Appendix D – Telecommunication Reports

Wind Power GeoPlanner™

Microwave Study

Freeborn

Prepared on Behalf of
Invenergy LLC

December 6, 2016

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: Freeborn

Counties: Freeborn (MN), Mower (MN), Worth (IA)

State: Minnesota and Iowa

Number of Turbines: TBD

Blade Diameter: 116 meters

Hub Height: TBD

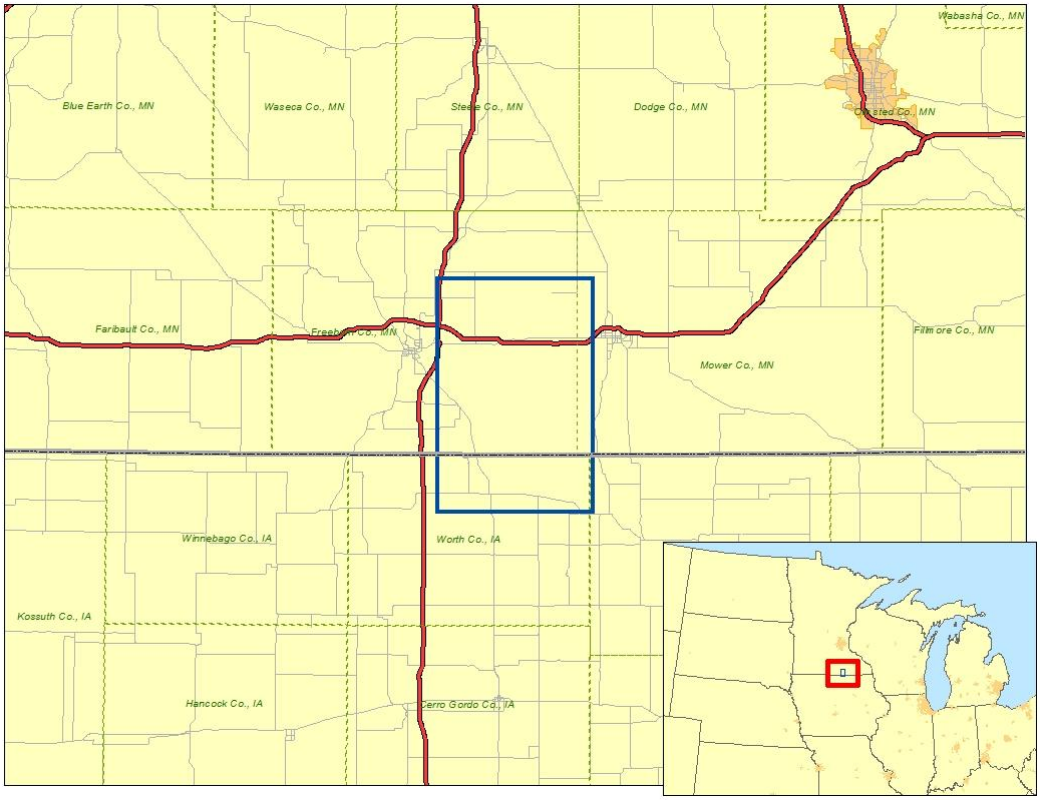


Figure 1: Area of Interest

3. 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.

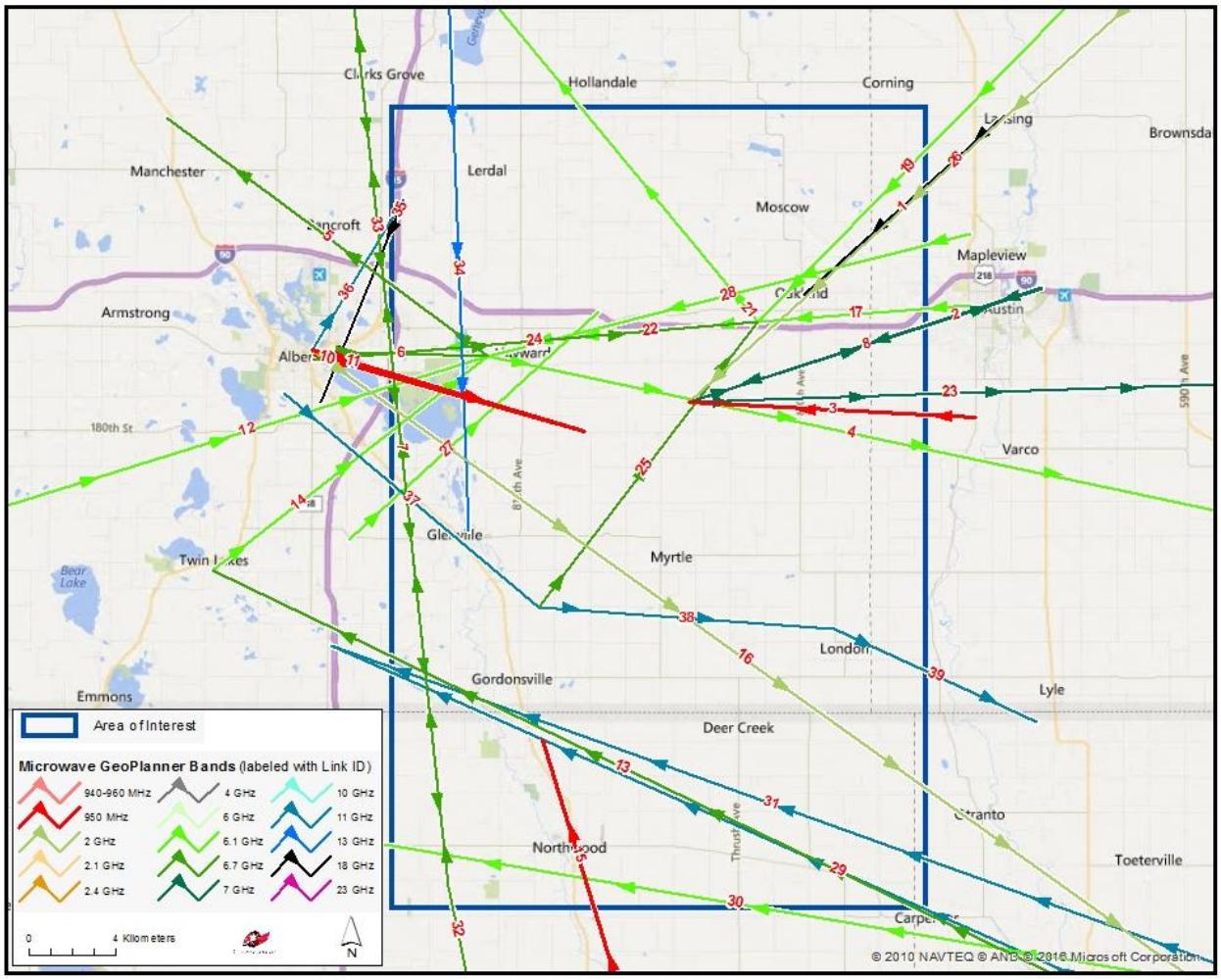


Figure 2: Microwave Paths that Intersect the Area of Interest

[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.

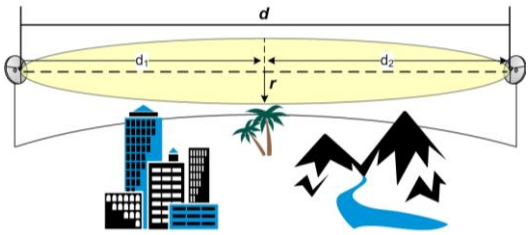
ID	Status	Callsign 1	Callsign 2	Band	Path Length (km)	Licensee
1	Licensed	KPH213	RXONLY	2 GHz	65.83	KAAL-TV LLC
2	Licensed	KYR76	RXONLY	7 GHz	17.10	KAAL-TV LLC
3	Licensed	WBB411	RXONLY	950 MHz	13.21	Alpha 3E Licensee, LLC
4	Licensed	WEG336	WEG335	Lower 6 GHz	48.42	Interstate Power and Light Company
5	Licensed	WEG336	WQME714	Upper 6 GHz	18.40	Interstate Power and Light Company
6	Licensed	WGY635	WEG336	Upper 6 GHz	8.05	Interstate Power and Light Company
7	Licensed	WHC791	WHI758	Upper 6 GHz	43.01	Union Pacific Railroad Company
8	Licensed	WHS206	RXONLY	7 GHz	17.11	KAAL-TV LLC
9	Licensed	WHZ972	GLENVILL	13 GHz	27.00	Midcontinent Communications
10	Licensed	WLI768	RXONLY	950 MHz	12.92	Hometown Broadcasting of Austin, Inc.
11	Licensed	WLP693	RXONLY	950 MHz	13.09	Hometown Broadcasting, Inc.
12	Licensed	WNTP305	WEG336	Lower 6 GHz	33.21	Interstate Power and Light Company
13	Licensed	WPRR530	WPRY355	Upper 6 GHz	45.97	Dairyland Power Cooperative
14	Licensed	WPRY355	WQRX920	Lower 6 GHz	16.02	Dairyland Power Cooperative
15	Licensed	WPSG783	RXONLY	950 MHz	37.28	Alpha 3E Licensee, LLC
16	Licensed	WPXU324	RXONLY	2 GHz	53.05	LIN License Company, LLC
17	Licensed	WQGV813	WQVE274	Lower 6 GHz	9.87	MOWER, COUNTY OF
19	Licensed	WQIK762	WQIK790	Lower 6 GHz	29.01	Minnesota, State of (DOT)
21	Licensed	WQIK790	WQIK783	Lower 6 GHz	22.42	Minnesota, State of (DOT)
22	Licensed	WQIK790	WQUM858	Lower 6 GHz	20.52	Minnesota, State of (DOT)
23	Licensed	WQKZ238	RXONLY	7 GHz	50.62	KAAL-TV LLC
24	Licensed	WQOD365	WQOD375	Upper 6 GHz	20.52	Freeborn, County of
25	Licensed	WQOD366	WQOD375	Upper 6 GHz	16.62	Freeborn, County of
26	Licensed	WQQD511	WQQD512	18 GHz	12.42	Radio Link Internet
27	Licensed	WQQP734	WQQP733	Lower 6 GHz	15.60	Verizon Wireless
28	Licensed	WQRX918	WQRX920	Lower 6 GHz	23.00	Dairyland Power Cooperative
29	Proposed	ANSGAR	FREEBORN	11 GHz	44.77	GW Networks
30	Proposed	AT417791	AT417480	Lower 6 GHz	44.08	Rimi Networks
31	Proposed	MITCHELL	FREEBORN	11 GHz	48.82	GW Networks
32	Licensed	WHC413	WHC791	Upper 6 GHz	31.17	Union Pacific Railroad Company
33	Proposed	WHI758	WHC791	Upper 6 GHz	42.98	Union Pacific Railroad Company
34	Licensed	WQQS485	WQQS487	18 GHz	10.11	Sprint Spectrum L.P.
35	Licensed	WQVM801	WQVM806	11 GHz	8.02	T-Mobile License LLC
36	Licensed	WQXI963	WQXI965	11 GHz	15.35	LTD Broadband LLC
37	Proposed	WQXI965	WQYG949	11 GHz	13.69	LTD Broadband LLC
38	Proposed	WQYG949	WQYG950	11 GHz	10.26	LTD Broadband LLC

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)

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

The calculated Fresnel Zone shows the narrow area of signal swath and is calculated for each microwave path in the project area. In general, this is the area where the planned wind turbines should be avoided, if possible. A depiction of the individual Fresnel Zones is shown in Figure 3, and is also included in the shapefiles[3,4].

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

[4] 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.

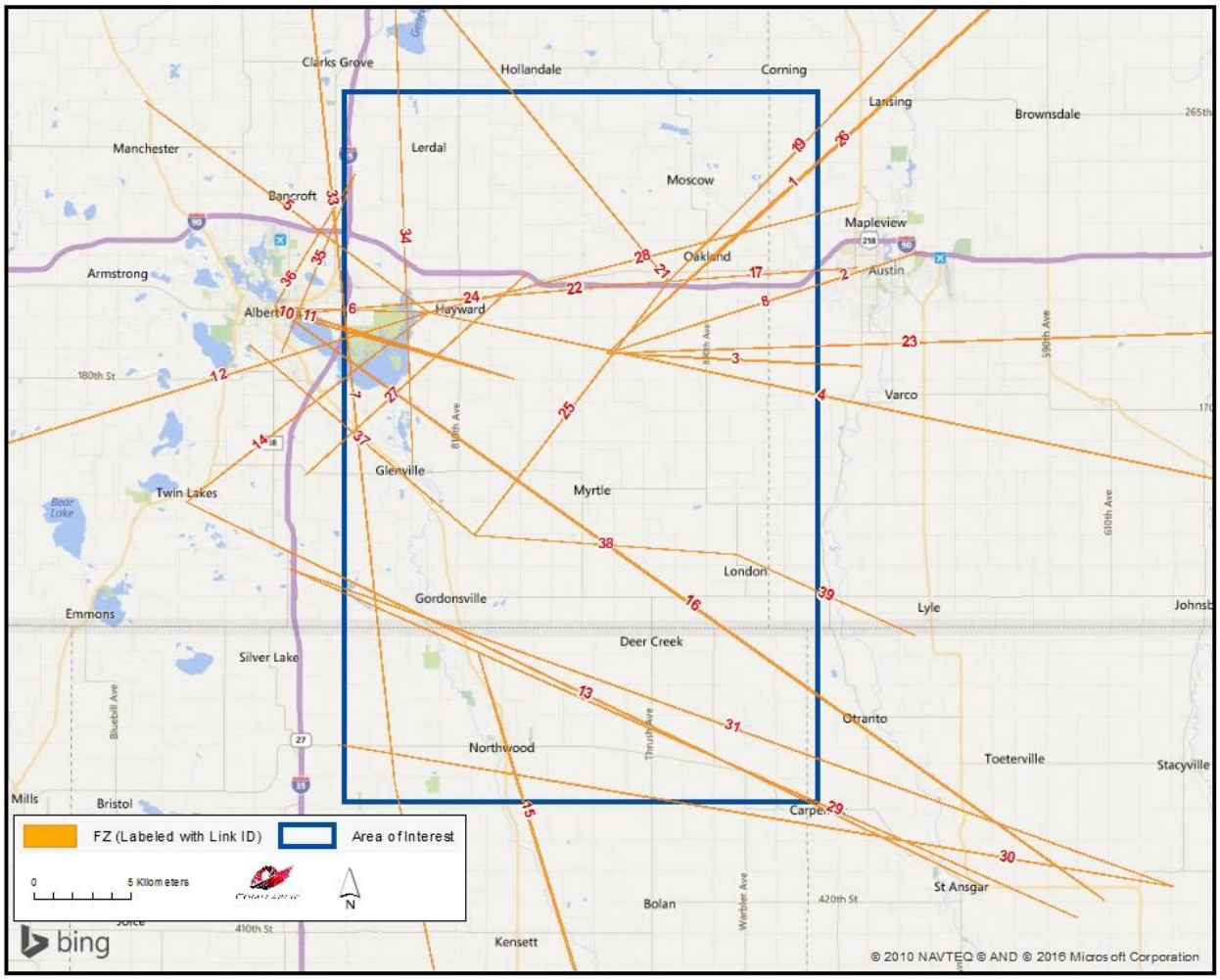


Figure 3: Fresnel Zones in the Area of Interest

Discussion of Potential Obstructions

Total Microwave Paths	Paths with Affected Fresnel Zones	Total Turbines	Turbines intersecting Fresnel Zones
36	N/A	N/A	N/A

For this project, turbine locations were not provided; thus we could not determine if any potential obstructions exist between the planned wind turbines and the incumbent microwave paths. If the latitude and longitude values for turbine locations are provided, Comsearch can identify where a potential conflict might exist.

4. Conclusion

This update study analyzed the microwave systems in a project area of interest slightly larger than that used for the Comsearch Geoplanner report completed in April 2015. Two paths (18 and 20) from the 2015 report were found to no longer be licensed and were not included in this study. Four additional licensed and six proposed paths were found and added to the study (29-38). In total, 36 paths were examined. The Fresnel Zones for these microwave paths were calculated and mapped. We recommend that all turbines be sited in locations that will not obstruct the Fresnel Zones.

5. Contact

For questions or information regarding the Microwave Study, please contact:

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Web site:	www.comsearch.com

Wind Power GeoPlanner™

AM and FM Radio Report

Freeborn

Prepared on Behalf of
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December 6, 2016

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1. Introduction

Comsearch analyzed AM and FM radio broadcast stations whose service could potentially be affected by the proposed Freeborn wind energy project in Freeborn and Mower Counties, Minnesota, and Worth County, Iowa.

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 KATE, which broadcasts out of Albert Lea, to the west of the project area of interest (AOI), and stations KAUS and KQAQ, broadcasting out of Austin, to the east. Stations KAUS and KQAQ are licensed separately for daytime and nighttime operations.

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 Project AOI (km)
1	KAUS	LIC	1480	1.0	Daytime	43.622222	-92.990556	2.03	2.19
2	KAUS	LIC	1480	1.0	Nighttime	43.622222	-92.990556	2.03	2.19
3	KATE	LIC	1450	1.0	Unlimited	43.633333	-93.370833	0.21	3.89
4	KQAQ	LIC	970	5.0	Daytime	43.707500	-92.945833	3.00	5.79
5	KQAQ	LIC	970	0.5	Nighttime	43.707500	-92.945833	3.00	5.79

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.

[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.

