
192	40193	365,836	5,222,282	0:00:00	Unoccupied
193	40336a	373,387	5,228,862	0:00:00	Unoccupied
194	40343	370,818	5,228,021	0:00:00	Unoccupied