Heritage Wind Project

Case No. 16-F-0546

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. His credentials are appended to his pre-filed testimony, enclosed with the cover letter to this submission. 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 non-participating 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 recent Siting Board Certificate Conditions on noise, and 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 showing the location of sensitive sound receptors within 1 mile of 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 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. The participant status of sensitive sound receptors is indicated to facilitate identification of applicable standards and design goals.

In total, 1,594 discrete receptors were analyzed for the project. These include 706 year-round and seasonal residences, 163 public areas (includes commercial and institutional), and 725 "unknown" structures (includes unknown, dilapidated residences, other, not present locations). Of the 706 residences, 32 were participating, and 674 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.

[1] Seasonal residences include cabins, campers, and hunting camps (identified by property tax codes) and any other seasonal residences with electric hook-ups/running water.

Field verification was completed to verify the findings of the desktop analysis, including consultation with the Town per Stipulations. If access for field verification was not possible, and aerial imagery could not provide an obvious classification of a structure (i.e. residential vs. non-residential), then the structure was classified as "unknown".

(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 Final Scoping Statement (FSS) is found below.

1) 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 measured, 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.

2) A winter "leaf-off" measurement program was conducted at eight locations for 17 days in February/March 2018, and a summer "leaf-on" measurement program was conducted at eight locations for 18 days in August/September 2018. Sound level data including A-weighted (dBA), one-third octave band data from 6.3 Hertz (Hz) to 20,000 Hz, and full octave band data from 16 Hz to 16,000 Hz were collected during day and night using a suitably calibrated sound level meter and octave band frequency analyzer (see Chapter 6 of the PNIA).

3) 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.

4) Infrasound data down to 0.5 Hz were collected at two locations during the ambient measurement programs (summer and winter).[2] Details of this are found in Chapter 8.7 and Figures 8-10 and 8-11 of the PNIA.

5) 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).

6) 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 7-66 of the PNIA.

7) 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 7-66 of the PNIA.

[2] This exceeds the minimum number of locations required in the stipulations, which mandated the collection of infrasound at only one location. See Final Scoping Statement, page 82, section 19(b)(4).

8) 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.

9) Measurement locations, including GPS coordinates and AADT information of the nearest road, aerial maps, and a justification for location selection are found in Table 6-1 and Chapter 6 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. Future sound levels during construction of the Facility and related facilities at the most potentially impacted and representative receptors was conducted using computer noise modeling. Details of the analysis and findings are presented in Chapter 11 of the PNIA. The noise modeling adhered to the following stipulated parameters:

1) Modeling and analysis procedures generally followed the guidelines and recommendations of the FHWA Highway Construction Noise Handbook (FHWA-HEP-06-015, U.S. DOT, August 2006).
2) Reference sound source information was obtained from either Epsilon measurements of comparable equipment or the Federal Highway Administration's (FHWA) Roadway Construction Noise Model (FHWA Roadway Construction Noise Model User's Guide, FHWA-HEP-05-054, US DOT, January 2006).
3) 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. Construction work is expected to occur from 5 AM to 9 PM Monday through Saturday. Work on Sundays, holidays, and extended hours would be done with advance notification and approval. 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.
4) 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.
5) Worst-case sound levels from construction are expected to be 57 dBA or less at all non-participating residences.[3] 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. Sound level contours for the three areas of construction analyzed are found in Figure 11-1 of the PNIA. Tabular findings at the most impacted receptors are found in Tables 11-2 to 11-4 of the PNIA.

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

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

A noise impact study has been conducted to estimate the future sound level to be produced by the operation of the Facility, related facilities, and ancillary equipment. See Chapters 9 to 13 of the PNIA.

1) The study was conducted in accordance with the following parameters:

- 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.

