Final Report
Crowned Ridge Wind Farm
Shadow Flicker Study
Codington and Grant Counties, SD

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January 22,

2019

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TABLE OF CONTENTS

LIST OF TABLES

Report Update

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

Revision History

Revision No.	Revision Purpose	Date	Revised By
0	Original	1/22/2019	J. Haley

Executive Summary

EAPC was hired to provide estimates of the potential shadow flicker impacts for a proposed wind turbine layout in Codington and Grant Counties of the Crowned Ridge wind farm project in northeastern South Dakota. The scope of this report includes all proposed turbines included in the Crowned Ridge project that will be permitted separately through the South Dakota Public Utilities Commission. Locations of area occupied structures and a wind turbine layout using a mixture of wind turbines manufactured by General Electric (GE) were provided to EAPC by Crowned Ridge Wind, LLC. A computer model was built combining digital elevation data with the information supplied by Crowned Ridge Wind, LLC to generate shadow flicker models for the site. The resulting models were then used to perform shadow flicker calculations for the 150 turbines. Based on the calculations, site-wide realistic shadow flicker maps were produced to predict the shadow flicker at nearby residences within the Crowned Ridge Project area.

The model is based on a number of conservative assumptions. No credit was taken for the blocking effects of trees or buildings. The receptors were omni-directional rather than modeling specific facades of buildings, and the study assumes 100% turbine availability.

The scope of this study includes the shadow flicker impacts of the Crowned Ridge wind farm on the two counties it is located within, Codington and Grant. The shadow flicker ordinances of both counties limit the maximum number of shadow flicker to 30 hours per year at occupied structures.

For the shadow study in Codington County, the 67 occupied structures (33 participating and 34 non-participating) were represented in the model by omni-directional shadow receptors that simulate a 1 m x 1 m window at 1 m above ground level.

For the shadow study in Grant County, 58 occupied structures (17 participating and 41 non-participating) were represented in the model by omni-directional shadow receptors that simulate a 1 m x 1 m window at 1 m above ground level.

For the Crowned Ridge turbine array provided, no occupied structures experienced more than 29 hours and 50 minutes of shadow flickering per year based on realistic assumptions regarding operational time and sunshine probability, therefore, the Crowned Ridge wind farm is in compliance with the shadow flicker limitations set forth in both Codington County's Section 5.22.03 paragraph 13 of Ordinance #68, and Section 1211.04 paragraph 14 of Grant County's Ordinance 2016-01C, which is 30 hours per year.

1. INTRODUCTION

EAPC was hired to conduct shadow flicker studies for the regional development of the Crowned Ridge wind farm project located in Codington and Grant Counties in northeastern South Dakota. The regional development's layout consists of 137 GE 2.3 MW wind turbines with a hub height of 90 meters (including 20 alternate turbine locations) and 13 GE 2.3 MW wind turbines with a hub height of 80 meters for a total of 150 wind turbines. The locations of the proposed wind turbines were supplied by Crowned Ridge Wind, LLC.

From the database of occupied structures and coordinates supplied by Crowned Ridge Wind, LLC, 67 occupied structures (33 participating and 34 non-participating) in Codington County and 58 occupied structures (17 participating and 41 non-participating) in Grant County were found to be within 2 kilometers of a wind turbine and were included in the shadow models. Shadow flicker does not extend beyond a distance of approximately 1,700 meters from the wind turbine base.

The area of interest for this report is located in Codington and Grant Counties near the town of Watertown in northeastern South Dakota. The surrounding terrain has a change in elevation across the project site ranging from 475 to 621 meters (1,558 to 2,037 feet) at the wind turbine base. The region's vegetation is comprised primarily of prairie grass and agricultural land. The project overview map can be found in Appendix A.

2. BACKGROUND

Shadow flicker from wind turbines occurs when rotating wind turbine blades move between the sun and the observer. Shadow flicker is generally experienced in areas near wind turbines where the distance between the observer and wind turbine blade is short enough that sunlight has not been significantly diffused by the atmosphere. When the blades rotate, this shadow creates a pulsating effect, known as shadow flicker. If the blade's shadow is passing over the window of a building, it will have the effect of increasing and decreasing the light intensity in the room at a low frequency in the range of 0.4 to 0.78 Hz, hence the term "flicker." In this case, with a maximum rotational speed of 15.6 rpm for the GE 2.3-116, the frequency would be 0.78 Hz. This flickering effect can also be experienced outdoors, but the effect is typically less intense, and becomes less intense when farther from the wind turbine causing the flicker.

This flickering effect is most noticeable within approximately 1,000 meters of the turbine, and becomes more and more diffused as the distance increases. Beyond 1,700 meters, the shadow flicker effects are indistinguishable. There are no uniform standards defining what distance from the turbine is regarded as an acceptable limit beyond which the shadow flicker is considered to be insignificant. The same applies to the number of hours of flickering that is deemed to be acceptable. For this study, in the interest of being conservative, any occupied structure within 2,000 meters of a wind turbine was included in the analysis.

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

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

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

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

3. *STUDY METHODOLOGY*

This shadow flicker analysis was performed utilizing windPRO, which has the ability to calculate detailed shadow flicker maps across an entire area of interest or at site-specific locations using shadow receptors.

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

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

The point-specific shadow flicker calculation is run at a higher resolution as compared to the shadow flicker map calculation to utilize the highest precision available within windPRO. Shadow flicker at each shadow receptor location is calculated every minute of every day for an entire year. Shadow receptors can be configured to represent an omni-directional window of a specific size at a specific point (greenhouse mode) or a window facing a single direction of a specific size at a specific point (single direction mode). The shadow receptors used in this analysis were configured as greenhouse-mode receptors representing a 1 m x 1 m window located 1 m above ground level. This represents more of a "worst-case" scenario and thus will produce more conservative results since it assumes that all windows are always in direct line of sight with the turbines and the sun.

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

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

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

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

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

Turbine Specifications: A wind turbine's total height and rotor diameter will be included in the windPRO shadow flicker model. The taller the wind turbine, the more likely shadow flicker could have an impact on local shadow receptors as the ability to clear obstacles (such as hills or trees) is greater, although in this analysis, no credit is taken for any such blockage from trees. The larger the rotor diameter is, the wider the area where shadows will be cast. Also included with the turbine specifications are the cut-in and cut-out wind speeds within which the wind turbine is operational. If the wind speed is below the cut-in

threshold or above the cut-out threshold, the turbine rotor will not be spinning and thus shadow flicker will not occur.

Shadow Receptor Coordinates: As with the wind turbine coordinates, the elevation, distance and orientation of a shadow receptor in relation to the wind turbines and the sun are the main factors in determining the impact of shadow flicker. EAPC was provided with coordinates for all participating and non-participating occupied structures found to be located within 2 kilometers of the 150 proposed wind turbine locations.

Monthly Sunshine Probabilities: windPRO calculates sunrise and sunset times to determine the total annual hours of daylight for the modeled area. To further refine the shadow flicker calculations, the monthly probability of sunshine is included to account for cloud cover. The greater the probability of cloud cover, the less of an impact from shadow flicker. The monthly sunshine probabilities for many of the larger cities across the United States are available from the National Climatic Data Center (NCDC). For this study, 18 years' worth of monthly sunshine probability data were retrieved for Huron, SD, which was the closest, most representative station, to create the long-term representative monthly sunshine probabilities. The long-term representative monthly average sunshine probabilities are presented below in Table 1.

Table 1: Huron, SD monthly sunshine probabilities

Huron, SD Monthly Sunshine Probabilities (1965-1983)												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sunshine %	0.62	0.62	0.62	0.59	0.66	0.69	0.76	0.74	0.69	0.59	0.51	0.51
retrieved from: http:// http://www1.ncdc.noaa.gov/pub/data/ccd-data/pctpos15.dat												

Joint Wind Speed and Direction Frequency Distribution: A set of long-term corrected wind distributions was provided by Crowned Ridge Wind, LLC to represent the annual wind speed and direction distribution for the project site. This data was used to estimate the probable number of operational hours for the wind turbines from each of the 12 wind direction sectors. During operation, the wind turbine rotors will always be assumed to face into the wind and automatically orient themselves as the wind direction changes. Shadow flicker can only occur when the blades are turning and the wind turbine rotor is between the sun and the receptor. Shadow flicker is most significant when the rotor is facing the sun.

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

Wind Turbines from Adjacent Projects: The Crowned Ridge II project is adjacent to the Crowned Ridge project. Because shadow flicker impacts are cumulative, there will be impacts from the Crowned Ridge II project that will be additive to the impacts from the Crowned Ridge project. The Crowned Ridge II wind turbine array was included in the model to capture the full shadow flicker impacts on the receptors, which are included in the tabular results; however, the shadow flicker iso-line maps only show the shadow flicker from the Crowned Ridge array.

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

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

4. RESULTS OF ANALYSIS

The term "realistic" as used in this report means that turbine operational hours and direction as well as local sunshine probabilities have been factored in, but no blocking or shading effects due to trees or structures have been accounted for. This means that the realistic estimates are still inherently conservative values. Also, the realistic shadow flicker hours predicted by windPRO assumes an availability factor of 100% which is very unlikely to be the case. Actual availability factors will likely be in the range of 95-98%, however, with a conservative approach to estimating shadow flicker totals, the realistic estimates are not discounted accordingly.

<u>Crowned Ridge Codington County Turbines</u>

For Codington County, a total of 67 (33 participating and 34 non-participating) occupied structures within 2 kilometers of a wind turbine were analyzed and standard resolution realistic shadow flicker maps were generated for the turbine array.

The 67 shadow receptors were then modeled as greenhouse-mode receptors and the estimated shadow flicker was calculated for the array. No shadow receptors are expected

to experience more than 28 hours and 42 minutes of shadow flicker per year. Therefore, the Crowned Ridge wind farm would be in compliance with Section 5.22.03 paragraph 13 of Ordinance #68. Of the 67 receptors, the number that registered no shadow flicker hours was 13 (19.4%).

The maximum modeled expected shadow flicker at a participating receptor is 28 hours and 42 minutes and the maximum modeled expected shadow flicker at a non-participating receptor is 28 hours and 20 minutes. Table 2 contains the realistic shadow flicker distribution of the 67 occupied residences.

Table 2: Codington County occupied structures realistic shadow flicker distribution.

Realistic Shadow Flicker (hrs/year)	Number of Non-Participating Occupied Structures	Number of Participating Occupied Structures
0	12	1
0 to 5	5	3
5 to 10	10	6
10 to 15	2	6
15 to 20	1	5
20 to 25	1	6
25 to 30	3	6
30+	0	0

<u>Crowned Ridge Grant County Turbines</u>

For Grant County, 58 (17 participating and 41 non-participating) occupied structures within 2 kilometers of a wind turbine were found and analyzed. Standard resolution realistic shadow flicker maps were generated for the turbine array.

The 58 shadow receptors were then modeled as greenhouse-mode receptors and the estimated shadow flicker was calculated for the array. No occupied structures are expected to experience more than 29 hours and 50 minutes of shadow flicker per year. Therefore, the Crowned Ridge wind farm would be in compliance with Section 1211.04 paragraph 14 of Grant County's Ordinance 2016-01C. Of the 58 occupied structures, the number that registered no shadow flicker hours was 19 (32.7%).

The maximum modeled expected shadow flicker at a participating receptor is 29 hours and 50 minutes and the maximum modeled expected shadow flicker at a non-participating receptor is 25 hours and 18 minutes. Table 3 contains the realistic shadow flicker distribution of the 58 occupied structures.

Table 3: Grant County occupied structures realistic shadow flicker distribution.

