EIGHT POINT WIND ENERGY CENTER

Case No. 16-F-0062

1001.19 Exhibit 19

Noise and Vibration

Contents

Tables

Figures

Appendices

Exhibit 19: Noise and Vibration

A Noise Impact Assessment (NIA) of the noise impacts associated with construction and operation of the Facility, related facilities and ancillary equipment was prepared by Robert O'Neal of Epsilon Associates, Inc. (Epsilon). This report is attached as Appendix 19-1 of this Application. Mr. O'Neal has over 25 years of experience in the areas of community noise impacts, meteorological data collection, and analyses. His noise impact evaluation experience includes the design and implementation of sound level measurement programs, modeling of future impacts, conceptual mitigation analyses, and compliance testing. He is Board Certified by the Institute of Noise Control Engineering (INCE) in Noise Control Engineering and is a Certified Consulting Meteorologist (CCM) by the American Meteorological Society. Both of these certifications are national programs. Modeling of future potential noise impacts was done in accordance with ISO 9613.

19(a) Sensitive Sound Receptor Map

A map showing the location of sensitive sound receptors in relation to the Facility is provided in Figure 3-1 of the NIA. The map shows the location of residences, outdoor public facilities and areas, hospitals, schools, places of worship, and other noise-sensitive receptors. The receptors are broken into two categories, participating and non-participating, and identified as such on the figure. It should be noted that participating landowners have signed contracts which include an easement (or waiver) for effects including sound. During the course of the noise impact assessment, the size of the Project Area was significantly reduced. Therefore, many receptors which were originally within one mile of the Project are now considerably further away from the Project but were retained in the evaluation for consistency.

19(b) Evaluation of Ambient Pre-Construction Baseline Noise Conditions at Receptors

On behalf of the Applicant, Epsilon completed winter (leaf off) and summer (leaf on) background sound monitoring at seven (winter) and eight (summer) representative locations, determined based upon distance to proposed wind turbines and land-use. Each of the locations are described in Section 6.2 of the NIA. See Figure 6-1 of the NIA for locations of the monitoring sites, along with Figure 19-1 of this Application. GPS coordinates of the sound microphones are found in Table 6-1 of the NIA. Annual Average Daily Traffic (AADT) data for the nearest roads to each monitoring location are discussed in Section 6.2 of the NIA. Broadband (dBA), octave band, one-third octave band, and infrasound data were measured 24 hours per day for at least 14 days in each season.

Ambient Audible Range Sound Level Monitoring

Background sound level monitoring was performed continuously at these locations in the winter of 2017 (February 28 through March 16, 2017) and the summer of 2016 (June 16 through July 1). Sound level data were collected using either a Larson Davis (LD) model 831 sound level meter (SLM) equipped with a LD PRM831 preamplifier and a PCB 377B20 half-inch microphone, or a Rion NL-21 SLM equipped with a Rion UC-52 microphone and Rion NH-21 preamplifier. All SLMs were housed in environmental protection kits. The kit included an untreated ACO 7-inch diameter 20 pores per inch (ppi) open cell foam windscreen to reduce wind-induced noise over the microphone. Each microphone was mounted at a height of four feet above ground level in accordance with American National Standards Institute (ANSI) S12.9-1992/Part 2 (R2013). The sound level meters meet Type 1 ANSI/ASA S1.4, IEC 61672 Class 1, or IEC 61672 Class 2 standards.

Ambient Infrasound Level Monitoring

Infrasound measurements were collected during the summer season and winter season using the Norsonic Type 140 SLM equipped with a Norsonic Type 1209 preamplifier and a G.R.A.S. 40AN or Norsonic Nor1225 half-inch microphone. The microphone is designed to measure audible frequencies as well as inaudible (infrasound) frequencies down to 0.5 hertz (Hz). The infrasound SLM utilized the same environmental protection kit as the other SLMs with a 7-inch diameter windscreen to reduce wind-induced noise over the microphone that was tripod-mounted 4 feet above ground level. The infrasound meter collected continuous broadband and 1/3 octave-band ambient sound pressure level data at two locations.

The SLMs were used to collect continuous ambient sound pressure level data at each location and set to log data every 10 minutes with a one-second time history data using the "fast" response setting. Each meter has data logging capability and was programmed to log statistical data every 10 minutes for the following parameters: L_{eq}, L_{10}, L_{50}, L_{90}, L_{max}, and L_{min}. Over 30,000 10-minute measurements were collected during this study over both seasons. All meters used in the winter survey were calibrated and certified as accurate to standards set by the National Institute of Standards and Technology (NIST). These calibrations were conducted by an independent laboratory within 12 months of field placement and certificates of calibration are provided in Appendix B of the NIA. All measurement equipment was calibrated (i.e., sensitivity checked) in the field before and after the surveys with the manufacturer's acoustical calibrators.

In order to understand how the existing sound levels are influenced by wind speed, HOBO H21-002 micro-weather stations with tripods and data loggers were used to record continuous wind speed data at several of the sound monitoring locations in the winter survey. A Rainwise WindLog anemometer was used during the summer survey. The sensors were mounted approximately two meters above ground level and were logged every 10 minutes. Precipitation, temperature, and relative humidity data from Tarantine Field Airport National Weather Service (NWS) station in Wellsville were used for the summer survey. The NWS station is located approximately 14 miles from the nearest sound monitoring location. The State University of New York (SUNY) MesoNet station in Hartsville was used as the source of precipitation, temperature, and relative humidity for the winter survey. The Hartsville station is approximately 5 miles from the nearest sound monitoring location. Monitoring periods that experienced ground-level wind-speeds with an average wind speed greater than 5 meters per second (m/s) and/or precipitation were excluded from the analysis, as per Method #1 in ANSI S12.18-1994. Any measurements during temperatures outside the temperature range of 14 degrees Fahrenheit (°F) to 122 °F were considered invalid due to the SLM specifications. In addition, periods outside the relative humidity range of 25% to 90% were excluded for the measurements taken with the Larson Davis Model 831, periods outside the relative humidity range of 5% to 90% were excluded for measurements taken with the Norsonic Type 140 SLM, and periods outside the relative humidity range of 10% to 90% were excluded for measurements taken with the Rion NL-21 SLM. NWS data from the summer and winter monitoring periods are presented in Appendix C of the NIA. Wind speed from the on-site meteorological tower is provided under confidential cover information pursuant to NY Public Officer's Law Section 87(2)(d) and 16 NYCRR 6-1.4.

Intermittent noise was "filtered" by reporting the L90 metric which eliminates the transient and intermittent sound sources. Seasonal noise was excluded by using the method in ANSI Standard S12.100-2014 to report the A-weighted, noise compensated (ANS-weighted metric) which excludes sounds above the 1000 Hz octave band (or above the 1250 one-third octave band). During summer monitoring, the measurements were affected by insect noise at one or more locations. A high-frequency natural sound (HFNS) filter was applied to the measured 1/3 octave-band data from which a broadband sound level was calculated. This technique removes all sound energy above the 1,250 Hz frequency one-third octave band. Two of the summer monitors only measured broadband sound levels. Therefore, the "measured to ANS" difference found in the locations with octave band data was applied to the two broadband-only sites to calculate an ANS-filtered value. The ANS filtering method was also applied to the winter monitoring period. Periods of rain, thunderstorms in the vicinity, excessive wind (wind speed exceeding 5 meters per second at the sound microphone) and snow as well as weather conditions out of the range of specifications for the sound equipment were noted and excluded from calculation of ambient noise results.

Baseline Noise Monitoring Results

Baseline noise data were analyzed and are reproduced in the NIA in both temporal and spectral formats. A summary of ambient noise monitoring results at each of the monitoring sites in the winter and summer is provided below. See the NIA in Appendix 19-1 for full detail regarding these results.

The ambient (L_{90}) ANS-weighted sound levels measured at each monitor location for each monitoring period are summarized below for daytime and nighttime monitoring in Table 19-1 and 19-2, respectively. The ANS-weighted sound levels are 0-3 dBA lower than actual measured sound levels in the winter season, and 2-6 dBA lower than actual measured sound levels in the summer season when insect activity is most pronounced.

