Attachment 7

Wind Power GeoPlanner™

Doppler Weather Radar Study

Antrim Wind Energy Project

Prepared on Behalf of
Eolian Renewable
Energy LLC

January 13, 2016

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Table of Contents

1. Introduction - 1 -

2. Project Area - 1 -

3. Technical Data - 3 -

4. Impact Assessment - 6 -

5. Conclusions - 7 -

6. Contact - 7 -

Appendix

1. Introduction

The purpose of this document is to describe the research, calculations, and analysis performed to assess the impact of the proposed Antrim Wind Energy Project on the operation of Doppler Weather Radar Systems owned and operated by television stations and commercial interests within 250 kilometers of the project. This study was performed for Eolian Renewal Energy LLC.

2. Project Area

The location of the Antrim Wind Energy Project in Hillsborough County, New Hampshire is shown in Figure 1. The proposed turbines will have a maximum hub height of 92.5 meters and a rotor diameter of up to 113 meters, giving the structures an overall maximum height of 149 meters above ground level. At the time of this study, there are 9 turbines proposed for the Antrim Wind Energy Project. Table 1 lists these turbines and their coordinates within the project area. A detailed view is provided in Figure 2.

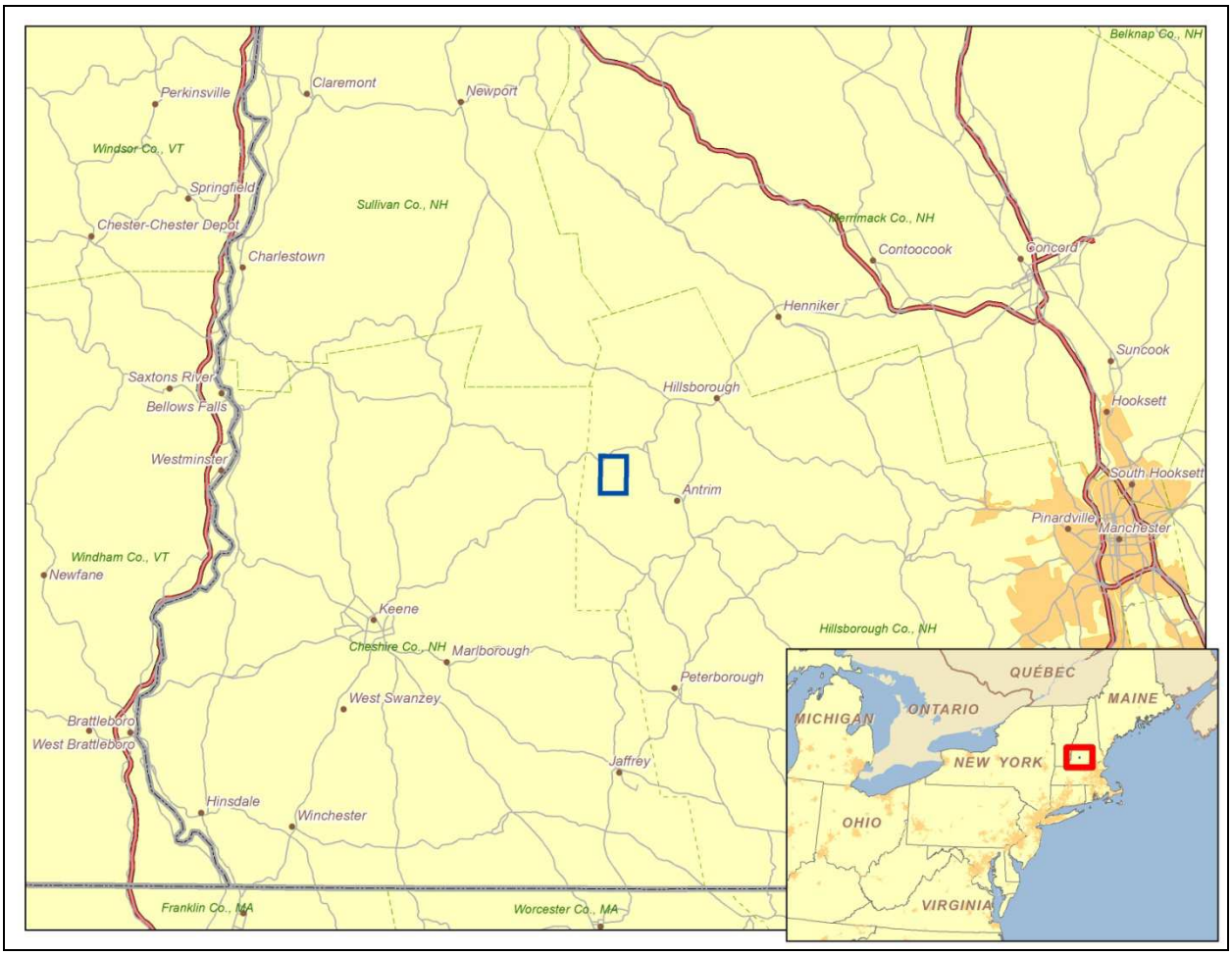


Figure 1: Location of Antrim Wind Energy Project in the State of New Hampshire

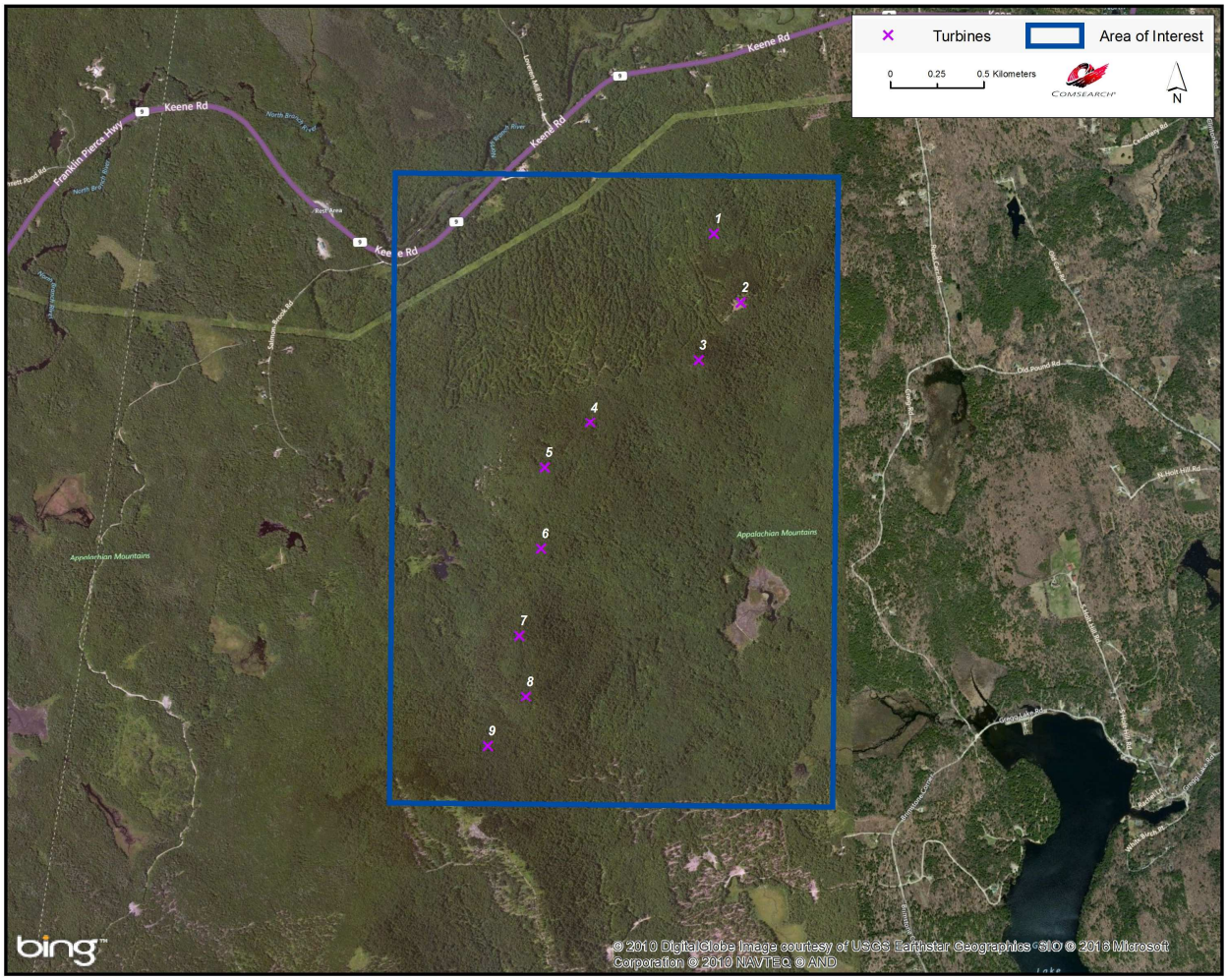


Figure 2: Location of Turbines within Antrim Wind Energy Project

Turbine ID	Latitude (NAD83)	Longitude (NAD83)
1	43.067575	-72.007848
2	43.064157	-72.006230
3	43.061470	-72.009134
4	43.058647	-72.016440
5	43.056539	-72.019531
6	43.052631	-72.019973
7	43.048422	-72.021600
8	43.045503	-72.021322
9	43.043156	-72.023944

Table 1: Wind Turbine Coordinates

3. Technical Data

Tables 2 and 3 contain the technical parameters of the commercial Doppler radar systems located within 250 kilometers of the center of the project area, including geographical data and ownership[1]. A depiction of the location of the Doppler radar systems with respect to the project boundaries appears in Figure 3.

