Cassadaga Wind Project

Case No. 14-F-0490

Exhibit 19

Noise and Vibration

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EXHIBIT 19 NOISE AND VIBRATION

A Preconstruction Noise Impact Assessment (PNIA) for the construction and operation of the Facility was prepared by Ken Kaliski and Isaac Old of RSG Inc. (RSG). This report is attached as Appendix Z to this Application. Mr. Kaliski is Board Certified through the Institute of Professional Engineers and is a licensed professional engineer (VT, NH, MA, MI, IL).

(a) Sensitive Sound Receptor Map

A map of the Noise Impact Study Area showing the location of sensitive sound receptors in relation to the Facility is provided in Figure 19-1. Sensitive sound receptors included 678 non-participating residences, two locations within Boutwell Hill State Forest, a cabin rental business, and five seasonal homes. Residences on participating parcels are not considered sensitive receptors, and impacts to such receptors have not been included in the analyses presented in this Exhibit and in the PNIA. A desktop analysis using aerial imagery and field verification was used to develop and classify sensitive sound receptors within the Facility Site boundary. For sensitive receptors outside the Facility Site boundary, only aerial imagery and limited field verification was used to identify those receptors within 1 mile of the nearest turbine. 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 assumed to be a sensitive sound receptor (i.e. residential).

(b) Ambient Pre-construction Baseline Noise Conditions

Ambient Noise Monitoring Locations

On behalf of the Applicant, RSG completed winter (leaf off) and summer (leaf on) background sound level monitoring at six representative locations within the Facility Site vicinity. Monitoring sites were chosen to capture a variety of existing sound level conditions in the Facility Site. Metrics characterizing potential soundscapes of the area were developed and sites that were diversified amongst these metrics were selected for monitoring. The various representative areas include rural residential, farming, town, low and high traffic roads, high truck traffic, and remote areas.

Each of the six locations are described below. See Figure 3 of the PNIA for locations of the monitoring sites. Photographs of the set up monitors are also included in the PNIA.

- **Monitor 1: Agricultural** - This monitor was installed at 2872 Thornton Road in Sinclairville, near the intersection with Johnson Road. It was located on the southern property line of an active dairy operation. For the winter monitoring period, the monitor was installed near the fence dividing the dairy barn from the eastern pasture. This location was next to an occupied mobile home. To mitigate transient events experienced during winter monitoring related to the residents of the mobile home, the monitor for summer monitoring was moved to the west, on the opposite side of the mobile home. The summer monitor was installed near the fence dividing the dairy barn from the adjacent pasture to the south, approximately 90 feet from the road.

- **Monitor 2: Boutwell Hill** – This monitor was installed at 7241 Housington Road, Cherry Creek, in the wooded area approximately 118 feet from the road. The monitoring location is representative of a rural residential property in a remote area, with homesteads located to the north and Boutwell Hill State Forest to the south. An anemometer was co-located with the microphone.

  Infrasound monitoring was also conducted at this site (although at a slightly different location) from March 20 to March 28, 2016. The monitor was approximately 560 feet east of Housington Road, in a clearing behind the camp located on the property.

- **Monitor 3: Charlotte Cemetery** – This monitor was installed at on the western side of Charlotte Cemetery, at 6921 CTR 77 (County Road 49) in Charlotte. The monitor was located in one of the more densely populated areas of the Facility Site, representing a town setting. The monitor was placed approximately 425 feet from Charlotte Center Road. An anemometer was co-located with the microphone.

- **Monitor 4: Nelson Road** – This monitor was installed at 6662 CTR 75 (Nelson Road) in Sinclairville. The monitoring location is representative of a rural residential landscape surrounded by active farmland and a high-speed local road. The monitor was placed behind an uninhabited residence, approximately 184 feet from the road and 75 feet from the northernmost house.

- **Monitor 5:** Pickup Hill – This monitor was installed at 6281 Pickup Hill Road in Cherry Creek. The monitor was sited behind the house situated there, approximately 131 feet from the road and 29.5 feet from the house. Although Pickup Hill includes an active dairy operation across the road, the house shielded the monitor from its higher sound levels. Thus, it is representative of a rural residential homestead adjacent to an active dairy farm. An anemometer, temperature gauge, and rain gauge were also included in the installation.

- **Monitor 6: Wooded Area** – This monitor was installed approximately 2543 feet south of Cassadaga Road and approximately 2323 feet west of North Hill Road in Cassadaga. The installation was well into the woods, approximately 328 feet from each of two open fields bordering the woods. The surrounding fields were not under cultivation; the monitoring location is representative of a remote location adjacent to low traffic roads with logging traffic.

Ambient Audio Range Sound Level Monitoring

Background sound level monitoring was performed at these six locations in the winter of 2014 (December 15 or 16 through December 30, 2014) and the summer of 2015 (June 25 through July 14, 2015). Sound level data were collected using Cesva SC310 and Svantek 979 ANSI/IEC Type I sound level meters, in accordance with standards ANSI S1.4-1983, "Specifications for Sound Level Meters" and IEC 61672-1 (2002-05), "Electroacoustics – Sound Level Meters – Part 1: Specifications". Each sound level meter's microphone was mounted on a wooden stake at a height of approximately 4 feet and protected by an ACO-Pacific hydrophobic seven-inch diameter windscreen. Before and after measurement periods, sound level meters were calibrated with Cesva CB-5, Brüel and Kjær Type 4231, or Larson Davis CAL200 calibrators. The sound level meter frequency response and settings are included Table 7 of the PNIA.

