High Bridge Wind Project

Case No. 18-F-0262

1001.19 Exhibit 19

Noise and Vibration

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EXHIBIT 19 NOISE AND VIBRATION

This exhibit includes a detailed analysis of the potential sound impacts associated with the construction and operation of the Facility. In order to assess the potential sound impacts, a Preconstruction Noise Impact Assessment (PNIA) for the construction and operation of the Facility was prepared by Robert O'Neal of Epsilon Associates, Inc. (Epsilon). The PNIA is attached as Appendix 19-A to this Exhibit. Mr. O'Neal has over thirty years of experience in the areas of community noise impacts, meteorological data collection, and analyses. 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. The modeling performed by Epsilon for the Facility is sufficiently conservative in predicting sound impacts and includes the turbine with the highest sound power levels presented in the Article 10 Application.

The Facility has been designed so that no sensitive sound receptors, as defined below, will exceed 45 dBA $Leq_{9hr\ night}$, and no participating receptors will exceed 55 dBA $Leq_{9hr\ night}$. These proposed design goals minimize and mitigate any adverse impacts associated with the sound produced by the construction and operation of the Facility, and are consistent with 1999 and 2009 World Health Organization (WHO) guidelines to address sleep disturbance and health effects. Other project design goals and regulatory limits to minimize potential impacts are described further below.

(a) Sensitive Sound Receptor Map

A map of the Noise Impact Study Area showing the location of sensitive sound receptors and participating receptors within 1 mile of the Facility components which generate noise (i.e., turbines, substation, etc.) is provided in Figure 19-1. Sensitive sound receptors include residences (participating, non-participating, full-time, and seasonal[1]), outdoor public facilities and areas, schools, hospitals, care centers, libraries, places of worship, cemeteries, public parks and public campgrounds, summer camps, and any historic resources listed or eligible for listing on the State or National Register of Historic Places, and Federal and New York State lands.

In total, 818 discrete receptors were analyzed for the project. These include 774 residences, 15 public areas, and 29 "unknown" structures. All "unknown" structures were conservatively assumed to be residences thus making a total of 803 residences. Of the 803 residences, 53 were participating, and 750 were non-participating. A desktop analysis using aerial imagery and tax classification codes from the New York Office of Real Property database were used to develop and classify sensitive sound receptors within 1 mile of proposed turbine sites. Field verification was completed to verify the findings of the desktop analysis. If access for field verification was not possible, and aerial

[1] Seasonal residences include cabins and hunting camps (identified by property tax codes) and any other seasonal residences with septic systems/running water.

imagery could not provide an obvious classification of a structure (i.e. residential vs. non-residential), then the structure was classified as "unknown" and considered a sensitive sound receptor.

(b) Ambient Pre-Construction Baseline Noise Conditions

An evaluation of the ambient pre-construction baseline noise conditions was carried out for this Project. The details of the ambient study are described in the PNIA. A summary of information consistent with the Revised Scoping Statement (RSS) is found below.

1) A summer "leaf-on" measurement program was conducted at seven locations for 17 days in August/September 2018, and a winter "leaf-off" measurement program was conducted at seven locations for 17 days in January 2019. Both A-weighted and one-third octave band data were collected during day and night using a suitably calibrated sound level meter and octave band frequency analyzer (see Chapter 6 of the PNIA).

2) The ambient pre-construction baseline sound levels were filtered to exclude seasonal and intermittent noise by using a high-frequency natural sound (HFNS) filter and the L90 metric respectively (see Chapter 7.1 of the PNIA).

3) A high-frequency natural sound filter was applied to the measured one-third octave-band data from which a broadband sound level was calculated for both the summer and winter monitoring seasons. This technique removes all sound energy above the 1,250 Hertz frequency band. The methodology for the filtration process is as specified in ANSI/ASA S12.100-2014 and the sound pressure levels presented in this report using this methodology are indicated as ANS-weighted levels (see Chapter 7.1 of the PNIA). The temporal accuracy section of the ANSI S12.9-1992/Part 2 document requires that the data collection must be long enough to achieve the desired confidence interval. 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 size of this confidence interval places the data set into one of three categories referred to as Class A, Class B, and Class C, listed here from most precise to least precise (see Chapter 8.6 of the PNIA).

4) Graphical timelines for the A-weighted L_{eq} and the L_{90} broadband noise levels for each pre-construction sound measurement location are found in Figures 7-5 to 7-30 of the PNIA.

5) Figures for the un-weighted L_{eq} and the L_{90} full-octave band noise levels (after exclusions, starting at the 16 Hz full octave band or 12.5 1/3 octave band) for each pre-construction measurement location are found in Figures 7-7 to 7-32 of the PNIA.

6) Figures of the L_{90} 10-minute noise levels vs. wind speeds at 10 meters as extrapolated from the meteorological tower are found in Figures 8-4 to 8-9 of the PNIA.

7) A description of how the pre-construction ambient surveys were conducted including specifications for sound instrumentation and weather meters, calibration, settings, positions that were tested, noise descriptors collected, range of sound frequencies evaluated, weather conditions, testing conditions to be excluded, schedules and time frames, testing methodologies and procedures, provisions for evaluation of

existing tones and sounds with strong low frequency noise content are found in Chapters 6 and 7 of the PNIA.

8) Measurement locations, including GPS coordinates and AADT information of the nearest road, and a justification for location selection are found in Table 6-1 and Chapter 6.2 of the PNIA.

9) See the response to item 19(b)(1) above. All data were collected for a minimum of 14 consecutive days.

10) Temporal accuracy of the L_{eq} and the L_{90} ambient data was calculated to a 95% confidence interval using the technique in Section 9 of ANSI S12.9-1992/Part 2 (R2013) (see Chapter 8.6 of the PNIA).

11) Infrasound data down to 0.5 Hz were collected at one location during the ambient measurement programs (summer and winter). Details of this are found in Chapter 8.7 and Figure 8-10 of the PNIA.

12) The sound instrumentation for ambient sound surveys complied with the following standards: ANSI S1.43-1997 (R March 16, 2007). Specifications for Integrating- Averaging Sound Level Meters; ANSI S1.11-2004 (R June 15, 2009) Specification for Octave-Band Analog and Digital Filters, and ANSI S1.40-2006 (R October 27, 2011) (Revision of ANSI 1.40-1984) Specifications and Verification Procedures for Sound Calibrators.

13) Data collected out of the range of operation of the sound instrumentation was excluded. Sound data collected at ground-level wind speeds exceeding 5 meters per second (11 miles-per-hour) at the sound microphone or portable weather station heights were also excluded. Pre-construction sound level data collected during periods of rain, thunderstorms and snowstorms were not used in the calculation of background sound levels. These exclusions are indicated on the graphs specified in Figures 7-5 to 7-30 of the PNIA.