ID	Call Sign	Frequency (MHz)	Antenna Height (meters)	Output Power (Watts)	Distance to Nearest Turbine (km)
1	WPXG555	5400-5600	23.0	1000000	86.59
2	WPTN202	5350-5650	41.1	346737	97.98
3	WPYR578	5350-5460	53.0	200	120.32
4	WPZR862	5550-5600	39.0	250000	134.08
5	WPQG659	5450-5550	30.0	350000	134.55
6	WPDM616	8500-1000	4.0	0.005	138.30
7	WPRT837	5460	45.7	200	154.57
8	WPLW289	8500-10000	4.0	0.005	163.00
9	WPWD240	9410	0.9	25000	170.90
10	WPFQ435	8500-10000	5.0	0.005	191.35
11	WQSC328	9410	7.6	10	192.91
12	WPJU561	5350	39.0	200	195.06
13	WPWR862	9550-10550	4.6	0.001	220.93
14	WPWR862	9550-10550	4.6	0.001	220.94

Table 2: Technical Data for Commercial Interest and Television Station Doppler Radar Systems within 250 Kilometers of the Antrim Wind Energy Project

[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.

ID	Call Sign	Owner- Operator	Location	Latitude (NAD83)	Longitude (NAD83)
1	WPXG555	CBS Communications Services, Inc.	Worcester, MA	42.271833	-71.871139
2	WPTN202	WCVB Hearst Television, Inc.	Hopkinton, MA	42.244361	-71.517306
3	WPYR578	WWLP Broadcasting, LLC	Agawam, MA	42.083694	-72.703972
4	WPZR862	WNYT-TV, LLC	Brunswick, NY	42.785917	-73.628194
5	WPQG659	Meredith Corporation - WFSB	East Granby, CT	41.940028	-72.699806
6	WPDM616	MPM Silicones, LLC	Waterford, NY	42.797861	-73.684556
7	WPRT837	WRGB Licensee, LLC	Niskayuna, NY	42.813194	-73.891250
8	WPLW289	Brayton Point Energy, LLC	Somerset, MA	41.712611	-71.189222
9	WPWD240	Entergy Nuclear Generation Company	Plymouth, MA	41.939917	-70.575028
10	WPFQ435	Allnex USA, Inc.	Wallingford, CT	41.433444	-72.849556
11	WQSC328	Dominion Nuclear Connecticut	Waterford, CT	41.309806	-72.170417
12	WPJU561	WTNH Broadcasting, LLC	Hamden, CT	41.427583	-72.950111
13	WPWR862	IBM Research and Development, Inc.	Poughkeepsie, NY	41.652389	-73.940694
14	WPWR862	IBM Research and Development, Inc.	Poughkeepsie, NY	41.652306	-73.940722

Table 3: Location and Ownership of Commercial Interest and Television Station Doppler Radar Systems within 250 Kilometers of the Antrim Wind Energy Project

