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ACOUSTICAL MODELING ANALYSIS

FOR

SCHUMANN WIND DEVELOPMENT

UMATILLA COUNTY, OREGON

May 12, 2017

Prepared for

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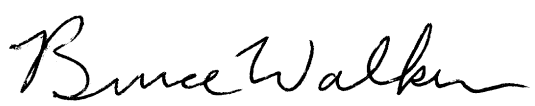

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OVERVIEW

Schumann Wind, LLC (Schumann Wind) proposes to install an array of up to five 1.7 – 2.3 MW wind turbines in Umatilla County, north of Athena, OR. The alternatives depicting both a four and five-turbine project design are described in greater detail in the Project Description below, and are shown in Figure 1 and Figure 2. The five-turbine array is similar to the four-turbine array, with the former having three turbines in the more-distant row. The predominant wind direction is from the southwest, so that the nearest residence is upwind of the turbine array approximately 72% of the time per wind direction data shown in Figure 7. Existing turbines are located on the property to the north of Res 1, with the nearest turbine 0.4 miles northwest from the residence.

Per County requirements, the minimum setback between turbines and residences (Res 1 to T-E1 and T-E2) is 2.0 miles. Complementary to the two-mile setback requirement, State and County noise regulations limit wind-turbine noise to L_{A50} and L_{A10} of 36 dB or 10 dB above ambient noise, whichever is greater. With six existing turbines within one mile of Res 1, background noise below the assumed ambient noise level of 26 dB is highly unlikely. However, Schumann Wind has requested that off-site sound levels be predicted relative to the 36 dB State and County limits.

As described in the analysis below, computations at all surrounding residences have demonstrated sound levels below 30 dB and therefore in compliance with the State and County regulations.

