Wind Power GeoPlanner™

Microwave Study

Crocker Wind Farm

Prepared on Behalf of
Crocker Wind Farm, LLC

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1. Introduction

Microwave bands that may be affected by the installation of wind turbine facilities operate over a wide frequency range (900 MHz – 23 GHz). Comsearch has developed and maintains comprehensive technical databases containing information on licensed microwave networks throughout the United States. These systems are the telecommunication backbone of the country, providing long-distance and local telephone service, backhaul for cellular and personal communication service, data interconnects for mainframe computers and the Internet, network controls for utilities and railroads, and various video services. This report focuses on the potential impact of wind turbines on licensed, proposed and applied non-federal government microwave systems.

2. Project Overview

Project Information

Name: Crocker Wind Farm
County: Clark
State: South Dakota

Number of Turbines: 120
Blade Diameter: 110-136 meters
Hub Height: 80-100 meters

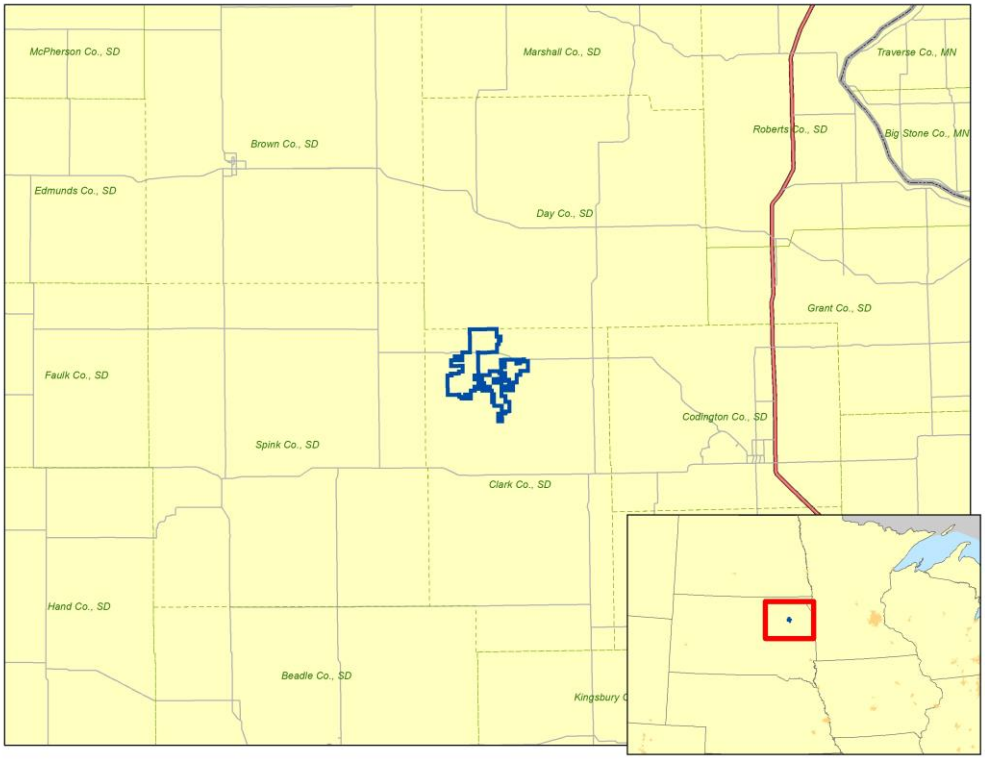


Figure 1: Area of Interest

3. Two-Dimensional Fresnel Zone Analysis

Methodology

Our obstruction analysis was performed using Comsearch's proprietary microwave database, which contains all non-government licensed, proposed and applied paths from 0.9 - 23 GHz[1]. First, we determined all microwave paths that intersect the area of interest[2] and listed them in Table 1. These paths and the area of interest that encompasses the planned turbine locations are shown in Figure 2.

