Bluestone Wind Project

Case No. 16-F-0559

1001.19 Exhibit 19

Noise and Vibration

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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 X to this Application. 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. Both of these certifications are national programs. The Application will include a detailed Curriculum Vitae for Mr. O'Neal demonstrating his qualifications as an expert in this field. 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 $Leq_{8hr\ night}$, and no participating receptors will exceed 55 dBA $Leq_{8hr\ night}$. These proposed regulatory limits minimize and mitigate any adverse impacts associated with the sound produced by the construction and operation of the Facility, and are consistent with World Health Organization (WHO) guidelines to address sleep disturbance and health effects. Other project design goals and suggested 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, POI substation, etc.) is provided in Figure 9-2 of the PNIA. Sensitive sound receptors include residences (participating, non-participating, full-time, and seasonal), 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. Seasonal residences include cabins and hunting camps (identified by property tax codes) and any other seasonal residences with septic systems/running water. Sensitive sound receptors within 1 mile of the wind turbines, substation, and battery storage facility which are the only Facility components that will produce sound, include 64 participating receptors and 328 non-participating receptors. 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 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

Ambient Noise Monitoring Locations

On behalf of the Applicant, Epsilon completed winter (leaf off) and summer (leaf on) background sound level monitoring at seven representative locations in and around the Facility Area. Monitoring locations were selected to be representative of nearby residences in various directions from the Facility.

Each of the seven locations are described below. See Figure 6-1 and Table 6-1 of the PNIA for locations and coordinates of the monitoring sites. Photographs of the setup monitors are also included in the PNIA. The New York State Department of Transportation (NYSDOT) was checked for Annual Average Daily Traffic (AADT) counts in the vicinity of the sound level meters (SLM). The section of Interstate 86 (I-86; State Route 17) immediately south of the Facility had an AADT ranging from 8,294 to 10,834 vehicles in 2015, Route 41 in the eastern portion of the Facility had an AADT ranging from 524 to 714 vehicles in 2015, and Route 233 in the western portion of the Facility had an AADT of 562 in 2015 (NYSDOT, 2018). Other roads in the Facility Area generally carry less traffic than these roads.

- Monitor 1 – This monitor was installed near Old Route 17 in the Town of Windsor. The meter was placed approximately 15 meters north of the road and is representative of existing sound levels along Old Route 17 and in near proximity to Interstate 86. This monitor is representative of some receptors south of turbines 7 and 37.

- Monitor 2 – This location was selected to be representative of the northwestern vicinity of the Facility. There was a change in property permissions between the winter and summer monitoring. Therefore, a different monitor location was used in the summer program. Both monitoring locations are representative of the northwestern vicinity of the Facility.

  Winter – The monitor was placed at a residence on Ostrander Road in the Town of Windsor approximately 20 meters southwest of the road in an open field.

  Summer – The monitor was placed at a residence on Cresson Hill Road in the Town of Windsor approximately 15 meters south of the road.

- Monitor 3 – The monitor was placed at the Sky Lake Camp property on Sky Lake Road in the Town of Windsor. The meter was placed approximately 25 meters south of the road and is representative of receptors in the west-central area of the Facility. In addition to sound data collection, continuous ground level wind

speed and direction were made at this location during both summer and winter monitoring programs. During the summer, temperature, relative humidity, and precipitation measurement were also collected.

- Monitor 4 – The monitor was placed on Pazzelli Road in the Town of Sanford. The meter was placed in a field approximately 15 meters southwest of the road. This location is representative of receptors in the central vicinity of the Facility.

- Monitor 5 – The monitor was placed along the eastern side of Farnham Road in the Town of Sanford. The meter was positioned approximately 15 meters from the road and the location is representative of receptors in the southeast area of the Facility.

- Monitor 6 – The monitor was placed along Mooney Pond Road, to the east of Parker Road in the Town of Sanford. The meter was positioned approximately 15 meters east of Parker Road. This location is representative of receptors in the northern area of the Facility.

- Monitor 7 – The monitor was placed along Loomis Hill Road in the Town of Sanford, approximately 15 meters southwest of the road. The location is representative of receptors within the eastern portion of the Facility. In addition to sound data collection, continuous ground level wind speed and direction were made at this location during both summer and winter monitoring programs.

Ambient Sound Level Monitoring

Background sound level monitoring was performed at these seven locations in the winter (leaf-off) of 2017 (March 2 through March 17) and summer (leaf-on) of 2017 (August 9 through August 24). Sound level data were collected using either a Larson Davis (LD) model 831 SLM equipped with a LD PRM831 preamplifier and a PCB377B20 or 3770 half-inch microphone, or a Norsonic model Nor140 SLM equipped with a Norsonic Nor1209 preamplifier and a G.R.A.S. 40AN half-inch microphone along with an environmental protection kit to measure both A-weighted (dBA) and one-third octave bands from 20 Hz to 10,000 Hz. Each microphone was tripod-mounted at a height of approximately 4 feet (1.2 meters) above ground level in accordance with ANSI S12.9-1992/Part 2.

Both sound level meters meet Type 1 ANSI/ASA S1.4, ANSI S1.43-1997 and IEC Class 1 standards for sound level meters. The SLMs were calibrated and certified in accordance with standards set by the National Institute of Standards and Technology. The octave band filters for all instruments meet ANSI S1.11-2204. Calibrations were conducted by an independent laboratory within 12 months of field placement. All measurement equipment was calibrated in the field before and after the surveys with the manufacturer's acoustical calibrator in accordance with the standards of IEC

60942-2003 Class 1L and ANSI/ASA S1.40-2006. The certificates of calibration are included in Appendix B of the PNIA.

Infrasound was measured during both monitoring periods at Monitor 5, using a Norsonic Nor140 SLM as described above. The G.R.A.S. 40 AN microphone is designed to measure audible frequencies as well as infrasound frequencies down to 0.5 Hz. The infrasound meter collected continuous broadband and one-third octave-band ambient sound pressure level data. The meter logged data every 10 minutes with statistical data for the following parameters: L_{eq}, L_{10}, L_{50}, L_{90}, L_{min}, and L_{max}. Results are shown in Figure 8-10 of the PNIA.

The meters continuously measured and stored broadband (A-weighted) and one-third octave band sound levels at 10-minute intervals. Data were excluded from the analysis under the following conditions: precipitation, wind gusts or speeds over 11 miles per hour, temperatures outside of the range of 14 ºFahrenheit (ºF) to 122 ºF, humidity outside the range of 1 to 99%, intermittent noise not characteristic of the area, and seasonal sound sources. Periods that were not excluded from averaging are referred to in the PNIA and in this Exhibit as "valid periods." The periods of excluded data are displayed graphically in Section 7 of the PNIA.

Meteorological stations were co-located with sound monitors in the field. Wind speeds were logged at two monitoring locations (Monitor 3 and Monitor 7), while air temperature and precipitation were logged at one of the locations (Monitor 3). Wind data loggers were used to record continuous wind speed and direction during both summer and winter monitoring periods. All other meteorological data were logged during summer monitoring.

Baseline Noise Monitoring Results

Baseline noise data were analyzed and are reproduced in the PNIA (Appendix X) for both broadband and spectral sound level data. Results were presented in three different ways, described in the bullets below. A discussion of the format of the results is provided here and a summary of the results is presented below, graphics and plots are contained in the PNIA.

- Time history graphics – for each location, results are presented as graphs of sound level, precipitation, and maximum wind gust speed as a function of time throughout the monitoring period. Each point on the graph represents data summarized for a single 10-minute interval. Equivalent continuous sound levels (L_{eq}) are the energy-average level over 10 minutes. 10th-percentile sound levels (L_{90}) are the statistical value above which 90% of the sound levels occurred during those 10 minutes. The data from periods which were excluded from processing are included in the graphs but shown in lighter colors. The bands at the bottom of the graph indicate that data were excluded in the particular 10-minute period; the color designates the reason that data

were excluded. Ground-level wind speed data came from the two anemometers, which were paired with monitoring locations as discussed above. Precipitation and instrumentation operative exceedances are from the Deposit MesoNet station located approximately 4 miles from the closest monitoring location.

- Full octave band summaries – Plots of overall unweighted spectral levels from 31.5 Hz to 16,000 Hz for all valid periods are provided for each monitoring site. Each point on the plot represents the statistical level of the respective full octave band for the specified period. Four sets of L_{eq} and four sets of L_{90} data are presented in each plot: day and night for winter and summer monitoring periods.
- Tonal prominence of one-third octave bands was quantified for all valid periods for each monitor in each season. The one-third octave-band data span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for discrete tones. Tonality is defined by S12.9-2005 Part 3.

A summary of ambient noise monitoring results at each of the monitoring sites in the winter and summer is provided. See the PNIA for full detail regarding these results.

- Monitor 1 – Sound levels at this location were influenced by vehicular traffic on Old Route 17 and I-86, occasional rattling from a nearby sign, machinery noise from an auto body shop, birds, and occasional aircraft. Sound level-versus-time graphs include L_{eq} and L_{90} sound pressure levels and ground-level wind speeds measured at Monitor Location 3. Logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones in the winter season. Pure tones were present at the 5,000 Hz frequency for the summer season, likely due to bird and insect activity. Figures 7-3 through 7-6 of the PNIA show the time history 10-minute L_{eq}, 10-minute L_{90}, octave band, and tonality results from the monitoring at this location.

- Monitor 2 – Placement of the monitor changed between the winter and summer measurement programs due to a change of permission. Sound levels at the winter location monitor were influenced by wind, birds, vegetation rustle, occasional trains, and distant traffic. At the summer location, sound levels were influenced by birds, owls, insects, and distant vehicles. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter season. A pure tone exists at 5,000 Hz for the summer season, likely due to insect activity. Figures 7-7 through 7-10 of the PNIA show the time history 10-minute L_{eq}, 10-minute L_{90}, octave band, and tonality results from the monitoring at this location.