(c) Future Noise Levels at Receptors during Facility Construction

Construction of wind power projects requires the operation of heavy equipment and construction vehicles for various activities including construction of access roads, excavation and pouring of foundations, the installation of buried and above ground electrical interconnects, and the erection of turbines. The noise generated by these activities will be associated with gasoline and diesel-powered engines, back-up warning signals, operating dump trucks, and possibly impact noise from jackhammers and/or rock drills, or even localized blasting, if required due to geotechnical conditions. Construction is expected to occur from approximately April to December at turbine sites and at the areas of the concrete batch plant, substation, and battery storage facility. Excavation work is expected to occur from early morning to the evening. In some instances, concrete foundation work and turbine erection work could extend into the overnight hours depending on the weather and timing of a concrete pour, which must be continuous.

Three areas within the Facility were analyzed for construction noise impacts. Sound levels were analyzed at the most potentially impacted and representative receptors using the ISO 9613-2 3-D sound propagation standard as implemented in the Cadna/A software package. Reference sound source information was obtained from either Epsilon measurements or the FHWA's Roadway Construction Noise Model (RCNM). Modeling and analysis procedures generally followed the guidelines and recommendations of the FHWA Highway Construction Noise

Handbook. Worst-case sound levels from construction are expected to be 57 dBA or less at all residences[2]. While the sounds of construction may be audible at times throughout the project area, they are not excessively high or unusual, and do not present an undue adverse impact. Details of the analysis and findings are presented in Chapter 11 of the PNIA.

(d) Estimated Sound Levels to be Produced by Operation of the Facility

1) Future sound levels associated with the proposed Project were predicted using the Cadna/A noise calculation software developed by DataKustik GmbH. This software implements the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation) for full octave bands from 31.5 Hertz (Hz) to 8000 Hz. The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple reflections, drop-off with distance, and atmospheric absorption. The Cadna/A software allows for octave band calculation of sound from multiple sources as well as computation of diffraction. No meteorological correction (Cmet) was used, and no CONCAWE meteorological correction was used.

2) Full octave band calculations from 31.5 Hz to 8000 Hz were performed for the Facility using the ISO 9613-2 standard.

3) Four wind turbine models are currently under consideration for this project:

   - GE 5.5-158; hub height either 107.4m or 125.4m
   - Nordex N149/4.8; hub height either 105m or 125m
   - Siemens Gamesa Renewable Energy SG4.5-145; hub height either 107.5m or 127.5m
   - Vestas V150-5.6; hub height either 105m or 125m

   Each of the four wind turbine sound levels were predicted using unique model runs and the results presented in Chapter 9 of the PNIA. In this way, the specific broadband and octave band levels associated with each wind turbine were used in the modeling.

4) Tables 9-1 and 9-2 of the PNIA report the sound power level information from the wind turbine manufacturers as a function of wind speed, the angular rotor speeds, and rated power of the turbines. All sound power level data includes the benefit of low-noise blades, sometimes referred to as serrated trailing edges, or low-noise trailing edge blades. All wind turbine manufacturers provided sound power level data for the 16, 31.5, and 63 Hz octave bands. The highest sound power level of all octave bands from 16 Hz to 8000 Hz are shown in Tables 9-3A and 9-3B in the PNIA. For each octave band, the highest sound power level published by the manufacturer has been used and input to the Cadna model, regardless of the wind speed at which they occur. When combined into an overall A-weighted sound level, this represents an additional 0.0 to 0.5 dBA of conservatism to model results depending on the wind turbine manufacturer. In addition, an uncertainty factor "K" of 2.0 dBA was assumed and added to the sound power level for each modeled wind turbine.

[2]By way of comparison, normal conversation between two people is about 55-60 dBA.

5) Spectral ground absorption "G" was calculated using a G-factor of 0.5 which corresponds to "mixed ground" consisting of both hard and porous ground cover. This is consistent with the modeling guidelines of Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects, NARUC, prepared by Hessler Associates, Inc., October 2011 (NARUC 2011). According to the Massachusetts Study on Wind Turbine Acoustics,[3] "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." A recent post-construction measurement program conduction 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.

6) For the purposes of evaluating community complaint potential, the conservative set of modeling assumptions for this analysis is consistent with the modeling recommendations in NARUC 2011 with the exception that NARUC 2011 does not include the uncertainty factor "K", and the modeling for this project does add the "K" factor. Thus, these model results are more conservative (higher) than what NARUC would predict.

7) The predicted sound levels from ISO 9613-2 are reported for all sensitive receptors in tabular format for each of the four wind turbine manufacturers in Appendix E of the PNIA. Each wind turbine manufacturer's results are presented both by receptor ID and sorted from highest to lowest sound levels. Sound levels at sensitive receptors and external property boundaries were generated by modeling a grid to generate graphical isolines (noise contours) of A-weighted decibels for the worst-case Leq 9-hour wind turbine (SG 4.5-145), and the worst-case Leq, night, outside wind turbine (Nordex N149/4.8). These isolines are presented in Figure 9-2 and Figure 9-3 respectively in the PNIA. Full-size drawings were delivered to DPS and DOH in electronic media as well as in hardcopy format.

8) Participating and nonparticipating property boundaries are differentiated in the sound contour drawings. See Figures 9-2 and 9-3 in the PNIA. Each property is labeled with their unique tax code. Only parcels with a signed contract as of this filing are shown as participating.

9) Details of all the modeling assumptions are found in Chapter 9.3 of the PNIA. A temperature of 10 degrees Celsius and 70% relative humidity was used to calculate atmospheric absorption for the ISO 9613-2 model.

10) Tables 9-10 to 9-13 in the PNIA summarize the short-term results for each wind turbine under consideration. For the GE 5.5-158 there is one non-participating receptor with an Leq (9-hour) sound level of 47 dBA, and five non-participants at 46 dBA. For the Nordex N149/4.8 there is one non-participating receptor with an Leq (9-hour) sound level of 46 dBA. For the SG 4.5-145 there is one non-participating receptor with an Leq (9-hour) sound level of 47 dBA, and three non-participants at 46 dBA. However, NRO will be used to reduce worst-case sound levels to 45 dBA at these receptors, in the event the GE, Nordex, or SG turbines are used. For the Vestas V150-5.6, all non-participating receptors will be at 45 dBA or less without the use of any NRO.

11) A full year of 2018 on-site meteorological data were used to calculate the hub height wind speed and related sound power levels for each hour of the year (8760 hours). Table 9-6 of the PNIA summarizes the wind speeds for the year in terms of hours below cut-in speed, above cut-out speed, and missing data. From these data, it can be seen that the wind turbines would be expected to operate at some level approximately

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

93% of the year (8,188 hours) with a 105m hub height or 94% of the year (8,257 hours) with a 125m hub height. The hourly wind speeds drive the resultant sound power level of the wind turbines. Using these data, the sound level exceeded for 10% of the time over the course of one year (L10) was calculated, as well as the sound exceeded for 50% of the time over the course of one year (L50). These calculations were done for two scenarios: i) all hours in a year (including hours below cut-in speed and above cut-out wind speed), and ii) only those hours in a year above cut-in speed and below cut-out wind speed. The L10 and L50 wind speed results are summarized in Table 9-7 of the PNIA, and the associated sound power levels for each wind turbine under consideration, are shown in Table 9-8 of the PNIA. The sound power levels in Table 9-8 do not include any uncertainty factor. Details of data and calculations are in spreadsheet format and will be filed with the Hearing Examiner and treated by the Records Access Officer or other presiding officer as confidential. The annual L10 and L50 values for all receptors are presented in Table F-1 (Method 1 – No Zeros) and Table F-2 (Method 2 – With Zeros) in Appendix F of the PNIA.