Realistic Shadow Flicker (hrs/year)	Number of Non-Participating Occupied Structures	Number of Participating Occupied Structures
0	15	4
0 to 5	10	1
5 to 10	7	2
10 to 15	4	3
15 to 20	3	3
20 to 25	1	2
25 to 30	1	2
30+	0	0

Crowned Ridge Turbines Summary

For the Crowned Ridge Project, no occupied structures are expected to experience more than 29 hours and 50 minutes of shadow flicker per year, for both counties. The summary of results is shown in table 4 below. The full table of results from the realistic shadow flicker study can be found in Appendix C. Table C-1 lists the results sorted by receptor number and Table C-2 lists the results sorted by shadow flicker hours from highest to lowest., The Crowned Ridge II wind turbine array was included in the model to capture the full shadow flicker impacts on the receptors, which are included in the tabular results; however, the shadow flicker iso-line maps only show the shadow flicker from the Crowned Ridge array. The maps showing the shadow flicker impact iso-lines for the Crowned Ridge wind farm are in Appendix D.

Table 4: Summary of shadow flicker predictions.

County	Feature	Shadow Limit (hr/yr)	Maximum Predicted (hr/yr)
Codington	Participating Occupied Structures	30	28:42
	Non-Participating Occupied Structures	30	28:20
Grant	Participating Occupied Structures	30	29:50
	Non-Participating Occupied Structures	30	25:18

5. CONCLUSIONS

The shadow flicker impact on the receptors was calculated with reductions due to turbine operational direction and sunshine probabilities included. For both counties, no occupied structures are expected to experience more than 29 hours and 50 minutes of shadow flicker per year.

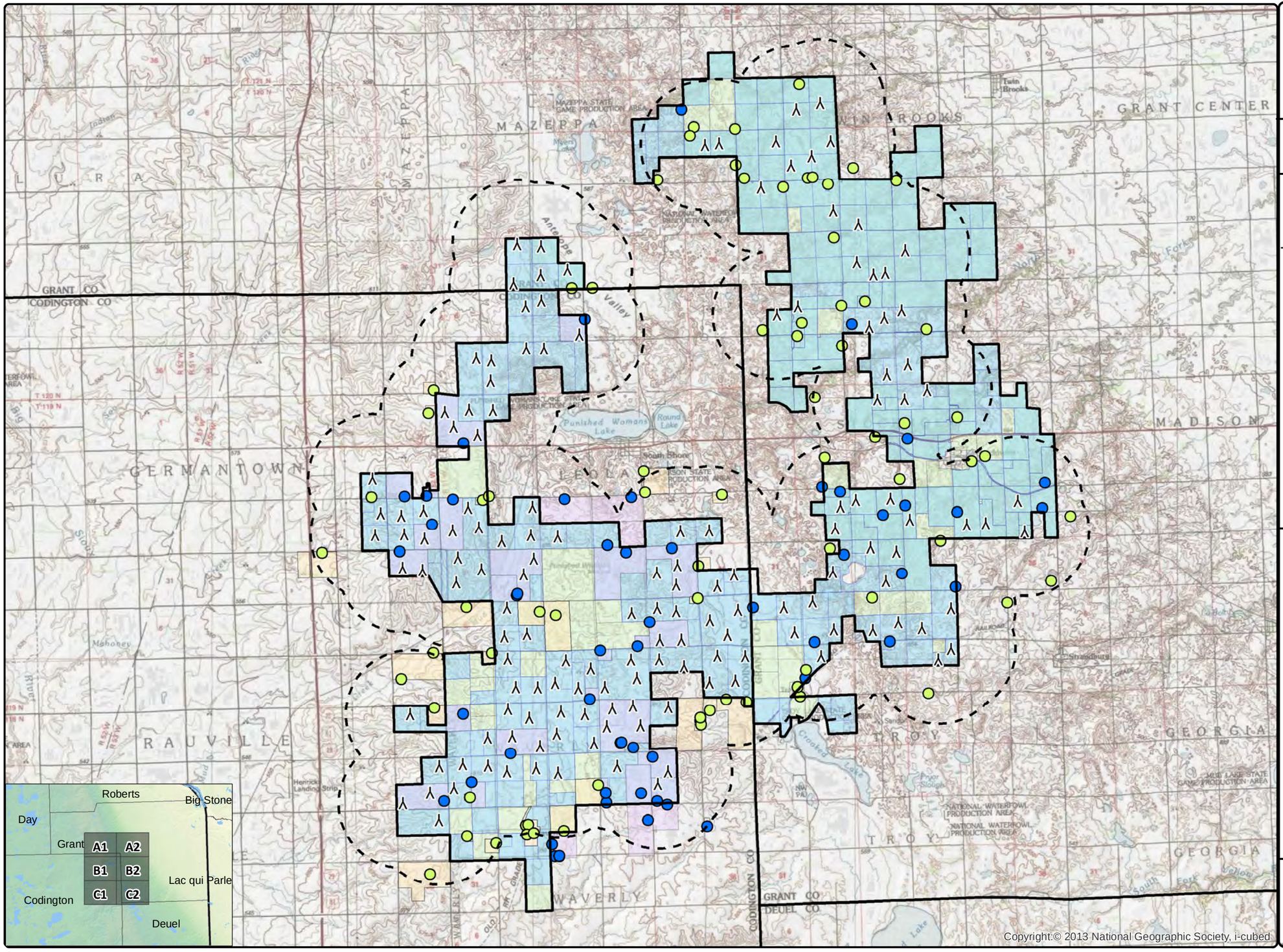
This shadow flicker analysis is based on a number of conservative assumptions including:

- No credit was taken for the blocking effects of trees or buildings.
- The receptors were omni-directional rather than modeling specific facades of buildings.
- Study assumes 100% turbine availability
- Study assumes all turbine locations, including alternates, are built and operating

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

APPENDIX A: CROWNED RIDGE WIND ENERGY PROJECT SITE OVERVIEW MAP

Exhibit A1-I



0 0.75 1.5 3 Mile

EAPC WIND ENERGY

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Crowned Ridge Wind Farm
Project Overview Map

Client

SWCA Environmental Consultants

Project Description

Wind turbine layout with land parcels within the project footprint and existing occupied strucures and occupied Codington County land parcels within 2 km of a wind turbine.

Location: Watertown, SD
Project #: 20174430

Issue Dates

#	Description	Date
1	Original	2019.01.15

Drawn By: AS | *Checked By: JH*

Legend

- Crowned Ridge Turbines
- 2 km Turbine Buffer
- County Lines
- CR1 Project Boundary
- Non-Participants
- Participants
- Participating Codington Parcels
- Non-Part. Codington Parcels
- Participating Land Parcels
- Non-Participating Land Parcels

N W E S

APPENDIX B: WIND TURBINE COORDINATES

Crowned Ridge Wind Farm
GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14

WTG	Turbine Type	Easting (m)	Northing (m)	Base Elev. AMSL (m)	Sound Profile
CRI-1	GE2.3 116RD 90HH r2.madE	659,443	5,003,083	610.2	LNTE
CRI-2	GE2.3 116RD 90HH r2.madE	660,185	5,003,010	598.1	LNTE
CRI-3	GE2.3 116RD 90HH r2.madE	661,008	5,002,288	584.2	LNTE
CRI-4	GE2.3 116RD 90HH r2.madE	660,173	5,002,120	602.4	LNTE
CRI-5	GE2.3 116RD 90HH r2.madE	659,337	5,001,862	609.9	LNTE
CRI-6	GE2.3 116RD 90HH r2.madE	660,193	5,001,329	610.4	LNTE
CRI-7	GE2.3 116RD 90HH r2.madE	659,705	5,001,146	618.0	LNTE
CRI-8	GE2.3 116RD 90HH r2.madE	661,380	5,000,282	588.3	LNTE
CRI-9	GE2.3 116RD 90HH r2.madE	659,731	4,999,855	613.3	LNTE
CRI-10	GE2.3 116RD 90HH r2.madE	660,280	4,999,837	615.0	LNTE
CRI-11	GE2.3 116RD 90HH r2.madE	658,170	4,999,546	611.0	LNTE
CRI-12	GE2.3 116RD 90HH r2.madE	658,644	4,999,460	615.0	LNTE
CRI-13	GE2.3 116RD 90HH r2.madE	658,622	4,998,843	613.3	LNTE
CRI-14	GE2.3 116RD 90HH r2.madE	657,947	4,997,935	618.3	LNTE
CRI-15	GE2.3 116RD 90HH r2.madE	658,688	4,997,924	618.9	LNTE
CRI-16	GE2.3 116RD 90HH r2.madE	657,203	4,997,856	611.9	LNTE
CRI-17	GE2.3 116RD 90HH r2.madE	657,476	4,997,410	611.1	LNTE
CRI-18	GE2.3 116RD 90HH r2.madE	658,217	4,997,154	618.0	LNTE
CRI-19	GE2.3 116RD 90HH r2.madE	654,954	4,995,804	601.1	LNTE
CRI-20	GE2.3 116RD 90HH r2.madE	659,920	4,994,924	594.4	LNTE
CRI-21	GE2.3 116RD 90HH r2.madE	657,925	4,994,896	617.1	LNTE
CRI-22	GE2.3 116RD 90HH r2.madE	656,543	4,994,796	616.5	LNTE
CRI-23	GE2.3 116RD 90HH r2.madE	655,208	4,994,717	594.5	LNTE
CRI-24	GE2.3 116RD 90HH r2.madE	655,852	4,994,652	609.0	LNTE
CRI-25	GE2.3 116RD 90HH r2.madE	658,251	4,994,286	606.0	LNTE
CRI-26	GE2.3 116RD 90HH r2.madE	665,405	4,994,191	578.3	LNTE
CRI-27	GE2.3 116RD 90HH r2.madE	657,442	4,994,187	621.0	LNTE
CRI-28	GE2.3 116RD 90HH r2.madE	664,517	4,994,168	579.0	LNTE
CRI-29	GE2.3 116RD 90HH r2.madE	655,940	4,994,069	606.9	LNTE
CRI-30	GE2.3 116RD 90HH r2.madE	659,871	4,994,052	593.6	LNTE
CRI-31	GE2.3 116RD 90HH r2.madE	655,030	4,994,051	603.0	LNTE
CRI-32	GE2.3 116RD 90HH r2.madE	660,704	4,993,998	606.0	LNTE
CRI-33	GE2.3 116RD 90HH r2.madE	656,566	4,993,941	618.0	LNTE
CRI-34	GE2.3 116RD 90HH r2.madE	658,966	4,993,856	599.6	LNTE
CRI-35	GE2.3 116RD 90HH r2.madE	657,602	4,993,347	607.5	LNTE
CRI-36	GE2.3 116RD 90HH r2.madE	659,966	4,993,319	594.0	LNTE
CRI-37	GE2.3 116RD 90HH r2.madE	664,419	4,993,110	587.2	LNTE
CRI-38	GE2.3 116RD 90HH r2.madE	658,338	4,992,981	600.5	LNTE
CRI-39	GE2.3 116RD 90HH r2.madE	656,507	4,992,958	609.0	LNTE
CRI-40	GE2.3 116RD 90HH r2.madE	655,889	4,993,035	603.0	LNTE
CRI-41	GE2.3 116RD 90HH r2.madE	663,782	4,992,883	597.2	LNTE

Crowned Ridge Wind Farm
GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
continued