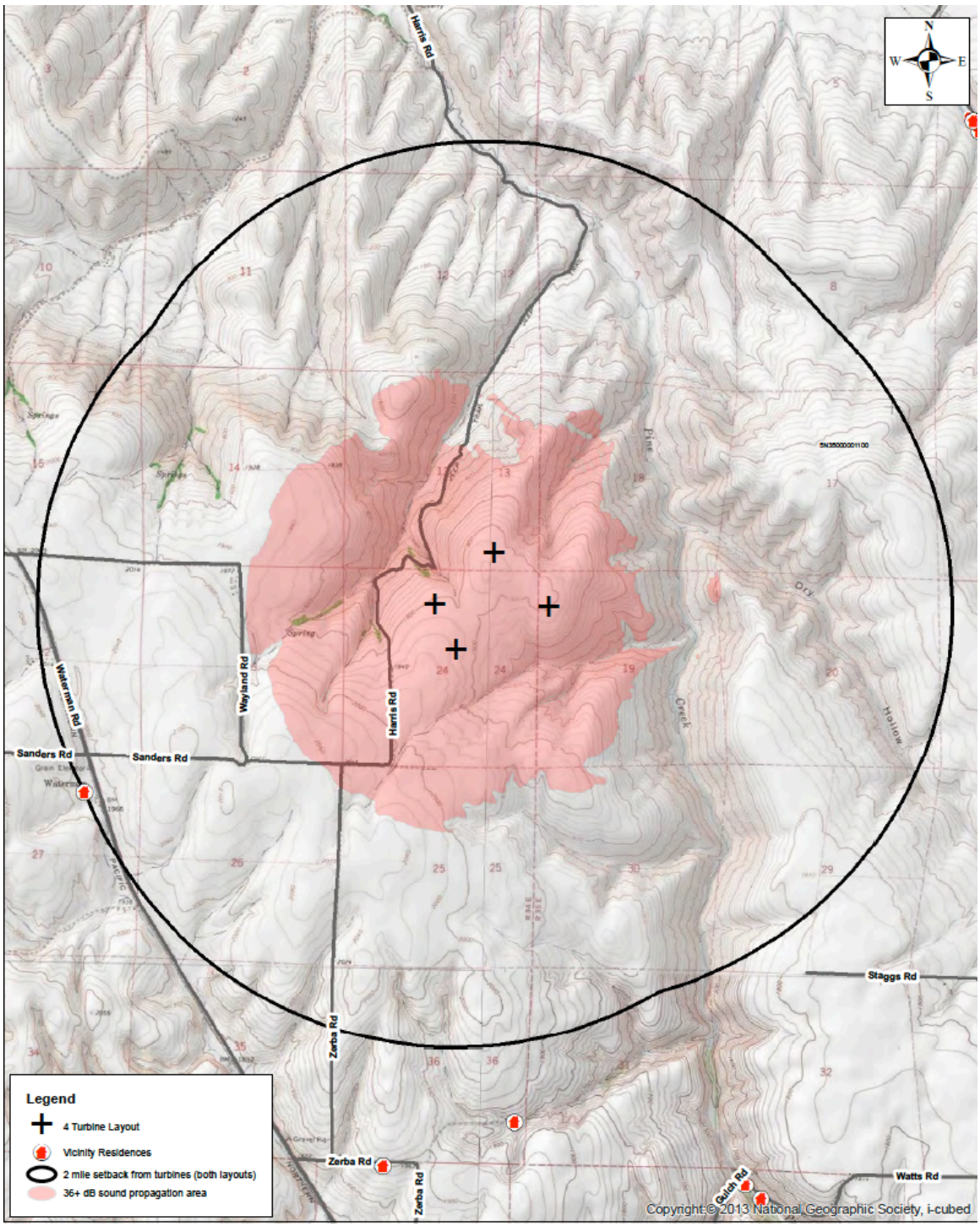

Figure 1. Four Turbine Array and Nearest Residences in Proposed Project Area Showing Two-Mile Setback Line and Area Exposed to 36 dB and Above Sound Levels

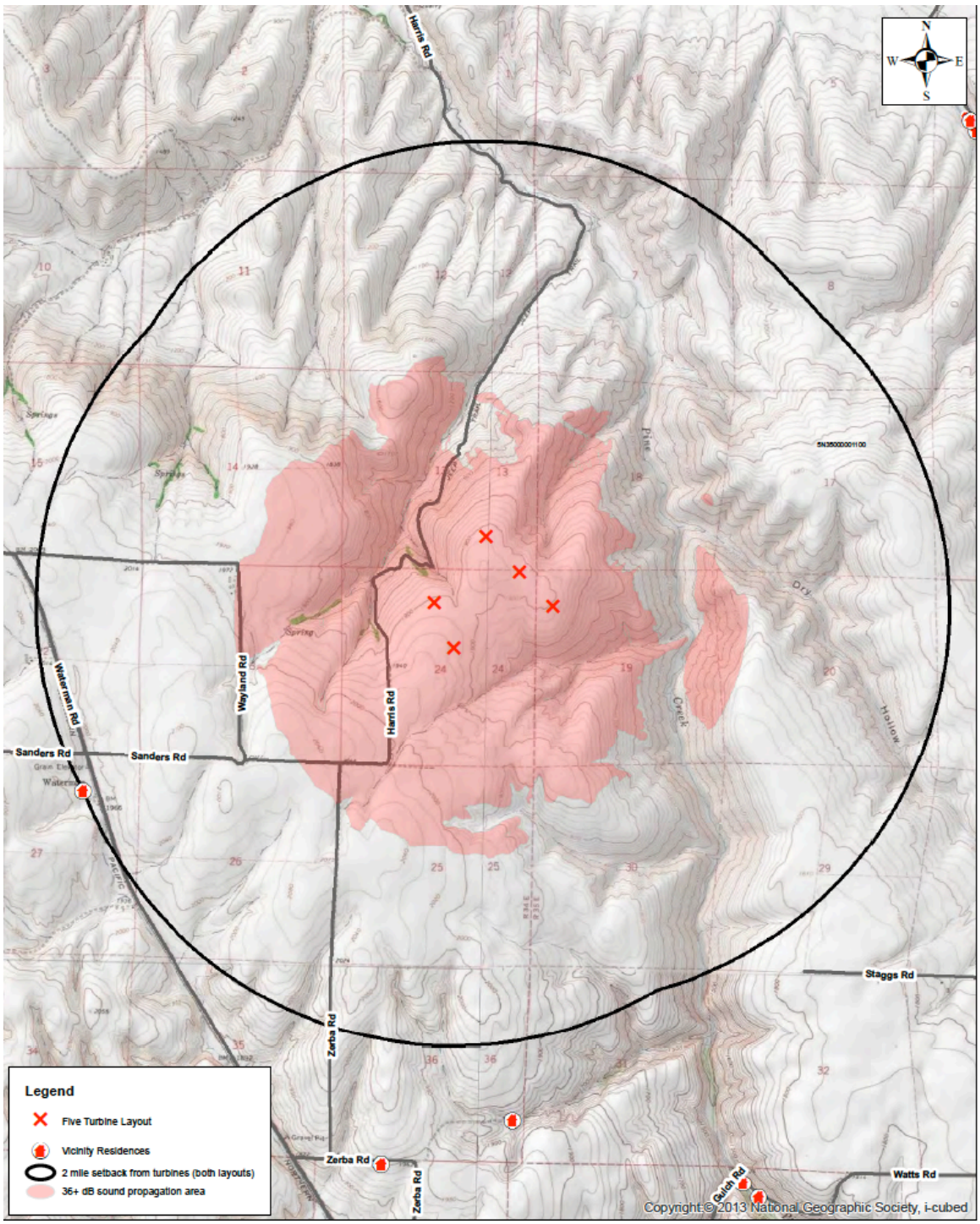

Figure 2. Five Turbine Array and Nearest Residences in Proposed Project Area Showing Two-Mile Setback Line and Area Exposed to 36 dB and Above Sound Levels

