Appendix F

Telecommunication Studies

Wind Power GeoPlanner™

Land Mobile & Emergency Services Report

Three Waters Wind Farm

Prepared on Behalf of
Three Waters Wind
Farm, LLC

April 24, 2019

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Table of Contents

1. Introduction

An assessment of the emergency services in the Three Waters Wind Farm project area was performed by Comsearch to identify potential impact from the planned turbines. We evaluated the registered frequencies for the following types of first responder entities: police, fire, emergency medical services, emergency management, hospitals, public works, transportation and other state, county, and municipal agencies. We also identified all industrial and business land mobile radio (LMR) systems and commercial E911 operators within the proposed wind energy facility boundaries. This information is useful in the planning stages of the wind energy facility because the data can be used in support of facility communications needs and to evaluate any potential impact on the emergency services provided in that region. An overview of the project area, which is located in Jackson County, Minnesota, appears below in Figure 1.

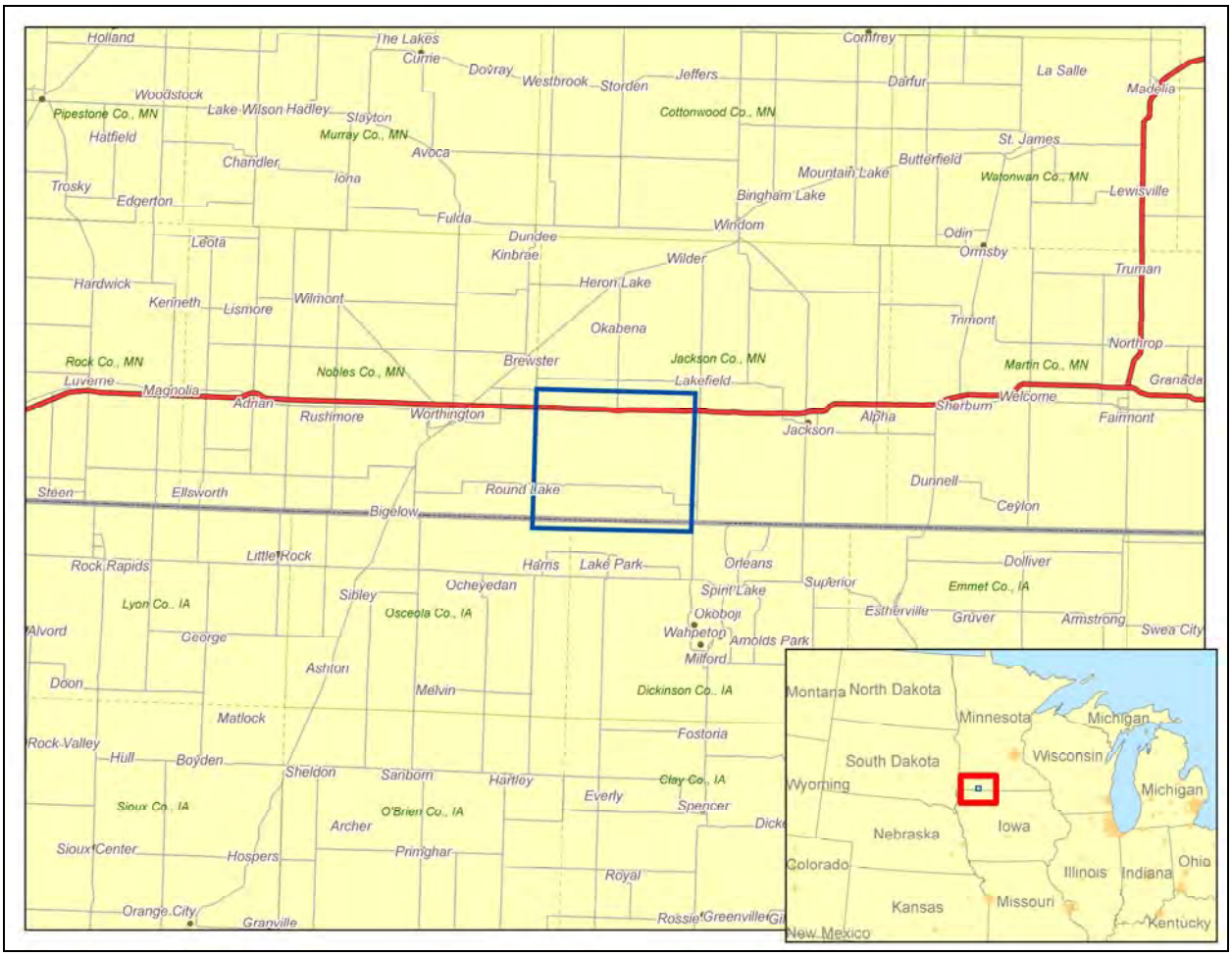

Figure 1: Area of Interest (AOI)

2. Summary of Results

Our land mobile and emergency services incumbent data[1] was derived from the FCC's Universal Licensing System (ULS) and the FCC's Public Safety & Homeland Security bureau. We identified both site-based licenses as well as regional area-wide licenses designated for public safety use.

Site-Based Licenses

The site-based licenses were imported into GIS software and geographically mapped relative to the wind energy project area of interest as defined by the customer. Each site on the map was given an ID number and associated with site information in a data table. A depiction of the fixed-site licenses in and around the project area appears in Figure 2.

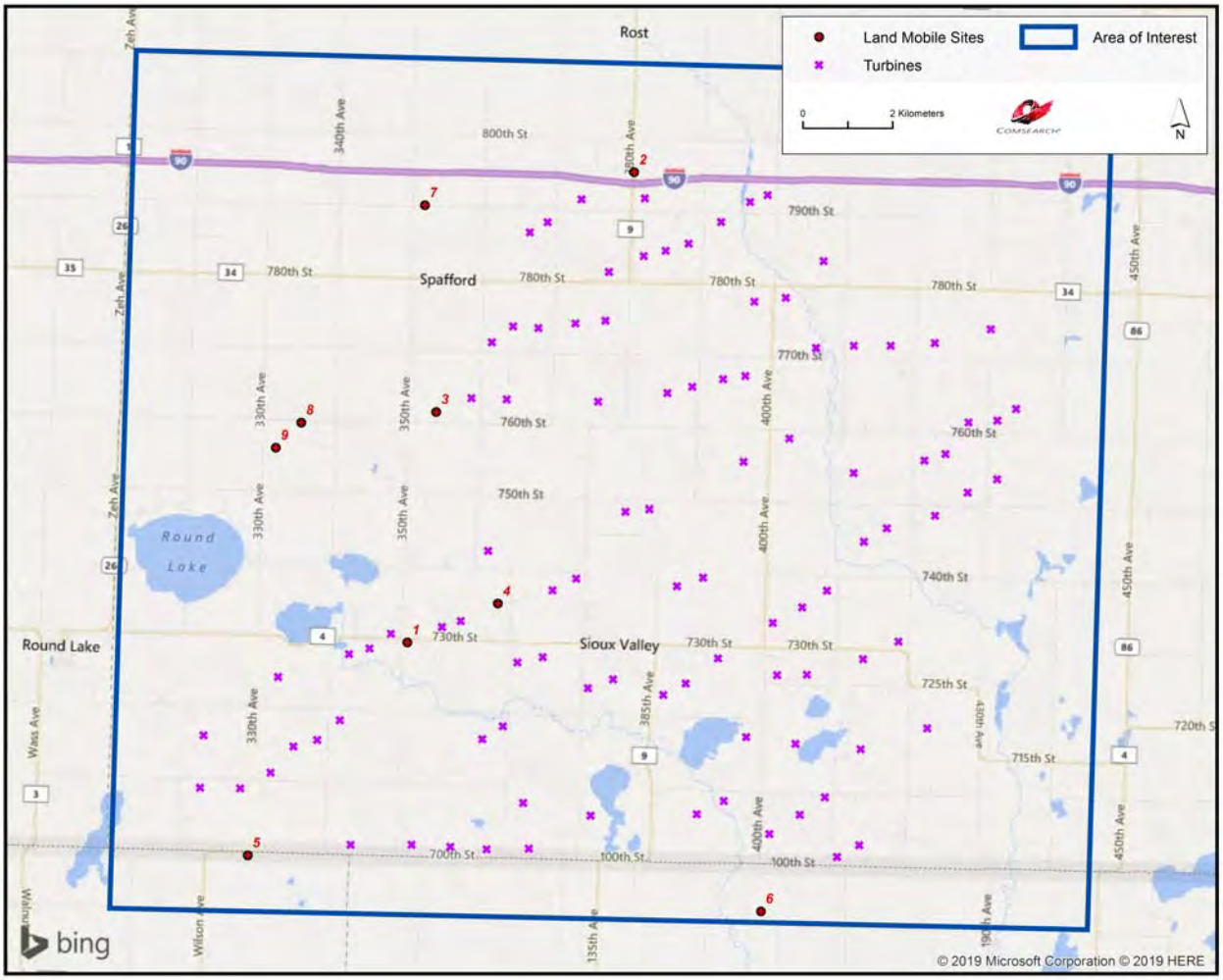

Figure 2: Land Mobile & Emergency Service Sites in Area of Interest

Figure 2 identifies nine site-based licenses in and around the Three Waters Wind Farm project area of interest. Specific information about these sites is provided in Table 1.

ID	Call Sign	Frequency Band (MHz)	Licensee	Antenna Height AGL (m)	Latitude (NAD83)	Longitude (NAD83)	Distance to Nearest Turbine (km)
1	WQEJ378	150-174	Federated Rural Electric Association	11.0	43.543028	-95.373333	0.41
2	WQEJ383	150-174	Federated Rural Electric Association	11.0	43.638583	-95.314444	0.63
3	WQSZ779	450-470	Kazemba, James A.	36.6	43.589361	-95.367194	0.85
4	WQUI613	450-470	Meyer Farms, LLC	38.1	43.551361	-95.348639	0.92
5	WNIU966	450-470	Rowe, Allen E.; Rowe, Randy A.	18.0	43.499417	-95.415556	1.51
6	WNGH820	450-470	Terrafact, Inc.	22.0	43.491083	-95.273889	1.74
7	WQBF965	450-470	Post, John	36.0	43.630778	-95.371944	2.42
8	WQNC459	450-470	Riley, Dan	13.7	43.586472	-95.404278	3.83
9	WQNC459	450-470	Riley, Dan	33.5	43.581278	-95.411083	4.50

Table 1: Land Mobile & Emergency Service Sites in Area of Interest

Area-Wide Licenses

The regional area-wide licenses were compiled from FCC data sources and identified for each county intersected by the wind energy project area. The Three Waters Wind Farm project is located in Jackson County, Minnesota, part of Public Safety Region #22, which contains all the counties in Minnesota. The regional public safety operations are overseen by the entity listed below.

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Chairman, Public Safety Region #22
Minnesota Department of Transportation
Office of Statewide Radio Communications
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The chairperson for Region #22 serves as the representatives for all public safety entities in the area and is responsible for coordinating current and future public safety use in the wireless spectrum. In the bands licensed by the FCC for area-wide first responders, which include 220

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

MHz, 700 MHz, 800 MHz and 4.9 GHz, as well as the traditional Part 90 public safety pool of frequencies, thirteen licenses were found for the State of Minnesota and one for the County of Jackson (see Table 2). These area-wide licenses are designated for mobile use only.

ID	Licensee	Area of Operation	Frequency Band (MHz)
1	American National Red Cross	Statewide: Minnesota	25-50
2	Cart, Inc.	Statewide: Minnesota	150-174
3	Greater Northwest Emergency Medical Services	Statewide: Minnesota	450-470
4	Hennepin, County of	Statewide: Minnesota	25-50, 150-174, 406-413, 450-470, 800/900
5	Jackson, County of	Countywide: Jackson	150-174
6	Minneapolis, City of	Statewide: Minnesota	2450-2500
7	Minnesota, State of	Statewide: Minnesota	0-10, 150-174, 450-470, 769-775/799-805, 800/900, 2450-2500, 4940-4990
8	Minnesota Canine Search Rescue and Tracking	Statewide: Minnesota	150-174
9	Minnesota Department of Public Safety	Statewide: Minnesota	150-174
10	National Ski Patrol System, Inc.	Statewide: Minnesota	150-174
11	Nevada Division of Forestry	Statewide: Minnesota	150-174
12	Northstar Search and Rescue	Statewide: Minnesota	150-174
13	Rochester, City of	Statewide: Minnesota	150-174
14	Saint Louis, County of	Statewide: Minnesota	150-174, 450-470, 800/900

Table 2: Regional Licenses

E911 Operators

Wireless operators are granted area-wide licenses from the FCC to deploy their cellular networks, which often include handsets with E911 capabilities. Since mobile phone market boundaries differ from service to service, we disaggregated the carriers' licensed areas down to the county level. We have identified the type of service for each carrier in Jackson County, Minnesota, in Table 3.

Mobile Phone Carrier	Service[2]
AT&T	AWS, Cellular, PCS, WCS, 700 MHz
DISH Network	AWS, 700 MHz
Sprint	PCS
Standing Rock Telecommunications	PCS
TerreStar	AWS
T-Mobile	AWS, PCS, 700 MHz
Verizon	AWS, Cellular, PCS, 700 MHz

Table 3: Mobile Phone Carriers in Area of Interest with E911 Service

[2] AWS: Advanced Wireless Service at 1.7/2.1 GHz
CELL: Cellular Service at 800 MHz
PCS: Personal Communication Service at 1.9 GHz
WCS: Wireless Communications Service at 2.3 GHz
700 MHz: Lower 700 MHz Service

3. Impact Assessment

The first responder, industrial/business land mobile sites, area-wide public safety, and commercial E-911 communications as described in this report are typically unaffected by the presence of wind turbines, and we do not anticipate any significant harmful effect to these services in the Three Waters Wind Farm project area. Although each of these services operates in different frequency ranges and provides different types of service including voice, video and data applications, there is commonality among these different networks with regard to the impact of wind turbines on their service. Each of these networks is designed to operate reliably in a non-line-of-sight (NLOS) environment. Many land mobile systems are designed with multiple base transmitter stations covering a large geographic area with overlap between adjacent transmitter sites in order to provide handoff between cells. Therefore, any signal blockage caused by the wind turbines does not materially degrade the reception because the end user is likely receiving signals from multiple transmitter locations. Additionally, the frequencies of operation for these services have characteristics that allow the signal to propagate through wind turbines. As a result, very little, if any, change in their coverage should occur when the wind turbines are installed.

When planning the wind energy turbine locations in the area of interest, a conservative approach would dictate not locating any turbines within 77.5 meters of land mobile fixed-base stations to avoid any possible impact to the communications services provided by these stations. This distance is based on FCC interference emissions from electrical devices in the land mobile frequency bands. As long as the turbines are located more than 77.5 meters from the land mobile stations, they will meet the setback distance criteria for FCC interference emissions in the land mobile bands.

4. Recommendations

In the event that a public safety entity believes its coverage has been compromised by the presence of the wind energy facility, it has many options to improve its signal coverage to the area through optimization of a nearby base station or even adding a repeater site. Utility towers, meteorological towers or even the turbine towers within the wind project area can serve as the platform for a base station or repeater site.

5. Contact

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Mobile Phone Carrier Report

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Table of Contents

1. Introduction

Comsearch has developed and maintains comprehensive technical databases containing information on licensed mobile phone carriers across the US. Mobile phone carriers operate in multiple frequency bands and are often referred to as Advanced Wireless Service (AWS), Personal Communication Service (PCS), 700 MHz Band, Wireless Communications Service (WCS), and Cellular. They hold licenses on an area-wide basis which are typically comprised of several counties.