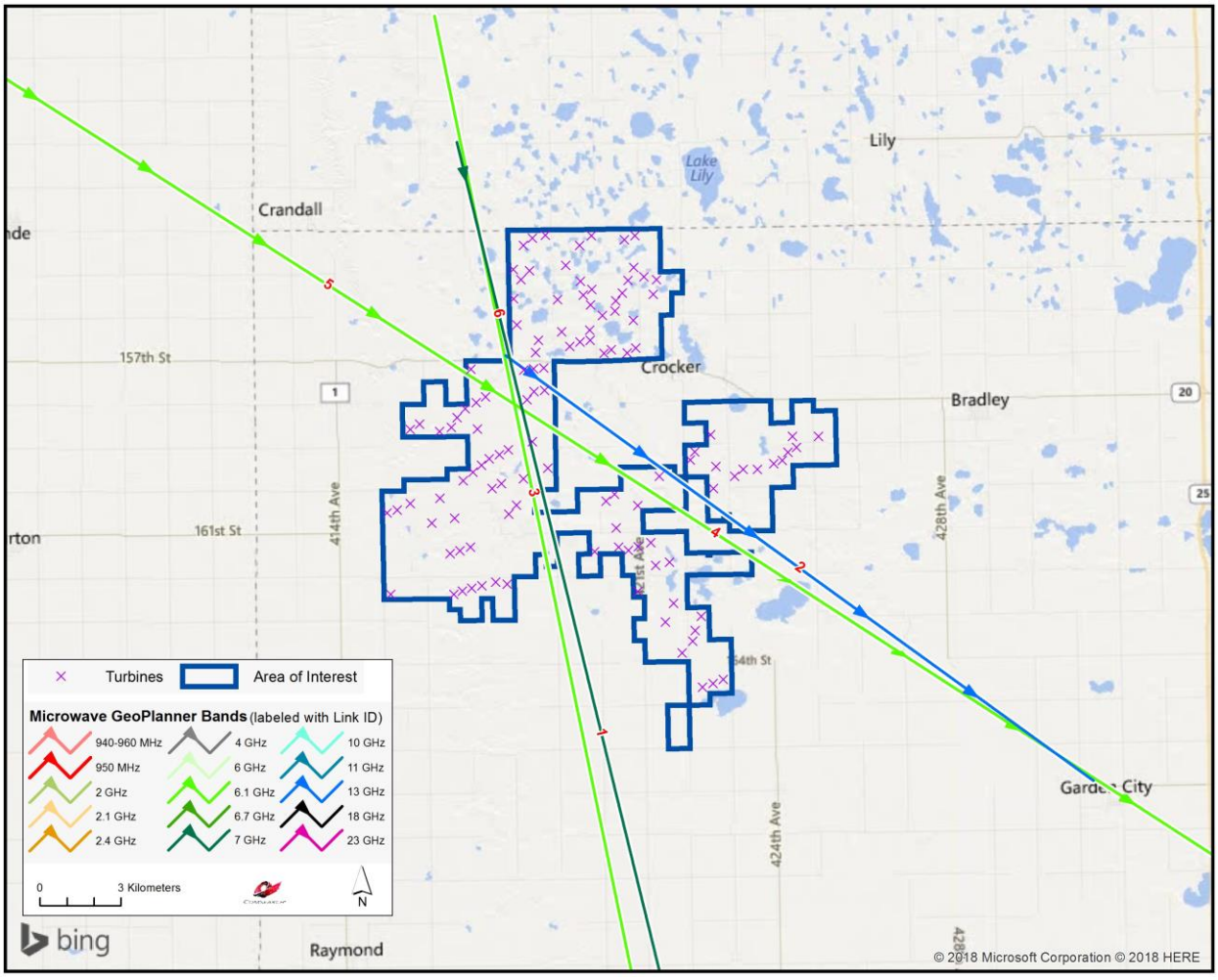


Figure 2: Microwave Paths that Intersect the Area of Interest

[1] Please note that this analysis does not include unlicensed microwave paths or federal government paths that are not registered with the FCC.

[2] We use FCC-licensed coordinates to determine which paths intersect the area of interest. It is possible that as-built coordinates may differ slightly from those on the FCC license.