NOISE CRITERIA

The State of Oregon and Umatilla County noise limits for wind turbine are based on the 50th and 10th percentiles, meaning sound levels that are exceeded 50% or 10% of the time during any measurement hour. The basic requirement is that neither of these may be increased more than 10 dB above ambient conditions. The ambient conditions can be determined by field measurements or assumed to be 26 dB. Therefore, the minimum value of a wind turbine noise criterion is 36 dB (10 dB above the ambient baseline). In other words, the sound emitted by wind turbines may not exceed 36 dB at any residence for more than 10% of the time in any hour. In practice, noise levels in windy environments are usually 40 dB or greater, but Schumann Wind has opted to accept the baseline in lieu of field demonstrations.

PROJECT DESCRIPTION

The project will utilize either four or five GE wind turbines, mounted on towers with 80-meter hub height. Figure 1 and Figure 2 display the proposed project configurations for each alternative.

- Five-Turbine Alternative: 1 ea. GE 1.79-100 and 4 ea. GE 1.7-103 (Turbine T-E1 is the 1.79-100)

- Four-Turbine Alternative: 1 ea. GE 1.79-100 and 3 ea. GE 2.3-116 (Turbine T-E1 is the 1.79-100)

NOISE MODELING

Manufacturer's noise emission levels are presented as tables of octave or 1/3-octave effective sound power levels as functions of wind speed. In general, the noise level rises monotonically with wind speed but the octave band levels are sometimes higher at intermediate speeds. For purposes of conservatism, the highest octave band levels were combined to obtain composite spectra and overall levels. In addition, the composite levels were raised by 4 dB to allow for variations in turbine emissions and propagation conditions. The composite manufacturer's spectral data are shown in Figure 8. Overall emission levels, corresponding to spectra applied in modeling, including the +4 dB adjustment are shown in Table 1.

Table 1. Proposed Turbine Properties[123]:

Turbine Type	Power	Rotor Diameter	Modeled L_{WA}
GE 1.79-100	1.79 MW	100 m	109.6 dB
GE 1.7-103	1.7 MW	103 m	111.8 dB
GE 2.3-116	2.3 MW	116 m	111.6 dB

Note that the emission levels are presented as A-weighted Sound Power Levels (L_{WA}) and that these are not Sound Pressure Levels L_A that are experienced or

measured. At a distance of two miles, L_A would be nominally 88 dB below L_{WA} over flat, open ground.

Sound levels at off-site locations were computed using the ISO 9613-2 propagation model as implemented in SoundPlan 7.3. Ground absorption was entered as 0.5, which is typical for sandy soil and farmland. Terrain effects are fully modeled using SoundPlan's digital ground model, computed from area topographic maps. Atmospheric conditions were entered as 10°C, 70% Humidity, which sets a near-minimum atmospheric absorption rate at frequency ranges dominant in wind turbine noise. SoundPlan treats all computation directions as "downwind" of sources, adding to conservatism. Results of the average (L_{eq}) sound level computations are shown in Table 2. Typically, L_{50} is approximately 1 dB lower than L_{eq} and L_{10} is approximately 2 dB higher than L_{eq}. Sound levels at all residences are well below the 36 dB minimum criterion level for either the four or five turbine configuration.

In addition to the individual off-site location computations, average (L_{eq}) sound levels were computed on a 10 x 10 meter grid in the area (approximately 1.6 million points) and then converted to noise contour maps. Noise contours for the four-turbine array are shown in Figure 3 and contours for the five-turbine array are shown in Figure 4. AutoCAD files for these and also the 36 dB criterion contour lines have been provided for overlay on site graphics (as shown in Figures 1 and 2).