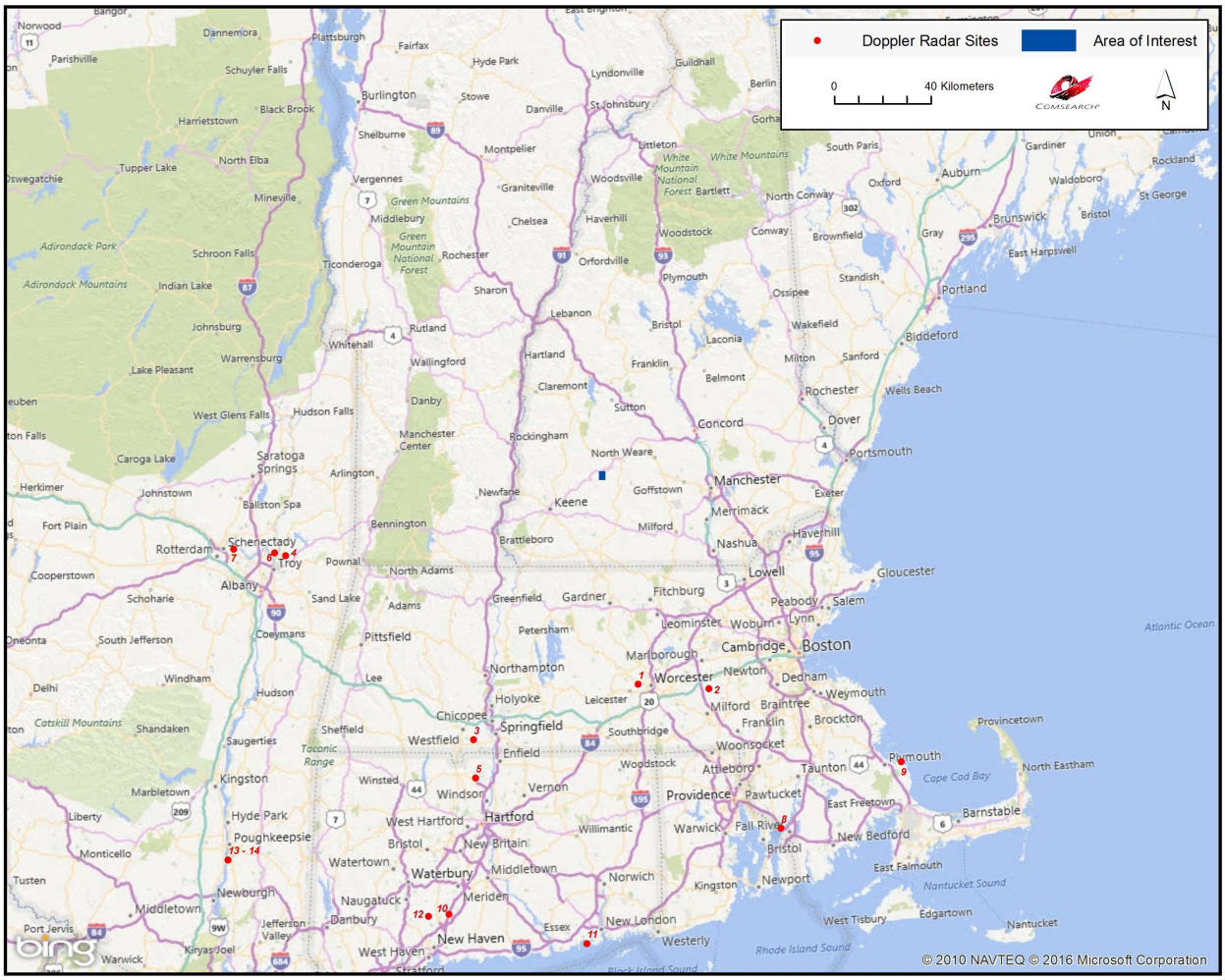


Figure 3: Location of Doppler Radar Systems within 250 Kilometers of the Antrim Wind Energy Project

4. Impact Assessment

The technical approach to determine the potential impact of the turbines on the Doppler radar systems in the area is to calculate whether the wind turbines are in line-of-sight of the radar systems. The wind turbines of the Antrim Wind Energy Project have the potential to block radar coverage and produce false targets if the turbines are in line-of-sight of the radar systems' transmitted signals. When performing an initial approximation to determine line-of-sight, the factors that should be considered are the height of the radar systems' antennas and the overall height of the wind turbines. The overall maximum tip height of any of the wind turbines in the project is 149 meters.

The following formula shows that the distance to the horizon for a radar antenna as a function of the height of the antenna.

$$D_1 = (2*H_R)^{½}$$

Where,

D_1 = Distance to the horizon, miles
H_R = Height of the radar antenna above sea level, feet

To determine the line-of-sight distance to the horizon for the wind turbines in the project area, we used the height of tallest blade tip above sea level. The tallest blade tip height is 149 meters or 489 feet. Therefore, using this height in feet above sea level and the formula above, the distance to the horizon for the wind turbines, D_2, is 67 miles. To determine the line-of-sight distance from the Doppler radar systems to the turbines the following formula is used.

$$D_T = D_1 + 67.0$$

Where,

D_T = Distance for line-of-sight from the radar antenna to the tip height of the wind turbines, miles

Using the D_T formula, line-of-sight is determined. The results of the calculations are shown in Table 4.

Doppler Radar ID	Call Sign	Ground Elev (ft)	Ant Hgt AGL (ft)	Ant Hgt MSL (ft)	D_1 (mi)	D_2 (mi)	D_T (mi)	Dist to Nearest Turbine (mi)	LOS Possible
1	WPXG555	996.7	75.5	1072.2	46.3	67.0	113.3	53.8	Yes
2	WPTN202	462.9	134.8	597.8	34.6	67.0	101.6	60.9	Yes
3	WPYR578	639.8	173.9	813.6	40.3	67.0	107.3	74.8	Yes
4	WPZR862	61.0	128.0	189.0	19.4	67.0	86.4	83.3	Yes
5	WPQG659	170.9	98.4	269.4	23.2	67.0	90.2	83.6	Yes
6	WPDM616	131.2	13.1	144.4	17.0	67.0	84.0	85.9	No

7	WPRT837	445.2	149.9	595.1	34.5	67.0	101.5	96.0	Yes
8	WPLW289	16.4	13.1	29.5	7.7	67.0	74.7	101.3	No
9	WPWD240	20.0	3.0	23.0	6.8	67.0	73.8	106.2	No
10	WPFQ435	65.6	16.4	82.0	12.8	67.0	79.8	118.9	No
11	WQSC328	0.0	24.9	24.9	7.1	67.0	74.1	119.9	No
12	WPJU561	698.8	128.0	826.8	40.7	67.0	107.7	121.2	No
13	WPWR862	61.0	15.1	76.1	12.3	67.0	79.3	137.3	No
14	WPWR862	61.0	15.1	76.1	12.3	67.0	79.3	137.3	No

Table 4: Line-of-Sight Condition of the Doppler Radar Systems to the Wind Turbines

From the results in Table 4 it was determined that six of the nine radar systems (ID #1 – 5, #7) could have a line-of-sight condition with the wind turbines. To verify this condition, a terrain profile was generated from the six radars to the center of the wind project area (please see Figure 3). According to the terrain profiles, there is terrain blockage between the antenna of the six radars and the wind project area. Therefore, line-of-sight conditions do not exist between the six radars and the wind turbines. The path profiles are provided in the Appendix section of this report.