WTG	Turbine Type	Easting (m)	Northing (m)	Base Elev. AMSL (m)	Sound Profile
CRI-43	GE2.3 116RD 90HH r2.madE	666,181	4,992,815	577.8	LNTE
CRI-44	GE2.3 116RD 90HH r2.madE	665,665	4,992,460	576.0	LNTE
CRI-46	GE2.3 116RD 90HH r2.madE	664,387	4,992,505	591.0	LNTE
CRI-48	GE2.3 116RD 90HH r2.madE	663,794	4,991,782	587.5	LNTE
CRI-49	GE2.3 116RD 90HH r2.madE	664,385	4,991,685	581.6	LNTE
CRI-50	GE2.3 116RD 90HH r2.madE	662,999	4,991,622	612.0	LNTE
CRI-51	GE2.3 116RD 90HH r2.madE	666,299	4,991,723	575.3	LNTE
CRI-52	GE2.3 116RD 90HH r2.madE	665,426	4,991,398	575.6	LNTE
CRI-53	GE2.3 116RD 90HH r2.madE	659,750	4,990,981	598.7	LNTE
CRI-54	GE2.3 116RD 90HH r2.madE	665,979	4,990,946	573.7	LNTE
CRI-55	GE2.3 116RD 90HH r2.madE	659,045	4,990,899	597.0	LNTE
CRI-56	GE2.3 116RD 90HH r2.madE	664,548	4,990,794	591.9	LNTE
CRI-57	GE2.3 116RD 90HH r2.madE	663,874	4,990,787	600.1	LNTE
CRI-58	GE2.3 116RD 90HH r2.madE	665,663	4,990,303	585.0	LNTE
CRI-59	GE2.3 116RD 90HH r2.madE	666,523	4,990,291	573.0	LNTE
CRI-60	GE2.3 116RD 90HH r2.madE	659,155	4,990,208	593.9	LNTE
CRI-61	GE2.3 116RD 90HH r2.madE	662,982	4,990,178	612.0	LNTE
CRI-62	GE2.3 116RD 90HH r2.madE	660,954	4,990,155	600.8	LNTE
CRI-63	GE2.3 116RD 90HH r2.madE	664,627	4,989,977	588.7	LNTE
CRI-64	GE2.3 116RD 90HH r2.madE	663,858	4,990,188	604.5	LNTE
CRI-65	GE2.3 116RD 90HH r2.madE	661,732	4,989,898	609.0	LNTE
CRI-66	GE2.3 116RD 90HH r2.madE	663,165	4,989,613	614.9	LNTE
CRI-67	GE2.3 116RD 90HH r2.madE	666,226	4,989,531	574.8	LNTE
CRI-68	GE2.3 116RD 90HH r2.madE	665,420	4,989,461	585.0	LNTE
CRI-69	GE2.3 116RD 80HH r2.madE	660,621	4,989,453	605.4	LNTE
CRI-70	GE2.3 116RD 90HH r2.madE	662,171	4,989,319	611.0	LNTE
CRI-71	GE2.3 116RD 80HH r2.madE	659,405	4,989,320	607.4	LNTE
CRI-72	GE2.3 116RD 80HH r2.madE	660,087	4,989,309	606.0	LNTE
CRI-73	GE2.3 116RD 90HH r2.madE	661,344	4,989,297	609.8	LNTE
CRI-74	GE2.3 116RD 90HH r2.madE	663,041	4,988,744	615.0	LNTE
CRI-75	GE2.3 116RD 90HH r2.madE	664,137	4,988,702	609.0	LNTE
CRI-76	GE2.3 116RD 90HH r2.madE	662,399	4,988,667	615.0	LNTE
CRI-77	GE2.3 116RD 80HH r2.madE	659,158	4,988,642	612.0	LNTE
CRI-78	GE2.3 116RD 80HH r2.madE	660,811	4,988,558	604.2	LNTE
CRI-79	GE2.3 116RD 90HH r2.madE	656,125	4,988,485	595.0	LNTE
CRI-80	GE2.3 116RD 90HH r2.madE	661,552	4,988,481	608.8	LNTE
CRI-81	GE2.3 116RD 90HH r2.madE	659,825	4,988,365	606.5	LNTE
CRI-82	GE2.3 116RD 90HH r2.madE	663,271	4,988,133	613.0	LNTE
CRI-83	GE2.3 116RD 90HH r2.madE	662,227	4,988,103	606.5	LNTE
CRI-84	GE2.3 116RD 80HH r2.madE	660,677	4,987,880	600.5	LNTE
CRI-85	GE2.3 116RD 90HH r2.madE	659,295	4,987,798	612.0	LNTE

Crowned Ridge Wind Farm
GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
continued

WTG	Turbine Type	Easting (m)	Northing (m)	Base Elev. AMSL (m)	Sound Profile
CRI-86	GE2.3 116RD 90HH r2.madE	658,534	4,987,759	613.3	LNTE
CRI-87	GE2.3 116RD 90HH r2.madE	661,830	4,987,596	609.0	LNTE
CRI-88	GE2.3 116RD 90HH r2.madE	660,157	4,987,492	603.0	LNTE
CRI-89	GE2.3 116RD 80HH r2.madE	657,758	4,986,926	614.9	LNTE
CRI-90	GE2.3 116RD 80HH r2.madE	658,545	4,986,881	612.0	LNTE
CRI-91	GE2.3 116RD 80HH r2.madE	657,023	4,986,868	612.0	LNTE
CRI-92	GE2.3 116RD 80HH r2.madE	660,039	4,986,804	606.9	LNTE
CRI-93	GE2.3 116RD 80HH r2.madE	659,133	4,986,700	608.0	LNTE
CRI-94	GE2.3 116RD 80HH r2.madE	660,716	4,986,660	600.7	LNTE
CRI-95	GE2.3 116RD 90HH r2.madE	657,488	4,986,184	612.0	LNTE
CRI-96	GE2.3 116RD 90HH r2.madE	656,744	4,986,037	609.0	LNTE
CRI-97	GE2.3 116RD 80HH r2.madE	655,899	4,985,715	592.6	LNTE
CRI-98	GE2.3 116RD 90HH r2.madE	657,015	4,985,192	609.0	LNTE
CRI-99	GE2.3 116RD 90HH r2.madE	672,521	4,990,188	556.7	LNTE
CRI-100	GE2.3 116RD 90HH r2.madE	668,885	4,990,286	585.0	LNTE
CRI-101	GE2.3 116RD 90HH r2.madE	672,921	4,990,513	544.6	LNTE
CRI-102	GE2.3 116RD 90HH r2.madE	668,059	4,991,023	580.9	LNTE
CRI-103	GE2.3 116RD 90HH r2.madE	669,279	4,991,115	582.0	LNTE
CRI-104	GE2.3 116RD 90HH r2.madE	672,009	4,991,151	555.0	LNTE
CRI-105	GE2.3 116RD 90HH r2.madE	670,488	4,991,091	571.7	LNTE
CRI-106	GE2.3 116RD 90HH r2.madE	671,278	4,991,335	567.0	LNTE
CRI-107	GE2.3 116RD 90HH r2.madE	667,723	4,991,800	582.0	LNTE
CRI-108	GE2.3 116RD 90HH r2.madE	672,917	4,991,775	541.2	LNTE
CRI-109	GE2.3 116RD 90HH r2.madE	670,897	4,992,616	557.3	LNTE
CRI-111	GE2.3 116RD 90HH r2.madE	671,220	4,993,526	550.6	LNTE
CRI-112	GE2.3 116RD 90HH r2.madE	670,419	4,993,665	561.0	LNTE
CRI-113	GE2.3 116RD 90HH r2.madE	675,201	4,994,165	497.6	LNTE
CRI-114	GE2.3 116RD 90HH r2.madE	669,318	4,994,256	561.8	LNTE
CRI-115	GE2.3 116RD 90HH r2.madE	673,402	4,994,374	516.4	LNTE
CRI-116	GE2.3 116RD 90HH r2.madE	671,642	4,994,527	531.0	LNTE
CRI-117	GE2.3 116RD 90HH r2.madE	669,488	4,994,930	545.6	LNTE
CRI-118	GE2.3 116RD 90HH r2.madE	669,961	4,995,134	540.3	LNTE
CRI-119	GE2.3 116RD 90HH r2.madE	674,992	4,995,107	492.0	LNTE
CRI-120	GE2.3 116RD 90HH r2.madE	671,034	4,995,179	536.2	LNTE
CRI-121	GE2.3 116RD 90HH r2.madE	670,629	4,998,259	531.0	LNTE
CRI-122	GE2.3 116RD 90HH r2.madE	671,475	4,998,261	517.8	LNTE
CRI-123	GE2.3 116RD 90HH r2.madE	672,180	4,998,561	505.0	LNTE
CRI-124	GE2.3 116RD 90HH r2.madE	670,926	4,999,036	523.3	LNTE
CRI-125	GE2.3 116RD 90HH r2.madE	671,580	4,999,340	509.8	LNTE
CRI-126	GE2.3 116RD 90HH r2.madE	670,382	5,000,519	516.0	LNTE
CRI-127	GE2.3 116RD 90HH r2.madE	670,845	5,000,795	507.4	LNTE

Crowned Ridge Wind Farm
GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
continued

WTG	Turbine Type	Easting (m)	Northing (m)	Base Elev. AMSL (m)	Sound Profile
CRI-128	GE2.3 116RD 90HH r2.madE	671,388	5,001,034	498.4	LNTE
CRI-129	GE2.3 116RD 90HH r2.madE	667,516	5,000,900	553.8	LNTE
CRI-130	GE2.3 116RD 90HH r2.madE	668,158	5,001,149	546.0	LNTE
CRI-131	GE2.3 116RD 90HH r2.madE	670,512	5,002,137	504.0	LNTE
CRI-132	GE2.3 116RD 90HH r2.madE	670,875	5,002,186	499.0	LNTE
CRI-133	GE2.3 116RD 90HH r2.madE	669,990	5,002,521	502.6	LNTE
CRI-134	GE2.3 116RD 90HH r2.madE	671,497	5,002,893	483.0	LNTE
CRI-Alt1	GE2.3 116RD 90HH r2.madE	673,995	4,994,412	508.0	LNTE
CRI-Alt2	GE2.3 116RD 90HH r2.madE	669,250	4,992,900	562.3	LNTE
CRI-Alt3	GE2.3 116RD 90HH r2.madE	668,624	4,991,988	581.3	LNTE
CRI-Alt4	GE2.3 116RD 90HH r2.madE	670,047	5,003,703	495.4	LNTE
CRI-Alt7	GE2.3 116RD 90HH r2.madE	669,265	5,004,141	504.3	LNTE
CRI-Alt8	GE2.3 116RD 90HH r2.madE	667,012	5,004,840	525.5	LNTE
CRI-Alt9	GE2.3 116RD 90HH r2.madE	667,945	5,005,534	511.0	LNTE
CRI-Alt11	GE2.3 116RD 90HH r2.madE	668,585	5,005,813	499.5	LNTE
CRI-Alt12	GE2.3 116RD 90HH r2.madE	665,718	5,006,213	532.5	LNTE
CRI-Alt14	GE2.3 116RD 90HH r2.madE	667,485	5,006,268	514.9	LNTE
CRI-Alt15	GE2.3 116RD 90HH r2.madE	669,174	5,006,282	480.8	LNTE
CRI-Alt16	GE2.3 116RD 90HH r2.madE	665,280	5,006,161	540.0	LNTE
CRI-Alt17	GE2.3 116RD 90HH r2.madE	668,112	5,007,271	490.7	LNTE
CRI-Alt18	GE2.3 116RD 90HH r2.madE	668,857	5,007,463	475.0	LNTE
CRI-Alt19	GE2.3 116RD 90HH r2.madE	663,816	4,986,314	613.1	LNTE
CRI-Alt20	GE2.3 116RD 90HH r2.madE	664,124	4,986,705	611.8	LNTE
CRI-Alt22	GE2.3 116RD 90HH r2.madE	662,551	4,986,877	614.6	LNTE
CRI-Alt42	GE2.3 116RD 90HH r2.madE	659,646	4,992,833	585.0	LNTE
CRI-Alt45	GE2.3 116RD 90HH r2.madE	657,553	4,992,576	599.8	LNTE
CRI-Alt47	GE2.3 116RD 90HH r2.madE	659,131	4,991,788	579.0	LNTE