This report focuses on the potential impact of wind turbines on mobile phone operations in and around the project area. Comsearch provides additional wind energy services, a description of which is available upon request.

2. Summary of Results

Methodology

Our mobile phone analysis was performed using Comsearch's proprietary carrier database, which is derived from a variety of sources including the Federal Communications Commission (FCC). Since mobile phone market boundaries differ from service to service, we disaggregated the carriers' licensed areas down to the county level. Then we compiled a list of all mobile phone carriers in the main counties that intersect the area of interest. The area of interest was defined by the client and encompasses the planned turbine locations. A depiction of the wind project area and counties appears below.

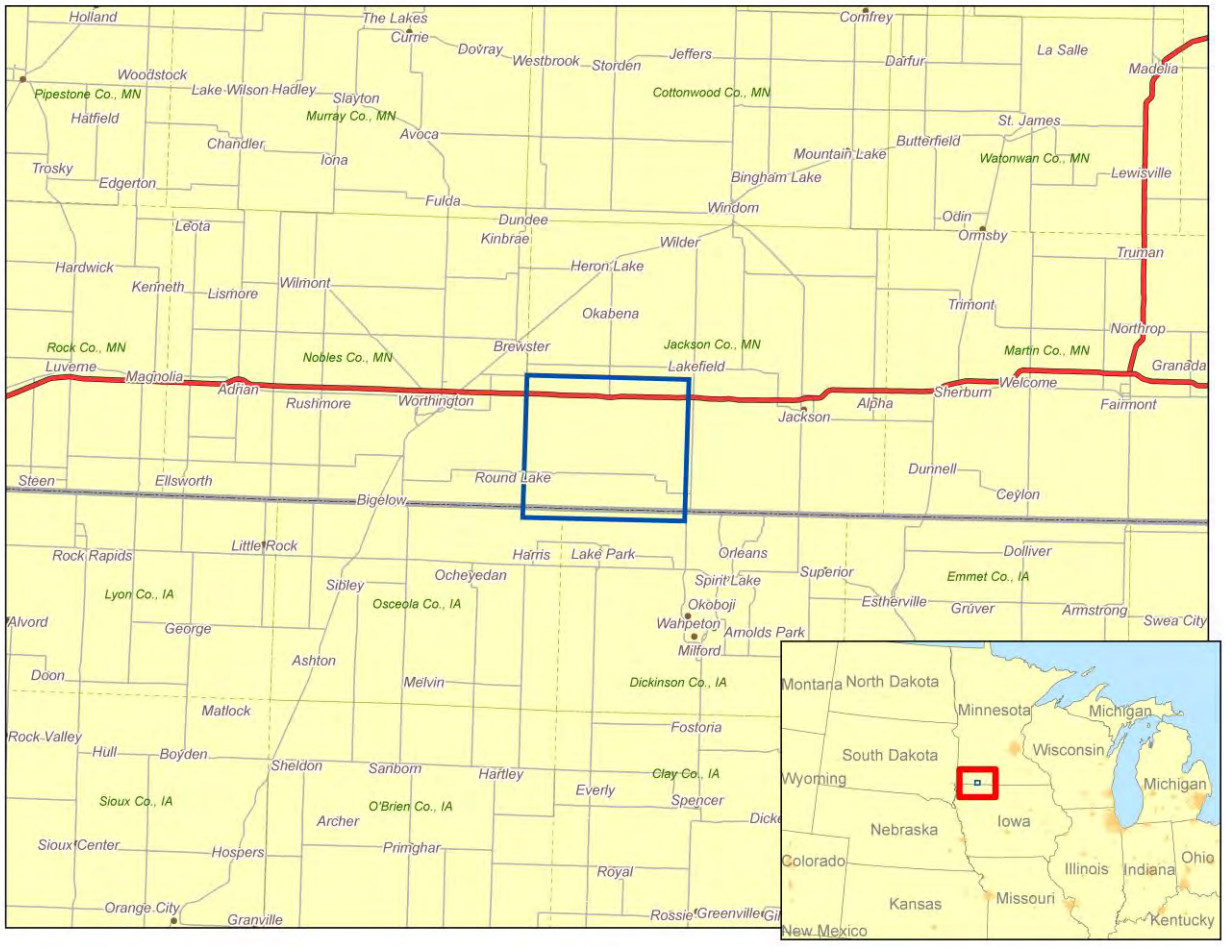

Figure 1: Counties that intersect the Area of Interest

Results
The Three Waters Wind Farm Project is located in Jackson County, Minnesota. We have identified the type of service, channel block, market ID and FCC callsign for each carrier in the county of interest. A description of the various service types and geographic market areas is below with a summary table on the following page.

AWS
AWS licensees won their spectrum in an auction that started in August 2006. The licensees are authorized by 734 Cellular Market Areas (CMA) for Block A, 176 Economic Areas (BEA) for Blocks B and C, and 12 Regional Economic Area Groupings (REAG) for Blocks D, E and F. This spectrum at 1.7 and 2.1 GHz was allocated for mobile broadband and advanced wireless services. Partitioning and leases are permitted in the band.

Cellular
Licensees are authorized by Metropolitan and Rural Statistical Areas, also known as CMAs. Unserved areas can be covered by licensees other than the original A or B block licensee. To determine the most realistic coverage, we compiled the Cellular Geographic Service Areas (CGSA) from the 32 dBu contours defined by Part 22.911(a) of the FCC rules. Mobile services are provided at 800 MHz and partitioning and leases are permitted in the band.

PCS
There have been nine auctions for this band, with the last one being held in August 2008. Licensees are authorized by 51 Major Trading Areas (MTA) for Blocks A and B, 493 Basic Trading Areas (BTA) for Blocks C through F, and 176 Economic Areas (EA) for Block G. This band has been heavily partitioned and disaggregated both by counties and by smaller polygons within counties (known as undefined areas or partial counties). The 1.9 GHz PCS carriers provide mobile services and leases are permitted in the band.

700 MHz Band
Originally used for analog television broadcasting, this band consists of an upper and lower band, each having its own set of frequency blocks. There have been three auctions in this band with the last one (Auction 73) being held in 2008 and mobile phone carriers eventually winning licenses for Blocks A, B, and C of the Lower 700 MHz band and Block C of the Upper 700 MHz band. Licensees are authorized by 176 Economic Areas (EA) for Lower Block A, 734 Cellular Market Areas (CMA) for Lower Blocks B and C, and 12 Regional Economic Area Groupings (REAG) for Upper Block C. Partitioning and leases are permitted in the band.

WCS
Mobile services provided in the 2.3 GHz band occupy frequency blocks above and below the spectrum allocated for Satellite Digital Audio Radio Service (SDARS) from 2320 MHz to 2345 MHz. WCS licensees are authorized by 52 Major Economic Areas (MEA) for Blocks A and B and 12 Regional Economic Area Groupings (REAG) for Blocks C and D. Partitioning and leases are permitted in the band.

Service[1]	Mobile Phone Carrier	Channel Block	County	ST	Market ID	Callsign
AWS	AT&T	A	Jackson	MN	CMA490	WQGT839
AWS	T-Mobile	B	Jackson	MN	BEA107	WQQA213
AWS	AT&T	B	Jackson	MN	BEA107	WQXQ400
AWS	T-Mobile	C	Jackson	MN	BEA107	WQXK768
AWS	T-Mobile	D	Jackson	MN	REA003	WQQA469
AWS	Verizon	E	Jackson	MN	REA003	WQPZ950
AWS	Verizon	F	Jackson	MN	REA003	WQGA717
Cellular	AT&T	A	Jackson	MN	CMA490	KNKN282
Cellular	Verizon	B	Jackson	MN	CMA490	KNKN290
PCS	Standing Rock Telecommunications	A	Jackson	MN	MTA012	WQYR221
PCS	T-Mobile	B	Jackson	MN	MTA012	KNLF224
PCS	Verizon	C	Jackson	MN	BTA481	KNLF485
PCS	Verizon	C	Jackson	MN	BTA481	WPOJ816
PCS	Verizon	D	Jackson	MN	BTA481	KNLH771
PCS	Verizon	E	Jackson	MN	BTA481	KNLG884
PCS	AT&T	F	Jackson	MN	BTA481	WQAQ254
PCS	Sprint	G	Jackson	MN	BEA107	WQKT215
700 MHz	T-Mobile	Lower A	Jackson	MN	BEA107	WQJQ710
700 MHz	AT&T	Lower B	Jackson	MN	CMA490	WQIZ624
700 MHz	AT&T	Lower C	Jackson	MN	CMA490	WPWV448
700 MHz	AT&T	Lower D	Jackson	MN	EAG704	WPZA238
700 MHz	DISH Network	Lower E	Jackson	MN	BEA107	WQJZ249
700 MHz	Verizon	Upper C	Jackson	MN	REA003	WQJQ691
WCS	AT&T	A	Jackson	MN	MEA020	KNLB218
WCS	AT&T	B	Jackson	MN	MEA020	KNLB292
WCS	AT&T	C	Jackson	MN	REA003	WPQL713
WCS	AT&T	D	Jackson	MN	REA003	WQDM396

Table 1: Mobile Phone Carriers in the Area of Interest

[1] AWS: Advanced Wireless Service at 1.7/2.1 GHz
CELL: Cellular Service at 800 MHz
PCS: Personal Communication Service at 1.9 GHz
700 MHz: Commercial Mobile Phone at 700 MHz
WCS: Wireless Communication Service at 2.3 GHz

FCC-Licensed Sites

For competitive and confidentiality reasons, most mobile phone carriers' individual sites are not licensed with the FCC. However, in the cellular band, if a base station extends the existing Cellular Geographic Service Area (CGSA), then it must be recorded with the FCC. We identified one cellular site near the Three Waters Wind Farm area of interest. Figure 2 on the next page depicts its location in relation to the area of interest and Table 2 contains the technical parameters on the FCC license.

Callsign	Licensee	Structure Height to Tip (m)	ASR Number	Location Address	Latitude (NAD83)	Longitude (NAD83)	Distance to the Closest Turbine (m)
KNKN282	AT&T	108.2	1203057	798 4TH AVENUE (107886)	43.680222	-95.163861	8916

Table 2: FCC-Licensed Mobile Phone Sites

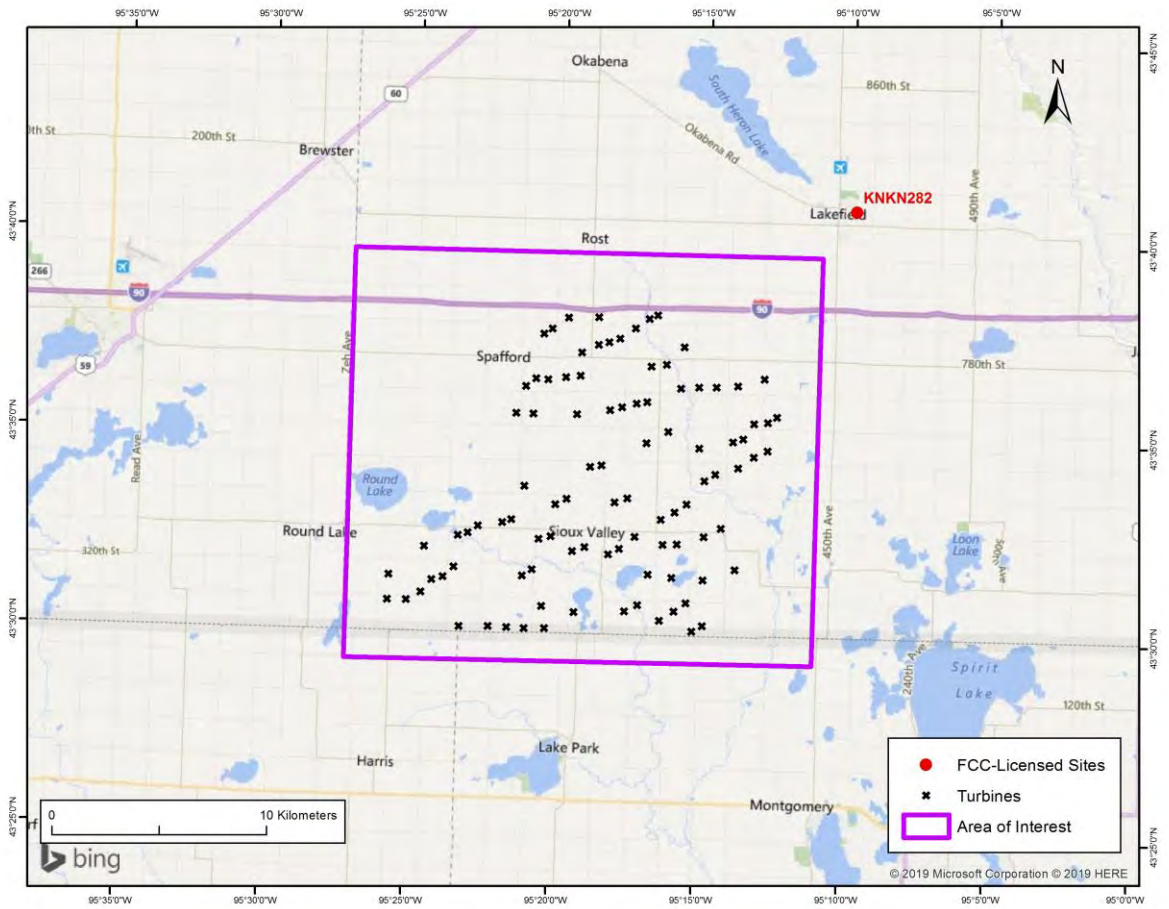

Figure 2: FCC-Licensed Mobile Phone Sites near the Area of Interest

Impact Assessment and Distance Setback Requirements

The cellular mobile phone signal propagation is typically not affected by physical structures because the beam widths of the radiated signal from the base stations and mobile units are very wide and the wavelength of the signal is long enough to wrap around objects such as wind turbine towers and blades. In addition, the cellular network consists of multiple base stations that are designed so that if the connection cannot be made to one base station it will shift to adjacent base stations to make the connection. This enables cellular mobile telephone systems to provide coverage in areas that are congested with physical structures such as downtown urban areas. Areas containing wind turbines have less of a coverage issue than urban areas, so the wind turbines presence does not require any special setback for signal obstruction consideration other than physical clearance of the blades. From an electromagnetic interference standpoint, the emissions from the wind turbines, which are specified by the FCC, should be taken into account to ensure they will not interfere with the base stations or the mobile units. Part 15 of the FCC regulations covers the emissions from unintentional radiating devices, such as wind turbines. The field strength limits for the emissions from unintentional radiators is given in paragraph 15.109 of Part 15 of the FCC rules. The emission limits are stated for a distance of 3 meters or approximately 10 feet and are shown below.