5. Conclusions

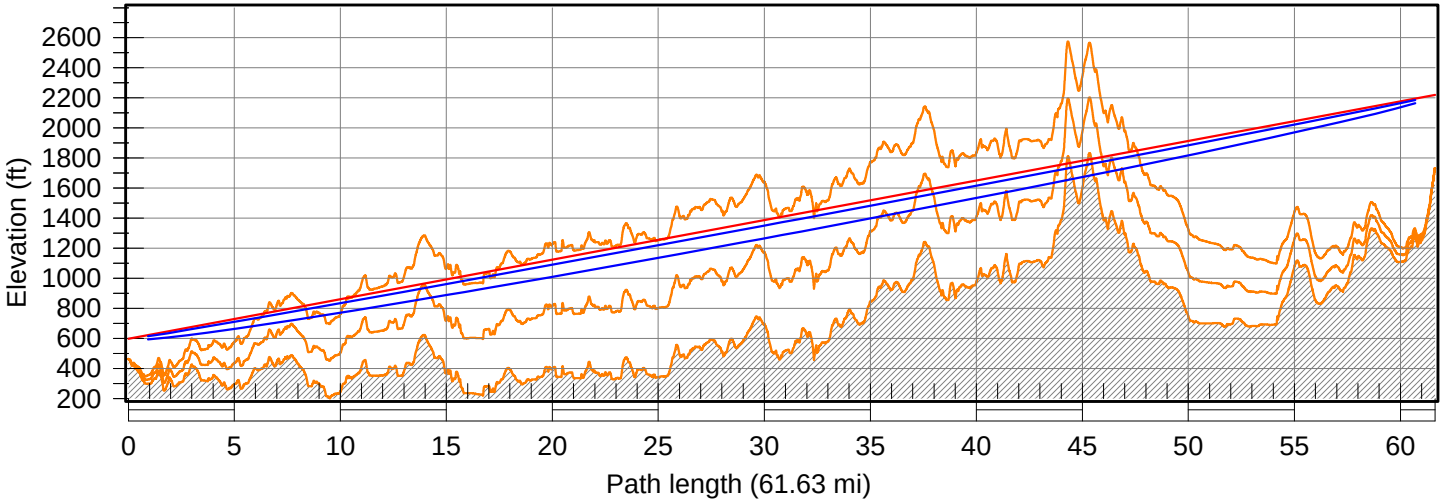
Based on the calculations and analysis described in this report, none of the nine Doppler radar systems in the vicinity of the Antrim Wind Energy Project could be impacted by the project's planned wind turbines.

6. Contact

For questions or information regarding the Doppler Radar Study, please contact:

Contact person: Denise Finney
Title: Account Manager
Company: Comsearch
Address: 19700 Janelia Farm Blvd., Ashburn, VA 20147
Telephone: 703-726-5650
Fax: 703-726-5595
Email: dfinney@comsearch.com
Web site: www.comsearch.com