APPENDIX C: TABLE OF SHADOW FLICKER RESULTS

Table C-1: Crowned Ridge Shadow Flicker Tabular Results Sorted by Receptor ID
Realistic case shadow results at existing structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Codington County

Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-C1-NP	Non-P	656,743.00	4,983,525.00	595.9	0:00	5,541
CR1-C2-NP	Non-P	658,791.00	4,984,483.00	601.6	0:00	6,273
CR1-C3-NP	Non-P	657,888.00	4,984,697.00	604.2	4:10	3,294
CR1-C4-NP	Non-P	659,744.00	4,984,749.00	605.9	0:00	5,981
CR1-C5-NP	Non-P	659,958.00	4,984,794.00	605.2	0:00	5,659
CR1-C6-P	Participant	662,989.00	4,995,228.00	599.8	0:00	6,102
CR1-C7-NP	Non-P	660,893.00	4,984,861.00	593.2	0:00	3,022
CR1-C9-P	Participant	665,352.00	4,985,004.00	609.0	18:25	1,621
CR1-C10-P	Participant	663,510.00	4,985,195.00	609.0	12:55	1,762
CR1-C11-P	Participant	664,111.00	4,985,679.00	609.0	12:03	1,614
CR1-C12-P	Participant	662,222.00	4,985,736.00	603.0	18:29	2,201
CR1-C12-1-P	Participant	662,199.00	4,986,047.00	606.0	10:06	2,818
CR1-C13-P	Participant	663,792.00	4,985,785.00	612.0	22:39	1,739
CR1-C14-NP	Non-P	657,982.00	4,985,894.00	609.0	9:59	1,880
CR1-C15-P	Participant	663,291.00	4,986,026.00	615.0	21:43	1,952
CR1-C16-NP	Non-P	661,960.00	4,986,288.00	606.0	7:49	2,736
CR1-C17-P	Participant	658,031.00	4,986,373.00	609.1	26:40	1,886
CR1-C18-P	Participant	663,651.00	4,987,157.00	610.5	23:07	2,146
CR1-C19-P	Participant	659,243.00	4,987,276.00	611.5	21:20	1,722
CR1-C20-P	Participant	663,054.00	4,987,455.00	606.0	16:02	2,336
CR1-C26-P	Participant	657,767.00	4,988,493.00	597.0	7:32	3,484
CR1-C27-NP	Non-P	656,876.00	4,988,683.00	583.0	6:58	2,549
CR1-C28-NP	Non-P	665,429.00	4,988,598.00	590.8	2:43	2,831
CR1-C29-NP	Non-P	666,572.00	4,988,867.00	575.9	6:54	2,457
CR1-C30-P	Participant	661,699.00	4,988,957.00	615.0	23:21	1,614
CR1-C31-NP	Non-P	665,939.00	4,988,950.00	585.4	0:00	2,126
CR1-C32-NP	Non-P	655,843.00	4,989,581.00	568.6	0:00	3,714
CR1-C33-NP	Non-P	656,839.00	4,990,404.00	569.8	0:00	6,719
CR1-C34-NP	Non-P	658,661.00	4,990,389.00	589.1	26:03	1,726
CR1-C35-P	Participant	662,025.00	4,990,475.00	609.0	11:47	2,123
CR1-C36-P	Participant	663,181.00	4,990,600.00	615.0	25:52	1,532
CR1-C37-P	Participant	663,563.00	4,991,342.00	605.1	27:44	1,631
CR1-C38-NP	Non-P	660,639.00	4,991,557.00	597.0	6:04	3,474
CR1-C39-NP	Non-P	660,144.00	4,991,670.00	588.0	6:55	2,605
CR1-C40-NP	Non-P	657,865.00	4,991,818.00	583.8	6:42	2,690
CR1-C41-NP	Non-P	665,053.00	4,992,084.00	576.1	20:43	2,359
CR1-C42-P	Participant	659,458.00	4,992,229.00	580.0	11:54	1,801
CR1-C44-NP	Non-P	665,076.00	4,993,095.00	578.2	28:20	2,159
CR1-C45-NP	Non-P	653,390.00	4,993,503.00	573.0	1:41	5,673

Table C-1: Crowned Ridge Shadow Flicker Tabular Results Sorted by Receptor ID
Realistic case shadow results at existing structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Codington County
continued

Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-C46-P	Participant	655,802.00	4,993,540.00	609.7	25:38	1,680
CR1-C47-P	Participant	662,825.00	4,993,508.00	613.8	5:00	3,750
CR1-C48-P	Participant	664,247.00	4,993,646.00	588.0	3:46	1,923
CR1-C49-P	Participant	662,250.00	4,993,731.00	609.0	1:12	5,148
CR1-C50-P	Participant	656,806.00	4,994,388.00	621.0	28:30	1,591
CR1-C51-P	Participant	657,455.00	4,995,160.00	621.0	24:39	1,768
CR1-C52-NP	Non-P	654,924.00	4,995,231.00	603.0	6:46	1,883
CR1-C53-NP	Non-P	663,376.00	4,996,043.00	578.6	0:00	7,201
CR1-C54-NP	Non-P	663,421.00	4,995,376.00	583.4	0:00	5,351
CR1-C55-P	Participant	660,914.00	4,995,169.00	607.9	2:51	3,360
CR1-C56-P	Participant	655,953.00	4,995,244.00	606.0	28:42	1,972
CR1-C57-P	Participant	656,628.00	4,995,266.00	615.0	10:23	1,568
CR1-C58-P	Participant	657,781.00	4,996,906.00	615.0	15:49	1,647
CR1-C59-P	Participant	661,548.00	5,000,754.00	584.1	7:36	1,644
CR1-C60-NP	Non-P	656,855.00	4,998,565.00	613.5	3:29	2,592
CR1-C61-NP	Non-P	656,690.00	4,997,831.00	612.0	27:42	1,686
CR1-C62-NP	Non-P	658,375.00	4,995,138.00	615.0	18:05	1,676
CR1-C63-NP	Non-P	658,566.00	4,995,254.00	612.6	10:42	2,408
CR1-C64-P	Participant	659,436.00	4,992,174.00	581.0	19:47	1,614
CR1-C65-NP	Non-P	665,805.00	4,995,305.00	579.0	1:29	3,884
CR1-C66-NP	Non-P	659,718.00	4,985,032.00	606.0	0:00	5,800
CR1-C67-NP	Non-P	659,789.00	4,985,057.00	606.0	0:00	5,791
CR1-C68-P	Participant	662,652.00	4,987,606.00	609.0	8:10	2,146
CR1-C69-P	Participant	662,685.00	4,987,619.00	609.0	7:45	2,185
CR1-C70-NP	Non-P	665,135.00	4,988,293.00	595.7	12:05	3,540
CR1-C71-NP	Non-P	665,137.00	4,988,378.00	594.6	7:28	3,448
CR1-C72-NP	Non-P	665,158.00	4,988,170.00	595.2	7:38	3,776
CR2-C150-P	Participant	657,178.00	4,985,788.00	612.0	9:58	1,640

Table C-1: Crowned Ridge Shadow Flicker Tabular Results Sorted by Receptor ID
Realistic case shadow results at existing structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Grant County
continued

Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-G12-NP	Non-P	668,229.00	4,989,039.00	575.0	0:00	4,623
CR1-G13-NP	Non-P	672,216.00	4,989,142.00	558.0	0:00	3,576
CR1-G14-NP	Non-P	668,156.00	4,989,332.00	574.1	0:00	3,940
CR1-G15-P	Participant	668,396.00	4,989,607.00	576.0	0:00	2,746
CR1-G16-NP	Non-P	668,419.00	4,989,861.00	576.0	0:00	2,070
CR1-G18-P	Participant	668,678.00	4,990,722.00	585.0	22:28	1,585
CR1-G19-P	Participant	671,018.00	4,990,744.00	570.0	5:42	2,077
CR1-G21-P	Participant	666,766.00	4,991,807.00	577.1	28:59	1,555
CR1-G22-NP	Non-P	674,670.00	4,991,955.00	527.6	0:00	5,781
CR1-G23-NP	Non-P	670,471.00	4,992,104.00	560.1	5:16	2,185
CR1-G24-P	Participant	673,058.00	4,992,440.00	539.4	0:00	2,231
CR1-G25-P	Participant	671,391.00	4,992,858.00	549.0	14:36	1,804
CR1-G26-NP	Non-P	672,589.00	4,993,869.00	531.0	8:15	3,140
CR1-G27-NP	Non-P	676,630.00	4,994,642.00	480.8	2:54	4,944
CR1-G28-P	Participant	673,113.00	4,994,772.00	514.1	22:47	1,614
CR1-G32-P	Participant	669,477.00	4,995,401.00	546.0	19:55	1,545
CR1-G33-P	Participant	668,911.00	4,995,550.00	548.7	4:00	2,779
CR1-G34-NP	Non-P	671,320.00	4,995,798.00	531.0	1:28	2,238
CR1-G36-NP	Non-P	673,559.00	4,996,344.00	498.1	0:00	6,211
CR1-G37-NP	Non-P	668,998.00	4,996,452.00	549.0	0:00	5,246
CR1-G38-NP	Non-P	673,972.00	4,996,493.00	494.5	0:00	5,646
CR1-G41-P	Participant	671,563.00	4,997,050.00	497.7	0:00	3,983
CR1-G42-NP	Non-P	670,566.00	4,997,097.00	518.9	0:00	3,819
CR1-G43-NP	Non-P	661,141.00	5,001,721.00	584.2	18:19	1,909
CR1-G44-NP	Non-P	661,781.00	5,001,732.00	583.7	2:49	3,123
CR1-G59-P	Participant	675,755.00	4,994,888.00	488.3	12:40	2,605
CR1-G60-P	Participant	675,830.00	4,995,687.00	477.0	5:42	3,343
CR1-G65-P	Participant	671,496.00	4,994,973.00	537.0	29:50	1,539
CR1-G66-P	Participant	670,802.00	4,994,681.00	539.8	16:39	1,801
CR1-G67-P	Participant	669,597.00	4,993,440.00	555.8	12:03	2,106
CR1-G68-NP	Non-P	669,159.00	4,993,632.00	564.7	2:09	2,113
CR1-G77-NP	Non-P	676,031.00	4,992,629.00	503.1	0:00	5,728
CR1-G81-NP	Non-P	671,478.00	4,997,523.00	508.7	0:00	2,421
CR1-G105-NP	Non-P	668,696.00	4,998,325.00	549.0	0:00	6,345
CR1-G108-NP	Non-P	669,516.00	5,001,186.00	522.2	11:37	3,586
CR1-G109-NP	Non-P	667,064.00	5,000,425.00	566.4	0:59	2,152
CR1-G110-NP	Non-P	671,218.00	5,005,064.00	456.4	0:00	5,889
CR1-G113-NP	Non-P	666,228.00	5,005,549.00	537.0	7:15	2,746

