Memo

Date:	Tuesday, March 23, 2020
Project:	Great Pathfinder Wind Project
To:	Holly McCoy-Nelson (Apex)
From:	Dan Schmidt and Robert Brenneman (HDR)
Subject:	Wind Farm Acoustical Analysis Study – Vestas V150 Wind Turbine Layout 24

Project Description

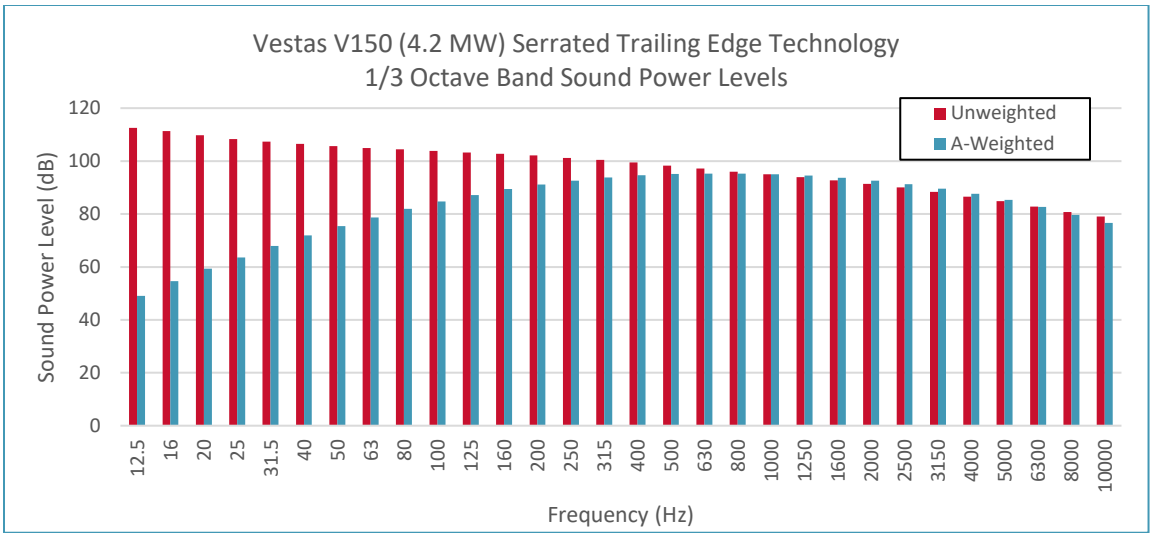
The Great Pathfinder wind farm project proposes to construct and operate up to 74 Vestas V150 (4.2 MW) wind turbine generator systems in Boone County, IA. The 3-bladed wind turbines will utilize serrated trailing edge technology to reduce noise emissions. The hub height is proposed to be 105 m (344.5 ft.). Noise emissions related to Layout 24 are considered herein.

Acoustical Criteria

Section 8.04 *Commercial / Utility Wind Energy Systems* of Boone County Ordinance No. 88 addresses wind farm noise emissions. Item #11 of 8.04.08 states that *"No Commercial / Utility WECS shall exceed 50 dBA at the nearest structure or use."* where the term WECS refers to a Wind Energy Conservation System (a wind farm). The ordinance also requires an acoustical analysis be provided to Boone County.

Acoustical Analysis Methodology

Manufacturer's apparent sound power level data for Vestas V150 wind turbines, shown below, were utilized to acoustically model noise emissions for the Great Pathfinder wind farm. The sound data reflect the highest levels associated with serrated trailing edge technology wind turbine operations.



To account for uncertainty within the manufacturer's published data, 2 dB has been added to each of the shown 1/3 octave band sound power levels. In addition to the 74 wind turbines that are proposed to comprise the wind farm, the 7 spare locations have also been modeled for conservativeness to reflect noise emissions from a total of 81 wind turbine units. The acoustical analysis for Layout 24 was performed utilizing industry-accepted Cadna-A computer software, an environmental noise modeling program based on ISO-9613 (the international acoustical standard for outdoor sound propagation). This software calculates frequency-dependent sound emissions from the proposed wind turbines (hub heights at 105 m or 344.5 ft.) to surrounding receivers in the study area (1.52 m or 5 ft. above ground). Model calculations include the factors important to sound propagation over distance, such as geometrical spreading, downwind conditions, soft ground absorption coverage (G = 0.5 for agricultural applications), temperature (50° F), and relative humidity (60%), among others. Cadna-A also conservatively assumes downwind propagation in all directions. Using this information, Cadna-A calculated A-weighted sound pressure levels at the receiver locations and throughout a Cartesian coordinate grid (used to create noise contours).