- Monitor 3 – Sounds levels at this location were influenced by rustling vegetation, overhead planes, audible wind, birds, insects, faint Interstate 86 traffic, and the occasional car on William Law Road. Sound level-versus-time graphs are provided in this section. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for either season. Figures 7-11 through 7-14 of the PNIA show

the time history 10-minute L_{eq}, 10-minute L_{90}, octave band, and tonality results from the monitoring at this location.

- Monitor 4 – Sound levels at this location were influenced by wind, occasional vehicle traffic on Pazzelli Road, overhead planes, rustling vegetation, birds, faint stream noise, and occasional farm animals. Logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter season. A pure tone exists at 5,000 Hz for the summer season, likely due to insect activity. Figures 7-15 through 7-18 of the PNIA show the time history 10-minute L_{eq}, 10-minute L_{90}, octave band, and tonality results from the monitoring at this location.

- Monitor 5 – Sound levels during winter monitoring were influenced by distant traffic noise from I-86, occasional aircraft, stream noise, bird, insects and vehicles along Farnham road. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter season. A pure tone exists at 5,000 Hz for the summer season, likely due to insect activity. Figures 7-19 through 7-22 of the PNIA show the time history 10-minute L_{eq}, 10-minute L_{90}, octave band, and tonality results from the monitoring at this location.

- Monitor 6 – Sound levels at this monitor were influenced by occasional traffic from Route 41 to the west, wind, rustling vegetation, stream noise, insects, birds, and a neighborhood dog barking. The logarithmically averaged one-third octave-band levels sound levels demonstrate no existing tones for the winter season. Pure tones exist at the 5,000 Hz and 8,000 Hz frequencies for the summer season likely due to birds and insect activity. Figures 7-23 through 7-26 of the PNIA show the time history 10-minute L_{eq}, 10-minute L_{90}, octave band, and tonality results from the monitoring at this location.

- Monitor 7 – Sound levels during the winter season at this monitoring location were influenced by wind noise, vegetation rustle, birds, sounds from nearby residences, and insects. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter season. A pure tone exists at 5,000 Hz for the summer season, likely due to insect activity. Figures 7-27 through 7-30 of the PNIA show the time history 10-minute L_{eq}, 10-minute L_{90}, octave band, and tonality results from the monitoring at this location.

The ANS-weighted sound levels measured at each monitor location for each monitoring period are summarized in Section 19(f). Intermittent noise was "filtered" by reporting the L_{90} metric which eliminates intermittent sound sources. Seasonal noise was excluded by using the method in ANSI Standard S12.100-2014 to report the A-weighted, noise-compensated (ANS-weighted metric) which excludes sounds above the 1000 Hz octave band. Periods of rain and

snow, excessive wind (10-minute average above 5 m/s), as well as weather conditions out of the range of specifications for the equipment were noted and excluded from calculation of ambient noise results. Monitoring sites were chosen to capture a variety of existing sound level conditions. Results of the ambient baseline noise monitoring are provided in Section 19(f).

Comparison of Sound Levels to Windspeed

Hub height wind speeds during the ambient monitoring programs were calculated based on measurements from an on-site 60-meter meteorological tower. The wind speed sensor mounted at 59 meters was used to extrapolate wind speeds up to the 130-meter hub height by the Applicant's meteorologists. The 10-meter wind speed is the wind speed as it was measured at the Facility's on-site meteorological tower extrapolated down to a 10-meter height. The sound pressure levels of the L_{90} (for daytime, nighttime, and combined for both winter and summer monitoring) were plotted against 10-meter wind speed to determine whether there is a correlation between wind speed and ambient sound level (Figures 8-4 through 8-9 of the PNIA). A linear regression is shown for the comparison, with the equation for the best-fit line and coefficient of determination (R^2) to indicate the quality of relationship between 10-meter wind speed and monitored sound levels. For the summer monitoring, there was a weak positive correlation between sound pressure level and wind speed, and this became stronger as wind speeds increased. The coefficient of determination for the summer period ranged from 0.0027 to 0.0132 and for the winter period ranged from 0.2584 to 0.2862. While there is a correlation between sound level and hub height wind speed, there is still considerable variability in sound level at a given wind speed. This indicates that wind speed is not the sole determinant of the background sound level. In addition, Figures 8-1 and 8-2 of the PNIA include a comparison between the hub height wind speed compared to the 10-minute sound level (L_{eq} and L_{90}) for each individual 10-minute period.

Temporal Accuracy

Temporal accuracy of the monitoring data was analyzed according to ANSI S12.9 Part 2. The standard analyzes the representativeness of the measurement data for a particular measurement location. The goal of the sound measurement program is to achieve a 95% confidence interval which would allow for a statement of 95% confidence that the true long-term average of a sound level falls within the given interval. The size of this confidence interval places the data set into one of three classes. Class "A" is for precision measurements, with Class "B" and Class "C" being less precise. Normality of the data set is then calculated using a Kolmogorov-Smirnov test. The PNIA applied the methodology to the L_{90} and L_{eq} metrics. Temporal accuracy tables for summer daytime, summer nighttime, winter daytime, and winter nighttime are included in Section 8.6 of the PNIA. The yearly daytime and yearly nighttime tables, shown below in Table 19-1 and 19-2, respectively, are composed of the summer and winter data combined for each time period (day or night). The same information was calculated for the L_{eq} and is found in Table 8-15 (Yearly Daytime) and Table 8-16 (Yearly Nighttime) of the PNIA.

Table 19-1. Monitoring Temporal Accuracy (ANSI 12.9 Part 2) – Based on Yearly Daytime L_{90} Sound Levels

	Monitor 1	Monitor 2	Monitor 3	Monitor 4	Monitor 5	Monitor 6	Monitor 7
Number of Samples	26	27	27	19	27	26	26
95% Confidence Interval Mean (dBA)	42.04	25.84	31.28	25.10	32.74	40.25	35.28
Upper Confidence Interval (dBA)	1.40	2.29	3.59	3.23	3.89	10.93	5.63
Lower Confidence Interval (dBA)	1.26	1.90	2.77	2.53	2.96	7.16	4.03
Measurement Class[1]	A	B	C	C	C	< C	< C
Normality	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1] Measurement Class < C is representative of a class worse than C.

Table 19-2. Monitoring Temporal Accuracy (ANSI 12.9 Part 2) – Based on Yearly Nighttime L_{90} Sound Levels

	Monitor 1	Monitor 2	Monitor 3	Monitor 4	Monitor 5	Monitor 6	Monitor 7
Number of Samples	21	23	23	18	22	22	21
95% Confidence Interval Mean (dBA)	27.96	24.55	27.03	24.01	35.81	35.05	43.03
Upper Confidence Interval (dBA)	1.64	4.25	3.39	4.38	8.45	12.24	10.86
Lower Confidence Interval (dBA)	1.45	3.17	2.64	3.22	5.60	7.71	6.89
Measurement Class[1]	A	C	C	C	< C	< C	< C
Normality	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1] Measurement Class < C is representative of a class worse than C.

(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 turbine components. 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 of the turbines will take place primarily on remote hills and/or in the middle of farm fields throughout the Facility Site, generally away from residences. Any work done on roads and utilities could be close to sound receptors, but this work will be conducted for only a short duration.

Noise resulting from construction was modeled with the ISO 9613-2, *Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation* (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 Federal Highway Administration's (FWHA) Roadway Construction Noise Model (RCNM). Three

areas within the Facility Area were chosen to calculate representative construction sound levels. The areas are listed below.

- Area 1 – This area includes the closest receptor to a turbine site (ID #268). Modeling for this area assumed simultaneous construction activity at turbine sites WTG1, WTG4, and WTG36. Excavation work, foundation work, and turbine erection were modeled at these sites.
- Area 2 – This area includes all receptors in the vicinity of the concrete batch plant. Modeling for this area assumed simultaneous construction activity at the batch plant, and the three closest turbine sites to the bath plant during foundation work (WTG3, WTG10, and WTG11).
- Area 3 – This area includes all receptors in the vicinity of the substation and battery storage facility. Modeling assumed simultaneous construction activity at the substation/battery storage area, and at the two closest turbine sites to the substation (WTG27 and WTG30). Excavation work and foundation work were modeled at these sites.

For each of the three areas, cumulative construction sound levels at the ten closest receptors have been calculated. These receptors included both non-participants and participants.

Table 19-3 shows the modeled A-weighted sound power levels for the louder pieces of construction equipment expected to be used during construction of the Facility, along with the phase of construction in which the equipment will be used.

Table 19-3. Sound Levels for Noise Sources Included in Construction Modeling

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

The results of the modeling are shown as maximum 1-second L_{eq} sound levels with all pieces of equipment for each phase operating at the sites. These results overstate expected real-world results since under actual construction conditions, not all pieces of equipment will be operating at the same exact time, and the highest sound levels from every piece of equipment will not tend to occur at the same time, as was assumed in the modeling.

Area 1

The cumulative impacts from each of the three main phases of construction (excavation, foundation work, turbine erection) were calculated with the Cadna model for the ten closest receptors to construction activity. The loudest phase in this area will be excavation. Figure 11-1 of the PNIA displays the predicted sound contour of excavation activity occurring simultaneously at the three turbine sites (WTG1, WTG4, and WTG36). The highest sound level at a non-participating receptor within this area is 52 dBA during excavation (Receptor #118), 45 dBA during foundation pouring (Receptors #59 and #118), and 49 dBA during turbine erection (Receptors #59 and #118). Additional modeling results for this area are listed in Table 11-2 of the PNIA.

Area 2

The cumulative impacts from foundation work were calculated with the Cadna model for the ten closest receptors to construction activity within this area. Figure 11-1 of the PNIA displays the predicted sound contour of foundation work occurring simultaneously at the batch plant and the three closest turbine sites (WTG1, WTG4,

and WTG36). The highest sound level at a non-participating receptor within this area is 44 dBA during foundation work, at Receptors #91 and #220. Additional modeling results for this area are listed in Table 11-3 of the PNIA.