ID	Status	Callsign 1	Callsign 2	Band	Path Length (km)	Licensee
1	Licensed	WIW99	RXONLY	7 GHz	43.08	South Dakota Brd of Dir of ED Telecom
2	Licensed	WMV705	RXONLY	13 GHz	26.93	Red River Broadcast Co., LLC
3	Licensed	WPSZ826	WQOM534	6.1 GHz	39.15	NorthWestern Corporation
4	Licensed	WQDT284	WQDT285	6.1 GHz	25.21	Northern Border Pipeline Company
5	Licensed	WQDT323	WQDT284	6.1 GHz	53.36	Northern Border Pipeline Company
6	Licensed	WQEJ924	RXONLY	7 GHz	43.08	South Dakota Brd of Dir of ED Telecom

Table 1: Summary of Microwave Paths that Intersect the Area of Interest

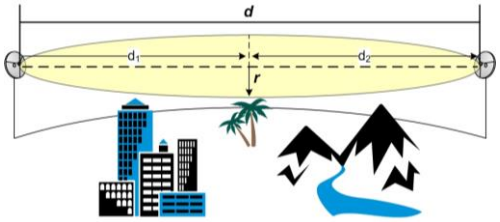
(See enclosed mw_geopl.xlsx for more information and
GP_dict_matrix_description.xls for detailed field descriptions)

Verification of Coordinate Accuracy

It is possible that as-built coordinates may differ from those on the FCC license. For this project, all six paths cross within close proximity of the proposed turbines and the tower locations for these paths will have a critical impact on the result. Therefore, we verified these locations using aerial photography. All of the towers were found to be slightly off and were moved to their locations based on the aerial photos[3].

Next, we calculated a Fresnel Zone for each path based on the following formula:

$$r \cong 17.3\sqrt{\frac{n}{F_{GHz}}\left(\frac{d_1 d_2}{d_1 + d_2}\right)}$$



Where,

r	=	Fresnel Zone radius at a specific point in the microwave path, meters
n	=	Fresnel Zone number, 1
F_{GHz}	=	Frequency of microwave system, GHz
d_1	=	Distance from antenna 1 to a specific point in the microwave path, kilometers
d_2	=	Distance from antenna 2 to a specific point in the microwave path, kilometers

In general, this is the area where the planned wind turbines should be avoided, if possible. A depiction of the Fresnel Zones for each microwave path listed can be found in Figure 3, and is also included in the enclosed shapefiles[4,5].

[3] See enclosed mw_geopl.shp and mw_geopl_fcc.shp for details.

[4] The ESRI® shapefiles enclosed are in NAD 83 UTM Zone 14 projected coordinate system.