Radiated Emission Limits at 3 Meters

Frequency of Emission (MHz)	Field Strength (microVolts/meter)
30 – 88	100
88 – 216	150
216 – 960	200
> 960	500

From these limits and the receiver sensitivity of the cellular base stations and mobile units we can determine a setback requirement for wind turbines and cellular system. The typical sensitivity of mobile units is -90 dBm ($1X10^{-12}$ Watts) and the typical sensitivity of base stations is -93 dBm ($5X10^{-13}$ Watts). The gain of mobile unit antennas are -10dB or 0.1 and the gain of base station antennas are 17 dB or 50. The effective area (A) of the mobile unit and base station antennas are determined from the following formula.

$$A = G*\lambda^2 / 4*\pi$$

Where,
G = Antenna Gain, number
λ = Wavelength, 0.353 meters
π = 3.14

This gives us an effective area for the mobile unit antenna of $9.9X10^{-4}$ meter^2 and the effective area for the base station antenna of 0.496 meter^2. Using the typical receiver sensitivities of the mobile and base units above, we can determine their power flux density (P_D) from the following formula:

$$P_D = S/A$$

Where S is defined as the sensitivity for Mobile Unit or for the Base Station expressed in Watts

To calculate the electric field strength (E) we use the following formula:

$$E = (P_D * 377)^{½}$$

So for the mobile unit, P_D = 1.01X10^{-9} Watts/meter^2 and E = 617 microVolts/meter. And, for the base station unit, P_D= 1.008X10^{-12} Watts/meter^2 and E= 19.4 microVolts/meter.

These results show that the mobile units' sensitivity expressed as field strength is above the level allowed as an emission for the wind turbines at a distance of 3 meters. Therefore, no setback for the use of a mobile unit is needed beyond 3 meters. Since the base station has field strength sensitivity below the allowed emission level of the wind turbines a setback distance is needed to ensure that the base stations will not be affected. The field strength of the emission is inversely proportional to separation distance in meters. To determine the setback distance to reduce the field strength to 19.4 microVolts/meter the following formula is used.

D = (500 MicroVolts/meter)*(3 meters) / 19.4 MicroVolts/meter

Where,
D = Setback Distance for Base Station to avoid interference, meters

Thus the setback distance for the cellular tower base station from the wind turbines should be 77.3 meters or greater.

Summary
The telephone communications in the mobile phone carrier bands are typically unaffected by the presence of the wind turbines and we do not anticipate any significant harmful effect to mobile phone services in the Three Waters Wind Farm area. Mobile phone systems are designed with multiple base transmitter stations covering a specific area. Since mobile telephone signals are designed with overlap between adjacent base transmitter sites in order to provide handoff between cells, any signal blockage caused by the wind turbines does not materially degrade the reception because the end user may be receiving from multiple transmitter locations. For example, if a particular turbine attenuates the signal reception into a mobile phone, the phone may receive an alternate signal from a different transmit location, resulting in no disruption in service. Mobile phone systems that are implemented in urban areas near large structures and buildings often have to combat even more problematic signal attenuation and reflection conditions than rural areas containing a wind energy turbine facility.

For the cellular towers located within the project area, no setback distance is required from an interference standpoint other than physical clearance of the blades. From an electromagnetic

standpoint, a setback distance of 77.3 meters should be used to meet FCC emission requirements.

In the unlikely event that a mobile phone carrier believes their coverage has been compromised by the presence of the wind energy facility, they have many options to improve their signal coverage to the area through optimization of a nearby base transmitter or even adding a new sector or cell site. Utility towers, meteorological towers or even the turbine towers within the wind project area can serve as the platform for a base transmit site or cell enhancer.

3. Contact Us

For questions or information regarding the Mobile Phone Carrier Report, please contact:

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Wind Power GeoPlanner™

AM and FM Radio Report

Three Waters Wind Farm

Prepared on Behalf of
Three Waters Wind
Farm, LLC

May 31, 2019

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1. Introduction

Comsearch analyzed AM and FM radio broadcast stations whose service could potentially be affected by the proposed Three Waters Wind Farm project in Jackson County, Minnesota.

2. Summary of Results

AM Radio Analysis
Comsearch found five database records[1] for AM stations within approximately 30 kilometers of the project, as shown in Table 1 and Figure 1. These records represent station KKOJ, which broadcasts out of Jackson, Minnesota, to the east of the project; KWOA, out of Worthington, to the west; and KDOM, out of Windom, to the northeast. KWOA and KDOM are licensed separately for daytime and nighttime operations, with a higher transmit power permitted during daytime hours.

ID	Call Sign	Status[2]	Frequency (kHz)	Transmit ERP[3] (kW)	Operation Time	Latitude (NAD 27)	Longitude (NAD 27)	Required Separation Distance[4] (km)	Distance to Nearest Turbine (km)
1	KKOJ	LIC	1190	5.0	Daytime	43.529167	-95.001389	2.52	17.88
2	KWOA	LIC	730	1.0	Daytime	43.630000	-95.678056	0.41	23.39
3	KWOA	LIC	730	0.159	Nighttime	43.630000	-95.678056	0.41	23.39
4	KDOM	LIC	1580	1.0	Daytime	43.861389	-95.097222	1.90	29.05
5	KDOM	LIC	1580	0.002	Nighttime	43.861389	-95.097222	1.90	29.05

Table 1: AM Radio Stations within 30 Kilometers of Project Area

[1] Comsearch makes no warranty as to the accuracy of the data included in this report beyond the date of the report. The data presented in this report is derived from the AM/FM station's FCC license and governed by Comsearch's data license notification and agreement located at http://www.comsearch.com/files/data_license.pdf. The coordinates provided for AM station KVWC were adjusted slightly based on aerial imagery.

[2] LIC = Licensed and operational station; APP = Application for construction permit; CP=Construction permit granted; CP MOD = Modification of construction permit.

[3] ERP = Transmit Effective Radiated Power.

[4] The required separation distance is based on the lesser of 10 wavelengths or 3 kilometers for directional antennas and 1 wavelength for non-directional antennas.

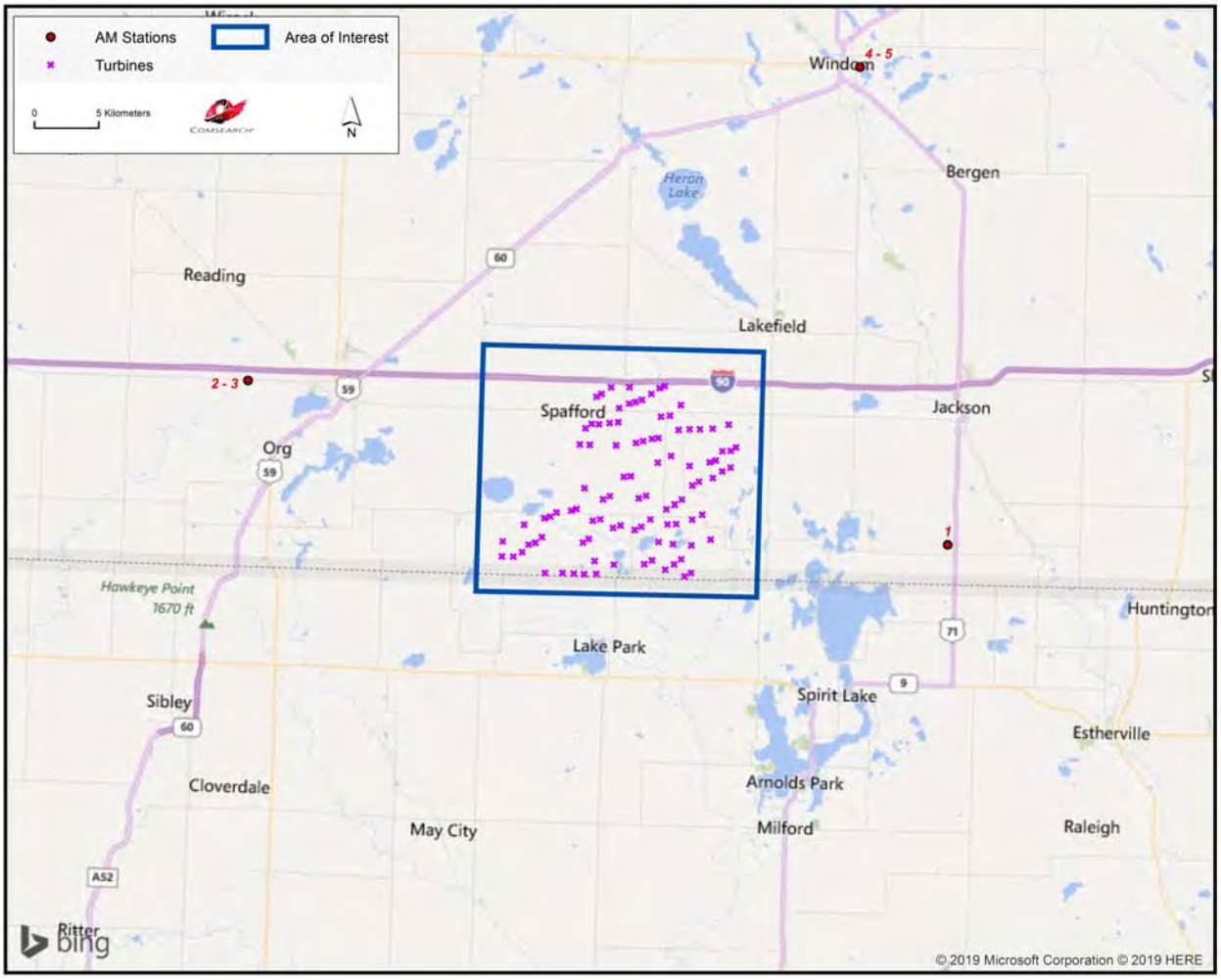

Figure 1: AM Radio Stations within 30 Kilometers of Project Area

FM Radio Analysis

Comsearch determined that there were fifteen database records for FM stations within approximately 30 kilometers of the Three Waters Wind Farm project, as shown in Table 2 and Figure 1. Only fourteen of these stations are currently licensed and operational, four of which are translators that broadcast with limited range.

KITN is the only local FM station inside the project area.

ID	Call Sign	Status[5]	Service[6]	Frequency (MHz)	Transmit ERP[7] (kW)	Latitude (NAD 27)	Longitude (NAD 27)	Distance to Nearest Turbine (km)
1	KITN	LIC	FM	93.5	50.0	43.525278	-95.413056	0.87
2	KUQQ	LIC	FM	102.1	50.0	43.405556	-95.083611	17.23
3	KUOO	LIC	FM	103.9	50.0	43.405556	-95.083611	17.23
4	KJIA	LIC	FM	88.9	50.0	43.342778	-95.206667	18.13
5	K210CG	LIC	FX	89.9	0.25	43.404167	-95.062222	18.68
6	K255CY	LIC	FX	98.9	0.25	43.404167	-95.062222	18.68
7	K249EO	LIC	FX	97.7	0.25	43.615000	-94.963333	19.82
8	KUXX	LIC	FM	105.7	25.0	43.615000	-94.963333	19.82
9	KUSQ	LIC	FM	95.1	100.0	43.630000	-95.678056	23.39
10	K262AR	LIC	FX	100.3	0.25	43.630000	-95.678056	23.39
11	KMRR	LIC	FM	104.9	25.0	43.286944	-95.142778	25.55
12	KZTP	LIC	FM	104.3	3.4	43.541667	-95.751389	26.19
13	KRLP	LIC	FM	88.1	0.6	43.884167	-95.182222	28.74
14	K276GN	CP	FX	103.1	0.25	43.884167	-95.182222	28.74
15	KDOM-FM	LIC	FM	94.3	5.7	43.885000	-95.182222	28.83

Table 2: FM Radio Stations within 30 Kilometers of Project Area

[5] LIC = Licensed and operational station; APP = Application for construction permit; CP=Construction permit granted; CP MOD = Modification of construction permit.

[6] FM = FM broadcast station; FX = FM translator station; FL = Low-power FM station; FS = FM auxiliary (backup) station; FB = FM booster station.

[7] ERP = Transmit Effective Radiated Power.

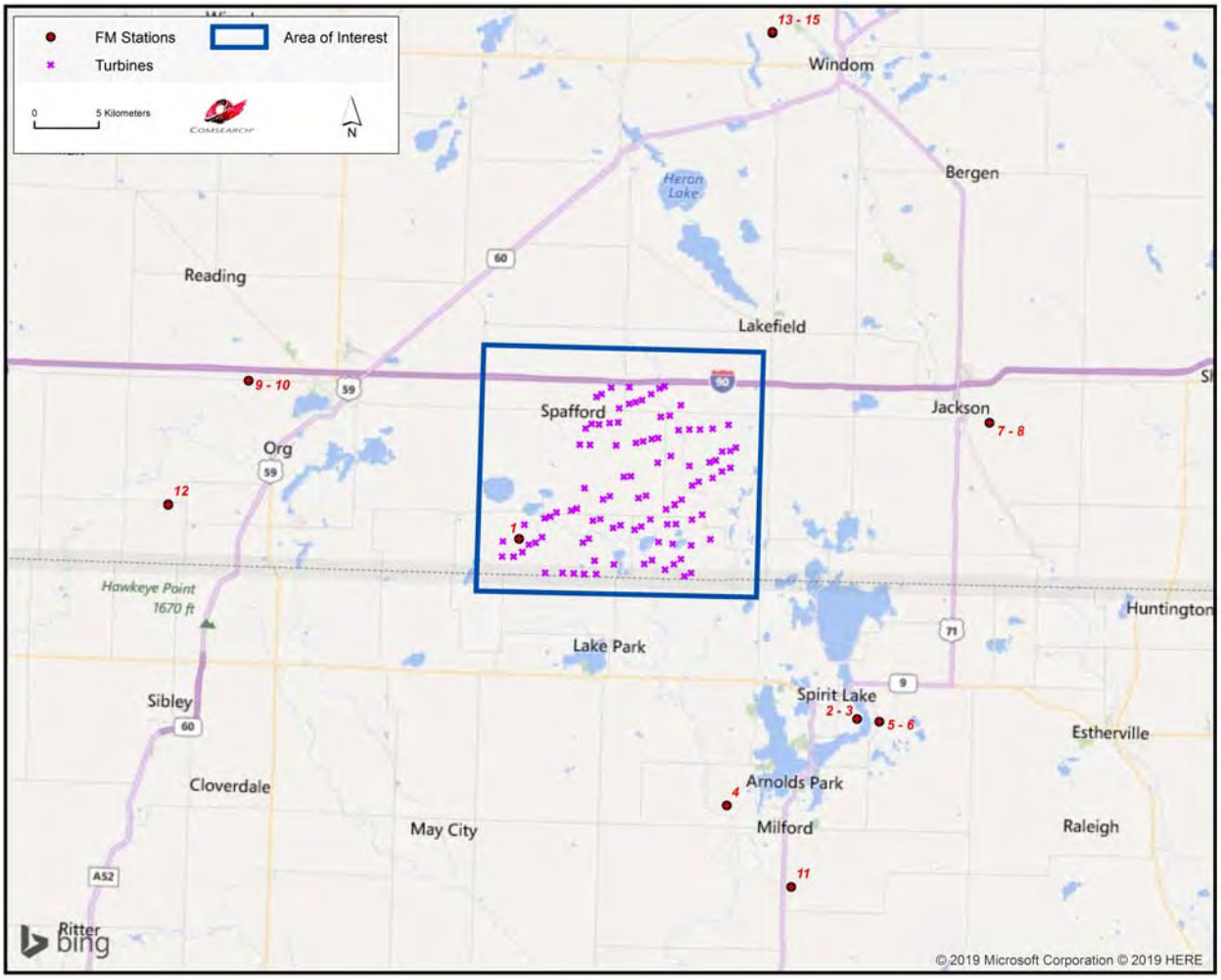

Figure 1: FM Radio Stations within 30 Kilometers of Project Area

3. Impact Assessment

The exclusion distance for AM broadcast stations varies as a function of the antenna type and broadcast frequency. For directional antennas, the exclusion distance is calculated by taking the lesser of 10 wavelengths or 3 kilometers. For non-directional antennas, the exclusion distance is simply equal to 1 wavelength. Potential problems with AM broadcast coverage are only anticipated when AM broadcast stations are located within their respective exclusion distance limit from wind turbine towers. The closest operational AM station to the Three Waters Wind Farm project, KKOJ, is more than 17.8 kilometers from the nearest wind turbine. As there were no stations found within 3 kilometers of the project, which is the maximum possible exclusion distance based on a directional AM antenna broadcasting at 1000 KHz or less, the project should not impact the coverage of local AM stations.