The meters continuously logged overall and 1/3-octave band sound pressure levels once each second. Audio signals from each microphone were recorded continuously throughout the monitoring period to aid in source identification. The Cesva SC310 sound level meters were connected to Roland R-05 digital sound recorders. The Svantek 979 meter recorded digital audio internally. Over 4,000 hours of sound level data were collected during this study.

Sound level data from each monitor were averaged into sequential 10-minute periods and summarized over the entire monitoring period. Data were excluded from averaging under the following conditions: rain and thunderstorm events, wind gust speeds above 11.2 miles per hour, intermittent noise not characteristic of the area, and during site setup, servicing, and microphone calibration. Had temperature reached below 14 degrees Fahrenheit, these data would have been excluded as well; however, these conditions did not exist during the study period.

Particularly during summer monitoring, biogenic sounds, including insects, frogs, and birds, were present. These are considered "seasonal sounds." To exclude these sounds, the "Ai" frequency-weighting network was applied to all logged summer data to which bird and insect sound was found. If tones[1] above 1.25 kHz were detected, then the Ai-

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[1] Sounds considered tonal that get the Ai weight applied are those for which a prominent discrete high frequency (>1.25 kHz) tone is found using either of the two methods:

1. If a 1/3 octave band exceeds the neighboring 1/3 octave band on either side by more than 5 dB (as in ANSI S12.9 Part 3 Annex B), or

weighted sound level was recalculated by summing 1/3 octave bands from 20 Hz to 1.25 kHz. This effectively removes the high-frequency portion of the sound.

This filtering method was also applied to the winter monitoring period. However, during wintertime monitoring, birdcalls were rare or non-existent and thus had no impact on the averaging. One exception occurred when a flock of geese surrounded a monitor for several minutes, honking loudly, which was excluded from the data.

Periods that were not excluded from averaging are referred to in the PNIA and in this Exhibit as “valid periods.”

Meteorological stations were co-located with selected monitors in the field. Wind speeds were logged at three of the six monitoring locations (Charlotte Cemetery, Pickup Hill, and Boutwell Hill), while air temperature and precipitation were logged at one of the locations (Pickup Hill). Wind speeds were collected every three seconds and the average and maximum for each one-minute period was logged. All other meteorological data were logged every one minute.

The four monitoring locations in the western portion of the Noise Impact Study Area (Wooded Area, Charlotte Cemetery, Nelson Road, and Agricultural) use the wind data measured at Charlotte Cemetery to determine what periods of time were invalid due to high winds. The two sites in the eastern portion of the Noise Impact Study Area (Pickup Hill and Boutwell Hill) were both equipped with anemometers for summer monitoring. Wind data from Pickup Hill were used to determine non-valid periods due to high winds for both monitoring locations for winter. The rain and temperature gauges at Pickup Hill were used to eliminate rain events and temperatures outside of equipment thresholds in the determination of valid monitoring periods. The anemometer at Charlotte Cemetery did not function properly during a storm from December 17 to 18, 2014. Likewise, it froze after December 28. Therefore, no wind data are shown for those periods.

Ambient Infrasound Level Monitoring

Ambient infrasound measurements were performed using a Svantek SV979 ANSI/IEC Type 1 sound level meter, equipped with a Svantek SV17 preamplifier and a Brüel and Kjær 4964 infrasound microphone. The microphone was mounted on a metal tripod at a height of 1.5 meters (5 feet) and covered with a custom-made infrasound windscreen, designed and constructed by Sanchez Industrial Design (SID). The windscreen is a diameter of 71 cm (28 in). The measurement system was calibrated before and after the measurement period with a Brüel and Kjær 4231 calibrator.

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2. If a 1/3 octave band exceeds the average of the two neighboring lower and two neighboring upper 1/3 octave bands on each side by more than 5 dB, the latter method is used to capture complex bird harmonic sounds that would not be considered tonal under the first method.

The sound level meter was set to log sound levels once each 10 seconds. Parameters recorded included, LG_{EQ}, LC_{EQ}, LA_{EQ}, and LG_{peak} overall sound levels, as well as 1/3 octave band sound levels over the range from 0.8 Hz to 20 kHz. Audio was also recorded by the sound level meter to aid in sound source identification.

To test the noise floor of the Svantek sound level meter, a “dummy” microphone was installed in place of the installed mic. The dummy mic has the same impedance as a real mic, but with no microphone diaphragm to react to sound. The measurement system has a very low internal noise level, below 10 dB in all 1/3 octave bands and below 0 dB between 12.5 Hz and 5 kHz. The noise floor is lower than the ISO 399-7 human audibility thresholds, except between 3.15 kHz and 5 kHz.

A second noise floor test was conducted, where the sound level meter (with microphone) was installed in a basement sound isolation room over a 20-hour period. The minimum 10-second 1/3-octave band sound levels during this period are shown in Figure 23 of the PNIA. From 0.8 to 160 Hz, the minimum sound levels are more than 5 dB higher than the dummy mic noise floor, indicating the presence of inaudible low-frequency sound and infrasound, even in that quiet environment.

A meteorological station was co-located with the infrasound level meter at Boutwell Hill. The station was a HOBOware unit, with wind speed, wind direction, temperature, and rainfall sensors. Data from the station were used to determine periods that fell outside of the equipment operational ranges. The weather station was set to log data at one minute intervals. Humidity data were obtained from the Chautauqua County-Jamestown Airport.

During analysis of the data collected at Boutwell Hill, the 10-second raw data was summarized into 10-minute periods. Data were excluded from the averaging under the following conditions: rain and thunderstorm events, wind gust speeds above 11.2 miles per hour, relative humidity over 90%, intermittent noise not characteristic of the area, and during setup servicing, and microphone calibration. Temperatures below 14 degrees Fahrenheit would have been excluded, however, such conditions did not exist during infrasound monitoring. Some seasonal biogenic sounds were present, such as birds and frogs. These were removed from the data set using the “Smart Ai” filter described above, which only eliminated high frequency sound when high frequency tones are present. In any event, the filtered bird, frog, and insect sound do not extend into or affect the results from the infrasonic region.

