



**ENGINEERING REPORT
CONCERNING THE EFFECTS UPON
FCC LICENSED RF FACILITIES
DUE TO CONSTRUCTION OF THE
GREAT PATHFINDER WIND ENERGY PROJECT
In
BOONE & HAMILTON COUNTIES, IOWA**

**Prepared for
Apex Clean Energy
Lake Elmo, Minnesota**

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I. INTRODUCTION

This engineering report describes the results of a study and analysis to determine the locations of federally-licensed (FCC) microwave and fixed station radio frequency (RF) facilities that may be adversely impacted as a result of the construction of the Great Pathfinder Wind Energy Project in Boone and Hamilton Counties, Iowa. This document describes impact zones and any necessary mitigation procedures, along with recommendations concerning individual wind turbine siting. All illustrations, calculations and conclusions contained in this document are based on FCC database records¹.

Frequently, wind turbines located on land parcels near RF facilities can cause more than one mode of RF impact, and may require an iterative procedure to minimize adverse effects. This procedure is necessary in order to ensure that disruption of RF facilities either does not occur or, in the alternative, that mitigation procedures will be effective. The purpose of this study is to facilitate the siting of turbines to avoid such unacceptable impact.

The Great Pathfinder Wind project as currently planned involves the construction of up to 74 wind turbines just southeast of the city of Stratford, in northern Boone County and southwestern Hamilton County, Iowa. The wind turbines proposed to be erected will have a hub height of 98 meters and a rotor diameter of 140 meters. The maximum blade tip height therefore would be 168 meters AGL.

Using industry standard procedures and FCC databases, a search was conducted to determine the presence of any existing microwave paths crossing the subject property, land mobile and other RF facilities within or adjacent to the identified area and broadcast signals receivable in the area.

¹ The databases used in creating the attached tables and maps are generally accurate, but anomalies have been known to occur. Generally, for wind turbine siting, an on-site verification survey is often suggested as part of the due diligence process.



A specific turbine layout has been submitted for analysis. Accordingly, this report will address the potential conflicts that may be caused by the proposed turbines.

The following tabulation and analysis consists of four sections:

1. Microwave point-to-point path analysis²
2. Land mobile, public safety and other communications tower sites
3. Broadcast AM, FM and TV
4. Radar and NTIA Notification

The attached figures were generated based upon the operating parameters of the FCC-licensed stations as contained in the FCC station database, with corrections of the antenna locations as needed.

The following analysis examines the pertinent FCC licensed services in the area for impact. This analysis assumes that all licensed services have been designed and constructed according to FCC requirements and good engineering practice. If this is not the case, the impacted facility must share responsibility with the wind project developer for the costs of any mitigation measures³.

Each of the RF analyses is described separately in the sections that follow.

II. ANALYSIS OF MICROWAVE LINKS

An extensive analysis was undertaken to determine the likely effect of the new wind turbine farm upon the existing microwave paths, consisting of a Fresnel x/y/z axis study. The microwave paths have been overlaid on Google Earth™ maps, and the images of the microwave paths and the proposed turbines are also available in a KMZ file.

Important Note: Microwave path studies are based upon third party and FCC databases that normally exhibit a high degree of accuracy and reliability. Although Evans performs due diligence to ensure that all existing microwave facilities are represented, we cannot be responsible for errors in FCC databases that may lead to incomplete results. However, should such situations occur, Evans would perform an engineering analysis to determine how the additional facilities can be accommodated or, if wind turbine structures are already built, determine a method to re-direct an impacted beam path.

² Only point-to point microwave facilities were considered (for instance, a study of earth station facilities is not included).

³ For instance, some microwave paths may have insufficient ground clearances as they are presently configured.



For this microwave study, *Worst Case Fresnel Zones* (WCFZ) were calculated for each microwave path. The mid-point of a microwave path is the location where the widest (or worst case) Fresnel zone occurs. The radius R of the Worst Case Fresnel Zone, in meters, is calculated for each path using the following formula:

$$R \cong 8.65 \sqrt{\frac{D}{F_{GHz}}}$$

where D is the microwave path length in kilometers and F_{GHz} is the frequency in gigahertz.

In general, the WCFZ is defined by the cylindrical area whose axis is the direct line between the microwave link endpoints and whose radius is R as calculated above. This is the zone where the siting of obstructions should be avoided. Evans Engineering Solutions has identified 6 unique licensed microwave links from the FCC database that are within 2 miles of the project area. These microwave links are listed in Table 1 and mapped in Figures 1 through 4.

Call Sign 1	Call Sign 2	Site 1 Name	Site 2 Name	Freq. (MHz)	WCFZ (m)	Licensee
WPSS723	WQOX693	Stanhope	Stratford	6063.8/6315.84	12.3	USCOC of Greater Iowa, LLC
WQQH317	WQQH355	Mackey	Water Tower	11035/11525	9.6	County of Boone
WQQQ931	WQQQ932	Stratford	Coalville	6063.8/6315.84	17.6	Verizon Wireless, LLC
WQWN958	WQWN959	InfoBunker	VastIP	10995-11565	10.8	Mark Hermanson
WQWN958	WRAC750	InfoBunker	Sansguard	10855/11345	7.3	Mark Hermanson
WREI725	WREI731	DM02029A	DM04045A	6093.45/6345.49	18.4	T-Mobile License, LLC

Table 1 – Active Microwave Links in and near Great Pathfinder Project Area

As can be seen in Figures 1 through 4, the microwave paths listed in Table 1 do not cross the areas where there will be turbines. Thus, no significant constraints on turbine siting within the project area are imposed by FCC-licensed microwave paths.