The coverage of FM stations is generally not susceptible to interference caused by large objects, such as wind turbines, especially when they are sited in the *far field* region of the radiating FM antenna, which mitigates the risk of distorting the antenna's radiation pattern. However, within the antenna's *near field* region, radiation pattern distortion can become a factor. Signal attenuation is also possible but can be difficult to quantify without precise field measurements.

The nearest operational station to the Three Waters Wind Farm project, KITN, is located approximately 873 meters from the nearest turbine (#61). After considering the rotational sweep of the turbine blades (63.5 meters), the total separation distance between the station antenna and the tip of turbine blades reduces to 809.5 meters. Based on the antenna configuration for KITN as observed from the field (see Figure 3), a conservative near-field radius was calculated at 642 meters[8]. Station KITN and its proximity to the proposed turbines are depicted below in Figure 4. Because the blade sweep of turbine #61 clears the near field of station KITN by approximately 167 meters, the station should not be impacted by the proposed turbines.

The next closest FM stations to the project, KUQQ and KUOO, are both more than 17.2 kilometers from the nearest turbine and well out of range of impact.

[8] The near-field radius calculation is based on the KITN broadcast frequency of 93.5 MHz and assumes the presence of ten antenna bays with full-wave inter-bay spacing.

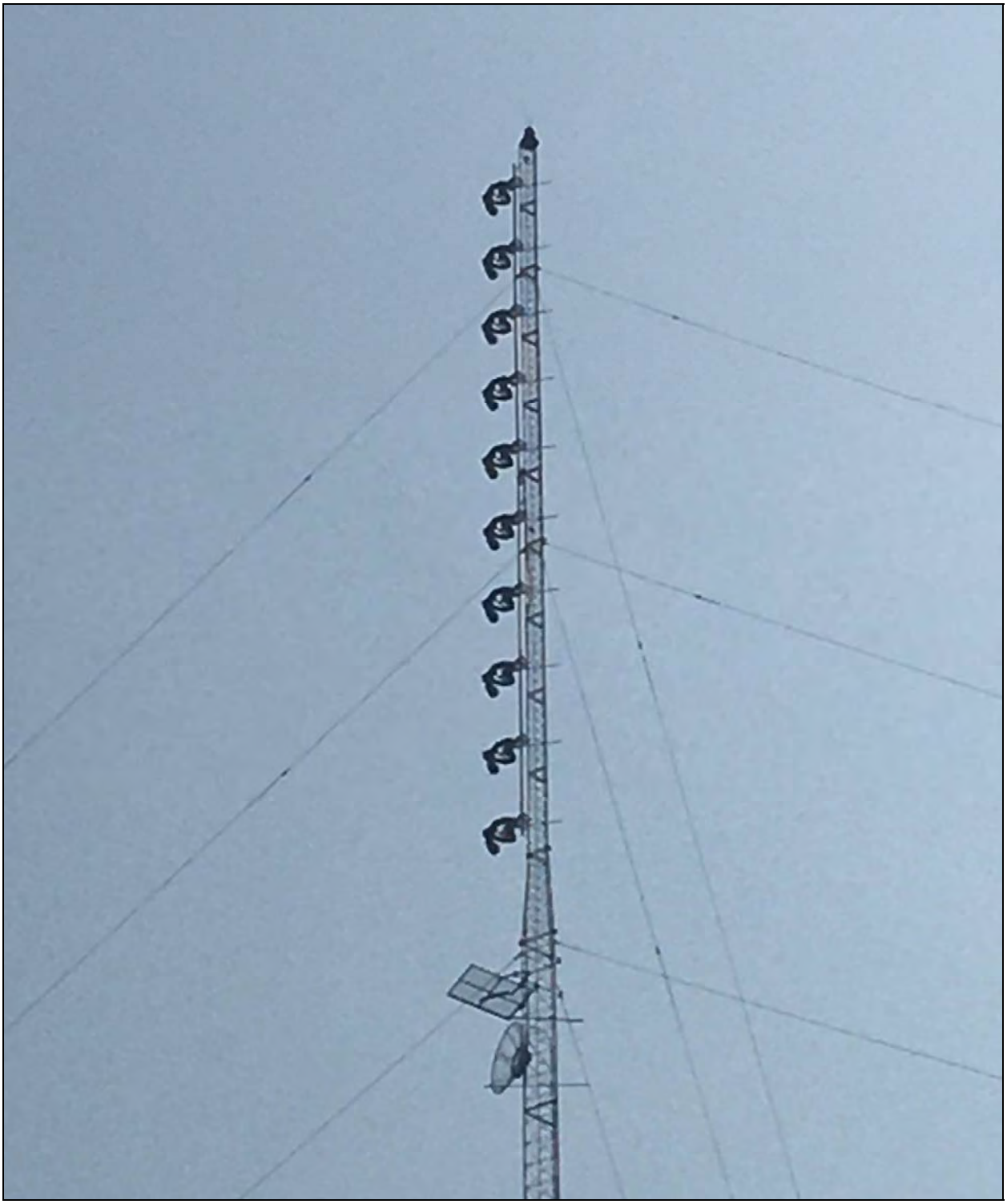

Figure 3: FM Station KITN Antenna

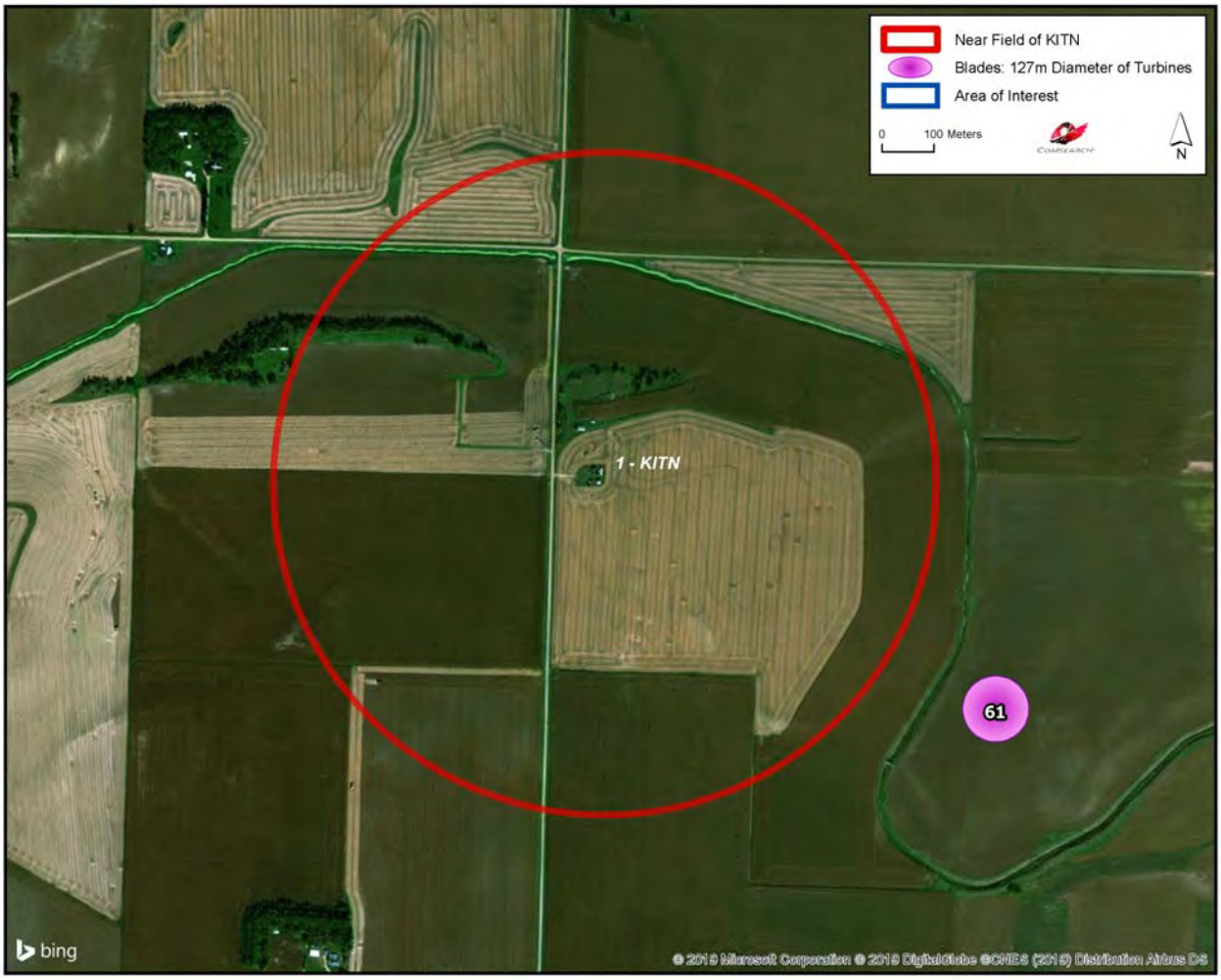

Figure 4: FM Station KITN and Adjacent Wind Turbines

4. Recommendations

Since no impact on the licensed and operational AM or FM broadcast stations was identified in our analysis, no recommendations or mitigation techniques are required for this project.

5. Contact

For questions or information regarding the AM and FM Radio Report, please contact:

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Wind Power GeoPlanner™

Off-Air TV Analysis

Three Waters Wind Farm

Prepared on Behalf of
Three Waters Wind
Farm, LLC

April 24, 2019

COMSEARCH®
A CommScope Company

Table of Contents

1. Introduction

Off-air television stations broadcast signals from terrestrially-based facilities directly to television receivers. Comsearch identified those off-air stations whose service could potentially be affected by the proposed Three Waters Wind Farm project in Jackson County, Minnesota. Comsearch then examined the coverage of the stations and the communities in the area that could potentially have degraded television reception due to the location of the proposed wind turbines.

2. Summary of Results

The proposed wind energy project area and local communities are depicted in Figure 1, below.

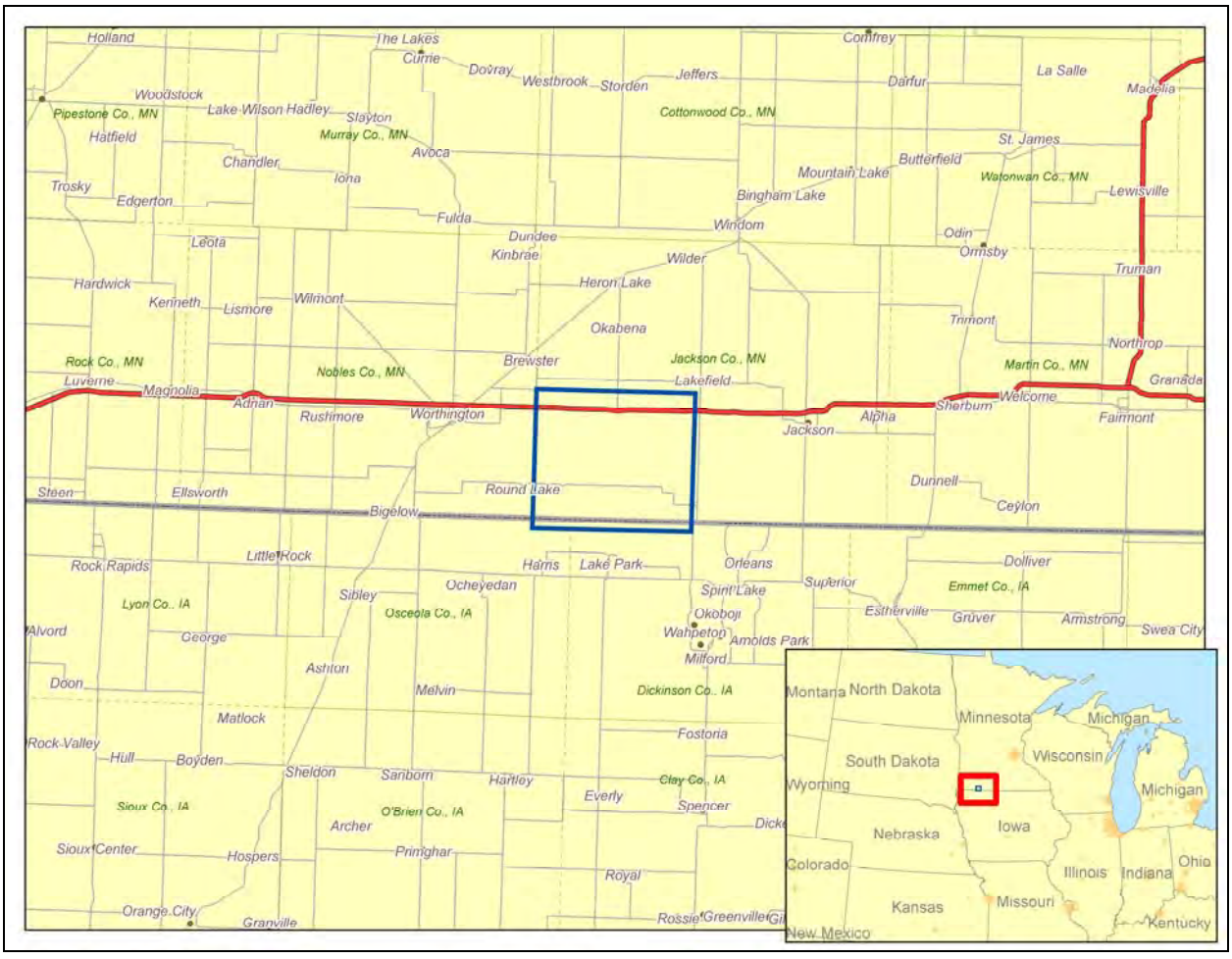

Figure 1: Wind Farm Project Area and Local Communities

To begin the analysis, Comsearch compiled all off-air television stations[1] within 150 kilometers of the project area of interest (AOI). TV stations at a distance of 150 kilometers or less are the most likely to provide off-air coverage to the project area and neighboring communities. These stations are listed in Table 1, below, and a plot depicting their locations is provided in Figure 2. There are a total of 191 database records for stations within approximately 150 kilometers of the limits of the project AOI. Of these stations, only 126 are currently licensed and operating, 109 of which are low-power stations or translators. Translator stations are low-power stations that receive signals from distant broadcasters and retransmit the signal to a local audience. These stations serve local audiences and have limited range, which is a function of their transmit power and the height of their transmit antenna.