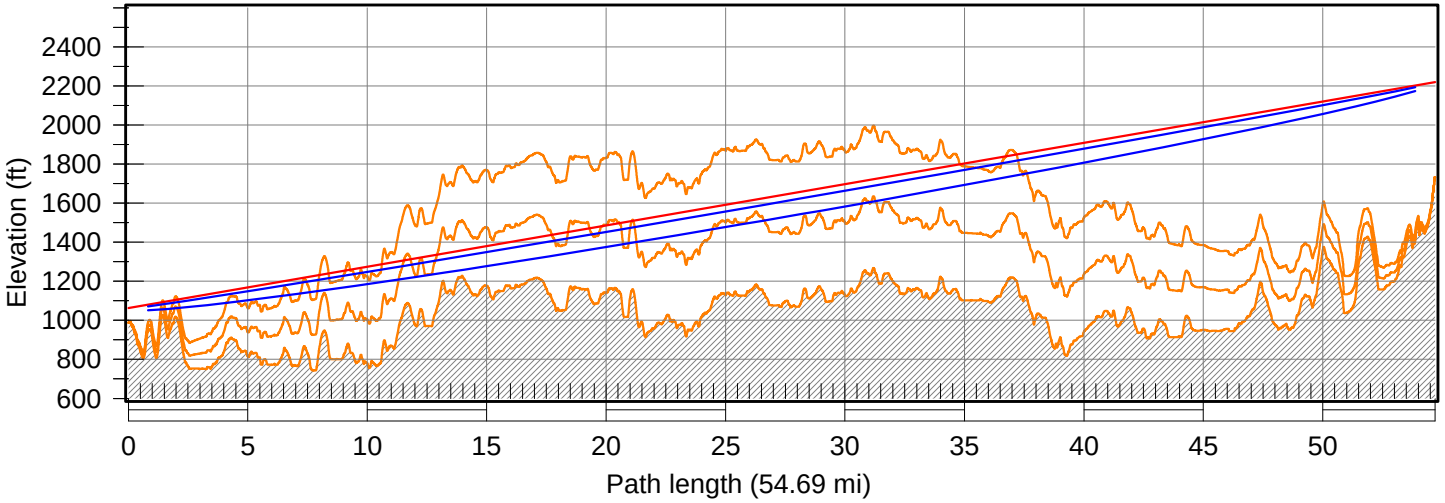
Appendix



Radar #2	
Latitude	42 14 39.70 N
Longitude	071 31 02.30 W
Azimuth	335.63°
Elevation	463 ft ASL
Antenna CL	134.8 ft AGL

Frequency (MHz) = 5350.0
K = 1.33, 0.67
%F1 = 100.00, 30.00

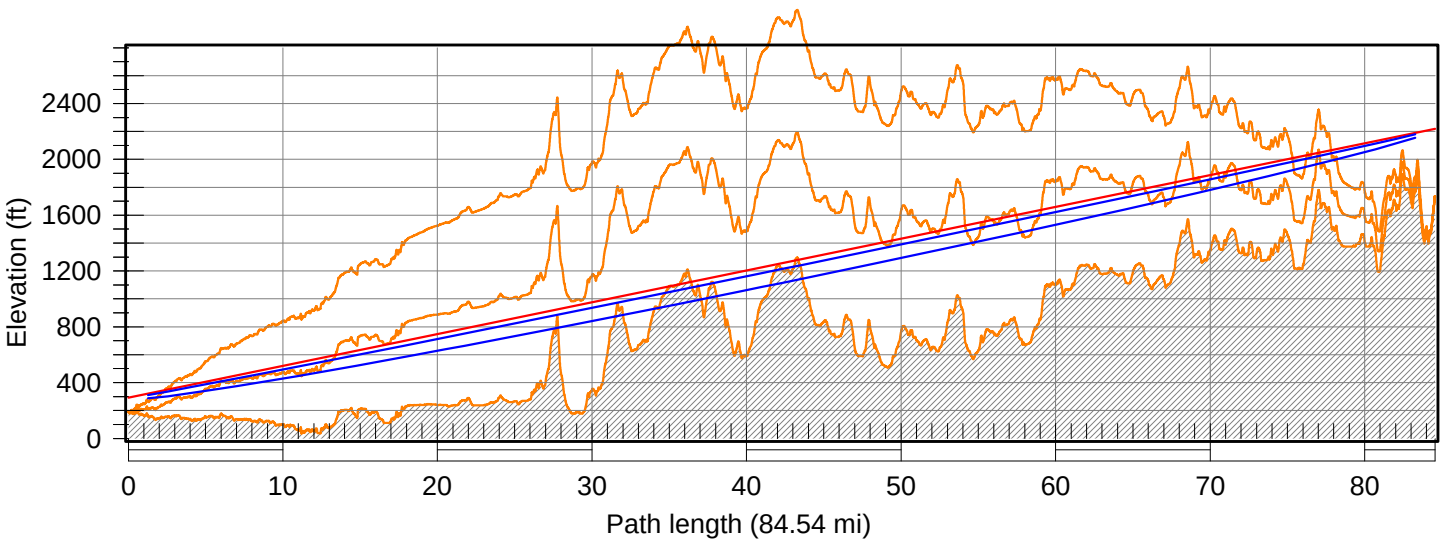
Turbine #5	
Latitude	43 03 23.54 N
Longitude	072 01 10.31 W
Azimuth	155.29°
Elevation	1730 ft ASL
Antenna CL	489.0 ft AGL



Radar #1	
Latitude	42 16 18.60 N
Longitude	071 52 16.10 W
Azimuth	352.11°
Elevation	987 ft ASL
Antenna CL	75.5 ft AGL