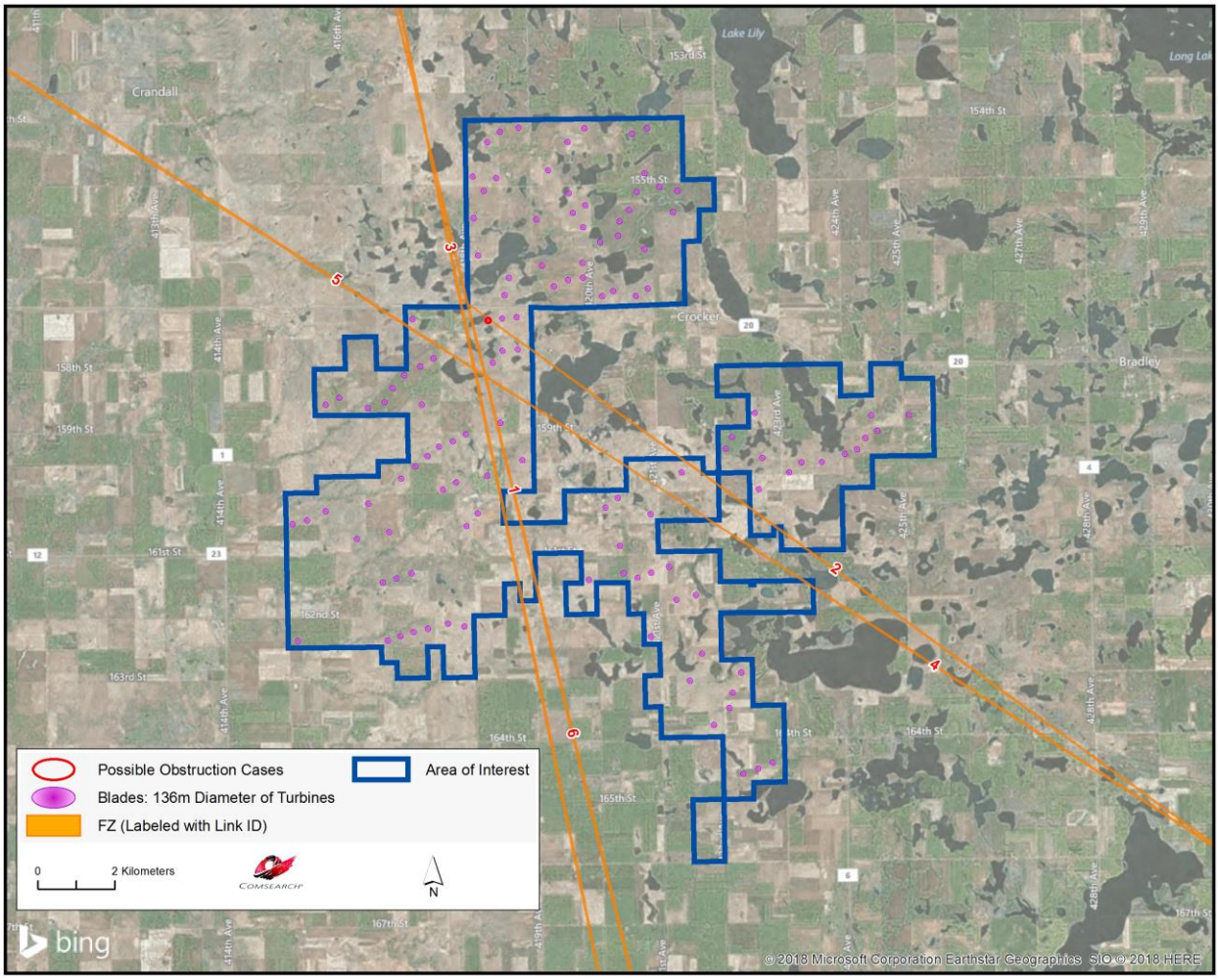


Figure 3: Fresnel Zones in the Area of Interest

Discussion of Potential Two Dimensional Obstructions

Total Microwave Paths	Paths with Affected Fresnel Zones	Total Turbines	Turbines intersecting the Fresnel Zones
6	1	120	1

Table 2: Fresnel Zone Analysis Result

[5] Comsearch makes no warranty as to the accuracy of the data included in this report beyond the date of the report. The data provided in this report is governed by Comsearch's data license notification and agreement located at http://www.comsearch.com/files/data_license.pdf.

For this project, 120 turbines were considered in the analysis, each with a blade diameter of 110-136 meters and turbine hub height of 80-100 meters. Of those turbines, one was found to intersect the Fresnel Zone of one microwave path using the maximum blade length. Figure 4 contains a detailed depiction of the potential obstruction scenario and Table 3 contains a summary of the affected turbines. A cross sectional analysis was performed in Section 4 to determine the diagonal clearance value for this case shown in four calculations representing the max and min blade length and hub height.