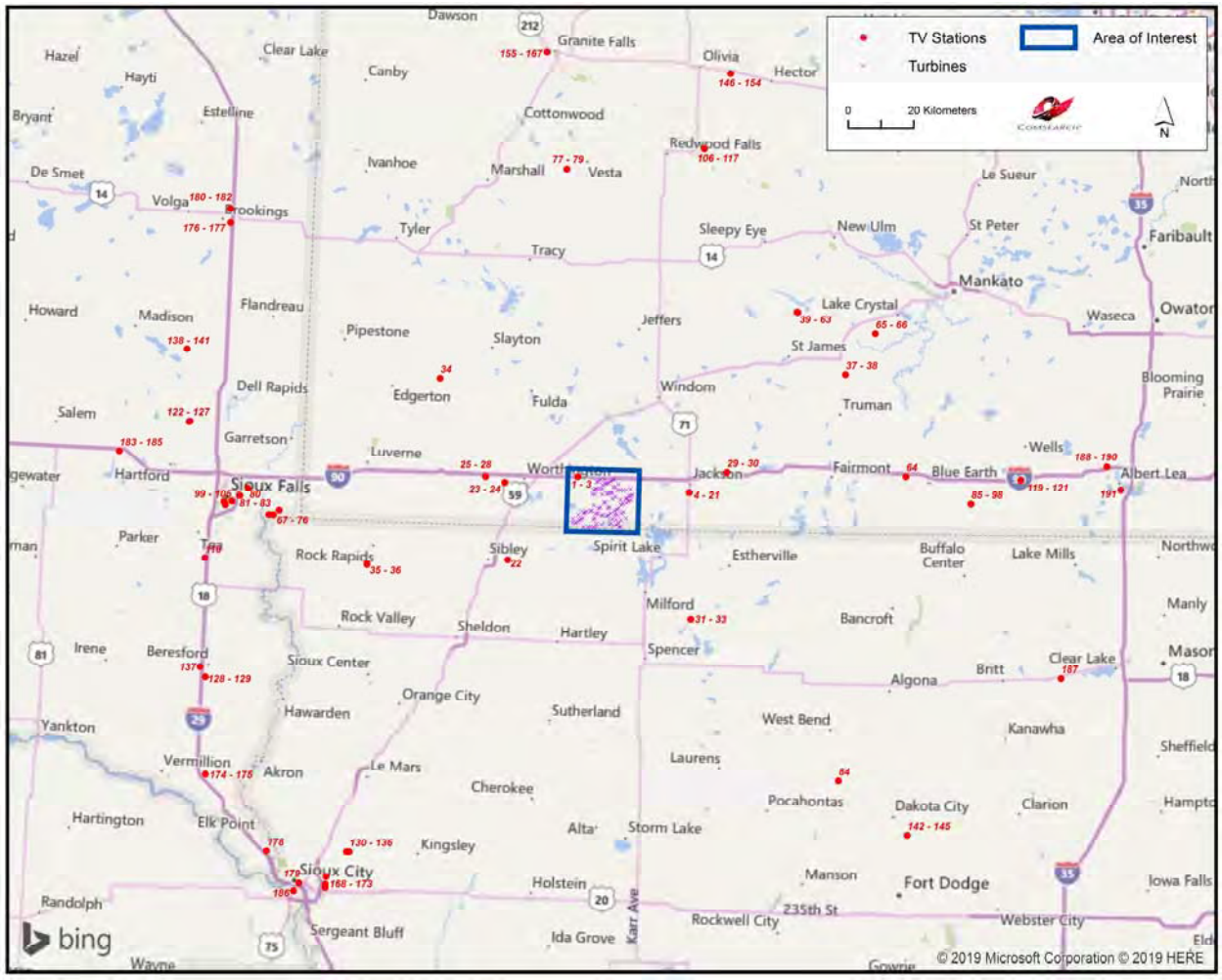

Figure 2: Plot of Off-Air TV Stations within 150 Kilometers of Project Area

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

ID	Call Sign	Status	Service[2]	Channel	Transmit ERP[3] (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
1	K20LV-D	CP	LD	20	1.0	43.639556	-95.414028	5.95
2	K24KZ-D	CP	LD	24	1.0	43.639556	-95.414028	5.95
3	K44LS-D	CP	LD	44	1.0	43.639556	-95.414028	5.95
4	K17MY-D	LIC	LD	17	2.0	43.603333	-94.992778	17.36
5	K19HZ-D	LIC	LD	19	3.1	43.603333	-94.992778	17.36
6	K36IV-D	LIC	LD	22	1.9	43.603333	-94.992778	17.36
7	K23FO-D	LIC	LD	23	3.1	43.603333	-94.992778	17.36
8	K27NF-D	LIC	LD	27	3.1	43.603333	-94.992778	17.36
9	K28OI-D	LIC	LD	28	3.1	43.603333	-94.992778	17.36
10	K29LV-D	LIC	LD	29	3.1	43.603333	-94.992778	17.36
11	K30KQ-D	LIC	LD	30	2.1	43.603333	-94.992778	17.36
12	K31NT-D	LIC	LD	31	3.1	43.603333	-94.992778	17.36
13	K34NU-D	LIC	LD	34	3.1	43.603333	-94.992778	17.36
14	K35IZ-D	LIC	LD	35	3.1	43.603333	-94.992778	17.36
15	K36IV-D	LIC	LD	36	1.5	43.603333	-94.992778	17.36
16	K17MY-D	LIC	LD	40	2.1	43.603333	-94.992778	17.36
17	K27NF-D	LIC	LD	41	3.1	43.603333	-94.992778	17.36
18	K28OI-D	LIC	LD	43	2.1	43.603333	-94.992778	17.36
19	K29LV-D	LIC	LD	45	3.1	43.603333	-94.992778	17.36
20	K31NT-D	LIC	LD	50	2.1	43.603333	-94.992778	17.36
21	K34NU-D	LIC	LD	51	3.1	43.603333	-94.992778	17.36
22	K26JI-D	LIC	LD	26	14.0	43.403333	-95.668611	22.87
23	K18MO-D	LIC	LD	18	2.5	43.617111	-95.689056	23.48
24	K18MO-D	LIC	LD	22	1.8	43.617111	-95.689056	23.48
25	K17MA-D	CP	LD	17	1.0	43.631861	-95.761861	29.49
26	K27ML-D	CP	LD	27	1.0	43.631861	-95.761861	29.49
27	K42LR-D	CP	LD	42	1.0	43.631861	-95.761861	29.49
28	K50NJ-D	CP	LD	50	1.0	43.631861	-95.761861	29.49
29	K33MW-D	CP	LD	33	2.0	43.661222	-94.853472	29.54
30	K39MD-D	CP	LD	39	2.0	43.661222	-94.853472	29.54
31	K18KG-D	LIC	LD	18	6.9	43.255556	-94.976667	35.33

[2] Definitions of service and status codes:
DT – Digital television broadcast station
DX – Digital auxiliary (backup) facility
TX – Translator station
LD – Low-power digital television broadcast station
DC – Class A digital television broadcast station
LIC – Licensed and operational station
CP – Construction permit granted
CP MOD – Modification of construction permit
APP – Application for construction permit, not yet operational

[3] ERP = Transmit Effective Radiated Power

ID	Call Sign	Status	Service[2]	Channel	Transmit ERP[3] (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
32	KBVK-LP	CP	LD	20	6.8	43.255556	-94.976667	35.33
33	KBVK-LP	LIC	LD	21	6.8	43.255556	-94.976667	35.33
34	KSMN	LIC	DT	15	200.0	43.897778	-95.947500	57.31
35	K43LX-D	CP	LD	33	15.0	43.379167	-96.196667	63.88
36	K43LX-D	CP MOD	LD	33	15.0	43.376583	-96.196822	63.96
37	K38MY-D	CP	LD	13	0.35	43.936750	-94.410833	74.27
38	KEYC-TV	LIC	DT	12	52.7	43.936944	-94.410833	74.29
39	K16CG-D	LIC	LD	16	1.8	44.107778	-94.598889	74.32
40	K17MW-D	LIC	LD	17	0.5	44.107778	-94.598889	74.32
41	K41IZ-D	LIC	LD	18	0.4	44.107778	-94.598889	74.32
42	K19LI-D	LIC	LD	19	0.5	44.107778	-94.598889	74.32
43	K20LP-D	LIC	LD	20	1.3	44.107778	-94.598889	74.32
44	K21DG-D	CP	LD	21	0.35	44.107778	-94.598889	74.32
45	K22MQ-D	LIC	LD	22	0.5	44.107778	-94.598889	74.32
46	K23MF-D	LIC	LD	23	1.3	44.107778	-94.598889	74.32
47	K24JV-D	CP	LD	24	0.35	44.107778	-94.598889	74.32
48	K29IE-D	LIC	LD	29	3.0	44.107778	-94.598889	74.32
49	K31KV-D	LIC	LD	31	1.8	44.107778	-94.598889	74.32
50	K35KI-D	LIC	LD	35	1.8	44.107778	-94.598889	74.32
51	K17MW-D	LIC	LD	40	1.8	44.107778	-94.598889	74.32
52	K22MQ-D	LIC	LD	45	1.8	44.107778	-94.598889	74.32
53	K28OH-D	LIC	LD	49	3.0	44.107778	-94.598889	74.32
54	K23MF-D	CP	LD	51	3.0	44.107778	-94.598889	74.32
55	K14KE-D	LIC	LD	14	1.5	44.106944	-94.595833	74.42
56	K21DG-D	LIC	LD	21	2.0	44.106944	-94.595833	74.42
57	K26CS-D	LIC	LD	26	2.0	44.106944	-94.595833	74.42
58	K26CS-D	CP	LD	26	1.7	44.106944	-94.595833	74.42
59	K28OH-D	LIC	LD	28	0.5	44.106944	-94.595833	74.42
60	K30FN-D	LIC	LD	30	12.0	44.106944	-94.595833	74.42
61	K30FN-D	CP	LD	30	2.0	44.106944	-94.595833	74.42
62	K34JX-D	LIC	LD	34	2.0	44.106944	-94.595833	74.42
63	K41IZ-D	LIC	LD	41	2.0	44.106944	-94.595833	74.42
64	K45MN-D	CP	LD	45	1.0	43.658556	-94.176750	83.49
65	K43JE-D	CP	LD	25	7.5	44.051500	-94.299972	88.50
66	K43JE-D	LIC	LD	43	10.82	44.051500	-94.299972	88.50
67	KELO-TV	LIC	DT	11	30.0	43.518611	-96.535000	89.42
68	KSFY-TV	LIC	DT	13	22.7	43.518611	-96.535000	89.42
69	KABY-LD	LIC	LD	20	13.2	43.518611	-96.535000	89.42
70	KDLT-TV	CP	DT	21	589.0	43.505000	-96.556389	91.16
71	KDLT-TV	CP	DT	21	257.0	43.505000	-96.556389	91.16
72	KDLT-TV	CP	DT	21	257.0	43.505000	-96.556389	91.16
73	KDLT-TV	LIC	DT	47	1000.0	43.505000	-96.556389	91.16

ID	Call Sign	Status	Service[2]	Channel	Transmit ERP[3] (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
74	KTTW	LIC	DT	7	7.5	43.505278	-96.572222	92.44
75	KWSD	LIC	DT	36	36.9	43.505278	-96.572222	92.44
76	KWSD	APP	DT	36	1000.0	43.505278	-96.572222	92.44
77	K43MH-D	CP	LD	34	5.0	44.484167	-95.491111	95.48
78	K43MH-D	CP	LD	34	5.0	44.484167	-95.491111	95.48
79	K43MH-D	LIC	LD	43	5.5	44.484167	-95.491111	95.48
80	KCSD-TV	LIC	DT	24	80.9	43.574417	-96.655583	99.31
81	K22KD-D	CP	LD	22	3.0	43.553889	-96.685000	101.60
82	K56GF	CP	LD	23	15.0	43.553889	-96.685000	101.60
83	K56GF	LIC	TX	56	10.1	43.553889	-96.685000	101.60
84	KTIN	LIC	DT	25	600.0	42.817417	-94.411639	102.23
85	K14KD-D	LIC	LD	14	3.0	43.585833	-93.929722	103.18
86	K40JS-D	LIC	LD	16	3.0	43.585833	-93.929722	103.18
87	K47MI-D	LIC	LD	17	3.0	43.585833	-93.929722	103.18
88	K49JG-D	LIC	LD	19	3.0	43.585833	-93.929722	103.18
89	K21KF-D	LIC	LD	21	3.0	43.585833	-93.929722	103.18
90	K27FI-D	LIC	LD	27	3.0	43.585833	-93.929722	103.18
91	K29IF-D	LIC	LD	29	3.1	43.585833	-93.929722	103.18
92	K31EF-D	LIC	LD	31	3.0	43.585833	-93.929722	103.18
93	K51KB-D	LIC	LD	34	3.0	43.585833	-93.929722	103.18
94	K35IU-D	LIC	LD	35	3.0	43.585833	-93.929722	103.18
95	K40JS-D	LIC	LD	40	3.0	43.585833	-93.929722	103.18
96	K47MI-D	LIC	LD	47	3.0	43.585833	-93.929722	103.18
97	K49JG-D	LIC	LD	49	3.0	43.585833	-93.929722	103.18
98	K51KB-D	LIC	LD	51	3.0	43.585833	-93.929722	103.18
99	K04RR-D	CP	LD	4	3.0	43.538083	-96.714306	103.93
100	K06QJ-D	CP	LD	6	3.0	43.538083	-96.714306	103.93
101	KCPO-LP	LIC	TX	26	7.57	43.526750	-96.738167	105.85
102	KAUN-LP	CP	TX	25	0.88	43.535556	-96.743056	106.25
103	KCWS-LP	CP	TX	27	0.68	43.535556	-96.743056	106.25
104	KAUN-LP	LIC	TX	42	0.88	43.535528	-96.743083	106.26
105	KCWS-LP	LIC	TX	44	0.68	43.535528	-96.743083	106.26
106	K39CH-D	LIC	LD	15	0.37	44.549694	-94.966944	104.66
107	K46FY-D	LIC	LD	16	0.5	44.549694	-94.966944	104.66
108	K22KU-D	LIC	LD	22	0.39	44.549694	-94.966944	104.66
109	K25II-D	LIC	LD	25	0.387	44.549694	-94.966944	104.66
110	K28LL-D	LIC	LD	28	0.382	44.549694	-94.966944	104.66
111	K48GQ-D	LIC	LD	29	0.5	44.549694	-94.966944	104.66
112	K33LB-D	LIC	LD	33	0.375	44.549694	-94.966944	104.66
113	K50KF-D	LIC	LD	35	0.5	44.549694	-94.966944	104.66
114	K39CH-D	LIC	LD	39	0.369	44.549694	-94.966944	104.66
115	K46FY-D	LIC	LD	46	0.36	44.549694	-94.966944	104.66