Table 19-1. Daytime Ambient L_{90} (dBA) Sound Pressure Level Summary

Location	Overall (dBA)		Winter (dBA)		Summer (dBA)	
	Measured	ANS	Measured	ANS	Measured	ANS
Winter 1 / Summer 6	31	30	34	33	28	26
Winter 2 / Summer 8	30	29	31	31	29	27
Winter 3 / Summer 8	30	29	31	30	29	27
Winter 4 / Summer 8	30	29	31	30	29	27
Winter 5 / Summer 5	37	35	38	36	35	33
Winter 6 / Summer 6	32	30	35	34	28	26
Winter 7 / Summer 7	31	29	31	30	30	28
Daytime Average	**31**	**30**	**33**	**32**	**30**	**28**

Table 19-2. Nighttime Ambient L_{90} (dBA) Sound Pressure Level Summary

Location	Overall (dBA)		Winter (dBA)		Summer (dBA)	
	Measured	ANS	Measured	ANS	Measured	ANS
Winter 1 / Summer 6	26	23	28	26	23	20
Winter 2 / Summer 8	26	22	24	22	27	21
Winter 3 / Summer 8	27	23	27	25	27	21
Winter 4 / Summer 8	27	23	26	24	27	21
Winter 5 / Summer 5	30	27	29	26	30	27
Winter 6 / Summer 6	27	24	30	28	23	20
Winter 7 / Summer 7	24	21	26	25	22	16
Nighttime L90 Average	**26**	**23**	**27**	**25**	**26**	**21**

Table 19-3 summarizes the combined monitoring period, in which statistical averages were calculated for the entire dataset, including daytime, nighttime, and both seasons for the L_{eq} and L_{90} sound levels. These values are ANS-weighted. Figure 7-3 through 7-33 in the NIA provide the detailed results for each measurement location graphically as a function of time and frequency for the L_{eq} and L_{90}. These graphs show the periods that were excluded along with the reason for exclusion. Frequency graphs corresponding to the one-third and full-octave band noise levels after exclusions for the whole range of frequencies of interest for all noise descriptors collected are also presented.

Table 19-3. Ambient Annual Broadband Sound Pressure Level

Location	L_{eq} (dBA)	L_{90} (dBA)
Winter 1 / Summer 6	37	28
Winter 2 / Summer 8	35	27
Winter 3 / Summer 8	33	27
Winter 4 / Summer 8	36	27
Winter 5 / Summer 5	41	33
Winter 6 / Summer 6	36	29
Winter 7 / Summer 7	33	26
Annual Average	**36**	**28**

Comparison of Sound Levels to Windspeed

Wind speeds at hub height (60 meters or 196.85 feet) were measured at a meteorological tower within the site. A 58-meter wind speed sensor was used to extrapolate wind speeds up to hub height. Sound pressure levels of both L_{eq} and L_{90} were plotted against hub height wind speed in order to determine whether there is a correlation between wind speed and ambient sound level. Wind speeds below 4 meters per second (m/s) were excluded because the proposed wind turbines would not be operational at wind speeds lower than 4 m/s. For both L_{EQ} and L_{90} measurements, there was some correlation between sound pressure level and wind speed, with the correlation becoming stronger as wind speeds increased. The correlation was more pronounced during the nighttime hours (see Figure 8-1 and 8-2 of the NIA).

On-site ground level wind speeds were also plotted against 10-minute L_{90} sound levels. The maximum, minimum, and average sound levels for each ground level speed were plotted. There was a correlation between ground level wind speed and L_{90} sound levels, which improved as wind speed increases (see Figure 8-3 and 8-4 of the NIA). Figures of the L_{90} 10-minute sound levels versus wind speeds at 10 meters above ground level are shown in the NIA as Figures 8-5 through 8-10.

Temporal Accuracy

Temporal accuracy of the monitoring data was analyzed for the L_{eq} and L_{90} noise descriptors according to the procedures in ANSI S12.9-1992/Part 2. The standard analyzes the representativeness of the measurement data for a particular measurement location. The goal of the sound measurement program is to achieve a 95% confidence interval which would allow for a statement of 95% confidence that the true long-term average sound level falls within the given interval. The confidence intervals are categorized into three classes. Class "A" is for precision measurements, with Class "B" and Class "C" being less precise. Normality of the data set is then calculated using a Kolmogorov-Smirnov test.

Analysis results are shown below in Table 19-4a for the L_{90} and Table 19-4b for the L_{eq}. All of the sites achieved Class "A" precision status for L_{eq} and L_{90}. None of the sites fit the criteria for normality.

Table 19-4a. Temporal Accuracy Summary (ANSI 12.9-1999/Part 2) -- L_{90}

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Winter 1 / Summer 6	2816	35.22	0.48	0.49	A	Not Normal
Winter 2 / Summer 8	2248	30.08	0.22	0.23	A	Not Normal
Winter 3 / Summer 8	2578	30.6	0.22	0.22	A	Not Normal
Winter 4 / Summer 8	2589	32.58	0.34	0.35	A	Not Normal
Winter 5 / Summer 5	2869	40.67	0.45	0.47	A	Not Normal
Winter 6 / Summer 6	2809	40.67	0.45	0.47	A	Not Normal
Winter 7 / Summer 7	2834	33.24	0.37	0.38	A	Not Normal

Table 19-4b. Temporal Accuracy Summary (ANSI 12.9-1999/Part 2) -- L_{eq}

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Winter 1 / Summer 6	2816	46.19	0.67	0.69	A	Not Normal
Winter 2 / Summer 8	2248	40.47	0.38	0.39	A	Not Normal
Winter 3 / Summer 8	2578	40.14	0.35	0.37	A	Not Normal
Winter 4 / Summer 8	2589	45.39	0.56	0.58	A	Not Normal
Winter 5 / Summer 5	2869	50.2	0.52	0.54	A	Not Normal
Winter 6 / Summer 6	2809	43.78	0.56	0.58	A	Not Normal
Winter 7 / Summer 7	2834	44.38	0.55	0.57	A	Not Normal

Infrasound and Low Frequency

Infrasound and low frequency sound pressure levels were measured at two locations during both winter and summer seasons. The frequency range of these data is from 0.5 Hz to 200 Hz. The sound levels were summarized by averaging sound level data from all winter daytime hours, winter nighttime hours, summer daytime hours, and summer nighttime hours within each one-third octave band. The data indicate that infrasound and low frequency currently exist at Point Peninsula, and that sound levels increase as wind speed increases. See Figures 8-11 through 8-18 of the NIA for more detail.

19(c) Evaluation of Future Noise Levels during Construction

Facility construction will require the operation of heavy equipment for activities such as right-of-way clearing, access road construction, material and component delivery, installation of electrical interconnect, turbine foundation construction, turbine erection, and site restoration. The noise generated by these activities will be associated with gasoline and diesel-powered engines as well as impact noise from jackhammers and/or rock drills, or localized blasting, if required due to geotechnical conditions. It is expected that Facility-related construction noise will be similar to that of typical road or utility construction projects.

Noise resulting from construction was modeled using the Federal Highway Administration (FHWA) Roadway Construction Noise Model (RCNM). Reference sound source information was obtained from either Epsilon measurements or the FHWA's RCNM, and are shown in Table 19-5. All modeled sources were assumed to be operating at their maximum sound level simultaneously which ensures a conservative result.

Table 19-5. Sound Levels for Noise Sources Included in Construction Modeling

Phase	Equipment	Sound Level at 50 Feet (dBA)
Excavation	Grader	85
Excavation	Bulldozer	82
Excavation	Front-end loader	79
Excavation	Backhoe	78
Excavation	Dump Truck	76
Excavation	Roller	80
Excavation	Excavator	81
Excavation	Rock-drill	89
Foundation	Concrete mixer truck	79
Foundation	Concrete pump truck	81
Foundation	Concrete batch plant	83
Turbine erection	Large crane #1	81
Turbine erection	Large crane #2	81
Turbine erection	Component delivery	84
Turbine erection	Air compressor	78

To understand possible sound levels from temporary construction activity at various locations, a "table of sound levels vs. distances" has been created. Table 19-6 presents the propagation modeling results for construction activity at various distances ranging from 500 feet to 5,280 feet (one mile). The results show that the excavation phase is expected to be the loudest phase.

Table 19-6. Construction Noise Modeling Results – Various Distances (dBA)

Distance (feet)	Excavation	Foundation	Turbine Erection
500	65	59	62
1000	59	53	56
1500	56	50	53
2000	53	47	50
2640 (0.5 mile)	51	45	48
5280 (1 mile)	45	39	42

Table 19-7 presents the 10 closest receptors to a wind turbine, the existing daytime and nighttime ambient average sound levels (ANS values) from the nearest measurement locations described in Chapter 8 of the NIA, and the approximate sound levels of construction from each phase at these locations. Sound levels from construction of the wind energy Project will be 10-15 decibels higher than existing daytime ambient sound levels at the nearest receptors, but will be typical levels for construction activity.

The closest non-participating receptor to a wind turbine is ID #337 which is approximately 1,531 feet from Wind Turbine Generator (WTG) 9. The next closest wind turbine to ID #337 is WTG Alt. 1 approximately 3,500 feet away. Therefore, if excavation work is occurring at WTG 9 and foundation work is occurring at WTG Alt. 1 simultaneously, worst-case impacts at ID #337 would be approximately 56 dBA (56 dBA + 45 dBA ~ 56 dBA). In other words, sound levels from the louder phase of construction will predominate at any given location during construction.

Table 19-7. Summary of Construction Noise Modeling Results Compared to Existing L_{eq} (ANS) Sound Levels (dBA)

Receptor ID	Existing day/night	Excavation	Foundation	Turbine Erection
1972	39/32	56	50	53
767	42/32	56	50	53
337	42/32	56	50	53
421	37/29	56	50	53
771	40/36	56	50	53
281	42/32	56	50	53
696	44/33	56	50	53
323	44/33	56	50	53
326	40/31	56	50	53
693	40/31	56	50	53

19(d) Estimate of Future Sound Levels from the Facility

Discussion of Selected Modeling Methodologies

Sound level modeling for operation of the Facility was conducted in accordance with the standard ISO 9613-2, *Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation*. This standard prescribes a conservative method for calculating environmental noise from a variety of sources at a distance and predicts equivalent continuous A-weighted sound pressure levels under conditions favorable for sound propagation (i.e., downwind propagation, ground-based temperature inversion). In addition, the full octave bands from 31.5 Hz to 8,000 Hz are calculated.