Study Results

Based on the methodology above, wind turbine noise emissions within the project boundary are expected to comply with 50 dBA County zoning ordinance requirements. Table 1, below, groups the number of receiver dwellings according to sound levels emitted from wind turbines. Refer to the appendix for noise contour locations, wind turbine (source) and occupied dwelling (receiver) locations, and specific levels at each receiver location.

Table 1: Summary of Wind Turbine Noise Emissions Levels at Receiver Dwelling Locations

Receiver Sound Pressure Levels (dBA)	Quantity of Receiver Dwellings in Sound Level Zone
45.0 – 47.1	21
40.0 – 44.9	65
35.0 – 39.9	46
30.0 – 34.9	36
25.0 – 29.9	26
20.0 – 24.9	11
15.0 – 19.9	6
14.9 or Less	7

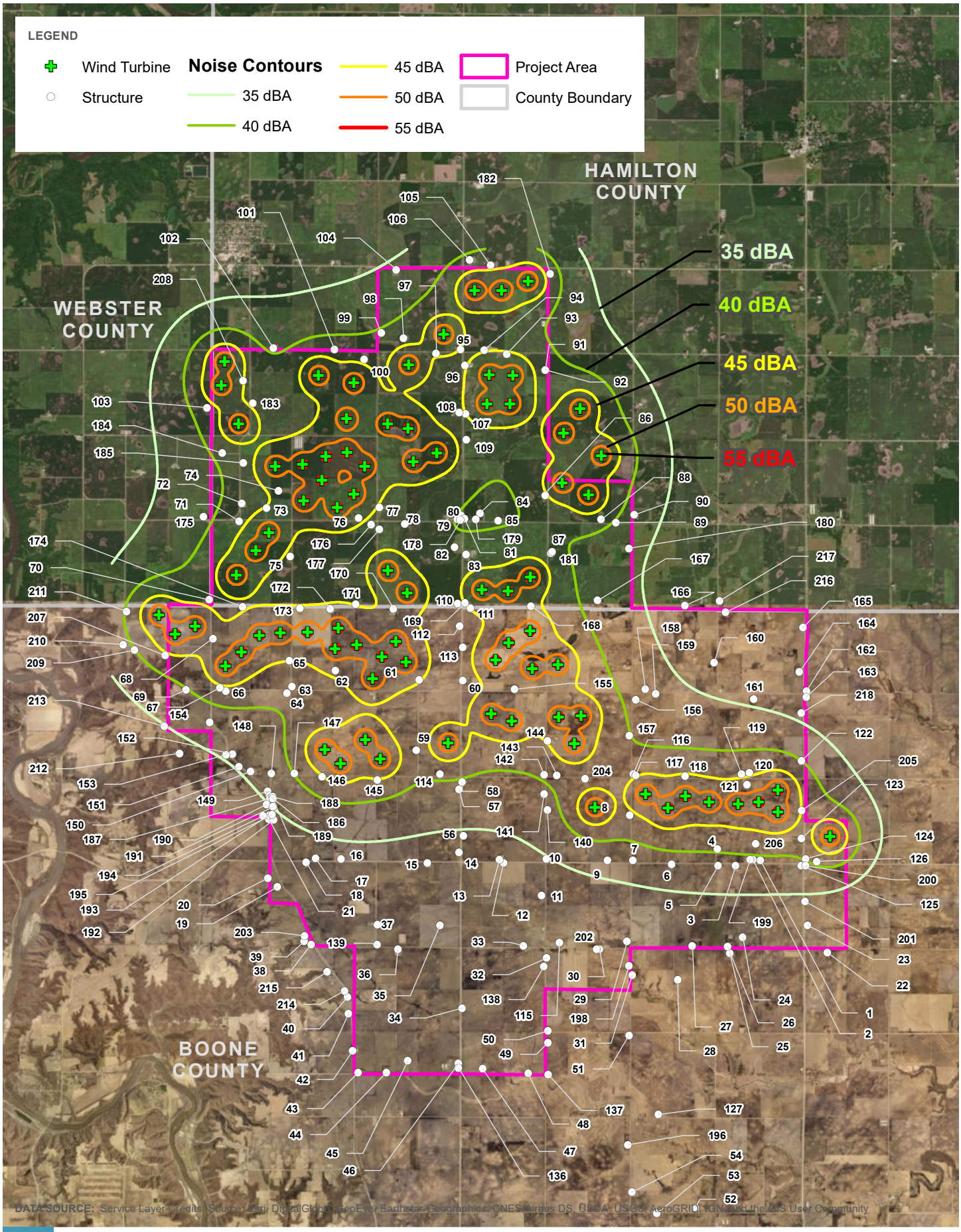
Conclusion

Based on predictive acoustic computer modeling, sound emissions to occupied dwellings from wind turbines for the Great Pathfinder project are expected to be in compliance with the 50 dBA Boone County zoning ordinance requirement.

Appendix

Appendix materials follow:

- Great Pathfinder Acoustic Source, Receiver Locations, and Noise Contours (Appendix A)
- Wind Turbine Sound Emission Levels at Receiver Locations (Appendix B)



WIND TURBINE SOUND EMISSION CONTOURS

APPENDIX A

0 Miles 1

PATH: \\MSPE-GIS-FILE\GISPROJ\APEXWINDENERGY\10196302_GREATPATHFINDER\7.2_WIP\MAP_DOCS\CUP\MAP_8X11_P_NOISECONTOURS.MXD - USER: DSCHMIDT - DATE: 3/26/2020

Wind Turbine Sound Levels at Structure Locations				
Occupied Dwelling Location	Wind Turbine Sound Level (dBA)	Coordinates (UTM)		
		X	Y	Z (Height)
		(m)	(m)	(m)
GREATPATH_HOMES00001	39.3	433446.67	4668622.84	1.52
GREATPATH_HOMES00002	39.3	433302.35	4668638.16	1.52
GREATPATH_HOMES00003	38.3	432981.13	4668525.31	1.52
GREATPATH_HOMES00004	40.5	432639.49	4668837.84	1.52
GREATPATH_HOMES00005	38.2	432647.17	4668520.94	1.52
GREATPATH_HOMES00006	38.0	431768.38	4668554.39	1.52