Baseline Noise Monitoring Results

Baseline noise data were analyzed and are reproduced in the PNIA in both temporal and spectral formats. Results were presented in three different ways, described in the bullets below. A discussion of the format of the results is provided here and summary of the results is presented below, but please see the PNIA for the graphics and plots themselves.

- Time history graphics – for each location, results are presented as graphs of sound level 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 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. Wind speed data came from the three anemometers which were paired with monitoring locations as discussed above. Wind data are presented as the maximum gust speed occurring at any time during the 10-minute interval; they are not averaged.

- One-third octave band summaries – Plots of overall unweighted spectral levels for all valid periods are provided for each monitoring site. Each point on the plot represents the statistical level of the respective one-third octave band for the specified period. Four sets of L_{50}s are presented in each plot: day and night for winter and summer monitoring periods.

- Tonal prominence of one-third octave bands were quantified for all valid periods for each monitor in each season. Tonality is defined by S12.9-2013 Part 3 – Annex B which sets a frequency dependent quantity, K_T, to indicate if a one-third octave band is tonal or not. A particular one-third octave band is considered tonal if it exceeds the level of the adjacent one-third octave by the prescribed limit. The tonality limits, K_T, are shown below in Table 19-1. Every second of monitor data was analyzed for tonality, which is expressed as seconds of tonality per 10-minute period (up to 600 seconds).

Table 19-1. Limits for One-Third Octave Band Tonality Designation

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

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

- **Monitor 1: Agricultural** – The winter soundscape at the Agricultural monitoring location was dominated by farm activities, traffic on adjacent roads, and weather patterns. Residual sound levels, as measured by L_{90} time histories, showed that winter daytime sound was actually lower at this site than during the night, due to operation of a blower that supplied heat to a dairy barn at night. Noise levels were highest during twice-daily milking sessions. Tonal analysis of winter sound monitoring data showed a prominent source in the 63 Hz one-third octave band, which is the milk pump used during milking operations. Other milking equipment or harmonics of the milk pump likely contributed to the presence of intermittent tones in the 125, 250, 630, 800, and 2,000 Hz one-third octave bands.

  The summer soundscape was also dominated by milking, but also included traffic passbys, especially during daytime hours. Tractor operations were typical during the day between milking sessions. Unlike in the winter, sound levels were lower overnight in the summer because the heater was not being used. The tonal analysis revealed fewer one-third octave bands containing tones than the winter monitoring. The major tones are located in the 63, 125, and 630 Hz octave bands. Tonal activity at 2,500 Hz and above was generated by biogenic sources and was excluded by way of Ai-weighting.

- **Monitor 2: Boutwell Hill –** Winter background sound levels at the Boutwell Hill monitoring location were dominated by wind blowing through trees, with higher sound levels (visible in L_{EQ} data) due to jet aircraft flyovers and occasional passing logging trucks. This is a quieter site typical of remote forested areas. Very little tonal sound was measured during winter monitoring at this site.

  The summer soundscape was controlled by the same factors as those in the winter, with the additional background noise due to lawn equipment, and occasional gunshots. The monitor was placed in a sheltered forested area, and no data were invalidated due to high wind speeds. Daytime truck traffic in the winter on Housington Road produced a peak in the 63 Hz one-third octave band. The elevated one-third octave bands between 63 Hz and 250 Hz observed in the summer were a result of the increased outdoor human activity, particularly the operation of lawn equipment. Tonal noises measured during summer monitoring were from insects, frogs, and birds, and were excluded from the statistical analysis of sound levels via Ai-weighting.

  Infrasound monitoring at the Boutwell Hill location showed that the L_{10} infrasound levels are up to 20 dB higher than the L_{90} levels and the L_{EQ} infrasound levels are higher than the L_{10} levels. This indicates that high levels of infrasound are generated by infrequent events, such as windy periods. Other sound sources that resulted in elevated infrasound levels included aircraft overflights and thunder. The L_{10} 1/3-octave bands in the infrasonic region are below human perception thresholds.

- **Monitor 3: Charlotte Cemetery** – Winter background sound at this monitoring site was dominated by wind blowing through nearby trees and traffic passing on Charlotte Center Road. Average sound levels were slightly higher during the day, as expected. No notable tonal sources were measured during winter monitoring.

  Summer background sound was dominated by wind blowing through nearby trees, lawn mowing, and passbys from large trucks and motorcycles. Passenger cars were not a significant source of sound at the monitor, although noise from trucks and motorcycles were frequent. Almost all of the tonal activity at the site was from biogenic sources, which were excluded from the sound level averaging by Ai-weighting.

- **Monitor 4: Nelson Road** – Like Charlotte Cemetery, winter background sound was dominated by wind and to a lesser extent by passing traffic. There were also a fair number of aircraft flyover events; many of those were masked by the sound generated by moderate winds. To the extent that a diurnal pattern appears (often masked by stormy weather), it was largely due to the reduction in both vehicular and aircraft traffic during the night. Very few tonal sources were present at this site.

  The background sound levels during summer monitoring were dominated by wind, passing traffic, outdoor activities on neighboring properties, and aircraft flyover events. The reduction of levels at night were due to diminishing human activity, particularly the decreased frequency of vehicle passbys and aircraft flyovers. However, truck passbys in the nighttime hours had an influence on the nighttime L_{EQ}. The existence of tones at the site was limited to biogenic noise at higher frequencies and a persistent bullfrog in the 315 Hz one-third octave band.