The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain. The acoustical modeling software used here was Cadna /A, from Datakustik GmbH. ISO 9613-2 assumes downwind sound propagation between every source and every receiver, consequently, all wind directions, including the prevailing wind directions, are taken into account.

In addition, the CONCAWE (Conservation of Clean Air and Water in Europe) meteorological adjustments (denoted K4 in the CONCAWE standard) were also utilized in order to estimate project sound levels over the course of one year. Over the course of a year, sound levels associated with the operation of wind turbines will at times be less than the modeled worst-case/short-term sound levels. In order to quantify this reduction, differences in the wind turbine sound power levels due to changes in hub height wind speeds and variability in meteorological conditions (stability, wind direction, and wind speed) were addressed in the sound level modeling through modifications to the inputs and through the addition of the CONCAWE meteorological adjustments. The Cadna/A modeling software allows for the inclusion of the CONCAWE meteorological adjustments to the ISO 9613-2 calculations.

(1) Sound Propagation

The Project Area was modeled with mixed ground (G=0.5). A temperature of 10 degrees Celsius (°C; 50°F) and 70% relative humidity was used to calculate atmospheric absorption in accordance with the standard. These conditions result in the smallest reduction in sound levels at the key frequencies for A-weighted sound levels. No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

The sound level analysis includes 35 wind turbines, four of which are alternate wind turbines. The wind turbine layout consists of 31 General Electric (GE) 3.43-137 units and four GE 2.3-116 LNTE (low-noise trailing edge) units. The 31 three-blade GE 3.43-137 turbines (including the four alternates) will have a rotor diameter of 137 meters and placed atop 110-meter towers and the four three-blade GE 2.3-116 LNTE turbines will have a rotor diameter of 116 meters and placed atop 94-meter towers. Technical reports from GE were provided for each wind turbine model which documented the expected sound power levels associated with the proposed wind turbines. Under peak sound level producing conditions (hub height wind speed of at least 9 m/s for the GE 3.43-137 and at least 10 m/s for the GE 2.3-116) each wind turbine has an A-weighted sound power level of 106.0 dBA with an additional 2 dB added to account for uncertainties. The Applicant anticipates this turbine, or a similar turbine, will have the highest sound power levels of any model under consideration. This model wind turbine is also expected to have the highest sound power levels in the low frequency bands of 16, 31.5 and 63 Hz of any models under consideration.

Sound pressure levels due to operation of all 35 wind turbines and the substation transformer were modeled at 763 receptors within and surrounding the Project Area. Results calculated with these parameters represent the highest 1-hour equivalent average sound level (L_{eq}) that will be emitted by the Facility. In addition to modeling at discrete points, sound levels were also modeled throughout a large grid of receptor points, each spaced 20 meters apart to allow for the generation of sound level isolines. Results are presented in both tabular format (see Appendix E of the NIA) and through graphical isolines of A-weighted decibels overlaid on property boundaries (see Figure 9-2 of the NIA). Contours are at 1-dBA increments with every 5 dBA contour differentiated. Both “participating” and “non-participating” properties are identified in the figures.

(2) (3) CONCAWE Meteorological Conditions

Over the course of a year, sound levels associated with the operation of wind turbines will at times be less than the modeled worst-case/short-term sound levels. In general, the sound levels will be largely driven by the hourly hub height wind speed which drives the resultant sound power level of the wind turbines. One year of hourly meteorological data (January 1, 2016 to December 31, 2016) was provided by the Applicant (8,760 hours). This allowed for calculation of worst-case (L10) and typical (L50) annual operational sound levels. This data is proprietary, therefore, the Applicant will seek the requisite trade secret protection for this information pursuant to POL Section 87(2) (d) and 16 NYCRR § 6-1.3.

Unlike the short-term modeling described above, the long-term modeling used a ground absorption factor of 1.0 as documented in the literature. Stability, wind direction, and wind speed were the meteorological parameters that were set in each of the model runs. The matrix of modeled inputs for these parameters is presented in Table 9-4 of the NIA. Stability categories have been grouped because attenuation does not vary between stabilities for a given wind speed and direction. Wind directions in 45 degree increments were modeled to allow for a reasonable variety of upwind, downwind, and crosswind conditions to be considered. Wind speeds were selected based on category thresholds and ANSI measurement restrictions. This combination of stability, wind directions, and wind speeds yields 72 different meteorological conditions.

The stability class for each hour in the dataset was determined using the Turner Method as described in the U.S. Environmental Protection Agency (USEPA) Meteorological Monitoring Guidance for Regulatory Modeling Applications (USEPA, 2000). Quality Controlled Local Climatological Data (QCLCD) consisting of hourly summaries for sky conditions, wind speed, wind direction, ceiling height, and precipitation for Wellsville Municipal Airport, Wellsville, NY for the same one-year period along with solar altitude, sunrise, and sunset determinations based on a solar calculations spreadsheet available from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) Research, Earth System Laboratory website were used for the stability class determination. These calculations are proprietary, therefore, the Applicant will seek the requisite trade secret protection for this information pursuant to POL Section 87(2) (d) and 16 NYCRR § 6-1.3.

(4) Other Noise Sources

In addition to the wind turbines, there will be a collector substation located within the Project Area off Town Line Road. One 34.5/115 kV step-up transformer rated at 115 MVA is proposed for the substation. The transformer sound power was estimated using the techniques in the Electric Power Plant Environmental Noise Guide (Edison Electric Institute), and was included in the operational noise modeling. There may be an emergency generator located at the Operations and Maintenance (O&M) building in the event utility-supplied power is temporarily unavailable. This piece of equipment will only run in emergencies and for periodic daytime-only testing as directed by the manufacturer. For these reasons, sound levels from the operation of the emergency generator were not included in the site-wide model.

(5) Accuracy of models

The conservative set of modeling assumptions for this analysis has been verified through post-construction sound level measurement programs at operating wind energy facilities. According to the Massachusetts Study on Wind Turbine Acoustics, "The ISO 9613-2 model with mixed ground (G=0.5) with +2 dB added to the results was most precise and accurate at modeling the hourly L_{eq}, as compared to individual five minute periods".[1] In addition, a recent post-construction measurement program conducted by Epsilon in the Rocky Mountain region found measured sound levels met the regulatory sound level limit under worst-case operating conditions at locations modeled to be at the regulatory limit. Unlike the short-term modeling, the long-term modeling used a ground absorption factor of 1.0 instead of 0.5. This is consistent with the approach presented by Evans and Cooper in their comparisons of sound prediction methods which states that, "Completely absorptive ground (G=1) has been assumed as the use of reflective ground has previously been found to result in significant over-predictions with the CONCAWE methodology."[2] The Project region primarily consists of rolling terrain and lacks significant changes in elevation. Therefore, no terrain concavity adjustment was implemented in the model.

Spectral ground absorption was calculated using a G-factor of 0.5 which corresponds to "mixed ground" consisting of both hard and porous ground cover. No significant water bodies are present in the modeling area, therefore, a G=0 for water bodies was not used. As noted above in the Massachusetts Study on Wind Turbine Acoustics, "The ISO 9613-2 model with mixed ground (G=0.5) with +2 dB added to the results was most precise and accurate at modeling the hourly L_{eq}, as compared to individual five minute periods." The National Association of Regulatory Utility Commissioners (NARUC) Grants & Research Department published a report entitled "Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects" (October 2011) which recommends a G=0.5 for the ISO 9613-2 standard.

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[1] RSG et al, "Massachusetts Study on Wind Turbine Acoustics," Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016.

[2] Comparison of Predicted and Measured Wind Farm Noise Levels and Implications for Assessments of New Wind Farms, T. Evans and J. Cooper, Acoustics Australia 40(1), April 2012.

(6) Model Corrections

Equivalent (L_{eq}) sound levels were calculated for a variety of meteorological conditions. When compared to the short-term modeling results, certain conditions resulted in CONCAWE sound levels exceeding ISO 9613-2 sound levels. However, the ISO 9613-2 modeling results yield accurate to conservative operational sound levels as noted in item (5) above. Therefore, CONCAWE modeled results that exceed ISO 9613-2 modeled results are considered overly conservative and were replaced by the ISO 9613-2 results for that particular meteorological condition. This resulted in adjustments to the CONCAWE modeled sound levels ranging from 0 to 7 dBA.

In addition, the long-term sound levels have been analyzed using two methodologies. The first method (no zeros) includes only periods when the wind turbines are expected to be operating based on the annual meteorology (i.e., above cut-in wind speed). This is conservative in that there will be periods during the year when the sound level associated with the wind turbines will be zero because they will not be operating. These periods have the potential to reduce the sound levels for the various metrics presented in this analysis. The second method includes both operational and non-operational periods (with zeros) in the calculation (8,760 hours/year). This is representative of long-term/annual conditions because it includes periods when the wind turbines are not operating. For the highest 50 receptors, typical noise levels range from 34 to 44 dBA for the first method and from 33 to 44 dBA for the second method. Appendix F of the NIA has detailed results from these methods.