Table C-1: Crowned Ridge Shadow Flicker Tabular Results Sorted by Receptor ID
Realistic case shadow results at principle structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Grant County
continued

Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-G114-NP	Non-P	666,214.00	5,006,667.00	520.8	23:18	2,205
CR1-G115-NP	Non-P	664,933.00	5,006,731.00	544.6	7:58	2,188
CR1-G117-NP	Non-P	663,801.00	5,005,084.00	581.3	0:00	6,004
CR1-G124-P	Participant	669,843.00	5,000,605.00	525.0	19:21	1,791
CR1-G125-NP	Non-P	668,289.00	5,000,643.00	543.0	15:48	1,716
CR1-G126-NP	Non-P	672,157.00	5,000,446.00	484.3	3:21	3,176
CR1-G127-NP	Non-P	669,534.00	4,999,939.00	533.9	2:23	3,369
CR1-G128-NP	Non-P	670,242.00	5,001,314.00	513.0	14:58	2,612
CR1-G129-NP	Non-P	673,111.00	4,997,703.00	477.8	2:27	4,153
CR1-G130-NP	Non-P	668,147.00	5,000,233.00	549.0	0:00	3,005
CR1-G131-NP	Non-P	668,466.00	5,005,145.00	505.1	1:31	2,133
CR1-G132-NP	Non-P	669,098.00	5,004,948.00	501.0	7:38	2,703
CR1-G133-NP	Non-P	669,881.00	5,005,460.00	478.8	3:26	3,556
CR1-G135-NP	Non-P	668,616.00	5,005,161.00	504.2	8:10	2,142
CR1-G136-NP	Non-P	667,706.00	5,004,861.00	522.0	10:34	2,277
CR1-G137-NP	Non-P	666,501.00	5,005,136.00	529.5	18:36	1,939
CR1-G138-NP	Non-P	664,809.00	5,006,456.00	549.0	25:18	1,824
CR1-G139-NP	Non-P	668,199.00	5,008,062.00	475.9	8:05	2,612
CR1-G140-P	Participant	664,546.00	5,007,269.00	551.1	0:00	4,360
CR1-G149-NP	Non-P	669,284.00	5,003,283.00	503.2	12:39	2,815

Table C-2: Crowned Ridge Shadow Flicker Tabular Results Sorted by Real Case Shadow Flicker Hours/Year
Realistic case shadow results at existing structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Codington County

Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-C44-NP	Non-P	665,076.00	4,993,095.00	578.2	28:20	2,159
CR1-C61-NP	Non-P	656,690.00	4,997,831.00	612.0	27:42	1,686
CR1-C34-NP	Non-P	658,661.00	4,990,389.00	589.1	26:03	1,726
CR1-C41-NP	Non-P	665,053.00	4,992,084.00	576.1	20:43	2,359
CR1-C62-NP	Non-P	658,375.00	4,995,138.00	615.0	18:05	1,676
CR1-C70-NP	Non-P	665,135.00	4,988,293.00	595.7	12:05	3,540
CR1-C63-NP	Non-P	658,566.00	4,995,254.00	612.6	10:42	2,408
CR1-C14-NP	Non-P	657,982.00	4,985,894.00	609.0	9:59	1,880
CR1-C16-NP	Non-P	661,960.00	4,986,288.00	606.0	7:49	2,736
CR1-C72-NP	Non-P	665,158.00	4,988,170.00	595.2	7:38	3,776
CR1-C71-NP	Non-P	665,137.00	4,988,378.00	594.6	7:28	3,448
CR1-C27-NP	Non-P	656,876.00	4,988,683.00	583.0	6:58	2,549
CR1-C39-NP	Non-P	660,144.00	4,991,670.00	588.0	6:55	2,605
CR1-C29-NP	Non-P	666,572.00	4,988,867.00	575.9	6:54	2,457
CR1-C52-NP	Non-P	654,924.00	4,995,231.00	603.0	6:46	1,883
CR1-C40-NP	Non-P	657,865.00	4,991,818.00	583.8	6:42	2,690
CR1-C38-NP	Non-P	660,639.00	4,991,557.00	597.0	6:04	3,474
CR1-C3-NP	Non-P	657,888.00	4,984,697.00	604.2	4:10	3,294
CR1-C60-NP	Non-P	656,855.00	4,998,565.00	613.5	3:29	2,592
CR1-C28-NP	Non-P	665,429.00	4,988,598.00	590.8	2:43	2,831
CR1-C45-NP	Non-P	653,390.00	4,993,503.00	573.0	1:41	5,673
CR1-C65-NP	Non-P	665,805.00	4,995,305.00	579.0	1:29	3,884
CR1-C1-NP	Non-P	656,743.00	4,983,525.00	595.9	0:00	5,541
CR1-C2-NP	Non-P	658,791.00	4,984,483.00	601.6	0:00	6,273
CR1-C31-NP	Non-P	665,939.00	4,988,950.00	585.4	0:00	2,126
CR1-C32-NP	Non-P	655,843.00	4,989,581.00	568.6	0:00	3,714
CR1-C33-NP	Non-P	656,839.00	4,990,404.00	569.8	0:00	6,719
CR1-C4-NP	Non-P	659,744.00	4,984,749.00	605.9	0:00	5,981
CR1-C54-NP	Non-P	663,421.00	4,995,376.00	583.4	0:00	5,351
CR1-C5-NP	Non-P	659,958.00	4,984,794.00	605.2	0:00	5,659
CR1-C66-NP	Non-P	659,718.00	4,985,032.00	606.0	0:00	5,800
CR1-C67-NP	Non-P	659,789.00	4,985,057.00	606.0	0:00	5,791
CR1-C7-NP	Non-P	660,893.00	4,984,861.00	593.2	0:00	3,022
CR1-C53-NP	Non-P	663,376.00	4,996,043.00	578.6	0:00	7,201
CR1-C56-P	Participant	655,953.00	4,995,244.00	606.0	28:42	1,972
CR1-C50-P	Participant	656,806.00	4,994,388.00	621.0	28:30	1,591
CR1-C37-P	Participant	663,563.00	4,991,342.00	605.1	27:44	1,631
CR1-C17-P	Participant	658,031.00	4,986,373.00	609.1	26:40	1,886
CR1-C36-P	Participant	663,181.00	4,990,600.00	615.0	25:52	1,532

Table C-2: Crowned Ridge Shadow Flicker Tabular Results Sorted by Real Case Shadow Flicker Hours/Year
Realistic case shadow results at existing structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Codington County
continued

Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-C46-P	Participant	655,802.00	4,993,540.00	609.7	25:38	25:38
CR1-C51-P	Participant	657,455.00	4,995,160.00	621.0	24:39	24:39
CR1-C30-P	Participant	661,699.00	4,988,957.00	615.0	23:21	23:21
CR1-C18-P	Participant	663,651.00	4,987,157.00	610.5	23:06	23:07
CR1-C13-P	Participant	663,792.00	4,985,785.00	612.0	22:38	22:39
CR1-C15-P	Participant	663,291.00	4,986,026.00	615.0	21:42	21:43
CR1-C19-P	Participant	659,243.00	4,987,276.00	611.5	21:20	21:20
CR1-C64-P	Participant	659,436.00	4,992,174.00	581.0	19:47	19:47
CR1-C12-P	Participant	662,222.00	4,985,736.00	603.0	18:29	18:29
CR1-C9-P	Participant	665,352.00	4,985,004.00	609.0	18:24	18:25
CR1-C20-P	Participant	663,054.00	4,987,455.00	606.0	16:01	16:02
CR1-C58-P	Participant	657,781.00	4,996,906.00	615.0	15:49	15:49
CR1-C10-P	Participant	663,510.00	4,985,195.00	609.0	12:55	12:55
CR1-C11-P	Participant	664,111.00	4,985,679.00	609.0	12:03	12:03
CR1-C42-P	Participant	659,458.00	4,992,229.00	580.0	11:54	11:54
CR1-C35-P	Participant	662,025.00	4,990,475.00	609.0	11:46	11:47
CR1-C57-P	Participant	656,628.00	4,995,266.00	615.0	10:23	10:23
CR1-C12-1-P	Participant	662,199.00	4,986,047.00	606.0	10:06	10:06
CR2-C150-P	Participant	657,178.00	4,985,788.00	612.0	9:58	9:58
CR1-C68-P	Participant	662,652.00	4,987,606.00	609.0	8:10	8:10
CR1-C69-P	Participant	662,685.00	4,987,619.00	609.0	7:44	7:45
CR1-C59-P	Participant	661,548.00	5,000,754.00	584.1	7:36	7:36
CR1-C26-P	Participant	657,767.00	4,988,493.00	597.0	7:32	7:32
CR1-C47-P	Participant	662,825.00	4,993,508.00	613.8	5:00	5:00
CR1-C48-P	Participant	664,247.00	4,993,646.00	588.0	3:46	3:46
CR1-C55-P	Participant	660,914.00	4,995,169.00	607.9	2:51	2:51
CR1-C49-P	Participant	662,250.00	4,993,731.00	609.0	1:12	1:12
CR1-C6-P	Participant	662,989.00	4,995,228.00	599.8	0:00	0:00

Table C-2: Crowned Ridge Shadow Flicker Tabular Results Sorted by Real Case Shadow Flicker Hours/Year
Realistic case shadow results at existing structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Grant County
continued