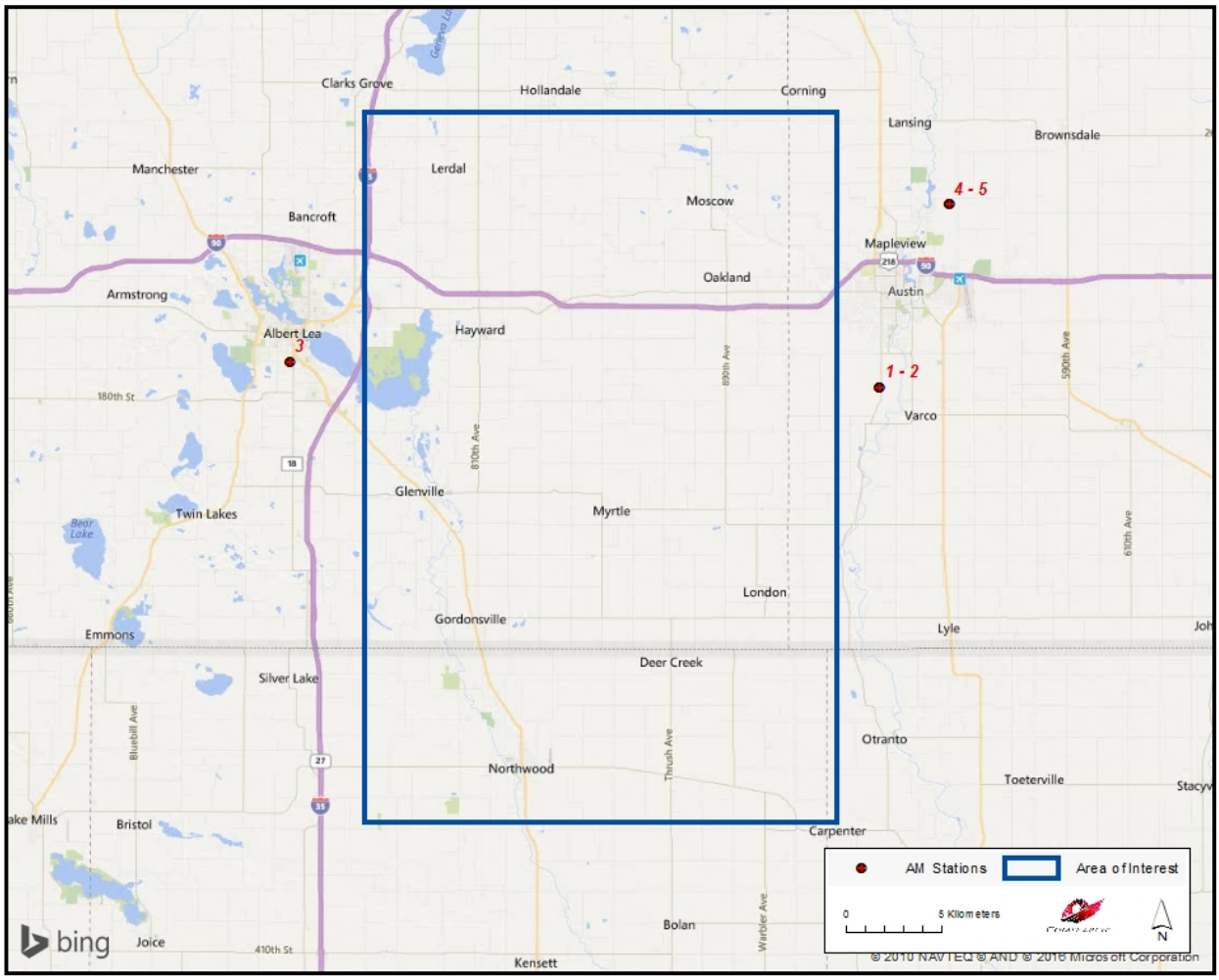

Figure 1: AM Radio Stations within 30 Kilometers of Project Area

FM Radio Analysis

Comsearch determined that there were twenty-five database records for FM stations within a 30-kilometer radius of the Freeborn wind energy project, as shown in Table 2 and Figure 2. Only twenty-three of these stations are currently licensed and operating, ten of which are low-power or translator stations that operate with limited range.

There are five licensed stations operating within the project area of interest: KAUS-FM, KQPR, KNSE, K270BQ, and KYTC. Translator station K270BQ has recently been granted a construction permit that will actually relocate the station outside the Freeborn project area of interest. However, for the time being, K270BQ continues to operate inside the project area at the coordinates identified on its licensed record.

The next closest FM station, KMSK, is located approximately 1.3 kilometers from the limits of the project area.

ID	Call Sign	Status[5]	Service[6]	Frequency (MHz)	Transmit ERP[7] (kW)	Latitude (NAD 27)	Longitude (NAD 27)	Distance to Project AOI (km)
1	KAUS-FM	LIC	FM	99.9	100.0	43.628333	-93.153333	0.00
2	KQPR	LIC	FM	96.1	25.0	43.616111	-93.213056	0.00
3	KNSE	LIC	FM	90.1	6.0	43.640833	-93.147500	0.00
4	K270BQ	LIC	FX	101.9	0.25	43.543111	-93.238972	0.00
5	KYTC	LIC	FM	102.7	25.0	43.488333	-93.236667	0.00
6	K270BQ	CP	FX	101.9	0.25	43.652889	-93.326528	0.30
7	KMSK	LIC	FM	91.3	0.135	43.677500	-93.001111	1.34
8	K224DM	LIC	FX	92.7	0.25	43.627778	-93.363611	3.31
9	K299AL	LIC	FX	107.7	0.25	43.627778	-93.363611	3.31
10	K277AD	LIC	FX	103.3	0.1	43.670278	-92.976944	3.29
11	K280EF	LIC	FX	103.9	0.009	43.670278	-92.976944	3.29
12	K280EB	LIC	FX	103.9	0.01	43.649167	-93.367500	3.61
13	KCPI	LIC	FM	94.9	5.0	43.633333	-93.370833	3.89
14	K220AR	LIC	FX	91.9	0.014	43.643611	-93.383889	4.94
15	KBDC	LIC	FM	88.5	68.0	43.370000	-93.274167	5.37
16	KSMA-FM	LIC	FM	98.7	25.0	43.364722	-93.048056	5.99
17	KUEL-LP	LIC	FL	97.1	0.028	43.360000	-93.323889	6.47
18	K252DM	LIC	FX	98.3	0.25	43.858500	-93.048944	11.98
19	KJCY	LIC	FM	95.5	6.0	43.364444	-92.851111	14.77

[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.

ID	Call Sign	Status[5]	Service[6]	Frequency (MHz)	Transmit ERP[7] (kW)	Latitude (NAD 27)	Longitude (NAD 27)	Distance to Project AOI (km)
20	K252DM	CP	FX	98.5	0.25	43.887083	-92.848944	20.35
21	KYBA	LIC	FM	105.3	50.0	43.673056	-92.698333	25.75
22	KIAI	LIC	FM	93.9	100.0	43.168250	-93.100889	27.80
23	KNSM	LIC	FM	91.5	8.0	43.157500	-93.136389	28.99
24	KIOW	LIC	FM	107.3	25.0	43.283889	-93.630556	29.15
25	KCJL-LP	LIC	FL	95.1	0.1	43.992500	-92.860000	29.70

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

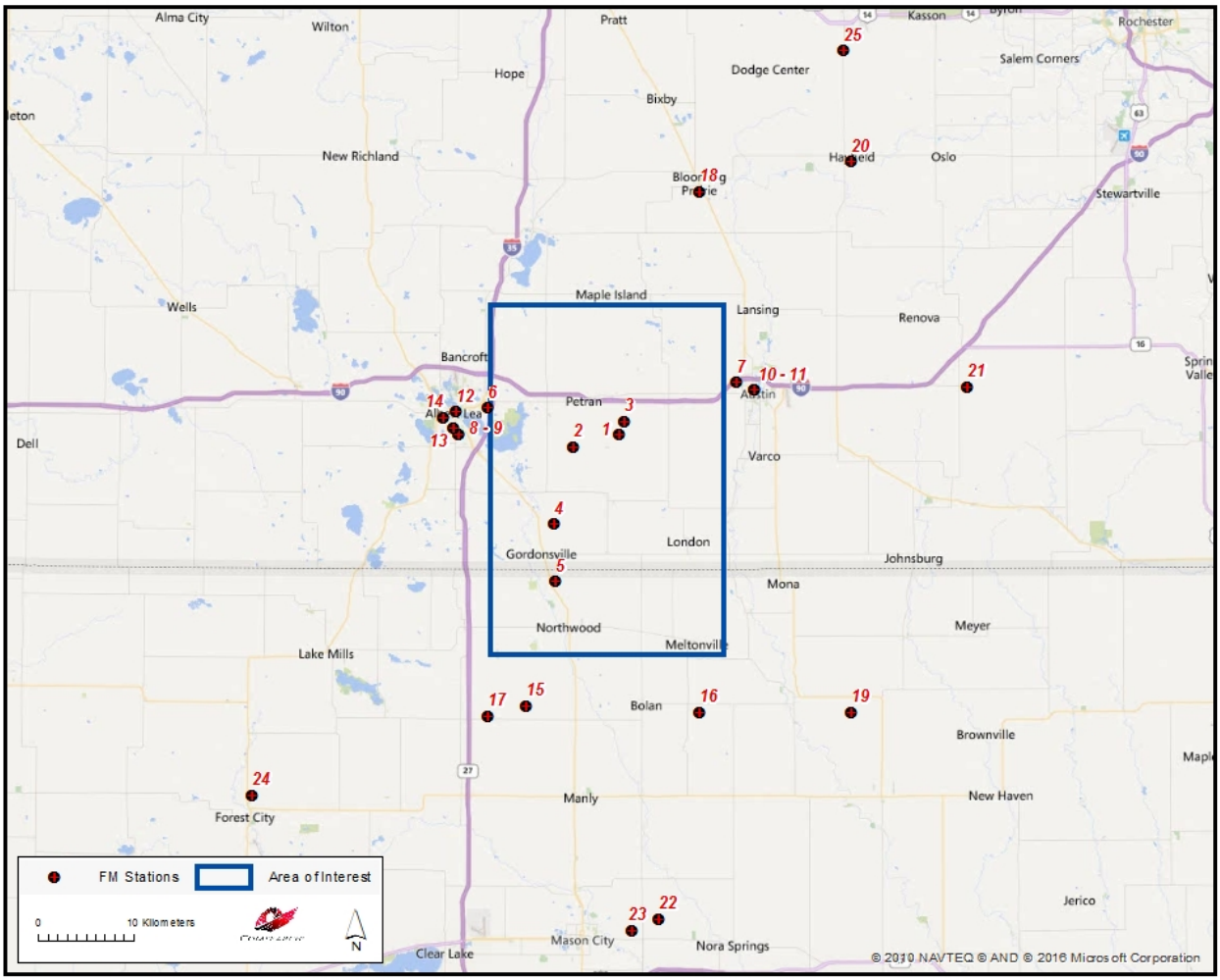

Figure 2: FM Radio Stations within 30 Kilometers of Project Area

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 AM station to the Freeborn wind energy project, KAUS, is approximately 2.19 kilometers from the limits of the project area of interest. Based on its transmit frequency of 1480 KHz, station KAUS has a setback distance requirement of 2.03 kilometers. Even after accounting for the proposed turbine blade swath of 58 meters, any turbines located directly at the eastern edge of the project area of interest should meet this requirement. The next closest AM station, KATE, is located more than 3.8 kilometers from the limits of the project. As there were no other 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 effect of wind turbines on FM radio coverage and reception is expected to be minimal as long as the turbines are sited in the far-field region of the broadcast antennas and line-of-sight to the populations served by the FM stations is maintained. All of the wind turbines in the Freeborn project should be sited in the far-field region of an existing FM antenna in order to minimize the risk of distorting its radiation pattern. For FM frequencies, this translates to a minimum separation distance of 450 meters between the tip of the wind turbine blade and the FM antenna location.

4. Recommendations

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

With regard to the FM broadcast stations, the project wind turbines should be placed at lower ground elevations relative to the FM towers, such that the maximum height reached by the rotating blades remains below the height of the FM antennas. If this is not possible, Comsearch recommends that field strength measurements of the actual FM coverage be taken before and after the construction of the project. In the event that significant audio distortion is observed for a given station, one option is to raise that station's broadcast antenna on the same tower in order to clear the obstructing wind turbines, provided that the tower has sufficient height and space. The new antenna height would need to be above the maximum blade height of the surrounding wind turbines. As an alternative, an auxiliary broadcast antenna could be installed on a different tower in order to compensate for lost coverage.

Any relocation of a station's antenna or changes to its operation will require costs for hardware, space acquisition, administration, planning, lost operation time and coordination with the FCC.

Project personnel should contact the FM stations to discuss the potential impact of the wind turbines and the options for mitigation, if necessary.

5. Contact

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

Contact person:	Denise Finney
Title:	Account Manager
Company:	Comsearch
Address:	19700 Janelia Farm Blvd., Ashburn, VA 20147
Telephone:	703-726-5650 (office) / 703-726-5595 (fax)
Email:	dfinney@comsearch.com
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2	KAUS	LIC	1480	1.0	Nighttime	43.622222	-92.990556	2.03	10.25
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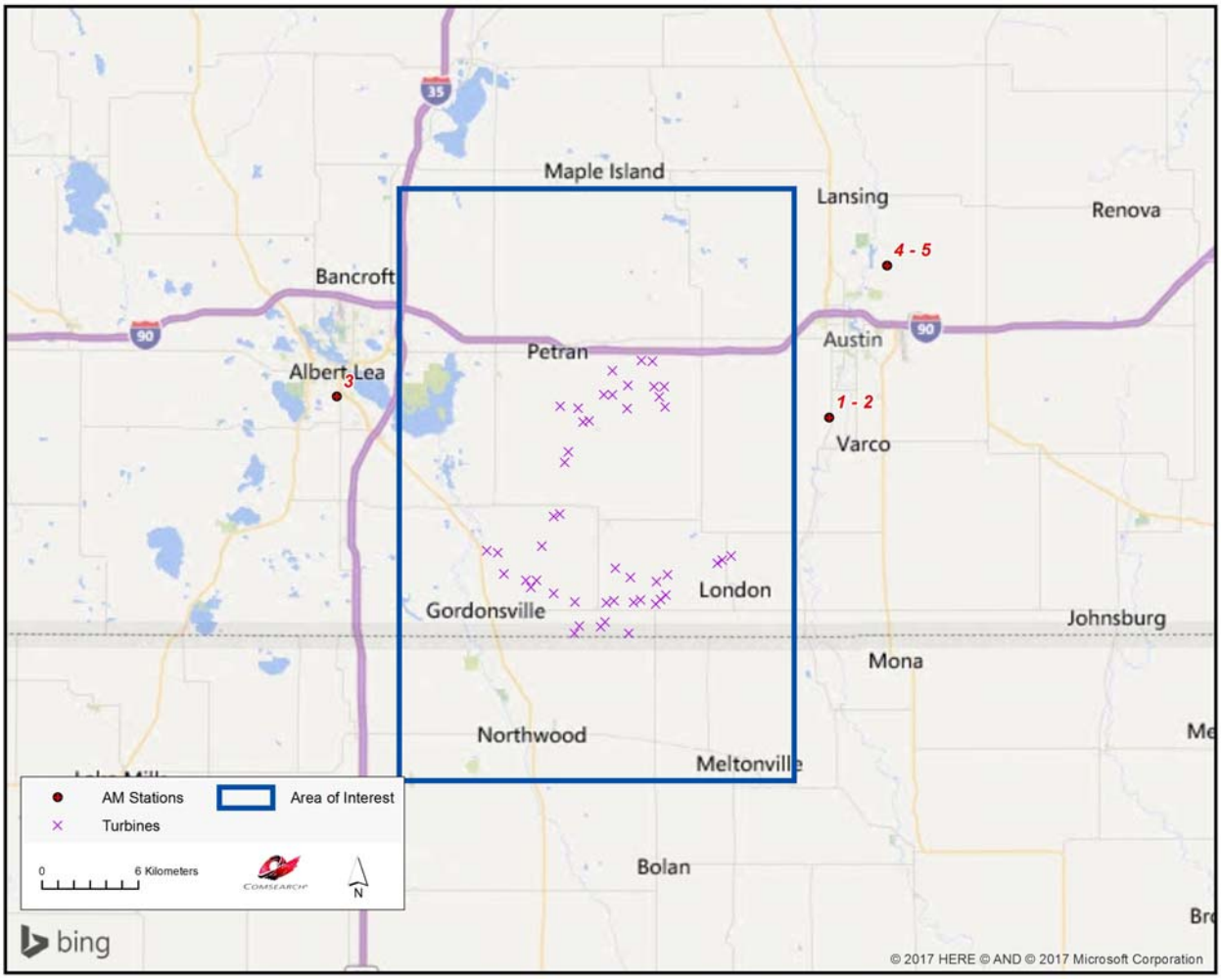

Figure 1: AM Radio Stations within 30 Kilometers of Project Area

FM Radio Analysis

Comsearch determined that there were nineteen database records for FM stations within a 30-kilometer radius of the Freeborn wind energy project, as shown in Table 2 and Figure 2. Only eighteen of these stations are currently licensed and operating, nine of which are low-power or translator stations that operate with limited range.

There are five licensed stations operating within the project area of interest: KNSE, KAUS-FM, K270BQ, KQPR, and KYTC. Translator station K270BQ has recently been granted a construction permit that will actually relocate the station outside the Freeborn project area of interest. However, for the time being, K270BQ continues to operate inside the project area at its present location.

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11	K299AL	LIC	FX	107.7	0.25	43.627778	-93.363611	12.55
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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.

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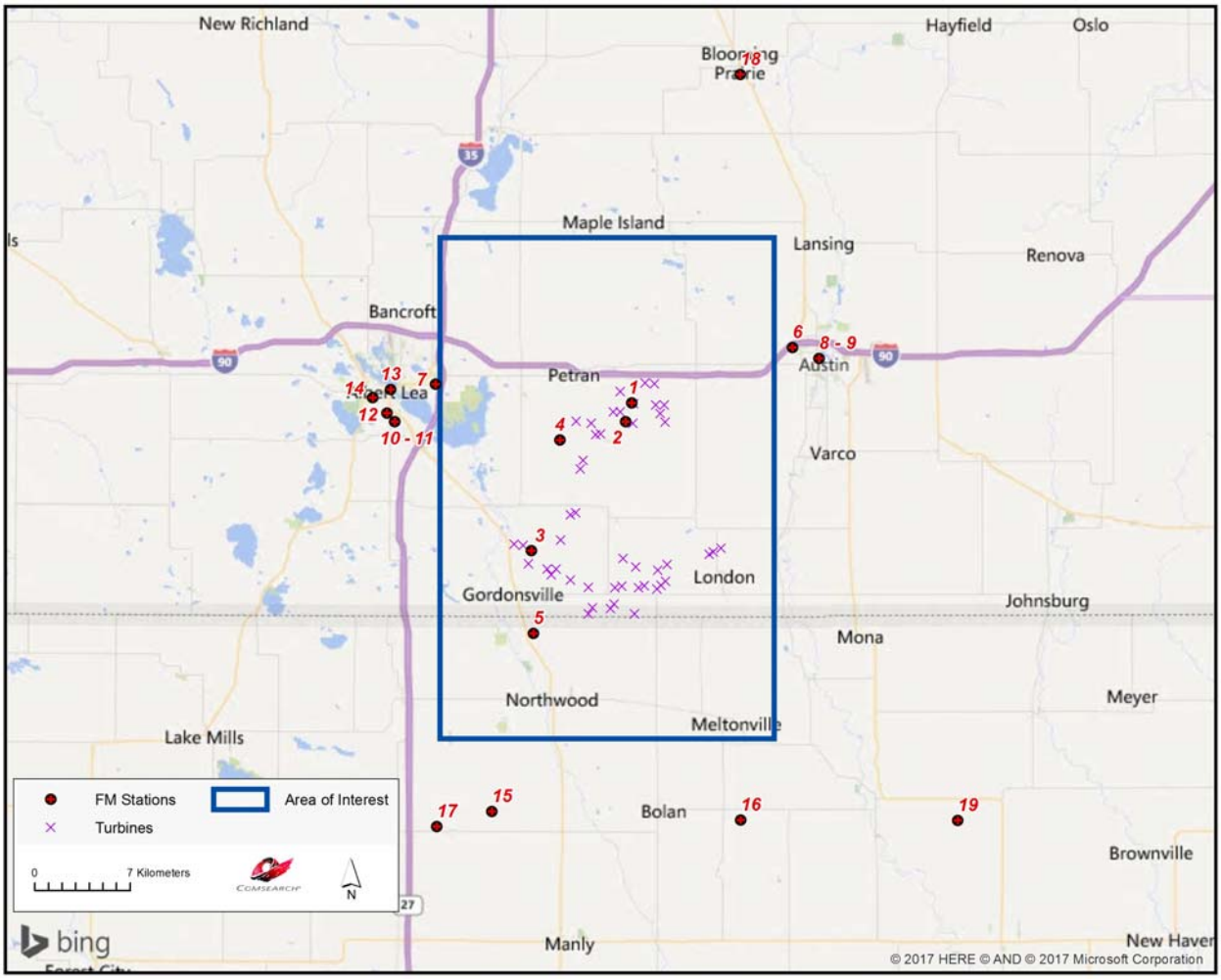

Figure 2: FM Radio Stations within 30 Kilometers of Project Area

Due to their close proximity to the proposed wind turbines, Comsearch used aerial imagery to verify the location of FM stations KNSE, KAUS-FM, and K270BQ[8]. The actual location of FM station KNSE was identified at 43.638187° N, 93.148376° W (NAD 83), approximately 295 meters southwest of the location defined by the coordinates listed on the station's FCC license (see Figure 3). This places KNSE within approximately 290 meters of the nearest turbine in the Freeborn wind energy project, #10. The tower location for FM station KAUS-FM was visually confirmed at 43.628315° N, 93.153234° W (NAD 83), just 22 meters east of the location defined by the station's licensed coordinates (see Figure 4), which places KAUS-FM within 530 meters of turbine #15. Finally, translator station K270BQ was identified at 43.543077° N, 93.239780° W (NAD 83), 50 meters west of its licensed location (see Figure 4) and approximately 642 meters from turbine #23.