Frequency (MHz) = 5400.0
K = 1.33, 0.67
%F1 = 100.00, 30.00

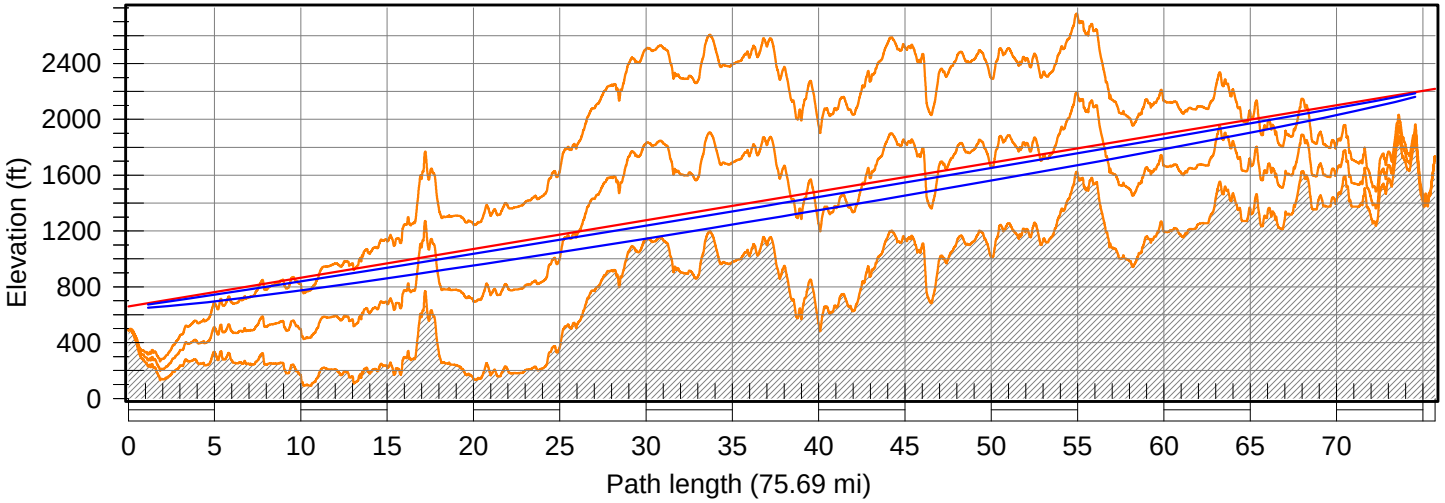
Turbine #5	
Latitude	43 03 23.54 N
Longitude	072 01 10.31 W
Azimuth	172.00°
Elevation	1730 ft ASL
Antenna CL	489.0 ft AGL



Radar #5	
Latitude	41 56 24.10 N
Longitude	072 41 59.30 W
Azimuth	24.04°
Elevation	194 ft ASL
Antenna CL	98.4 ft AGL

Frequency (MHz) = 5450.0
K = 1.33, 0.67
%F1 = 100.00, 30.00

Turbine #5	
Latitude	43 03 23.54 N
Longitude	072 01 10.31 W
Azimuth	204.50°
Elevation	1730 ft ASL
Antenna CL	489.0 ft AGL

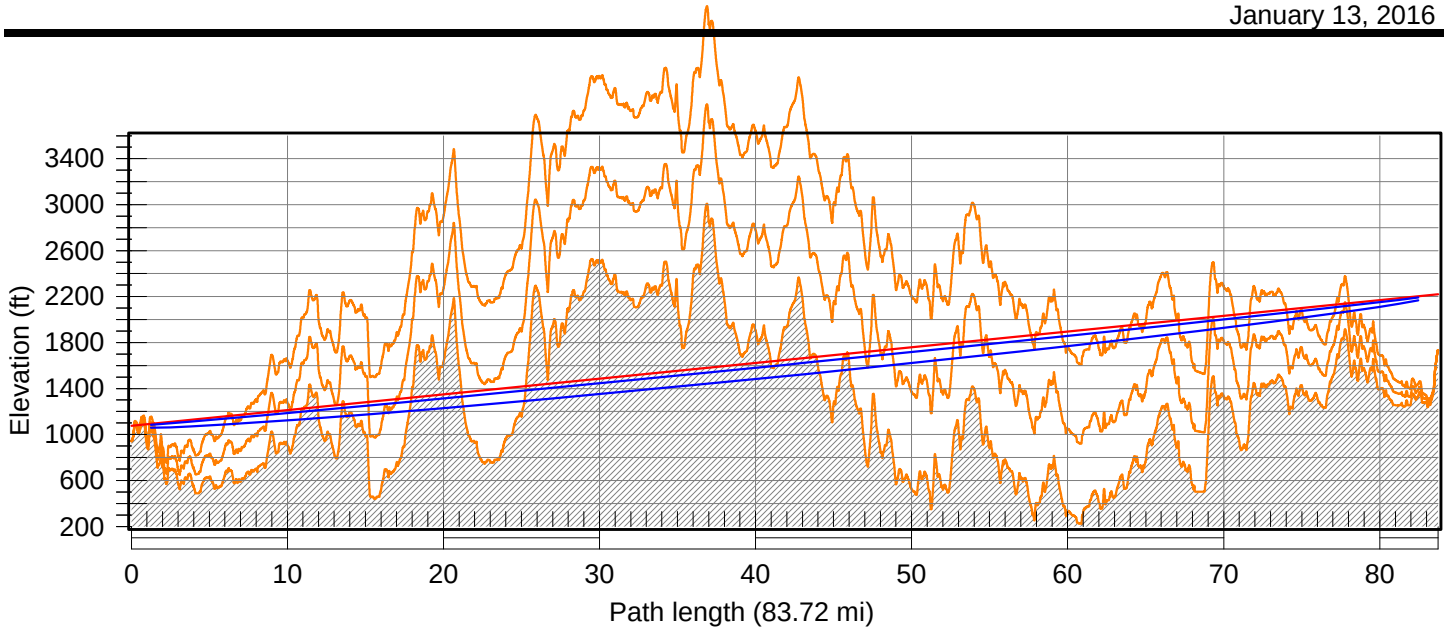


Radar #3	
Latitude	42 05 01.30 N
Longitude	072 42 14.30 W
Azimuth	27.24°
Elevation	486 ft ASL
Antenna CL	173.9 ft AGL