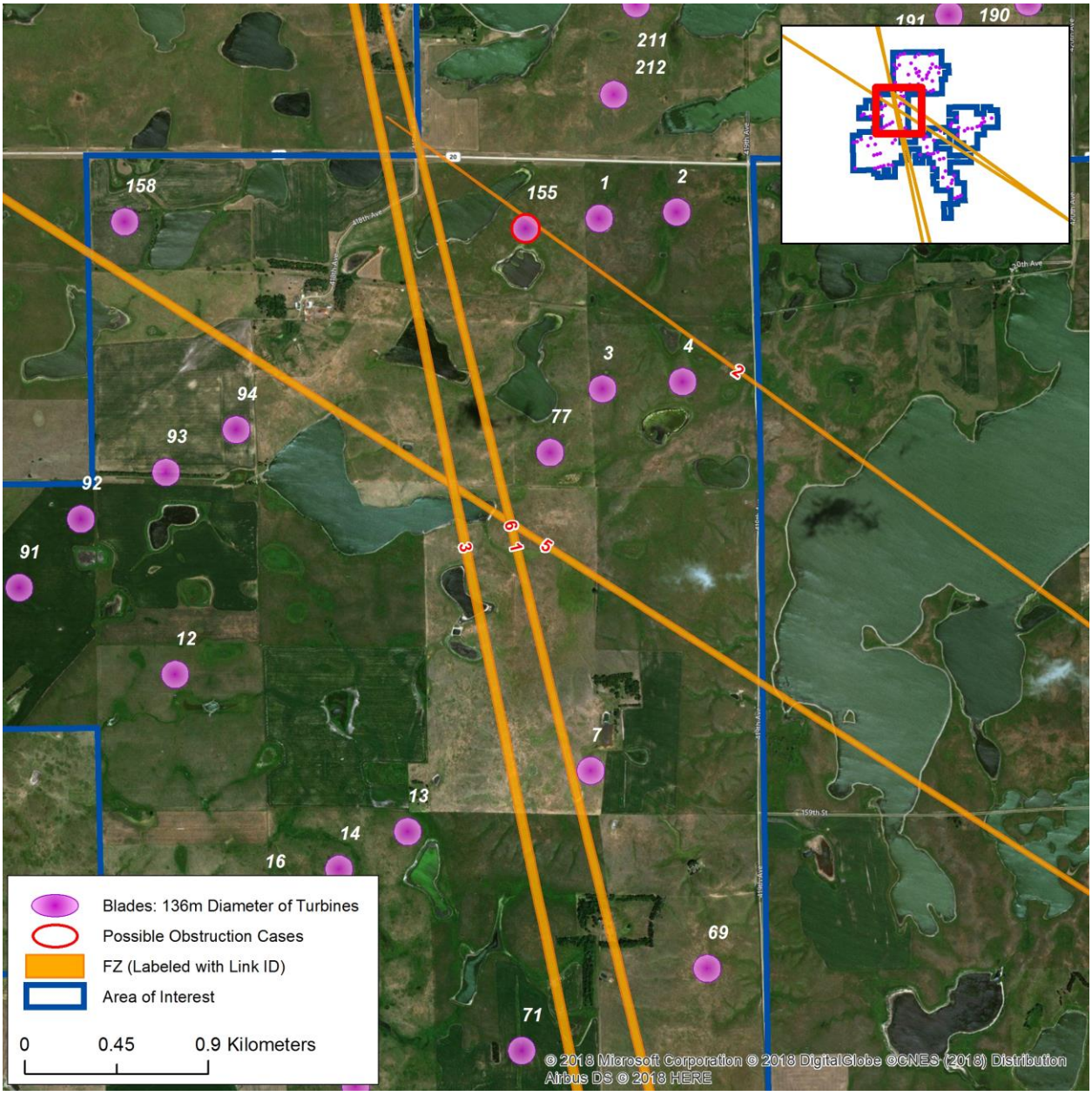


Figure 4: Potential Obstruction Case (Turbine 155) and Turbine 7 Sited close to Path 1, 6