ID	Call Sign	Status	Service[2]	Channel	Transmit ERP[3] (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
116	K48GQ-D	LIC	LD	48	0.357	44.549694	-94.966944	104.66
117	K50KF-D	LIC	LD	50	0.354	44.549694	-94.966944	104.66
118	NEW	APP	LD	35	15.0	43.376667	-96.805500	112.44
119	K26MG-D	CP	LD	26	1.0	43.652528	-93.742222	118.44
120	K28MU-D	CP	LD	28	1.0	43.652528	-93.742222	118.44
121	K50NB-D	CP	LD	50	1.0	43.652528	-93.742222	118.44
122	K18IW-D	LIC	LD	18	3.0	43.752278	-96.885389	120.27
123	K31KU-D	LIC	LD	31	3.0	43.752278	-96.885389	120.27
124	K32JG-D	LIC	LD	32	3.0	43.752278	-96.885389	120.27
125	K18IW-D	CP	LD	18	3.0	43.751389	-96.889444	120.57
126	K31KU-D	CP	LD	31	3.0	43.751389	-96.889444	120.57
127	K32JG-D	CP	LD	32	3.0	43.751389	-96.889444	120.57
128	KUSD-TV	LIC	DT	34	277.0	43.050278	-96.783889	121.37
129	NEW	APP	LD	35	10.0	43.050278	-96.783889	121.37
130	KTIV	LIC	DT	14	1000.0	42.586667	-96.221944	121.47
131	KPTH	LIC	DT	30	871.0	42.586667	-96.221944	121.47
132	KMEG	LIC	DT	32	1000.0	42.586667	-96.221944	121.47
133	KMEG	LIC	DT	39	1000.0	42.586667	-96.221944	121.47
134	KPTH	LIC	DT	49	1000.0	42.586667	-96.221944	121.47
135	K06QG-D	CP	LD	6	0.3	42.586667	-96.222222	121.49
136	KCAU-TV	LIC	DT	9	43.9	42.586389	-96.232500	121.96
137	K38NJ-D	CP	LD	38	2.0	43.077000	-96.804861	121.68
138	K21LK-D	CP	LD	21	2.0	43.949417	-96.909833	128.38
139	K30LV-D	CP	LD	30	2.0	43.949417	-96.909833	128.38
140	K33LR-D	CP	LD	33	2.0	43.949417	-96.909833	128.38
141	NEW	APP	LD	48	2.0	43.949417	-96.909833	128.38
142	K28NF-D	CP	LD	28	1.0	42.671667	-94.153333	128.46
143	KAJR-LD	CP	LD	36	15.0	42.671667	-94.153333	128.46
144	KEOF-LD	CP	LD	43	15.0	42.671667	-94.153333	128.46
145	KCYM-LD	CP	LD	45	15.0	42.671667	-94.153333	128.46
146	K47JE-D	CP	LD	15	1.0	44.759139	-94.873333	129.04
147	K18IR-D	LIC	LD	18	0.79	44.759139	-94.873333	129.04
148	K38LC-D	LIC	LD	21	0.79	44.759139	-94.873333	129.04
149	K49AJ-D	CP	LD	31	0.79	44.759139	-94.873333	129.04
150	K51AL-D	LIC	LD	34	0.79	44.759139	-94.873333	129.04
151	K38LC-D	LIC	LD	38	0.79	44.759139	-94.873333	129.04
152	K47JE-D	LIC	LD	47	0.62	44.759139	-94.873333	129.04
153	K49AJ-D	LIC	LD	49	0.79	44.759139	-94.873333	129.04
154	K51AL-D	LIC	LD	51	0.79	44.759139	-94.873333	129.04
155	K14OL-D	LIC	LD	14	1.8	44.804722	-95.580556	131.76
156	K16CP-D	LIC	LD	16	1.8	44.804722	-95.580556	131.76
157	K21LF-D	LIC	LD	19	1.8	44.804722	-95.580556	131.76

ID	Call Sign	Status	Service[2]	Channel	Transmit ERP[3] (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
158	K21LF-D	LIC	LD	21	1.8	44.804722	-95.580556	131.76
159	K22DO-D	LIC	LD	22	1.7	44.804722	-95.580556	131.76
160	K40MC-D	LIC	LD	26	1.8	44.804722	-95.580556	131.76
161	K29JW-D	LIC	LD	29	1.8	44.804722	-95.580556	131.76
162	K31PG-D	LIC	LD	31	1.8	44.804722	-95.580556	131.76
163	K45DJ-D	LIC	LD	33	1.8	44.804722	-95.580556	131.76
164	K35DK-D	LIC	LD	35	1.8	44.804722	-95.580556	131.76
165	K49LV-D	LIC	LD	36	1.8	44.804722	-95.580556	131.76
166	K31PG-D	LIC	LD	41	1.8	44.804722	-95.580556	131.76
167	K45DJ-D	LIC	LD	45	1.8	44.804722	-95.580556	131.76
168	KBWF-LD	CP MOD	LD	14	15.0	42.514722	-96.304444	131.85
169	KSIN-TV	LIC	DT	28	400.0	42.514722	-96.304444	131.85
170	K45LM-D	CP	LD	45	4.0	42.493417	-96.305778	133.91
171	KEJK-LD	CP	LD	16	8.0	42.484861	-96.305556	134.71
172	KEJK-LD	LIC	LD	16	6.0	42.484861	-96.305556	134.71
173	KSXC-LD	LIC	LD	26	15.0	42.484861	-96.305556	134.71
174	K33LS-D	CP	LD	33	1.0	42.782056	-96.767111	135.78
175	K44KV-D	CP	LD	44	1.0	42.782056	-96.767111	135.78
176	K50DG-D	LIC	LD	25	4.5	44.300833	-96.766667	136.69
177	K50DG-D	LIC	LD	50	4.5	44.300833	-96.766667	136.69
178	K22KJ-D	CP	LD	22	1.0	42.579694	-96.527917	136.96
179	KCAU-TV	LIC	LD	30	2.7	42.493861	-96.403083	138.27
180	K17NF-D	LIC	LD	17	7.014	44.339444	-96.768889	139.20
181	K17NF-D	CP	LD	17	4.27	44.339444	-96.768889	139.20
182	K17NF-D	LIC	TX	40	13.5	44.339444	-96.768889	139.20
183	K33NF-D	CP	LD	33	1.0	43.659861	-97.147444	139.63
184	K35LZ-D	CP	LD	35	1.0	43.659861	-97.147444	139.63
185	K38OZ-D	CP	LD	38	1.0	43.659861	-97.147444	139.63
186	KBWF-LD	LIC	LD	29	15.0	42.472500	-96.422500	141.13
187	KAAL	LIC	LD	33	8.3	43.105917	-93.585361	141.40
188	K30NI-D	CP	LD	30	1.0	43.690333	-93.417778	144.80
189	K32LB-D	CP	LD	32	1.0	43.690333	-93.417778	144.80
190	K44LT-D	CP	LD	44	1.0	43.690333	-93.417778	144.80
191	K40JT	LIC	TX	40	10.7	43.627778	-93.363889	148.87

Table 1: Off-Air TV Stations within 150 Kilometers of Project Area

3. Impact Assessment

Based on a contour analysis of the licensed stations within 150 kilometers of the Three Waters Wind Farm project, it was determined that eight of the full-power stations and fifteen of the low-power stations may have their reception disrupted in and around the project (see Table 2). The areas primarily affected would include TV service locations within 10 kilometers of the wind energy project with clear line-of-sight (LOS) to a proposed wind turbine but not to the respective station. After the wind turbines are installed, communities and homes in these locations may have degraded reception of these stations. This is due to multipath interference caused by signal scattering as TV signals are reflected by the rotating wind turbine blades and mast.

ID	Call Sign	Status	Service[4]	Channel	Transmit ERP[5] (kW)	Latitude (NAD 83)	Longitude (NAD 83)	Distance to Nearest Turbine (km)
5	K19HZ-D	LIC	LD	19	3.1	43.603333	-94.992778	17.36
7	K23FO-D	LIC	LD	23	3.1	43.603333	-94.992778	17.36
11	K30KQ-D	LIC	LD	30	2.1	43.603333	-94.992778	17.36
14	K35IZ-D	LIC	LD	35	3.1	43.603333	-94.992778	17.36
15	K36IV-D	LIC	LD	36	1.5	43.603333	-94.992778	17.36
16	K17MY-D	LIC	LD	40	2.1	43.603333	-94.992778	17.36
17	K27NF-D	LIC	LD	41	3.1	43.603333	-94.992778	17.36
18	K28OI-D	LIC	LD	43	2.1	43.603333	-94.992778	17.36
19	K29LV-D	LIC	LD	45	3.1	43.603333	-94.992778	17.36
20	K31NT-D	LIC	LD	50	2.1	43.603333	-94.992778	17.36
21	K34NU-D	LIC	LD	51	3.1	43.603333	-94.992778	17.36
22	K26JI-D	LIC	LD	26	14.0	43.403333	-95.668611	22.87
24	K18MO-D	LIC	LD	22	1.8	43.617111	-95.689056	23.48
31	K18KG-D	LIC	LD	18	6.9	43.255556	-94.976667	35.33
33	KBVK-LP	LIC	LD	21	6.8	43.255556	-94.976667	35.33
34	KSMN	LIC	DT	15	200.0	43.897778	-95.947500	57.31
38	KEYC-TV	LIC	DT	12	52.7	43.936944	-94.410833	74.29
67	KELO-TV	LIC	DT	11	30.0	43.518611	-96.535000	89.42
68	KSFY-TV	LIC	DT	13	22.7	43.518611	-96.535000	89.42
73	KDLT-TV	LIC	DT	47	1000.0	43.505000	-96.556389	91.16
84	KTIN	LIC	DT	25	600.0	42.817417	-94.411639	102.23
133	KMEG	LIC	DT	39	1000.0	42.586667	-96.221944	121.47
136	KCAU-TV	LIC	DT	9	43.9	42.586389	-96.232500	121.96

Table 2: Licensed Off-Air TV Stations Subject to Degradation

[4] Definitions of service and status codes:
DT – Digital television broadcast station
LD – Low-power digital television broadcast station
LIC – Licensed and operational station

[5] ERP = Transmit Effective Radiated Power

4. Recommendations

While TV signals are reflected by wind turbines, which can cause multipath interference to the TV receiver, modern digital TV receivers have undergone significant improvements to mitigate the effects of signal scattering. When used in combination with a directional antenna, it becomes even less likely that signal scattering from wind farms will cause interference to digital TV reception.

Nevertheless, signal scattering could still impact certain areas currently served by the TV station mentioned above, especially those that would have line-of-sight to at least one wind turbine but not to the station antenna. In the unlikely event that interference is observed in any of the TV service areas, it is recommended that a high-gain directional antenna be used, preferably outdoors, and oriented towards the signal origin in order to mitigate the interference.
Both cable service and direct broadcast satellite service will be unaffected by the presence of the wind turbine facility and may be offered to those residents who can show that their off-air TV reception has been disrupted by the presence of the wind turbines after they are installed.

5. Contact

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Wind Power GeoPlanner™

Microwave Study

Three Waters Wind Farm

Prepared on Behalf of
Three Waters Wind
Farm, LLC

April 22, 2019

COMSEARCH
A CommScope Company

Table of Contents

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: Three Waters Wind Farm

County: Jackson

State: Minnesota

Number of Turbines: 98

Blade Diameter: 127 meters

Hub Height: 89 or114 meters

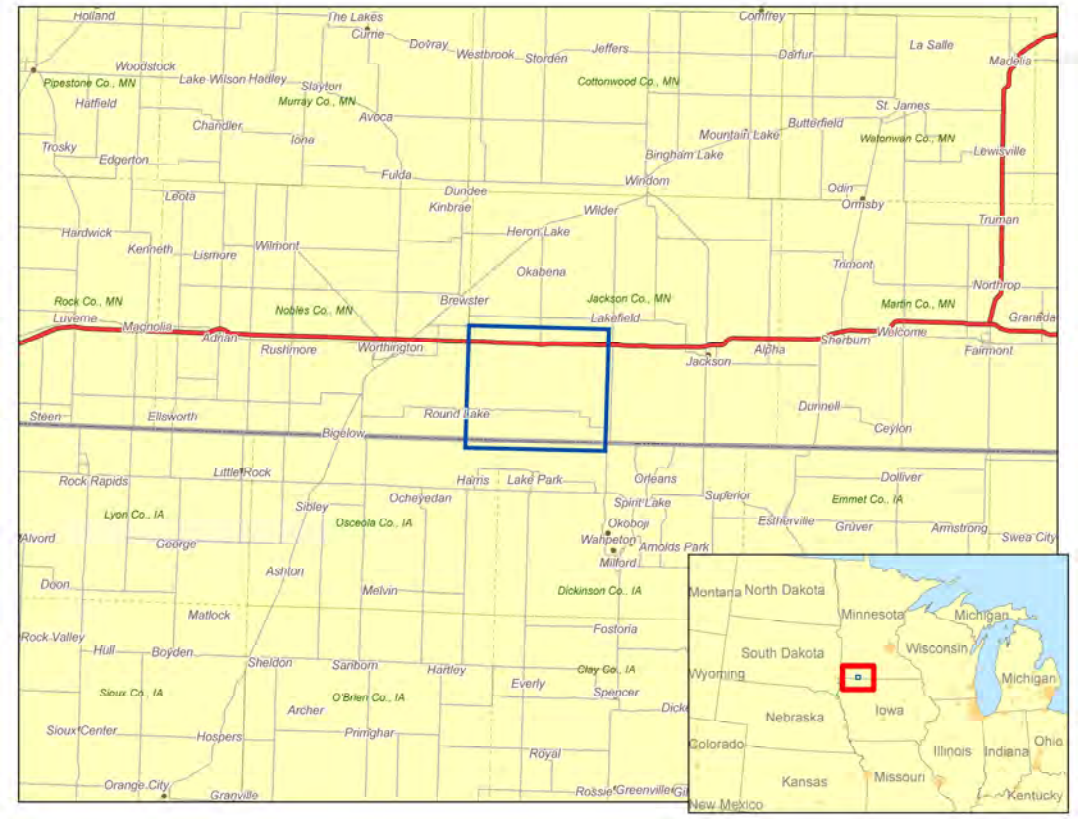


Figure 1: Area of Interest

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.