- Use of the 1.5m receptor height, coupled with the other conservative modeling assumptions discussed in Chapter 9.3, has proven to be an accurate predictor of actual sound levels in the real world. For example, the Massachusetts Clean Energy Center "Massachusetts Study on Wind Turbine Acoustics" (February 2016) showed 1-hour measured L_{eq} sound levels matched well with modeled values at this height. Four seasons of sound level measurements at a ridgeline wind farm in Maine using a 1.5-meter receptor height were likewise less than pre-construction modeled sound levels ("Regulating and predicting wind turbine sound in the U.S."; Kaliski, Bastasch, and O'Neal, presented at INTER-NOISE 2018, Chicago, IL, 2018).

  Cooper and Evans present the results of a detailed study comparing measured versus modeled sound levels.[4] The modeling used a 1.5-meter receptor height but did not use a 2 dBA manufacturer's uncertainty factor. Once the 2 dBA uncertainty is factored in, the results found that modeling overpredicted actual measured results except in cases of "concave" topography between the wind turbine and receptor. In that case an additional 3 dBA is recommended to be added to the modeling results (see next section for further discussion of concavity). In addition, a receptor height of 1.5 meters is the recommended height in the NARUC-2011 document as required in the Project's understanding of the required DPS scope of studies.

  The conservative set of modeling assumptions for this analysis is consistent with the modeling recommendations in NARUC 2011 with the exception that NARUC 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. In addition, the use of these model inputs has been verified through post-construction sound level measurement programs at operating wind energy facilities. According to the Massachusetts Study on Wind Turbine Acoustics,[5] "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

[4] J. Cooper and T. Evans, "Accuracy of noise predictions for wind farms," 5th International Conference on Wind Turbine Noise, Denver, CO, August 2013.

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

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.

- An examination of the topography was made between the wind turbines and receptors where modeled results were within 3 dBA of the design goal. A look at the terrain profiles indicate generally flat, or gently sloping terrain, and no instances of the concave geometry as described in Evans and Cooper.[6] This is consistent with the guidance from the Institute of Acoustics discussion of propagation "across a valley" where a correction factor may be warranted.[7] No such topography exists in the facility area, therefore, no concave correction was used in the modeling.

- No corrections or adjustments were applied to the model or calculation results.

2) No attenuation of sound that transiently occurs due to weather or temperature was taken in the modeling. Consistent with the ISO 9613-2 standard, the modeling used a temperature of 10 degrees Celsius and 70% relative humidity for atmospheric absorption. These values yield the lowest reduction in sound due to absorption and thus under other conditions, absorption may be higher and sound levels lower than predicted by the model.

(e) Future Noise Levels at Receptors During Facility Operation

A noise impact study has been conducted to estimate the future sound level to be produced by the operation of the Facility, related facilities, and ancillary equipment. See Chapters 9 to 13 of the PNIA. The study includes:

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

Future A-weighted (dBA) and full octave band calculations from 31.5 Hz to 8000 Hz were performed for the Facility using the methodology described above in 19(d). Tables E-1 to E-2 and E-1.1 to E-2.1 in 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) Prominent Discrete Tones

Tonal audibility may be reported by the wind turbine manufacturers through the IEC 61400-11 standards process.[8] According to the standard, a tone is audible if the tonal audibility is above 0 dB. According to the technical documentation from GE for the 5.5-158 wind turbine, the tonal audibility is less than 4 dB. Similar information for the Vestas V162-5.6 was not available from the manufacturer.

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

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[6] Evans, T. and J. Cooper, "Comparison of Predicted and Measured Wind Farm Noise Levels and Implications for Assessments of New Wind Farms," Acoustics Australia, Vol. 40, No. 1, April 2012.

[7] "A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise," Institute of Acoustics, Hertfordshire, UK, May 2013.

[8] *Wind turbines—Part 11: Acoustic noise measurement techniques,* International Electrotechnical Commission IEC 61400-11, Edition 3.0, Geneva, Switzerland, 2012.

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. Though not applicable from a regulatory perspective, 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 using a spreadsheet approach at the nearest ten (10) potentially impacted and representative receptor locations using equations accounting for hemispherical radiation and atmospheric absorption. These receptors included both non-participants and participants.

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 12-4 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. A more detailed discussion of this is found in Chapter 12.9 of the PNIA.

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 39 dBA at all non-participating sensitive receptors[9]. 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

[9] For perspective, a quiet library is around 35 dBA.