- **Monitor 5: Pickup Hill** – Winter background sound at this monitoring location was dominated by twice-daily milking operations, other dairy operations, passing traffic, wind-generated noise, and aircraft flyovers. The presence of the dairy operation is evident in the tonal analysis, with the most prominent tones at the site in the 160, 250, and 1,250 Hz one-third octave bands.

  Most of the dominant sources during the summer monitoring period were similar to those in the winter monitoring period. Seasonal tractor use took place around the property and was excluded from the statistical calculations. One significant change at the Pickup Hill site between the winter and summer monitoring periods was the addition of a latticed tower and a 10 kW BWC Excel wind turbine on the property, about 360 feet southwest of the monitor. The sound from the small wind turbine and its tower were not quantified but appeared to be masked by local wind. The tonal analysis revealed a tone in the 80 Hz one-third octave band, with a harmonic in the 160 Hz one-third octave band that was generated by the milking operation across the street. Biogenic noise above 1,000 Hz was also responsible for most of the prominent tones at the monitoring location.

- **Monitor 6: Wooded Area –** Almost all dominant sounds were due to winds blowing through the trees and aircraft flyovers. Very little traffic-related noise was observed at the monitoring location. The background sound levels at this monitoring location were lower, relative to other sites, at times, with the L_{EQ} dropping below 20 dBA on one night. The tonal analysis indicates the presence of a tone in the 500 Hz one-third octave band, whose source is unknown.

  Summer sound level monitoring revealed background noises from the same sources in summer as in winter. An apparent diurnal pattern in the sound level data was caused by a diurnal pattern in wind gust speed. The sound levels at this monitoring location declined when there was no wind in the trees, with the L_{EQ} dropping below 20 dBAi on several occasions. Almost all dominant sounds were due to wind blowing through the trees and aircraft flyovers. Only haul truck traffic on Cassadaga Road and North Hill Road was audible at the monitor. The surrounding fields were not being cultivated. The results show evidence of biogenic noise above 1,000 Hz at the monitor, as well as the existence of some unidentified tonal elements between 200 and 500 Hz.

The sound levels measured at each monitor location for each monitoring period are summarized below for the winter season and summer season in Tables 19-2, and 19-3 respectively. Typically, the equivalent continuous sound levels (L_{EQ}) at night are less than those measured during the daytime, which was true for most monitoring locations in this study. At some of the more remote sites, dominant sources of sound from human activity were not observed (other than aircraft flyovers) and levels during the day and at night were comparable. These sites also had overall lower sound levels at night, at times dropping down below 20 dBA. However, overall L_{EQ} ranged from 37 dBA to 47 dBA during the winter and 34 dBA to 50 dBA during the summer.

Table 19-2. Sound Pressure Levels at Preconstruction Monitoring Locations, Winter

Location	Average Sound Pressure Level (dBA)											
	Overall				Day				Night			
	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}
Agricultural	47	31	41	49	48	30	41	49	44	32	41	44
Boutwell Hill	40	20	30	41	41	21	31	42	38	19	28	40
Charlotte Cemetery	40	29	35	42	41	30	36	43	37	28	34	40
Nelson Road	41	25	34	43	41	27	35	43	40	24	32	42
Pickup Hill	39	25	31	39	40	25	32	40	36	24	30	39
Wooded Area	37	22	31	40	36	22	31	39	37	21	30	41
Season Average	**42**	**27**	**36**	**44**	**43**	**27**	**36**	**44**	**40**	**27**	**35**	**41**

Table 19-3. Sound Pressure Levels at Preconstruction Monitoring Locations, Summer

Location	Average Sound Pressure Level (dBA)											
	Overall				Day				Night			
	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}
Agricultural	46	27	37	47	48	31	42	49	40	25	30	42
Boutwell Hill	37	21	29	39	39	23	31	41	33	20	25	36
Charlotte Cemetery	49	30	37	44	51	32	38	46	38	29	34	40
Nelson Road	39	26	32	40	40	27	33	42	37	25	31	38
Pickup Hill	50	27	33	40	52	28	34	42	36	25	31	38
Wooded Area	34	22	28	37	35	23	29	37	33	21	26	36
Season Average	**46**	**26**	**34**	**42**	**48**	**29**	**37**	**44**	**37**	**25**	**31**	**39**

The distribution of monitoring locations throughout the Facility region provided data on a variety of soundscapes. Table 19-4 below summarizes the combined monitoring period, in which statistical averages were calculated for the entire data set, including summer and winter data. The divergence of overall equivalent continuous levels, 90th-percentile (L_{10}) and 10th-percentile levels (L_{90}) at the monitoring locations indicates that the soundscapes were dominated by transient or intermittent sounds (such as aircraft overflights or passing automobiles). Statistical nighttime levels were higher at the Agricultural site because work started before daytime hours every day and a barn heater ran through the night during the winter. In the summer, the highest nighttime L_{90} was observed at the Charlotte Cemetery monitor due to increased human activity in warmer weather around a relatively populated area.

The overall equivalent average (L_{EQ}) sound levels ranged from 36 to 49 dBA during the day and 35 to 42 dBA during the night, including both summer and winter monitoring results. The L_{90} sound levels, which are sound levels exceeded 90 percent of the time, ranged from 22 to 31 dBA during the day and 21 to 29 dBA at night. The L_{10} sound levels, which are sound levels exceeded 10 percent of the time, ranged from 39 to 50 dBA during the day and 38 to 44 dBA during the night. Facility-wide logarithmic averages of the overall levels calculated at each monitoring location are given in the bottom row of Table 19-4.