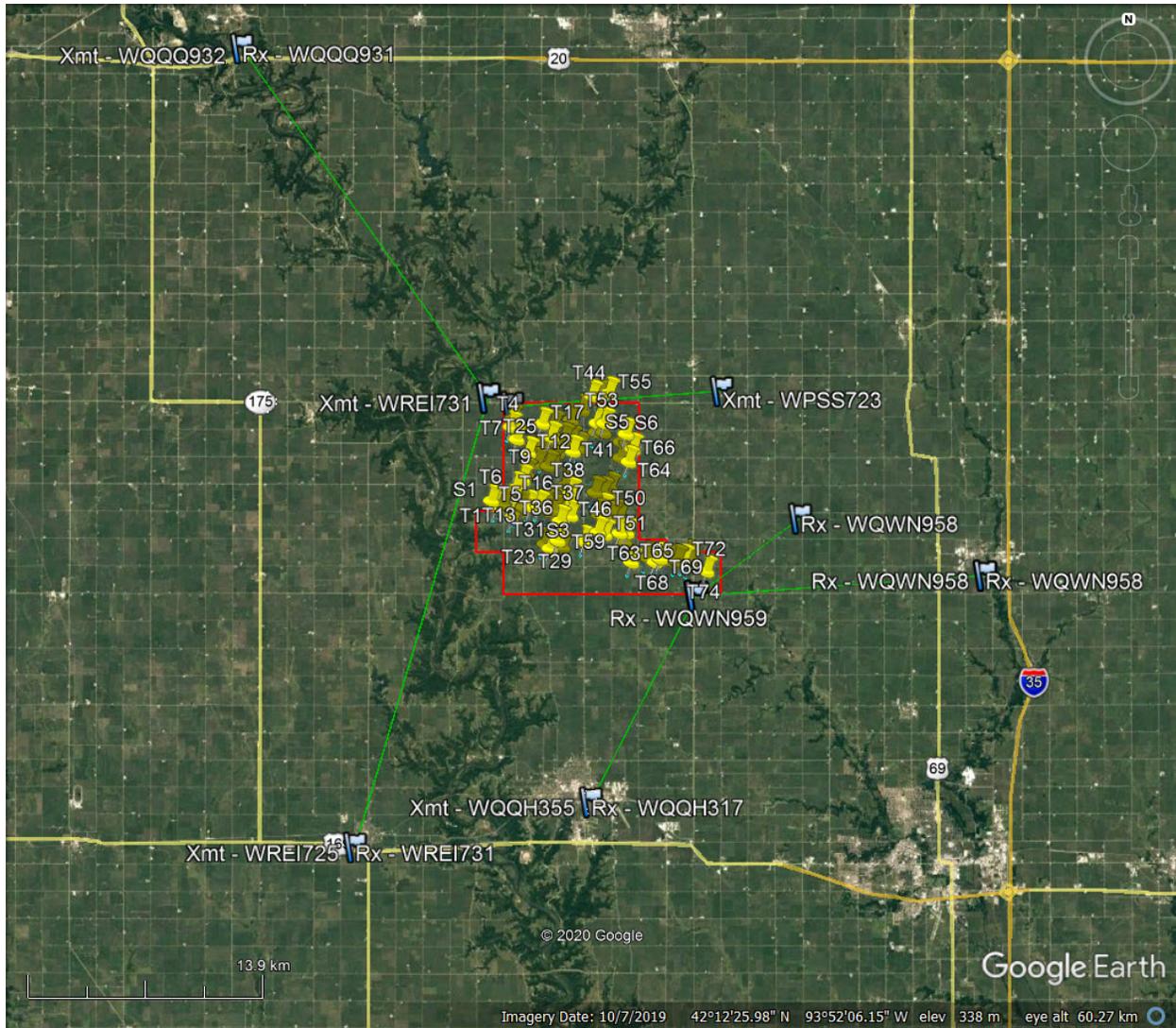


Figure 1 – Licensed Microwave Paths in or near Great Pathfinder Project Area

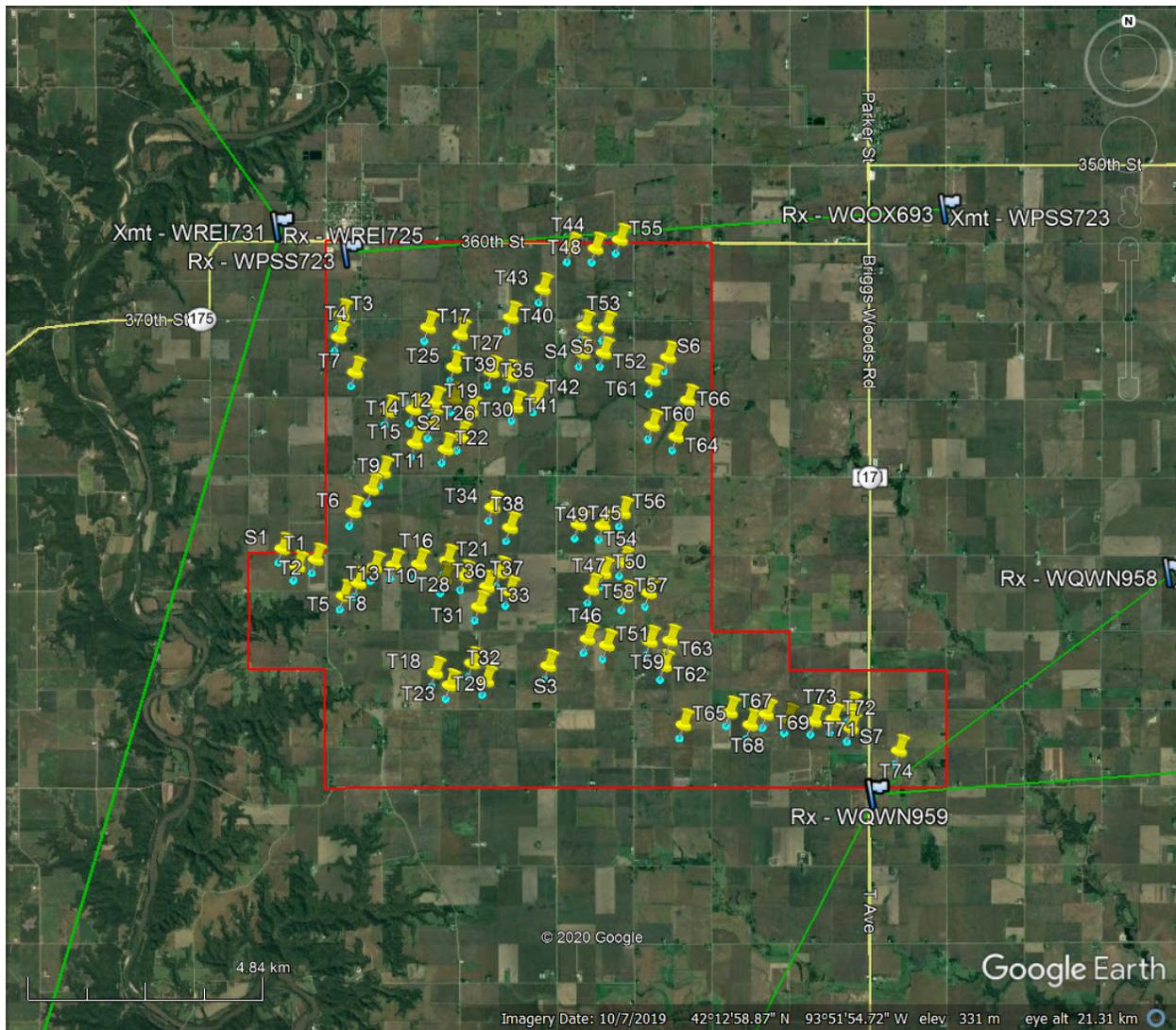


Figure 2 – Close-Up of Licensed Microwave Paths in or near Great Pathfinder Project Area