12) The same full year of on-site wind speed data discussed in Exhibit 19(d)(11) were used to calculate an equivalent sound level for all nighttime hours in one year (Leq, night, outside). This was done using the percent time matched to sound power level at a given wind speed and was calculated on an energy basis for all wind turbines under consideration. These calculations were done for two scenarios: all hours in a year (including hours below cut-in wind speed), and only those hours in a year above cut-in speed. There were zero hours above cut-out speed. The associated sound power levels for each wind turbine under consideration, are shown in Table 9-9 of the PNIA. The sound power levels in Table 9-9 do not include any uncertainty factor. Details of data and calculations are in spreadsheet format and will be filed with the Hearing Examiner and treated by the Records Access Officer or other presiding officer as confidential. The annual nighttime Leq (Leq, night, outside) values for all receptors are presented in Table F-1 (Method 1 – No Zeros) and Table F-2 (Method 2 – With Zeros) in Appendix F of the PNIA.

13) Chapter 9.3 of the PNIA has a detailed discussion of the accuracy of the propagation model, methodology, ground absorption, assumptions, and the correlation between measured and predicted sound levels from projects such as this. This section also includes a discussion of the site topography. One area of the project appears to have concave slopes, thus the receptors in this area were further adjusted upward by an additional 2 dBA to account for this factor. Those receptors are listed in Table E-5 of the PNIA.

    The highest 1-hour predicted sound levels from are reported for all sensitive receptors in tabular format for each of the four wind turbine manufacturers in Appendix E of the PNIA. The highest Leq 1-hour sound levels at each receptor are conservatively assumed to be the same as the highest Leq 9-hour sound level. The highest Leq 15-hour sound level is conservatively assumed to be the same as the highest Leq 9-hour sound level.

14) The sound level modeling included any contributions from the collection substation and the battery storage facility which are part of this project. Additional details on these sources are found in Chapter 9.2 of the PNIA.

15) Seven bodies of water with moderate width (greater than 500 feet) were identified within the Project area, including North Pond. These seven areas were set to G=0 representing completely reflective surfaces. This is the most conservative setting available.

(e) Future Noise Levels at Receptors During Facility Operation

This section of Exhibit 19 will address the following areas:

1) Modeled A-weighted/dBA sound levels at all sensitive receptors.

   Future noise levels during operation of the proposed Facility have been calculated using the methodology described above in 19(d) under the heading Sound Propagation Modeling – ISO 9613-2. Tables E-1 and E-1.1 of Appendix E of the PNIA provides the predicted A-weighted (dBA) sound pressure levels at all sensitive receptors for each wind turbine under consideration.

2) Tonal Evaluation

   ANSI S12.9 Part 3, Annex B, section B.1 (informative) presents a procedure for testing for the presence of a prominent discrete tone. According to the standard, a prominent discrete tone is identified as present if the time-average sound pressure level in the one-third octave band of interest exceed the arithmetic average of the time-average sound pressure level for the two adjacent one-third bands by any of the following constant level differences: 15 dB in low-frequency one-third-octave bands (from 25 up to 125 Hz); 8 dB in middle-frequency one-third-octave bands (from 160 up to 400 Hz); or, 5 dB in high-frequency one-third-octave bands (from 500 up to 10,000 Hz). A source of sound with a tone may be more annoying at the same A-weighted sound level than a source without a tone. Typically, the tone must be loud enough so that it is prominent, and thus annoying. The State of Illinois Pollution Control Board noise regulations recognize this fact by noting that their prominent discrete tone rule does not apply if the one-third octave band levels are 10 dB or more below the octave band limits in the IPCB regulations.

   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 ten (10) potentially impacted and representative receptor locations (both non-participants and participants) using equations accounting for hemispherical radiation and atmospheric absorption.

   The same method was used to assess whether a prominent discrete tone exists from the wind turbines. Calculations for both the transformer and wind turbines used a spreadsheet approach since ISO 9613-2 does not accommodate one-third octave band data. For these calculations, the turbine manufacturer with the most tonal one-third octave band spectrum was used, representing the worst-case turbine for tonality. The results of these calculations are included in Table 12-6 of the PNIA and indicate that sound pressure levels due to the closest wind turbines at each of these locations are not predicted to result in any prominent discrete tones.

   One-third octave band sound power levels for the substation transformer were not supplied by the vendor for the substation equipment; therefore, a quantitative evaluation of one-third octave band sound using the spreadsheet modeling approach was not possible. In general, 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 35 dBA at all non-participating sensitive receptors[4]. Therefore, prominent discrete tones from the substation are not a concern with this Project.

3) Amplitude Modulation

With respect to wind turbines, amplitude modulation 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 interaction with the wake of the blade. The modulation is not infrasound; rather, it is a variation in audible sound that is synchronized with the passage of the turbine blades. The fundamental frequency of the modulations is usually coincident with the rotational speed of the turbine multiplied by the number of blades:

Modulation frequency = (RPM x Number of blades)/60 seconds per minute

The rotor speed (RPM) varies according to the type of wind turbine and operating conditions. For example, if a three-bladed turbine is turning at 15 RPM, the fundamental modulation frequency would be 0.75 Hz. The time it takes for a complete modulation cycle (the period) is 1/frequency. In this case, the cycle time would be about 1.33 seconds.

Normal amplitude modulation from wind turbines is generally characterized as "swishing," which is a broadband sound. Under some circumstances it is characterized as "thumping," which has a faster rise time and is composed of sound at lower frequencies. A "churning" sound has also been described, which is made up of broadband mid-frequency sound, but with a faster rise-and-fall rate.

The Massachusetts Study on Wind Turbine Acoustics[5] measured amplitude modulation in detail and came to the following primary conclusions:

- Low frequency sound and infrasound from with wind turbines are not modulated for the most part, and sounds in the frequency range from about 250 Hz to 2 kHz are amplitude-modulated.
- The technique of calculating a spectrogram from A-weighted sound levels and one-third octave band levels is very effective at revealing the signature of amplitude modulated wind turbine sound. A logging interval of 125 milliseconds or faster is required.
- The maximum observed increase in modulation depth was at 500 Hz.
- The measured sound level, wind speed, and distance to turbine have the greatest impact on modulation depth.
- Approximately 90% of all measured amplitude modulation depth was 2 dB or less, while over 99.9% was 4.5 dB or less.
- Wind turbulence, wind shear, and yaw error have a lesser, but statistically significant, effect on amplitude modulation depth compared to distance and sound level.