Area 3

The cumulative impacts from excavation work and foundation work were calculated with the Cadna model for the ten closest receptors to construction activity within this area. Figure 11-1 of the PNIA displays the predicted sound contour of excavation work occurring simultaneously at the substation/battery storage facility and the two closest turbine sites to the substation (WTG27 and WTG32). The highest sound level at a non-participating receptor within this area is 54 dBA during excavation work, at Receptors #155 and #308. Additional modeling results for this area are listed in Table 11-4 of the PNIA.

Construction is proposed to take place from April to October at turbine sites and at the areas of the batch plant, substation, and battery storage facility. Construction of each wind turbine from excavation to foundation pouring to turbine erection is roughly a 90-day process. Excavation work is expected to occur from early morning to the evening. 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.

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

Sound Propagation Modeling – ISO 9613-2

Modeling of noise levels for operation of the Facility was performed using the Cadna/A noise calculation software developed by DataKustik GmbH. This software implements the ISO 9613-2 international standard for sound propagation. 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.

Model input parameters are listed in Appendix D of the PNIA. Thirty-three turbine locations were modeled with each of the turbine models under consideration for the Facility. The GE 3.8-137 turbine has the highest broadband A-weighted sound power level of all turbines under consideration for the Facility, and therefore it results in the highest sound levels. The broadband and maximum octave-band sound power levels for each turbine are included in Table 9-2 and 9-3 of the PNIA, respectively. The model also included the location of the substation transformer and battery storage facility with associated sound power levels provided by the Applicant (Tables 9-4 and 9-5 of the PNIA include the sound power levels for the substation and battery facility, respectively).

Elevation contours for the modeling domain were directly imported into Cadna/A which allowed for consideration of terrain shielding where appropriate. The site topography is gently sloping or steady-sloping from the wind turbines to the sensitive receptors. The Study Area was modeled with a spectral ground absorption using a G-factor of 0.5, corresponding to "mixed ground" consisting of both hard and porous ground cover, consistent with the modeling guidelines used by NARUC (2011) and a 2 dBA additional uncertainty factor added to the turbine sound power. Four bodies of water of significant width (greater than 500 feet; including Marsh Pond, Deposit Reservoir, Sky Lake, Deer Lake) had a G-factor of 0 to represent completely reflective surfaces. This is the most conservative setting available. All modeled sources were assumed to be operating simultaneously and at the design wind speed corresponding to the greatest sound level impacts. Meteorological conditions assumed in the model (temperature = 10 ºCelsius (C) and relative humidity = 70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1000 Hz octave bands. The meteorological correction term (Cmet) was set to zero and no additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

The conservative set of modeling assumptions for this analysis is consistent with the modeling recommendations used by NARUC (2011) with the exception that NARUC does not include the uncertainty factor, and the modeling for this Facility does add it. Thus, these model results are more conservative than what NARUC guidelines would predict. In addition, these model parameters have been shown to yield conservative results for noise impacts from wind turbines, though the level of conservativeness depends on several factors including: turbine layout, meteorology, receiver height, and topography (Duncan and Kaliski, 2008; Bowdler et al., 2009; Evans and Cooper, 2012). The accuracy of the selected outdoor propagation model used here is corroborated by other studies. For example, according to the Massachusetts Study on Wind Turbine Acoustics (RSG, 2016), "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 Leq, as compared to individual five minute periods." A recent postconstruction 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.

Turbines were modeled at the manufacturer's maximum apparent sound power level, except that the low-frequency octave bands were replaced by the highest octave band sound power of any turbine considered for the Facility. All turbine data used is the most recently available from the manufacturer at the time the PNIA was prepared. Results calculated with these parameters represent the highest 1-hour equivalent average sound level that will be emitted by the Facility.

A closer 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 gently sloping or steady-sloping terrain, and no instances of concave geometry was found.

Sound pressure levels due to operation of all 33 wind turbines, collector substation transformer, and battery storage components were modeled at 392 receptors within and surrounding the Facility Area. The sound levels calculated are 1-hour L_{eq} sound levels. The 2012 National Association of Regulatory Utility Commissioners (NARUC) concluded that a planning guideline of 45 dBA is an appropriate regulatory limit outside a residence at night (NARUC, 2012).

Unmitigated Results

Tables E-1 through E-4 in Appendix E of the PNIA shows the predicted "Facility-only" short-term broadband (dBA) and octave-band (dB) predicted sound levels at each of the 392 sensitive receptors for each turbine. For the GE 3.8-137 turbine (the turbine that resulted in the highest modeled sound levels), the highest sound level at a sensitive receptor is 50 dBA (participating). The broadband sound levels range from 28 to 50 dBA. In addition, sound level contours generated from modeling results of the GE 3.8-137 turbine are presented in Figure 9-2 of the PNIA. The sound contour figure set for short-term sound level results was generated only for this turbine model because it has the highest A-weighted sound power level. The results in Figure 9-2 of the PNIA include the effects of Noise Reduced Operating where applicable (see below).

Mitigated Results

In order to demonstrate compliance at all non-participating receptors, this model requires some of the wind turbines to be placed in Noise Reduced Operating (NRO) mode. There are multiple NRO mode options to reach the design goal of 45 dBA at all non-participating receptors. Specific mitigation measures will be presented in the compliance filing report upon selection of a final turbine vendor. Results for the GE 3.8-137 turbine have assumed two wind turbines were placed in NRO modes. Wind Turbine 1 is assumed to be NRO mode 106, which represents a 1 dBA reduction for the turbine, and Wind Turbine 27 is assumed to be NRO mode 103, which represents a 4 dBA reduction for the wind turbine. Under normal operation, this wind turbine can produce up to 3,830 kW of electricity. Under NRO mode 106, the maximum power output is 3,735 kW, and under NRO mode 103, the maximum power output is 3,185 kW.

Annualized Modeling Using Hourly Meteorological Adjustments

As described below in 19(g), WHO, in its *Guidelines for Community Noise* (1999), recommended 45 dBA averaged over an eight-hour night and a 60 dBA maximum, measured outside the bedroom window, to protect against sleep disturbance. In October 2009, the World Health Organization for Europe updated the 1999 review of the scientific

literature, and found a no-adverse-effect noise level of 40 dB $L_{night,outside}$, which is the A-weighted annual average nighttime sound level. Over the course of a year, sound levels associated with the operation of wind turbines will at times be less than the modeled worst-case/short-term sound levels. In order to quantify this reduction, differences in the wind turbine sound power levels due to changes in hub height wind speeds were addressed in the sound level modeling meteorological calculations.

A full year of 2017 on-site meteorological data (from tower 1001) were used to calculate the hub height wind speed and related sound power levels for each hour of the year (8,760 hours). The hourly wind speeds drive the resultant sound power level of the wind turbines. From these data, the sound level exceeded for 10% of the time over the course of one year (L_{10}) was calculated, as well as the sound exceeded for 50% of the time over the course of one year (L_{50}). These calculations were done for two scenarios: all hours in a year (including hours below cut-in speed and above cut-out wind speed), and only those hours in a year above cut-in speed and below cut-out wind speed. The former scenario (no zeros) is conservative since there will be periods during the year when the sound level associated with the wind turbines will be zero as they will not be operating. These periods have the potential to reduce the sound levels for the various metrics presented in this analysis. The latter scenario (with zeros) includes both operational and non-operational periods in the calculation. This is more representative of long-term annual conditions as there will be periods during a year when the wind turbines are not operating. For each of these long-term scenarios, the wind turbine with the highest resulting sound power level has been modeled. For the L_{10} modeling, that turbine is the GE 3.8-137 and for the L_{50} modeling, that turbine is the Nordex N149. The sound power levels for each turbine for the L_{10} and L_{50} are included in Table 9-8 of the PNIA.

The same full year of on-site wind data, described above, were used to calculate an equivalent sound level for all nighttime hours in one year ($L_{eq,\ night\text{-}outside}$). 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 each turbine under consideration. These calculations were also done for two scenarios: all hours in a year (including hours below the cut-in wind speed), and only those hours in a year above the cut-in speed. There were only four hours above cut-out speed. Details of data and calculations are in spreadsheet format and will be filed with the Hearing Examiner and treated by the Records Access Office or other presiding officer as confidential. Sound power levels for each turbine for the $L_{eq,\ night\text{-}outside}$ are included in Table 9-9 of the PNIA.

Using the highest resulting sound power levels from Table 9-8, the annual Project L_{10} and L_{50} sound level at each noise sensitive location was calculated. Using the highest resulting sound power levels from Table 9-9, the annual $L_{eq\ night\text{-}outside}$ noise level was calculated at each of the modeled noise sensitive locations. The annual Facility L_{10} sound levels ranged from 26 to 50 dBA for both methods (no zeros and with zeros). The highest L_{10} at a non-participating receptor

is 44 dBA (Receptor #s 133 and 207). The annual Facility L_{50} sound levels range from 27 to 50 dBA for both method calculations. The highest L_{50} at a non-participating receptor is 44 dBA (Receptor #133).

Annual nighttime $L_{eq\text{-}night\text{-}outside}$ Facility sound levels range from 26 to 50 dBA for the no zeros method calculation and 25 to 50 dBA for the with zeros method calculations. The highest $L_{eq,\ night\text{-}outside}$ level at a non-participating receptor is 42 dBA (Receptor #133 and 207). In addition to these discrete modeling points, sound level contours generated from the modeling grid are presented in Figure 9-3 of the PNIA. This sound contour figure set for annual nighttime $L_{eq,\ night\text{-}outside}$ Facility sound levels was generated only for the Nordex N149 wind turbine model, because it has the highest A-weighted sound power level for this metric.