GREATPATH_HOMES00007	37.6	431045.82	4668634.10	1.52
GREATPATH_HOMES00008	43.9	430989.85	4669488.31	1.52
GREATPATH_HOMES00009	37.1	430564.67	4668636.61	1.52
GREATPATH_HOMES00010	34.7	429408.70	4668669.42	1.52
GREATPATH_HOMES00011	32.1	429313.45	4667974.10	1.52
GREATPATH_HOMES00012	33.2	428600.66	4668594.81	1.52
GREATPATH_HOMES00013	33.4	428526.05	4668667.84	1.52
GREATPATH_HOMES00014	33.5	427763.37	4668804.79	1.52
GREATPATH_HOMES00015	33.0	427167.15	4668602.75	1.52
GREATPATH_HOMES00016	33.4	425536.13	4668698.42	1.52
GREATPATH_HOMES00017	32.9	425055.07	4668704.62	1.52
GREATPATH_HOMES00018	32.4	424873.62	4668633.60	1.52
GREATPATH_HOMES00019	30.2	424332.11	4668173.06	1.52
GREATPATH_HOMES00020	30.4	424148.17	4668335.03	1.52
GREATPATH_HOMES00021	34.0	424177.13	4669454.44	1.52
GREATPATH_HOMES00022	29.1	434701.03	4666875.83	1.52
GREATPATH_HOMES00023	31.7	434333.46	4667389.05	1.52
GREATPATH_HOMES00024	31.3	433105.11	4667174.53	1.52
GREATPATH_HOMES00025	30.2	432862.68	4666865.16	1.52
GREATPATH_HOMES00026	30.7	432817.86	4667000.12	1.52
GREATPATH_HOMES00027	30.7	432154.68	4667013.42	1.52
GREATPATH_HOMES00028	28.7	431875.62	4666373.46	1.52
GREATPATH_HOMES00029	30.6	430923.30	4667108.67	1.52
GREATPATH_HOMES00030	29.9	430401.06	4666965.34	1.52
GREATPATH_HOMES00031	28.8	431020.05	4666472.83	1.52
GREATPATH_HOMES00032	29.0	429404.06	4666800.16	1.52
GREATPATH_HOMES00033	29.3	428968.41	4667037.30	1.52
GREATPATH_HOMES00034	26.5	427803.81	4665865.30	1.52
GREATPATH_HOMES00035	29.7	427391.69	4667430.20	1.52
GREATPATH_HOMES00036	28.5	426593.71	4666982.33	1.52
GREATPATH_HOMES00037	29.5	426212.11	4667452.94	1.52
GREATPATH_HOMES00038	28.0	424959.41	4667074.58	1.52
GREATPATH_HOMES00039	28.0	424827.45	4667138.08	1.52
GREATPATH_HOMES00040	26.2	425642.21	4666078.08	1.52
GREATPATH_HOMES00041	25.6	425654.47	4665769.04	1.52
GREATPATH_HOMES00042	24.3	425728.68	4665070.33	1.52