[4] For perspective, a quiet library is around 35 dBA.
[5] *Massachusetts Study on Wind Turbine Acoustics,* Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, RSG et al., 2016.

- The turbulence intensity does not show any trend with respect to sound levels.

The U.K. Department of Energy and Climate Change[6] reviewed research into the effects of and response to the acoustic character of amplitude modulation. The report indicated that it is not possible to predict or forecast whether amplitude modulation will be present on a site. The report also noted that a threshold for excessive amplitude modulation is not straightforward and available research does not identify a clear onset of increased annoyance from amplitude modulation.

The Applicant proposes to address potential amplitude modulation complaints through the complaint resolution process for sound complaints included as Appendix 19-B. Based on the conditions and parameters involving the complaint, the Applicant will assess whether or not a sound complaint could be caused by amplitude modulation. If the Applicant determines that the cause of the complaint is amplitude modulation, there are a few mitigation options which could be considered by the Applicant. Two possible mitigation options to reduce the amplitude modulation associated with complaints ("thumping") have been identified by Cand and Bullmore.[7] The studies found that thumping occurred under transient stall effects occurring over part of the turbine blade surfaces. Two mitigation measures were tested and found to reduce amplitude modulation depth significantly. These two mitigation techniques are a "kit" offered as an option by Original Equipment Manufacturers (OEMs) and installed on the blades designed to improve or modify the flow of air on the blades to reduce stall, and a software design change which modified the turbine blade pitch control angle by several degrees under specific wind regime conditions. The exact details of any proposed resolution or mitigation, if any, will be established prior to the start of construction.

Section 10.5 of the IEC 61400-11 standard used for reference sound level measurements of all wind turbines by the manufacturers, notes that amplitude modulation is an optional data element that may be reported during testing. Annex A and B of this standard also contain a brief mention of AM and its relationship to turbulence conditions.

In order to determine wind shear and turbulence intensity conditions, Epsilon obtained one year (8760 hours) of meteorological data collected from an on-site 60-meter meteorological tower within the Project site area. The meteorological data measured for calendar year 2018 include wind speed, wind direction, and wind speed standard deviation at multiple heights. The wind speed and wind speed standard deviation data were used for the wind shear and turbulence intensity calculations. Ten-minute wind speed data were also used to compute the average hourly wind speed. Details are found in Chapter 10 of the PNIA.

For a 105-meter hub height, the overall average wind shear for the year is 0.41, the minimum is -2.45 (wind decreasing with height), and the maximum is 3.20. Wind shear is simply the change of wind speed with height above ground level. The wind shear is from a measured height of 32 meters above ground to the proposed hub height of 105 meters above ground. Meteorologists from High Bridge Wind provided the extrapolated wind speed data to 105 meters.

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

[7] *Measurements demonstrating mitigation of far-field AM from wind turbines,* M. Cand and A. Bullmore, 6th International Meeting on Wind Turbine Noise, Glasgow, Scotland, April 2015

For a 125-meter hub height, the overall average wind shear for the year is also 0.41, the minimum is -2.42 (wind decreasing with height), and the maximum is 3.14. The wind shear is from a measured height of 32 meters above ground to the proposed hub height of 125 meters above ground. Meteorologists from High Bridge Wind provided the extrapolated wind speed data to 125 meters. Figures 10-1 and 10-2 of the PNIA present the annual average wind shear coefficient by hour at each hub height. These figures show that wind shear at this site is typical which is not surprising considering the combination of land uses (field and forest) in the surrounding area. Wind shear is typically lower during the daytime hours when the atmosphere is less stable as compared to the higher wind shear values at night when the atmosphere is more stable.

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 10-3 of the PNIA presents the annual average hourly turbulence intensity at this site at a height of 105 meters above ground based on the on-site meteorological tower. The overall average turbulence intensity for the year is 0.13, the minimum is 0.03, and the maximum is 3.23. Results show that turbulence intensity is higher during the day than at night, and especially high around mid-day.

Figure 10-4 of the PNIA presents the annual average hourly turbulence intensity at this site at a height of 125 meters above ground based on the on-site meteorological tower. The overall average turbulence intensity for the year is 0.12, the minimum is 0.02, and the maximum is 4.59. Results show that turbulence intensity is higher during the day than at night, and can be variable at any time.

Figures 10-5 and 10-6 of the PNIA show the annual average turbulence intensity by hub height wind speed for the proposed hub heights of 105m and 125m respectively. These data show that turbulence intensity is relatively steady up to 10 m/s. As hub height wind speed increases, turbulence intensity becomes less variable, as shown by the decrease of the difference between the 95th and 5th turbulence intensity percentiles. Wind speeds much above 15 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.

No literature was found documenting a change in turbulence or wind shear at a site created by the installation of wind turbines. One would expect that since wind turbines generate turbulence in the wake of their blades, there may be some change in localized turbulence after the installation of wind turbines. No change in wind shear would be expected.

4) An Evaluation of the Potential for Low Frequency and Infrasound

"Infrasound" is sound pressure fluctuations at frequencies below about 20 Hz. Sound below this frequency is only perceptible at relatively high magnitudes. "Low frequency sound" is in the nominal audible range of human hearing, that is, above 20 Hz, but below 200 Hz.

i) Low frequency sound levels for the full octave bands equal to or greater than 31.5 Hertz were evaluated at all sensitive receptors for all wind turbines under consideration for this project. The results are presented in Appendix E of the PNIA.

ii) Since the ISO 9613-2 standard does not include the 16 Hz frequency, results at the 16 Hz octave band for each receptor and for each wind turbine manufacturer were extrapolated from the 31.5 Hz

results. The extrapolation is the difference between the specific manufacturer's sound power data at 16 Hz and the sound power data at 31.5 Hz used for modeling as presented in Table 9-3B in the PNIA. The results are presented in Appendix E of the PNIA.