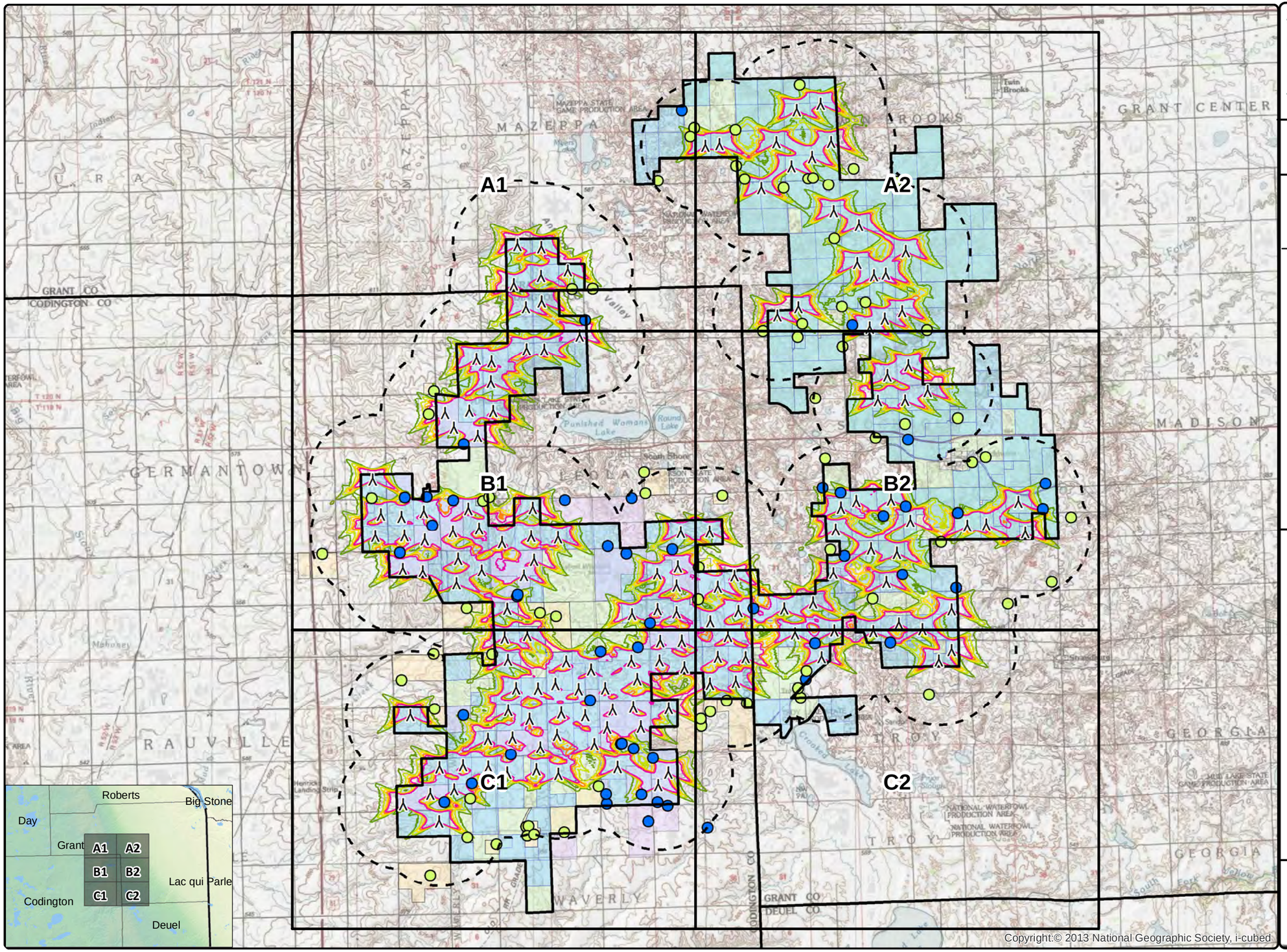
Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-G138-NP	Non-P	664,809.00	5,006,456.00	549.0	25:18	1,824
CR1-G114-NP	Non-P	666,214.00	5,006,667.00	520.8	23:18	2,205
CR1-G137-NP	Non-P	666,501.00	5,005,136.00	529.5	18:36	1,939
CR1-G43-NP	Non-P	661,141.00	5,001,721.00	584.2	18:19	1,909
CR1-G125-NP	Non-P	668,289.00	5,000,643.00	543.0	15:48	1,716
CR1-G128-NP	Non-P	670,242.00	5,001,314.00	513.0	14:58	2,612
CR1-G149-NP	Non-P	669,284.00	5,003,283.00	503.2	12:39	2,815
CR1-G108-NP	Non-P	669,516.00	5,001,186.00	522.2	11:37	3,586
CR1-G136-NP	Non-P	667,706.00	5,004,861.00	522.0	10:34	2,277
CR1-G26-NP	Non-P	672,589.00	4,993,869.00	531.0	8:15	3,140
CR1-G135-NP	Non-P	668,616.00	5,005,161.00	504.2	8:10	2,142
CR1-G139-NP	Non-P	668,199.00	5,008,062.00	475.9	8:05	2,612
CR1-G115-NP	Non-P	664,933.00	5,006,731.00	544.6	7:58	2,188
CR1-G132-NP	Non-P	669,098.00	5,004,948.00	501.0	7:38	2,703
CR1-G113-NP	Non-P	666,228.00	5,005,549.00	537.0	7:15	2,746
CR1-G23-NP	Non-P	670,471.00	4,992,104.00	560.1	5:16	2,185
CR1-G133-NP	Non-P	669,881.00	5,005,460.00	478.8	3:26	3,556
CR1-G126-NP	Non-P	672,157.00	5,000,446.00	484.3	3:21	3,176
CR1-G27-NP	Non-P	676,630.00	4,994,642.00	480.8	2:54	4,944
CR1-G44-NP	Non-P	661,781.00	5,001,732.00	583.7	2:49	3,123
CR1-G129-NP	Non-P	673,111.00	4,997,703.00	477.8	2:27	4,153
CR1-G127-NP	Non-P	669,534.00	4,999,939.00	533.9	2:23	3,369
CR1-G68-NP	Non-P	669,159.00	4,993,632.00	564.7	2:09	2,113
CR1-G131-NP	Non-P	668,466.00	5,005,145.00	505.1	1:31	2,133
CR1-G34-NP	Non-P	671,320.00	4,995,798.00	531.0	1:28	2,238
CR1-G109-NP	Non-P	667,064.00	5,000,425.00	566.4	0:59	2,152
CR1-G12-NP	Non-P	668,229.00	4,989,039.00	575.0	0:00	4,623
CR1-G16-NP	Non-P	668,419.00	4,989,861.00	576.0	0:00	2,070
CR1-G14-NP	Non-P	668,156.00	4,989,332.00	574.1	0:00	3,940
CR1-G22-NP	Non-P	674,670.00	4,991,955.00	527.6	0:00	5,781
CR1-G13-NP	Non-P	672,216.00	4,989,142.00	558.0	0:00	3,576
CR1-G77-NP	Non-P	676,031.00	4,992,629.00	503.1	0:00	5,728
CR1-G38-NP	Non-P	673,972.00	4,996,493.00	494.5	0:00	5,646
CR1-G37-NP	Non-P	668,998.00	4,996,452.00	549.0	0:00	5,246
CR1-G42-NP	Non-P	670,566.00	4,997,097.00	518.9	0:00	3,819
CR1-G81-NP	Non-P	671,478.00	4,997,523.00	508.7	0:00	2,421
CR1-G36-NP	Non-P	673,559.00	4,996,344.00	498.1	0:00	6,211
CR1-G105-NP	Non-P	668,696.00	4,998,325.00	549.0	0:00	6,345

Table C-2: Crowned Ridge Shadow Flicker Tabular Results Sorted by Real Case Shadow Flicker Hours/Year
Realistic case shadow results at principle structures
Results using GE 2.3-116-90 m HH, GE 2.3-116-80 m HH WTG's
UTM NAD83 Zone 14
Grant County
continued

Receptor ID	Participation Status	Easting (m)	Northing (m)	Elevation AMSL (m)	Real Case Shadow (hrs/year)	Distance to Nearest Turbine (ft)
CR1-G110-NP	Non-P	671,218.00	5,005,064.00	456.4	0:00	5,889
CR1-G117-NP	Non-P	663,801.00	5,005,084.00	581.3	0:00	6,004
CR1-G130-NP	Non-P	668,147.00	5,000,233.00	549.0	0:00	3,005
CR1-G65-P	Participant	671,496.00	4,994,973.00	537.0	29:50	1,539
CR1-G21-P	Participant	666,766.00	4,991,807.00	577.1	28:59	1,555
CR1-G28-P	Participant	673,113.00	4,994,772.00	514.1	22:47	1,614
CR1-G18-P	Participant	668,678.00	4,990,722.00	585.0	22:28	1,585
CR1-G32-P	Participant	669,477.00	4,995,401.00	546.0	19:55	1,545
CR1-G124-P	Participant	669,843.00	5,000,605.00	525.0	19:21	1,791
CR1-G66-P	Participant	670,802.00	4,994,681.00	539.8	16:39	1,801
CR1-G25-P	Participant	671,391.00	4,992,858.00	549.0	14:36	1,804
CR1-G59-P	Participant	675,755.00	4,994,888.00	488.3	12:40	2,605
CR1-G67-P	Participant	669,597.00	4,993,440.00	555.8	12:03	2,106
CR1-G19-P	Participant	671,018.00	4,990,744.00	570.0	5:42	2,077
CR1-G60-P	Participant	675,830.00	4,995,687.00	477.0	5:42	3,343
CR1-G33-P	Participant	668,911.00	4,995,550.00	548.7	4:00	2,779
CR1-G15-P	Participant	668,396.00	4,989,607.00	576.0	0:00	2,746
CR1-G24-P	Participant	673,058.00	4,992,440.00	539.4	0:00	2,231
CR1-G41-P	Participant	671,563.00	4,997,050.00	497.7	0:00	3,983
CR1-G140-P	Participant	664,546.00	5,007,269.00	551.1	0:00	4,360

APPENDIX D: STANDARD RESOLUTION SHADOW FLICKER MAPS

Exhibit A1-I



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Crowned Ridge Wind Farm
Shadow Flicker Iso-Lines
Overview Map

Client

SWCA Environmental Consultants

Project Description

Wind turbine layout with occupied structures within 2 km.

Predicted shadow flicker levels at existing residences.

Location: Watertown, SD

Project #: 20174430

Issue Dates

#	Description	Date
1	Original	2019.01.15

Drawn By: AS *Checked By: JH*

Legend

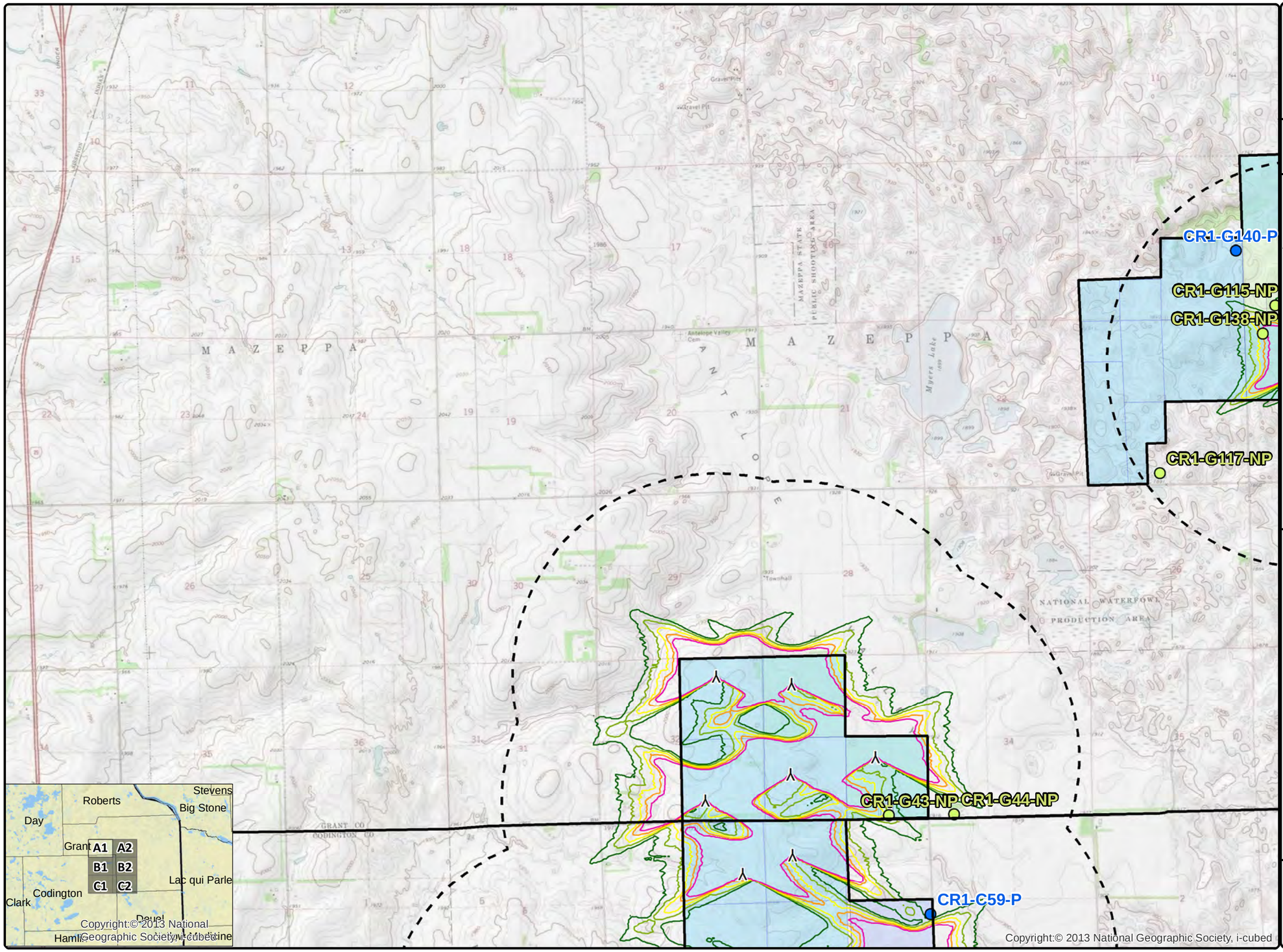
- Crowned Ridge Turbines
- 2 km Turbine Buffer
- County Lines
- CR1 Project Boundary
- Non-Participants
- Participants

Shadow Flicker (hr/yr)

- 10
- 15
- 20
- 25
- 30
- Participating Codington Parcels
- Non-Part. Codington Parcels
- Participating Land Parcels
- Non-Participating Land Parcels

N W E S

Exhibit A1-I



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Crowned Ridge Wind Farm
Shadow Flicker Iso-Lines

Client

SWCA Environmental Consultants

Project Description

Wind turbine layout with occupied structures within 2 km.