Wind Turbine Sound Levels at Structure Locations				
Occupied Dwelling Location	Wind Turbine Sound Level (dBA)	Coordinates (UTM)		
		X	Y	Z (Height)
		(m)	(m)	(m)
GREATPATH_HOMES00043	23.6	425834.15	4664662.23	1.52
GREATPATH_HOMES00044	23.7	426367.26	4664658.81	1.52
GREATPATH_HOMES00045	24.2	426773.64	4664873.50	1.52
GREATPATH_HOMES00046	24.4	427728.78	4664817.75	1.52
GREATPATH_HOMES00047	24.3	428183.34	4664710.51	1.52
GREATPATH_HOMES00048	24.3	429040.21	4664627.77	1.52
GREATPATH_HOMES00049	25.5	429415.24	4665196.82	1.52
GREATPATH_HOMES00050	26.0	429421.06	4665424.36	1.52
GREATPATH_HOMES00051	26.0	430950.42	4665330.47	1.52
GREATPATH_HOMES00052	19.0	432183.47	4662067.25	1.52
GREATPATH_HOMES00053	19.0	431457.56	4661962.06	1.52
GREATPATH_HOMES00054	19.9	430987.66	4662367.72	1.52
GREATPATH_HOMES00055	12.8	431031.14	4659344.29	1.52
GREATPATH_HOMES00056	34.6	427848.42	4669120.69	1.52
GREATPATH_HOMES00057	38.6	427767.46	4669995.34	1.52
GREATPATH_HOMES00058	39.5	427829.69	4670134.58	1.52
GREATPATH_HOMES00059	42.9	426968.79	4670747.37	1.52
GREATPATH_HOMES00060	43.1	427850.87	4672043.28	1.52
GREATPATH_HOMES00061	45.4	427031.63	4672066.20	1.52
GREATPATH_HOMES00062	46.5	425448.86	4672254.99	1.52
GREATPATH_HOMES00063	41.9	424629.43	4671946.87	1.52
GREATPATH_HOMES00064	41.3	424529.61	4671833.69	1.52
GREATPATH_HOMES00065	45.1	424576.37	4672442.46	1.52
GREATPATH_HOMES00066	43.5	423378.02	4671879.09	1.52
GREATPATH_HOMES00067	44.0	423262.87	4671937.82	1.52
GREATPATH_HOMES00068	46.5	423141.32	4672873.10	1.52
GREATPATH_HOMES00069	39.8	422628.38	4671907.89	1.52
GREATPATH_HOMES00070	44.0	423073.50	4673597.59	1.52
GREATPATH_HOMES00071	43.5	423649.50	4675083.75	1.52
GREATPATH_HOMES00072	42.2	423696.59	4675424.80	1.52
GREATPATH_HOMES00073	45.3	424166.76	4675329.82	1.52
GREATPATH_HOMES00074	46.4	424392.45	4675651.55	1.52
GREATPATH_HOMES00075	44.0	424604.40	4674408.61	1.52
GREATPATH_HOMES00076	46.3	425901.62	4675128.42	1.52
GREATPATH_HOMES00077	44.6	426293.83	4675326.51	1.52
GREATPATH_HOMES00078	41.8	426778.20	4675010.46	1.52
GREATPATH_HOMES00079	39.9	427769.19	4675088.35	1.52
GREATPATH_HOMES00080	39.9	427836.67	4675171.65	1.52
GREATPATH_HOMES00081	39.8	427901.50	4675105.86	1.52
GREATPATH_HOMES00082	40.7	427712.71	4674564.90	1.52
GREATPATH_HOMES00083	41.5	427925.70	4674431.02	1.52
GREATPATH_HOMES00084	39.6	428193.46	4675203.87	1.52