The number of receptors with sound pressure levels equal to or greater than 65 dB are found for each wind turbine manufacturer in Tables 12-2 to 12-5 of the PNIA. A list of receptors with sound levels equal to or greater than 65 dB at 16, 31.5, or 63 Hz is found in Tables E-6.1, E-6.2, and E-6.3 of the PNIA respectively.

iii) Infrasound and low frequency sound levels down to 0.5 Hz were calculated using a spreadsheet approach for the nearest 10 receptors to any wind turbine. These receptors included non-participating and participating locations. These ten receptor locations were scattered throughout the wind farm and were at a diverse assortment of locations throughout the wind farm, thus providing a good mix of worst-case conditions. Table 9-18 in the PNIA presents the highest infrasound sound power levels from each model under consideration for each one-third octave band. Table 9-19 in the PNIA presents the receptors, the wind turbines included in the calculations, and the distance from the wind turbine to each receptor. Inclusion of the more distant wind turbines is not necessary since they have a negligible effect on overall values which are controlled by the closest turbine(s). The results are shown in Table 9-20 in the PNIA for both the one-third octave bands and full octave bands at each of the ten locations analyzed. The results in Table 9-20 show the cumulative impact of infrasound from multiple wind turbines at a given location.

iv) Details on the available sound data, methodology used for the calculations, and literature references is found in Chapter 4.6.2 and Chapter 9.6 of the PNIA

(f) Predicted Sound Levels Table

(1) Daytime Ambient Noise

The daytime ambient noise level was calculated from summer and winter background sound level monitoring data. This is equal to the lower tenth percentile (L90) of sound levels measured during the daytime (7:00 AM – 10:00 PM) at each of the monitoring locations. These results are provided in Table 19-1 below (same as Table 8-1 in the PNIA). Sound levels in this section are presented both "as measured" and "ANS-weighted" (dBA) which removes all sound energy above the 1,250 Hertz frequency band. The ANS methodology is as specified in ANSI/ASA S12.100-2014 and is primarily aimed at removing high-frequency insect noise.

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
Location 1	24.5	20.9	22.3	20.7	33.4	21.0
Location 2	23.1	18.7	20.9	17.3	39.4	19.5
Location 3	29.7	24.2	24.2	23.6	37.2	24.7
Location 4	22.8	18.3	19.2	17.2	33.6	19.0
Location 5	28.4	22.8	26.5	25.2	35.4	22.3
Location 6	31.7	26.9	26.9	26.6	35.7	27.1
Location 7	22.0	19.2	20.3	18.3	41.5	20.1

(2) Summer Nighttime Ambient Noise

The summer nighttime ambient noise level was calculated from summer background sound level monitoring data. This was equal to the L_{90} of sound levels measured at night (10:00 PM – 7:00 AM) during the summer at each of the monitoring locations. These results are provided below in Table 19-2 (same as Table 8-2 in the PNIA).

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
Location 1	22.4	16.5	20.7	18.5	27.3	16.3
Location 2	23.3	17.1	19.3	14.7	41.5	17.1
Location 3	24.4	12.7	15.8	11.0	31.4	12.8
Location 4	26.2	12.4	16.0	11.3	37.5	12.6
Location 5	28.5	20.3	26.6	25.2	32.8	20.0
Location 6	23.3	13.7	18.4	16.5	30.1	13.4
Location 7	21.8	13.8	17.6	13.5	39.7	13.9

(3) Winter Nighttime Ambient Noise

The winter nighttime ambient noise level was calculated from winter background sound level monitoring data. This was equal to the L_{90} of sound levels measured at night (10:00 PM – 7:00 AM) during the winter at each of the monitoring locations. These results are provided above in Table 19-2.

(4) Future Daytime Noise Level

The worst-case future noise level during the daytime period (7:00 AM – 10:00 PM) at all receptors was determined by logarithmically adding the daytime ambient sound level (L_{90}) (Table 19-1) as related to the use and soundscape of the location being evaluated, calculated from background sound level monitoring in the summer and winter, to the modeled upper 10th percentile sound level (L_{10}) of the Facility. The L_{10}

statistical noise descriptor corresponds to estimates for one year of operation using the sound power levels for the worst-case wind turbine model (SG4.5-145) as presented in Table 9-8 of the PNIA. 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 of the PNIA. Worst case future daytime noise levels range from 27 to 47 dBA for the Method 1 and the Method 2 calculations. The highest L_{10} sound level at a non-participating receptor is 45 dBA.

(5) Future Summer Nighttime Noise Level

The worst-case future noise level during the summer nighttime period at all receptors was determined by logarithmically adding the summer nighttime ambient sound level (L_{90}) (Table 19-2) as related to the use and soundscape of the location being evaluated, calculated from background sound level monitoring, to the modeled upper 10th percentile sound level (L_{10}) of the Facility. The L_{10} statistical noise descriptor corresponds to estimates for one year of operation using the sound power levels for the worst-case wind turbine model (SG4.5-145) as presented in Table 9-8 of the PNIA. 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 of the PNIA. Worst-case future total summer nighttime noise levels range from 22 to 47 dBA for the Method 1 and the Method 2 calculations.

(6) Future Winter Nighttime Noise Level

The worst-case future noise level during the winter nighttime period at all receptors was determined by logarithmically adding the winter nighttime ambient sound level (L_{90}) (Table 19-2) as related to the use and soundscape of the location being evaluated, calculated from background sound level monitoring, to the modeled upper 10th percentile sound level (L_{10}) of the Facility. The L_{10} statistical noise descriptor corresponds to estimates for one year of operation using the sound power levels for the worst-case wind turbine model (SG4.5-145) as presented in Table 9-8 of the PNIA. 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 of the PNIA. Worst case future winter nighttime noise levels range from 23 to 47 dBA for the Method 1 and the Method 2 calculations.

(7) Daytime Ambient Average Noise Level

Measured daytime average ambient levels are presented in Table 19-3 below (same as Table 8-3 in the PNIA). The daytime ambient average noise level was calculated by logarithmically averaging sound pressure levels (L_{eq}) (after exclusions) from the background sound level measurements over the daytime period at each monitoring location. These calculations include both summer and winter data combined.

Table 19-3. Daytime Ambient L_{eq} (dBA) Sound Pressure Level Summary

Location	Overall (dBA)	
	Measured	ANS
Location 1	55.9	53.9
Location 2	45.8	39.9
Location 3	60.0	57.9
Location 4	51.0	49.6
Location 5	45.6	39.3
Location 6	62.7	61.4
Location 7	65.7	60.7

(8) Typical Facility Noise Level

Typical Facility noise levels for each sensitive receptor were calculated as the median sound pressure level emitted by the Facility at each evaluated receptor (L_{50}). The median sound pressure level was calculated by determining the frequency of site specific meteorological conditions and sound emissions for the Facility due to those conditions. The L_{50} statistical noise descriptor corresponds to estimates for one year of operation using the sound power levels for the worst-case wind turbine model (N149/4.8) as presented in Table 9-8 of the PNIA. The Typical Facility sound levels are presented in Tables F-1 (Method 1 – No Zeros) and F-2 (Method 2 – With Zeros) in Appendix F of the PNIA.

(9) Typical Facility Daytime Noise Level

The typical Facility daytime (7:00 AM – 10:00 PM) noise level at all receptors was determined by logarithmically adding the daytime equivalent average sound level (L_{eq}) calculated from background sound level monitoring (Table 19-3) as related to the use and soundscape of the location being evaluated, to the modeled median Facility sound pressure level (L_{50}). The L_{50} statistical noise descriptor corresponds to estimates 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 of the PNIA. Typical Project daytime noise levels range from 39 to 61 dBA for the Method 1 and Method 2 calculations.