The annual L_{10}, L_{50}, and nighttime L_{eq} values for all receptors are presented in Table F-1 (no zeros method) and Table F-2 (with zeros method) in Appendix F of the PNIA.

(e) Future Noise Levels at Receptors During Facility Operation

This section of the Article 10 Application will provide the following:

(1) Future Noise Levels During Operation

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 9-2 and 9-3 of the PNIA provide the A-weighted broadband and unweighted full octave band sound power levels produced by Facility components and Tables E-1 through E-4 of Appendix E of the PNIA provides the predicted A-weighted (dBA) sound pressure levels at the discrete receptors.

(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 (ISO 961302 standard) is limited to octave band sound levels; therefore, a quantitative evaluation of one-third octave-band levels using the software was not possible. Instead, one-third octave band sound pressure levels due to the closest wind turbines were calculated at the nearest 10 potentially impacted and representative receptor locations (both participants and non-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 12-7 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 Facility the substation is modeled to be less than 36 dBA at all non-participating sensitive receptors. Therefore, prominent discrete tones from the substation are not a concern.

(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.

The greater the modulation in sound level, the greater the "modulation depth." The modulation depth is often measured from the minimum sound level to the maximum sound level, or "crest-to trough level". Half of this level is called the amplitude of the sine wave. For the perfect sine wave, the rms value defined above is equal to the modulation depth multiplied by the square root of two (1.414). The standard deviation is also approximately equal to the rms average level of the signal. This is important, as some of the methods used to quantify amplitude modulation of a signal use the rms of standard deviations.

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 measured amplitude modulation in detail and came to the following primary conclusions (RSG, 2016):

- 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 reviewed research into the effects of and response to the acoustic character of amplitude modulation (DECC, 2016). 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. Nonetheless, the report discusses a proposal put forth to possibly control amplitude modulation by establishing a penalty scheme for excessive amplitude modulation during periods of complaints.

The Applicant proposes to address potential amplitude modulation complaints through the complaint resolution process for sound complaints. 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 (Cand and Bullmore, 2015). 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" 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 determined through a compliance filing.

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 (8,760 hours) of meteorological data collected form an on-site 60-meter meteorological tower (#1001) within the Facility Area. The meteorological data was from 2017 and included 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 used to compute the average hourly wind speed.

The overall average wind shear for the year is 0.23, the minimum is -1.15 (wind decreasing with height), and the maximum is 1.99. The wind shear is from a measured height of 32 meters above ground to the tallest expected hub height of 130 meters above ground. Extrapolated wind speed data to 130 meters was provided by the Applicant's meteorologists. Figure 10-1 of the PNIA presents the annual average wind shear coefficient by hour for a full year. The figure shows that wind shear at the site is typical for the surrounding area and 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 130 meters above ground based on the on-site meteorological tower. The overall average turbulence intensity for the year is 0.13, the minimum is 0.0, and the maximum is 0.82. Results show that turbulence intensity is slightly higher during the day than at night, and can be variable at any time. Figure 10-3 of the PNIA shows the annual average turbulence intensity by hub height wind speed. These data show that turbulence intensity decreases slightly from cut-in speed to 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.

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) 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 100 to 200 Hz depending on the definition.

Research has shown that within the first 1,000 meters of a wind turbine, infrasound and low frequency sound levels decrease according to spherical spreading (-6 dB per doubling of distance). At distances beyond approximately 1,000 meters, the one-third octave band levels below approximately 70 Hz propagate cylindrically at closer to 3 dB per doubling of distance (Hubbard and Shepherd, 1991 and Keith et al., 2016).

Infrasound and low frequency levels were calculated assuming the following:

- 80 Hz and above – decrease spherically at all distances
- 63 Hz and below – decrease spherically from 0 to 1,000 meters; decrease cylindrically beyond 1,000 meters.

Sound pressure levels for the full octave bands equal to and greater than 31.5 Hz were evaluated using the methodology described in Exhibit 19(d) above for all sensitive receptors listed in Exhibit 19(a). The full octave band sound pressure levels are included in Appendix E of the PNIA. Using the assumptions above, infrasound and low frequency sound levels (lower than 31.5 Hz but equal to or greater than 0.5 Hz) were calculated using a spreadsheet approach for the nearest 10 receptors to any wind turbine. Two of the top 10 receptors had another receptor that was very similar in distance and influenced by the same wind turbines. Therefore, there were eight unique receptors analyzed. These eight locations were scattered throughout the wind farm, and were at end of wind turbine strings as well as in the middle of a string, thus providing a good mix of worst-case conditions. Table 9-19 of 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 of the PNIA for both the one-third octave bands and full octave bands at each of the eight locations analyzed. Sound pressure levels for the full octave bands equal to and greater than 31.5 Hz were evaluated using the methodology described in Exhibit 19(d) above for all sensitive receptors listed in Exhibit 19(a). The full octave band sound pressure levels are included in Appendix E of the PNIA.

Low frequency levels modeled 65 dB or greater for 16 Hz, 31.5 Hz, and 63 Hz is provided below in Table 19-4 for the GE 3.8-137. For the GE 3.8-137 wind turbine, 16 non-participating receptors are between 66 and 68 dB at 16 Hz under worst-case conditions. For the Vestas V150-4.2 wind turbine, 4 non-participating receptors are between 66 and 67 dB at 16 Hz under worst-case conditions. For the Nordex N149/4500 wind turbine, one non-participating receptor is at 66 dB at 16 Hz under worst-case conditions. For the Senvion 4.2M148 wind turbine, 24 non-participating receptors are between 66 and 70 dB at 16 Hz under worst-case conditions (however, since no 16 Hz data were provided for the Senvion, an extremely conservative estimate was made of the 16 Hz sound power level which likely raises these results).

The 16 Hz modeled results are conservative and likely overstate reality for the following reasons. The ISO 9613-2 modeling is inherently conservative with the assumption that every wind turbine is operating at maximum sound power simultaneously, and the receptor is downwind of every turbine regardless of orientation or wind direction. In addition, as stated in NARUC 2011 “the widespread belief that wind turbines produce elevated or even harmful

levels of low frequency and infrasonic sound is utterly untrue as proven repeatedly and independently by numerous investigators." This analysis will be re-run with the wind turbine of final choice, and compliance with the 16 Hz 65 dB criteria will be determined through actual post-construction sound level measurements.

Table 19-4. Receptors Modeled at 65 (dB) or Greater for Low Frequency Criteria

Modeled Sound Level (dB)	16 Hz		31.5 Hz		63 Hz	
	# Receptors		# Receptors		# Receptors	
	Participating	Non-participating	Participating	Non-participating	Participating	Non-Participating
71	0	0	0	0	0	0
70	1	0	0	0	0	0
69	1	0	0	0	0	0
68	7	1	0	0	0	0
67	15	8	0	0	0	0
66	7	7	0	0	0	0
65	5	8	1	0	0	0

GE provided one-third octave band sound power level data down to 12.5 Hz for the GE 3.8-137, Vestas provided one-third octave band sound power level data down to 6.3 Hz for the V150-4.2., Nordex provided one-third octave band sound power level data down to 10 Hz for the N149-4500, and Senvion provided one-third octave band sound power level data down to 20 Hz for the 4.2M148. No reference sound power level data below 6.3 Hz are available from any of the manufacturers. Therefore, sound power level data were extrapolated from each manufacturer's lowest published octave band down to 0.5 Hz. The extrapolation process assumed a 1 dB per octave increase in sound power levels from the lowest published value to 0.5 Hz as shown in the research (RSG, 2016). The infrasound and low frequency sound power levels are shown in Table 9-18 of the PNIA, and represent the highest sound level under any wind speed from any turbine model for each one-third octave band.

(f) Predicted Sound Levels Table

The A-weighted/dBA sound levels at the sensitive sound receptors identified in subsection (a), for the operating Facility are provided in tabular form in the subsections below. The tables include the following:

1) The daytime ambient noise level was calculated from summer and winter background sound level monitoring data. This is equal to the lower tenth percentile (L_{90}) of sound levels measured during the daytime (7 AM to 10 PM) at each of the monitoring locations.

2) The summer nighttime ambient noise level was calculated from summer background sound level monitoring data. This is equal to the lower tenth percentile (L_{90}) of sound levels measured at night (10 PM to 7 AM), during the summer at each of the monitoring locations.
3) The winter nighttime ambient noise level was calculated from background sound level monitoring data. This is equal to the lower tenth percentile (L_{90}) of sound levels measured at night (10PM to 7AM), during the winter at each of the monitoring locations.
4) The worst case future noise level during the daytime period was determined by logarithmically adding the daytime ambient sound level (L_{90}), calculated from background sound level monitoring (summer and winter), to the modeled upper tenth percentile sound level (L_{10}) of the Facility. The L_{10} statistical noise descriptor corresponds to estimates for one year of operation as described in Exhibit 19(d). Daytime is 15 hours (7 AM – 10 PM).
5) The worst case future noise level during the summer nighttime period was determined by logarithmically adding the most representative summer nighttime ambient sound level (L_{90}), as related to the location being evaluated, calculated from background sound level monitoring, to the modeled upper tenth percentile sound level (L_{10}) of the Facility at each evaluated sensitive sound receptor. The L_{10} statistical noise descriptor corresponds to one year of operation as described in Exhibit 19(d). Nighttime is 9 hours (10 PM – 7 AM).
6) The worst case future noise level during the winter nighttime period was determined by logarithmically adding the most representative winter nighttime ambient sound level (L_{90}), as related to the location being evaluated, calculated from background sound level monitoring to the modeled upper tenth percentile sound level (L_{10}) the Facility at each evaluated sensitive sound receptor. The L_{10} statistical noise descriptor corresponds to one year of operation as described in Exhibit 19(d). Nighttime is 9 hours (10 PM – 7 AM).
7) The daytime ambient average noise level was calculated by logarithmically averaging sound pressure levels (Leq) after exclusions from the background sound level measurements over the daytime period at each monitoring location. These calculations included both summer and winter data after all exclusions were applied. Daytime is 15 hours (7 AM – 10 PM).
8) Typical facility noise levels were calculated as the median sound pressure level emitted by the Facility. The median sound pressure level was calculated by determining the 50th percentile of the sound levels at a receptor. The L_{50} statistical noise descriptor corresponds to one year as described in Exhibit 19(d). Daytime is 15 hours (7 AM – 10 PM).
9) Typical Facility daytime noise levels were calculated after exclusions as the daytime equivalent average sound level (L_{eq}) that was measured, as related to the location being evaluated, logarithmically added to the median Facility sound pressure level (L_{50}) at each evaluated sensitive sound receptor. The L_{50} statistical noise descriptor corresponds to one year as described in Exhibit 19(d). Daytime is 15 hours (7 AM – 10 PM).