Table 2. Computed Off-Site Sound Levels for Four Turbine Alternative

Name	X meters	Y meters	Z meters	Nearest Turbine meters	Schumann 4 Only L_{eq} - dB	Schumann 4 & Existing 6 L_{eq} - dB
Res 1A	377271	5082297	630	6145	15.2	17.2
Res 1B	377480	5083926	659	5628	16.2	17.9
Res 1C	377561	5081596	598	6139	15.1	17.2
Ferguson	387749	5082042	493	4332	22.2	36.2
Res 1	380287	5082680	605	3219	23.6	24.8
Res 2	382712	5079654	598	4258	19.9	23.7
Res 3	383774	5080008	560	3900	21.1	26.1
Res 4	385615	5077420	520	6867	13.9	20.1
Res 5	385781	5079376	450	5153	18	24.9
Res 5A	386199	5079070	452	5620	16.7	22.8
Res 5B	385668	5079475	441	5013	19.1	25.5
Res 7	389026	5085905	329	5278	17	23.5
Res 8	389319	5085587	337	5489	16.5	23.4
Res 9	390007	5084927	355	6028	15.2	22.4
Res 10	390602	5084276	366	6582	13.9	21.4
Res 11	390725	5083640	373	6733	13.6	21.4
Res 12	390988	5081089	418	7649	11.9	19.8
Res 13	391067	5082182	398	7344	12.5	20.4
Res 14	391024	5079899	439	8243	10.9	18.6
Res 15	391049	5081615	408	7505	12.2	20.1
Res 16	391008	5082108	399	7308	12.5	20.4

Table 3. Computed Off-Site Sound Levels for Five Turbine Alternative

Name	X meters	Y meters	Z meters	Nearest Turbine meters	Schumann 5 Only L_{eq} - dB	Schumann 5 & Existing 6 Leq - dB
Res 1A	377271	5082297	630	6145	16.2	17.8
Res 1B	377480	5083926	659	5628	17.1	18.5
Res 1C	377561	5081596	598	6139	16.1	17.8
Ferguson	387749	5082042	493	4206	23.1	36.3
Res 1	380287	5082680	605	3218	24.3	25.4
Res 2	382712	5079654	598	4105	21	24.2
Res 3	383774	5080008	560	3742	22.3	26.5
Res 4	385615	5077420	520	6715	15.3	20.5
Res 5	385781	5079376	450	5010	19.3	25.2
Res 5A	386199	5079070	452	5456	17.9	23.2
Res 5B	385668	5079475	441	4869	20.4	25.8
Res 7	389026	5085905	329	5279	18.1	23.8
Res 8	389319	5085587	337	5456	17.6	23.6
Res 9	390007	5084927	355	5992	16.4	22.7
Res 10	390602	5084276	366	6530	15.2	21.6
Res 11	390725	5083640	373	6665	14.9	21.6
Res 12	390988	5081089	418	7536	13.2	20.1
Res 13	391067	5082182	398	7248	13.8	20.6
Res 14	391024	5079899	439	8115	12.3	18.8
Res 15	391049	5081615	408	7400	13.5	20.3
Res 16	391008	5082108	399	7211	13.8	20.7