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[10] 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.
- The turbulence intensity does not show any trend with respect to sound levels.

The U.K. Department of Energy and Climate Change[11] 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

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

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

to reduce the amplitude modulation associated with complaints ("thumping") have been identified by Cand and Bullmore.[12] 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, including formulae, are found in Chapter 10 of the PNIA.

For a 125-meter hub height, the overall average wind shear for the year is 0.31, the minimum is -0.75 (wind decreasing with height), and the maximum is 1.13. The wind shear is from a measured height of 32 meters above ground to the proposed hub height of 125 meters above ground. Figure 10-1 of the PNIA present the annual average wind shear coefficient by hour at a 125 meter 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 10-2 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 0.14, the minimum is 0.03, and the maximum is 1.2. Results show that turbulence intensity is higher during the day than at night, and can be variable at any time.

Figure 10-3 shows the annual average turbulence intensity by hub height wind speed for the proposed hub height of 125 meters. These data show that turbulence intensity decreases slightly from cut-in speed to 7 m/s and then slightly increase until 15 m/s. 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.

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[12] *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

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. The Applicant conducted an analysis of low frequency sound and infrasound in the PNIA, consistent with the Final Scoping Statement for this project, as follows:

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 (2.8 dB for one model and 3.7 dB for the other model). The results are presented in Appendix E of the PNIA. These results do not include reduction due to NRO.

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 12-3 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-3.1, E-3.2, and E-3.3 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 9-13 in the PNIA presents the highest infrasound sound power levels from each model under consideration for each one-third octave band. Table 9-14 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 9-15 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 9-15 show the cumulative impact of infrasound from multiple wind turbines at a given location. These results do not include reduction due to NRO.

iv) Details on the available sound data, methodology used for the calculations, and literature references are 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	25.8	23.4	23.0	21.9	41.2	24.7
Location 2	31.5	26.4	29.3	28.4	35.7	25.0
Location 3	33.4	31.7	31.2	30.8	44.1	33.0
Location 4	43.8	42.9	42.3	41.4	47.6	45.6
Location 5	25.4	22.6	22.8	19.9	35.4	25.9
Location 6	33.0	23.7	32.4	32.1	43.3	21.9
Location 7	24.5	20.2	21.8	18.3	32.7	21.3
Location 8	26.5	24.4	23.9	23.1	33.2	25.8

(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	17.1	13.7	16.3	12.0	38.7	16.6
Location 2	20.7	17.2	19.7	15.4	37.7	18.8
Location 3	21.6	20.3	20.3	18.4	40.0	24.6
Location 4	27.6	26.8	26.5	25.6	44.4	40.6
Location 5	19.0	14.6	18.1	13.4	35.7	23.0
Location 6	31.5	17.5	31.0	30.6	54.5	15.7
Location 7	17.8	12.7	16.6	11.7	33.4	15.4
Location 8	18.7	15.1	17.3	13.9	35.4	16.6

(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 10^{th} 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 (GE5.5-158) as presented in Table 9-7 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 30 to 47 dBA for the Method 1 and the Method 2 calculations.

(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 10^{th} 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 (GE5.5-158) as presented in Table 9-7 of the PNIA. These worst-case future noise levels during the summer nighttime 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 28 to 46 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 10^{th} 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 (GE5.5-158) as presented in Table 9-7 of the PNIA. These worst-case future noise levels during the winter nighttime 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 28 to 46 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	52.9	50.5
Location 2	52.5	51.7
Location 3	50.2	46.8
Location 4	65.3	63.8
Location 5	51.4	49.3
Location 6	51.4	46.5
Location 7	50.1	48.4
Location 8	49.7	48.4

(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 (GE5.5-158) as presented in Table 9-7 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 47 to 64 dBA for the Method 1 and Method 2 calculations.

Temporal and spatial accuracy of the ambient data were calculated for the Leq and L90 to a 95% confidence interval using the technique in section 9 of the ANSI S12.9-1992/Part 2 standard. The details are described in Chapter 8.6 of the PNIA, and the results presented in Tables 8-5 to 8-16 of the PNIA.