Wind Turbine Sound Levels at Structure Locations				
Occupied Dwelling Location	Wind Turbine Sound Level (dBA)	Coordinates (UTM)		
		X	Y	Z (Height)
		(m)	(m)	(m)
GREATPATH_HOMES00085	39.7	428537.16	4675059.41	1.52
GREATPATH_HOMES00086	44.5	429431.98	4675539.90	1.52
GREATPATH_HOMES00087	41.8	429528.02	4674444.25	1.52
GREATPATH_HOMES00088	42.0	430481.47	4675069.66	1.52
GREATPATH_HOMES00089	39.6	430753.17	4675017.89	1.52
GREATPATH_HOMES00090	37.9	431106.83	4675156.18	1.52
GREATPATH_HOMES00091	42.5	429443.60	4677902.21	1.52
GREATPATH_HOMES00092	42.5	429443.60	4677902.21	1.52
GREATPATH_HOMES00093	45.7	428716.52	4678205.95	1.52
GREATPATH_HOMES00094	44.6	428289.20	4678287.48	1.52
GREATPATH_HOMES00095	44.8	427847.30	4678297.20	1.52
GREATPATH_HOMES00096	44.7	427926.62	4677994.45	1.52
GREATPATH_HOMES00097	45.5	427385.49	4678225.07	1.52
GREATPATH_HOMES00098	43.2	426773.10	4678517.79	1.52
GREATPATH_HOMES00099	40.5	426349.05	4678625.35	1.52
GREATPATH_HOMES00100	43.8	426026.26	4678125.85	1.52
GREATPATH_HOMES00101	42.6	425466.82	4678313.88	1.52
GREATPATH_HOMES00102	39.6	424310.94	4678349.09	1.52
GREATPATH_HOMES00103	43.3	423056.45	4677234.42	1.52
GREATPATH_HOMES00104	35.9	426641.55	4679814.46	1.52
GREATPATH_HOMES00105	43.9	428422.36	4679879.84	1.52
GREATPATH_HOMES00106	41.5	428024.85	4679988.45	1.52
GREATPATH_HOMES00107	45.0	427937.33	4677084.81	1.52
GREATPATH_HOMES00108	44.2	427815.52	4677109.07	1.52
GREATPATH_HOMES00109	43.4	427943.23	4676591.69	1.52
GREATPATH_HOMES00110	43.8	427763.15	4673504.48	1.52
GREATPATH_HOMES00111	45.2	428005.72	4673408.64	1.52
GREATPATH_HOMES00112	43.0	427798.98	4673077.97	1.52
GREATPATH_HOMES00113	43.4	427858.03	4672676.01	1.52
GREATPATH_HOMES00114	41.1	427408.69	4670285.23	1.52
GREATPATH_HOMES00115	29.9	429648.54	4667091.20	1.52
GREATPATH_HOMES00116	43.9	431056.58	4670260.59	1.52
GREATPATH_HOMES00117	44.5	431106.58	4670242.07	1.52
GREATPATH_HOMES00118	45.7	432040.03	4670221.69	1.52
GREATPATH_HOMES00119	44.2	433104.98	4670253.18	1.52
GREATPATH_HOMES00120	44.2	433253.15	4670280.96	1.52
GREATPATH_HOMES00121	47.1	433202.22	4670050.93	1.52
GREATPATH_HOMES00122	40.0	434232.90	4670493.95	1.52
GREATPATH_HOMES00123	42.9	434227.35	4669030.80	1.52
GREATPATH_HOMES00124	40.4	434301.12	4668643.04	1.52
GREATPATH_HOMES00125	39.0	434218.31	4668518.46	1.52
GREATPATH_HOMES00126	41.0	434510.36	4668595.41	1.52