19(e) Evaluation of Future Noise Levels during Operation of the Facility

(1) Predicted A-weighted/dBA Sound Levels

The model predicted 1-hour equivalent (L_{eq}) A-weighted sound levels at each of the sensitive receptor locations, based on the turbine manufacturer regarding the unique operational noise characteristics of the selected turbine model. The worst-case future noise levels range from 13 to 48 dBA. Appendix E of the NIA includes the A-weighted and octave band modeled sound levels (Table E-1).

In addition to these discrete modeling points, sound level isolines generated from the modeling grid are presented in Figure 9-2 of the NIA, accompanied by a series of inset maps that provide a higher level of detail at all modeled receptors.

Table 19-8 presents the number of sensitive noise receptors that have been modeled to experience a worst-case 1-hour L_{eq} sound level of 40 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. Because the usage of each receptor/structure has not been identified, it has been assumed that all receptors are residential.

Table 19-8. Participating and Non-Participating Receptors Modeled 40 dBA or Greater

Modeled Leq Sound Level (dBA)[1]	# of Receptors	
	Participating	Non-Participating
48	1	0
47	0	0
46	0	0
45	2	0
44	9	4
43	10	5
42	17	10
41	2	10
40	4	13

Notes: 1. Rounded to the nearest whole decibel.

(2) Tonal Evaluation

Aerodynamic noise is the primary source of noise associated with wind turbines. These acoustic emissions can be either tonal or broadband. Tonal noise occurs at discrete frequencies, whereas broadband noise is distributed with little peaking across the frequency spectrum. For the purposes of this evaluation, a prominent discrete tone is identified as present if the tone is audible and the time-average sound pressure level (L_{eq}) in the 1/3 octave band of interest exceeds the arithmetic average of the time-average sound pressure level for the two adjacent 1/3 octave bands by any of the constant level differences listed in Table 19-9 below. This method is consistent with the approach presented in ANSI S12.9, Part 3, Annex B, Section B.1.

Table 19-9. Limits for One-Third Octave Band Tonality Designation

One-Third Octave Bands	Tonality Limit (K_T)
25 to 125 Hz	15 dB
160 to 400 Hz	8 dB
500 Hz to 10 kHz	5 dB

Sound pressure level calculations using the Cadna/A modeling software which incorporates the ISO 9613-2 standard is limited to octave band sound levels; therefore a quantitative evaluation of one-third octave band sound levels using the modeling software was not possible. Instead, one-third octave band sound pressure levels due to the closest wind turbines were calculated at the nearest 10 potentially impacted and representative receptor locations using equations accounting for hemispherical radiation and atmospheric absorption. The results are presented in Table 12-2 of the NIA and show that received sound pressure levels due to the closest wind turbines at each of these locations are not predicted to result in any prominent discrete tones as defined in the stipulations.

Substation transformers have the potential to create a prominent discrete tone at nearby receptors, specifically during the ONAN (fans off) condition. For this Project the substation is modeled to be less than 28 dBA at all sensitive receptors. Therefore, prominent discrete tones from the substation are not a concern with this Project.

(3) Amplitude Modulation

With respect to turbines, amplitude modulation (AM) is a recurring variation in the overall level of sound over time. The modulation sound is typically broadband, and it comes from interactions of the blade with the atmosphere, wind turbulence, directionality of the broadband sound of the blades, or tower interact with the wake of the blade. The modulation is not infrasound. Normal amplitude modulation from wind turbines is generally characterized as “swishing.” Under certain conditions in can be characterized as “thumping” or “churning.”

The current body of work on amplitude modulation indicates that it is not possible to predict or forecast its occurrence. Design considerations for minimization, and practical post-construction operational mitigation options are in the early phases of development. Current research indicates that is not possible to predict or forecast the occurrence of amplitude modulation at a site.[3] Research has shown that approximately 90% of all measured AM depth is 2 dBA or less, while 99.9% is 4.5 dBA or less. A detailed literature review of AM is found in Section 12.8 of the NIA.

In order to determine wind shear and turbulence intensity conditions, Epsilon obtained one year (8760 hours) of meteorological data collected from an on-site meteorological tower (#4549) within the Project boundary. The meteorological data measured in 2016 include wind speed and wind direction. The wind speed and wind direction data were used for the wind shear and turbulence intensity calculations. Formulae for these calculations are found in Section 10 of the NIA. Wind speed standard deviation was calculated using the 10-minute wind speed data for every hour. Ten minute wind speed data were also used to compute the average hourly wind speed.

Figure 10-1 from the NIA presents the wind shear coefficient by hour for a full year. This shows that wind shear at this site is low which is not surprising considering the combination of land uses (field and forest) and elevation changes in the surrounding area. Wind shear is lower during the afternoon hours when the atmosphere is less stable as compared to the higher wind shear values at night when the atmosphere is more stable.

As discussed in IEC 61400-11, Annex B turbulence is a natural part of the wind environment. The turbulence intensity is calculated as the average of the ratio of standard deviation of wind speed divided by the average wind speed over a given time period at a certain height. Figure 10-2 from the NIA

[3] *Wind Turbine AM Review: Phase 2 Report,* U. K. Department of Energy & Climate Change, prepared by WSP Parsons Brinckerhoff, August 2016.

presents the hourly turbulence intensity at this site at a height of 110 meters above ground based on the on-site meteorological tower. Results show that turbulence intensity is slightly higher during the day than at night, and can be variable at any time. Figure 10-3 from the NIA shows the turbulence intensity by hub height wind speed. These data show that turbulence intensity decreases slightly from cut-in speed to 14 m/s. Wind speeds much above 14 m/s (over 30 mph) are associated with storm conditions and/or high ground level wind speeds, and thus are of less interest to understanding wind turbine only sound levels.

Epsilon found no literature documenting a change in turbulence or wind shear at a site created by the installation of wind turbines. However, since wind turbines generate turbulence in the wake of their blades, there may be a change in turbulence once the wind turbines are operating. No change in wind shear as a result of the installation of wind turbines is expected.

(4) Infrasound and Low-Frequency Sound

Infrasound is sound pressure fluctuations at frequencies below about 20 Hz. Sound below this frequency is only audible at very high magnitudes—levels not produced by wind turbines. Low frequency sound is in the audible range of human hearing, that is, above 20 Hz, but below 200 Hz. Measurements of infrasound at distances from wind turbines typical of their nearest residential neighbors have consistently found that infrasound levels are below published audible human perception limits. Epsilon's research indicates that there is no audible infrasound either outside or inside homes 1,000 feet from a wind turbine. A full review of the literature regarding wind turbines and perception of infrasound is provided in Section 4.6.2 of the NIA, and is also reproduced below in 19(k).

The proposed wind turbines for this project, the GE 2.3-116 and GE 3.4-137, have one-third octave band sound power level data available from 12.5 Hz to 10,000 Hz. No reference sound power level data below 12.5 Hz are available from the manufacturer. Therefore, sound power level data were extrapolated from 12.5 Hz down to 0.5 Hz. The extrapolation process assumed a 1 dB per octave increase in sound power levels from 12.5 Hz to 0.5 Hz as shown in the research.[4] The infrasound and low frequency sound power levels represent the highest sound level under any wind speed for each one-third octave band. Infrasound and low frequency level for the Facility were calculated assuming that the sound levels decrease spherically at all distances at 80 Hz and above and that sound levels decrease spherically out to 1,000 meters, and cylindrically beyond 1,000 meters at 63 Hz and below. Detailed results for the most potentially impacted receptors are shown in Table 9-8 of the NIA.

The ANSI standard ANSI S12.2, "Criteria for Evaluating Room Noise," establishes low frequency noise criteria to prevent "perceptible vibration and rattles in lightweight wall and ceiling structures." ANSI S12.9 Part 4 addresses the annoyance of sounds with strong low-frequency content; Annex D of this standard establishes that low frequency sound annoyance is minimal when the 16 Hz, 31.5 Hz, and 63 Hz octave band sound pressure levels are each less than 65 dB. Sound pressure levels at 16 Hz, 31.5 Hz, and 63 Hz for criteria under these two standards is provided below in Table 19-10 where they are compared

[4] *Massachusetts Study on Wind Turbine Acoustics,* Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, RSG et al., 2016.

to low frequency levels predicted at the worst-case participating and non-participating receptors. Results show that the sound levels from the Facility will be below the threshold for moderately perceptible vibration and rattle in all three bands, as defined in ANSI 12.2-2008. Furthermore, at the worst-case participating and non-participating receptors, the Facility will generate infrasound and low frequency noise at levels below a level at which annoyance is minimal for each octave band frequency. As Table 19-10 shows, the modeled low frequency noise is below all ANSI guidelines at the worst case receptor locations. Therefore, this conclusion applies to other more distant receptors.