(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 applicable noise standards and design goals for the Facility are summarized in Table 19-4. A copy of the local law is included as part of Exhibit 31, Appendix 31-A.

As noted in the NARUC 2012 report[13], 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. These include a 45 dBA 9-hour L_{eq} daytime and nighttime limit at a non-participating residence (Goal #1). This design goal is based on previously issued Certificates for Cassadaga Wind, Baron Winds, and Number Three Wind, and the WHO eight-hour guideline to minimize sleep disturbance. A design goal of 55 dBA 9-hour L_{eq} (day and night) is established for a participating residence and is also based on previously issued Certificates for Cassadaga Wind, Baron Winds, Bluestone Wind, Canisteo Wind, and Number Three Wind, and the WHO guideline to minimize annoyance (Goal #2). 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 if a pure tone occurs (Goal #5; #8). This design goal was adopted for previously issued Certificates for Cassadaga Wind, Baron Winds, Eight Point Wind, and Number Three Wind and will be the design goal for this project.

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. This limit was adopted for previously issued Certificates

13 Wind Energy & Wind Park Siting and Zoning Best Practices and Guidance for States, NARUC, prepared by National Regulatory Research Institute, January 2012.

for Cassadaga Wind, Baron Winds, Eight Point Wind, and Number Three Wind and will be the design goal for this project (Goal #6).

The WHO 1999 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 consistent with Eight Point Wind's Certificate Condition 64(d)(iii) and a reasonable design goal (Goal #10). 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 (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). These design goals were adopted for previously issued Certificates for Cassadaga Wind, Baron Winds, Eight Point Wind, and Number Three Wind and will be the design goals for this project.

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. This design goal was adopted for previously issued Certificates for Cassadaga Wind, Barons Wind, Eight Point Wind, and Number Three Wind and will be the design goal for this project (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 (Goal #11).

In 2018, the WHO released another report[14] 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."

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

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. The 2018 WHO report found low quality evidence regarding wind turbine noise causing annoyance. The evidence is considered low quality due to inconsistencies and imprecision in the studies. The studies show that annoyance is due to many other factors besides noise. 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 Chapter 4.6 of the PNIA). The 2018 WHO report did note that the latest environmental noise guidelines for the European Region supersede the 1999 WHO guidelines except in the area of indoor guideline values.

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. The recent Order Granting a Certificate for the Baron Winds LLC project (Case 15-F-0122) concurred when the Siting Board ruled that the WHO 2018 guidelines should not be imposed because of the limitations of the guidelines themselves. The Siting Board noted "…the application of the WHO 2018 guidelines is unnecessary in order to avoid or minimize the Facility's impacts related to noise and, for the reasons described above, may not be practical." In addition, the Siting Board in the Number Three Wind decision stated "…we do not believe that the WHO 2018 guidelines provide a sound basis for establishing a lower short-term noise standard. Where we have found that a regulatory limit is sufficiently protective, we will expect the parties in future cases to adhere to it, unless and until developments in the relevant science suggest that an additional increment of protection is necessary."

The sound levels calculated are 1-hour L_{eq} sound levels. A review of 8,760 hours (one year) of on-site wind speed data found that there were only three (3) of the 365 nights in an entire year that maintained a hub height wind speed of 10 m/s for all 9 hours of the night to produce the highest sound level from the GE5.5-158 wind turbine for those 9 consecutive hours. Therefore, on those nights, the Leq 9-hour sound level would be equal to the highest Leq 1-hour. On all other nights, the Leq 9-hour sound level will be less than the sound levels calculated by the Leq 1-hour. The same is true for the daytime sound levels where there was only one (1) day in the entire year that maintained a hub height wind speed of 10 m/s for all 15 hours of the day to produce the highest sound level from the GE5.5-158 wind turbine for those 15 consecutive hours. The same worst-case 1-hour modeled sound level is assumed to be equal to the worst-case modeled 15-hour daytime level.