Table 19-4. Sound Pressure Levels at Preconstruction Monitoring Locations, Overall (Winter and Summer)

Location	Average Sound Pressure Level (dBA)											
	Overall				Day				Night			
	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}	L_{EQ}	L_{90}	L_{50}	L_{10}
Agricultural	46	28	40	49	48	31	42	50	42	25	36	44
Boutwell Hill	40	21	30	41	40	22	31	42	39	20	26	40
Charlotte Cemetery	47	30	36	42	49	31	37	45	38	29	34	40
Nelson Road	40	26	33	42	40	27	34	42	38	25	31	40
Pickup Hill	47	26	32	40	49	27	33	41	36	25	31	38
Wooded Area	36	22	29	39	36	23	30	39	35	21	28	40
Average	**45**	**26**	**35**	**44**	**46**	**28**	**36**	**45**	**39**	**25**	**32**	**41**

Comparison of Sound Levels to Windspeed

Wind speeds at hub height (305 feet) were measured at a meteorological tower located within the Facility Site. Sound pressure levels of both L_{90} and L_{EQ} were plotted against hub height wind speed in order to determine whether there is a correlation between wind speed and ambient sound level. Wind speeds below 4 meters per second were excluded because the proposed wind turbines would not be operational at wind speeds lower than 4 meters per second. The analysis plotted the median sound pressure level, as well as the middle 80th percentile of sound pressure level against hub height wind speed. For both L_{EQ} and L_{90} measurements, there was positive correlation between sound pressure level and wind speed, although this correlation became stronger as wind speeds increased. The correlation was also stronger for L_{90} data versus Leq data, since the L_{90} data has had intermittent anthropogenic sounds, such as car passbys, filtered out. 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. Even at 15 meters per second, the middle 80 percent ofL_{90}'s ranges from 35 to 44 dBA, a 9 dB spread. At 4 meters per second this spread is 12 dB for the L_{90} and 17 dB for the L_{EQ}. In other words, wind speed is not the sole determinant of the background sound level.

Temporal Accuracy

Temporal accuracy of the monitoring data was analyzed according to ANSI 12.9 Part 2. The standard analyzes the representativeness of the measurement data for a particular measurement location. This is accomplished through calculating the day-night average sound level (L_{dn}) for each day within the monitoring period and then determining the 95th percentile confidence interval for the data series. These confidence intervals are categorized into three classes. Class "A" is for precision measurements, with Class "B" and Class "C" being less precise. Normality of the data set is then calculated using a Kolmogorov-Smirnov test.

Analysis results are shown below in Table 19-5. Three of the sites achieved Class “A” or “B” status, and all sites fit the criteria for normality. The sites that met the criteria for Class “A” or “B” were either located near to a higher traffic road (Charlotte Cemetery and Nelson Road) or have a major nearby sound source (the pumps that were part of the dairy operations at the Agricultural site). The other sites were either in rural areas, near low traffic roads, or had a sound source added between the two monitoring seasons (the small wind turbine at Pickup Hill). More rural sites have soundscapes dominated by biogenic sounds (birds, wind, etc), that may vary more from day to day and there may also be no dominant sound source to stabilize sound levels over long periods.

The ANSI 12.9 Part 2 method is primarily intended for areas with major sound sources such as military installations, airports, roadways, and railways and is not specifically developed for rural sites.

Table 19-5. Monitoring Temporal Accuracy (ANSI 12.9 Part 2)

	Agricultural	Boutwell Hill	Charlotte Cemetery	Nelson Road	Pickup Hill	Wooded Area
Number of Samples	30	34	34	30	32	31
Upper Confidence Interval (dB)	0.7	4.2	2.6	2.0	3.8	3.9
Lower Confidence Interval (dB)	0.8	6.4	3.8	3.0	5.9	6.2
Measurement Class	A	>C	B	A	>C	>C
Normality	Yes	Yes	Yes	Yes	Yes	Yes

(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. Construction of the turbines will take place primarily on remote forested ridgelines and 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 sound propagation modeling algorithm, and modeled sound power levels (dBA) of equipment that will be used in construction. Construction sound propagation modeling was conducted at proposed Turbine 11, which is the turbine located closest to a non-participating receptor, and Turbine 1, which is located a typical distance from a non-participating receptor. Noise from the laydown area/concrete batch plant were modeled as well.

Table 19-6 shows the modeled A-weighted sound power level generated by equipment that will be used in construction at wind turbine sites and at the laydown area/concrete batch plant site, as well as sound pressure levels at the closest non-participating receptor from the turbine site or laydown area. Maps showing sound pressure level contours around these three sites are included in Figures 107-111 of the PNIA.

Table 19-6. Modeled Maximum Sound Power Levels for Construction

Equipment	Modeled Sound Power (dBA)	Sound Pressure Level at Closest Non-Participating Receptor from T11 (dBA)	Sound Pressure Level at Closest Non-Participating Receptor from T1 (dBA)	Sound Pressure Level at Closest Non-Participating Receptor from Laydown Yard/Batch Plant (dBA)
Turbine Construction Site				
Bulldozer	117	47	36	-
Backhoe	112	42	37	-
Concrete Truck	113	43	38	-
Chipper	131	61	56	-
Heavy Truck	115	42	37	-
Medium Truck	110	38	32	-
2250 S3 Lift Crane	110	35	35	-
M250 Auxiliary Crane	114	39	40	-
Excavator	115	46	41	-
Pneumatic Drill	132	54	47	-
Truck Being Loaded with Rock	118	50	44	-
Total – Site Clearing	131	61	56	-
Total – Turbine Erection	117	42	42	-
Total – Foundation	120	50	45	-
Total - Excavation	132	53	50	-
Laydown Area/Concrete Batch Plant				
Cement Blower	115	-	-	49
Cement Blower Truck	101	-	-	48
Concrete Truck - Mixing	110	-	-	44
Backup Alarm	109	-	-	43
Heavy Truck	115	-	-	35

When the sources divided among construction phase, the land clearing construction phase is the loudest at both locations. During this phase the highest 1-second Leq was 56 dBA at the closest non-participating receptor to the Turbine 1 site and 61 dBA at the closest non-participating receptor to the Turbine 11 site. At the laydown area/concrete batch plant, the highest sound level was 49 dBA.