[8] A small amount of variance between a station's actual geographic coordinates and those reported on the station's license is fairly typical. In the case of FM station KNSE, where the discrepancy was more significant, Comsearch contacted Minnesota Public Radio, the station owner, to independently confirm the station's location.

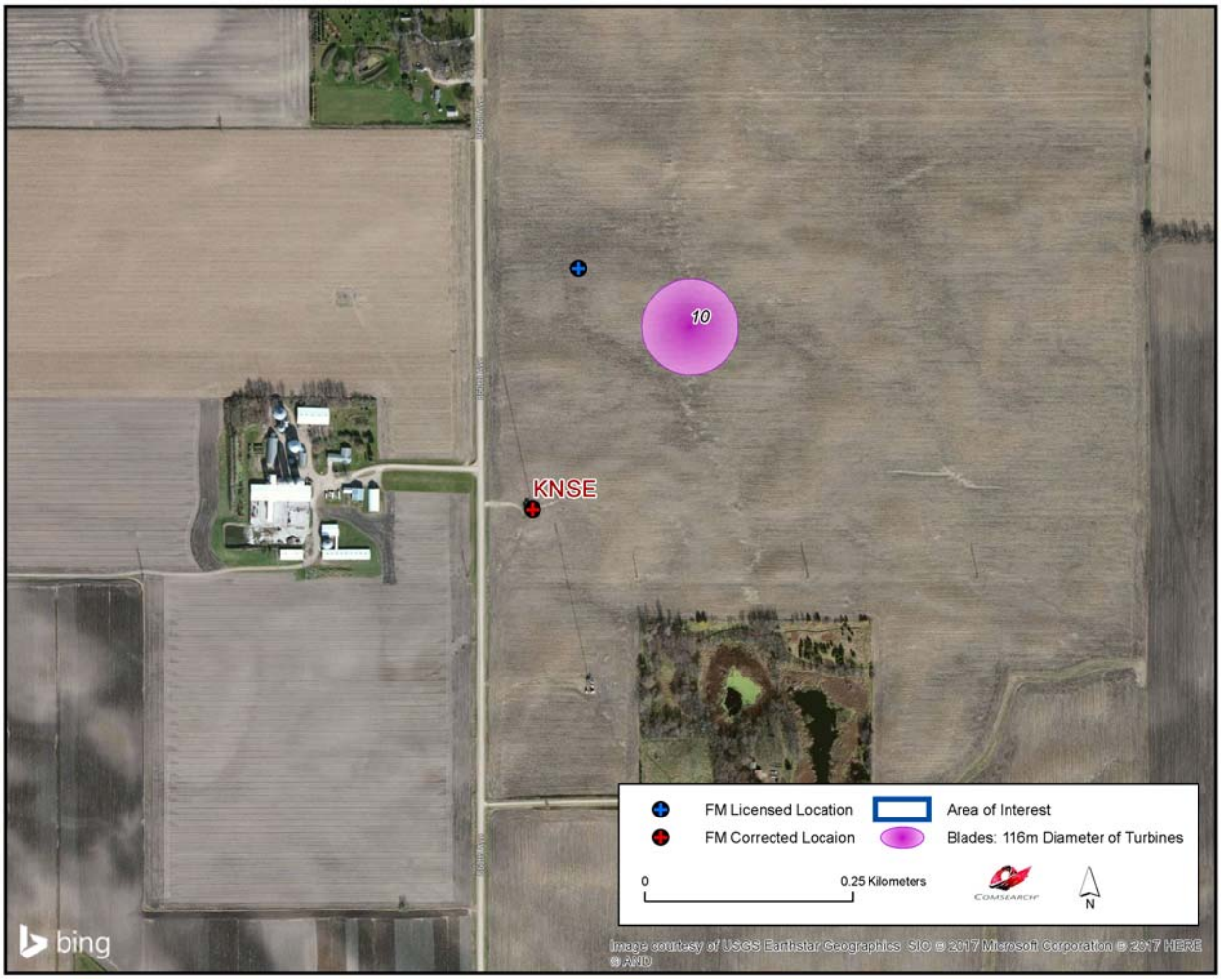

Figure 3: Location of FM Station KNSE with Respect to Location Listed on FCC License

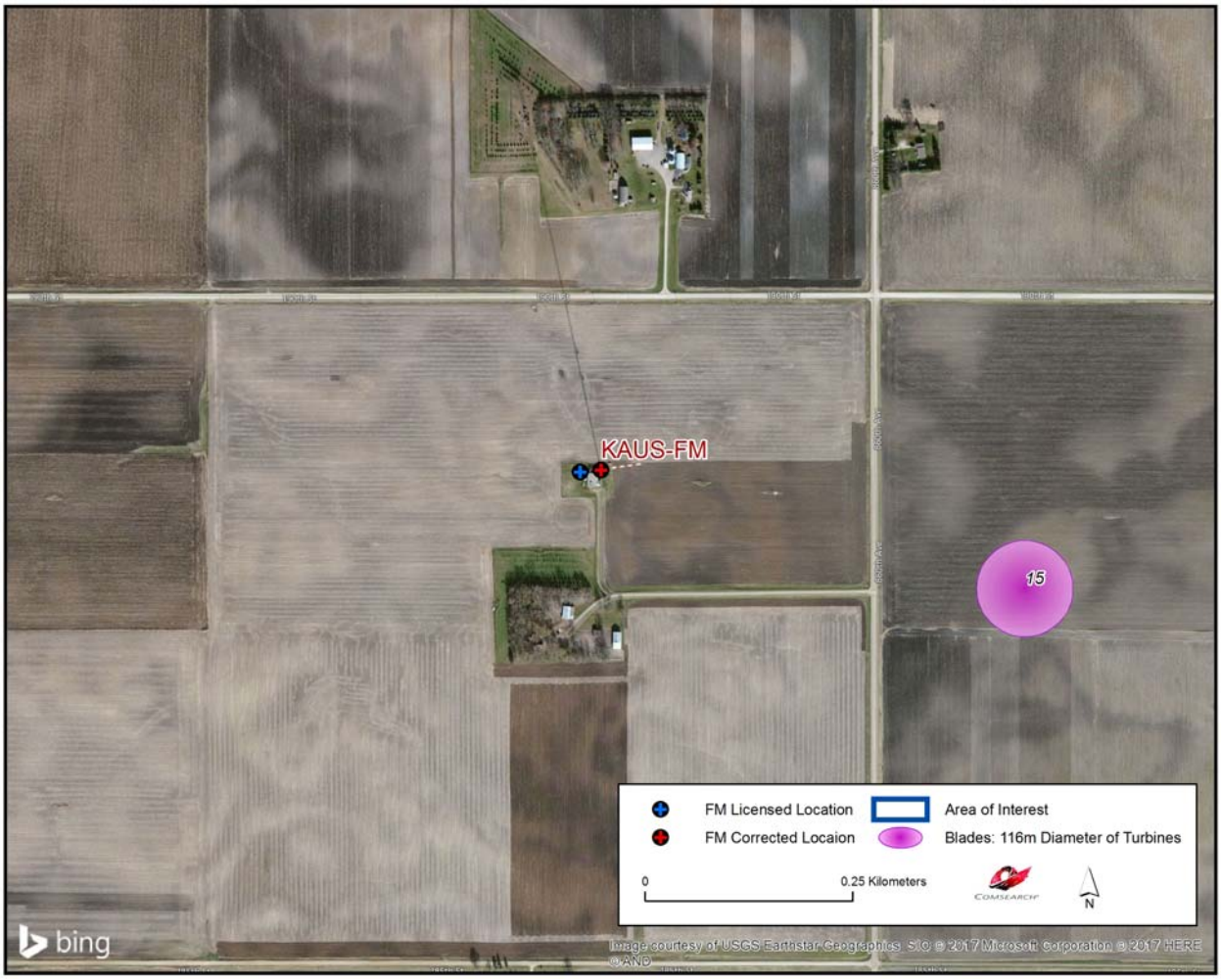

Figure 4: Location of FM Station KAUS-FM with Respect to Location Listed on FCC License

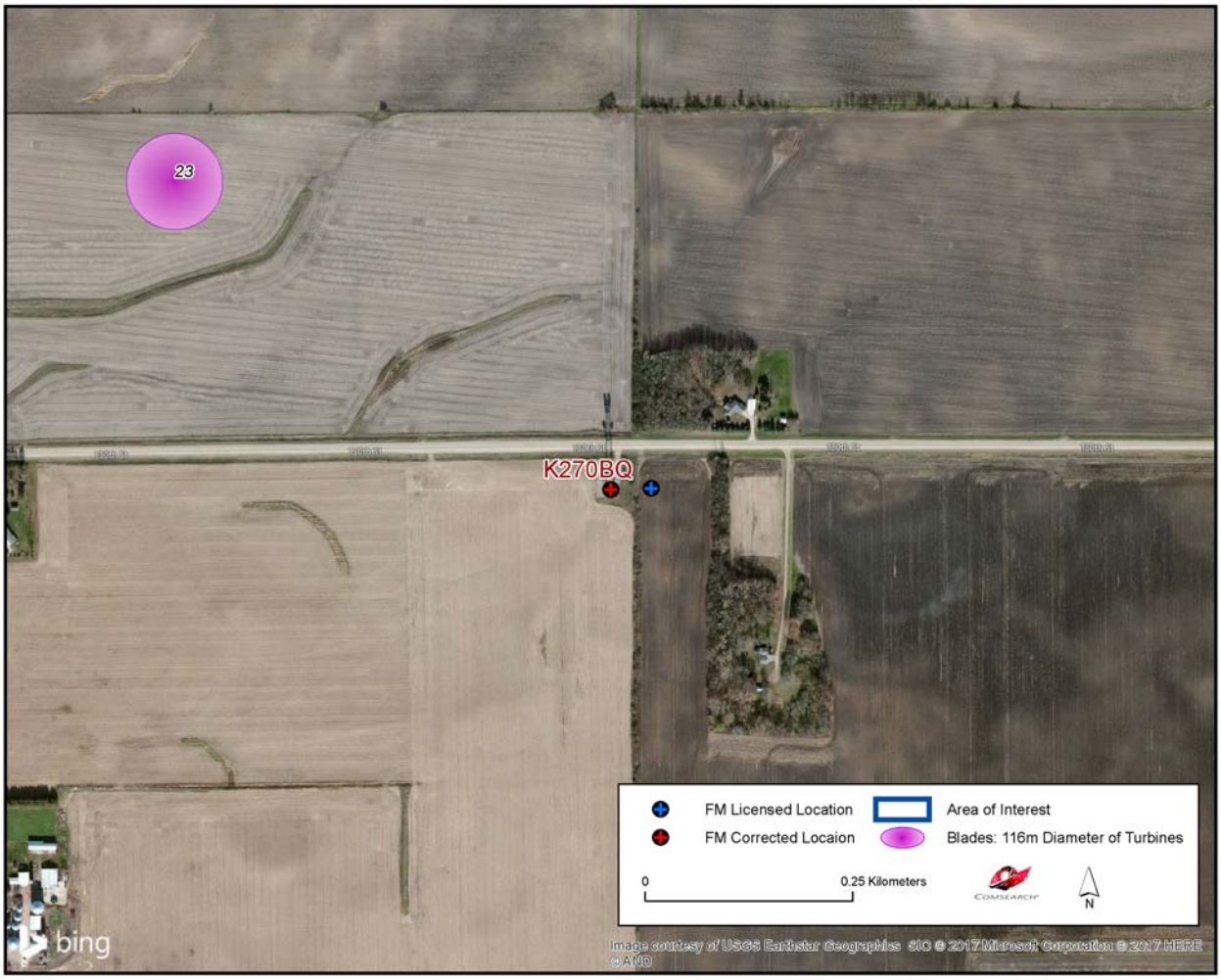

Figure 5: Location of FM Station K270BQ with Respect to Location Listed on FCC License

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 AM station to the Freeborn wind energy project, KAUS, is more than 10.2 kilometers from the nearest 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 wind turbines, especially when turbines are sited in the *far field* region of the radiating FM antenna in order to avoid the risk of distorting the antenna's radiation pattern. The closest operational station to the Freeborn wind energy project, KNSE, is located approximately 290 meters from the nearest turbine (#10). After considering the rotational sweep of the turbine blades (58 meters), the total separation distance between the station antenna and the tip of turbine blades reduces to 232 meters. At distances less than 500 meters, radiation pattern distortion could become a factor. Signal attenuation is also possible, but can be difficult to quantify without precise field measurements.

FM station KAUS-FM is similarly subject to interference. Taking into account the 58-meter turbine blade sweep, the total separation distance between KAUS-FM and the nearest turbine (#15) is 472 meters.

Translator station K270BQ, which is the only other FM station in close range of the project turbines, falls out of range of potential interference with a total separation distance of 594 meters after subtracting the 58-meter blade sweep.

Stations KNSE, KAUS-FM, and K270BQ and their proximity to the proposed turbines are depicted below in Figures 6 and 7.