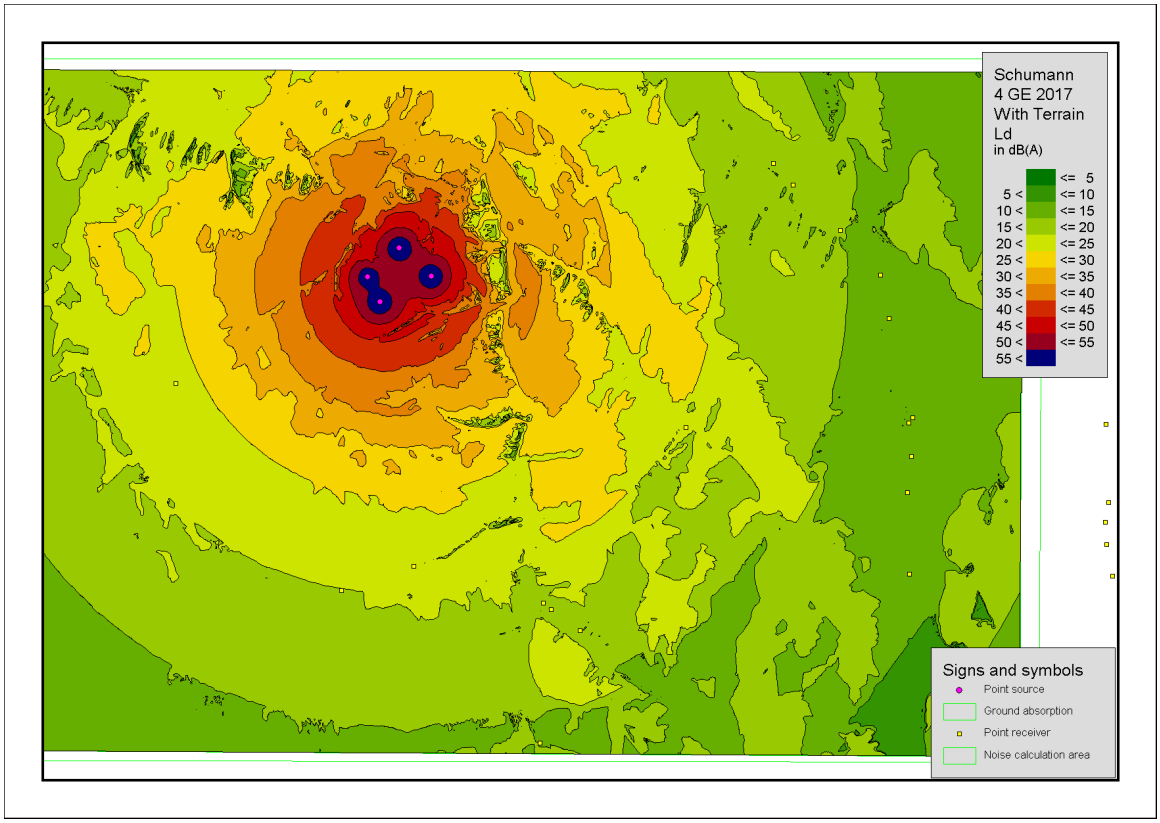

Figure 3. 5 dB Increment Noise Contours for Four-Turbine Schumann Array

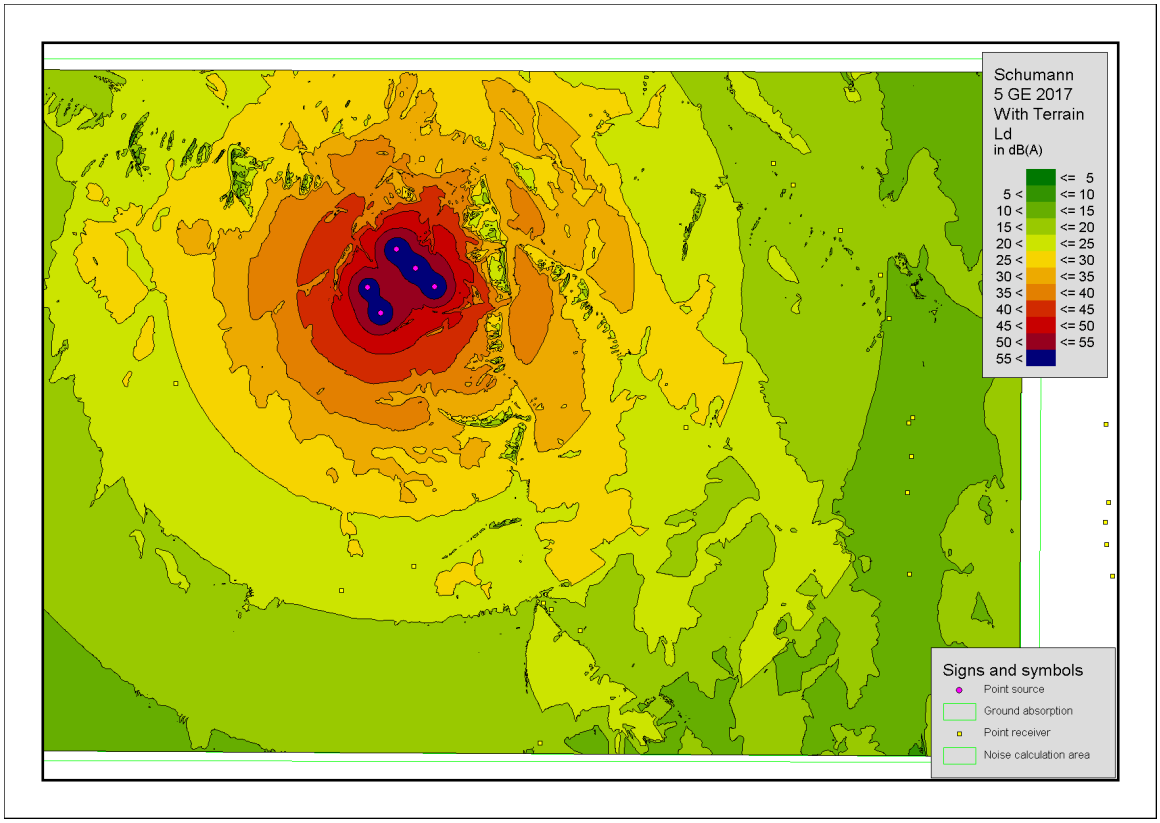

Figure 4. 5 dB Increment Noise Contours for Five-Turbine Schumann Array

CONTINGENCY

It is clear from Table 2 and Table 3 and Figures 3 and 4 that under conditions modeled, off-site sound levels resulting from operation of the Schumann project will be in compliance with regulatory criteria by a significant margin. In the rare situations where atmospheric structure results in anomalous propagation, the computed margin plus the 4 dB emissions margin will insure against adverse impacts.