Table 19-10. Low Frequency Noise Compared with ANSI 12.2 and ANSI 12.9 Standards

1/1 Octave Band Center Frequency	**16 Hz**	**31.5 Hz**	**63 Hz**
Modeled Worst Case Participating Receptor (ID #281)	60 dB	57 dB	55 dB
Modeled Worst Cast Non-Participating Receptor (ID #771)	57 dB	55 dB	53 dB
Low Frequency Guidelines			
Clearly perceptible vibration and rattles likely (ANSI 12.2-2008 Section 6)	*75 dB*	*75 dB*	*80 dB*
Moderately perceptible vibration and rattle likely (ANSI 12.2-2008 Section 6)	*65 dB*	*65 dB*	*70 dB*
Sound Level Below Which Annoyance is Minimal (ANSI 12.9 Part 4 Annex D)	*65 dB*	*65 dB*	*65 dB*

19(f) Sound Level at Receptors Table

The Application includes evaluation of the equivalent (L_{eq}) (see (f)(7) and (f)(9)), worst case (L10) (see (f)(1) and (f)(4); (f)(2) and (f)(5); (f)(3) and (f)(6)), and typical (L50) (see (f)(8) and (f)(9)) operational noise levels. The A-weighted/dBA sound levels, in tabular form, includes and excludes the periods when the turbines will not be operating (rotating) in the calculations of the yearly average for operational sound levels (see Appendix G of the NIA). The predicted sound levels are shown through graphical isolines of A-weighted decibels (Figure 9-2, maps 1-21 of the NIA). Contours are in 1-dBA increments, and include all sound receptors identified in section (a) of this exhibit. Digital color drawings showing noise contours on the map indicated in section (a) are included with the Application. Full size hardcopy of Figures 9-1 and 9-2 (NIA) are also included with this Application. Measured ambient data were assigned to each specific potentially impacted and representative noise receptor giving consideration to similarity of soundscapes between the evaluated position and the location where the ambient noise levels were measured (see Table G-1 in the NIA).

(1) Daytime Ambient Noise Level

Daytime ambient lower tenth percentile (L_{90}) noise levels calculated from summer and winter background sound level monitoring data is available in Table 8-1 of the NIA.

(2) Summer Nighttime Ambient Noise Level

Summer nighttime ambient lower tenth percentile (L_{90}) noise levels calculated from summer background sound level monitoring data are available in Table 8-2 of the NIA.

(3) Winter Nighttime Ambient Noise Level

Winter nighttime ambient lower tenth percentile (L_{90}) noise levels calculated from winter background sound level monitoring data are available in Table 8-2 of the NIA.

(4) Worst-case Future Daytime Noise Level

The worst-case future noise level during the daytime period at the first 50 receptors with the greatest predicted short-term sound level (i.e., by the short-term ISO 9613-2 modeling scenario) has been determined by logarithmically adding the daytime ambient sound level (L_{90}) (see Section 19(f)(1)) to the modeled upper tenth percentile sound level (L_{10}) of the Project. The future sound levels at all other receptors are expected to be lower than the future sound levels at the 50 receptors with the greatest short-term levels. The L_{10} statistical noise descriptor corresponds to estimates for one year of operation. These worst-case future noise levels during the daytime period are presented in Table G-2A (Method 1 – No Zeros) and Table G-2B (Method 2 – With Zeros) in Appendix G. Worst case future daytime noise levels range from 41 to 48 for the Method 1 calculations and from 40 to 48 for the Method 2 calculations.

(5) Worst-Case Future Summer Nighttime Noise Levels

The worst case future noise level during the summer nighttime period at the 50 receptors with the greatest predicted short-term sound level has been determined by logarithmically adding the summer nighttime ambient sound level (L_{90}) (see Section 19(f)(2)) to the modeled upper tenth percentile sound level (L_{10}) of the Project. The future sound levels at all other receptors are expected to be lower than the future sound levels at the 50 receptors with the greatest short-term levels. The L_{10} statistical noise descriptor corresponds to estimates for summer nighttime period for one year of operation. These worst case future noise levels during the summer nighttime period are presented in Table G-2A (Method 1) and Table G-2B (Method 2) in Appendix G. Worst case future total summer nighttime noise levels range from 39 to 48 dBA for the Method 1 and the Method 2 calculations.

(6) Worst-Case Future Winter Nighttime Noise Levels

The worst case future total noise level during the winter nighttime period at the 50 receptors with the greatest predicted short-term sound level has been determined by logarithmically adding the winter nighttime ambient sound level (L_{90}) (see Section 19(f)(3)) to the modeled upper tenth percentile sound level (L_{10}) of the Project. The future sound levels at all other receptors will be lower than the future sound levels at the 50 receptors with the greatest short-term levels. The L_{10} statistical noise descriptor corresponds to estimates for winter nighttime period for one year of operation. These worst case future noise levels during the winter nighttime period are presented in Table G-2A (Method 1) and Table G-2B (Method 2) in Appendix G. Worst case future winter nighttime noise levels range from 40 to 48 dBA for the Method 1 and the Method 2 calculations.

(7) Daytime Ambient Average Noise Level

The daytime ambient average noise level (L_{eq}) was calculated by logarithmically averaging sound pressure levels (L_{eq}) from the background sound level measurements over the daytime period at each monitoring location. The results are available in Table 8-3 of the NIA.

(8) Typical Facility Noise Levels

Typical Facility noise levels for each noise sensitive location listed in Section (a)(3) were calculated as the median sound pressure level emitted by the Facility at each evaluated receptor. The median sound pressure level was calculated by determining the 50^{th} percentile (L_{50}) of the sound levels predicted at a particular receptor in the daytime during one year and corrected for overly conservative CONCAWE results using ISO 9613-2 methodology. These values are presented in Table F-1A and Table F-1B in Appendix F of the NIA. Typical Project noise levels range from 34 to 44 dBA for the Method 1 calculations and from 33 to 44 dBA for the Method 2 calculations. The realistic scenario (including zero hours) shows sound levels 1-2 dBA lower as compared to excluding those hours.

(9) Typical Facility Daytime Noise Levels

The typical Project daytime noise level at the 50 receptors with the greatest predicted short-term sound level has been determined by logarithmically adding the daytime equivalent average sound level (L_{eq}) (see Section 19(f)(7)) to the modeled median Project sound pressure level (L_{50}) (see Exhibit 19 (f)(8)). The future sound levels at all other receptors will be lower than the future sound levels at the 50 receptors with the greatest short-term levels. The L_{50} statistical noise descriptor corresponds to estimates for the daytime period for one year of operation. These typical Project daytime noise levels are presented in Table G-2A (Method 1) and Table G-2B (Method 2) in Appendix G. Typical Project daytime noise levels range from 39 to 46 dBA for the Method 1 calculations and from 38 to 45 dBA for the Method 2 calculations.

19(g) Applicable Noise Standard and Facility Compliance

Local Regulations

The Eight Point Wind Energy Center is proposed within the Towns of West Union and Greenwood, Steuben County, NY. Steuben County does not have any noise regulations applicable to wind turbine operation. In West Union, Local Law No. 1 of 2017 entitled “Wind Energy Facilities” Section 15.A limits sound levels generated by WTGs to 50 dBA (L_{10}) measured over an hour at a residence. This standard applies day or night. If the ambient exceeds 50 dBA, the standard is ambient plus 6 dBA. In addition, each WTG must be located at least 1,400 feet from the exterior of an off-site residence. In Greenwood, Local Law No. 1 of 2017 entitled “Amended Wind Energy Facility Law” Section 15.A contains the same sound standards as the Town of West Union.

The short-term ISO 9613-2 model results are presented in terms of a 1-hour or 8-hour L_{eq}. The L_{10} from an operating wind turbine is 1-2 dBA higher than the L_{eq}.[5] Thus, a modeled L_{eq} value of 48-49 dBA would be comparable to an L_{10} of 50 dBA. All predicted L_{eq} sound levels from the Project are 48 dBA or less, therefore, the Project will meet the local sound level limit. Steuben County does not have any noise regulations applicable to wind turbine operation.

Federal Guidelines

There are no federal community noise regulations applicable to wind farms.

(1) NYSDEC Program Policy

There is no quantitative state noise standard that applies to this Facility. There are, however, guidelines provided by the New York State Department of Environmental Conservation (NYSDEC) in its Program Policy entitled *Assessing and Mitigating Noise Impacts* (NYSDEC, 2001). The Program Policy includes information about background sound level measurements, jurisdiction limits of the NYSDEC, and a review of guidelines from the other sources, among other topics. The sound level guidelines are found in Section V.B.1.c. Two types of thresholds are mentioned—one that is relative to existing background sound levels, and the other that is fixed. There are no NYSDEC lands within the Project Area, therefore, no evaluation was made of the NYSDEC Program Policy.

(2) World Health Organization Guidelines--1999

The World Health Organization (WHO) has published "Guidelines for Community Noise" (WHO, 1999) which uses research on the health impacts of noise to develop guideline sound levels for communities. Note that these guidelines were not specifically developed for wind turbine noise.