The same full year of on-site wind speed data were used to calculate an equivalent sound level for all nighttime hours in one year ($L_{eq,\ night,\ outside}$). 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 9-8 of the PNIA.

Table 19-4 Summary of Sound Standards and Design Goals - Heritage Wind

#	Design Goal. (Not to exceed)	Assessment Location	Noise descriptor	Period of Time	Participant Status	Design Goals and basis
1	45 dBA	At residence, Outdoor	Leq	8-hour; day or night	Non-participant	Certificate Condition 72(a) Case 16-F-0328 and WHO-1999
2	55 dBA	At residence, Outdoor	Leq	8-hour; day or night	Participant	Certificate Condition 72(a) Case 16-F-0328
3	40 dBA	At residence, Outdoor	Lnight-outside (Leq)	Annual; nighttime. (2009-WHO)	Non-participant	Certificate Condition 68(d)(i) Case 16-F-0328 and WHO-2009
4	50 dBA	At residence, Outdoor	Lnight-outside (Leq)	Annual; nighttime. (2009-WHO)	Participant	Certificate Condition 68(d)(ii) Case 16-F-0328 and WHO-2009
5	No audible prominent tones or 5 dBA penalty if they occur.	At residence, Outdoor	Leq	1-hour	Non-participant	Certificate Condition 72(c) Case 16-F-0328
6	65 dB at 16, 31.5, and 63 Hz full-octave bands.	At residence, Outdoor	Leq	1-hour; daytime and nighttime	Non-Participant	Certificate Condition 72(d) Case 16-F-0328
7	No perceptible vibrations	At residence, Indoor	See ANSI S2.71-1983 (R August 6, 2012).	See ANSI S2.71-1983 (R August 6, 2012).	Non-participant	Vibrations. Certificate Condition 72(e) Case 16-F-0328
8	40 dBA (subject to 5-dBA prominent tones penalty, if they occur).	At residence, Outdoor	Leq	1-hour	Non-participant	Collector substation; Certificate Condition 72(f) Case 16-F-0328
10	55 dBA	At Property line; Outdoor	Leq	1-hour; daytime and nighttime	Non-participant	Boundary lines and Lands Except Wetlands; Certificate Condition 64(d)(iii) Case 16-F-0062
11	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)	National Association of Regulatory Utility Commissioners. NARUC-2011

(h) Noise Standards Comparison

The predicted sound levels from the ISO 9613-2 modeling are reported for all sensitive receptors in tabular format in both broadband and octave bands from 16 Hz to 8000 Hz in Appendices E, F, and G of the PNIA. These tables include the noise descriptor (Leq; L90; etc), duration of evaluation (1-hour; 9-hour; annual; etc), trime of day (nighttime; daytime), season, participation status, and receptor type. Detailed summary tables of receptors over 35 dBA for both short-term and annual impacts are found in Tables 9-9 to 9-12 of the PNIA. A detailed discussion of the sound modeling inputs is found in Chapter 9 of the PNIA, and Appendix D of the PNIA provides a detailed listing of the model inputs for all sound sources and receptors. Graphical isolines (noise contours) from 30 dBA to 55 dBA in 1 dBA increments of A-weighted decibels at sensitive receptors and external property boundaries are provided for the maximum Leq-9-hour-nighttime in an entire year (Figure 9-2 of the PNIA) and the Leq, night, outside for one year (Figure 9-3 of the PNIA). Full-size hard copies of Figures 9-2 and 9-3 have been submitted to DPS and DOH staff, and provided in electronic format as well.

The results of the maximum Leq-9-hour nighttime sound level modeling are summarized below for each modeled wind turbine type.