Construction is proposed to take place from April to October at turbine sites. Major construction work, such as clearing for the access roads, will occur primarily from early morning to late evening (7:00 am to 10:00 pm); however, wind turbine erection work may extend all night, but wind turbine erection does not involve the use of louder construction equipment.

Due to the setbacks involved and the limited duration of the activities, construction noise should not create undue adverse impacts.

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

Discussion of Selected Modeling Methodologies

Sound propagation modeling was conducted under two methodologies: ISO 9613-2 and CONCAWE. A discussion of selection of these methods is provided here, in accordance with Stipulation 19(d). Specific methodologies, ground absorption values, and assumptions of these modeling methods are described under the headings below.

In the United States ISO 9613-2 is by far the most common algorithm used for sound propagation modeling, particularly for wind turbine noise. To RSG's knowledge, the only other algorithm used is CONCAWE, but only in conjunction with ISO 9613-2 for special cases of modeling annualized sound levels under varying meteorological conditions.

CONCAWE was originally developed for the petroleum energy industry in Europe. Characteristics of the model that are unique are the ability to predict sound levels for particular wind speeds and atmospheric stability classes. The CONCAWE meteorological adjustments, used with ISO 9613-2, was used for the Kingdom Community wind project, in Lowell, Vermont during permitting. In that case, one of the residences most exposed to wind turbine sound was modeled to have an annualized equivalent sound level of 40 dBA. Post-construction measurements of the same project and at the same location were conducted for seven seasons, for a minimum of two weeks per season. The turbine-only sound level averaged over all seasons was measured to be 35 dBA. That is, the model over-predicted annual average sound levels by about 5 dB. This indicates that the modeling, performed for the project, in a similar manner as described above, is conservative.

Sound Propagation Modeling – ISO 9613-2

Modeling of noise levels for operation of the Facility was in accordance with the standard ISO 9613-2, *Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation*. This standard prescribes a conservative method for calculating environmental noise from a variety of sources at a distance and predicts equivalent continuous A-weighted sound pressure levels under conditions favorable conditions for sound propagation (i.e., downwind propagation, ground-based temperature inversion). More detail on ISO-9613-2 is included in Section 11.1 of the PNIA.

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

Model input parameters are listed in Appendix B of the PNIA. Fifty-eight turbine locations were modeled with the Gamesa G114 2.625 MW turbine. This is the turbine with the highest sound power levels presented in the Article 10 Application, and was modeled in order to provide a conservative estimate of noise impacts. The Study Area was modeled with mixed ground (G=0.5) and a 2 dB uncertainty factor added to the turbine sound power. Foliage was not modeled. These model parameters have been shown to yield conservative results for noise impacts from wind turbines (Duncan and Kaliski, 2008; Bowdler et al., 2009; Evans and Cooper, 2012). Turbines were modeled at the manufacturer's guaranteed maximum sound power level of 106.6 dBA with an additional 2 dB added to account for uncertainties. 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.

The transformer sound power was determined using the National Electrical Manufacturer's Association standard, NEMA TR-1, which lists maximum sound pressure level. The model assumed the physical dimensions and sound spectrum for a similar sized transformer measured elsewhere by RSG.

Unmitigated Results

One-hour equivalent average (L_{eq1-h}) sound power level contours resulting from operation of the Facility are shown in Figure 96 of the PNIA. In this case, the highest sound level at a non-participating receptor is 51 dBA, 6 dB above the nighttime design goal for the Facility and 3 dB above the daytime design goal for the facility. A total of 41 non-participating residences exceeded 45 dBA. Sound levels at Facility Site parcel boundaries range from 30 dBA to 57 dBA.

Mitigated Results

In order for the Facility to achieve the 45 dBA $_{L(8)}$ design goal at permanent non-participating residences, Noise Reduced Operations (NROs) were applied to some proposed turbines and three turbines were removed from the array since the sound level reduction required to bring the Facility into compliance was greater than the NRO noise reduction typically available. One-hour equivalent average (L_{eq1-h}) sound power level contours resulting from operation of the Facility with NROs applied are shown in Figure 97 of the PNIA. Sound levels from the transformer were also mitigated, by assuming that the transformer is specified with a 10 dB noise attenuation package. Similar attenuation could also be achieved by installing a sound barrier around the transformer. Assuming these mitigation measures, the highest sound level at a permanent non-participating residence would be 45 dBA. The highest sound level at a seasonal home would be 48 dBA. For more information on NROs proposed for the Facility, please see 19(e)(3), below.

Annualized Modeling Using Hourly Meteorological Adjustments - CONCAWE

As described below in 19(g), the World Health Organization, in its *Guidelines for Community Noise* (1999), reviewed the latest research on the health effects of noise and 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 2000 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.

The sound propagation modeling methodology described above under the heading *Sound Propagation Modeling* calculates the maximum one-hour sound level for the proposed Facility, based on a worst-case meteorology of a moderate nighttime inversion, or equivalently, winds blowing from each source to each receptor. In reality, only one wind direction occurs at a time, and winds are not such that they are always generating the highest sound output from the turbines. As a result, the eight-hour, and annual average nighttime, L_{50}, and even L_{10} sound levels will tend to be less than the one maximum one-hour L_{EQ}.