(g) Applicable Noise Standards

Noise standards applicable to the Facility Site, as well as noise guidelines that are required by or recommended by various agencies, are described below. More information on these standards is included in Chapter 4 of the PNIA. The input parameters, assumptions and standards that were used for purposes of predicting sound pressure levels from the Facility's turbines are discussed in detail in Section (d) above. The compliance with these standards is discussed below and in Table 19-4 in Exhibit 19(h).

As noted in the NARUC 2012 report[8], a balance must be struck between avoiding or minimizing potential impacts from wind turbine generated sound while not imposing regulatory standards which are so stringent that they do not afford additional benefits but instead are prohibitive to project viability. Regulatory limits for other power generation and mechanical processes never seek inaudibility but rather to limit noise from a source to a reasonably acceptable level. The ten standards and design goals for this project are described in more detail below.

As part of the project, noise design goals were developed based on a literature review in order to balance reasonable development and minimize annoyance to the community.[9] These include a 45 dBA L_{eq} nighttime limit at a non-participating residence (Goal #1). This is based on the WHO eight-hour guideline to minimize sleep disturbance. A 50 dBA L_{eq} daytime limit at a non-participating residence (Goal #1A) is based on the WHO daytime guideline to minimize annoyance. A design goal of 55 dBA L_{eq} (day and night) is established for a participating residence and is also based on the WHO guideline (Goals #2 and #2A). Another design goal for non-participating residences is to prohibit an "audible prominent tone" in accordance with ANSI S12.9 Part 3/Annex B Section B.1, or impose a 5 dBA penalty to the broadband limit (i.e., lower the broadband limit by 5 dBA) if a pure tone occurs (Goal #5).

Wind turbines produce infrasound but these levels are well below human thresholds of audibility. However, infrasound and low frequency energy can result in airborne vibration within homes if the levels are high enough. American National Standard ANSI S12.9-2005/Part 4 identifies that low frequency sound annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each 65 dB or less (Goal #6).

The WHO 1999 report[10] notes daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. Since a property line is not a "living area", or even an area where people routinely spend extended time, limiting 1-hour L_{eq} sound levels to 55 dBA or less at non-participating property lines is a reasonable design goal (Goal #8). With a limit of 55 dBA at the boundary line, sound levels inside the boundary line will be less than 55 dBA.

An annual nighttime level of 40 dBA ($L_{eq,\ night,\ outside}$) at a non-participating residence is another design goal as put forth by the WHO 2009[11] (Goal #3). This covers all the nighttime periods over the course of an entire year (365 days). This same annual nighttime design goal is 50 dBA at a participating residence (Goal #4).

[8] Wind Energy & Wind Park Siting and Zoning Best Practices and Guidance for States, NARUC, prepared by National Regulatory Research Institute, January 2012.
[9] The Town of Guilford is considering, but has not yet adopted, a local law governing wind energy generation facilities. If and when such local law is adopted, a supplement to the Application will be provided which discusses any applicable noise standards contained therein.
[10] Guidelines for Community Noise, World Health Organization, Geneva, 1999.
[11] Night Noise Guidelines for Europe, World Health Organization, Copenhagen, 2009.

Since ground-borne vibration from a wind farm is not a demonstrated issue to people in their homes, ground-borne vibration has a design goal but will only be analyzed through the post-construction complaint resolution program, if necessary (Goal #7). In order to minimize complaints, the long-term mean sound levels should be limited to 40 dBA (ideal) and 45 dBA (maximum) at a residence outdoors according to NARUC 2011 (Goal #9).

In 2018, the WHO released another report[12] which did include guidelines for wind turbines. This document proposes an annual average guideline of 45 dBA L_{den} (day-evening-night) over all days, evenings, and nights for wind turbines. The recommendation is "conditional" which "requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply."

The key findings of the 2018 WHO report related to health outcomes found no evidence that wind turbine noise is related to heart disease, hypertension, and sleep disturbance, and low quality evidence regarding wind turbine noise and its relationship to annoyance. Importantly, neither the Wind Turbine Noise and Health Study conducted by Health Canada, nor the 2018 Lawrence Berkeley National Laboratory studies, which found no health impacts from wind turbines, were included in the 2018 WHO report (see Section 4.6 of the PNIA).

Two key observations taken directly from the 2018 WHO report are:

- As the foregoing overview has shown, very little evidence is available about the adverse health effects of continuous exposure to wind turbine noise, and
- Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes.

Based on these findings, a 45 dBA annual L_{den} sound level is not appropriate as a design goal or permit condition, and thus will not be evaluated as part of this study.

(h) Noise Standards Comparison

Noise standards and design goals for the Facility, including state guidelines, WHO guidelines, and other federal agency guidelines, are provided below in Table 19-4. Based on the detailed analyses presented in this report, the future project sound levels will meet most design goals. NRO is needed for three manufacturers (GE; Nordex;

[12] Environmental Noise Guidelines for the European Region, World Health Organization Regional Office for Europe, Copenhagen, 2018.

SGRE) to meet the short-term sound limit at one to three receptors, while the other (Vestas) does not need NRO. In addition, two manufacturers (Vestas; SGRE) meet the low frequency design goal while two manufacturers are modeled to one to three dB over the goal (GE; Nordex). For the long-term annual $L_{night,\ outside}$ design goal at a non-participating residence, one manufacturer meets the limit (Vestas) while the other three have 5 to 7 locations modeled at 41 to 43 dBA. A detailed discussion is found in Chapter 13 of the PNIA.

Table 19-4. Summary of Compliance with Sound Standards and Design Goals

#	Design Goal. (Not to exceed)	Assessment Location	Noise descriptor	Period of Time	Participant Status	Design Goals and basis	Met?
1	45 dBA	At residence, Outdoor	Leq	9-hour nighttime	Non-participant	Design Goal; Certificate Condition 80(a) Case 14-F-0490 and WHO-1999	Yes
1A	50 dBA	At residence, Outdoor	Leq	15-hour daytime	Non-participant	Design Goal; WHO-1999	Yes
2	55 dBA	At residence, Outdoor	Leq	9-hour nighttime	Participant	Design Goal; Certificate Condition 80(a) Case 14-F-0490	Yes
2A	55 dBA	At residence, Outdoor	Leq	15-hour daytime	Participant	Design Goal; Certificate Condition 80(a) Case 14-F-0490	Yes
3	40 dBA	At residence, Outdoor	Lnight-outside (Leq)	Annual; nighttime. (2009-WHO)	Non-participant	Design Goal; Certificate Condition 80(b) Case 14-F-0490 and WHO-2009	Yes (Vestas) No (GE; SGRE; Nordex)
4	50 dBA	At residence, Outdoor	Lnight-outside (Leq)	Annual; nighttime. (2009-WHO)	Participant	Design Goal; Certificate Condition 80(b) Case 14-F-0490 and WHO-2009	Yes
5	No audible prominent tones or 5 dBA penalty if they occur.	At residence, Outdoor	Leq	1-hour	Non-participant	Design Goal; Certificate Condition 80(c) Case 14-F-0490	Yes
6	65 dB at 16, 31.5, and 63 Hz full-octave bands.	At residence, Outdoor	Leq	1-hour; daytime and nighttime	Non-Participant	Design Goal; Certificate Condition 80(d) Case 14-F-0490	Yes (Vestas; SGRE) No (GE; Nordex)
7	No perceptible vibrations	At residence, Indoor	See ANSI S 2.71-1983 (R August 6/2012).	See ANSI S 2.71-1983 (R August 6/2012).	Non-participant	Design Goal; Certificate Condition 80(e) Case 14-F-0490	Yes
8	55 dBA	Property line	Leq	1-hour; daytime and nighttime	Non-participant	Design Goal; Boundary lines and Lands Except Wetlands (WHO 1999)	No
9	40-45 dBA. Ideal and Maximum Design Goals, respectively	At residence, Outdoor	L90 (See NARUC-2011 for details)	Long-term mean as obtained with computer modeling.	Non-participant. (Daytime and nighttime)	Ideal and Maximum Design Goals; National Association of Regulatory Utility Commissioners. NARUC-2011	Yes