(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 (L_{90}) 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 19-5 below.

Table 19-5. Daytime Ambient L_{90} Sound Pressure Level

Location	Overall (dBA)		Winter (dBA)		Summer (dBA)	
	Measured	ANS	Measured	ANS	Measured	ANS
Monitor 1	43	40	39	38	46	41
Monitor 2	26	22	24	23	28	21
Monitor 3	26	24	25	24	26	23
Monitor 4	30	20	24	23	34	19
Monitor 5	29	24	30	28	29	23
Monitor 6	28	18	38	36	26	17
Monitor 7	25	23	22	19	37	30

(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 19-6.

Table 19-6. Nighttime Ambient L_{90} Sound Pressure Level

Location	Overall (dBA)		Winter (dBA)		Summer (dBA)	
	Measured	ANS	Measured	ANS	Measured	ANS
Monitor 1	31	25	28	27	48	25
Monitor 2	24	15	22	21	38	15
Monitor 3	23	20	24	24	23	19
Monitor 4	25	16	20	18	31	16
Monitor 5	29	20	25	23	33	19
Monitor 6	27	13	30	28	25	12
Monitor 7	24	23	21	19	36	28

(3) Winter Nighttime Ambient Noise

The winter 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 winter at each of the monitoring locations. These results are provided above in Table 19-6.

(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 19-5) 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 wind turbine model with the highest sound power level (GE 3.8-137). The worst-case future noise levels during the daytime period range from 27 to 50 dBA and are presented in Table G-2A (method 1 – no zeros) and Table G-2B (method 2 – with zeros) in Appendix G of the PNIA.

(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 19-6) 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 using the wind turbine model with the highest sound power level (GE 3.8-137). The L_{10} statistical noise descriptor corresponds to estimates for the summer nighttime period for one year of operation. The worst-case future noise levels during the summer nighttime period range from 26 to 50 dBA and are presented in Table G-2A (method 1) and Table G-2B (method 2) in Appendix G of the PNIA.

(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 19-6) 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 using the wind turbine model with the highest sound power level (GE 3.8-137). The L_{10} statistical noise descriptor corresponds to estimates for the winter nighttime period for one year of operation. The worst-case future noise levels during the winter nighttime period range from 27 to 50 dBA and are presented in Table G-2A (method 1) and Table G-2B (method 2) in Appendix G of the PNIA.

(7) Daytime Ambient Average Noise Level

Measured daytime average ambient levels are presented in Table 19-7 below. 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 19-7. Daytime Ambient L_{eq} Sound Pressure Level Summary

Location	Overall (dBA)	
	Measured	ANS
Monitor 1	58	57
Monitor 2	47	44
Monitor 3	49	48
Monitor 4	50	47
Monitor 5	49	47
Monitor 6	50	49
Monitor 7	50	48

(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 Annual Facility sound levels ranged from 27 to 50 dBA and are presented in Tables F-1 (method 1) and F-2 (method 2) in Appendix F of the PNIA.

(9) Typical Daytime Facility 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 19-7) as related to the use and soundscape of the location being evaluated, to the modeled median Facility sound pressure level (L_{50}) using the wind turbine model with the highest sound power level (Nordex N149). The L_{50} statistical noise descriptor corresponds to estimates for one year of operation. The typical Facility daytime noise levels ranged from 44 to 52 dBA and are presented in Table G-2A (for method 1) and Table G-2B (method 2) in Appendix G 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 Section 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 19-8 in Section (h).

Local Regulations

The Facility is located within the Towns of Sanford and Windsor in Broome County, New York. Broome County does not have any noise regulations applicable to wind turbine operation. Section 1402.5(A)(5) of the Town of Sanford local law establishes a standard of 50 dBA for sound levels generated by operation of Wind Energy Conversion Systems (WECS) measured at the exterior wall at a non-participating residence. Neither the metric nor the time period of evaluation is stated in the local law. Consistent with the sound level data provided by the wind turbine manufacturers (as required by standard) and other approved wind energy projects in NY State, a one-hour L_{eq} (day or night) was assumed as the metric and time period for evaluating compliance with the local law. The short-term ISO 9613-2 model results are presented in terms of 1-hour L_{eq}. The highest predicted 1-hour L_{eq} sound level in Sanford at a non-participating residence is 45 dBA at receptors #32, 133, 118, and 112. All predicted L_{eq} sound levels from the Facility are 50 dBA or less; therefore, the Facility will meet the local sound level limit. Exhibit 31 of this Application provides additional detail on these regulations.

State Standards

NYSDEC Program Policy

The NYSDEC published a guidance document for assessing noise impacts (NYSDEC, 2001). The policy states that the USEPA "Protective Noise Levels" guidance found that an annual sound level of 55 dBA was sufficient to protect the public health and welfare, and in most cases, did not create an annoyance.

The guidance document states that the addition of any noise source, in a non-industrial setting, should not raise the ambient noise level above a maximum of 65 dBA. This guidance document also states that sound level increases less than 3 dBA should have no appreciable effect on receptors, increases from 3-6 dBA may have potential for adverse noise impact only in cases where the most sensitive of receptors are present, and increases of more than 6 dBA may require a closer analysis of impact potential depending on existing sound levels and the character of surrounding land use and receptors. An increase of 10 dBA deserves consideration of avoidance and mitigation measures in most cases. For lands owned by NYSDEC, the Applicant agreed to utilize the NYSDEC policy to evaluate the potential sound impact at NYSDEC lands within one mile of a wind turbine.

The NYSDEC land nearest to a wind turbine is the Marsh Pond State Forest. Receptor ID #438 represents the area of frequent human use (campsite) within the Forest. Worst-case L_{eq} (1-hour sound levels are predicted to be 35-36 dBA

depending on the wind turbine model (see Appendix E of the PNIA). The existing ambient sound levels at Receptor #438 are represented by measurement Location 4. The quietest daytime summer ambient L90 is 34 dBA and the quietest nighttime summer ambient L_{90} is 31 dBA. Using these data, the worst-case L_{eq} (1-hour) sound levels are 3-5 dBA above the quietest L_{90} ambient sound levels. Therefore, the Facility meets the design goal of a 6 dBA increase over ambient or less applied at NYSDEC land.

World Health Organization Guidelines – Short Term

The WHO established guidelines for sound levels (1999). The document states that daytime and evening outdoor living sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance from a steady, continuous source of noise. At night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA so that people may sleep with bedroom windows open. The time base for these sound levels is an average of 16 hours for daytime and 8 hours for nighttime. The short-term (1-hour) worst-case sound level modeling results included in Appendix E of the PNIA are conservative since the 8-hour average cannot be higher than the highest 1-hour sound level. To further illustrate this point, all 8,760 hours of the on-site hub height wind speeds were analyzed. Only 26 of the 365 nights in an entire year maintained a hub height wind speed high enough for all eight hours of the night to produce the highest sound level from the GE wind turbine for those eight consecutive hours. Likewise, that same analysis of 8,760 hours of wind data found that only six of the 365 days in an entire year maintained a hub height wind speed high enough for all 16 hours of the day to produce the highest sound level from the GE wind turbine for those 16 consecutive hours.

Table 9-10 to Table 9-13 in this PNIA summarize the results applicable to these goals. The results vary by the modeled wind turbine OEM. There are three to eight receptors with L_{eq} (8-hour) sound levels of 46-51 dBA. However, these receptors are participants in the project, and thus meet the L_{eq} (8-hour) design goal of 55 dBA. The highest sound level at a non-participating receptor is 45 dBA, therefore, the Facility meets the 45 dBA L_{eq} (8-hour) guideline established as a design goal for non-participants.

World Health Organization – Long-Term

In 2009, the WHO released another report entitled "Night Noise Guidelines for Europe." The 2009 WHO report recommends a Night Noise Guideline (NNG) of 40 dBA. However, the 40 dBA guideline is an "$L_{eq\text{-}night\text{-}outside}$" descriptor, which is not the same as a short-term measurement and therefore should not be compared with the short-term design goals for the Facility (i.e. 45 dBA discussed above). $L_{eq\text{-}night\text{-}outside}$ is defined as the A-weighted long-term average sound level determined over all the night periods of a year; in which the night is eight hours. The same 2009 WHO report notes that above an $L_{eq\text{-}night\text{-}outside}$ of 55 dBA, there is evidence that the risk of cardiovascular disease and other health effects increases. Therefore, consistent with a permit condition in Case 14-F-0490 [Cassadaga Wind], an annual

nighttime design goal of 50 dBA is used at a participating receptor. The $L_{eq\text{-}night\text{-}outside}$ is an annual average, and is not an appropriate descriptor to use for evaluating a permit's compliance criteria. An $L_{eq\text{-}night\text{-}outside}$ annual design goal should not be used as a permit compliance condition given the complexity and burden of measuring sound levels over the course of 365 consecutive nights. If a project meets the short-term (1-hour or 8-hour) worst-case sound level permit limits, then it confirms the modeling was accurate and thus an annual modeled sound level such as $L_{eq\text{-}night\text{-}outside}$ is sufficient to demonstrate expected annual sound levels.