To model the maximum eight-hour, and seasonal and annual average nighttime, L_{50}, and L_{10} sound level, sound propagation resulting from the Facility was modeled under a procedure that uses wind speed, wind direction, and temperature data collected from the existing Facility meteorological tower as well as cloud cover data from the closest National Weather Service station to model noise propagation under meteorological conditions that exist at the Facility Site. In this method, atmospheric stability was calculated based on wind speed, cloud cover, daytime/nighttime, and ceiling height, in accordance with USEPA's *Onsite Meteorological Program Guidance for Regulatory Modeling Applications*. A sound propagation model was run for 64 different combinations of wind speed, wind direction, and atmospheric stability, using the Cadna/A model and meteorological adjustments from Concawe's *The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighboring Communities*, as implemented in Cadna/A. A raw unadjusted sound level was obtained for each receptor for each hour by matching each hour's wind speed, wind direction, and stability class to those used in the model runs. The hourly sound level at each receptor was adjusted to account for the different sound power by hub height wind speed using the manufacturer sound curves. No sound will be generated below cut-in and above cut-out wind speeds. The sound power assumed in the model is adjusted based on a randomized normal distribution between -2 dB and +2 dB, such that during every hour, a randomly assigned value is added to the result. Sound levels during each night were calculated and averaged for the entire year. The model was calibrated for each receiver such that the maximum hourly sound level is the same as that run using ISO 9613-2, described above. After calibration, the calculations were repeated. Please see Section 11.3 of the PNIA for additional information on annual sound propagation modeling using meteorological adjustments.

Results

Results from annualized modeling using hourly meteorological adjustments from site-specific weather data are provided in Tables 30 and 31 of Appendix C of the PNIA, which show ambient and predicted noise levels modeled for all sensitive receptors in the Noise Impact Study Area. Under all circumstances and for all receptors, the modeling results show that WHO (1999) and WHO Europe (2009) guidelines are met. This methodology gives a higher one-hour maximum sound level than the unadjusted method from the previous section because this method uses more conservative assumptions.

(e) Future Noise Levels at Receptors During Facility Operation

(1) Future Noise Levels During Operation

Future noise levels during Facility operation have been calculated using the methodology described above in 19(d) under the heading *Sound Propagation Modeling – ISO 9613-2*. Table 29 of Appendix B provides unweighted full octave band sound levels at all sensitive sound receptors. Appendix B also includes ISO 9613-2 mitigated and unmitigated sound levels produced by Facility components (Table 27), and measured at the discrete receptors (Table 28). Appendix C of the PNIA includes A-weighted ambient and future sound levels for a variety of conditions at all sensitive receptors (Tables 30 and 31).

(2) Tonal Evaluation

Aerodynamic noise is the primary source of noise associated with wind turbines. These acoustic emissions can be either tonal or broadband. Tonal noise occurs at discrete frequencies, whereas broadband noise is distributed with little peaking across the frequency spectrum. Criteria for tonal noise at different 1/3 octave bands are defined in ANSI 12.9-2013 Part 3 – Annex B (see Table 19-1, above in 19(b)). A particular 1/3 octave band is considered tonal if it exceeds the level of the adjacent one-third octave by the prescribed limit.

While unusual, tonal noise can originate from unstable air flows over holes, slits, or blunt trailing edges on blades. Most modern wind turbines, including the Gamesa G114 2.625 MW turbine modeled in this study, have upwind rotors designed to prevent blade impulsive noise and reduce tonal noise.

Tonal prominence of the Gamesa G114 2.625 MW turbine does not meet the ANSI 12.9-2013 Part 3 - Annex B criteria in any 1/3 octave band. Therefore, tonal noise associated with the operating wind turbines is not anticipated. The transformer meets the criteria for the Fans Off (ONAN) conditions, but not the Fans On (ONAF) condition. Since the particular model for the transformer has not been chosen, the tonal prominence of the transformer that will be used is not known. Transformers are usually tonal in the 125 Hz, 250 Hz, 315 Hz, 500 Hz, or 630 Hz 1/3 octave bands during the ONAN condition, but not the ONAF condition due to masking from the cooling fans. The higher sound power of the ONAF configuration was modeled as a conservative assumption. Please see Section 11.1 of the PNIA for additional information.

(3) Turbine Model Selection and Avoidance/Minimization Measures

As described above in 19(d), sound propagation modeling assumed the wind turbines built for the Facility would be the Gamesa G114 2.625 MW turbine, which is the loudest turbine model currently proposed. Although the turbine model has not yet been selected for the Facility, the model ultimately chosen will not have sound power levels greater than the G114 2.625 MW, and could have sound power levels less than this model.

A discussion on the Applicant's avoidance and minimization of sound impacts is provided below in 19(j).