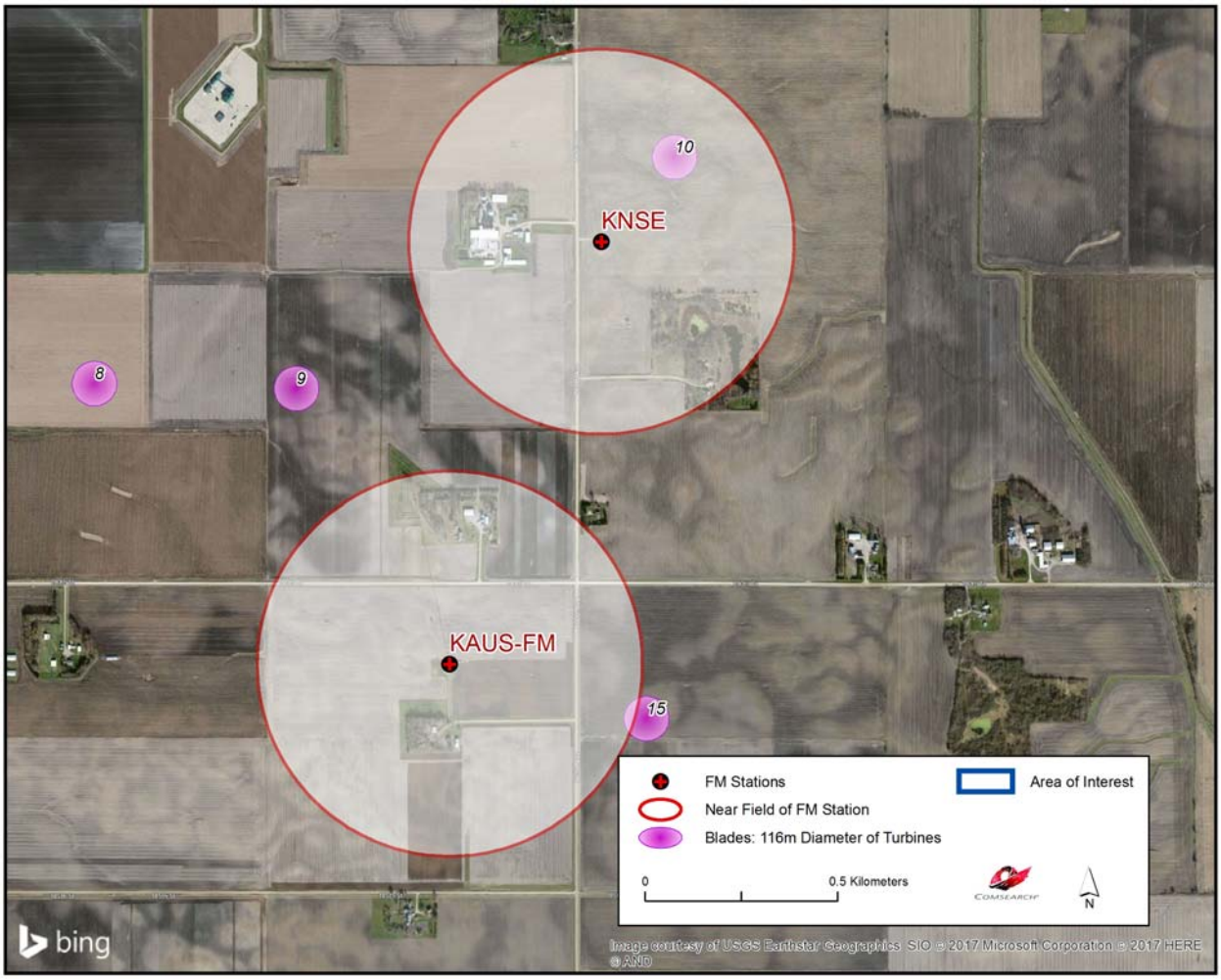

Figure 6: FM Stations KNSE and KAUS-FM and Adjacent Wind Turbines

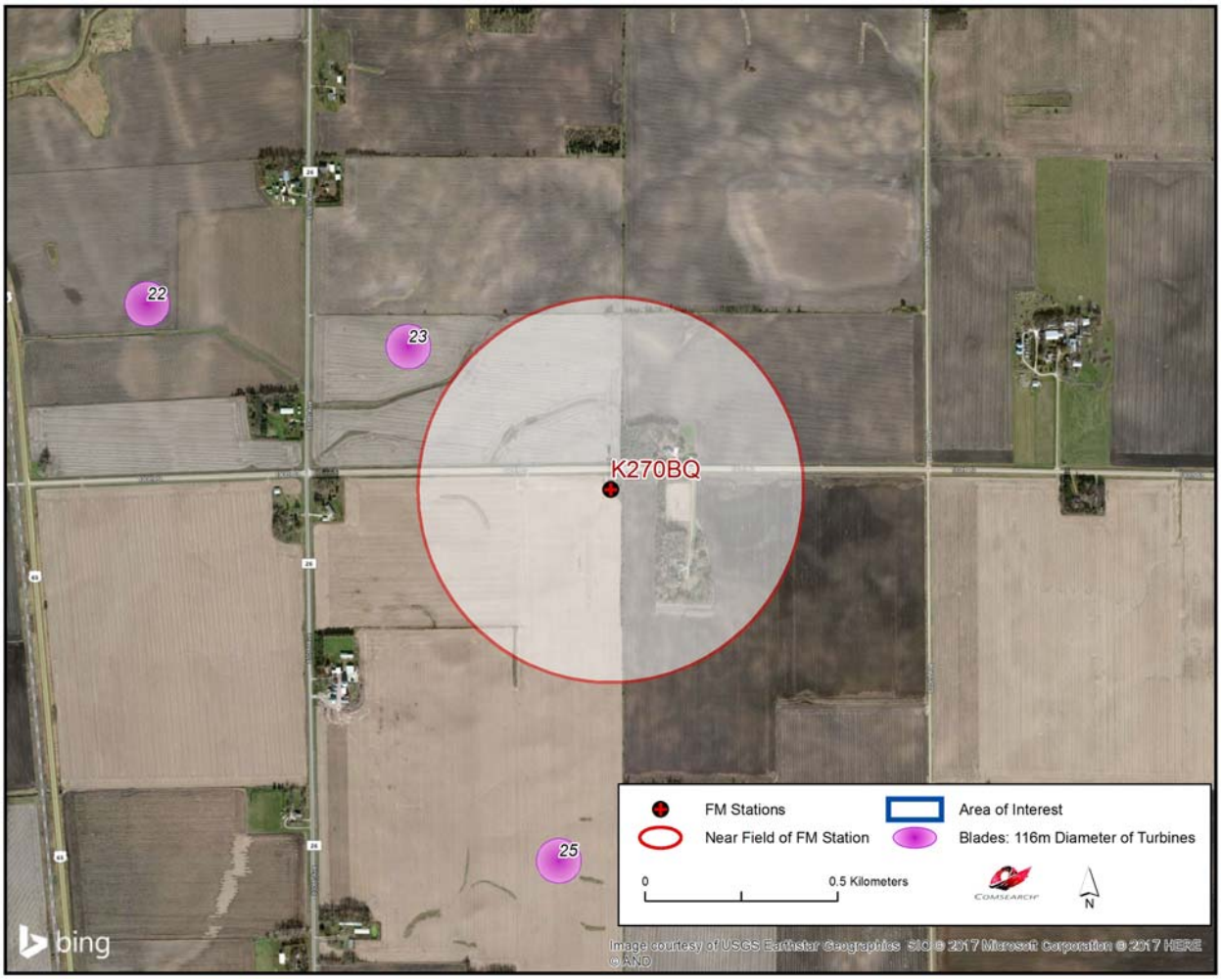

Figure 7: FM Station K270BQ and Adjacent Wind Turbines

4. Recommendations

Since our analysis did not identify any impact to the AM broadcast stations, no recommendations or mitigation techniques are required for this project.

With regard to the FM broadcast stations, KNSE and KAUS-FM were found to be potentially obstructed by wind turbines #10 and #15, respectively. Since FM radio operates in the VHF frequency band, signals can propagate over large distances despite partial obstructions between the broadcast station and FM receiver. Furthermore, FM radio uses frequency modulation, whereas signal perturbations due to wind turbines affect primarily the signal amplitude and phase (i.e., multipath). Notwithstanding these signal characteristics, it is recommended that turbine #10 be relocated to the far field region of station KNSE, while accounting for the blade length, in order to minimize the risk of distorting the radiation pattern of the FM station antenna. Similarly, turbine #15 should be relocated to the far field region of station KAUS-FM.

In addition, a baseline drive test measurement of the existing FM coverage of KNSE and KAUS-FM should be performed to determine the actual signal strength in potentially impacted areas prior to the construction of the wind energy facility. Following the construction, a similar drive test measurement could then be performed to determine the actual impact of the wind turbines. In the event that significant signal attenuation is observed after construction, a possible mitigation is to raise the FM antenna to a higher radiation center on the same tower. This is a tenable solution if the tower has sufficient height and space above the existing antenna installation.

If the same tower cannot be used, then another solution could involve the installation of an auxiliary broadcast antenna in order to fill in coverage in weak-signal areas impacted by the wind turbines after they are installed. Any relocation of the station's antenna or changes to its operation will require costs for hardware, space acquisition, administration, planning, lost operation time and coordination with the FCC.

5. Contact

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

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Web site:	www.comsearch.com

Wind Power GeoPlanner™

Communication Tower Study

Freeborn

Prepared on Behalf of
Invenergy LLC

December 8, 2016

COMSEARCH®
A CommScope Company

Table of Contents

1. Introduction

Our communication tower study was performed for Freeborn wind project in Freeborn County, Minnesota to identify all communication signal towers, and their owners, within the project area. This information is useful in the planning stages of the wind energy facilities to identify turbine setbacks and to prevent disruption to the services provided by the tenants on the towers. This data can be used in support of the wind energy facilities communications needs in addition to avoiding any potential impact to the current communications services provided in the region.

2. Summary of Results

The communication towers in the study area were derived from a variety of sources including the FCC's Antenna Structure Registration (ASR) database, Universal Licensing System (ULS), national and regional tower owner databases, and the local planning and zoning boards. The data[1] was imported into GIS software and the structures mapped in the wind energy area of interest. Each tower location is identified with a unique ID number associated with detailed structure and contact information provided in a spreadsheet attachment.

A total of 17 tower structures and 70 communication antennas were identified within the Freeborn project area using the data sources described in our methodology above. Fifteen of the structures found were registered with the FCC and contain 25 of the communication antennas. The remaining antennas may be located on a variety of structure types such as guyed towers, monopoles, silos or rooftops. The specific type of structure would normally need to be determined by an on-site visit.

Detailed information about the tower structures and communication antennas is provided in Table 1 and Table 2 including location coordinates, structure height above ground level, and owner-operator name[2]. Some communication towers were found to have inaccurate coordinates in the FCC license. The coordinates have been corrected using aerial imagery.

A discussion of turbine setback distances is provided in section three.

[1] 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.

[2] Please note that this report analyzes all known operators on the towers from data sources available to Comsearch. Unidentified operators may exist on the towers due to unlicensed or federal government systems, mobile phone operators with proprietary locations, erroneous data on the FCC license, and other factors beyond our control.

Tower ID	ASR Number	Owner	Structure Height AGL (m)	Latitude (NAD83)	Longitude (NAD83)
Tower001	1017894	Three Eagles of Mason City, Inc.	98.8	43.488472	-93.236665
Tower002	1024215	Com-Tec	61.0	43.543067	-93.239783
Tower003	1024056	Hometown Broadcasting, Inc.	98.1	43.616187	-93.213144
Tower004	1024162	KAAL-TV, LLC	290.4	43.628317	-93.153220
Tower005	1220263	CHRZ, MARK W	113.2	43.636278	-93.147500
Tower006	1044768	CHRZ, MARK W	121.9	43.638210	-93.148420
Tower007	1024312	INTERSTATE POWER AND LIGHT COMPANY	111.2	43.647526	-93.269298
Tower008	1222514	American Towers, LLC.	55.2	43.659639	-93.086750
Tower009	1251888	Minnesota, state of	100.6	43.662000	-93.114389
Tower010	1239127	United States Cellular Corporation	73.2	43.667333	-93.220972
Tower011	1251923	CCATT LLC	76.2	43.667333	-93.155722
Tower012	N/A	AMERICAN TOWER CORP	55.5	43.680867	-93.250347
Tower013	1282056	United States Cellular Corporation	45.7	43.453833	-93.223806
Tower014	1239127	United States Cellular Corporation	73.2	43.667333	-93.220972
Tower015	1032598	CC VIII Operating, LLC	106.7	43.679167	-93.041111
Tower016	1023404	American Towers, LLC.	55.2	43.712056	-93.316583
Tower017	N/A	Unknown	>58.8[3]	43.427611	-93.289778

Table 1: Summary of Tower Structures

[3] Height estimated based on highest antenna on tower (WHC791, ID 50)

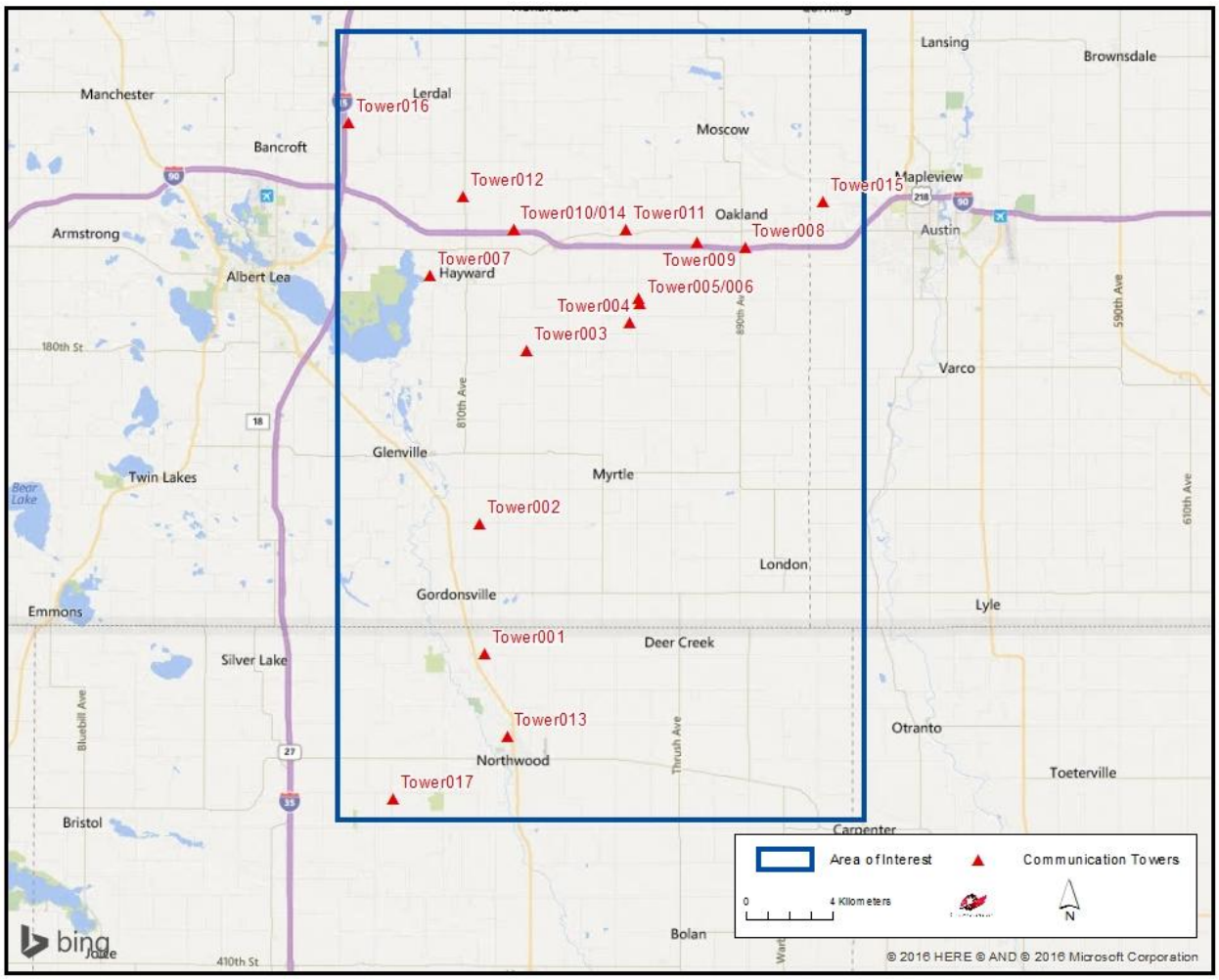

Figure 1: Towers in the Area of Interest

ID	Tower ID	Callsign	Service Type	Licensee	Antenna Height AGL (m)	Latitude (NAD83)	Longitude (NAD83)
1	Tower001	KYTC	FM	DIGITY 3E LICENSE, LLC	87.0	43.488472	-93.236665
2	Tower002	WQMR600	Land Mobile	FREEBORN, COUNTY OF	67.0	43.543067	-93.239783
3	Tower002	WQOD366	Microwave	FREEBORN, COUNTY OF	37.2	43.543067	-93.239783
4	Tower002	WQUX493	Land Mobile	AG POWER ENTERPRISES	71.3	43.543067	-93.239783
5	Tower002	K270BQ	FM	MINN-IOWA CHRISTIAN BROADCASTING, INC.	70.0	43.543067	-93.239783
6		WQTY224	Land Mobile	Belshan, Calvin	39.3	43.558111	-93.155750
7		WQBD389	Land Mobile	Union Pacific Railroad Company	4.0	43.560667	-93.272556
8		WPQF465	Land Mobile	NELSON, TERRENCE L	14.0	43.563833	-93.273806
9		WQUW526	Land Mobile	Heideman, Steven	35.1	43.571944	-93.216944
10		WQRZ604	Land Mobile	Glenville-Emmons School District #2886	38.0	43.572167	-93.280750
11		WPNQ607	Land Mobile	EXOL	4.0	43.572722	-93.291861
12		WNNM962	Land Mobile	KRAUSHAAR, STEVEN	18.0	43.583306	-93.151583
13	Tower003	KQPR	FM	HOMETOWN BROADCASTING, INC.	89.0	43.616187	-93.213144
14	Tower004	WHS206	Land Mobile	KAAL-TV, LLC	N/A	43.628317	-93.153220
15	Tower004	KAUS-FM	FM	DIGITY 3E LICENSE, LLC	298.0	43.628317	-93.153220
16	Tower004	KPL208	Land Mobile	DIGITY 3E LICENSE, LLC	91.0	43.628317	-93.153220
17	Tower004	WQKZ238	Land Mobile	KAAL-TV, LLC	312.7	43.628317	-93.153220
18	Tower006	KNSE	FM	MINNESOTA PUBLIC RADIO	82.0	43.638210	-93.148420
19	Tower006	KNBG837	Land Mobile	FREEBORN MOWER COOPERATIVE SERVICES	126.0	43.638210	-93.148420
20		WSZ679	Land Mobile	HAYWARD COOPERATIVE DBA ROBERT WITTMER	43.0	43.641639	-93.230472
21		WPPA626	Land Mobile	ALLIANCE PIPELINE L P	18.0	43.646639	-93.166861
22	Tower007	KNHK972	Land Mobile	DAIRYLAND POWER COOPERATIVE	70.0	43.647526	-93.269298
23	Tower007	WEG336	Microwave	Interstate Power and Light Company	85.3	43.647526	-93.269298
24	Tower007	WPBI318	Land Mobile	Interstate Power and Light Company	79.0	43.647526	-93.269298
25	Tower007	WQNW360	Microwave	INTERSTATE POWER AND LIGHT COMPANY	114.3	43.647526	-93.269298
26	Tower007	WQRX920	Microwave	DAIRYLAND POWER COOPERATIVE	114.3	43.647526	-93.269298
27		WQCY881	Land Mobile	SOY MOR BIODIESEL, LLC	23.1	43.658500	-93.294528
28	Tower008	K14PU-D	TV	LANDOVER 2 LLC	50.0	43.659639	-93.086750
29	Tower008	K19KB-D	TV	LANDOVER 2 LLC	50.0	43.659639	-93.086750
30	Tower008	K34MP-D	TV	LANDOVER 2 LLC	50.0	43.659639	-93.086750
31	Tower008	K47OF-D	TV	LANDOVER 2 LLC	50.0	43.659639	-93.086750
32		WQAR349	Land Mobile	Wangen, Marlowe	2.1	43.661472	-93.242556
33		WQHK535	Land Mobile	MINNESOTA, STATE OF	105.2	43.662000	-93.114389
34		WQIK790	Microwave	Minnesota, State of	44.2	43.662000	-93.114389

Continued on the Next Page

ID	Tower ID	Callsign	Service Type	Licensee	Antenna Height AGL (m)	Latitude (NAD83)	Longitude (NAD83)
35		WQMR600	Land Mobile	FREEBORN, COUNTY OF	96.0	43.662000	-93.114389
36		WQNG466	Land Mobile	MINNESOTA, STATE OF	104.3	43.662000	-93.114389
37		WQOD375	Microwave	FREEBORN, COUNTY OF	73.2	43.662000	-93.114389
38		WQVE274	Microwave	MOWER, COUNTY OF	38.0	43.662000	-93.114389
39		WRC267	Land Mobile	STROUF, WAYNE A	16.0	43.664417	-93.101583
40		KNKN403	Cellular	Alltel Communications, LLC	59.4	43.665861	-93.205139
41		WQQP733	Microwave	Verizon Wireless (VAW) LLC	44.5	43.665861	-93.205139
42	Tower011	KNKN572	Cellular	AT&T Mobility Spectrum LLC	79.2	43.667333	-93.155722
43		WQUW527	Land Mobile	LKQ Minnesota	17.7	43.667778	-93.298889
44		WPPH987	Land Mobile	NORTHERN COUNTRY COOP	52.0	43.672750	-93.087694
45		WQQD512	Microwave	Radio Link Internet	39.6	43.672833	-93.087944
46		WQUJ671	Land Mobile	Nielsen, Luke	35.7	43.676944	-93.287778
47		WQMN993	Land Mobile	Meyer, Doug	23.1	43.419444	-93.119167
48		WQNQ611	Land Mobile	DAVIDSON, MARK	32	43.419444	-93.118889
49		WQJR520	Land Mobile	Iberdrola Renewables, LLC	82.9	43.422222	-93.142361
50	Tower017	WHC791	Microwave	UNION PACIFIC RAILROAD	58.8	43.427444	-93.289917
51	Tower017	WNTU792	Microwave	UNION PACIFIC RAILROAD	57.9	43.427444	-93.289917
52	Tower017	KGL842	Land Mobile	UNION PACIFIC RAILROAD COMPANY	44.2/53.3	43.427611	-93.289778
53		WPYK354	Land Mobile	WORTH, COUNTY OF	23.8/29.9	43.444389	-93.217694
54		WSL886	Land Mobile	NORTHWOOD, CITY OF	11	43.444389	-93.217694
55		WZU224	Land Mobile	NORTHWOOD FIRE DEPT	30	43.444389	-93.217694
56		WQQX801	Land Mobile	Northwood-Kensett Schools	58	43.444389	-93.217417
57		WQQX801	Land Mobile	Northwood-Kensett Schools	9.8	43.445500	-93.219083
58		WQKB396	Microwave	WCTA Wireless, Inc.	64	43.449000	-93.212806
59		WQSX244	Land Mobile	Bloomingdale, Jim	15.2	43.461944	-93.232222
60		WQEP935	Land Mobile	Northwood Foods	16.1	43.461944	-93.222222
61		WPBF383	Land Mobile	DAHLBY, DALE	42	43.477444	-93.221028
62		WQYG949	Microwave	LTD Broadband LLC	33	43.534250	-93.070250
63	Tower002	WQXI965	Microwave	LTD Broadband LLC	70	43.543056	-93.239167
64		WQVN549	Land Mobile	Goslee, Larry	27.7	43.558056	-93.048056
65		WQSW614	Land Mobile	Lickteig & Bastyr Farms, LLC.	41.5	43.641389	-93.018056
66		KNBG837	Land Mobile	Freeborn Mower Cooperative Services	9	43.656611	-93.320194
67	Tower016	WQQS485	Microwave	Sprint Spectrum L.P.	45.4	43.712056	-93.316583
68	Tower016	WQVM806	Microwave	T-MOBILE LICENSE LLC	50	43.712056	-93.316583
69		WPAU761	Land Mobile	BAGLEY, JAMES	16	43.719417	-93.215472
70		WPNS523	Land Mobile		26	43.750250	-93.127972