Wind Turbine Sound Levels at Structure Locations				
Occupied Dwelling Location	Wind Turbine Sound Level (dBA)	Coordinates (UTM)		
		X	Y	Z (Height)
		(m)	(m)	(m)
GREATPATH_HOMES00127	22.7	431495.43	4663833.64	1.52
GREATPATH_HOMES00128	15.7	430904.17	4660206.99	1.52
GREATPATH_HOMES00129	15.1	431005.14	4660026.02	1.52
GREATPATH_HOMES00130	15.3	432178.62	4660250.81	1.52
GREATPATH_HOMES00131	14.6	432327.21	4659951.72	1.52
GREATPATH_HOMES00132	13.6	432664.39	4659694.54	1.52
GREATPATH_HOMES00133	14.1	433275.29	4659925.34	1.52
GREATPATH_HOMES00134	14.9	433460.49	4660410.71	1.52
GREATPATH_HOMES00135	12.8	432489.76	4659226.03	1.52
GREATPATH_HOMES00136	24.3	427728.27	4664732.77	1.52
GREATPATH_HOMES00137	24.3	429420.16	4664606.04	1.52
GREATPATH_HOMES00138	28.6	429345.93	4666634.61	1.52
GREATPATH_HOMES00139	28.6	426208.13	4667071.51	1.52
GREATPATH_HOMES00140	38.4	429435.03	4669592.07	1.52
GREATPATH_HOMES00141	39.1	429371.48	4669902.60	1.52
GREATPATH_HOMES00142	40.7	429377.76	4670260.30	1.52
GREATPATH_HOMES00143	41.5	429617.71	4670249.63	1.52
GREATPATH_HOMES00144	45.4	429445.10	4670904.31	1.52
GREATPATH_HOMES00145	44.7	426231.99	4670183.58	1.52
GREATPATH_HOMES00146	44.7	425185.07	4670248.16	1.52
GREATPATH_HOMES00147	40.2	424661.55	4670319.31	1.52
GREATPATH_HOMES00148	37.2	424228.99	4670320.36	1.52
GREATPATH_HOMES00149	35.7	424151.87	4669979.16	1.52
GREATPATH_HOMES00150	35.7	423835.37	4670352.99	1.52
GREATPATH_HOMES00151	35.3	423618.57	4670447.71	1.52
GREATPATH_HOMES00152	35.7	423498.59	4670684.51	1.52
GREATPATH_HOMES00153	35.4	423376.51	4670675.04	1.52
GREATPATH_HOMES00154	37.5	423068.14	4671287.56	1.52
GREATPATH_HOMES00155	46.1	428828.19	4671874.83	1.52
GREATPATH_HOMES00156	38.4	431118.32	4671662.23	1.52
GREATPATH_HOMES00157	40.1	430992.03	4670982.98	1.52
GREATPATH_HOMES00158	37.3	431296.19	4671859.67	1.52
GREATPATH_HOMES00159	36.8	431486.68	4671775.48	1.52
GREATPATH_HOMES00160	33.2	432600.70	4672359.14	1.52
GREATPATH_HOMES00161	34.4	433337.94	4671660.76	1.52
GREATPATH_HOMES00162	32.2	434336.71	4671807.05	1.52
GREATPATH_HOMES00163	32.6	434331.45	4671701.81	1.52
GREATPATH_HOMES00164	31.4	434202.00	4672169.09	1.52
GREATPATH_HOMES00165	29.5	434278.83	4673012.10	1.52
GREATPATH_HOMES00166	33.0	432053.05	4673436.08	1.52
GREATPATH_HOMES00167	38.2	430406.25	4673543.76	1.52
GREATPATH_HOMES00168	46.3	429145.83	4673448.15	1.52