Frequency (MHz) = 5350.0
K = 1.33, 0.67
%F1 = 100.00, 30.00

Turbine #5	
Latitude	43 03 23.54 N
Longitude	072 01 10.31 W
Azimuth	207.71°
Elevation	1730 ft ASL
Antenna CL	489.0 ft AGL

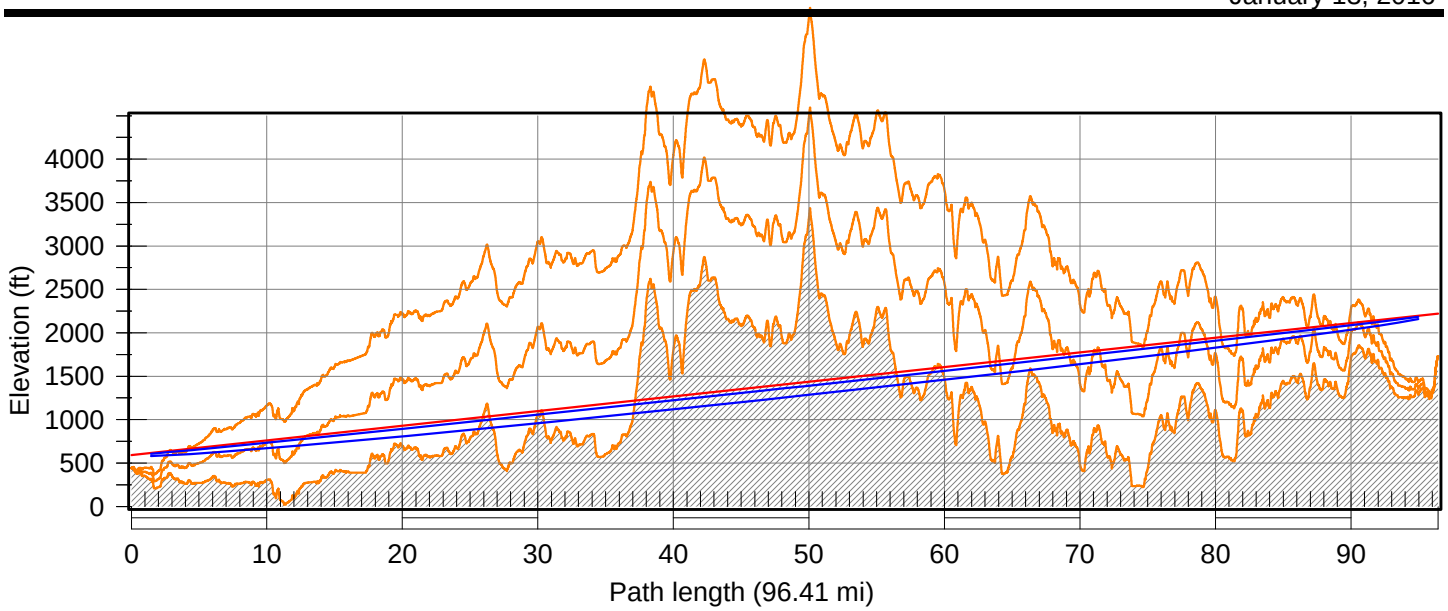
January 13, 2016



Radar #4	
Latitude	42 47 09.30 N
Longitude	073 37 41.50 W
Azimuth	76.56°
Elevation	949 ft ASL
Antenna CL	128.0 ft AGL

Frequency (MHz) = 5550.0
K = 1.33, 0.67
%F1 = 100.00, 30.00

Turbine #5	
Latitude	43 03 23.54 N
Longitude	072 01 10.31 W
Azimuth	257.66°
Elevation	1730 ft ASL
Antenna CL	489.0 ft AGL



Radar #7	
Latitude	42 48 47.50 N
Longitude	073 53 28.50 W
Azimuth	79.33°
Elevation	443 ft ASL
Antenna CL	149.9 ft AGL

Frequency (MHz) = 5460.0
K = 1.33, 0.67
%F1 = 100.00, 30.00

Turbine #5	
Latitude	43 03 23.54 N
Longitude	072 01 10.31 W
Azimuth	260.60°
Elevation	1730 ft ASL
Antenna CL	489.0 ft AGL