Table 2: Summary of Communication Antennas

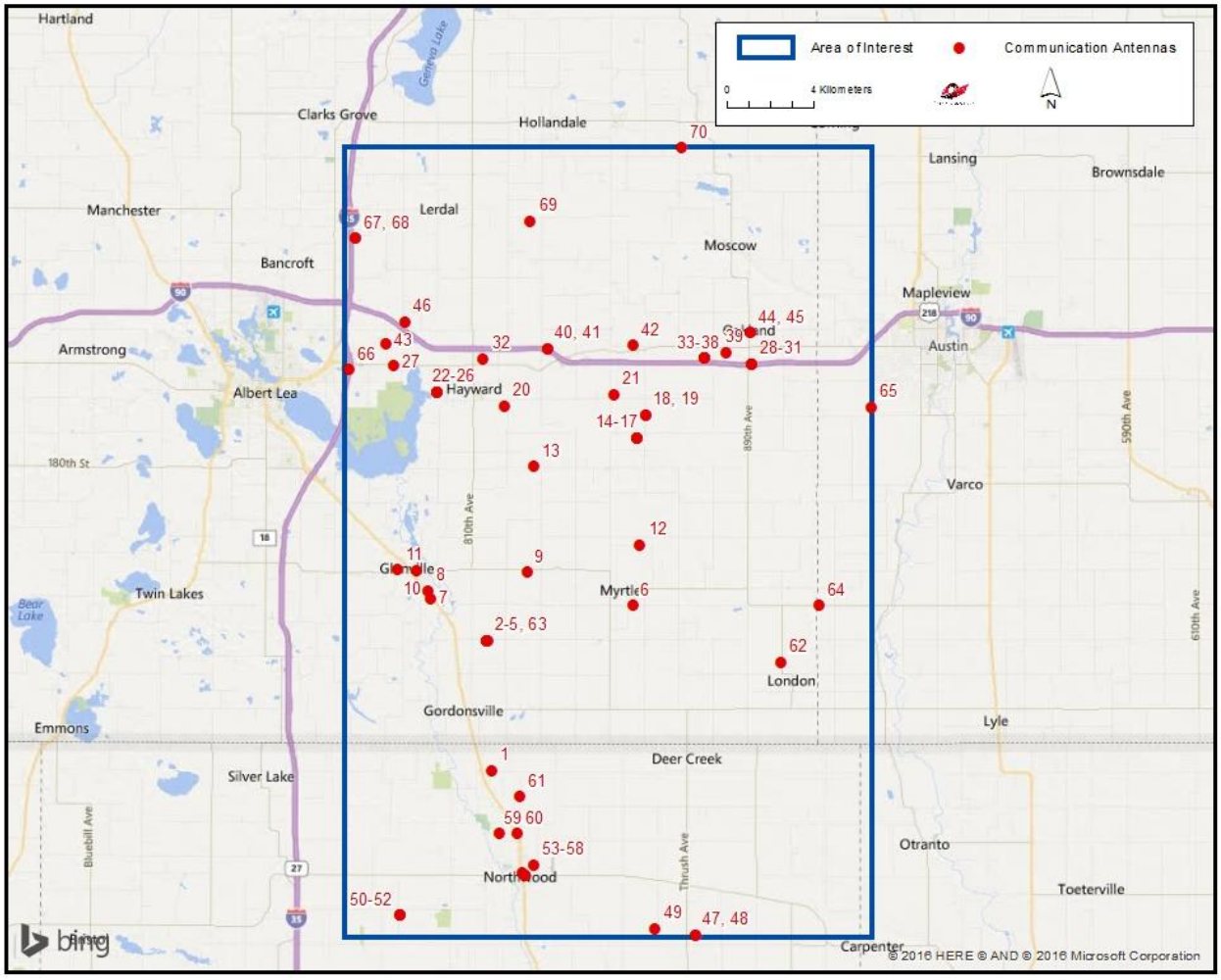

Figure 3: Communication Antennas within the Area of Interest

3. Discussion of Separation Distances

In planning the wind energy turbine locations, a conservative approach would dictate not locating any turbines in close proximity to existing tower structures to avoid any possible impact to the communications services provided by the structures. Reasonable distance between communication towers and wind turbine towers is a function of two things: (1) the physical turning radius of the wind turbine blades and (2) the characteristics of the communication systems on the communication tower.

Since wind turbine blades can rotate 360º, the first consideration of separation distance to other structures is clearance of the blades. If the blade radius is 50 meters, then a separation distance greater than 50 meters is necessary. From a practical standpoint, a setback distance greater than the maximum height of the turbine is necessary to insure a "fall" safety zone in the unlikely event of a turbine tower failure. Setback requirements for "fall" safety are typically specified by the local zoning ordinances.

The required separation distance based on the characteristics of the communication systems will vary depending on the type of communication antennas that are installed on the tower. For example, AM broadcast antennas should be separated by distances that allow for normal coverage which can extend up to 3 kilometers. For land mobile and mobile phone systems, setback distances are based on FCC interference emission limits from electrical devices in the land mobile and mobile phone frequency bands.

Finally, the tower structures identified could be a potential benefit in support of communications network needs for the wind energy facility. An example would be the implementation of a Supervisory Control and Data Acquisition (SCADA) system that monitors and provides communications access to the wind energy facility.

4. Conclusions

Our study identified 17 tower structures and 70 communication antennas within the project area. They are used for microwave, cellular, FM, TV, and land mobile services in the area. Detailed impact assessments should be performed for these service types.

5. Contact Us

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Wind Power GeoPlanner™

Mobile Phone Carrier Report

Freeborn

Prepared on Behalf of
Invenergy LLC

December 8, 2016

COMSEARCH
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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), 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.

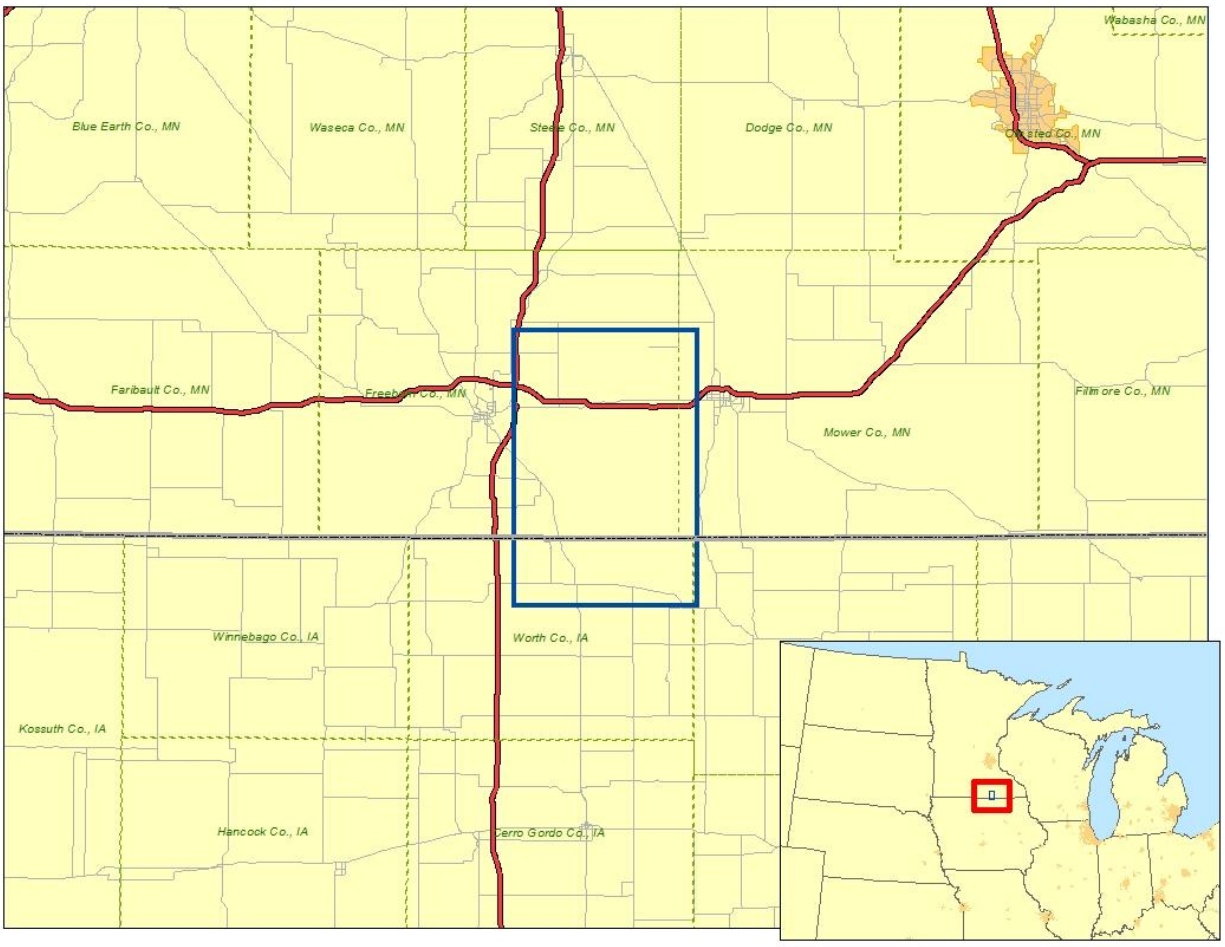

Figure 1: Counties that intersect the Area of Interest

Results
The Freeborn Project is located in Freeborn and Mower Counties, Minnesota as well as Worth County, Iowa. 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	Mower	MN	CMA492	WQGL794
AWS	T-Mobile	A	Freeborn	MN	CMA491	WQGL810
AWS	Winnebago Cooperative Telephone	A	Worth	IA	CMA425	WQLD570
AWS	Verizon Wireless	B	Mower	MN	BEA106	WQGA989
AWS	Verizon Wireless	B	Freeborn	MN	BEA107	WQGA990
AWS	Verizon Wireless	B	Worth	IA	BEA100	WQGA986
AWS	ABug Tussel Wireless	C	Mower	MN	BEA106	WQVD432
AWS	AT&T	C	Freeborn	MN	BEA107	WQGA778
AWS	Verizon Wireless	C	Worth	IA	BEA100	WQPZ953
AWS	T-Mobile	D	Mower	MN	REA003	WQQA471
AWS	T-Mobile	D	Freeborn	MN	REA003	WQQA469
AWS	Verizon Wireless	D	Worth	IA	REA003	WQPW449
AWS	T-Mobile	E	Freeborn, Mower	MN	REA003	WQGB376
AWS	Winnebago Cooperative Telephone	E	Worth	IA	REA003	WQOI347
AWS	Verizon Wireless	F	Freeborn, Mower	MN	REA003	WQGA717
AWS	T-Mobile	F	Worth	IA	REA003	WQPZ970
CELL	Verizon Wireless	A	Mower	MN	CMA492	WPSJ612
CELL	AT&T	A	Freeborn	MN	CMA491	KNKN572
CELL	US Cellular	A	Worth	IA	CMA425	KNKN435
CELL	Verizon Wireless	B	Mower	MN	CMA492	KNKN416
CELL	Verizon Wireless	B	Freeborn	MN	CMA491	KNKN403
CELL	Verizon Wireless	B	Worth	IA	CMA425	KNKQ267
PCS	Sprint Nextel	A	Freeborn, Mower	MN	MTA012	KNLF223
PCS	Verizon Wireless	A	Freeborn, Mower	MN	MTA012	WQIQ265
PCS	Winnebago Cooperative Telephone	A	Worth	IA	MTA032	WPQY728
PCS	US Cellular	A	Worth	IA	MTA032	WQUC595

[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

Service[1]	Mobile Phone Carrier	Channel Block	County	ST	Market ID	Callsign
PCS	Winnebago Cooperative Telephone	A	Worth	IA	MTA032	WQWC841
PCS	T-Mobile	B	Freeborn, Mower	MN	MTA012	KNLF224
PCS	Sprint Nextel	B	Worth	IA	MTA032	KNLF264
PCS	Verizon Wireless	C	Freeborn, Mower	MN	BTA378	WPOK679
PCS	AT&T	C	Freeborn, Mower	MN	BTA378	WPZU213
PCS	AT&T	C	Worth	IA	BTA285	WPSI621
PCS	Winnebago Cooperative Telephone	C	Worth	IA	BTA285	WQND993
PCS	AT&T	D	Mower	MN	BTA378	WQGH837
PCS	AT&T	D	Freeborn	MN	BTA378	WQGG305
PCS	US Cellular	D	Worth	IA	BTA285	KNLG770
PCS	Verizon Wireless	E	Freeborn, Mower	MN	BTA378	KNLG880
PCS	Verizon Wireless	E	Worth	IA	BTA285	KNLG876
PCS	US Cellular	F	Freeborn, Mower	MN	BTA378	KNLG954
PCS	AT&T	F	Worth	IA	BTA285	WQGG303
PCS	Sprint Nextel	G	Mower	MN	BEA106	WQKT214
PCS	Sprint Nextel	G	Freeborn	MN	BEA107	WQKT215
PCS	Sprint Nextel	G	Worth	IA	BEA100	WQKT292
700 MHz	US Cellular	Lower A	Mower	MN	BEA106	WQLE672
700 MHz	T-Mobile	Lower A	Freeborn	MN	BEA107	WQJQ710
700 MHz	US Cellular	Lower A	Worth	IA	BEA100	WQLE669
700 MHz	AT&T	Lower B	Mower	MN	CMA492	WQIZ626
700 MHz	AT&T	Lower B	Freeborn	MN	CMA491	WQIZ625
700 MHz	US Cellular	Lower B	Worth	IA	CMA425	WQLE741
700 MHz	AT&T	Lower C	Mower	MN	CMA492	WPWV450
700 MHz	AT&T	Lower C	Freeborn	MN	CMA491	WPWV449
700 MHz	AT&T	Lower C	Worth	IA	CMA425	WQDM569
700 MHz	AT&T	Lower D	Freeborn, Mower, Worth	MN,IA	EAG704	WPZA238
700 MHz	DISH Network	Lower E	Mower	MN	BEA106	WQJZ248
700 MHz	DISH Network	Lower E	Freeborn	MN	BEA107	WQJZ249
700 MHz	DISH Network	Lower E	Worth	IA	BEA100	WQJZ242
700 MHz	Verizon	Upper C	Freeborn, Mower, Worth	MN,IA	REA003	WQJQ691

Service[1]	Mobile Phone Carrier	Channel Block	County	ST	Market ID	Callsign
WCS	AT&T	A	Freeborn, Mower	MN	MEA020	KNLB218
WCS	AT&T	A	Worth	IA	MEA021	KNLB245
WCS	AT&T	B	Freeborn, Mower	MN	MEA020	KNLB292
WCS	AT&T	B	Worth	IA	MEA021	KNLB293
WCS	AT&T	C	Freeborn, Mower	MN	REA003	WPQL713
WCS	AT&T	C	Worth	IA	REA003	WPQL714
WCS	AT&T	D	Freeborn, Mower	MN	REA003	WQDM396
WCS	AT&T	D	Worth	IA	REA003	KNLB325

Table 1: Mobile Phone Carriers in the Area of Interest

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 two cellular sites within the Freeborn 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)
KNKN403	Verizon	59.4	N/A	83217 215th St.	43.665861	-93.205139
KNKN572	AT&T	79.2	1251923	85628 215th Street (42356)	43.667333	-93.155722

Table 2: FCC-Licensed Mobile Phone Sites

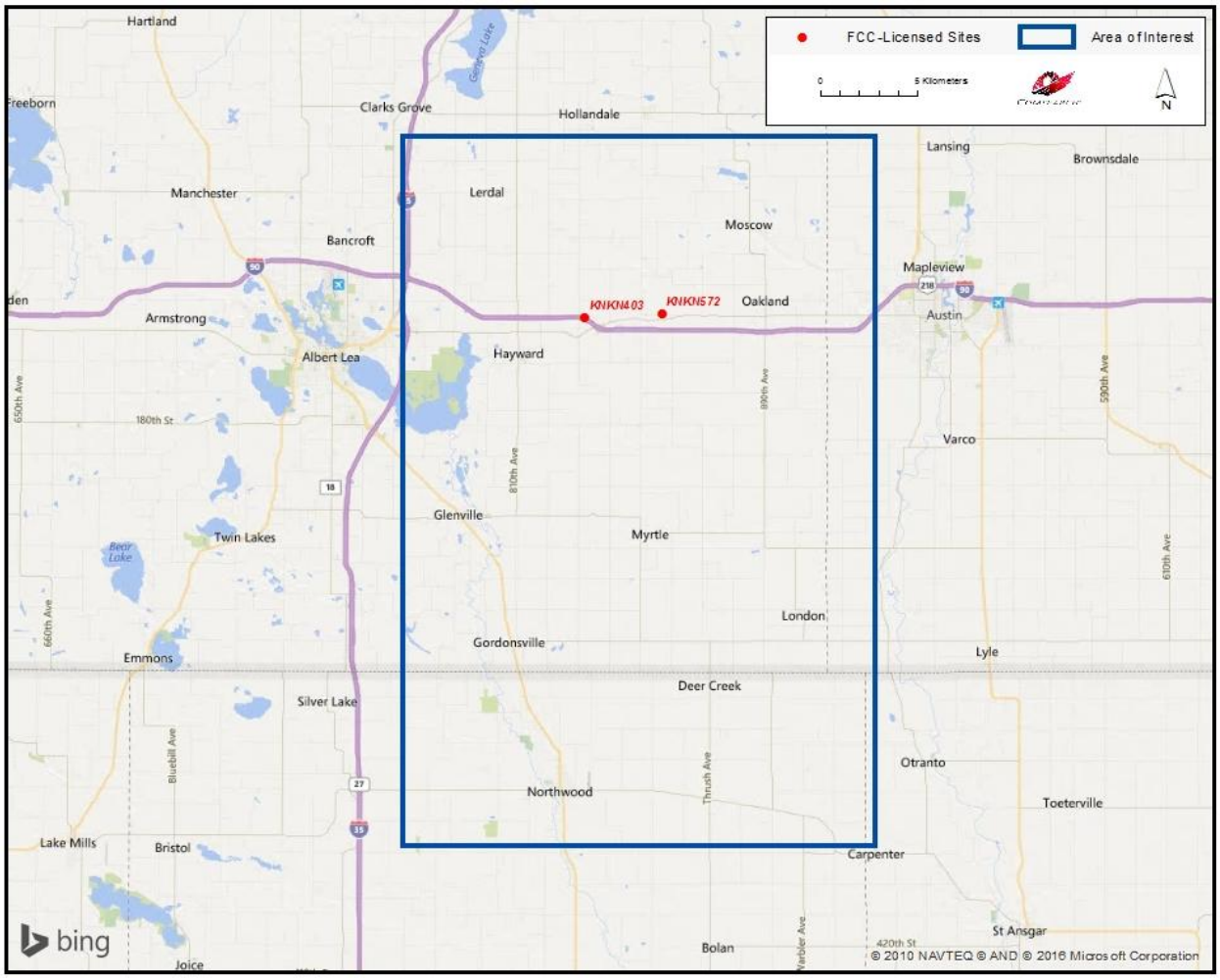

Figure 2: FCC-Licensed Mobile Phone Sites in the Area of Interest

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 Freeborn. 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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Web site:	www.comsearch.com

Wind Power GeoPlanner™

TV Coverage Impact Study

Freeborn

Prepared on Behalf of
Invenergy LLC

May 22, 2017

COMSEARCH
A CommScope Company

Table of Contents

1. Introduction

Over-the-air (OTA) television stations broadcast their signals from terrestrially-located facilities that can be received directly by a television receiver. Comsearch identified those television stations whose service could potentially be affected by the proposed Freeborn Wind Farm project in Freeborn County, Minnesota. Comsearch then examined the OTA coverage of these television stations along with the communities within the areas that could potentially have degraded television reception due to the location of the proposed wind energy project.