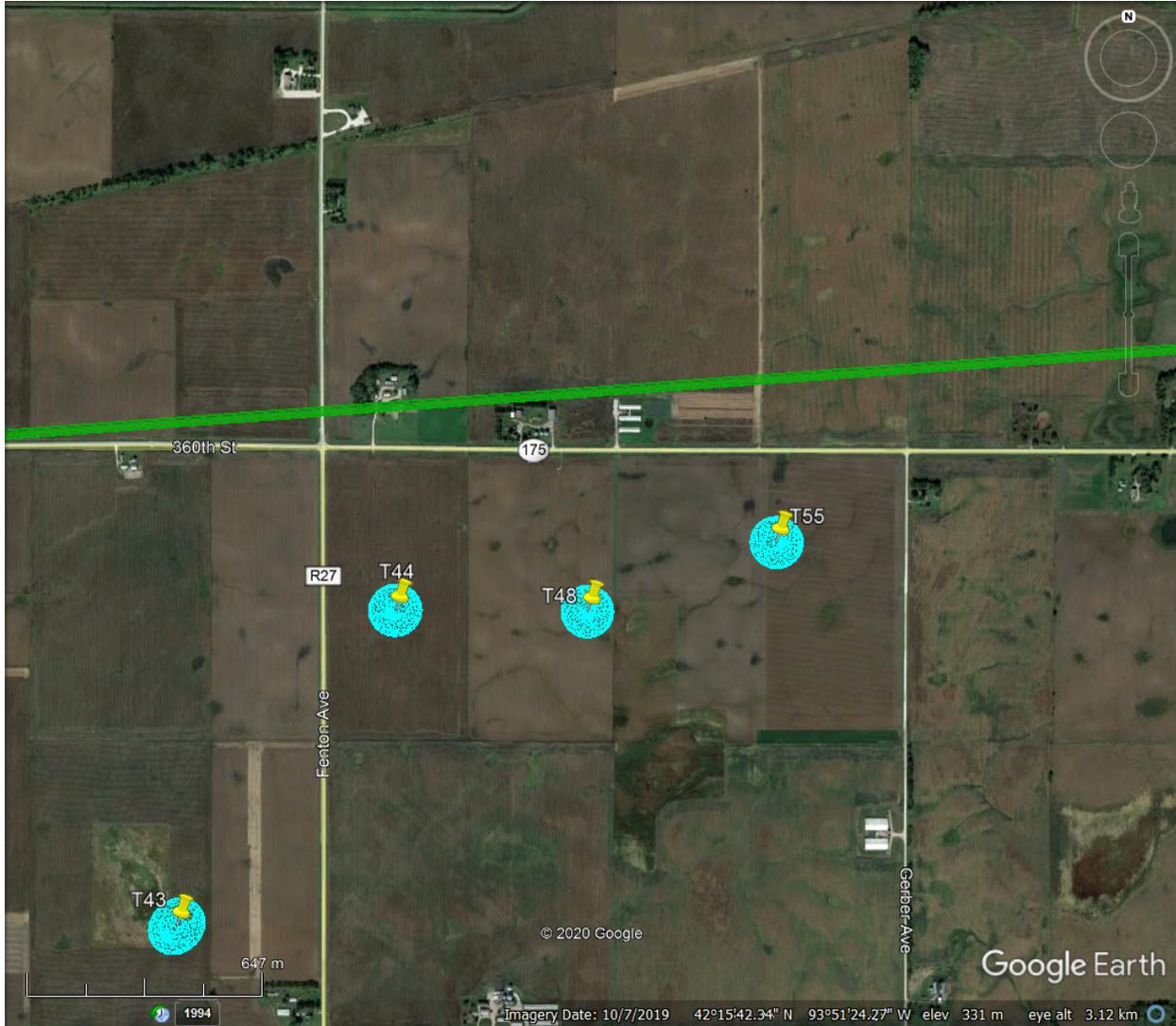


Figure 3 – Microwave Path WPSS723/WQOX693 near northernmost Turbines



Figure 4 – Microwave Path WQWN958/WRAC750 near Turbine 74



III. ANALYSIS OF FIXED RADIO FACILITIES

3.1 Land Mobile & Public Safety Facilities

A search of the FCC’s land mobile/public safety radio database revealed 7 land mobile transmitter stations that fall within the search area (about two miles beyond the project area boundaries). Three of the land mobile sites are each shared by two land mobile stations; thus, there are 4 unique land mobile sites in the search area. These land mobile stations are listed in Table 2 and mapped in Figures 5 and 6. The specifications on the land mobile stations can be found in the associated land mobile (LM) spreadsheet file.

One land mobile site, where stations WQDL877 and WQPZ737 (highlighted in yellow in Table 2) are located, is immediately adjacent to the project area and is near planned Turbine Site 74 (see Figure 6). Multi-directional transmitting facilities, including land mobile stations, that are within 450 meters of a turbine site customarily should be further evaluated for the possibility of transmitter interference caused by wind turbines. It appears from Figures 5 and 6 that none of the land mobile stations in the project area search are less than 450 meters from the nearest planned turbine.

The reader is referred to the provided KMZ file for more magnification and closer inspection.

Based on the current project layout, and assuming that the land mobile stations in and near the project area are actually located at their licensed locations, or located farther away from turbines, no adverse impact is expected to be caused to the transmissions of land mobile stations, including public safety stations, that are known to be in the area.

Call Sign	Latitude (NAD-83)	Longitude (NAD-83)	Ant. Ht. (m AGL)	Freq. (MHz)	Licensee
WQYW313	42.239389	-93.944917	15	451.925	Bergquist, Scott
KNBD613	42.270444	-93.927389	12	154.28	Stratford, Town of
WNPA805	42.270444	-93.927389	12	154.085	Stratford, Town of
WPRF504	42.151915	-93.893333	6.1	173.39	Xenia Rural Water District
WPTM573	42.151915	-93.893333	9.1	173.39	Xenia Rural Water District
WQDL877	42.165368	-93.793934	36.6	154.4	Boone, County of
WQPZ737	42.165368	-93.793934	36.6	151.4675	Boone, County of