Since $L_{eq\text{-}night\text{-}outside}$ considers 365 nights of operation, there will be some nights the wind turbines do not operate at all and many others where they will operate at a level below maximum sound level. Therefore, the $L_{eq\text{-}night\text{-}outside}$ sound level will always be lower than the worst-case (highest) short-term sound level measured on a given night. In other words, the $L_{eq\text{-}night\text{-}outside}$ guideline of 40 dBA, is not a 10-minute or 1-hour sound level, but is an annual level. Also, it is important to note that neither the 1999 or 2009 WHO guidelines were developed specifically for wind turbines and therefore, the annual average discussed by the 2009 WHO guidelines should not be used to create a regulatory standard for wind facilities.

The results of the annual nighttime $L_{eq\text{-}night\text{-}outside}$, sound level modeling are presented in Tables 9-14 to 9-17 of the PNIA, and presented in detail in Tables F-1 (without zeros) and F-2 (with zeros) in Appendix F of the PNIA. Annual nighttime $L_{eq\text{-}night\text{-}outside}$ Facility sound levels range from 26 to 50 dBA for "Method 1" (no zeros) and 25 to 50 dBA for "Method 2" (with zeros) calculations. The modeled level "without zeros" only includes nights when the winds are above cut-in speed, and thus the wind turbines are operating and generating sound. The modeled level "with zeros" includes sound levels from all 365 nights whether or not the wind turbines would be operating. Since the 2009 WHO document guideline sound level of 40 dBA includes all 365 nights of the year, the relevant set of calculations are those in Table F-2 which include model results from all 365 nights of a year. Calculating an annual sound level without including the nights when the wind turbines will not be operating is inconsistent with the 2009 WHO definition of the annual nighttime $L_{eq\text{-}night\text{-}outside}$. Therefore, the sound levels in Table F-1 (without zeros) are irrelevant, but have been provided to comply with Stipulation 19.

The Nordex N149 model was used to evaluate compliance with the design goal of 40 dBA $L_{eq,\ night,\ outside}$ because it is considered the "worst-case". The highest $L_{eq,\ night,\ outside}$ level at a non-participating residence is 42 dBA (Receptor IDs 133 and 207). There are nine (9) non-participating residences at 41 dBA or 42 dBA $L_{eq,\ night,\ outside}$. All other locations are 40 dBA or less. The GE 3.8-137 had four (4) non-participating residences at 41 dBA $L_{eq,\ night,\ outside}$. All other locations are 40 dBA or less using the GE 3.8-137. Modeling for the Vestas V150-4.2 and Senvion M148-4.2 wind turbines showed all non-participating receptors at an $L_{eq,\ night,\ outside}$ of 40 dBA or less. Therefore, all non-participating receptors meet the $L_{eq,\ night,\ outside}$ design goal of 40 dBA for all wind turbine models except the Nordex N149 which has

9 receptors at 41 dBA or 42 dBA, and the GE 3.8-137 which has 4 receptors at 41 dBA (Goal #6). The highest $L_{eq, night, outside}$ for a participating receptor using any wind turbine is 50 dBA (receptor ID 392). All other locations are 48 dBA or less. Therefore, all participating receptors meet the $L_{eq, night, outside}$ design goal of 50 dBA (Goal #7).

Federal Standards

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

ANSI S12.9-2005/Part 4

Annex D of the 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 less than 65 dB. Tables 12-2 to 12-5 of the PNIA show the highest sound level modeled in the 16, 31.5, and 63 Hz octave bands. Results vary by wind turbine manufacturer but all non-participating residences are below 65 dB at the 31.5 Hz and 63 Hz octave bands.

For the GE 3.8-137 wind turbine, 16 non-participating receptors are between 66 and 68 dB at 16 Hz under worst-case conditions. For the Vestas V150-4.2 wind turbine, 4 non-participating receptors are between 66 and 67 dB at 16 Hz under worst-case conditions. For the Nordex N149/4500 wind turbine, one non-participating receptor is at 66 dB at 16 Hz under worst-case conditions. For the Senvion 4.2M148 wind turbine, 24 non-participating receptors are between 66 and 70 dB at 16 Hz under worst-case conditions (however, since no 16 Hz data were provided for the Senvion, an extremely conservative estimate was made of the 16 Hz sound power level which likely raises these results). Therefore, future Project sound levels at all sensitive receptors will be almost at or slightly above the ANSI S12.9-2005/Part 4 Annex D guideline limits depending on which wind turbine is selected.

The 16 Hz modeled results are conservative and likely overstate reality for the following reasons. The ISO 9613-2 modeling is inherently conservative with the assumption that every wind turbine is operating at maximum sound power simultaneously, and the receptor is downwind of every turbine regardless of orientation or wind direction. In addition, as stated in the report by NARUC (2011), "this widespread belief that wind turbines produced elevated or even harmful levels of low frequency and infrasonic sound is utterly untrue as proven repeatedly and independently by numerous investigators." This analysis will be re-run with the wind turbine of final choice, and compliance with the 16 Hz 65 dB criteria will be determined through actual post-construction sound level measurements.

Tonality

As discussed in Section 12.9, ANSI S12.9 Part 3, Annex B, section B.1 (informative) presents a procedure for testing for the presence of a prominent discrete tone. The results presented in Table 12-2 of the PNIA show that received sound pressure levels due to the closest wind turbines are not predicted to result in any prominent discrete tones at

either participating or non-participating residents. For this Facility the collector substation is modeled to be less than 36 dBA at all non-participating sensitive receptors. Therefore, prominent discrete tones from the substation are not a concern with this Facility. The Facility thus meets the design goal of no pure tone at any non-participating resident.

Non-Residential Receptors

There are four non-residential receptors among the sensitive receptor set. These receptors are summarized in Table 13-1 of the PNIA along with the highest 1-hour L_{eq} modeled sound level from each wind turbine under consideration. The highest modeled sound level is 40 dBA. Therefore, the Facility meets the design goal of 50 dBA L_{eq} 1-hour at any non-residential receptor.

Vibration

The nearest operating wind turbine to a non-participating noise-sensitive receptor (#207) is approximately 1,086 feet (331 meters). Based on the literature findings presented in 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).

(h) Noise Standards Comparison

Noise standards applicable to the Facility, including local regulations, state guidelines, WHO guidelines, and other federal agency guidelines are provided below in Table 19-8. As is indicated in Table 19-8, the Facility is generally in compliance with all of the standards and guidelines applicable to the Facility, where applicable.

Table 19-8. Noise Standards and Degree of Compliance

Municipality/ Organization	Sound Level Limit	Assessment Location	Metric	Time Period	Participant Status	Does Facility Comply with Standard or Guideline
Town of Sanford Renewable Energy Systems §1402.5(A)(5)	50 dBA	Exterior wall of the nearest non-participating residence	Not Stated (assumed L_{eq})	Not Stated (assumed 1-hour); day or night	Non-participant	Yes
Program Policy Assessing Mitigating Noise Impacts Issued by the NYSDEC (NYSDEC, 2001)	6 dBA increase over ambient	Areas of human use	L_{90}	Not stated	NYSDEC Lands	Yes
Design Goal (1999 WHO Guidelines)	45 dBA	At residence	L_{eq}	8-hour; nighttime	Non-participant	Yes
Design Goal (1999 WHO Guidelines)	55 dBA	At residence	L_{eq}	8-hour; nighttime	Participant	Yes
Design Goal	55 dBA	Property line and lands (except wetlands)	L_{eq}	1-hour; day or night	Non-participant	Yes
Design goal	40 dBA	At residence	$L_{eq, night, outside}$	Annual; nighttime	Non-participant	No
Design goal (Permit condition Case 14-F-0490 [Cassadaga Wind])	50 dBA	At residence	$L_{eq, night, outside}$	Annual; nighttime	Participant	Yes
Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	65 dB at 16, 31.5, 63 Hz	At residence	L_{eq}	1-hour; day or night	Non-participant	No (16 Hz) Yes (31.5, 63 Hz)
Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	No pure tone or 5 dBA penalty if a prominent tone occurs	At residence	L_{eq}	1-hour; day or night	Non-participant	Yes
Design goal (ANSI/ASA S12.9-2007/Part 5)	50 dBA	Non-residential (historic venues; cemeteries; playgrounds; etc)	L_{eq}	1-hour	Non-participant	Yes
Design goal for vibrations	No perceptible indoor vibrations	At residence	See ANSI S2.71-1983 (R August 6/2012) for details	See ANSI S2.71-1983 (R August 6/2012) for details	Non-participant	Yes

(i) Noise Abatement Measures for Construction Activities

The Complaint Resolution Plan for the Facility, which is attached as Appendix R, has been provided to address complaints during the construction and operation of the Facility, including complaints regarding sound levels. In addition, a construction noise complaint resolution plan (CNCRP) will be provided during the construction period. The Applicant takes seriously any reasonable complaints that it receives from members of the public. Complaints will be able to be made in via phone, writing, or email. The Applicant will contact the individual within two business days of the complaint. The Applicant will implement a comprehensive complaint response for all registered 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.

The Complaint Resolution Plan specifically addresses noise complaints. If the noise complaint location is more than one mile from active construction activity, the complaint will be logged, but no action will be taken. If a noise complaint is less than one mile from construction activity a representative from the construction firm will visit the complaint during the construction activity to listen and observe. The construction personnel will try to determine if any equipment is not functioning properly and thus creating unusual sound. If so, the equipment will be repaired or replaced as soon as practical.