2. Summary of Affected TV Stations

The proposed wind energy project area of interest (AOI) and local communities are depicted in Figure 1A. A close-up view of the AOI with the proposed wind turbine layout is shown in Figure 1B.

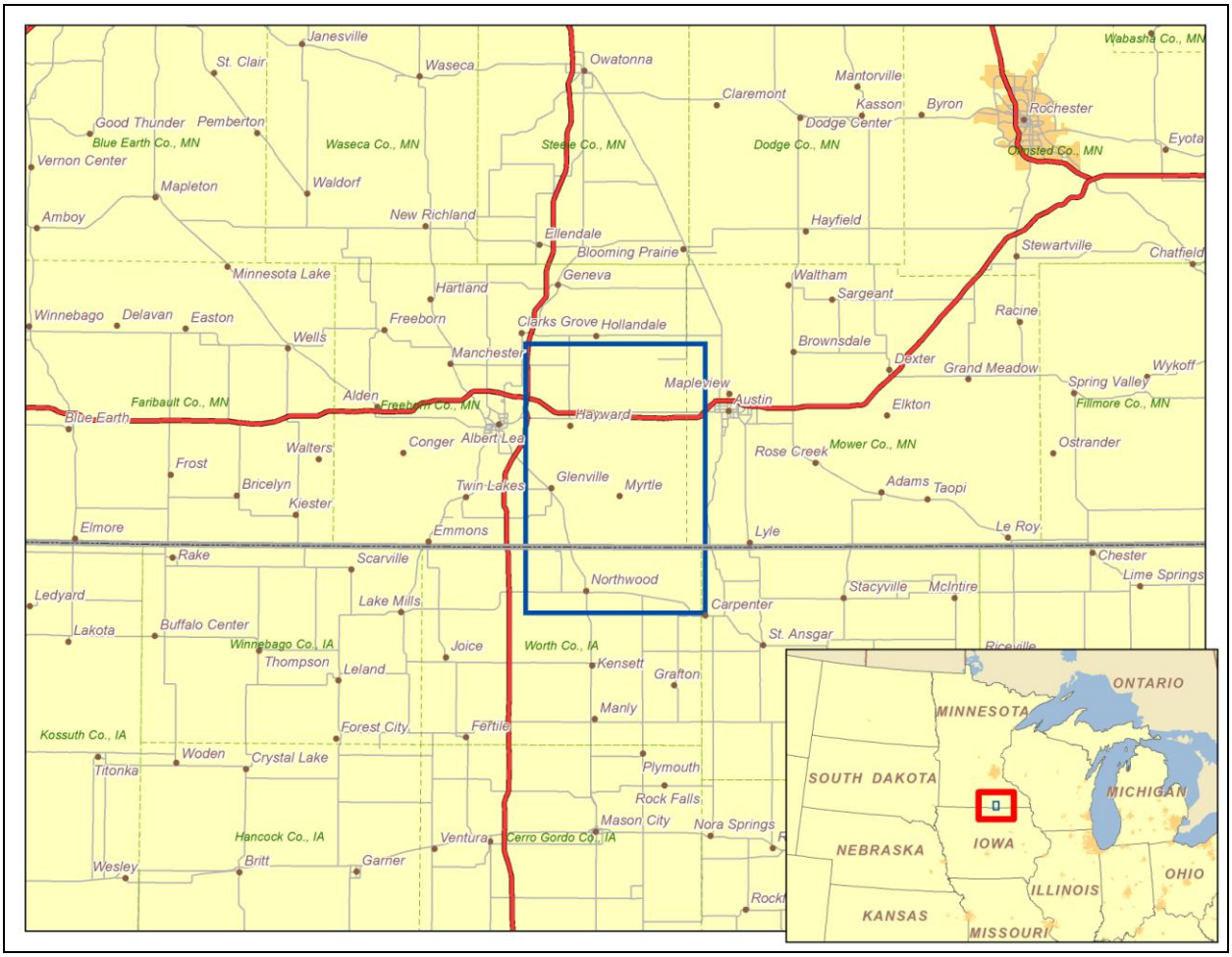

Figure 1A: Wind Farm Project Area and Local Communities

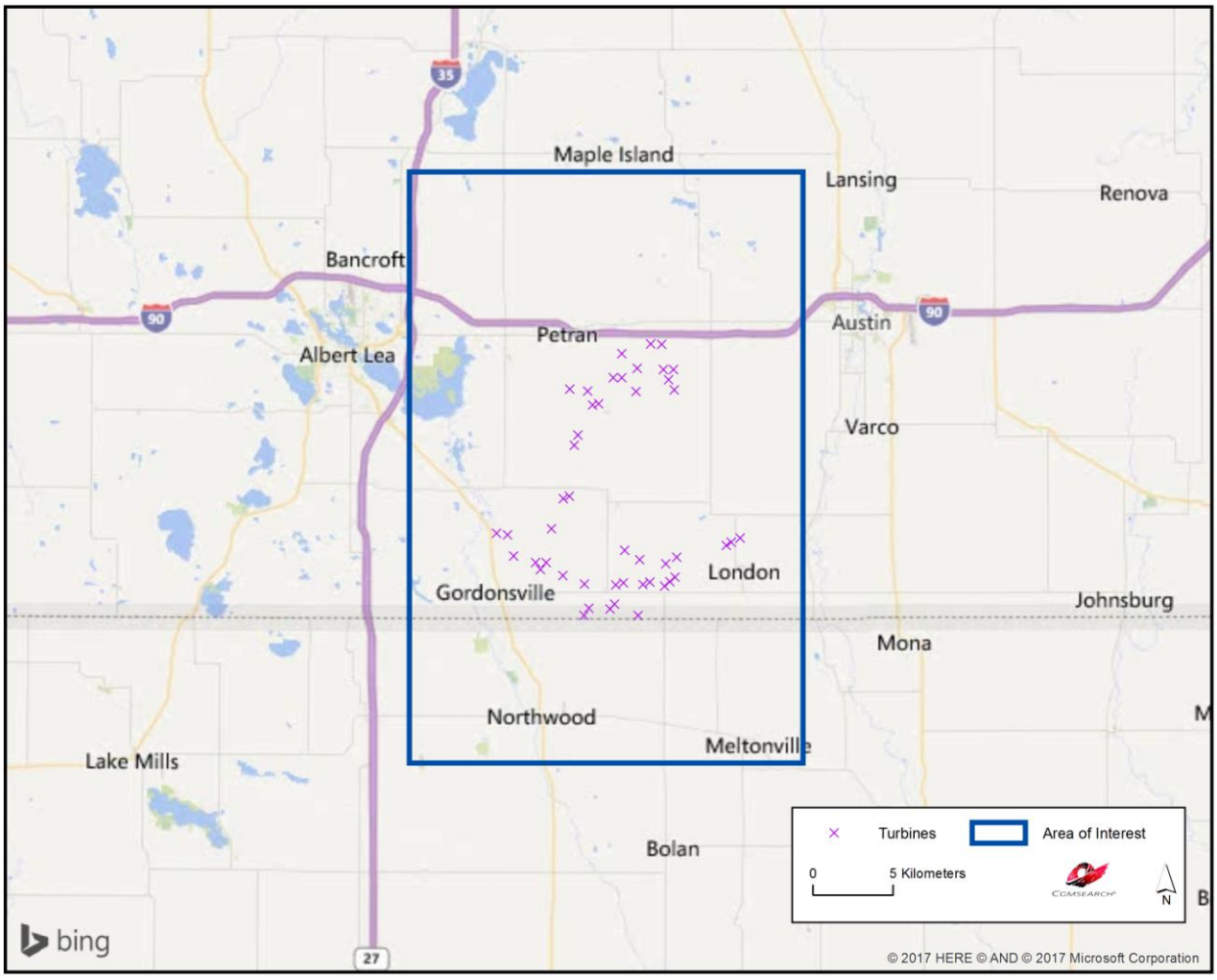

Figure 1B: Wind Farm Project Area and Turbine Layout

Based on the standard range of OTA television coverage, TV stations at a distance of 100 kilometers or less are the most likely to provide coverage to the project area and neighboring communities. To begin the analysis, Comsearch compiled a list of all OTA television stations[1] within 100 kilometers of the project. These stations are listed in Table 1 on the next page, and a plot depicting their geographic locations appears in Figure 2 below. There are a total of fifty-three database records for stations located within 100 kilometers of the project. Of these stations, twenty-one are currently licensed and operational and have been listed separately in Table 2. The remaining thirty-two stations are not operational and were therefore not considered in this analysis.

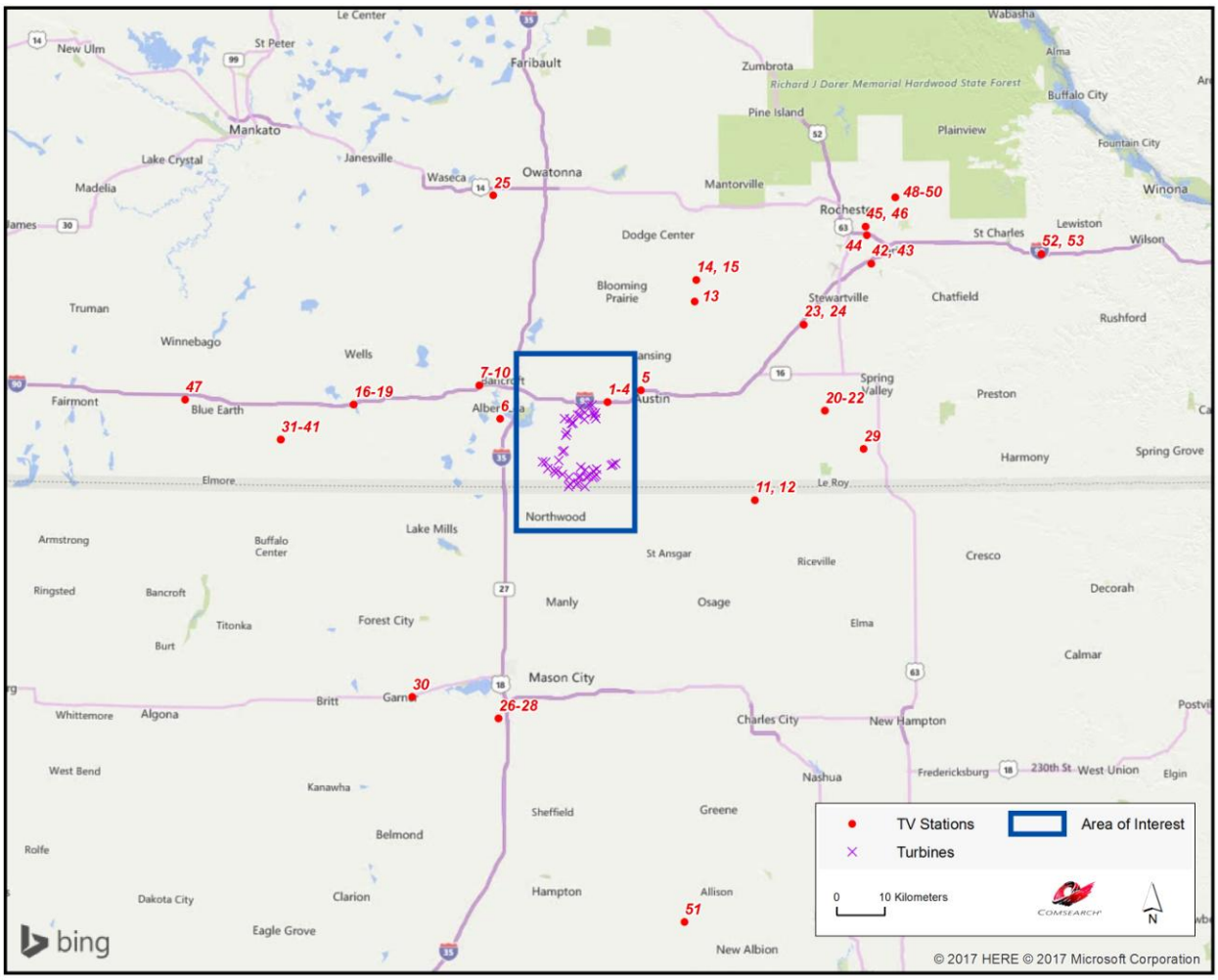

Figure 2: Plot of OTA TV Stations within 100 km of Project Area

[1] Comsearch makes no warranty as to the accuracy of the data included in this report beyond the date of the report.

ID	Call Sign	Status	Service[4]	Channel	Transmit ERP[5] (kW)	Latitude (NAD 27)	Longitude (NAD 27)	Distance to Nearest Turbine (km)
1	K14PU-D	CP	LD	14	1.0	43.659667	-93.086528	3.33
2	K19KB-D	CP	LD	19	1.0	43.659667	-93.086528	3.33
3	K34MP-D	CP	LD	34	1.0	43.659667	-93.086528	3.33
4	K47OF-D	CP	LD	47	1.0	43.659667	-93.086528	3.33
5	K40JT	CP	LD	40	15.0	43.681944	-93.000278	10.60
6	K40JT	LIC	TX	40	10.7	43.627778	-93.363611	12.55
7	K30NI-D	CP	LD	30	1.0	43.690361	-93.417556	19.00
8	K32LB-D	CP	LD	32	1.0	43.690361	-93.417556	19.00
9	K38OU-D	CP	LD	38	1.0	43.690361	-93.417556	19.00
10	K44LT-D	CP	LD	44	1.0	43.690361	-93.417556	19.00
11	KYIN	LIC	DT	18	533.0	43.475556	-92.708056	29.95
12	KIMT	LIC	DT	42	800.0	43.475556	-92.708056	29.95
13	K40JT	CP MOD	LD	40	15.0	43.848147	-92.861533	30.41
14	NEW	APP	LD	24	15.0	43.888083	-92.857639	33.90
15	W39DD-D	CP	LD	39	15.0	43.888083	-92.857639	33.90
16	K22LG-D	CP	LD	22	1.0	43.652556	-93.741972	41.06
17	K26MG-D	CP	LD	26	1.0	43.652556	-93.741972	41.06
18	K28MU-D	CP	LD	28	1.0	43.652556	-93.741972	41.06
19	K50NB-D	CP	LD	50	1.0	43.652556	-93.741972	41.06
20	KSMQ-TV	LIC	DT	20	319.2	43.642778	-92.526389	44.92
21	KAAL	LIC	DT	36	620.0	43.642778	-92.526389	44.92
22	KXLT-TV	LIC	DT	46	220.0	43.642778	-92.526389	44.92
23	K43OH-D	CP	LD	43	1.0	43.804056	-92.580028	47.05
24	K45MO-D	CP	LD	45	1.0	43.804056	-92.580028	47.05
25	K48KJ-D	LIC	LD	48	4.92	44.046139	-93.384222	47.80
26	K22LJ-D	CP	LD	22	5.0	43.066667	-93.365000	50.40
27	K27MI-D	CP	LD	27	3.0	43.066667	-93.365000	50.40
28	K38OW-D	CP	LD	38	10.0	43.066667	-93.365000	50.40
29	KTTC	LIC	DT	10	43.1	43.570833	-92.426944	51.72
30	KAAL	LIC	LD	33	8.3	43.105833	-93.585278	54.55
31	K14KD-D	LIC	LD	14	3.0	43.585833	-93.929444	54.70
32	K21KF-D	LIC	LD	21	3.0	43.585833	-93.929444	54.70
33	K23FY-D	LIC	LD	23	3.0	43.585833	-93.929444	54.70
34	K27FI-D	LIC	LD	27	3.0	43.585833	-93.929444	54.70

[4] Definitions of service and status codes:
DT – Digital television broadcast station
LD – Low power digital television broadcast station
TX – Translator station
LIC – Licensed and operational station
APP – Application for construction permit
CP – Construction permit granted
CP MOD – Modification of construction permit