<u>GE 5.5-158—no mitigation</u>

- All participants (any receptor type): 211 at 55 dBA or less
- Non-participant year-round residences: 3 at 48 dBA; 12 at 47 dBA; 30 at 46 dBA; 587 at 45 dBA or less
- Non-participant seasonal residences: 15 at 39 dBA or less
- Non-participant unknown: 2 at 48 dBA; 9 at 47 dBA; 32 at 46 dBA; 586 at 45 dBA or less
- Non-participant public: 6 at 46 dBA; 101 at 45 dBA or less

<u>GE 5.5-158—with mitigation (NRO)</u>

- All participants (any receptor type): 211 at 55 dBA or less
- Non-participant year-round residences: 632 at 45 dBA or less [25 at 45 dBA; 57 at 44 dBA; 43 at 43 dBA; 48 at 42 dBA; 51 at 41 dBA; 37 at 40 dBA; 57 at 39 dBA; 60 at 38 dBA; 40 at 37 dBA; 16 at 36 dBA]
- Non-participant seasonal residences: 15 at 38 dBA or less
- Non-participant unknown: 629 at 45 dBA or less [24 at 45 dBA; 39 at 44 dBA; 36 at 43 dBA; 34 at 42 dBA; 43 at 41 dBA; 40 at 40 dBA; 46 at 39 dBA; 41 at 38 dBA; 47 at 37 dBA; 27 at 36 dBA]

- Non-participant public: 107 at 45 dBA or less [3 at 45 dBA; 7 at 44 dBA; 4 at 43 dBA; 7 at 42 dBA; 2 at 41 dBA; 10 at 40 dBA; 5 at 39 dBA; 23 at 38 dBA; 9 at 37 dBA; 8 at 36 dBA]

Vestas V162-5.6—no mitigation

- All participants (any receptor type): 211 at 51 dBA or less
- Non-participant year-round residences: 632 at 45 dBA or less
- Non-participant seasonal residences: 15 at 36 dBA or less
- Non-participant unknown: 629 at 44 dBA or less
- Non-participant public: 107 at 43 dBA or less

The results of the maximum Leq-night-outside annual sound level modeling are summarized below for each example wind turbine type using the "with zeros" approach.

GE 5.5-158—no mitigation

- All participants (any receptor type): 211 at 49 dBA or less
- Non-participant (any receptor type): 4 at 43 dBA; 11 at 42 dBA; 38 at 41 dBA; 1330 at 40 dBA or less

Vestas V162-5.6—no mitigation

- All participants (any receptor type): 211 at 47 dBA or less
- Non-participant (any receptor type): 3 at 42 dBA; 1 at 41 dBA; 1379 at 40 dBA or less

(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 may be required at specific turbine sites. As needed, blasting will be limited to daytime hours and conducted in accordance with the Heritage Wind Preliminary Blasting Plan included in Appendix 21-C.
- Pile driving is not anticipated at this site. See Exhibit 21 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. Blade manufacturers are researching and testing ways to reduce sound levels from various tip shapes.

In addition, there are low noise trailing edge (LNTE) or serrated trailing edge (STE) options available for many wind turbine models (terminology depends on the manufacturer but the intent is the same). These are essentially plastic or metal sawtooth serrations that can be affixed to the blade's rear edge to reduce blade trailing edge noise. General Electric estimates that the LNTE option reduces sound levels 2-4 dBA as compared to unserrated blades.[15] Vendor sound data from other major manufacturers confirms this level of reduction. The sound modeling for this project assumed the use of LNTE or STE technology, and the inherent sound level reduction.

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

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15 *Wind Turbine Blade Noise Mitigation Technologies,* B. Petitjean et al., presented at Fourth International Meeting on Wind Turbine Noise, Rome, Italy, 2011.

propagation modeling in this Application includes results with NRO (mitigated) and without NRO (unmitigated) in Appendix E of the PNIA. In the PNIA, Tables E-1 and E-1.1 are the detailed unmitigated results for the GE 5.5-158 wind turbine and Tables E-1M and E-1.1M are the detailed mitigated results for the GE 5.5-158 wind turbine. In the PNIA, Tables E-2 and E-2.1 are the detailed unmitigated results for the Vestas V162-5.6 wind turbine. Since the Vestas V162-5.6 model meets the short-term Leq 8-hour design goal without mitigation, there are no "mitigation" tables for this wind turbine in Appendix E.

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

The Noise Complaint Resolution Plan is included as Appendix 19-B to this exhibit.