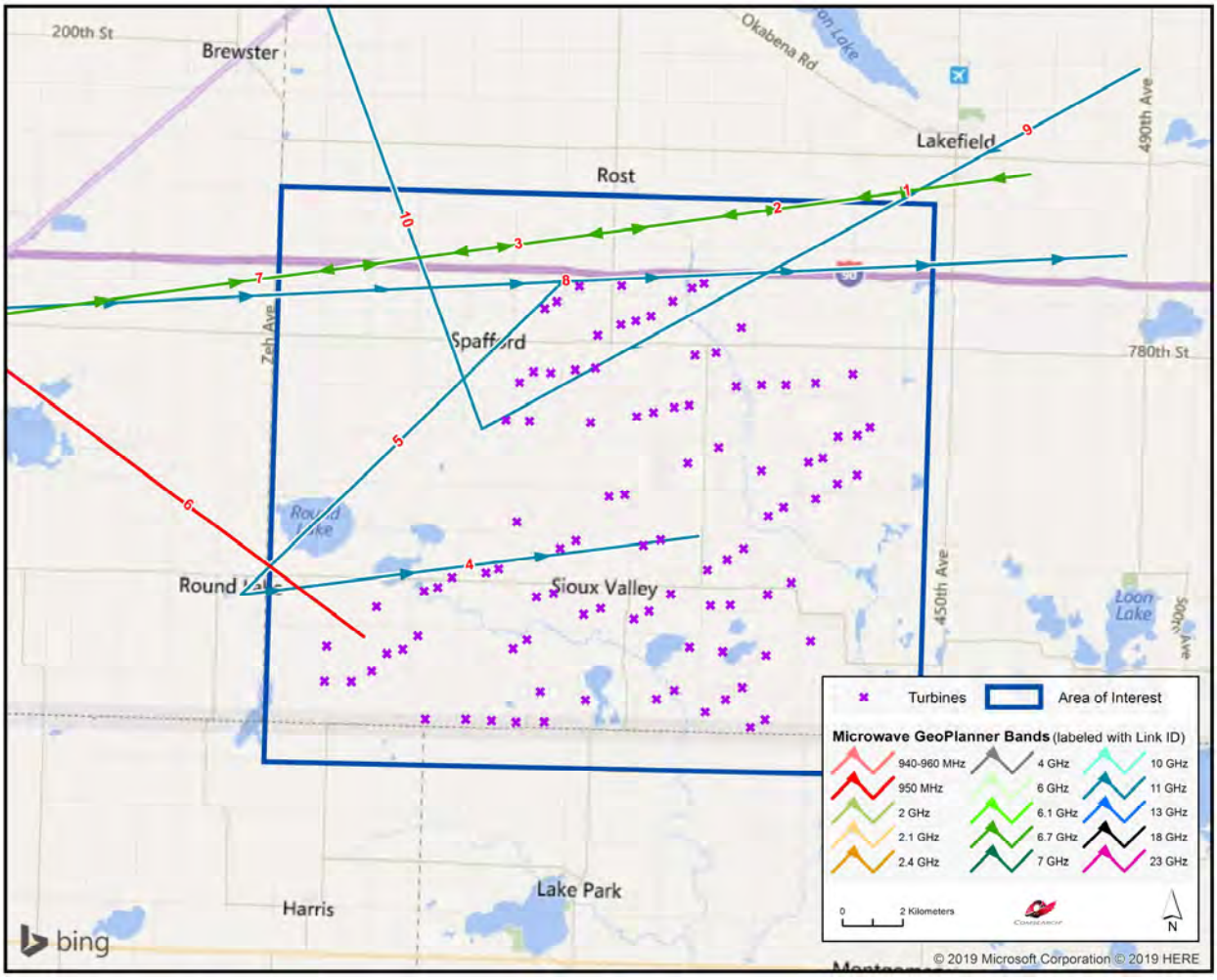


Figure 2: Microwave Paths that Intersect the Area of Interest

[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	Proposed	LAKEFIEL	RUSHMORE	Lower 6 GHz	45.84	Casbah, LLC
2	Proposed	LAKEFIEL	RUSHMORE	11 GHz	45.84	Casbah, LLC
3	Proposed	LAKEFIEL	RUSHMORE	Upper 6 GHz	45.84	Casbah, LLC
4	Applied	ROUNDLAK	HINTZELE	11 GHz	15.36	Back 40 Wireless
5	Applied	ROUNDLAK	POSTGRAI	11 GHz	15.17	Back 40 Wireless
6	Licensed	WMV551	RXONLY	950 MHz	18.24	Absolute Communications Ii, L.L.C.
7	Licensed	WNTP301	WNTP302	Upper 6 GHz	45.84	Interstate Power and Light Company
8	Licensed	WQWL669	WRCL401	11 GHz	39.47	Sprint Spectrum L.P.
9	Licensed	WQXN880	WQYI832	11 GHz	24.96	Minnesota Valley TV Improvement
10	Licensed	WQYI832	WQYI828	11 GHz	15.71	Minnesota Valley TV Improvement

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

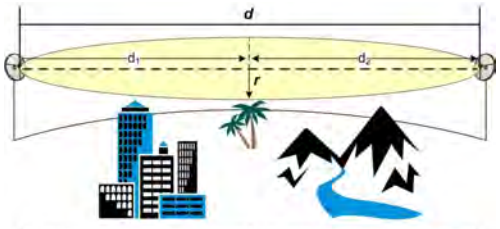
(See enclosed mw_geopl.xlsx for more information and GP_dict_matrix_description.xls for detailed field descriptions)

Verification of Coordinate Accuracy

It is possible that as-built coordinates may differ from those on the FCC license. For this project, all ten 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. Some 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

[3] See enclosed mw_geopl.shp (adjusted locations based on aerial photography/basis for report images and results) and mw_geopl_fcc.shp (locations solely based on FCC licensed information) for details.

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. Likewise, Comsearch recommends that an area directly in front of each microwave antenna should be avoided. This corresponds to the Consultation Zone which measures 1 kilometer along the main beam of the antenna and 24 ft (7.3 meters) wide. A depiction of the Fresnel Zones and Consultation Zones for each microwave path listed can be found in Figure 3, and is also included in the enclosed shapefiles[4,5].

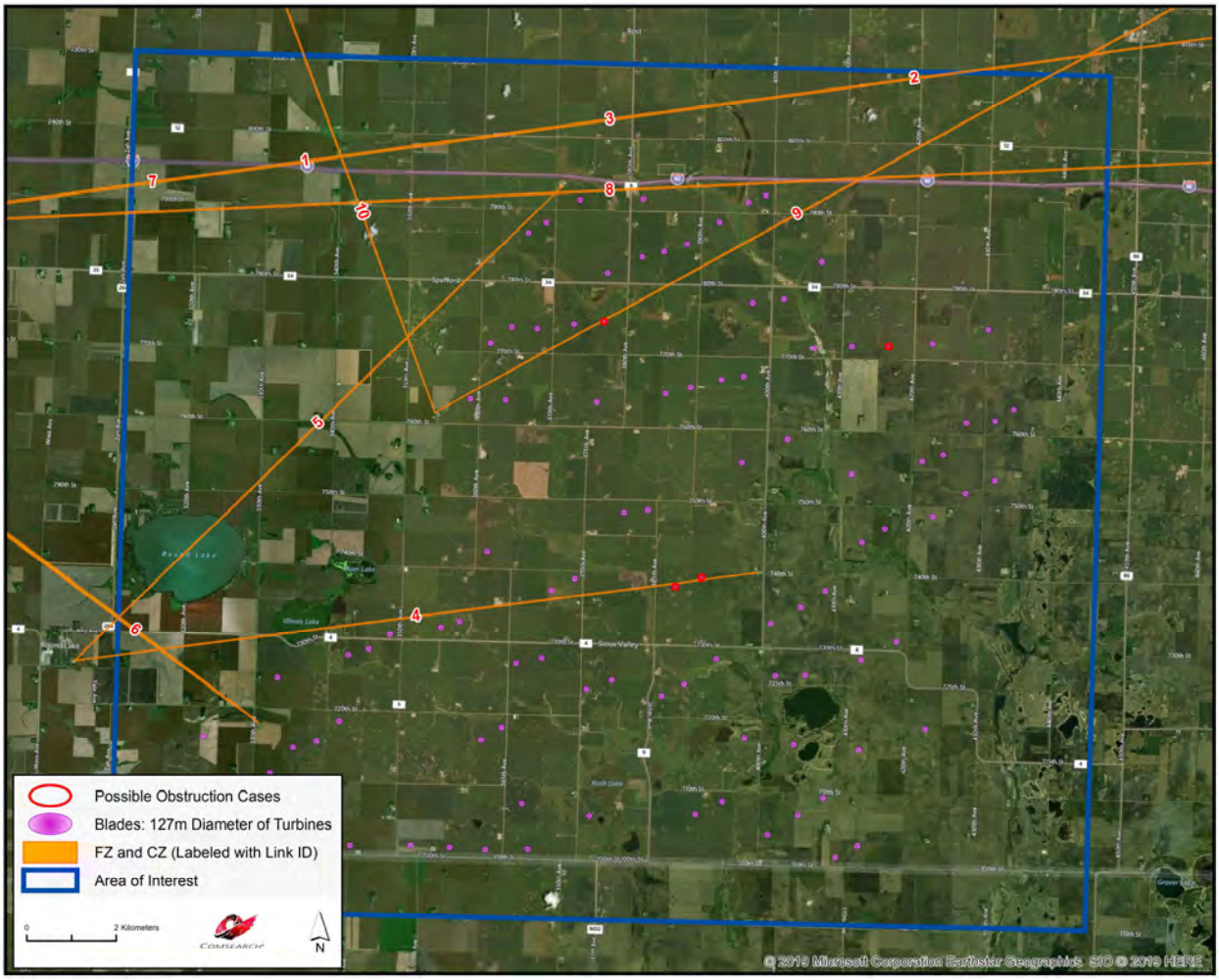


Figure 3: Fresnel Zones and Consultation Zones in the Area of Interest

[4] The ESRI® shapefiles enclosed are in NAD 83 UTM Zone 15 projected coordinate system.

[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.

Discussion of Potential Two Dimensional Obstructions

Total Microwave Paths	Paths with Affected Fresnel Zones	Total Turbines	Turbines intersecting the Fresnel Zones
10	2	98	3

Table 2: Fresnel Zone Analysis Result

For this project, 98 turbines were considered in the analysis, each with a blade diameter of 127 meters and turbine hub height of 89 or 114 meters. Of those turbines, three were found to intersect the Fresnel Zones of two microwave paths. Figure 4 and Figure 5 contain a detailed depiction of the potential obstruction scenarios 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 these cases.

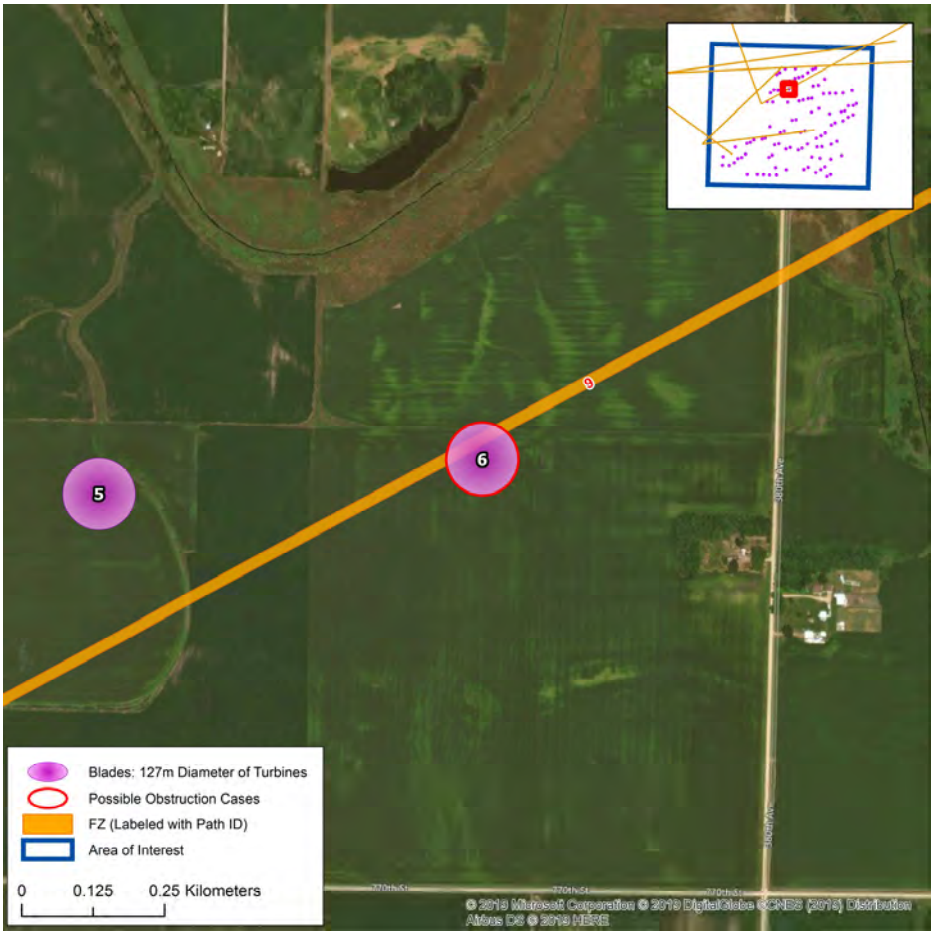


Figure 4: Potential Obstruction Cases (Turbine 6)

Figure 5: Potential Obstruction Cases
(Turbine 44 and Turbine 68)

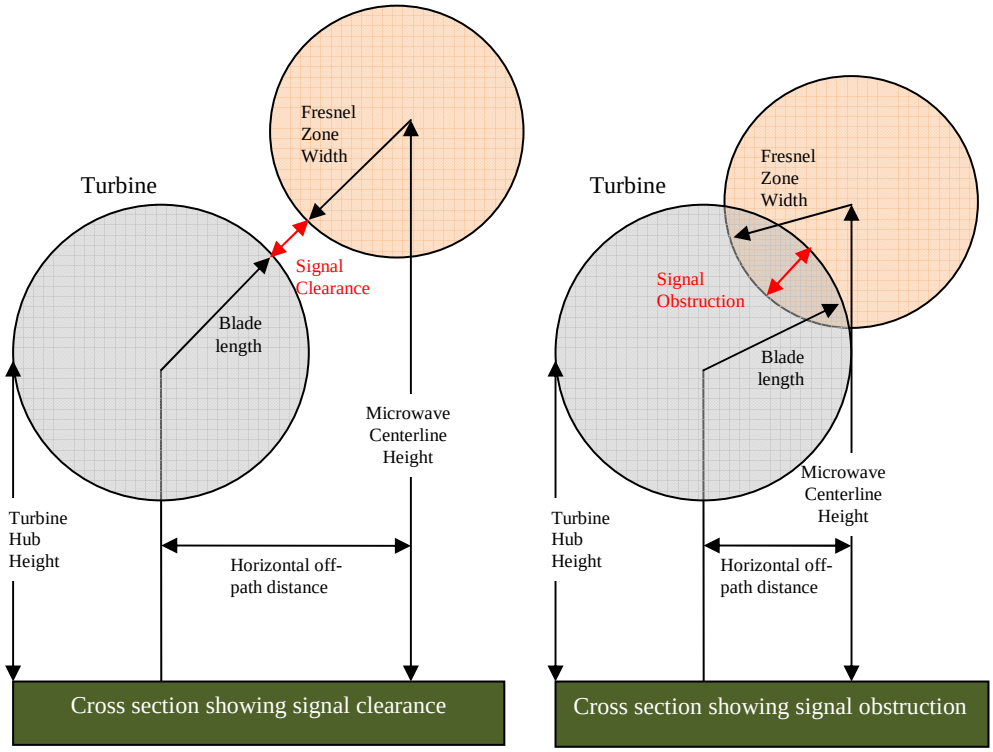
Turbine ID	Latitude (NAD83)	Longitude (NAD83)	Affected Microwave Path ID	Fresnel Zone Width at Turbine Location (m)	Horizontal off-path Distance (m)	Distance along the path from site 1 (km)	Horizontal Clearance (m)
6	43.60864320	-95.32116770	9	9.74	30.90	20.67	-42.34
44	43.55584250	-95.29946650	4	6.59	68.19	13.51	-1.90
68	43.55772360	-95.29233250	4	5.53	49.74	14.11	-19.28

Table 3: Turbines that Intersect Fresnel Zones

4. Cross Sectional Analysis

Our Fresnel Zone analysis in the previous section identified three potential obstruction cases that need to be further examined from a cross sectional perspective. The cases that will be analyzed in this section can be found in Table 3.

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 and Table 5 below. It shows negative clearance values indicating obstruction of the Fresnel zones and positive clearance values indicating clearance of the Fresnel zones.

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)
9	9.74	30.46	6	**89**	63.5	**-7.05**
4	6.59	31.96	44	**89**	63.5	**18.81**
4	5.53	36.23	68	**89**	63.5	**3.49**

Table 4: Cross Sectional Analysis Results
(If all Turbines have 89m Hub Height)

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)
9	9.74	30.46	6	**114**	63.5	**15.83**
4	6.59	31.96	44	**114**	63.5	**36.59**
4	5.53	36.23	68	**114**	63.5	**23.29**

Table 5: Cross Sectional Analysis Results
(If all Turbines have 114m Hub Height)

5. Conclusion

Our study identified eleven microwave paths intersecting the Three Waters Wind Farm project area. The Fresnel Zones for these microwave paths were calculated and mapped. Four turbines were found to intersect the two dimensional Fresnel Zones of four microwave paths. Based on the cross sectional analysis, it was determined that the blade of turbine ID 6 is only slightly higher than the beam path ID 9. If the turbine model with 89m hub height is chosen, it may obstruct the microwave path and potentially cause signal degradation. If the turbine model with 114m hub height is chosen, no turbines will cause obstruction to the microwave system in the area.