Table 2 – Land Mobiles Stations within 2 Miles of Project Footprint

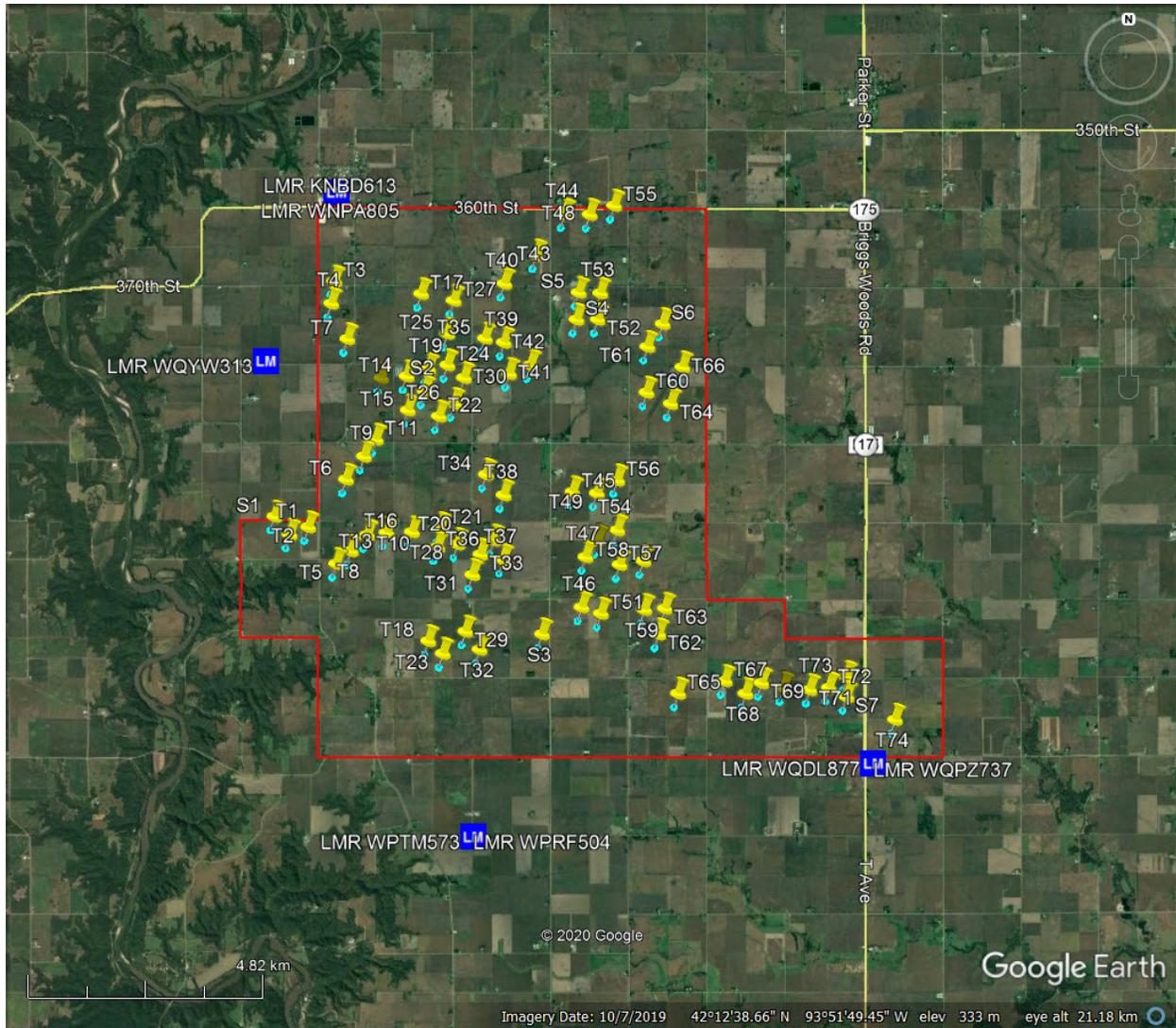


Figure 5 – Land Mobile Stations in or near Great Pathfinder Project Area

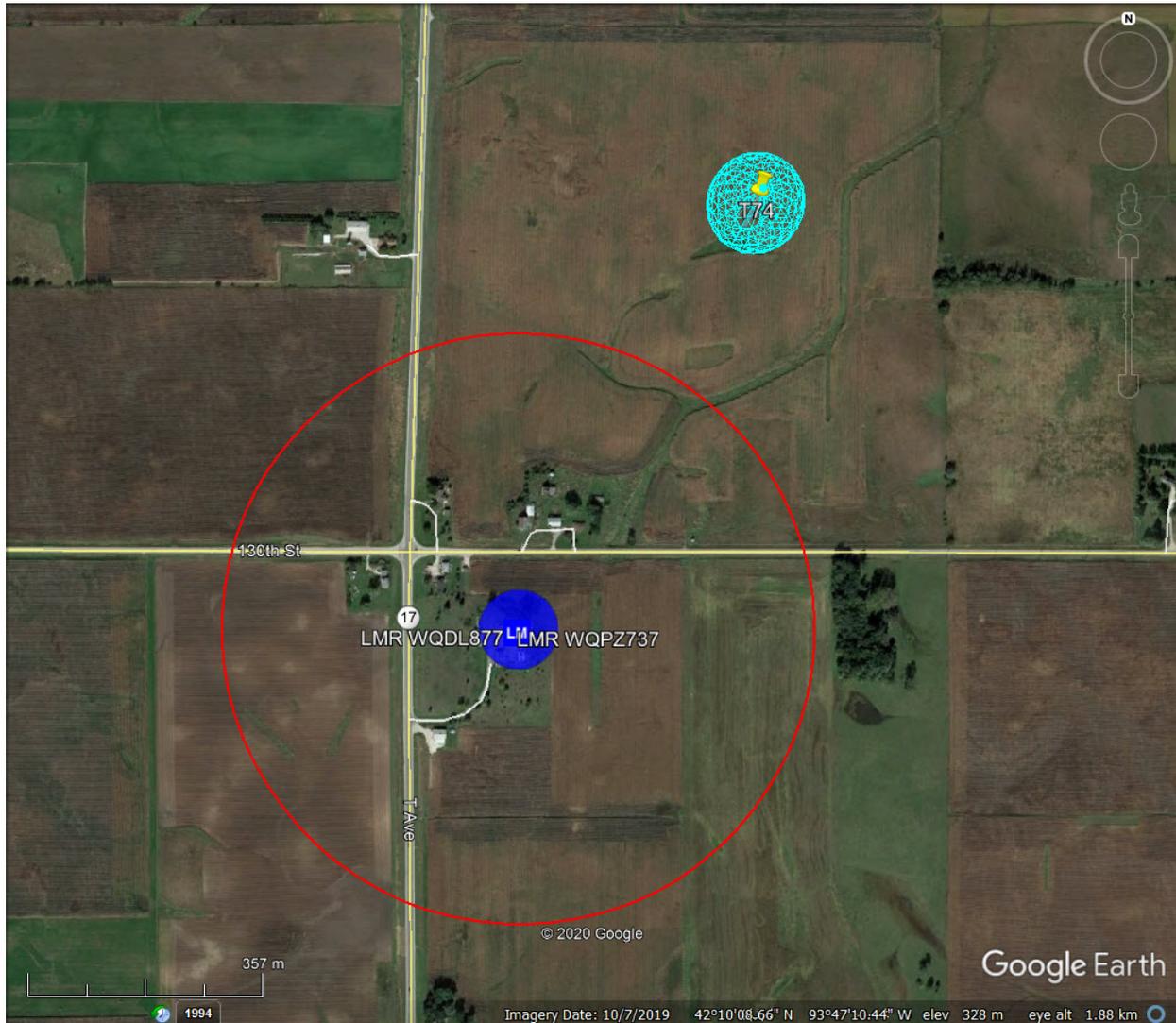


Figure 6 – Close-Up of Land Mobile Stations WQDL877 & WQPZ737 near Proposed Turbine 74

The red circle represents a suggested 450-meter turbine clearance from the land mobile site. This site is the location of the unregistered tower listed in Table 3 of this report.



3.2 Other Communications Sites

A search through the FCC registered antenna structures database and FCC license databases reveal communications towers located within five miles of the project footprint, which are listed in Table 3 and mapped in Figure 7. The antenna structure location closest to the project area is shown in Figure 6.

As mentioned previously, multi-directional transmitting facilities within 450 meters of a planned turbine customarily should be further evaluated for the possibility of turbine-related transmitter interference. The Great Pathfinder project is not expected to cause any turbine-related signal transmission problems to multi-directional transmitting facilities located at any of the tower sites listed in Table 3 and shown in Figures 6, 7 and 8, since the closest tower to the project, the unregistered tower listed in Table 3 below, which is used by Boone County and BTWI, a wireless broadband provider, is 710 meters from the nearest planned turbine (Turbine 74, see Figure 6).