Wind Turbine Sound Levels at Structure Locations				
Occupied Dwelling Location	Wind Turbine Sound Level (dBA)	Coordinates (UTM)		
		X	Y	Z (Height)
		(m)	(m)	(m)
GREATPATH_HOMES00169	45.1	427902.13	4673513.75	1.52
GREATPATH_HOMES00170	46.3	426551.18	4673408.91	1.52
GREATPATH_HOMES00171	44.9	425842.65	4673504.38	1.52
GREATPATH_HOMES00172	46.4	425361.54	4673414.35	1.52
GREATPATH_HOMES00173	45.6	424789.65	4673427.76	1.52
GREATPATH_HOMES00174	44.7	423706.27	4673465.79	1.52
GREATPATH_HOMES00175	39.0	422977.71	4675177.89	1.52
GREATPATH_HOMES00176	43.9	426135.92	4675000.75	1.52
GREATPATH_HOMES00177	43.1	426292.41	4674909.25	1.52
GREATPATH_HOMES00178	39.9	427824.92	4675072.05	1.52
GREATPATH_HOMES00179	39.7	428115.96	4675086.60	1.52
GREATPATH_HOMES00180	36.4	431002.57	4674525.68	1.52
GREATPATH_HOMES00181	41.5	429551.33	4674470.52	1.52
GREATPATH_HOMES00182	42.8	429544.71	4679717.22	1.52
GREATPATH_HOMES00183	44.1	423918.77	4677304.65	1.52
GREATPATH_HOMES00184	41.5	423339.33	4676368.02	1.52
GREATPATH_HOMES00185	43.0	423736.20	4676179.11	1.52
GREATPATH_HOMES00186	45.2	423739.38	4677736.45	1.52
GREATPATH_HOMES00187	35.6	424191.30	4669893.57	1.52
GREATPATH_HOMES00188	35.4	424196.44	4669840.59	1.52
GREATPATH_HOMES00189	35.8	424252.74	4669878.33	1.52
GREATPATH_HOMES00190	35.6	424254.83	4669835.84	1.52
GREATPATH_HOMES00191	34.8	424136.50	4669732.26	1.52
GREATPATH_HOMES00192	35.1	424258.09	4669686.07	1.52
GREATPATH_HOMES00193	34.2	424268.03	4669436.34	1.52
GREATPATH_HOMES00194	34.3	424181.40	4669529.90	1.52
GREATPATH_HOMES00195	33.9	424069.20	4669517.19	1.52
GREATPATH_HOMES00196	34.4	424233.39	4669532.80	1.52
GREATPATH_HOMES00197	21.7	430918.91	4663263.99	1.52
GREATPATH_HOMES00198	14.2	432930.91	4660003.27	1.52
GREATPATH_HOMES00199	29.2	430952.36	4666639.41	1.52
GREATPATH_HOMES00200	39.3	433256.72	4668634.91	1.52
GREATPATH_HOMES00201	39.2	434302.08	4668512.60	1.52
GREATPATH_HOMES00202	34.1	434287.15	4667838.61	1.52
GREATPATH_HOMES00203	29.9	430346.37	4666966.66	1.52
GREATPATH_HOMES00204	28.3	424837.63	4667245.34	1.52
GREATPATH_HOMES00205	42.8	430149.26	4670187.75	1.52
GREATPATH_HOMES00206	44.8	434234.50	4669560.40	1.52
GREATPATH_HOMES00207	42.0	433360.06	4668933.49	1.52
GREATPATH_HOMES00208	44.0	422240.66	4672553.30	1.52
GREATPATH_HOMES00209	39.8	421656.79	4672655.96	1.52
GREATPATH_HOMES00210	38.5	421446.92	4672765.65	1.52

Wind Turbine Sound Levels at Structure Locations				
Occupied Dwelling Location	Wind Turbine Sound Level (dBA)	Coordinates (UTM)		
		X	Y	Z (Height)
		(m)	(m)	(m)
GREATPATH_HOMES00211	40.5	421509.97	4673391.64	1.52
GREATPATH_HOMES00212	33.7	422499.80	4670704.67	1.52
GREATPATH_HOMES00213	34.9	422213.69	4671218.50	1.52
GREATPATH_HOMES00214	26.4	425585.34	4666198.19	1.52
GREATPATH_HOMES00215	27.0	425260.19	4666565.93	1.52
GREATPATH_HOMES00216	31.5	432821.00	4673307.53	1.52
GREATPATH_HOMES00217	31.6	432707.06	4673526.98	1.52
GREATPATH_HOMES00218	34.1	434237.30	4671393.33	1.52