Although impacts related to construction noise will be temporary, and are not anticipated to be significant, measures employed to minimize and mitigate temporary construction noise shall include:

- Limiting blasting and pile driving, if necessary, to daytime hours,
- Utilizing construction equipment fitted with exhaust systems and mufflers that have the lowest associated noise whenever those features are available,
- Maintaining equipment and surface irregularities on construction sites to prevent unnecessary noise,
- Configuring, to the extent feasible, the construction in a manner that keeps loud equipment and activities as far as possible from noise-sensitive locations,
- 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 and Occupational Safety and Health Administration (OSHA) requirements,
- Develop a staging plan that establishes equipment and material staging areas away from sensitive receptors when feasible, and
- Contractors will use approved haul routes to minimize noise at residential and other sensitive noise receptor sites on the mainland.

(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 taken into account NROs that could be used to bring the Facility into compliance with design goals. The use of NROs for this facility are discussed above in Section 19(d).

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. With sound propagation modeling using NROs, the highest sound level at a permanent non-participating residence would be 45 dBA.

According to the WHO 1999 Guidelines, the threshold for hearing impairment is 110 dBA ($L_{max, fast}$) 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 (L_{max}) (FWHA, 2006). The closest receptor to any wind turbine foundation will be well beyond 200 feet. This would result in an L_{max} 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 stats 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 sensitive sound receptors were modeled to have the highest operational sound level at 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 sensitive sound receptors were modeled to have the highest operational sound level at 45 dBA, the Facility will not result in interference with indoor or outdoor speech, as defined by USEPA guidelines.

(3) 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 below.

Audible Frequency Range

Several studies of human response to wind turbine sound were conducted in Europe in the early 2000s. Pedersen and Waye performed a cross-sectional study in Sweden in 2000 (Pedersen and Waye, 2000). A dose-response relationship between calculated A-weighted sound levels from wind turbines and noise annoyance was found. Noise annoyance was related to other subjective factors such as attitude and sensitivity. Attitude towards the visual aspect of wind turbines was strongly correlated to annoyance.

Another detailed field study was conducted in the Netherlands through the use of calculated sound levels and a questionnaire (Pedersen et al., 2008). A dose-response relationship between A-weighted sound levels and reported perception and annoyance was found. However, the study found that high turbine visibility enhances negative response, and having wind turbines visible from a dwelling significantly increases the risk of annoyance. Annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study also found that people who benefit economically from wind turbines have a significantly decreased risk of annoyance, even at the same sound levels. From that same study, it was found that of all sound sources that might disturb sleep in rural areas, 70% were not disturbed, 12% were disturbed by people/animals, 12% were disturbed by traffic/mechanical sounds, and 6% were disturbed by wind turbines (Bakker et al., 2012).

Observations of neighbors' reactions to newly operational wind farms suggest that it is not necessary to rigidly impose a maximum noise level of 40 dBA in order to avoid complaints. The National Association of Regulatory Utility Commissioners (NARUC) document recommends 40 dBA as an ideal design goal, if it can reasonably be achieved, but 45 dBA as an appropriate regulatory limit. Adverse reactions to wind turbine noise between 40 and 45 dBA is still quite low, at roughly 2% of wind-park neighbors, even in rural environments with low background levels (NARUC, 20112). This project is expected to be consistent with that statement as less than 6% of non-participating residences would be between 40-45 dBA using the NARUC modeling methodology and the worst-

case modeled wind turbine (GE 3.8-137). Of these 6%, only a subset are likely to complain about noise from the facility, rendering it consistent with the NARUC observation of approximately 2%.

Health Canada conducted a cross-section epidemiological study in 2013 in the provinces of Ontario and Prince Edward Island (PEI) on randomly selected participants living near and far from operating wind turbines (Health Canada, 2014). Calculated outdoor wind turbine sound levels were up to 46 dBA. Note that these sound levels represent typical worst-case long term (one year) average sound levels. Many peer-reviewed publications have been written based on the Health Canada research, including an analysis of annoyance.

One study reported annoyance toward several wind turbine features increased with increasing sound levels, including the following: noise, blinking lights, shadow flicker, visual impacts, and vibrations. In the entire study, approximately 7% reported a high level of annoyance from wind turbine noise. In the homes within the 40-46 dBA wind turbine noise area, approximately 13% reported a high level of annoyance. Annoyance was significantly higher in Ontario versus PEI at comparable sound levels (Michaud et al., 2016a).

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

In 2015, the U.S. Department of Energy funded Lawrence Berkeley National Laboratory (LBNL) to lead a 4-year project collecting data from a broad-based and representative sample of individuals living near U.S. wind power projects (Hoen et al., 2018). The aim was to broaden the understanding of how U.S. communities are reacting to the deployment of wind turbines, and to provide insights to those communities considering wind projects. Survey data were collected from 1,705 residents across 24 states who were living within 5 miles of 250 U.S. wind power projects. A 50-question multi-mode (phone, mail, and internet) survey was distributed to each homeowner in the sample, eliciting information on attitudes, stress reactions, perceived fairness of the process, relationship to the projects, attitudes, and demographic information. Regarding attitude toward the wind projects, 8% responded either very negative or negative, while the remaining 92% were neutral or positive. For just the respondents within 0.5 mile of a wind turbine, 25% were very negative or negative, and 75% were neutral or positive. Regarding annoyance, 5.6% of all respondents reported being somewhat, moderately, or very annoyed by the wind project. For the respondents within 0.5 mile of a wind turbine, 30% reported being somewhat, moderately, or very annoyed by the wind project.

Another portion of the LBNL study included modeled sound levels at more than 500 respondents homes near 15 existing wind projects. The results found that modeled sound levels alone are not a good predictor of annoyance. Prediction of annoyance was improved by including other variables in the model such as visibility of wind turbines, support or opposition to the project, compensation from the project, and when they moved into the area. Higher background sound levels appear to mask turbine sound and thus produce less annoyance.

Therefore, while attitudes are a strong predictor of annoyance towards a facility, and attitudes can't be predicted, but based on modeling, it is not anticipated that predicted sound levels will be in a range likely to contribute to a significant number of sound related complaints from the facility.

Infrasound and Low Frequency

Infrasound is generally defined as the portion of the frequency spectrum below 20 Hz. Low-frequency sound is generally considered in the frequency range from 20 Hz to 200 Hz.

Results of Epsilon research indicate that there is no audible infrasound either outside or inside homes at 1,000 feet from a wind turbine. Sound levels meet the ANSI standard for low frequency noise in bedrooms, classrooms, and hospitals, meet the ANSI standard for thresholds of annoyance from low frequency noise, and there should be no window rattles or perceptible airborne induced vibration of light-weight walls or ceilings within homes. In homes there may be slightly audible low frequency noise beginning at around 50 Hz (depending on other sources of low frequency noise); however, the levels are below criteria and recommendations for low frequency noise within homes (O'Neal et al., 2011).

Annex D in the 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 less than 65 dB. According to the standard, annoyance to sounds with strong low frequency content is virtually only an indoor issue.

Section 6 of the American National Standard ANSI/ASA S12.2-2008 discusses criteria for evaluating indoor low frequency room noise. These criteria assess the potential to cause perceptible airborne induced vibration and rattles. Outdoor low frequency sounds that are high enough can cause building walls to vibrate and windows to rattle. Window rattles are not low frequency noise, but may be caused by low frequency noise. ANSI/ASA S12.2 presents limiting levels at low frequencies (16, 31.5, 63 Hz) for assessing (a) the probability of clearly perceptible acoustically induced vibration and rattles in lightweight wall and ceiling constructions, and (b) the probability of moderately perceptible acoustically induced vibration in similar constructions. See Table 19-9 below. Research

has found that reduction of sound from outside to inside at these low frequencies is modest but not zero. Typical reductions with windows open are 3 dB, 6 dB, and 9 dB at 16, 31.5, and 63 Hz respectively (O'Neal et al., 2011). See Table 19-10 for the equivalent sound pressure levels based on these reductions.

Table 19-9. ANSI S12.2 Section 6 and S.12.9-2005/Part 4 Annex D Standards for Low Frequency Noise and

Full Octave Band Center Frequency	16 Hz	31.5 Hz	63 Hz
Clearly perceptible vibration and rattles likely (ANSI 12.2-2008 Section 6)	*75 dB*	*75 dB*	*80 dB*
Moderately perceptible vibration and rattle likely (ANSI 12.2-2008 Section 6)	*65 dB*	*65 dB*	*70 dB*
Minimal annoyance levels (ANSI S 12.9 2005/Part 4 Annex D)	*65 dB*	*65 dB*	*65 dB*

Table 19-10. Equivalent Outdoor Standards for Low Frequency Noise

Full Octave Band Center Frequency	16 Hz	31.5 Hz	63 Hz
Clearly perceptible vibration and rattles likely	*78 dB*	*81 dB*	*89 dB*
Moderately perceptible vibration and rattle likely	*68 dB*	*71 dB*	*79 dB*

The 2011 NARUC report stated, "the widespread belief that wind turbines produce elevated or even harmful levels of low frequency and infrasonic sound is utterly untrue as proven repeatedly and independently by numerous investigators" (NARUC, 2011).

(4) NYSDEC Program Policy Assessing and Mitigating Noise Impacts

The NYSDEC has published a guidance document for assessing noise impacts (NYSDEC, 2001). The policy states that the 1974 USEPA guidelines found that an annual sound level of 55 dBA L_{dn} was sufficient to protect the public health and welfare, and in most cases, did not create an annoyance. A 55 dBA L_{dn} would be equivalent to a daytime sound level of 55 dBA, and a nighttime sound level of 45 dBA, or a continuous level of approximately 49 dBA. The guidance document states that the addition of any noise source, in a non-industrial setting, should not raise the ambient noise level above a maximum of 65 dBA. The document also states that sound level increases less than 3 dBA should have no appreciable effect on receptors, increases from 3-6 dBA may have potential for adverse noise impact only in cases where the most sensitive of receptors are present, and an increase of more than 6 dBA may require a closer analysis of potential impact depending on existing sound levels and the character of surrounding land use and receptors. An increase of 10 dBA deserves consideration of avoidance and mitigation measures in most cases.