These 1999 WHO guidelines suggest that daytime and evening outdoor living areas sound levels at a residence should not exceed an average sound level (L_{eq}) of 55 dBA to protect against serious annoyance and 50 dBA L_{eq} to protect against moderate annoyance. This is based on an average sound level over a 16-hour day. During the night, the WHO recommends a sound level limit (L_{eq}) of 45 dBA at the outside living spaces, so that people may sleep with bedroom windows open (presumed sound level of 30 dBA inside). These L_{eq} are to be based on the average sound level for an eight-hour night.

According to the WHO 1999 "Guideline for Community Noise" document, sound levels at the outside facades of living spaces should not exceed a L_{eq} of 45 dBA, so that people may sleep with bedroom windows open. This is an 8 hour average. The short-term (1-hr) worst-case sound level modeling results are presented in Table E-1 in Appendix E of the NIA. The maximum sound level presented in this table is 48 dBA (ID #332). Although this sound level exceeds the 45 dBA guideline value, this sound level is modeled at a hunting cabin, and is a Participant in the project. Participating landowners have signed contracts which include an easement for effects including sound. The next highest sound level modeled

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[5] RSG et al., "Massachusetts Study on Wind Turbine Acoustics," Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016.

is 45 dBA with two Participating residents at this level. The highest sound level at a non-participating receptor is 44 dBA, therefore, the Project meets the 45 dBA guideline.

(3) World Health Organization Guidelines--2009

In 2009, the WHO released "Night Noise Guidelines for Europe." The 2009 WHO report recommends a Night Noise Guideline (NNG) of 40 dBA. However, the 40 dBA guideline is an "$L_{night,\ outside}$" descriptor, which is not the same as a short-term measurement. $L_{night,\ outside}$ is defined as the A-weighted long-term average sound level determined over all the night periods of a year; in which the night is eight hours (23:00 to 07:00 local time). Thus, the $L_{night,\ outside}$ is an annual average. Again, these guidelines were not developed specifically for wind turbine noise.

$L_{night,\ outside}$ sound level modeling results are presented in Tables F-1A (without zeros) and F1-B (with zeros) in Appendix F. The maximum L_{night} sound level presented in these tables is 45 dBA. Although this sound level exceeds the 40 dBA guideline value, this sound level is modeled at a hunting cabin (ID #332) which is not used full-time, and thus an annual guideline is not applicable. All Non-Participating residents are at an $L_{night,\ outside}$ sound level of 40 dBA or less. Since the 2009 WHO document guideline examines all 365 nights of the year, the relevant set of calculations are those in Table F1-B which include model results from all 365 nights of a year. These results show three participating residents (ID #324; ID #326; ID #330) are estimated to be at 41 dBA. Participating landowners have signed contracts which include an easement (or waiver) for effects such as sound. All other receptors will be at 40 dBA or less for an annual sound level. Therefore, all non-participating modeling receptors meet the $L_{night,\ outside}$ 40 dBA 2009 WHO guideline.

(4) National Association of Regulatory Utility Commissioners

The National Association of Regulatory Utility Commissioners (NARUC) Grants and Research Department published a report titled "*Wind Energy & Wind Park Siting and Zoning Best Practices and Guidelines for States*" (NARUC, 2012). The report includes guidelines for several critical wind power development issues, including noise. The study concluded that a long-term ("several weeks") mean sound level of 40 dBA is an ideal design goal, and 45 dBA is the target limit outside a residence at night. The sound levels were designed to minimize adverse reaction and prevent sleep disturbance. In other words, the 40/45 dBA levels were selected because they represent a sound level that probably would not be considered objectionable by the majority of neighbors. Another report produced by NARUC, "*Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects*" also uses the 40 dBA target outside all residences as an ideal design goal, with an acceptable limit of 45 dBA provided the number of homes within the 40 to 45 dBA range is relatively small.[6]

A conservative evaluation of this guideline would be to compare the short-term (1-hour) worst-case sound level modeling results as presented in Table E-1 in Appendix E (NIA) to the 45 dBA limit. The maximum sound level presented in this table is 48 dBA. Although this sound level exceeds the 45 dBA guideline value, this sound level is modeled at a hunting cabin (ID #332), and is a Participant in the

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[6] Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects, NARUC, prepared by Hessler Associates, Inc., October 2011.

project. The next highest sound level modeled is 45 dBA with two Participating residents at this level. The highest sound level at a non-participating receptor is 44 dBA, therefore, the Project meets the 45 dBA NARUC guideline. It must be stressed that the sound level guidelines of 40 dBA and 45 dBA in the NARUC document are “long-term means” while these model results are short-term (1-hour) results. The actual Project “long-term mean” sound levels will be lower than the modeled levels in Table E-1.

(5) American National Standards Institute

The American National Standards Institute (ANSI) standard ANSI S12.2-2008, “Criteria for Evaluating Room Noise,” establishes low frequency noise criteria to prevent “perceptible vibration and rattles in lightweight wall and ceiling structures.” If outdoor low frequency sounds are high enough, it can cause building walls and windows to vibrate and rattle. ANSI S12.2 includes limiting levels at low frequencies (16 Hz, 31.5 Hz, and 63 Hz) for assessing the probability of clearly and moderately perceptible acoustically induced vibration and rattles in lightweight wall and ceiling constructions. ANSI S12.9-2005/Part 4 addresses the annoyance of sounds with strong low-frequency content; Annex D of this standard establishes that low frequency sound annoyance is minimal when the 16 Hz, 31.5 Hz, and 63 Hz octave band sound pressure levels indoors are each less than 65 dB.

As shown in Table 19-10 above, the sound levels from the Facility will be below the threshold for moderately perceptible vibration and rattle in all three bands, as defined in ANSI S12.2-2008. Furthermore, at the worst-case participating and non-participating receptors, the Facility will generate infrasound and low frequency noise below the level for minimal annoyance at each octave band frequency as defined by ANSI S12.9-2005/Part 4.

(6) Ground-Borne Vibration

While not as much of a concern as airborne vibration, the potential for wind turbines to create adverse ground-borne vibration has also been investigated. While ground-borne vibrations caused by wind turbines are detectable with instruments, it is below the threshold of human perception. ANSI S2.71-1983 (R2012) sets recommendations for ground-borne vibration that are perceptible to humans within buildings. A basic rating is given in for the most stringent conditions, which correspond to the approximate threshold of perception of the most sensitive humans. From the base rating, multiplication factors are applied based on the location of the receiver (ANSI, 1983).

The nearest operating wind turbine to a non-participating noise-sensitive receptor (ID #337) is approximately 1,531 feet (466 meters). The frequency of rotation for the GE 3.43-137 wind turbine will range from 7.6 rotations per minute (rpm) to 12.1 rpm under all operating conditions. This translates to blade pass frequencies of 0.4 Hz to 0.6 Hz. The rpm and blade pass frequency of the GE 2.3-116 wind turbine is similar to the GE 3.43-137. Based on the literature findings presented in Section 4.7 of the NIA where ground-borne vibration was below perceptible thresholds at comparable distances, ground-borne vibrations from operation of this project will be below the thresholds as recommended in ANSI S2.71-1983 (R2012).

19(h) Noise Standards for the Facility

Noise standards used to evaluate the Facility sound levels are provided in Table 13-1 of the NIA. The table includes the sound levels, metrics, and period of time associated with the guidelines and standards. As indicated in Table 13-1 of the NIA and in Table 19-11, below, the Facility is in compliance with all of the standards and guidelines applicable to the Facility.

Many goals and guidelines are listed in Table 19-11. The proposed Project compliance standard is 45 dBA (1-hour L_{eq}) at a residence. This is more stringent than the local township standards of 50 dBA (L_{10}) at a residence. Details of how compliance with this standard will be demonstrated are contained in the "Eight Point Wind Sound Monitoring and Complaint Response Protocol" incorporated into the overall Complaint Resolution Plan and included with this Application as Appendix 19-2.

Table 19-11. Summary of Outdoor Sound Standards and Guidelines for Eight Point Wind

Municipality or Organization	Standard or Guideline	Sound Level	Assessment Location	Metric	Period of Time	Project Complies?
Town of West Union	Standard	50 dBA (any time)	Residence	L_{10}	1 hour	Yes
Town of Greenwood	Standard	50 dBA (any time)	Residence	L_{10}	1 hour	Yes
World Health Organization	Guideline	45 dBA	Residence	Leq	8 night hours	Yes[1]
World Health Organization	Guideline	50 dBA	Property line	Leq	16 day hours	Yes
World Health Organization	Guideline	40 dBA	Residence	L_{eq}	All night hours over 1 year	Yes[2]
NARUC	Guideline	45 dBA	Residence	Not stated	Long-term mean (many weeks)	Yes[1]
ANSI S12.9-2005/Part 4	Guideline	65 dB indoors	Residence	16/31.5/63 Hz	Not stated	Yes
ANSI S2.71-1983 (R2012)	Guideline	Varies by freq.[3]	Residence	1 Hz to 80 Hz	Not stated	Yes

1. All non-participating locations meet the guideline.
2. All non-participating locations meet the guideline when operational and non-operational hours are calculated with ISO 9613-2 adjustments to CONCAWE results.
3. Vibration

19(i) Noise Abatement Measures for Construction Activities

A Compliance Sound Monitoring and Complaint Resolution Protocol specific to wind turbine noise is included as Appendix 19-2. This plan serves as the noise complaint-handling procedure applicable during both Facility construction and operation. The plan was developed to ensure that the community has a method to register their noise complaints or concerns, and to provide checks so that the process is not abused. Complaints may be made in person at the Facility's construction or local operations office, via phone, or by writing. A representative of the Applicant will contact the individual as quickly as possible and in all instances in no less than 72 hours of receipt of the complaint. Separate complaint resolution steps will be taken for construction and operation complaints. Steps to address construction-related complaints include sending a representative to the site to listen and observe, assessing if there is equipment that is not functioning properly, taking sound level measurements to confirm sound levels at the site of the complaint (nighttime only), and mitigating with temporary barriers during construction if sound levels are determined to be too high.