6. Contact

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Wind Power GeoPlanner™

Wireless Internet Services Report

Three Waters Wind Farm

Prepared on Behalf of
Three Waters Wind
Farm, LLC

May 20, 2019

COMSEARCH®
A CommScope Company

Table of Contents

1. Introduction

Wireless internet providers, often called WISPs (Wireless Internet Service Providers), deliver internet services via radio transmission to business and/or residential subscribers. They compete with wired internet service providers such as the local phone and cable companies. Wireless internet providers can use various frequency bands in both licensed and unlicensed spectrum. Many rural community WISPs operate in the unlicensed spectrum since there is a lower barrier to entry without the costs associated with acquiring licensed spectrum. The most common unlicensed bands for this purpose are the 900 MHz, 2.4 GHz, and 5.8 GHz bands. There is also some activity in the "lite-licensed" 3.65 GHz band.

This report attempts to identify wireless internet providers in proximity to the Three Waters Wind Farm LLC project and evaluates the potential impact of wind turbines on their operations in and around the project area.

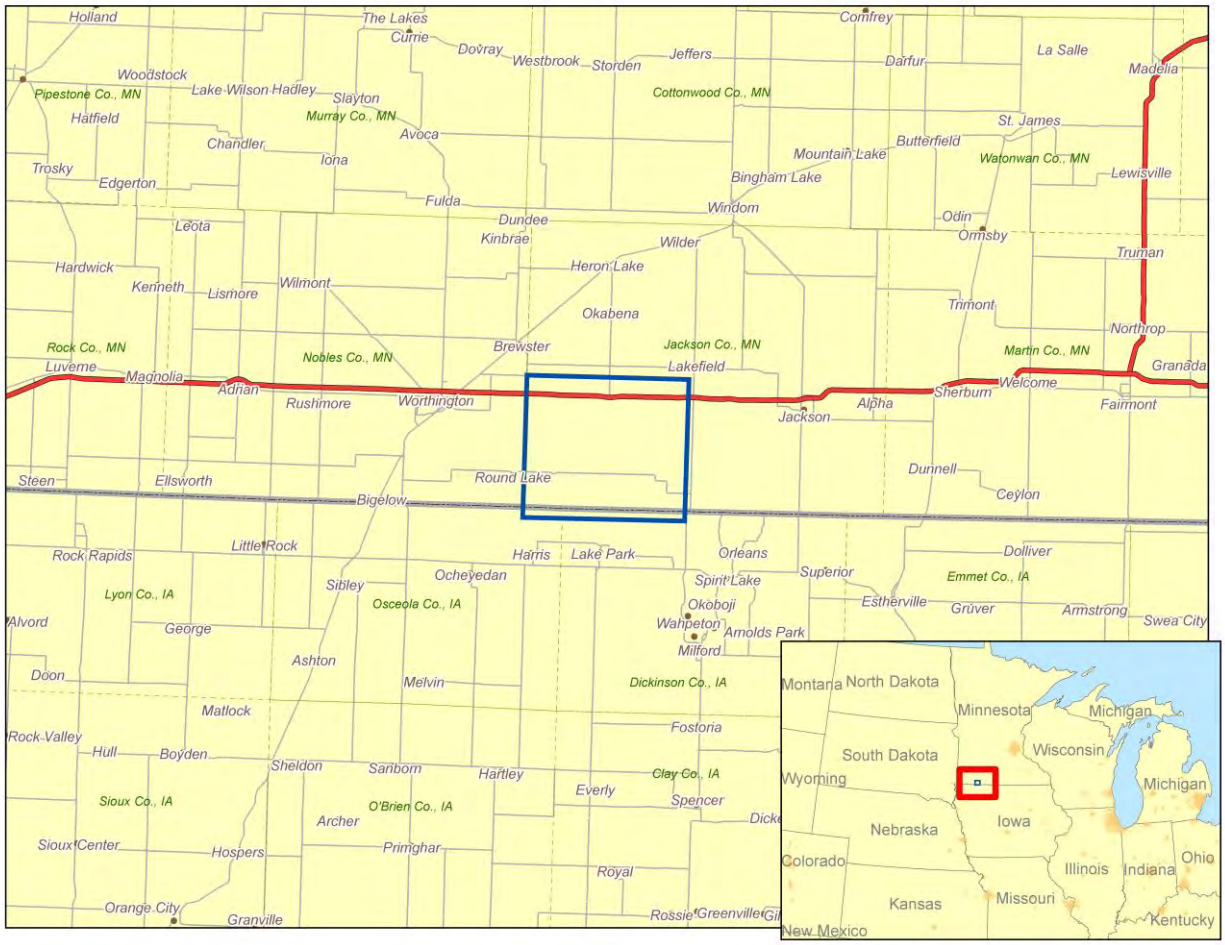

Figure 1: Three Waters Wind Farm Area

2. Summary of Results

Methodology

Most bands used for wireless internet services (primarily the unlicensed bands) have no reliable data source available since according to FCC rules, these systems are not required to license or register their transmitter locations. Therefore, the only band with a reliable data set to evaluate is the 3.65 GHz WBS (Wireless Broadband Systems) band, which by FCC rule requires registration of base and fixed transmitters. Our analysis will include any providers found in this band, but will not necessarily include providers with unlicensed systems. This is due to the lack of available data and the providers' lack of interference protection as a consequence of their unlicensed status.

Results

Our 3.65 GHz band search identified eight wireless internet systems within 50 km of the proposed turbines in the Three Waters Wind Project. Our search results are shown in Figures 2 and 3 and Table 1 below. The distances listed in Table 1 correspond to the shortest distance from a wireless transmitter and a proposed wind turbine.

Call Sign	Licensee	FRN	Number of Licensed Antennas	Distance to Nearest Turbine (km)
WQKH680	Minnesota Valley TV Improvement Corporation	0006118814	23	0.09
WQMY983	LocaLoop, Inc.	0020216909	37	0.37
WQPL282	Great Lakes Communication Corp	0013556972	33	0.57
WQTW870	FiberComm L.C.	0004338307	4	1.36
WQJX447	Evertek, Inc.	0011496445	4	2.66
WQPQ884	The Community Cable Television Agency of O' Brien County	0007069867	18	3.25
WQLW972	Northwest Communications, Inc	0003722410	3	3.47
WQVN642	Kappes, Thomas M	0024490484	4	5.67

Table 2: Summary of Licensed WISP Operators within 50 km of the Three Waters

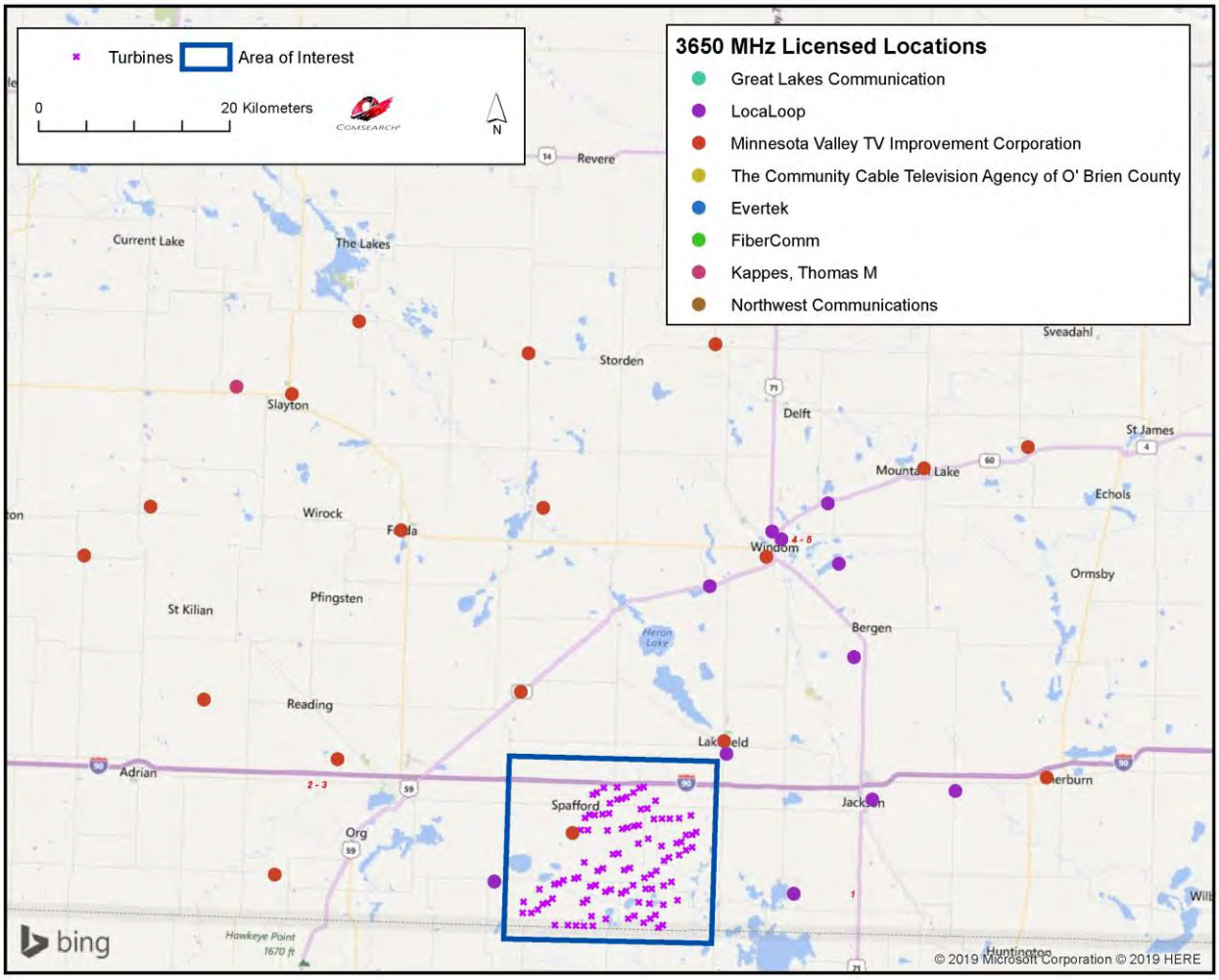

Figure 2: Licensed 3.65 GHz Transmitters within 50 km of the Proposed Turbines (North)

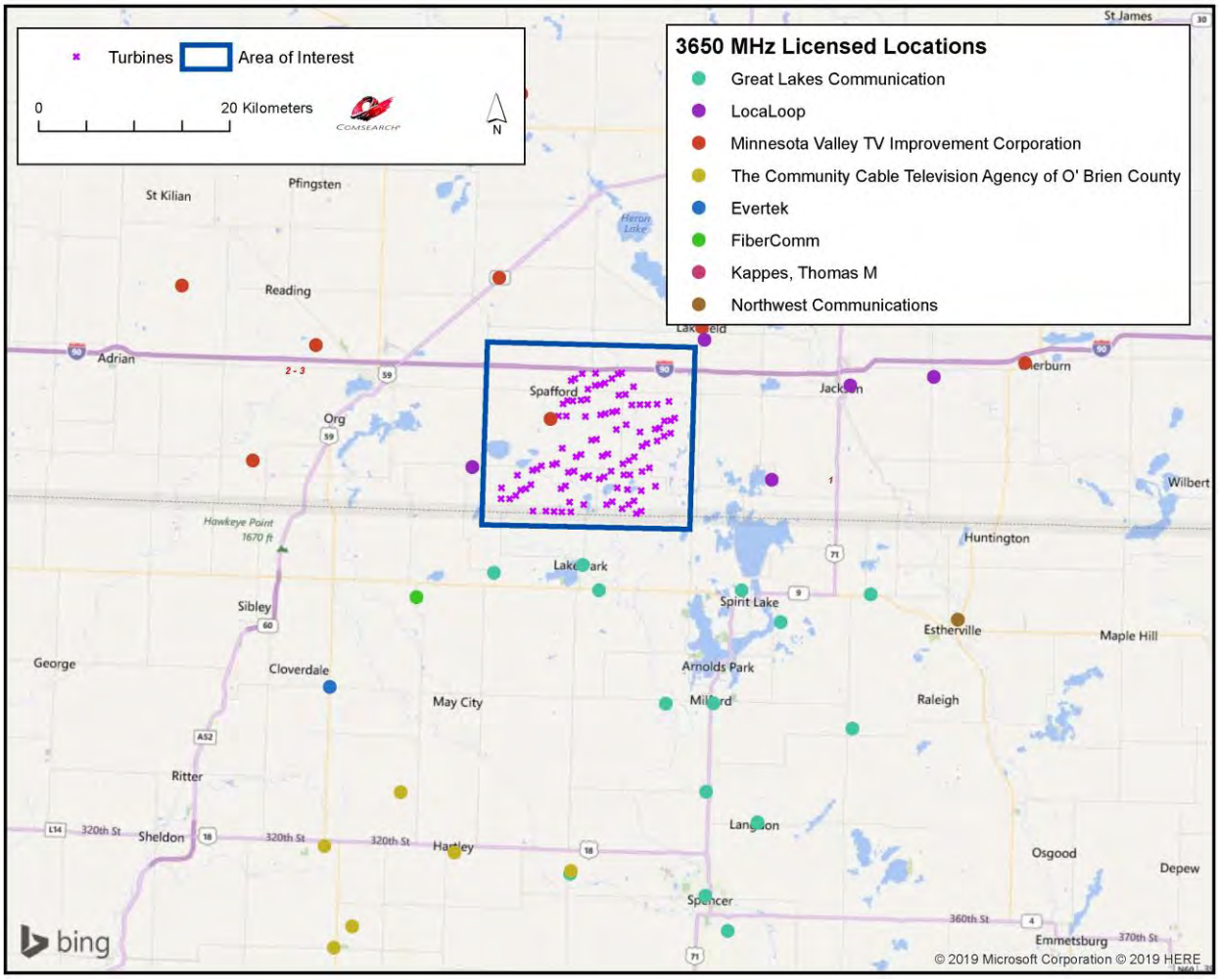

Figure 2: Licensed 3.65 GHz Transmitters within 50 km of the Proposed Turbines (South)

Unlicensed Bands

As mentioned previously, there are no reliable data sources for unlicensed wireless internet systems because they are not required to license or register their transmitter locations according to FCC rules.

Impact Assessment

The presence of wind turbines within a coverage area of a wireless Internet provider does not necessarily pose a problem for their provision of service. As shown in the maps, all of the providers identified in this report use multiple base transmitter sites in and around the project area. Therefore, some locations within their service area could receive coverage from more than one base transmitter in which case a WISP could simply assign a subscriber to the best-serving base transmitter (i.e., highest signal level). Hence, if a wind turbine obstructs the line-of-sight between a particular subscriber and a transmitter, the WISP could assign the affected subscriber to an alternate signal from a different transmitter location, thereby resulting in no disruption to service.

3. Conclusion

The presence of wind turbines within a coverage area of a wireless Internet provider does not necessarily pose a problem for their provision of service. In the event that a WISP carrier believes that their coverage has been compromised by the presence of the wind energy facility, they have many options to improve their signal coverage to the area. This includes the optimization of surrounding base stations or the addition of a new sector or cell site. Utility towers, other communications towers, or even a turbine tower within the wind project area can serve as the platform for a new base station, cell enhancer, or repeater.

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