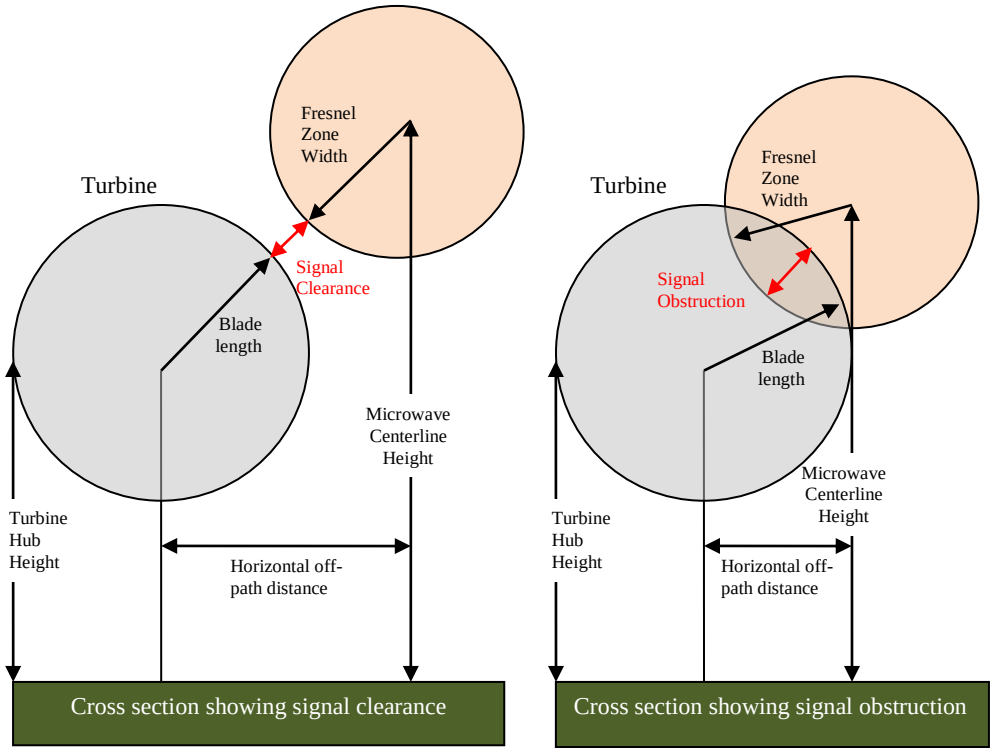
Turbine ID	Latitude (NAD83)	Longitude (NAD83)	Affected Microwave Path ID	Fresnel Zone Width at Turbine Location (m)	Horizontal off-path Distance (m)	Distance along the path from site 1 (km)	Horizontal Clearance (m)
155	45.105599	-97.854897	2	4.41	43.5	0.87	-(15.91–28.91)

Table 3: Turbines that Intersect Fresnel Zones

4. Cross Sectional Analysis

Our Fresnel Zone analysis in the previous section identified one potential obstruction case that needs to be further examined from a cross sectional perspective. The case that will be analyzed in this section can be found in Table 3. The horizontal clearance range represents the values calculated for both the max and min blade diameters (110-136 meters)

Our cross sectional analysis calculates the precise height and width of 100% of the first Fresnel Zone at the turbine location based on the antenna heights of the two link endpoints and the earth curvature bulge at the specific turbine location. The horizontal off-path distance was calculated in the previous section and the turbine hub height and blade length were provided by the client. The cross sectional analysis uses these values to calculate the clearance between the blades and the microwave Fresnel Zone as shown in the two diagrams below.



The results of the cross sectional calculations can be seen in Table 4 below. The results are broken down in four calculations representing the max and min dimensions of both the hub height and blade length. It shows negative clearance values indicating obstruction of the Fresnel zone and positive showing clearance. Note that the microwave centerline height for this case is lower than the hub height as opposed to higher as depicted in the diagrams on page 6.

Microwave Path ID	Fresnel Zone Width at Turbine Location (m)	Microwave Centerline Height at Turbine Location (m)	Turbine ID	Hub Height (m)	Blade Length (m)	Cross Sectional Clearance (m)
2	4.41	43.11	155	80	68	-15.37
2	4.41	43.11	155	80	55	-2.37
2	4.41	43.11	155	100	68	-0.79
2	4.41	43.11	155	100	55	12.21

Table 4: Cross Sectional Analysis Results

5. Conclusion

Our study identified 120 microwave paths intersecting the Crocker Wind Farm project area. The Fresnel Zones for these microwave paths were calculated and mapped. One turbine was found to intersect the two dimensional Fresnel Zone of one microwave path. Based on the cross sectional analysis, it was determined that it will clear the path if it is built with the minimum blade size and max hub height, otherwise it runs the risk of obstructing the microwave path and potentially causing signal degradation. One additional turbine, 7, was found to be sited very close to an existing path. Caution should be taken if attempting to adjust the location of this turbine.

6. Contact

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