(i) Noise Abatement Measures for Construction Activities

Noise due to construction is an unavoidable outcome of construction. The heavy civil and site work is expected to last approximately 6-9 months. Due to the large distances between construction activity and sensitive receptors, noise from construction is not expected to result in impacts. However, the Noise Complaint Resolution Plan provided with this Application contains the procedures 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 (BMP) such as those listed below.

- Blasting is anticipated at this site. Blasting will be limited to daytime hours and conducted in accordance with the High Bridge Wind Preliminary Blasting Plan included in Appendix 21-A.
- Pile driving is not anticipated at this site. If pile driving is required, it will be limited to daytime hours. See the preliminary geotechnical report for more detail.
- 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.
- Using back-up alarms with a minimum increment above the background noise level to satisfy the performance requirements of the current revisions of Standard Automotive Engineering (SAE) J994 and OSHA requirements.
- 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.

(j) Noise Abatement Measures for Facility Design and Operation

Adverse noise impacts will be avoided or minimized through careful siting of Facility components, the use of alternative designs, alternative technologies, and alternative facility arrangements, if necessary. The noise emitted by a wind turbine is predominantly determined by the aerodynamic broadband noise of the rotor blades. Blade noise increases with increasing wind speed until rated electrical power is reached. Sound power levels can be lowered by reducing the rotor speed through pitch adjustments, thus lowering and limiting the tip speed.

Most modern wind turbine manufacturers offer an option of using NROs. With the aid of the control system, the turbine can be switched to noise-reduced mode, based on pre-determined parameters, such as the time of day, wind direction, wind speed, etc. NRO can be implemented on an "as needed" bases through the use of software programming. Sound propagation modeling presented in this Exhibit has not taken credit for any NRO mode.

Due the inherent size of wind turbines, typical barrier structures are not practical to reduce sound.

(k) Community Noise Impacts

1) Potential for Hearing Damage

The Facility's potential to result in hearing damage was evaluated against three guidelines established by the OSHA, USEPA, and WHO. Comparison of sound propagation modeling to these guidelines shows that construction and operation of the Facility will not result in potential for hearing damage. Each of the standards and the Facility's compliance with them is further described below.

OSHA protects against the effects of noise exposure in the workplace. Permissible noise exposure levels for an 8-hour day are 90 dBA. At sound levels above 85 dBA over an 8-hour workday, employers shall provide hearing protection to employees. Sound pressure levels as generated by Facility construction and operation at sensitive sound receptors will be under this threshold, so the Facility will be in compliance with OSHA standards. Therefore, based on the OSHA standard, the Facility will not result in potential for hearing damage.

The USEPA established a noise guideline for protection against hearing loss in the general population (USEPA, 1974). The guideline identifies a sound level of 70 dBA over a 24-hour period as protective against hearing loss from intermittent sources of environmental noise. The highest sound level at a non-participating residence would be 45 dBA.

According to the WHO 1999 Guidelines, the threshold for hearing impairment is 110 dBA (Lmax, fast) or 120/140 dBA (peak at the ear) for children/adults. The FHWA Highway Construction Noise Handbook estimates construction blasting noise levels to be approximately 82 dBA at 200 feet (Lmax) (FWHA, 2006). The closest receptor to any wind turbine foundation will be well beyond 200 feet. This would result in an Lmax sound level of less than 82 dBA at any receptor. These sound levels are well below the WHO hearing impairment threshold and the Facility is not expected to result in hearing damage based on these guidelines.

In addition, if any blasting is required, the contractor responsible for blasting will have a Health & Safety Plan approved by the Applicant. This Plan will include the appropriate worker hearing protection and procedures to prevent hearing loss from impulse noise.

2) Potential for Speech Interference

The Facility's potential to result in indoor and outdoor speech interference was assessed using the framework provided in the WHO (1999) document Guidelines for Community Noise and in the USEPA (1974) document Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety.

The 1974 USEPA document states that 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 levels below which there are no effects on public health and welfare due to interference with speech or other activity. This includes a 5 dBA margin of safety. An outdoor L_{dn} is equivalent to a 24-hour sound level of 49 dBA. Because all non-participating sensitive sound receptors were modeled to have the highest operational sound level less than or equal to 45 dBA, the Facility will not result in interference with indoor or outdoor speech, as defined by USEPA guidelines.

The WHO recommends and indoor sound level of 35 dBA (L_{eq}) to protect speech intelligibility. This is equivalent to approximately 50 dBA L_{eq} outdoors based on reduction from outside to inside by approximately 15 dBA with windows open, and 25 dBA with windows closed (USEPA, 1974). Because all non-participating sensitive sound receptors were modeled to have the highest operational sound level of less than or equal to 45 dBA, the Facility will not result in interference with indoor or outdoor speech, as defined by USEPA guidelines.

3) Potential for Interference in Use of Outdoor Public Facilities

The 1974 U.S. EPA "Levels" document identifies an outdoor level of 55 dBA (L_{dn}) requisite to protect the public health and welfare with an adequate margin of safety. 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.

A detailed discussion of the NYSDEC Program Policy for Assessing and Mitigating Noise Impacts is found in Section 4.2 of the PNIA. The only NYSDEC lands in the project area is the Lyon Brook State Forest located on the northwest edge of the Project area off Wahlberg Road. From a review of the short-term sound level modeling figures in Chapter 9 of the PNIA, the nearest portion of the State Forest would be at 32 dBA or less under wort-case operating conditions. From Table 19-3, overall existing condition daytime ambient sound levels at Locations 1, 2, and 3 are 40-58 dBA while overall existing condition nighttime ambient sound levels are 33-50 dBA at the same locations (Table 8-4 in the PNIA). Thus, the average increase over background from the Project would be well below the 6 dBA threshold in the NYSDEC policy.