Predicted shadow flicker levels at existing residences.

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1	Original	2019.01.15

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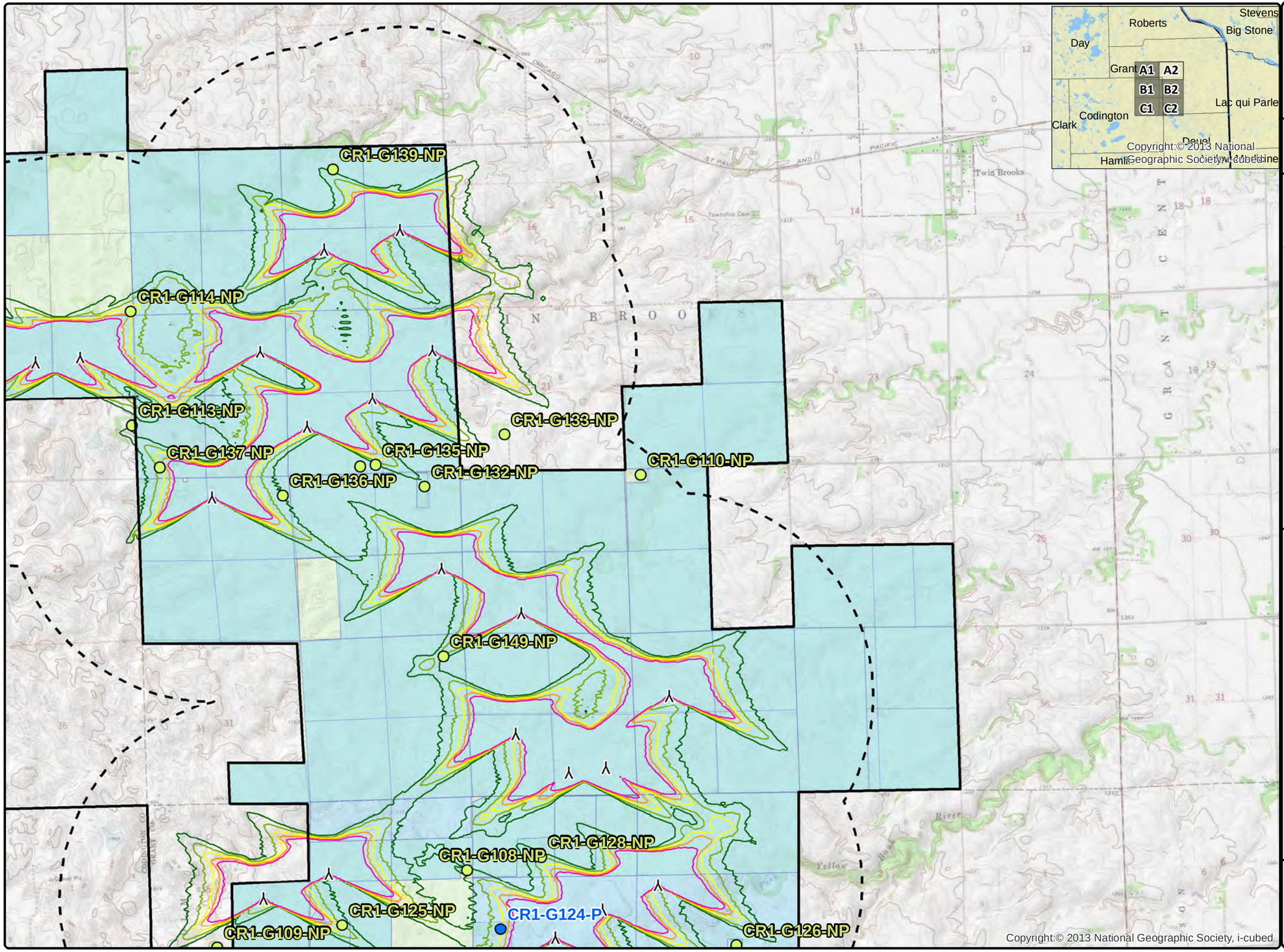
N W E S

Exhibit A1-I



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Crowned Ridge Wind Farm
Shadow Flicker Iso-Lines

Client

SWCA Environmental Consultants

Project Description

Wind turbine layout with occupied structures within 2 km.

Predicted shadow flicker levels at existing residences.

Location: Watertown, SD

Project #: 20174430

Issue Dates

#	Description	Date
1	Original	2019.01.15

Drawn By: AS *Checked By: JH*

Legend

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- CR1 Project Boundary
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- Participants

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- 10
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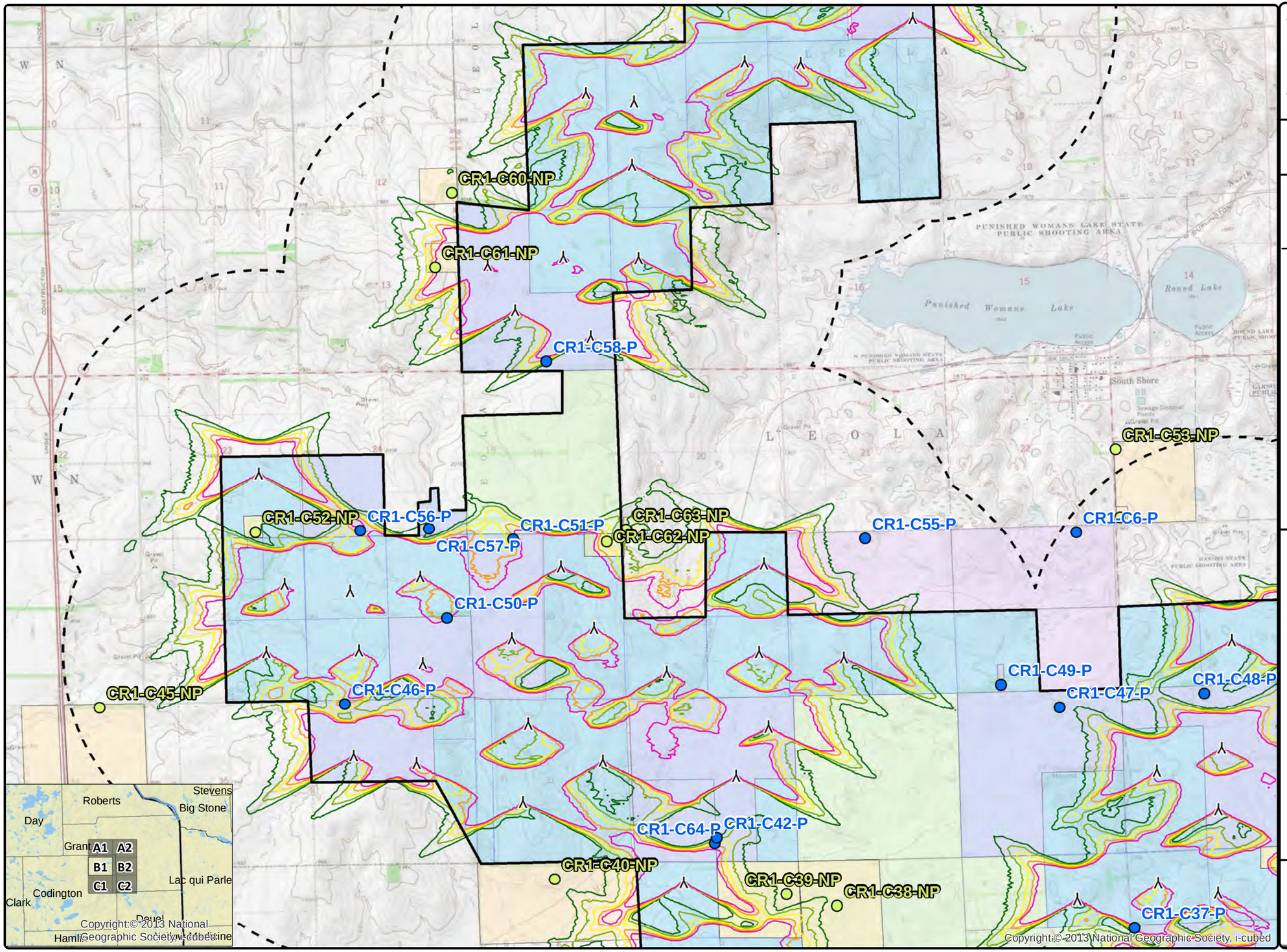
- Non-Part. Codington Parcels
- Participating Land Parcels
- Non-Participating Land Parcels

N W E S

Exhibit A1-I



0 0.25 0.5 1 Mile

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Crowned Ridge Wind Farm
Shadow Flicker Iso-Lines

Client

SWCA Environmental Consultants

Project Description

Wind turbine layout with occupied structures within 2 km.

Predicted shadow flicker levels at existing residences.