FCC ASR Registr. #	Owner	Location	Latitude	Longitude	Height AGL (m)
1222004	United States Cellular Corp.	Stanhope, IA	42-16-25.4N	093-46-32.4W	105.1
1232418	Cellco Partnership (Verizon)	Stratford, IA	42-16-13.1N	093-56-33.4W	79.2
1238633	Xenia Rural Water District	Stratford, IA	42-18-37.0N	093-53-01.0W	63.4
1276031	United States Cellular Corp.	Stratford, IA	42-15-56.3N	093-55-31.5W	79.2
1308877	FTC Tower Co, LLC	Stanhope, IA	42-16-04.7N	093-48-23.7W	93.0
<i>Not Regist.</i>	<i>Unknown</i>	Boone, IA	42-09-55.6N	093-47-38.6W	42.7

The listed coordinates for the above structures are from documents filed with the FCC and have not been verified by this consultant. Green-shaded records indicate towers containing microwave and/or land mobile facilities documented in Sections II and III of this report.

Table 3 – FCC-Notified Communications Towers within 5 miles of Project Footprint

The list in Table 3 is not necessarily a complete list of communications towers in the search area. Most antenna structures that don't exceed 200 feet (61 meters) in height do not have to be registered with the FCC and many radio transmitting base stations that are located on towers, including cell towers, don't require FCC licenses for specific locations. Only an on-site visual survey would determine the existence of all communications towers in the search area.