[5] ERP = Transmit Effective Radiated Power

ID	Call Sign	Status	Service[4]	Channel	Transmit ERP[5] (kW)	Latitude (NAD 27)	Longitude (NAD 27)	Distance to Nearest Turbine (km)
35	K29IF-D	LIC	LD	29	3.1	43.585833	-93.929444	54.70
36	K31EF-D	LIC	LD	31	3.0	43.585833	-93.929444	54.70
37	K35IU-D	LIC	LD	35	3.0	43.585833	-93.929444	54.70
38	K40JS-D	LIC	LD	40	3.0	43.585833	-93.929444	54.70
39	K47MI-D	LIC	LD	47	3.0	43.585833	-93.929444	54.70
40	K49JG-D	LIC	LD	49	3.0	43.585833	-93.929444	54.70
41	K51KB-D	LIC	LD	51	3.0	43.585833	-93.929444	54.70
42	NEW	APP	LD	41	1.0	43.917500	-92.404167	65.16
43	K41MP-D	CP	LD	41	1.0	43.917500	-92.404167	65.16
44	K33LJ-D	CP	LD	33	10.0	43.971056	-92.415250	67.26
45	NEW	APP	LD	24	3.0	43.986944	-92.418333	67.99
46	K31LN-D	CP	LD	31	4.0	43.986944	-92.418056	68.01
47	K45MN-D	CP	LD	45	1.0	43.658583	-94.176500	75.47
48	K25NK-D	CP	LD	51	15.0	44.041111	-92.340278	76.53
49	K25NK-D	LIC	LD	25	15.0	44.041139	-92.340111	76.54
50	K25NK-D	CP	LD	38	15.0	44.041139	-92.340111	76.54
51	K17MH-D	CP	LD	17	6.0	42.685833	-92.889722	92.93
52	K19IT-D	CP	LD	19	1.0	43.932222	-91.962222	98.56
53	K40NI-D	CP	LD	40	1.0	43.932194	-91.962167	98.56

Table 1: OTA TV Stations within 100 Kilometers of Project Area

ID	Call Sign	Status	Service[6]	Channel	Transmit ERP[7] (kW)	Latitude (NAD 27)	Longitude (NAD 27)	Distance to Nearest Turbine (km)
6	K40JT	LIC	TX	40	10.7	43.627778	-93.363611	12.55
11	KYIN	LIC	DT	18	533.0	43.475556	-92.708056	29.95
12	KIMT	LIC	DT	42	800.0	43.475556	-92.708056	29.95
20	KSMQ-TV	LIC	DT	20	319.2	43.642778	-92.526389	44.92
21	KAAL	LIC	DT	36	620.0	43.642778	-92.526389	44.92
22	KXLT-TV	LIC	DT	46	220.0	43.642778	-92.526389	44.92
25	K48KJ-D	LIC	LD	48	4.92	44.046139	-93.384222	47.80
29	KTTC	LIC	DT	10	43.1	43.570833	-92.426944	51.72
30	KAAL	LIC	LD	33	8.3	43.105833	-93.585278	54.55
31	K14KD-D	LIC	LD	14	3.0	43.585833	-93.929444	54.70
32	K21KF-D	LIC	LD	21	3.0	43.585833	-93.929444	54.70
33	K23FY-D	LIC	LD	23	3.0	43.585833	-93.929444	54.70
34	K27FI-D	LIC	LD	27	3.0	43.585833	-93.929444	54.70
35	K29IF-D	LIC	LD	29	3.1	43.585833	-93.929444	54.70
36	K31EF-D	LIC	LD	31	3.0	43.585833	-93.929444	54.70
37	K35IU-D	LIC	LD	35	3.0	43.585833	-93.929444	54.70
38	K40JS-D	LIC	LD	40	3.0	43.585833	-93.929444	54.70
39	K47MI-D	LIC	LD	47	3.0	43.585833	-93.929444	54.70
40	K49JG-D	LIC	LD	49	3.0	43.585833	-93.929444	54.70
41	K51KB-D	LIC	LD	51	3.0	43.585833	-93.929444	54.70
49	K25NK-D	LIC	LD	25	15.0	44.041139	-92.340111	76.54

Table 2: Operational OTA TV Stations within 100 Kilometers of Project Area

The FCC coverage contours for the twenty-one operational stations were plotted. Of these contours, only six (IDs 11, 12, 20, 21, 22, and 29) were found to intersect at least one wind turbine and were therefore subject to further analysis. As the coverage contours of the other fifteen operational stations do not extend into the project area, they should not be impacted by the proposed wind turbines.

In the following section, a detailed analysis is presented to assess the impact of the wind energy project on the six television stations identified above in terms of coverage, interference, and demographics. The analysis is based on 47 proposed wind turbines as shown in Figure 1, each having a hub height of 80 meters and a blade diameter of 116 meters, giving them an overall height of 138 meters above ground level (AGL).

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

[7] ERP = Transmit Effective Radiated Power

3. Impact Analysis of Operational TV Stations

The licensed operational television stations whose coverage is potentially impacted by the planned wind turbines are listed below in Table 3. The analysis performed in this section will define where potential signal reception degradation could occur.

Call Sign	Transmit Channel	Network Affiliate	Power (kW)	Antenna Height AGL (m)	Antenna Height AMSL (m)	Owner	Distance to Nearest Turbine (km)
KYIN	18	PBS	533.0	449.6	838.2	Iowa Public Broadcasting Board	29.95
KIMT	42	CBS	800.0	464.0	853.0	Rochester TV License Company, LLC	29.95
KSMQ-TV	20	PBS	319.2	305.0	717.0	KSMQ Public Service Media, Inc.	44.92
KAAL	36	ABC	620.0	328.0	740.0	KAAL-TV, LLC	44.92
KXLT-TV	46	FOX	220.0	345.0	757.0	Sagamorehill of Minnesota Licenses, LLC	44.92
KSMQ-TV	20	PBS	319.2	305.0	717.0	KSMQ Public Service Media, Inc.	44.92

Table 3: Summary of Operational Television Stations with the Potential of Degraded Coverage

Comsearch performed an impact assessment with respect to OTA coverage based on the maximum heights reached by the wind turbine blades relative to the broadcast antenna centerlines of the six television stations in Table 3. Using digital terrain elevation data with 30-meter resolution, Comsearch determined whether the overall peak height of the rotating blades would exceed that of any of the television broadcast antennas and thereby cause total blockage on a certain azimuth. Since each wind turbine stands at 138 meters AGL, and given that the tallest wind turbine in the project is located on a ground elevation of 393 meters, its blade tip above mean sea level (AMSL) would reach up to 531 meters. Therefore, all six of the stations above are at least 185 meters higher than any of the proposed wind turbines above mean sea level.

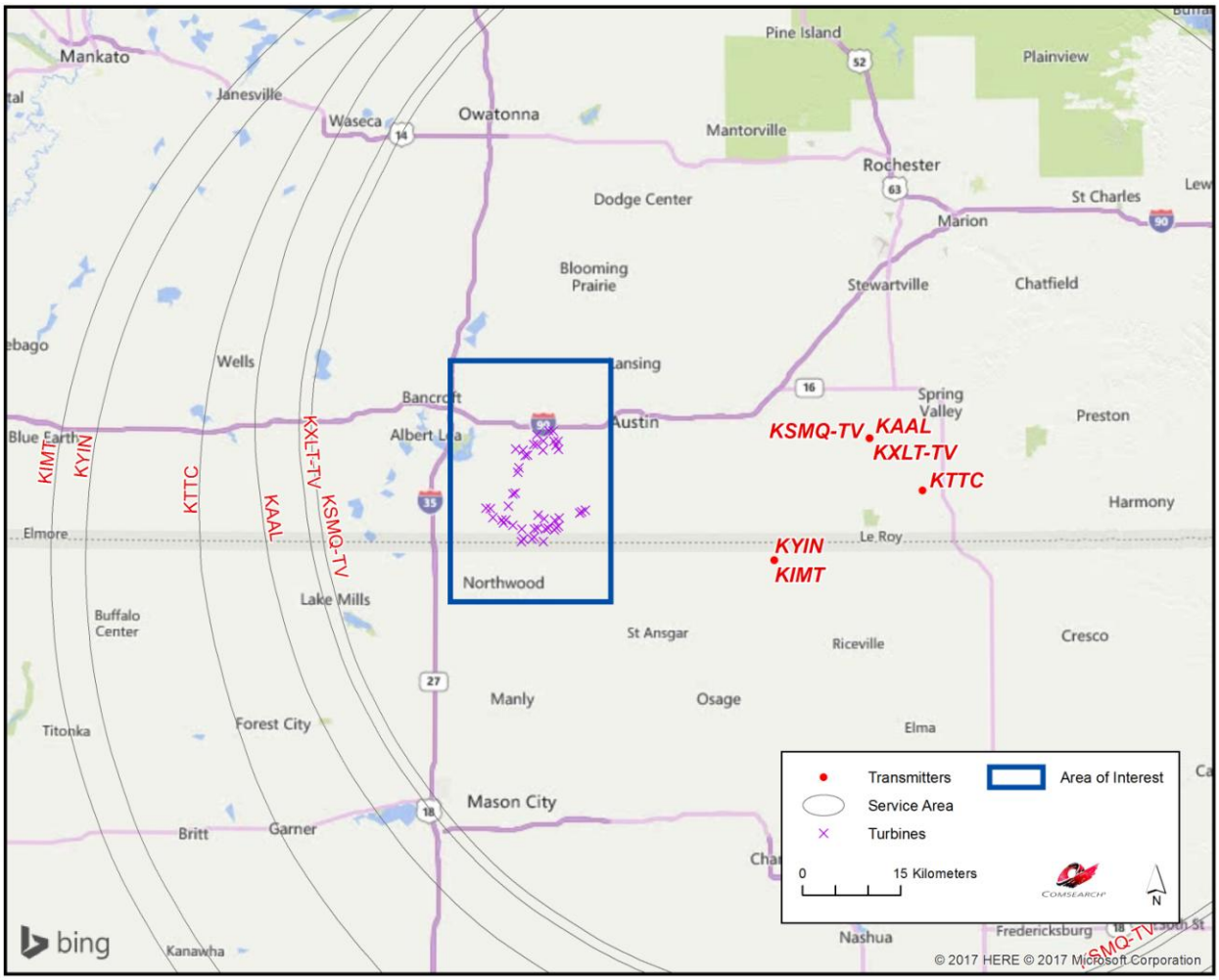

Figure 3: Plot of OTA TV Stations with Service Contours Overlapping Turbines

Compared to the obstruction potential of the proposed wind turbines, their scattering effects are generally considered to have a more significant impact to television signal reception. When signals are reflected and scattered by the wind turbines, they have a potential to cause multipath interference to the direct signal transmitted by the stations to a given receiver. The six stations listed in Table 3 are depicted in Figure 3 above along with their television coverage contours. Areas within the contours that are especially susceptible to this interference are those where the receiver antenna is within 10 kilometers and has line-of-sight to a wind turbine but no line-of-sight to the serving television station. These areas are depicted in Figures 4 through 9 as hashed regions and labeled as “At-Risk” areas. After the wind turbines are installed, communities and homes in these locations may experience degraded reception of the affected television station(s). The severity of the interference at a given receiver in these areas is a function of the receiver itself, the type and configuration of the receiver antenna, the orientation of the wind turbine, and other signal propagation factors. That being said, it should be noted that no disruption will occur to television service from cable company providers or direct broadcast satellite (DBS) service.