This standard was used to evaluate the one receptor located on NYSDEC land. The one receptor was modeled as a discrete point at a height of 1.5 meters above ground level to mimic the ears of a typical standing person. As

described in Section (g) above, the Facility is in compliance with this standard at the receptor located on NYSDEC land (Receptor #438).

(5) Potential for Structural Damage

Information regarding construction activities and blasting is included the Preliminary Blasting Plan (if blasting is deemed necessary) (Appendix HH) and is summarized in Exhibit 12 and Exhibit 21 of the Application. Blasting of bedrock is 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 addressed as per Exhibits 12 and 21.

(6) Potential for Ground-borne Vibration

While not studied nearly as extensively as airborne vibration, the potential for wind turbines to create adverse ground-borne vibration has been investigated. Measurement of ground borne vibration associated with wind turbine operations can be detectable with instruments but is below the threshold of perception, even within a wind farm.

Gastmeier and Howe measured vibration at a residence 325 meters (1,066 feet) from several 1.8 MW turbines and found vibration levels were well below the perception limits found in ISO 2631-2 (Evaluation of human exposure to whole-body vibration; Gastmeier and Howe, 2008).

The Massachusetts Department of Environmental Protection (MA DEP) and the Massachusetts Department of Public Health commissioned an expert panel who found that seismic motion from wind turbines is so small that it is difficult to induce any physical or structural response. Two reports cited in the MA DEP review (Styles, 2005; Schofield, 2010) indicate that at 100 meters from a wind turbine the maximum motion that is induced is 120 nanometers (at about 1 Hz). A nanometer is 10^{-9} meter. This is 1.2×10^{-7} meter of ground displacement. Extremely sensitive measuring devices have been used to detect this slight motion. To put the motion in perspective, the diameter of a human hair is on the order of 10^{-6} meter. The Schofield measurements were conducted on a Vestas V-47 with a maximum rotational rate of 29 rpm (blade pass frequency of 1.47 Hz).

Ground-borne vibration measurements were made by Epsilon from Siemens 2.3 and GE 1.5sle wind turbines in Texas (Epsilon, 2009). The maximum ground-borne vibration root-mean square (RMS) particle velocities were 0.071 mm/second (0.71×10^{-4} meters/second) in the 8 Hz one-third octave band. This was measured 1,000 feet

downwind from a GE 1.5sle WTG under maximum power output and high wind at the ground. The background ground-borne vibration RMS particle velocity at the same location was 0.085 mm/sec. Both of these measurements meet ANSI S2.71-198324 recommendations for perceptible vibration in residences during night time hours of 1.0×10^{-4} meters/second at 8 Hz. Soil conditions were soft earth representative of an active agricultural use. No perceptible vibration was felt from operation of the wind turbines. The GE 1.5sle has a maximum rotation rate of 20 rpm (blade pass frequency of 1 Hz), and the Siemens 2.3 has a maximum rotation rate of 15.4 rpm (blade pass frequency of 0.77 Hz).

ANSI S2.71-1983 presents recommendations for magnitudes of ground-borne vibration which humans will perceive and possibly react to within buildings. A basic rating is given in Table 1 of the standard for the most stringent conditions, which correspond to the approximate threshold of perception of the most sensitive humans. From the base rating, multiplication factors should be applied according to the location of the receiver; for continuous sources of vibration in residences at nighttime, the multiplication factor is 1.0 –1.4. For spaces in which the occupants may be sitting, standing, or lying at various times, the standard recommends using a combined axis rating which is obtained from the most stringent rating for each axis. Measurements in each of the 3 axes should be compared to the combined axis rating. Table 4-4 of the PNIA presents the base response velocity ratings for the combined axis. The velocity ratings are for RMS values.

The Ministry for the Environment, Climate and Energy of the Federal State of Baden-Wuerttemberg, Germany published a detailed study on infrasound and vibration from wind turbines (LUBW Ministry for the Environment, 2016). The results found that vibration velocity levels from a 2.4 MW Nordex N117 wind turbine at distances of less than 300 meters (~1,000 feet) were less than 0.1×10^{-4} meters/sec. Therefore, ground-borne vibration can be detected by instruments but is no different than the ever present background vibration and not a concern.

Table 19-11 below lists the maximum frequency of rotation and the mass of rotation for a single blade for each turbine evaluated in the PNIA.

Table 19-11. Frequency of Rotation and Masses

Turbine Model	Frequency of Rotation Range (rpm)	Mass of Rotation (pounds)	Blade Pass Frequency Range (Hz)
GE 3.8-137	6.3 - 13.6	40,124	0.3 – 0.7
Vestas V150-4.2	4.9 - 12.0	38,005	0.2 – 0.6
Nordex N149/4500	6.4 - 12.3	43,872	0.3 – 0.6
Senvion 4.2M148	5.0 – 10.5	46,297	0.3 – 0.5

The nearest operating wind turbine to a non-participating noise-sensitive receptor (#207) is approximately 1,086 feet (331 meters). Based on the existing literature findings where ground-borne vibration was below perceptible thresholds at comparable distances and frequency of rotation, ground-borne vibrations from operation of the Facility will be below the thresholds as recommended in ANSI S2.71-1983.

(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 19-9 in Section 19(k)(3) shows the low frequency ANSI 12.2-2008 and ANSI S12.9-2005/Part 4 criteria. Results from low frequency modeling show that the sound levels from the facility will be at or above the minimal annoyance levels at some receptors. The number of non-participating and participating receptors at or above the 65 dB level for each of the three low frequency octave bands are in Tables 12-2 through 12-5 of the PNIA for all turbine models under consideration.

Modeling results at the 31.5 Hz and 63 Hz low frequency octave bands has been calculated using the 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 highest manufacturer's sound power data at 16 Hz and the 31.5 Hz sound power data used for computer modeling. For the Senvion wind turbine model, no data was provided at the 16 Hz frequency, and therefore, the extrapolation was based upon the highest difference presented by a different manufacturer (GE 3.8-137). Complete octave band sound pressure level results at each receptor for each wind turbine manufacturer is presented in Appendix E of the PNIA.

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

The potential of low-frequency noise including infrasound and vibration from operation of the Facility to cause interference with the closest seismological and infrasound stations within 50 miles of the Facility 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 Broome 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 Bluestone Wind is located in Sadowa, Ontario, Canada (AS014) which is approximately 258 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, New York (BINY) approximately 24 miles to the west. Figure 12-1 of the PNIA shows station BINY in relation to the Facility Area. The next nearest USGS stations are, Erie, Pennsylvania (ERPA) approximately 229 miles to the west, and Lake Ozonia, New York (LONY) approximately 180 miles to the northeast. At these distance, adverse impacts to the regional seismological stations are not anticipated.

The two nearest hospitals to the project are the Barnes Kasson Hospital in Susquehanna, Pennsylvania approximately nine miles south of the nearest wind turbine, and the Our Lady of Lourdes Memorial Hospital in Binghamton, New York approximately 19 miles to the west of the nearest wind turbine.

(l) Post-construction Noise Evaluation Studies

The Applicant proposes post-construction sound monitoring to take place in the first year of operations and a protocol is attached in Appendix Y. 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). Sound levels will be measured 24 hours per day for at least 14 consecutive days. Testing is proposed at eight of the nearest residences to the Facility (six non-participants and two participants). The monitoring program will be conducted consistent with ANSI S12.18-1994 "Procedures for Outdoor Measurement of Sound Pressure Level". Within ANSI S12.18-1994, Method #1: "General method for routine measurements" will be followed. The program will generally be unattended but at least parts of two days and two nights will be augmented with attended observations during the program.

In addition, an attempt will be made to test at different locations within the Facility Area. These locations are described in Appendix Y. Testing at these locations is contingent upon receiving landowner permission.

Since this is a wind turbine project, the wind speeds during the sound study are important. The ground level wind speed has a direct influence on the sound levels, and is limited to 5 m/s (11 mph) by ANSI 12.18 Method #1. Ground level wind speed data will be continuously measured at 2 meters above ground level at a minimum of three locations. These wind speed locations will be coincident with sound level locations. Meteorological data, including at a minimum temperature, relative humidity, and precipitation, will be collected using either an on-site weather station or data available from the nearest New York State Mesonet system station.

Equipment which will be used for this program must include ANSI S1.4-1983 Type 1 Sound Level Meters. This instrument will have data logging capability and will be programmed to log statistical data every 10 minutes. One minute time history data will be collected as well. Audio recordings may also be collected at each site. The instruments will measure one-third octave bands from 12.5 Hz to 10,000 Hz, and A-weighted (dBA) data. This will allow for the evaluation of the 16, 31.5, and 63 Hz airborne vibration and rattle criteria. In addition, these one-third octave bands will allow for evaluation of a "pure tone" from 25 Hz to 10,000 Hz in accordance with ANSI S12.9 Part 3/Annex B Section B.1. The sound level meters will be placed no closer than 25 feet to a large reflecting surface such as the side of the house.

The following metrics will be measured at a minimum: L_{eq},, L_{10}, and L_{90}. All measurement equipment will be calibrated in the field before and after the surveys with the manufacturer's acoustical calibrator which meets the standards of IEC 60942-2003 Class 1L and ANSI/ASA S1.40-2006 (R2016). All equipment shall have been certified accurate by an independent laboratory within the 12 months prior to testing.

Additional detail regarding the equipment setup, data collection, data analysis, and reporting are included in Appendix Y.

(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 Complaint Resolution Plan for the Facility, which is attached as Appendix R, 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 local ordinances, the resident may issue a formal 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 inherent 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 local laws, 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 serrated edges help reduce turbulence and therefore noise emissions. Depending on the turbine, this may or may not be available post-construction. NROs were modeled in the PNIA assessment of noise impacts for several turbines, in order to bring the Facility in line with design goals. However, selection of NROs for the final Facility will ultimately depend on which turbine model is selected and the number of turbines constructed.

(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.

(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.

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