Noise due to construction is an unavoidable outcome of construction. The heavy civil and site work will last approximately six to nine months. Due to the large distances between construction activity and sensitive receptors, noise from construction is not expected to be an issue. However, the complaint resolution plan provided with this Application contains the procedure to be followed in the event of a noise complaint during construction. Nonetheless construction noise will be minimized through the use of best management practices (BMPs) such as those listed below.

- Blasting is likely at this site. Blasting will be limited to daytime hours and conducted in accordance with the Eight Point Wind Blasting Plan included as Appendix 21-3 of this Application.
- Pile driving is possible at the Site. If pile driving is required, it will be limited to daytime hours.
- Utilizing construction equipment fitted with exhaust systems and mufflers that have the lowest associated noise whenever those features are available.
- Maintaining equipment and surface irregularities on construction sites to prevent unnecessary noise.
- Configuring, to the extent feasible, the construction in a manner that keeps loud equipment and activities as far as possible from noise-sensitive locations.
- Develop a staging plan that establishes equipment and material staging areas away from sensitive receptors when feasible.
- Contractors shall use approved haul routes to minimize noise at residential and other sensitive noise receptor sites.

19(j) Noise Abatement Measures for Facility Design and Operation

Due to the inherent size of wind turbines, physical noise control measures, such as noise barriers, active noise control, and tree plantings, are impractical or impossible. However, some mitigation measures for noise are available, including using factory-installed measures, siting methods implemented during final Facility design, or measures implemented after the Facility is constructed. These methods are described below.

- **Wind Turbine Design** – Horizontal axis wind turbines, with three blades, positioned upwind of the tower are the only type used for utility-scale wind power. Turbines with the blades positioned downwind of the tower are obsolete and cause more noise issues than upwind designs because the blades pass through the wake of the tower. Vertical axis wind turbines are not available in megawatt scale. The design of the blade also can have a substantial impact on noise generation. Blade manufacturers are researching and testing ways to reduce sound levels from various tip shapes. In addition, there are LNTE options available for some wind turbine models. These are essentially metal sawtooth serrations that can be affixed to the edge of a blade to reduce blade trailing edge noise. The 2.3-116 wind turbine model is offered with the LNTE option and will be used for this Project.

- **Facility Siting** – Proper siting is another way to minimize and abate noise during the design of the project. Adequate setbacks between wind turbines and sensitive receptors will ensure the Project meets noise design goals. There are many different factors that go into the design of a wind turbine layout including wake effects between turbines, maximizing energy production based on the wind regime, environmental and regulatory setback requirements for other conditions (wetlands, etc.), access road configuration, and landowner property preferences. A project must also be of sufficient scale such that it is economically viable so that simply increasing a wind turbine setback from a sensitive receptor must take into consideration the ripple effect it could have on the other project design constraints.

- **Noise Reduced Operations (NROs)** – NROs are operational changes to reduce noise generation. NROs are usually accomplished by adjusting turbine blade pitch, slowing the rotor speed of the turbines, which reduces aerodynamic noise produced by the blades. NROs are an available technology on most modern wind turbines and may be used to reduce turbine sound power to a level at or below the sound power of the turbine modeled in the Application. NROs can be implemented on an as-needed basis. For example, they can be programmed for selected wind speeds, wind directions, and times of day. The programs can be adjusted at any time after the wind turbines have commenced operations. Based on the modeling analysis, the NRO mode is not anticipated to be necessary for this project.

The Complaint Resolution Plan for the Facility, which is attached as Appendix 19-2, incorporates a Complaint Resolution Plan specific to wind turbine noise. This plan serves as the noise complaint-handling procedure applicable during both Facility construction and operation. The plan is further described above in Section 19(i).

19(k) Community Noise Impacts

(1) Potential for Hearing Damage

The Facility's potential to result in hearing damage was evaluated against guidelines established by the Occupational Safety and Health Administration (OSHA), USEPA, and WHO. Hearing damage may begin at levels of 70 dBA for 24-hours, or 90 dBA for an 8-hour workday. Comparison of the sound propagation modeling to these guidelines shows that construction and operation of the Facility will be well below these levels, and not result in potential for hearing damage.

(2) Potential for Speech Interference

The 1974 USPEA "Levels" document states that at an outdoor level of 55 dBA (L_{dn}) there is 100% sentence intelligibility indoors, and 99% sentence intelligibility at 1 meter outdoors. These are the maximum sound level below which there are no effects on public health and welfare due to interference with speech or other activity. This has a 5 dBA margin of safety – in other words the EPA believes the actual threshold is 60 dBA but has reduced it by 5 dBA. An outdoor L_{dn} is equivalent to a 24-hour sound level of 49 dBA.

The "*Guideline for Community Noise*" (WHO, 1999) recommends an indoor sound level of 35 dBA (L_{eq}) to protect speech intelligibility. This is equivalent to approximately 50 dBA L_{eq} outdoors.

Comparison of the sound propagation modeling to these guidelines shows that operation of the Facility will be below these levels, and not result in potential for speech interference.

(3) Potential for Annoyance/Complaints

Studies of human response to wind turbine sound were performed in Europe in the early 2000s. Pederson and Waye performed a cross-sectional study in Sweden in 2004. A dose-response relationship between calculated A-weighted sound levels from wind turbines and noise annoyance was found. However, the study also found that annoyance was related to other subjective factors such as attitude and sensitivity. In particular, attitude towards the visual aspect of wind turbines was found to be strongly correlated to annoyance.

An additional study by Pederson (2009) found a dose-relationship between A-weighted sound levels and reported perception and annoyance. However, the study found that high turbine visibility enhances negative response, and having wind turbines visible from a dwelling increases the risk of annoyance. The study also found that people who benefit economically from wind turbines have a significantly decreased risk of annoyance, even at the same sound levels. The Pederson studies were performed by sending self-reporting surveys to respondents living in and around wind farms and comparing responses from these surveys to modeled sound levels at those residences. The study showed that noise annoyance was related both to actual noise impacts and to subjective factors such as attitude and sensitivity. In particular, attitude towards the visual aspect of wind turbines was strongly correlated to annoyance. Using the data from that study, researchers found that among respondents questioned about sleep disturbance in rural areas 70% were not disturbed, 12% were disturbed by people/animals, 12% were disturbed by traffic/mechanical sounds, and 6% were disturbed by wind turbines (Bakker et al., 2012).

A detailed literature search by McCunney et al. (2014) concluded that "annoyance associated with living near wind turbines is a complex phenomenon related to personal factors. Noise from turbines plays a minor role in comparison with other factors in leading people to report annoyance in the context of wind turbines."

Health Canada, in collaboration with Statistics Canada, conducted one of the most extensive studies to understand the impacts of wind turbine noise to-date (Health Canada, 2014). A cross-section epidemiological study was carried out in 2013 in the provinces of Ontario and Prince Edward Island (PEI) on randomly selected participants living near and far from operating wind turbines. Calculated outdoor wind turbine sound levels were up to 46 dBA. Note that these sound levels represent typical worst-case long term (one year) average sound levels.

Many peer-reviewed publications have been written based on the Health Canada research, including an analysis of annoyance. For example, Michaud et al report annoyance toward several wind turbine features increased with increasing sound levels, including the following noise, blinking lights, shadow flicker, visual impacts, and vibrations. In the entire study, approximately 7% reported a high level of annoyance from wind turbine noise. In the homes within the 40-46 dBA wind turbine noise area, approximately 13% reported a high level of annoyance. Annoyance was significantly higher in Ontario versus PEI at comparable sound levels (Michaud et al., 2016a).

Another publication from the Health Canada study found that the association between wind turbine noise levels and annoyance was found to be rather weak (R^2 = 9%). The R^2 improved after considering annoyance due to other wind turbine related features such as visibility, blinking lights on the nacelle, the perception of vibrations during wind turbine operation, and physical safety (Michaud et al., 2016b). This is consistent with the Pedersen research.