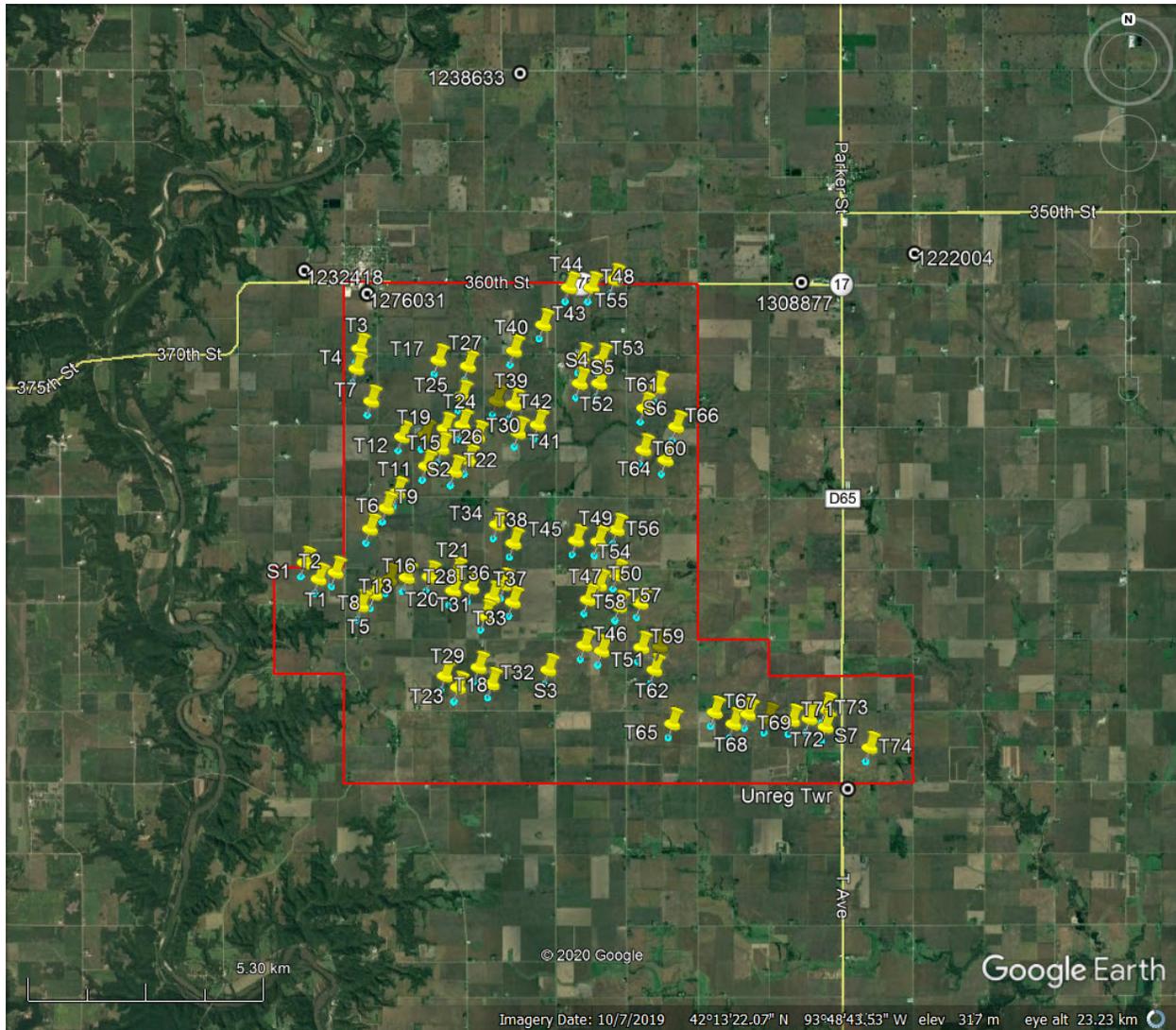


Figure 7 – FCC-Notified Antenna Towers within 5 miles of Project Footprint

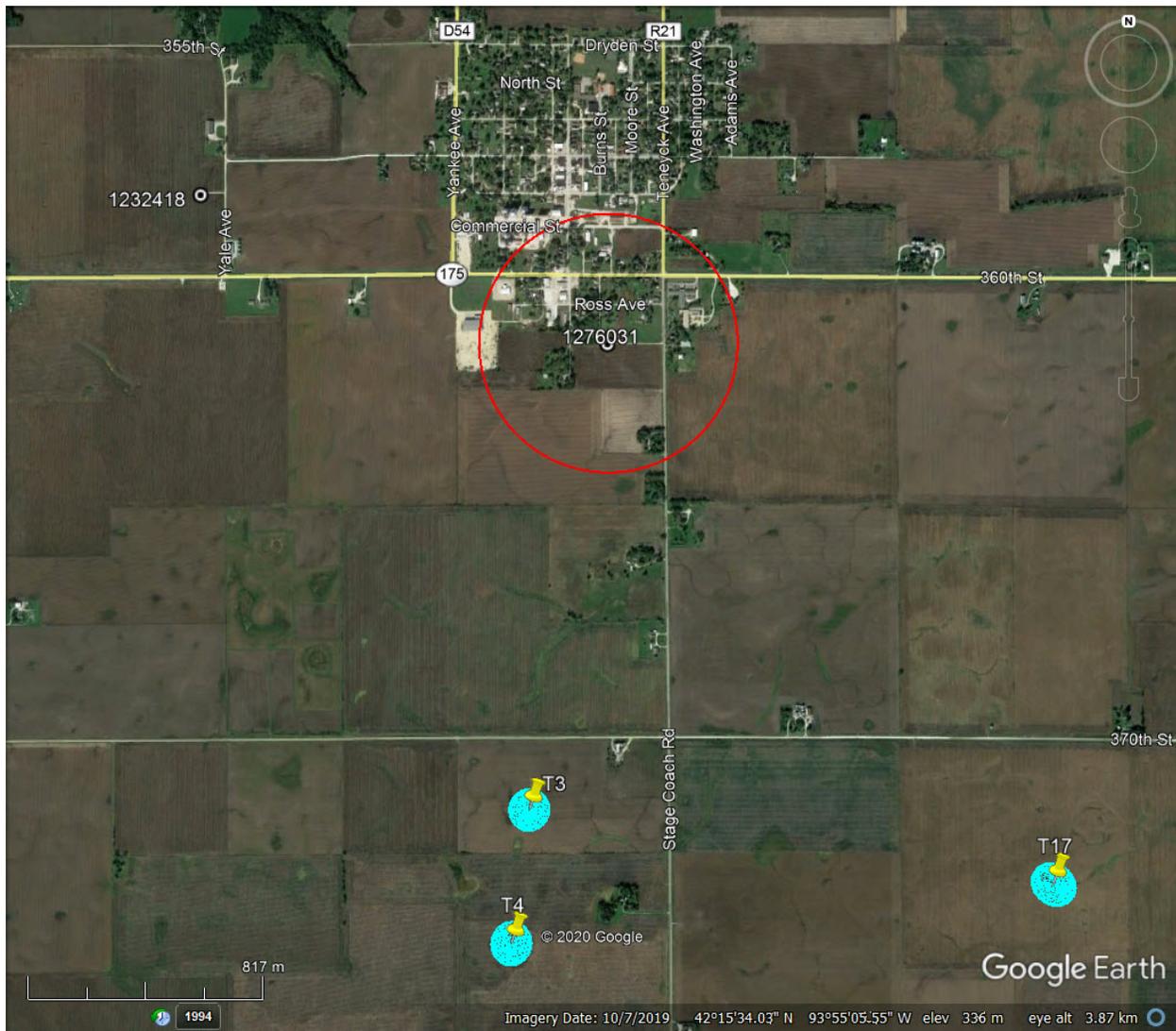


Figure 8 – FCC-Documented Antenna Structure (ASR 1276031) closest to Turbines

The red circle represents a recommended 450-meter suggested turbine clearance.



IV. ANALYSIS OF BROADCAST FACILITIES

4.1 TV Broadcast Facilities

The rotating blades of a wind turbine have the potential to disrupt over-the-air broadcast TV reception within a few miles of the turbine, especially when the direct path from the viewer's residence is obstructed by terrain. Interference is caused when signals reflected by the blades arrive at the viewer's TV antenna along with the direct signal. This is known as "multipath interference." However, as turbine manufacturers have replaced all-metal blades with blades constructed of mostly nonmetallic materials⁴, this effect has been reduced. Also, the new generation of HDTV receivers is better equipped to deal with minor multipath interference (which is manifested by "pixilating" or "freezing" of the digital picture) than analog TV sets, as special circuitry is employed to suppress the reflected signal. Occasionally, however, multipath interference from one or more turbines can cause video failure in HDTV receivers, especially if the receiver location is in a valley or other place of low elevation.

There is some possibility of signal disruption for residences that have to point their outdoor antennas through the turbine area, or that utilize "rabbit ear" antennas and/or older HDTV receivers. Most of this effect should be dissipated for locations two or more miles from a turbine, but some residual problems could be noted for HDTV receivers that are located below the grade level at the turbine base. Usually, a worst-case rule of thumb is that approximately 10% of the receiver locations may be affected to some extent within two miles of a large turbine when the turbine is between the TV station and the receiver. The usual effect is intermittent "pixilation" or freezing of the digital TV picture. This estimate is based upon Evans Engineering's experience with similar wind energy projects.

Boone and Hamilton Counties are in the Des Moines-Ames, IA Designated Market Area (DMA), which also includes Fort Dodge, as defined by Nielsen Media Research. All of the high-power TV stations in that market are predicted to reach the wind project area with a satisfactory over-the-air signal. The TV stations that have been determined to place a predicted FCC primary off-the-air service signal over all or part of the project area are listed in Table 4. The TV stations' service area boundaries are mapped in Figure 9.

⁴ Modern turbine blades are usually constructed from glass-reinforced plastic (GRP), although they usually contain some metal for strengthening, balance and grounding.



Call Sign	Type of Service	Network Affiliate	Virtual Channel	Actual Channel	City of License	Power (KW)	Ant. Height (m HAAT)	Dist. (km)	Direction
WOI	Conventional	ABC	5	5	Ames, IA	13.9	566	49.5	SSE
KCCI ⁵	Conventional	CBS	8	8	Des Moines, IA	28.3	597	49.2	SSE
KDIN-TV	Conventional	PBS	11	11	Des Moines, IA	22.5	600	49.5	SSE
WHO	Conventional	NBC	13	13	Des Moines, IA	36.5	600	49.5	SSE
KDSM-TV	Conventional	Fox	17	16	Des Moines, IA	1000	612	47.3	SSE
KDMI ⁶	Conventional	TCT	56	19	Des Moines, IA	839	610	47.3	SSE
KCWI-TV ⁷	Conventional	CW	23	23	Ames, IA	246	610	47.3	SSE
KTIN	Conventional	PBS	21	25	Fort Dodge, IA	600	355	80.9	NW
KFPX-TV	Conventional	ION	39	36	Newton, IA	270	564	49.2	SSE

Table 4 - TV Stations Serving Project Area

If the Great Pathfinder Wind project should cause disruptions to over-the-air TV viewing, methods to resolve them are available, and are as follows:

1. Relocation of the household antenna to receive a better signal
2. Installation of a better outside antenna, or one with a higher gain
3. Installation of satellite or cable TV

It is the opinion of this consultant that any disruptions to over-the-air TV broadcast signals, if they occur, can be resolved satisfactorily.

⁵ KCCI has an application pending at the FCC to increase power to 49.7 KW.

⁶ KDMI has an application pending at the FCC to increase power to 1000 KW

⁷ KCWI-TV has an application pending at the FCC to increase power to 1000 KW.