Location: Watertown, SD

Project #: 20174430

Issue Dates

#	Description	Date
1	Original	2019.01.15

Drawn By: AS *Checked By: JH*

Legend

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- CR1 Project Boundary
- Non-Participants
- Participants

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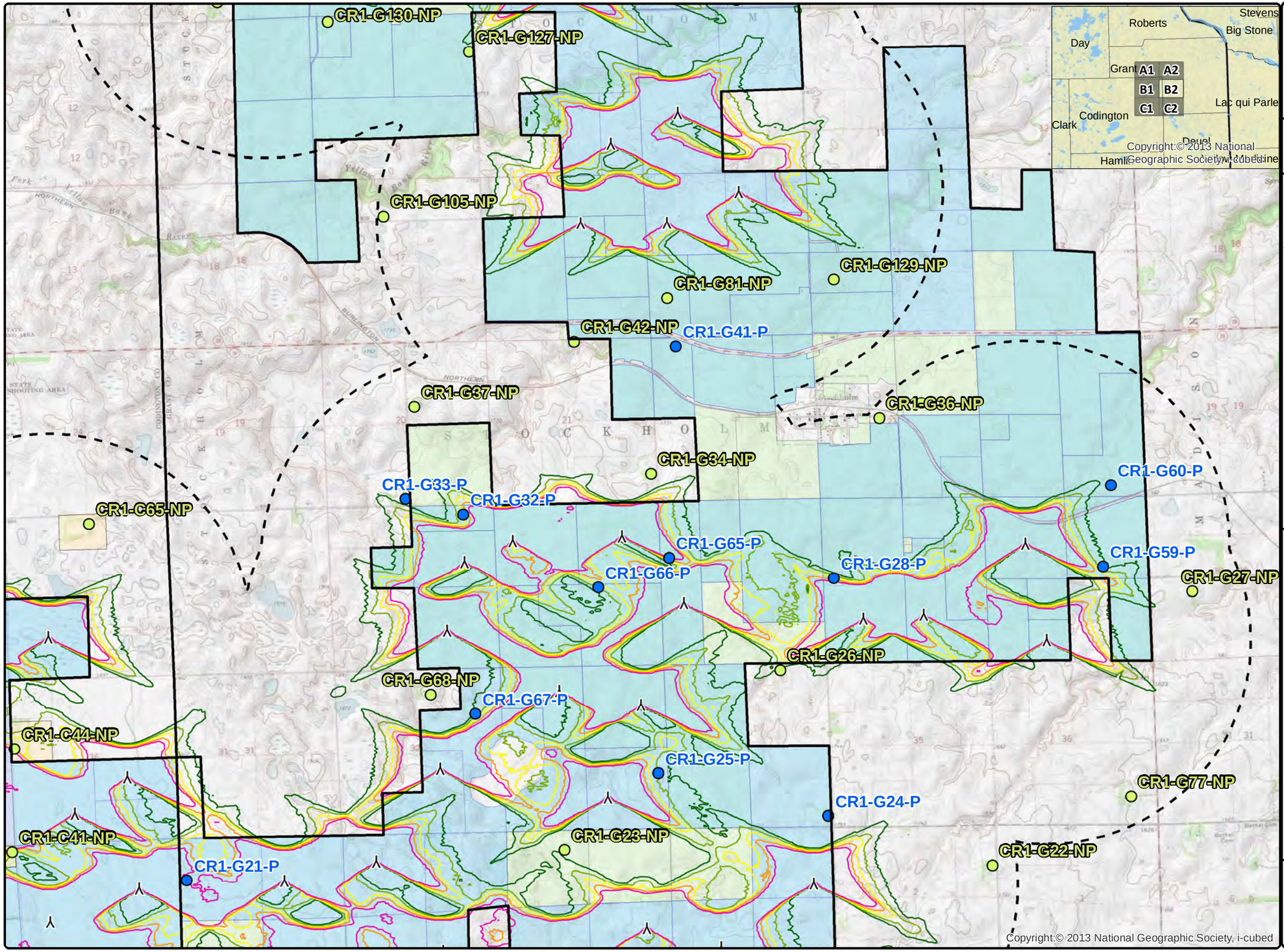
- Participating Codington Parcels
- Non-Part. Codington Parcels
- Participating Land Parcels
- Non-Participating Land Parcels

N W E S

Exhibit A1-I



0 0.25 0.5 1 Mile

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Crowned Ridge Wind Farm
Shadow Flicker Iso-Lines

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Drawn By: AS *Checked By: JH*

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- Participants

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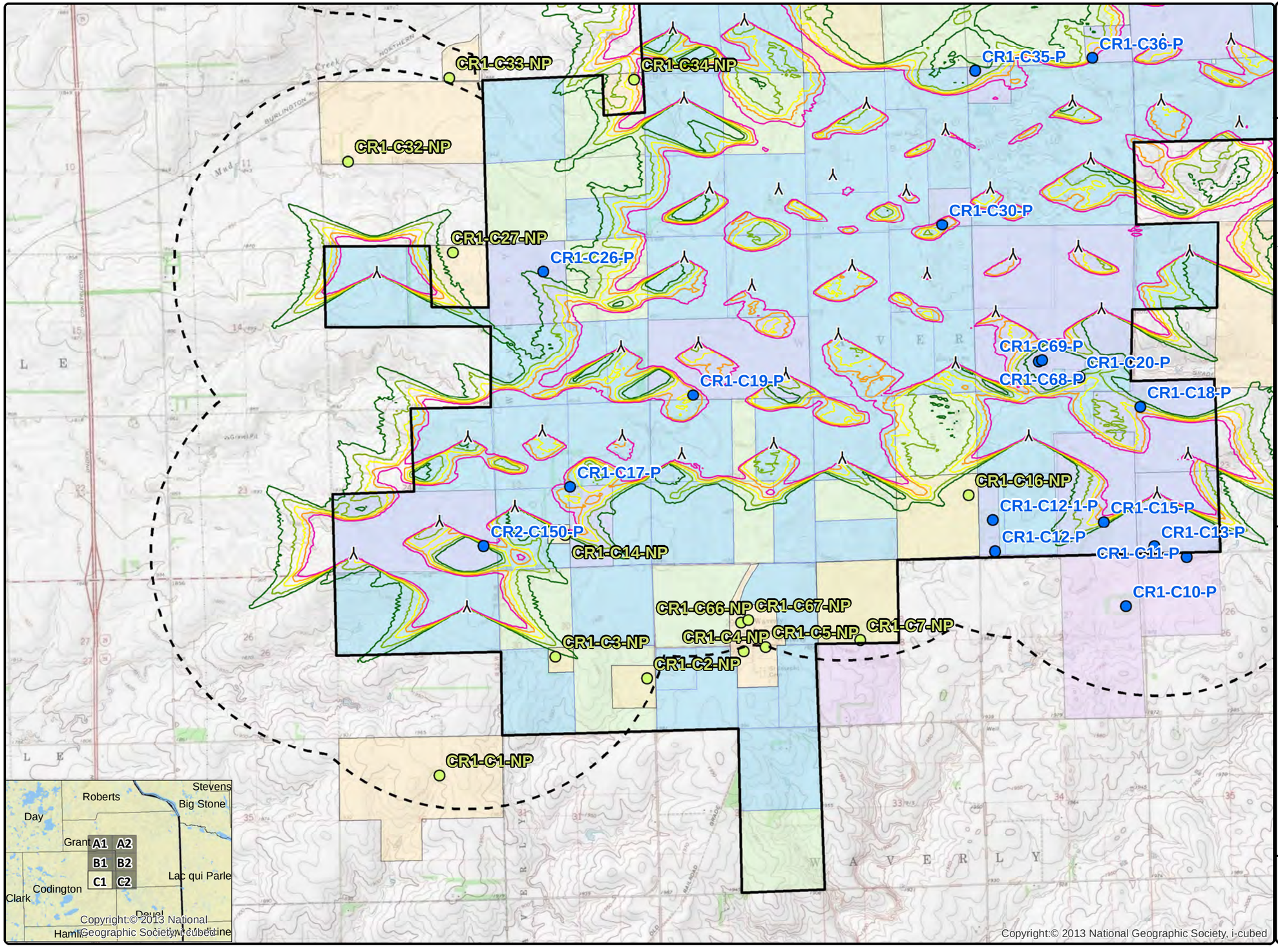
- Non-Part. Codington Parcels
- Participating Land Parcels
- Non-Participating Land Parcels

N W E S

Exhibit A1-I



0 0.25 0.5 1 Mile

EAPC WIND ENERGY

www.eapc.net | 701.775.3000

Crowned Ridge Wind Farm
Shadow Flicker Iso-Lines

Client

SWCA Environmental Consultants

Project Description

Wind turbine layout with occupied structures within 2 km.

Predicted shadow flicker levels at existing residences.

Location: Watertown, SD

Project #: 20174430

Issue Dates

#	Description	Date
1	Original	2019.01.15

Drawn By: AS | *Checked By: JH*

Legend

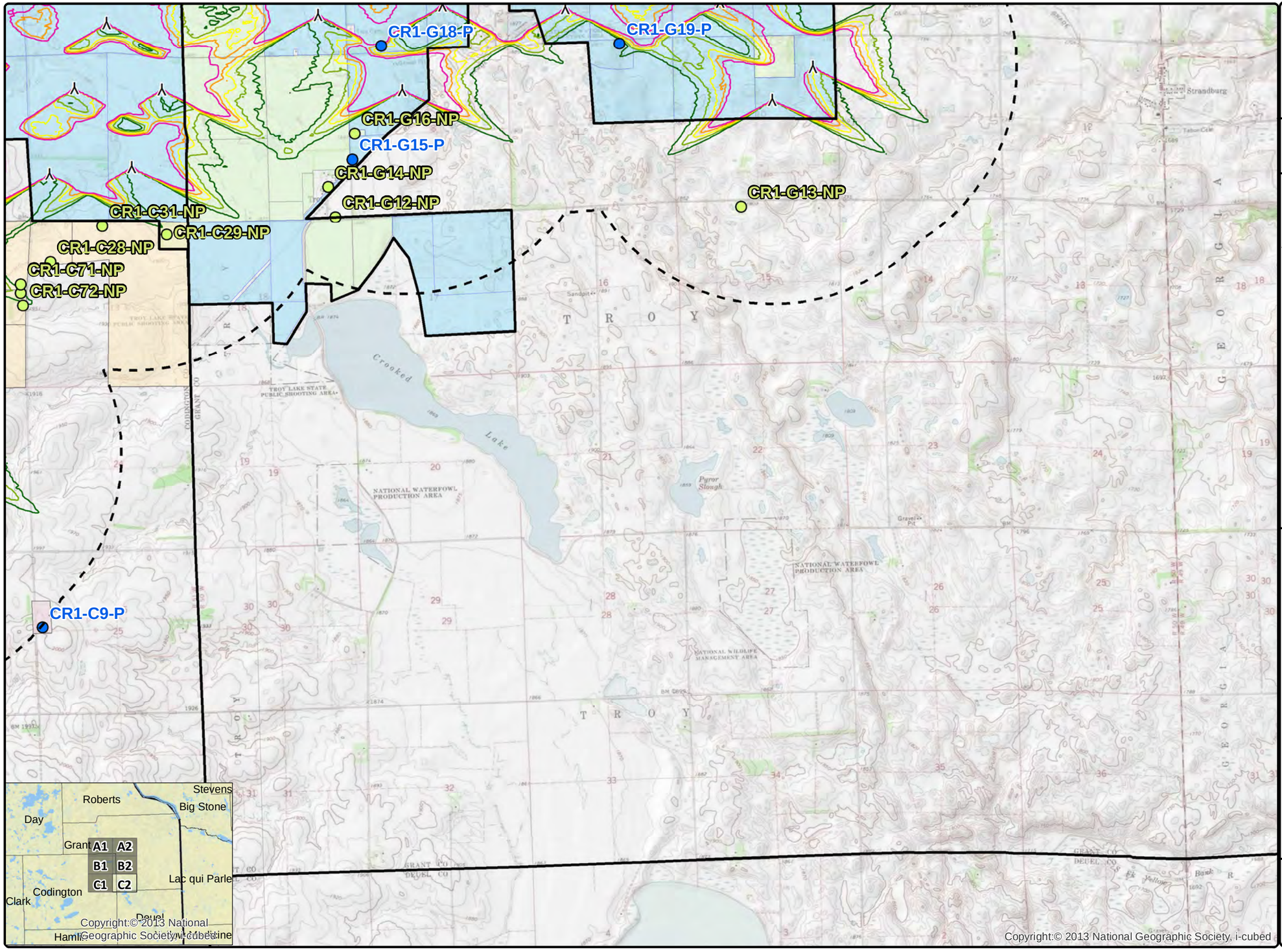
- Crowned Ridge Turbines
- 2 km Turbine Buffer
- County Lines
- CR1 Project Boundary
- Non-Participants
- Participants

Shadow Flicker (hr/yr)

- 10
- 15
- 20
- 25
- 30
- Participating Codington Parcels
- Non-Part. Codington Parcels
- Participating Land Parcels
- Non-Participating Land Parcels

N W E S

Exhibit A1-I



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