CUMULATIVE NOISE

Predicted turbine sound levels of 25 dB and below could raise the overall ambient noise level slightly. The degree of increase is dependent upon the actual ambient level. For example, a rough computation of the combined noise from the 9 nearest existing turbines to Res 1 is 43 dB. Adding 25 dB from Schumann would results i a total of 43.07 dB. Changes in sound level of less than 1 dB are nearly impossible to detect under field conditions. Changes of less than 0.1 dB are virtually unmeasurable.

At a location where the ambient noise level is 26 dB (the State ambient base level), adding 25 dB turbine noise would raise the overall level to 28.5 dB. Although this is not a negligible change, it is well below the 10 dB change allowed by the State of Oregon and County wind turbine noise regulations.

Extended measurements of background noise at Ferguson Ranch in 2011 indicated that the hourly ambient noise level in absence of wind turbines ranged from approximately 24 to 40 dB depending upon wind conditions, as shown in Figure 5 and Figure 6. At the low end of this range, which is likely applicable to other residences in the project area under locally calm conditions, turbine noise from the Schumann project would increase the ambient level between a fraction of a dB at the more remote locations and 2-3 dB at the nearest locations. At the upper end of the range, likely under windy conditions, the influence of Schumann project noise would be negligible.

A listing of computed ambient noise increases at each residence vs possible existing ambient noise from wind or other sources are shown in Table 4. Probable applicable conditions are shown in Bold.

Table 4. Increases in Ambient Noise Level from Turbines vs Existing Ambient Level

Name	Schumann 5 SPL	Ambient SPL						
		20	24	26	30	36	40	43
Res 1A	16.2	1.51	**0.67**	0.43	0.18	0.05	0.02	0.01
Res 1B	17.1	1.80	**0.81**	0.53	0.22	0.06	0.02	0.01
Res 1C	16.1	1.48	**0.65**	0.42	0.17	0.04	0.02	0.01
Ferguson	23.1	4.83	**2.58**	**1.80**	**0.81**	**0.22**	**0.09**	0.04
Res 1	24.3	5.67	3.16	2.24	1.04	0.28	0.12	**0.06**
Res 2	21	3.54	**1.76**	1.19	0.52	0.14	0.05	0.03
Res 3	22.3	4.31	**2.24**	1.54	0.68	0.18	0.07	0.04
Res 4	15.3	1.27	**0.55**	0.35	0.14	0.04	0.01	0.01
Res 5	19.3	2.67	**1.27**	0.84	0.35	0.09	0.04	0.02
Res 5A	17.9	2.09	**0.95**	0.63	0.26	0.07	0.03	0.01
Res 5B	20.4	3.21	**1.57**	1.06	0.45	0.12	0.05	0.02
Res 7	18.1	2.16	**0.99**	0.65	0.27	0.07	0.03	0.01
Res 8	17.6	1.97	**0.90**	0.59	0.24	0.06	0.02	0.01
Res 9	16.4	1.57	**0.70**	0.45	0.19	0.05	0.02	0.01
Res 10	15.2	1.24	**0.54**	0.35	0.14	0.04	0.01	0.01
Res 11	14.9	1.17	**0.50**	0.32	0.13	0.03	0.01	0.01
Res 12	13.2	0.82	**0.35**	0.22	0.09	0.02	0.01	0.00
Res 13	13.8	0.93	**0.40**	0.25	0.10	0.03	0.01	0.01
Res 14	12.3	0.68	**0.28**	0.18	0.07	0.02	0.01	0.00
Res 15	13.5	0.88	**0.37**	0.24	0.10	0.02	0.01	0.00
Res 16	13.8	0.93	**0.40**	0.25	0.10	0.03	0.01	0.01