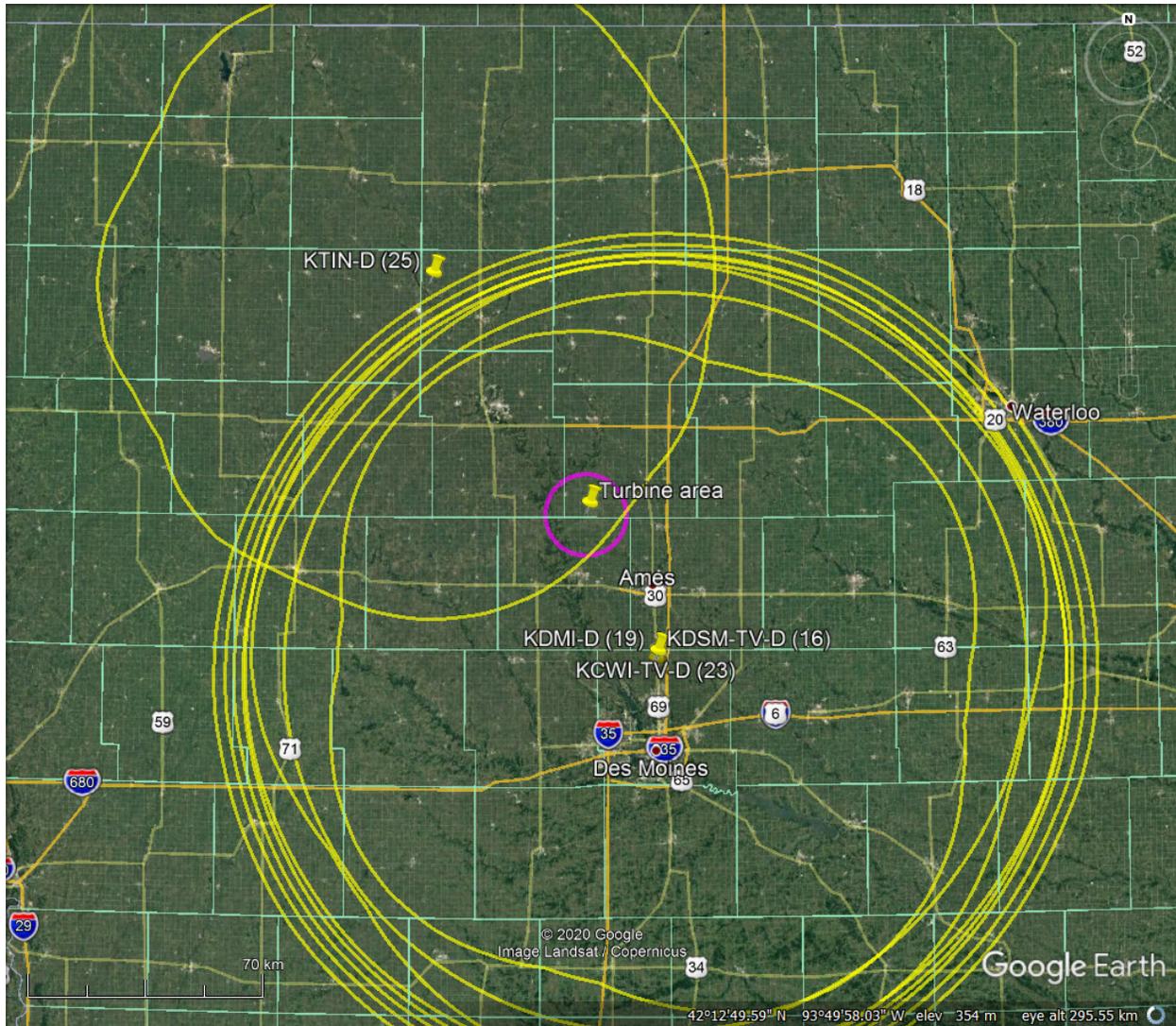


Figure 9 – Predicted Over-the-Air Television Coverage into Great Pathfinder Project Area



4.2 FM Facilities

The full-service FM stations that place a predicted primary signal over at least part of the project area are listed in the following Table 5. The FM stations' service area boundaries are mapped in Figure 10.

Call Sign	Freq. (MHz)	City of License	Power (KW)	Ant. Height (m HAAT)	Dist. (km)	Direction
KJTT	88.3	Story City, IA	1.9	70	24.2	E
KHOI	89.1	Story City, IA	2.75	77	26.6	ESE
WOI-FM	90.1	Ames, IA	100	454	49.5	SSE
KNSK	91.1	Fort Dodge, IA	100	326	80.9	NW
KICG	91.7	Perry, IA	10	109	18.2	SSW
KZLB	92.1	Fort Dodge, IA	6	98	40.9	NW
KJJY	92.5	West Des Moines, IA	41	165	61.9	S
KIOA	93.3	Des Moines, IA	82	325	72.9	SSE
KKEZ	94.5	Fort Dodge, IA	100	183	42.5	NW
KGGO	94.9	Des Moines, IA	100	325	72.9	SSE
KQWC-FM	95.7	Webster City, IA	25	100	28.3	N
KIAQ	96.9	Clarion, IA	100	176	56.2	NNW
KHKI	97.3	Des Moines, IA	105	143	62.1	S
KWQW	98.3	Boone, IA	41	165	44.1	SSE
KDRB	100.3	Des Moines, IA	100	547	47.3	SSE
KJYL	100.7	Eagle Grove, IA	25	100	49.9	NNW
KSTZ	102.5	Des Moines, IA	100	384	50.6	SSE
KOEZ	104.1	Ames, IA	100	308	35.2	S
KCYZ	105.1	Ames, IA	25	100	23.0	SE

Table 5 – FM Stations Serving Project Area

Real-world experience with wind farms has shown that FM broadcast station signals (88 to 108 MHz) are fairly insensitive to wind turbines, even in cases where the FM transmitting antenna is surrounded by turbines that are higher than the FM antenna. Because of the “capture effect” supported by the “discriminator” in FM receivers, significant disruptions to the above facilities are not expected. Although the received signal may vary with the blade rotation at some receiver locations in the immediate area, good quality FM radios should factor out such time-varying signals.

4.3 AM Facilities

Large metallic structures such as wind turbines can adversely affect the transmitted signals of AM broadcast stations up to three kilometers away. A search of the FCC's database revealed no AM facilities within the required notification distance of three kilometers from the wind project

boundaries. There should therefore be no reasonable expectations of disruptions in transmitted radiations on the AM band due to the presence of the turbines. Occasionally, depending upon ground conditions, local AM receivers may experience slight signal changes due to local effects, but such anomalies are not recognized by the FCC or the standards of good engineering practice as having an unduly adverse effect.