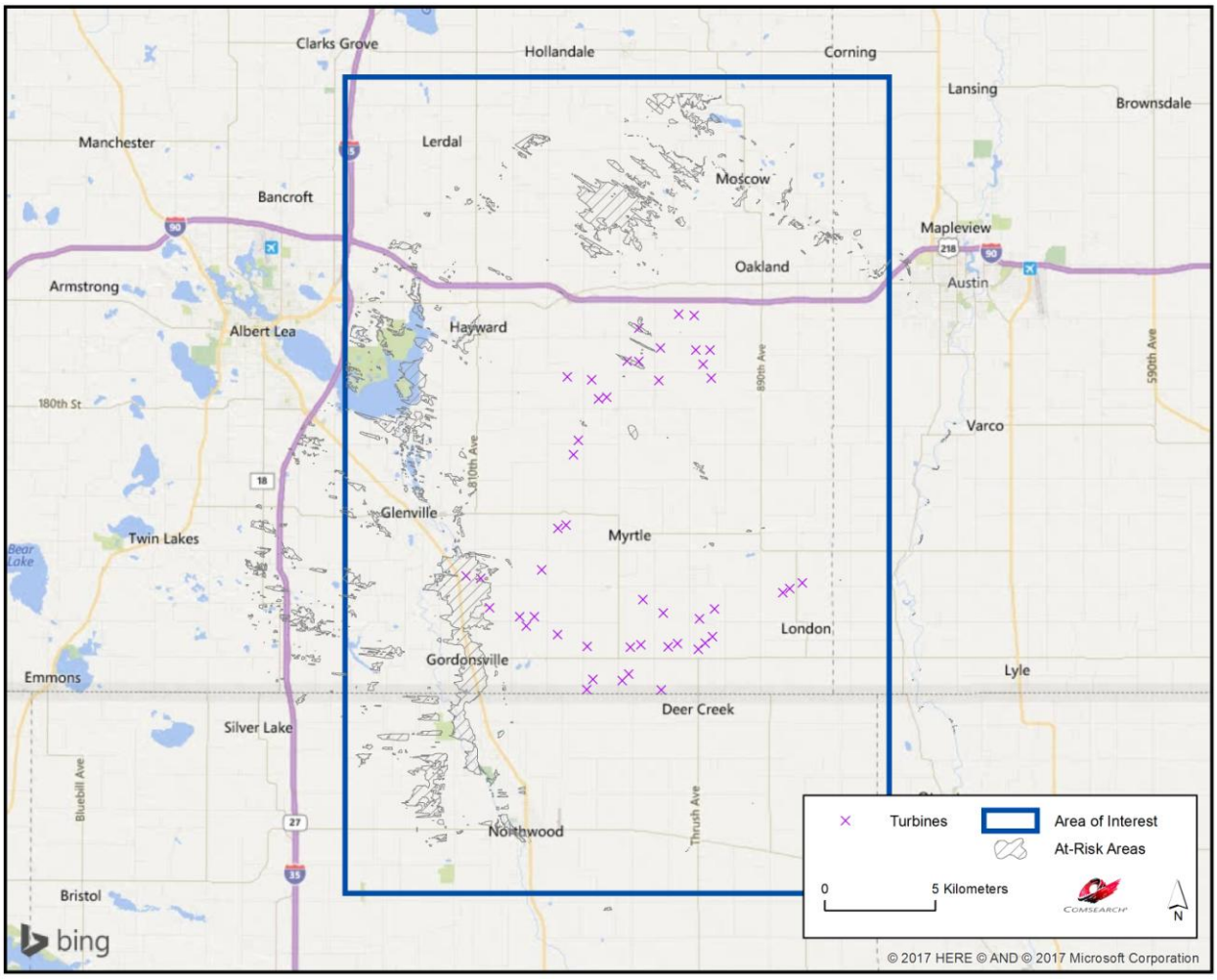

Figure 4: Areas Served by KYIN Station Potentially Impacted by Signal Scattering

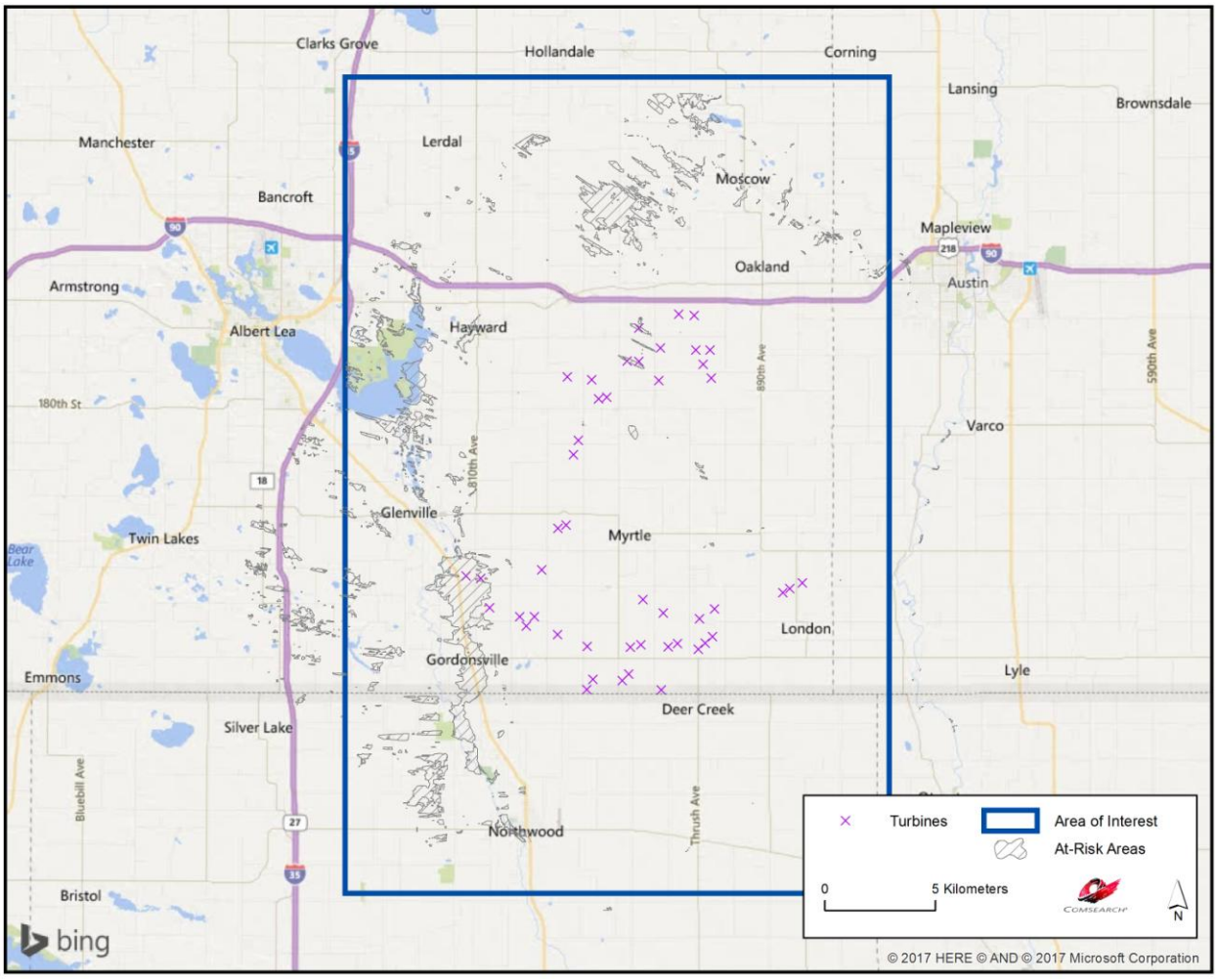

Figure 5: Areas Served by KIMT Station Potentially Impacted by Signal Scattering

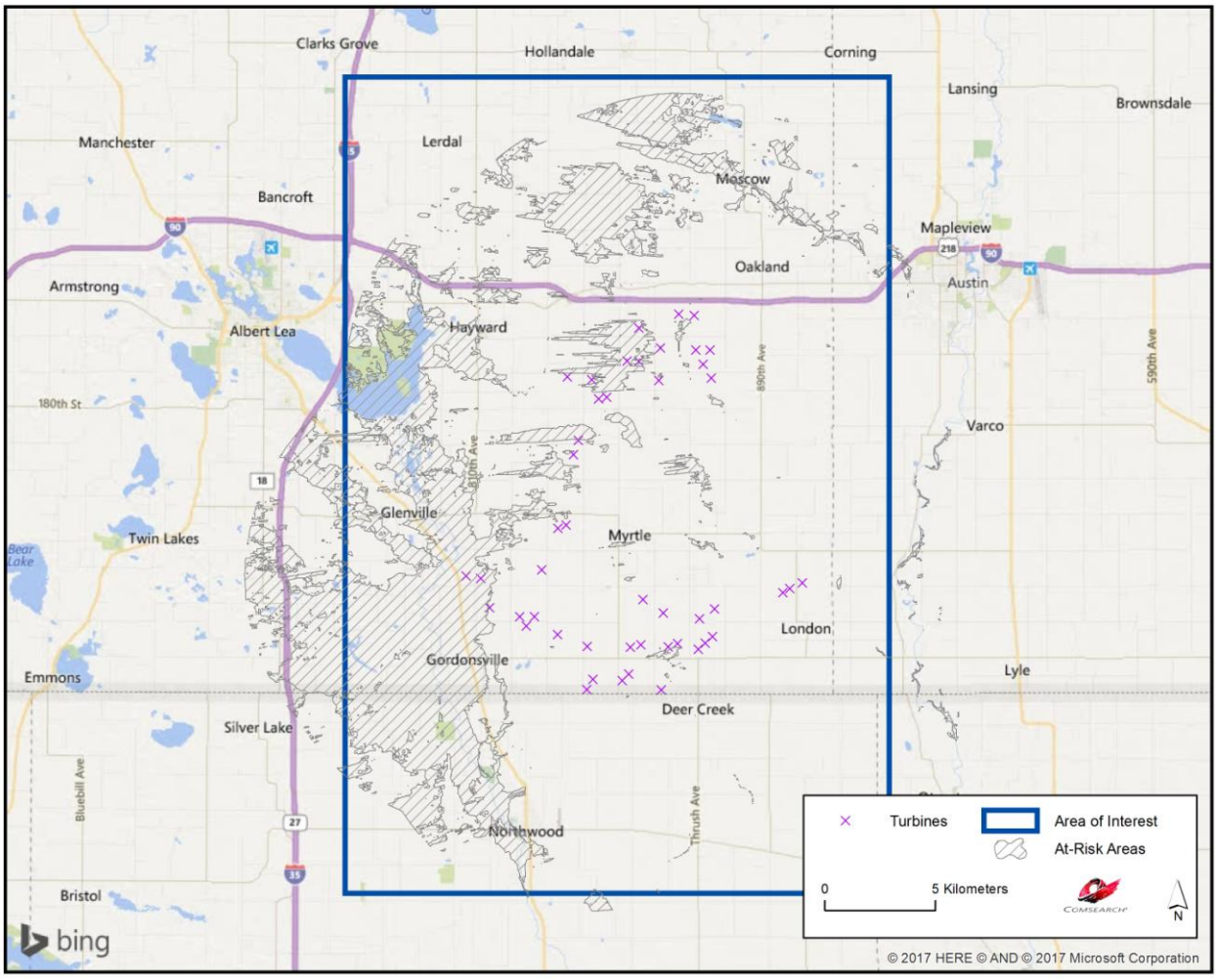

Figure 6: Areas Served by KSMQ-TV Station Potentially Impacted by Signal Scattering

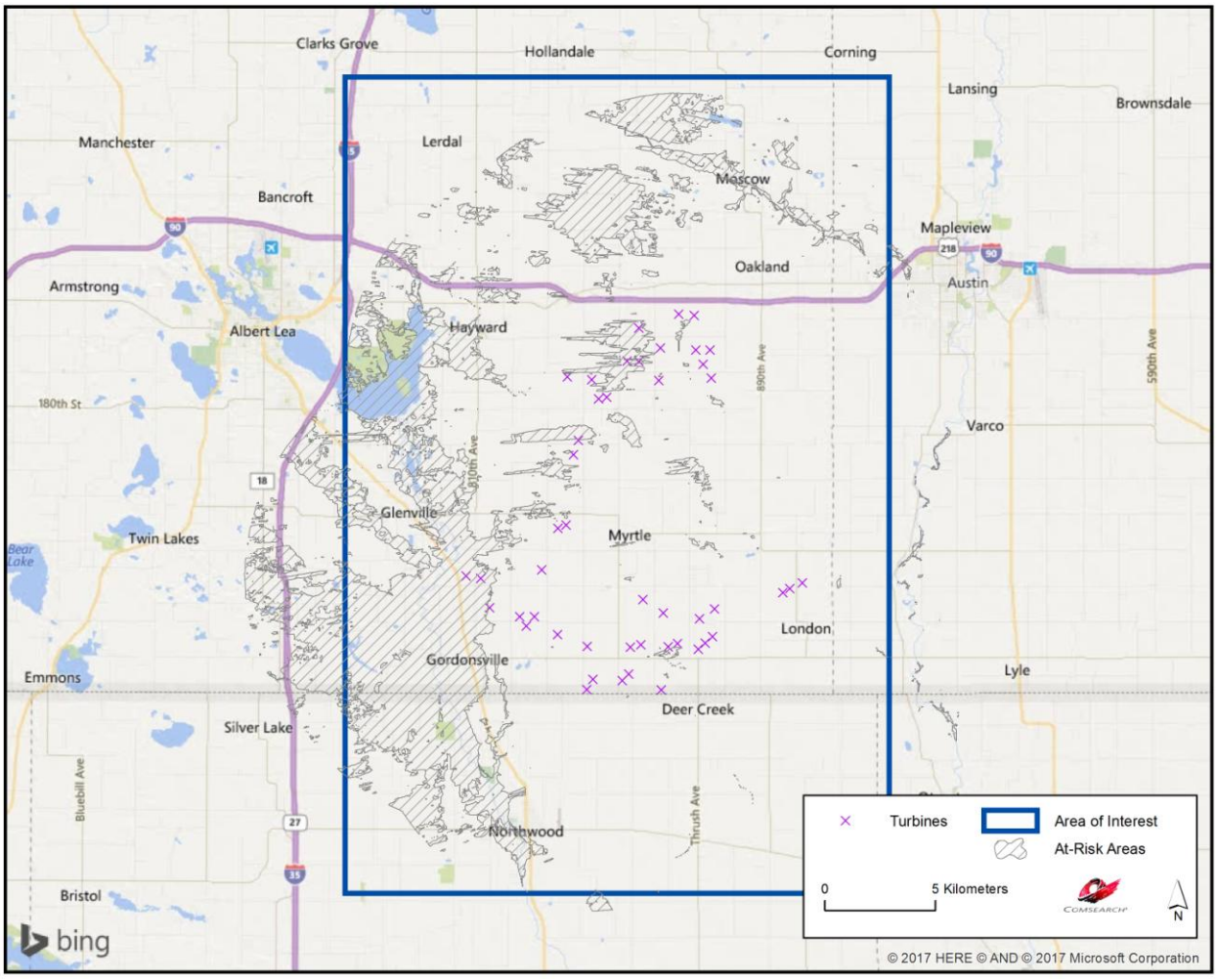

Figure 7: Areas Served by KAAL Station Potentially Impacted by Signal Scattering

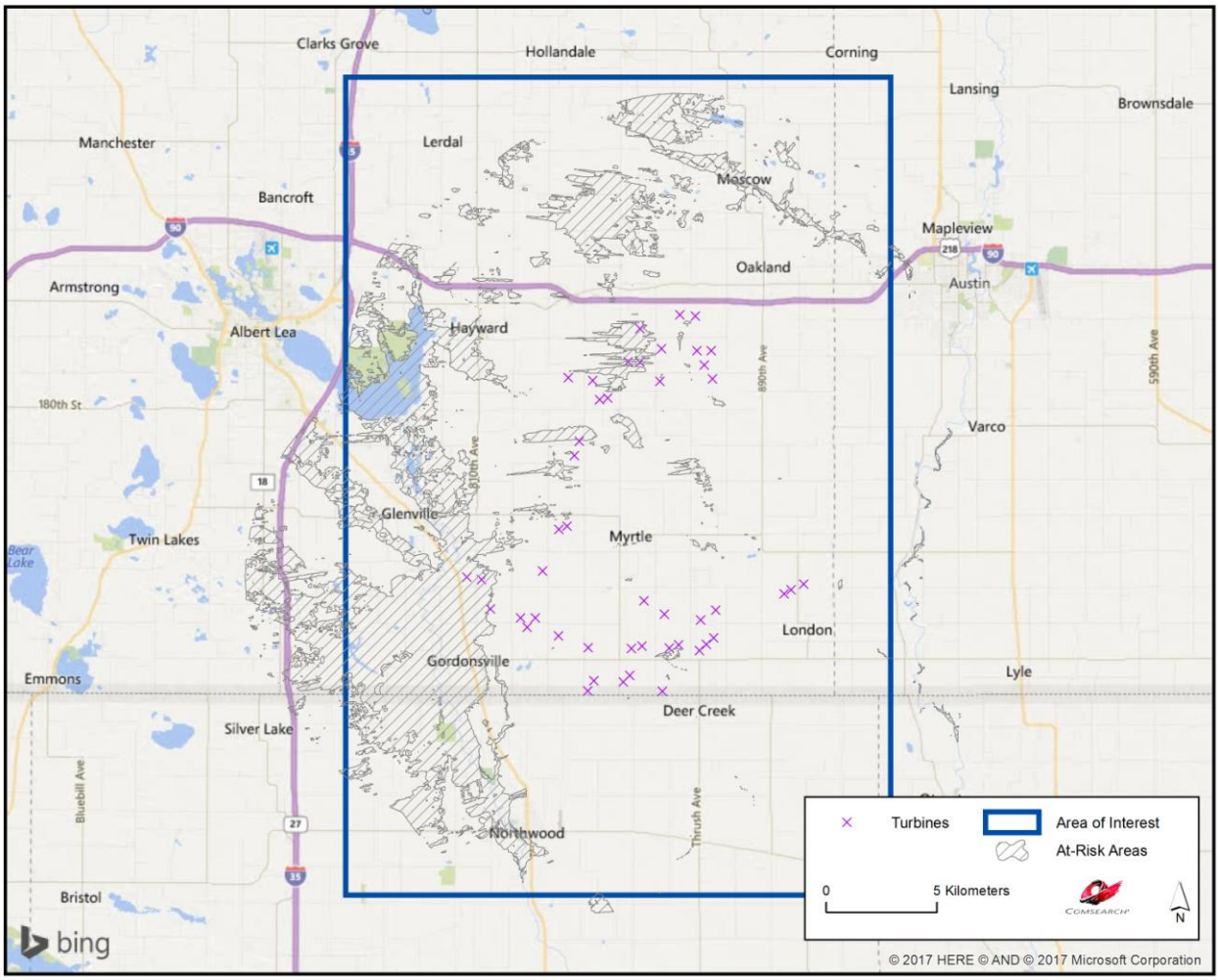

Figure 8: Areas Served by KXLT-TV Station Potentially Impacted by Signal Scattering

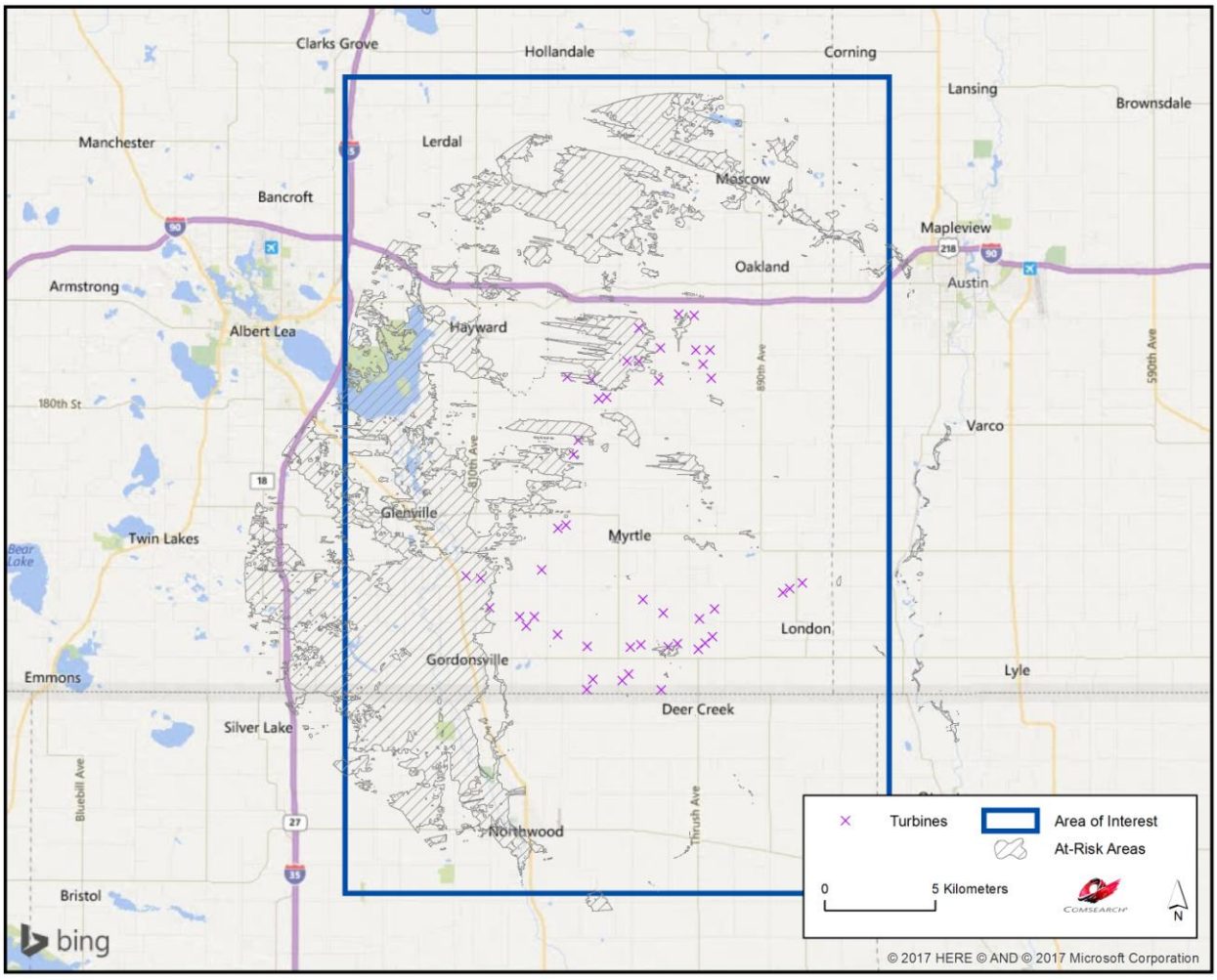

Figure 9: Areas Served by KTTC Station Potentially Impacted by Signal Scattering

Demographic Analysis

This analysis is based on the 2010 United States Census Block data for population and households in the vicinity of the project area. Our findings indicate that the proposed wind turbines have the potential to partially or fully impact 411 census blocks.

In reviewing the census data, it was determined that the most meaningful analysis for interpreting at-risk television reception could be gleaned by examining household data for the impacted census blocks. It is households that typically comprise the viewing audience for a television broadcast entity and their numbers better represent actual viewership than local overall population or broadcast station area coverage. The 411 census blocks intersecting the impacted areas have a total household count of 867. These households are clustered primarily in the towns of Glenville, Gordonsville, Hayward, and Northwood.

Table 4 below shows the estimated number of households served by each television station within their respective coverage contours. Based on the affected areas identified in the above figures, Comsearch then estimated the number of households potentially at risk of degraded OTA television service due to signal scattering and multipath interference. The results show that the station with the highest risk potential is KSMQ-TV for which approximately 187 households or roughly 0.35% of its viewing audience could be affected. Since households can receive more than one OTA television channel, many of those potentially "at-risk" for one station in Table 4 could also be "at-risk" for another station.

Call Sign	Service Area (km^2)	Affected Area (km^2)	Number of Households Served[8]	Number of Potentially At-Risk Households[3]	Percent of Audience Affected
KYIN	24693.48	37.52	66993	40	0.06%
KIMT	23851.54	34.20	77804	40	0.05%
KSMQ-TV	37848.83	188.02	53798	187	0.35%
KAAL	34267.08	167.54	63612	151	0.24%
KXLT-TV	28646.88	153.47	54496	131	0.24%
KTTC	38621.12	198.33	88610	186	0.21%

Table 4: Percentage of Television Station At-Risk Household Coverage

There are two distinct consequences of multipath interference that must be considered in evaluating the overall impact to the identified areas. The first consequence is on the viewing audience and whether it would deprive coverage to those who are dependent on OTA television service. The second consequence is on the television stations themselves and how interference would affect their business profile due to the impacted areas.

In evaluating the business impact on the six stations whose coverage could be impacted by the wind turbines, the household estimates in Table 4 are adjusted to 25% of the actual census count data. This adjustment is based on market research which pertains to how the US population chooses to receive television service across the country. In determining how many of the households could be affected by the wind turbines, it is important to consider information about OTA television usage that was published in an article on July 2016. Released by an independent research company, GfK, the article reported that "17% of US TV households now rely on broadcast-only (a.k.a. "over-the-air" or OTA) reception." The study further stated that 25% of US households were without cable or satellite TV. Of the two figures, the higher percentage was used in estimating the household counts in Table 4 in order to include all households that do not rely on cable or direct broadcast satellite (DBS) providers for TV service.

[8] This number was derived by applying a factor of 25% to the household census data, which is meant to approximate the portion of households that do not subscribe to cable or satellite TV service. (source)

4. Recommendations

Comsearch performed a geographic and demographic analysis of the over-the-air television stations that service the communities in and around the Freeborn Wind Farm project area. The analysis examined the coverage contours for each of the operational television stations and determined the areas where coverage degradation or multipath interference could occur due to signal scattering from the planned wind turbines. These areas were plotted and shown in Section 3.

While OTA television service could be impacted by wind turbines in the form of multipath interference at the television receiver, modern digital television receivers have undergone significant design improvements to mitigate the effects of interference due to signal scattering. When used in combination with a high-gain directional antenna, the receiver further enhances the signal and thus becomes more robust against an environment with multipath interference. Therefore, where there is a potential for multipath interference due to the presence of wind turbines, Comsearch recommends the use of a high-gain directional antenna, preferably outdoors, and oriented towards the television tower location in order to mitigate the impact.

For each of the six television stations listed in Table 4, Comsearch estimated that less than 0.5% of the served households could be impacted by the wind turbines. Potential degradation of coverage for this population could translate to loss of revenue for the respective stations since their normal revenue stream is based on advertising which, in turn, is based on the number of households reached. The impact on coverage, if it occurs after the project is built, could be mitigated with the installation of low-power translator stations, the design and planning of which is beyond the scope of this report. The objective of the translator station would be to re-broadcast an affected station's programming in the areas where interference issues could not be resolved by installing a high-performance outdoor antenna for the affected households.

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 OTA television reception has been disrupted by the presence of the wind turbines after they are installed.

5. Contact

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