The results of Epsilon research indicate that there is no audible infrasound either outside or inside homes at 1,000 feet from a wind turbine. Sound levels meet the ANSI standard for low frequency noise in bedrooms, classrooms, and hospitals, meet the ANSI standard for thresholds of annoyance from low frequency noise, and there should be no window rattles or perceptible airborne induced vibration of light-weight walls or ceilings within homes. In homes there may be slightly audible low frequency noise beginning at around 50 Hz (depending on other sources of low frequency noise); however, the levels are below criteria and recommendations for low frequency noise within homes (O'Neal, 2011). In addition, the 2011 NARUC report stated, "the widespread belief that wind turbines produce elevated or even harmful levels of low frequency and infrasonic sound is utterly untrue as proven repeatedly and independently by numerous investigators."

As described in Section 19(e), above, amplitude modulation is a recurring variation in the overall level of sound over time. It is in the audible sound range that is synchronized to the passage of the turbine blades and can often be described as a "thumping," "swishing," or "churning." The "Wind Turbine AM Review: Phase 2 Report" (DECC, 2016) found that research has not identified a clear onset of increased annoyance from amplitude modulation and, as such, there is no straightforward threshold for excessive amplitude modulation. However, a proposal for a penalty scheme for excessive amplitude modulation during a period of complaints was put forth. There would be no penalty for amplitude modulation depths of 0-3 dB, a sliding scale penalty (3-5 dB) for amplitude modulation depths of 3-10 dB, and a 5 dB penalty for amplitude modulation depths greater than 10 dB (DECC, 2016).Research has shown that approximately 90% of all measured AM depth is 2 dBA or less, while 99.9% is 4.5 dBA or less. Therefore, most AM would not qualify as "excessive" and would not lead to complaints.

In addition, research sponsored by RenewableUK has identified two possible mitigation options to reduce the amplitude modulation that is often associated with complaints. These mitigation measures include a "kit" installed on the blades designed to improve or modify the flow or air on the blades to reduce stall, and a software design change which modifies the turbine blade pitch control angle by several degrees under specific wind regime conditions (Cand and Bullmore, 2015).

Noise design goals for the Facility were selected based on applicable regulations and guidelines. The results of the NIA show that the future Facility sound levels will be sufficiently low that the potential for complaints and annoyance associated with noise from the Facility will be minimal. While the levels presented in the NIA do not mean the sound from the Facility will be inaudible or completely insignificant, it will generally be low enough that it will probably not be considered objectionable by the vast majority of neighbors. Also, as described in Table 13-1 of the NIA, the Facility is expected to meet all applicable local noise requirements and other guidelines and standards addressed in this Application.

Table 19-12 presents the number of sensitive noise receptors that have been modeled to experience a worst-case 1-hour L_{eq} sound level of 35 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. Because the usage of each receptor/structure has not been identified, it has been assumed that all receptors are residential. Participating landowners have signed contracts which include a waiver for effects including sound.

Table 19-12. Participating and Non-Participating Receptors Modeled 35 dBA or Greater

Modeled Leq Sound Level (dBA)[1]	# of Receptors	
	Participating	Non-Participating
48	1	0
47	0	0
46	0	0
45	2	0
44	9	4
43	10	5
42	17	10
41	2	10
40	4	13

Modeled Leq Sound Level (dBA)[1]	# of Receptors	
	Participating	Non-Participating
39	4	18
38	9	12
37	2	13
36	3	10
35	4	9

Notes: 1. Rounded to the nearest whole decibel.

(4) NYSDEC Program Policy

As discussed in Section 19(g), there are no NYSDEC lands within the Project Area, therefore, no evaluation was made of the NYSDEC Program Policy.

(5) Preliminary Blasting Plan

Information regarding construction activities and blasting will be included in the Preliminary Blasting Plan as discussed in Exhibit 21(h) (Geology, Seismology, and Soils) of the Application. Blasting of bedrock is expected to be required for construction of turbine foundations, and possibly for portions of the electrical interconnect lines. It is not currently anticipated that pile driving will be needed to construct this Project.

(6) Potential for Ground-Borne Transmitted Vibrations

The Applicant reviewed available literature for purposes of assessing the potential for ground-borne transmitted vibrations from the Facility to reach noise sensitive receptors and cause vibrations on the floors or on building envelop elements that may be perceived by the receptor. One study found that ground vibration at a residence 1,066 feet (325 meters) from several turbines were well below the human perception limits found in ISO 2631-2 “Evaluation of Human Exposure to Whole-Body Vibration Part 2” (Gastmeier and Howe, 2008). In addition, an expert panel commissioned by the Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health (2012) found that seismic motion from wind turbines is so small that it is difficult to induce any physical or structural response. A more detailed literature discussion is found in Section 4.7 of the NIA.

The nearest operating wind turbine to a non-participating noise-sensitive receptor (#337) is approximately 1,531 feet (466 meters). The frequency of rotation for the GE 3.4-137 wind turbine will range from 7.6 rpm to 12.1 rpm under all operating conditions. This translates to blade pass frequencies of 0.4 Hz to 0.6 Hz. The frequency of rotation for the GE 2.3-116 wind turbine will range from 5.5 rpm to 14.9 rpm under all operating conditions. This translates to blade pass frequencies of 0.3 Hz to 0.75 Hz. Based on the literature findings presented in Section 4.7 where ground-borne vibration was below perceptible thresholds at comparable distances and frequency of rotation, ground-borne vibrations from operation of this project will be below the thresholds as recommended in ANSI S2.71-1983 (R2012).

(7) Potential for Airborne Induced Vibrations

Sound levels from the maximum sound output of the wind turbines at the 31.5 Hz and 63 Hz octave bands are shown for all sensitive receptors in Table E-1 (Appendix E) of the NIA. Results for the 16 Hz octave band at the worst-case receptors are shown in Table 9-8 of the NIA. As discussed in Section 19(e)(4) above, and indicated in Table 19-10 above, the low frequency modeling results at the worst case participating and non-participating receptors are below the ANSI 12.2-2008 and ANSI S12.9-2005/Part 4 criteria for moderately perceptible vibration and rattles and below the minimal annoyance levels.

(8) Potential for Interference with Seismological and Infrasound Stations

Epsilon investigated the potential of low-frequency noise including infrasound and vibration from operation of the Project to cause interference with the closest seismological and infrasound stations within 50 miles of the Facility Site. The Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) website was reviewed for the nearest location of any infrasound monitoring stations. The nearest ones are in Bermuda (IS51) and Lac du Bonnet, Manitoba, Canada (IS10). Each site is approximately 1,000 miles from Steuben County, NY. There are also some seismic stations to monitor shock waves in the Earth as part of the CTBTO program. The nearest seismic monitor to Eight Point Wind is located in Sadowa, Ontario, Canada (AS014) which is approximately 190 miles away. Given these large distances and the relatively low levels of infrasound emissions from this project, we conclude there will be no impact to the CTBTO's ability to monitor infrasound.

There are two hospitals in Steuben County (Ira Davenport in Bath; St. James Mercy in Hornell). Each one is approximately 20 miles and 15 miles away from the nearest wind turbine respectively, and thus no medical activities would be affected by infrasound due to the project.

No significant cumulative impacts will result due to sound from other wind turbines operating in the Project Area as they are more than nine miles away from any of the wind turbines analyzed for this Project. Since sound is dominated by the closest source, and all impacts from the Project are below goals, any additional contributions from a more distant wind farm will be negligible.

19(l) Post-Construction Noise Evaluation Studies

A post-construction noise monitoring program is described in the Compliance Sound Monitoring and Complaint Resolution Protocol, included as part of the Complaint Resolution Plan in Appendix 19-2 of the Application. The design goal for the Facility is 45 dBA (L_{eq}) for nighttime noise at a residence, with a long-term design goal of 40 dBA covering the nighttime hours over the course of an entire year. The Applicant also has set a design goal of 65 dB at 16 Hz, 31.5 Hz, and 63 Hz octave bands to avoid airborne vibrations.

Local noise regulations limits sound levels generated by WTGs to 50 dBA (L_{10}) measured over an hour at a residence. This standard applies day or night. The post-construction noise evaluation studies will confirm compliance with these regulations as well as a limit of 45 dBA (1-hour L_{eq}) at a residence.

19(m) Post-Construction Operational Controls and Mitigation Measures to Address Complaints

The Applicant has developed a procedure for identifying and responding to reasonable complaints. See Section 19(i) above for a discussion of complaint handling procedures during construction, and Section 19(j) for potential operational mitigation measures.

19(n) Software Input Parameters, Assumptions, and Associated Data for Computer Noise Modeling

Specific modeling parameters, assumptions, and any associated data used in sound propagation modeling are included in Section 9.0 and Appendix D of the NIA. GIS files containing modeled topography, modeled turbine and substation locations, sensitive sound receptors, and all external boundary lines identified by Parcel ID number are being provided to the Department of Public Service (DPS) under separate cover in digital format. The Sound Power Levels for the GE 3.4-137 and GE 2.3-116 turbines will be submitted separately to DPS by digital means and it will be filed under confidential seal.

19(o) Terminology, Definitions, and Abbreviations

A glossary of terms, definitions, and abbreviations is found in Appendix H of the NIA, and a literature source list is found at the end of Exhibit 19.

19(p) Terminology, Definitions, and Abbreviations

The findings and results of Exhibit 19 are reported and presented in the same order as listed in the Stipulation. Details of some tables and results are referenced to the specific section of the NIA to avoid undue duplication of information.

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