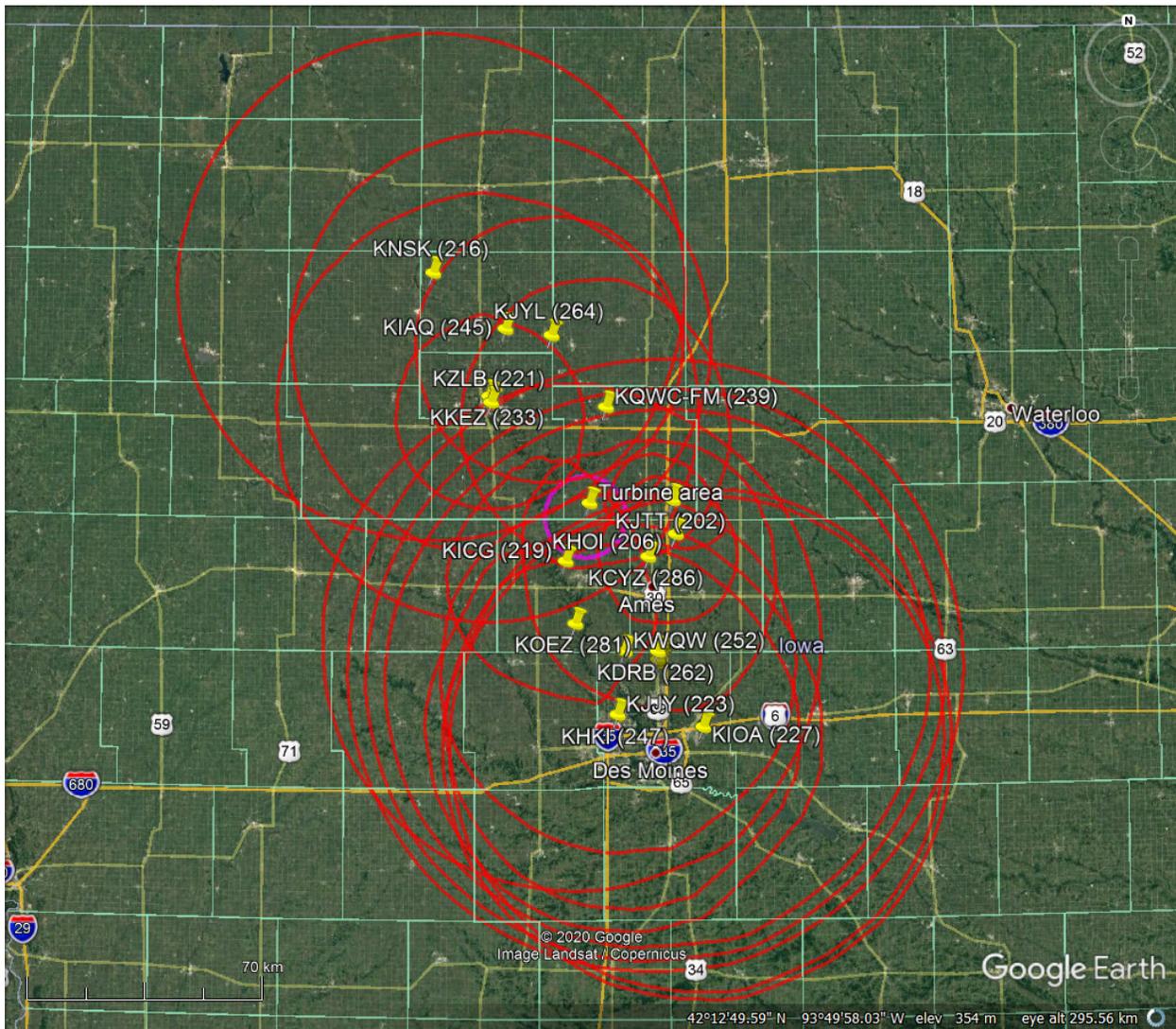


Figure 10 – Predicted FM Radio Coverage into Great Pathfinder Project Area

V. RADAR AND NTIA NOTIFICATION

5.1 DoD Radar Concerns

The Department of Defense (DoD) and the Department of Homeland Security *Long Range Radar Joint Program Office* “JPO” has adopted a “pre-screening tool” to evaluate the impact of wind turbines on air defense long-range radar. This tool was applied to the Great Pathfinder project area, and it returned a mixed result of “no anticipated impact” (green) and “impact likely” (yellow) to Air Defense and Homeland Security radars (see Figure 11). However, a definitive determination is obtained only after formal study by the DoD, which is triggered by the FAA 7460-1 notification process.



Figure 11 – DoD Long-Range Radar Screening

Map Legend:

- **Green:** No anticipated impact to Air Defense and Homeland Security radars. Aeronautical study required.
- **Yellow:** Impact likely to Air Defense and Homeland Security radars. Aeronautical study required.

5.2 NEXRAD

A pre-screening tool has been developed to evaluate the potential impact of obstructions to the NEXRAD Weather Surveillance Doppler Radar Stations. This tool was applied to the Great Pathfinder project area, and it returned a mixed result, shown in Figure 12, of “impacts not likely” (green) and “some impacts possible” (dark green) to weather radar operations. However, a definitive determination is obtained only after the NTIA review process.

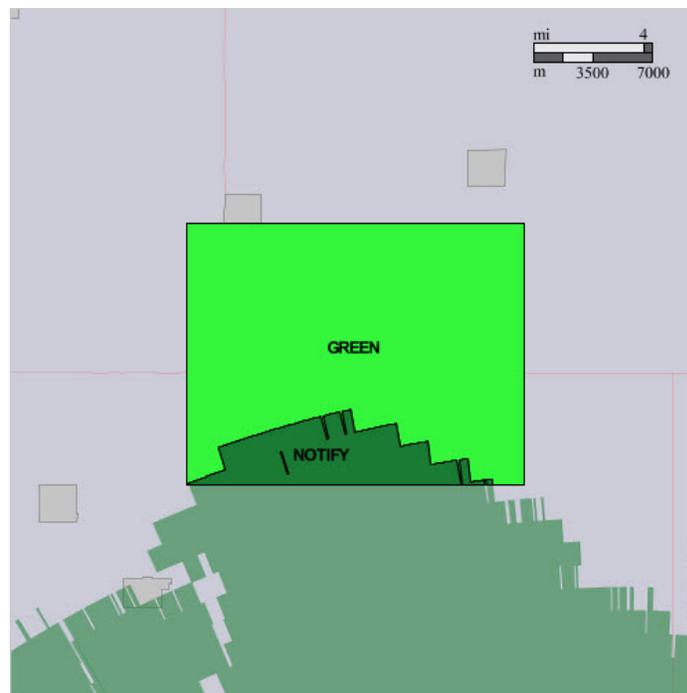


Figure 12 – NEXRAD Weather Radar Screening

Map Legend:

- **Green: No Impact Zone.** Impacts not likely. NOAA will not perform a detailed analysis, but would still like to know about the project.
- **Dk Green: Notification Zone.** Some impacts possible. Consultation with NOAA is optional, but NOAA would still like to know about the project.



5.3 NTIA NOTIFICATION

Operation of RF frequencies for federal government use is managed by the National Telecommunication Information Agency (NTIA), which is part of the U.S. Department of Commerce. The technical specifications for most government facilities are unavailable to the public. In order to avoid the derailment of the wind energy project due to late objections from a government agency, the NTIA should be notified of the proposed project during pre-construction planning. The NTIA has set in place a review process, wherein the Interdepartmental Radio Advisory Committee (IRAC), consisting of representatives from various government agencies, reviews new proposals for wind turbine projects for impact on government frequencies. In almost all cases, no adverse impact is found, and IRAC usually issues a determination in about 60 days.

On February 13, 2020, this office sent a notification of the Great Pathfinder Wind project to the NTIA for review. A determination letter was received on April 1, 2020 stating **No Harmful Interference Anticipated (NHIA)**. The Department of Commerce (DOC) had a concern about the location of the wind project relative to the NEXRAD station near Des Moines. Although the project is within the notification zone of the radar, the DOC stated that “there will be *low impact*” and requests only that they be notified if the project design substantially changes.



VI. CONCLUSIONS AND RECOMMENDATIONS

1. There are no FCC-licensed microwave paths that come close to the proposed turbines; therefore, turbine siting is not considered to be constrained by licensed microwave paths.
2. If an excessive amount of time goes by before the turbines are to be constructed (six months or more), it is recommended that the microwave study be updated in case new paths have been added to the FCC's database.
3. No land mobile transmitting stations are expected to be adversely affected, assuming that their transmitters are located exactly as per their FCC licenses.
4. Over-the-air TV interference due to operating wind turbines is unlikely to be a significant problem. Effective mitigation methods to resolve any interference that may occur are available, with satellite or cable service installation providing the worst-case solution. No radio broadcast facilities are likely to be affected.

Respectfully Submitted,

A handwritten signature in black ink, appearing to read "B. Benjamin Evans", is written over a light blue horizontal line.

B. Benjamin Evans
RF Impact Consultant
April 2, 2020