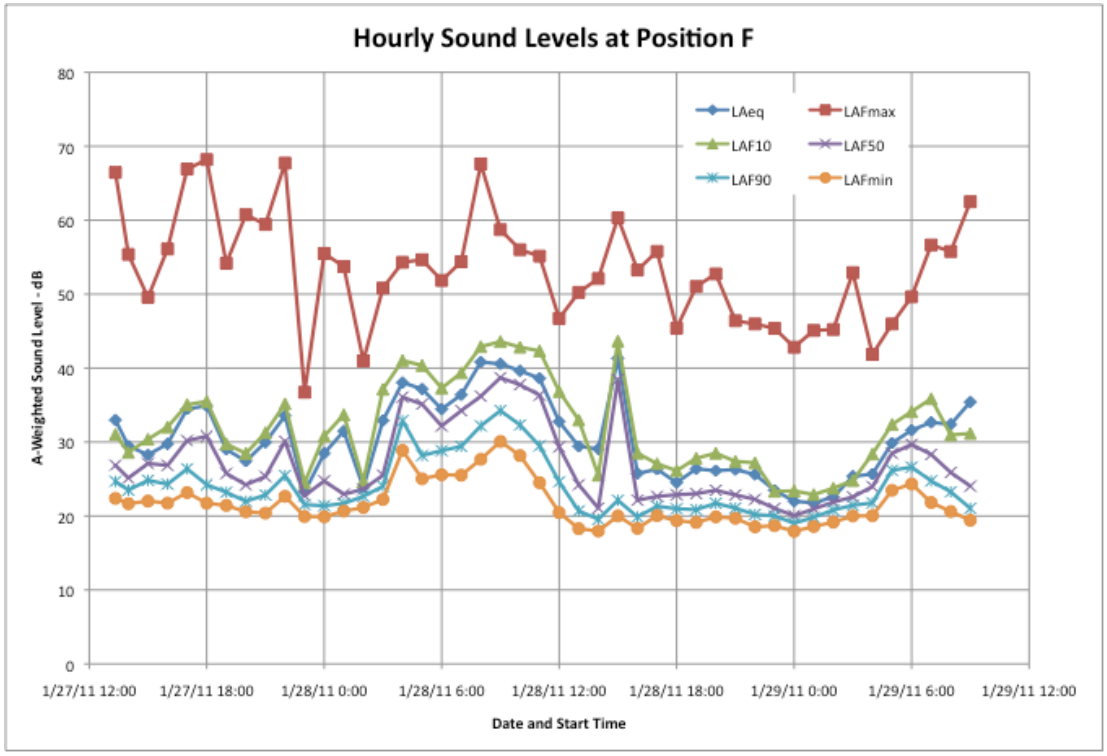

Figure 5. Ambient Noise Measured on Ferguson Ranch in January 2011

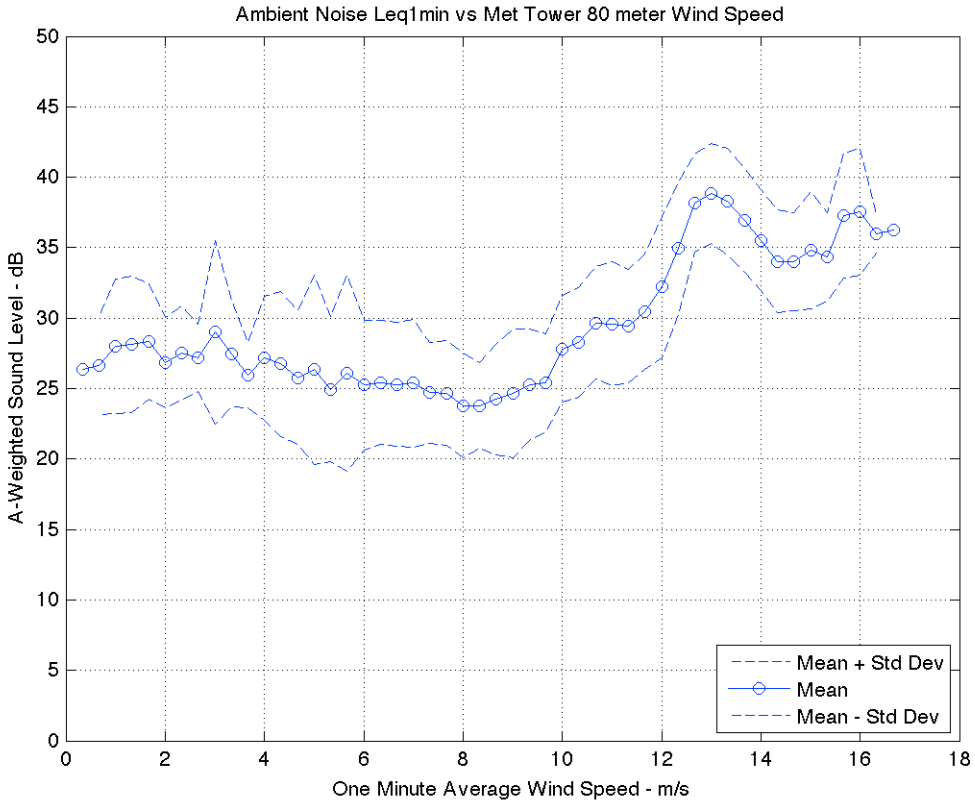

Figure 6. Regression Analysis of Short Term Noise vs Wind

BACKUP INFORMATION

Figure 7. Two Wind Roses from Project Area

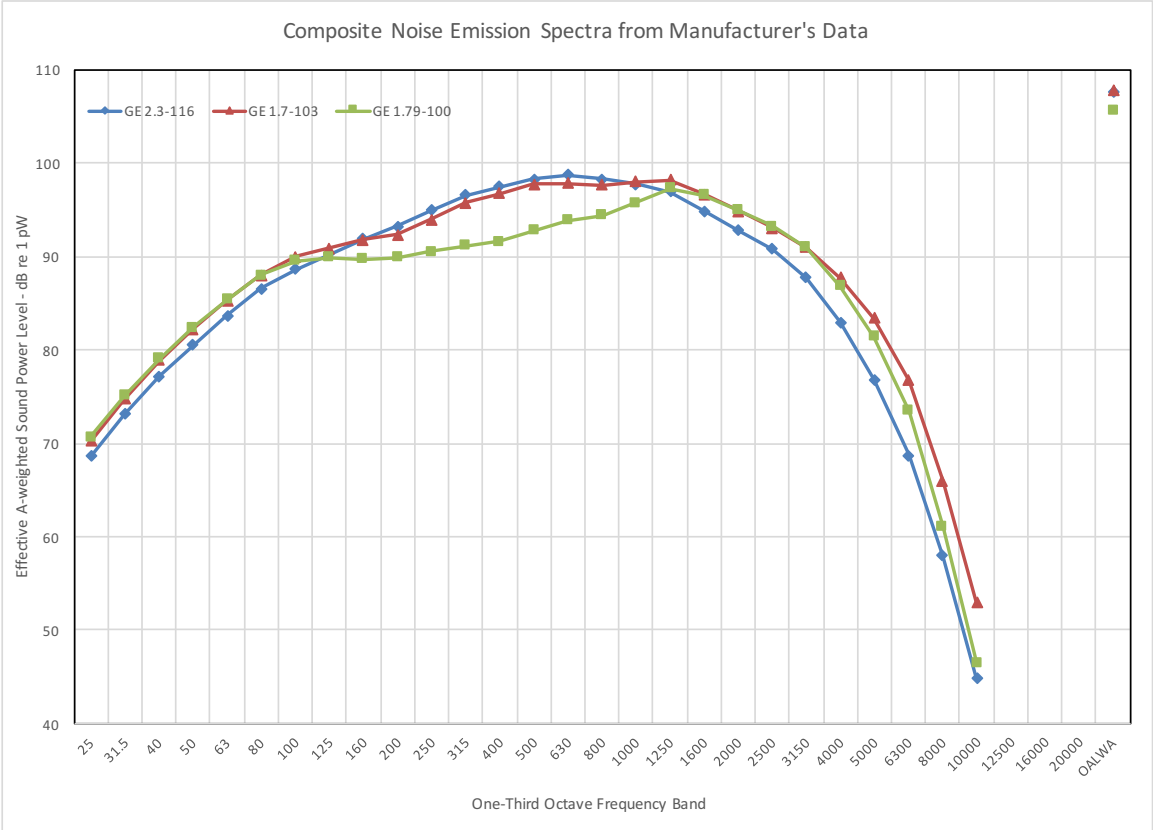

Figure 8. Composite Emission Spectra - 4 dB were added to these spectral levels for modeling purposes

CONCLUSION

Computations of project noise at all surrounding residences have demonstrated sound levels below 30 dB and therefore in compliance with the State and County regulations.

REFERENCES

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[1] General Electric Technical Documentation. Wind Turbine Generator Systems, 1.7-100 with LNTE, 50 Hz and 60 Hz: Product Acoustic Specifications

[2] General Electric Technical Documentation. Wind Turbine Generator Systems, 1.7-103 - 50 Hz and 60 Hz: Product Acoustic Specifications

[3] General Electric Technical Documentation. Wind Turbine Generator Systems, 2.3-116 - 50 Hz and 60 Hz: Product Acoustic Specifications