4) Potential for Annoyance/Complaints

As part of the Project, noise design goals were developed based on a literature review in order to balance reasonable development and minimize annoyance to the community. The frequency range 20 – 20,000 Hz is commonly described as the range of audible noise. The frequency range of low frequency sound is generally

from 20 Hz to 200 Hz, and the range below 20 Hz is often described as infrasound. The potential for the Facility to cause annoyance in the audible and infrasound ranges is discussed in detail in Section 4.6 of the PNIA.

The number of receptors modeled at worst-case sound levels of 35 dBA and above short-term are grouped by land use and participation status for each wind turbine manufacturer under consideration for this project. These sound levels are reported in 1 dBA intervals with sound levels rounded to the nearest integer. The results of these intervals are found in Tables 9-10 to 9-13 in the PNIA.

5) Potential for Structural Damage

Information regarding construction activities is included the Preliminary Blasting Plan (Appendix 21-A) and the Preliminary Geotechnical Report (Appendix 21-B), and is summarized in Exhibit 12 and Exhibit 21 of the Application. Blasting of bedrock is not expected to be required for construction of turbine foundations, and portions of the electrical interconnect lines. It is not anticipated that pile driving will be needed to construct this Facility. Potential for any cracks or structural damage due to impact activities during construction will be analyzed in Exhibits 12 and 21.

6) Potential for Ground-borne Vibration

Information regarding the potential for ground-borne vibration from operating wind turbines is discussed in detail in Chapter 4.7 of the PNIA. Based on the literature findings presented in Chapter 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 Air-borne Vibration

The potential for air-borne induced vibrations from the operation of the Facility to generate annoyance, cause vibrations, rumbles or rattles in windows, walls or floors of sensitive receptor buildings was analyzed by applying the outdoor criteria established in annex D of ANSI standard S12.9 - 2005/Part 4 and applicable portions of ANSI 12.2 (2008). Table 12-1 in the PNIA shows the low frequency ANSI 12.2-2008 and ANSI S12.9-2005/Part 4 criteria.

Modeling results at the 31.5 Hz and 63 Hz low frequency octave bands have been calculated using Cadna/A acoustic model. Results at the 16 Hz octave band, for each receptor and for each wind turbine manufacturer, were extrapolated from the 31.5 Hz results. The extrapolation for each is the difference between the manufacturer's sound power data at 16 Hz and the 31.5 Hz sound power data used for computer modeling. Complete octave band sound pressure level results at each receptor for the Project is presented in Appendix E of the PNIA.

The number of receptors with sound pressure levels equal to or greater than 65 dB are listed for each wind turbine manufacturer in Tables 12-2 to 12-5 of the PNIA. A list of receptors with sound levels equal to or greater than 65 dB at 16, 31.5, or 63 Hz is found in Tables E-6.1, E-6.2, and E-6.3 of the PNIA respectively. The 63 Hz sound levels will not be above 65 dB for any wind turbine under consideration. The 31.5 Hz sound levels may be above 65 dB for one non-participating receptor for one wind turbine under consideration; the other manufacturers are less than 65 dB at the 31.5 Hz band. For the 16 Hz band, two

manufacturers have no non-participating receptors over 65 dB, one has one receptor at 66 dB, and one manufacturer has 35 non-participating receptors at 66 to 68 dB.

8) Potential for Interference Technological, Industrial, or Medical Activities that are Sensitive to Sound

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 Project site was investigated. 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 Chenango County, NY. There are also some auxiliary seismic stations to monitor shock waves in the Earth as part of the CTBTO program. The nearest seismic monitor to High Bridge Wind is located in Sadowa, Ontario, Canada (AS014) which is approximately 248 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 is one US Geological Survey (USGS) seismological station within 50 miles of the site--Binghamton, NY (BINY) approximately 30 miles to the southwest. Figure 12-1 in the PNIA shows station BINY in relation to the Project Area. The next nearest USGS stations are, Erie, PA (ERPA) approximately 240 miles to the west, and Lake Ozonia, NY (LONY) approximately 155 miles to the northeast.

The three nearest hospitals to the project are the Tri-Town Regional Hospital in Sidney, NY approximately seven miles south of the nearest wind turbine, UHS Chenango Memorial Hospital in Norwich, NY approximately six miles northeast of the nearest wind turbine, and the A.O. Fox Hospital in Oneonta, NY approximately 18 miles to the east of the nearest wind turbine. Distances are "as the crow flies."

(l) Post-Construction Noise Evaluation Studies

The Applicant proposes post-construction sound monitoring to take place in the first year of operations. In general, two sound monitoring tests will be conducted within the first 12 months following commercial start-up: once during leaf-on (generally June to September) and once during leaf-off conditions (generally December to March). Testing is proposed at the nearest residences to the Facility, with specific locations based on the pre-construction modeling results. A Sound Monitoring and Compliance protocol with more information is attached as Appendix 19-C.

(m) Operational Controls and Mitigation Measures to Address Reasonable Complaints

The Applicant takes seriously any complaints that it receives from members of the public. The Noise Complaint Resolution Plan for the Facility, which is included as Appendix 19-B, includes a complaint response protocol specific to noise during Facility construction and operation. Should a resident feel the Facility is creating noise levels above those specified in the project's Certificate Conditions, the resident may issue a complaint. Complaints will be able to be made in person, via phone, or by email. The Applicant will contact the individual within two business days of the complaint. The Applicant will implement a comprehensive response for all registered, reasonable complaints, which

will include community engagement, gathering information, response to the complaint, a follow up after the response has been issued, and further action if the complainant believes that the issue continues to exist.

Due to the size of wind turbines, typical noise control measures to be installed post-construction, such as barriers or mufflers, are impractical or would destroy the utility of the wind turbines. In-spite of this, some post-construction mitigation measures for noise are available. Post-construction operational controls that could be utilized to reduce noise, should noise levels exceed those established in the Facility's Certificate, include NROs. NROs are usually accomplished by modifications in the pitch of the turbine blades, slowing the rotor speed of the turbines. This rotor speed reduction reduces aerodynamic noises produced by the turbine. In addition, some turbine models are available with serrated trailing edges, which help smooth the airflow in the wakes of the blade. The wind turbines proposed for this Facility already assume the serrated edges and therefore reduced noise emissions. A limited amount of NRO was modeled for a few turbines in the PNIA assessment of noise impacts, and thus could be an option if needed.

(n) Input Parameters, Assumptions, and Data Used for Modeling

Specific modeling parameters are included as Appendix D of the PNIA prepared by Epsilon. 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 DPS under separate cover in digital format. The manufacturer's technical data sheets with sound power information will be filed with the Hearing Examiner and treated by the Records Access Officer or other presiding officer as confidential. The digital Cadna/A input files will not be provided.

(o) Glossary of Terminology

A glossary of terms is included in Appendix H of the PNIA. References cited in the PNIA can be found as footnotes throughout the PNIA.

(p) Order of Findings

This exhibit has been formatted to be consistent with the order of the Revised Scoping Statement.