(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, and at a participating residence would be 55 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

One method to evaluate the potential for interference in the use of outdoor public facilities is to look at ANSI S12.9-2007/Part 5 "Quantities and Procedures for Description and Measurement of Environmental Sound – Part 5: Sound Level Descriptors for Determination of Compatible Land Use" (Reaffirmed September 5, 2012). The nearest public land near the project area is the Oak Orchard Wildlife Management Area located on the southwest edge of the Project area along Albion Road (receptor ID #1735). While wildlife management areas are not found in ANSI S12.9/Part 5, neighborhood parks are listed as compatible up to 55 dBA adjusted annual average day-night sound level (DNL).

From a review of the annual sound level modeling results in Table G-2 of the PNIA, the average annual sound levels (L_{50}) at receptor #1735 are 25 dBA using the loudest turbine under consideration. Assuming a 10 dBA penalty for all nighttime hours in a year would increase this sound level by ~6 dBA to 31 dBA which is well below the ANSI S12.9/Part 5 guideline for compatible land use of 55 dBA.

(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 Chapter 4.5 (NARUC 2011) and Chapter 4.6 of the PNIA. The effects of amplitude modulation and prominent tones are discussed in Chapters 12.8 and 12.9 of the PNIA respectively.

The number of receptors modeled at worst-case Leq-9-hour sound levels of 35 dBA and above 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 9-9 to 9-10 of the PNIA.

A Noise Complaint Resolution Plan is included as Appendix 19-B to the Application, to address these issues should they arise.

(5) Potential for Structural Damage

Information regarding construction activities is included the Preliminary Blasting Plan (included as Appendix 21-C), and the Preliminary Geotechnical Report, and is summarized in Exhibit 12 and Exhibit 21 of the Application. Blasting of bedrock may 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 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 closest locations are in Bermuda (IS51) and Lac du Bonnet, Manitoba, Canada (IS10). Bermuda (IS51) is approximately 1,050 miles from the Project, while Lac du Bonnet, Manitoba, Canada (IS10) is approximately 975 miles from the Project 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 Heritage Wind is located in Sadowa, Ontario, Canada (AS014) which is approximately 120 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 no US Geological Survey (USGS) seismological stations within 50 miles of the site. The nearest station is located at Binghamton, New York, over 100 miles to the southeast. No interference from the Facility is anticipated with these resources at these distances.

The two closest hospitals to the project are Medina Memorial Hospital in Medina, NY approximately 8.5 miles west northwest of the nearest wind turbine and Lakeshore Hospital in Brockport, NY approximately 8 miles to the east of the nearest wind turbine. Distances are "as the crow flies." No interference from the Facility is anticipated with these resources at these distances.

(7) 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 and 12.5 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).

(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. In addition, the Applicant will provide a noise and vibration complaint resolution plan during construction of the Facility. 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 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, including source location coordinates, source ground elevations and source heights above the ground, receptor location coordinates, receptor ground elevations and receptor heights, are included in 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 digital Cadna/A input files will not be provided unless requested in writing by DPS.

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. As of this date, technical data sheets on the NRO option for the GE5.5-158 are not yet available. These will be provided once they are produced by the manufacturer. Sound power level data were not available for the transformers. Details of the transformer sound level calculations are found in Chapter 9.2.2 of the PNIA.

(o) Glossary of Terminology

A glossary of terms is included in Appendix H of the PNIA. References cited in Exhibit 19 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 Final Scoping Statement.

FIGURES

EXHIBIT 19:
NOISE AND VIBRATION

Figure 19-1. Heritage Wind Project sensitive sound receptor map.

APPENDICES

EXHIBIT 19:
NOISE AND VIBRATION

Appendix A Heritage Wind Project, Pre-Construction sound level impact assessment (PNIA)

EXHIBIT 19:
NOISE AND VIBRATION

Appendix B Heritage Wind Project – Noise Complaint Resolution Plan

EXHIBIT 19:
NOISE AND VIBRATION

Appendix C Heritage Wind Project -- Sound monitoring and compliance protocol

EXHIBIT 19:
NOISE AND VIBRATION