(4) Potential for Low Frequency and Infrasound

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

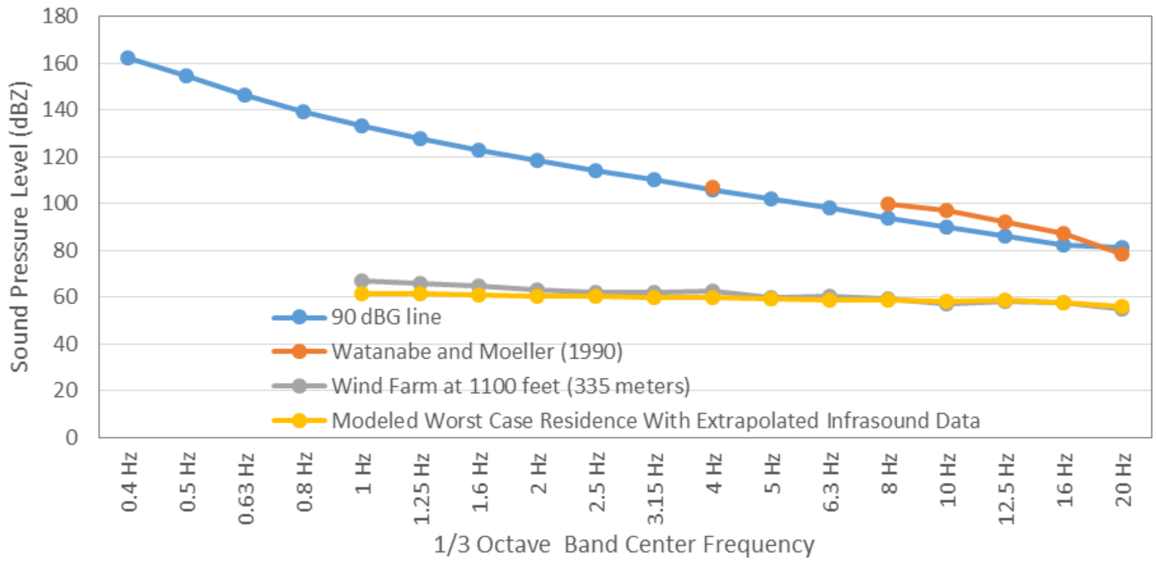
Hz, but below 100 to 200 Hz depending on the definition. Measurements of infrasound at distances from wind turbines typical of their nearest residential neighbors have consistently found that infrasound levels are below published audible human perception limits. A full review of the literature regarding wind turbines and perception of infrasound is provided in Section 4.5 of the PNIA, and is also reproduced below in 19(k)(3)(i). The review shows that wind turbine sound is often perceived as more intrusive than other environmental sound sources. This is due to the amplitude modulated character of the sound, tonal content, and low frequency content. Although wind turbines produce infrasound, it has been found to be below human hearing thresholds at receiver distances, and there is no conclusive proof that sub-audible infrasound is perceptible and can cause adverse health impacts.

While infrasound from wind farms has not been shown to be audible by humans, infrasound and low-frequency sound can create noise-induced vibration in lightweight structures. The American National Standards Institute (ANSI) standard ANSI S12.2, “Criteria for Evaluating Room Noise”, establishes low frequency noise criteria to prevent “perceptible vibration and rattles in lightweight wall and ceiling structures.” ANSI S12.9 Part 4 addresses the annoyance of sounds with strong low-frequency content; Annex D of this standard establishes a standard for minimal annoyance. Sound power levels at 16 Hz, 31.5 Hz, and 63 Hz for criteria under these two standards is provided below in Table 19-7, in comparison to extrapolated infrasonic and modeled low frequency levels predicted at the worst case non-participating receptor. The 16 Hz 1/1 octave band was extrapolated from the 31.5 Hz results assuming a slope of -4 dB per octave. Results show that the sound levels from the Facility will be below the threshold for moderately perceptible vibration and rattle in all three bands, as defined in ANSI 12.2-2008 Section 6. Furthermore, at the worst-case non-participating receptor, the Facility will generate infrasound and low frequency noise at levels below a level at which annoyance is minimal for each 1/1 octave band frequency.

Table 19-7. Low Frequency Noise Compared with ANSI 12.2 and ANSI 12.9 Standards

1/1 Octave Band Center Frequency	16 Hz	31.5 Hz	63 Hz
Modeled Worst Case Non-Participating Residence Sound Level	62 dB	58 dB	54 dB
Low Frequency Guidelines			
Clearly perceptible vibration and rattles likely (ANSI 12.2-2008 Section 6)	*75 dB*	*75 dB*	*80 dB*
Moderately perceptible vibration and rattle likely (ANSI 12.2-2008 Section 6)	*65 dB*	*65 dB*	*70 dB*
Sound Level Below Which Annoyance is Minimal (ANSI 12.9 Part 4 Annex D)	*65 dB*	*65 dB*	*65 dB*

Figure 96 of the PNIA, reproduced below as Graph 19-1 of this Exhibit, shows extrapolated modeling results from the worst case non-participating receptor. This data are extrapolated assuming a -4 dB/octave slope frequencies at and above the 16 Hz 1/1 octave band and a -1 dB/octave slope below 16 Hz. This shows that expected infrasonic sound levels are below perception thresholds.



Graph 19-1. Comparison of Modeled Sound and Extrapolated Infrasound Data with Hearing Thresholds of Watanabe and Moeller (1990) and ISO 7196 90 dBG equivalence

Please note that while sound power levels at 1/1 octave band center frequencies between 31.5 and Hz and 8 kHz are available for the Gamesa G114 2.625 MW turbine, the manufacturer does not report any infrasound data for this model.

(5) Basis of Sound Power Levels Used

Modeled sound power levels of wind turbines corresponded to the manufacturer's guaranteed maximum sound power level of 106.6 dBA, with a 2 dB uncertainty factor added to the sound power to account for uncertainties. All turbine noise data used was the most recently available from the manufacturer at the time the PNIA was prepared. As described above in 19(d), some turbines were modeled with NROs that would be applied in order to achieve Facility design goals. Sound power levels modeled at these turbines was between 1 and 5 dB less than sound power levels modeled without NROs, depending on the level of NRO applied.

The transformer sound power was determined using the NEMA TR-1 sound pressure level, along with the dimensions and spectrum of a similar sized transformer measured elsewhere by RSG. NEMA-1 TR-1 is a standard, produced by the National Electrical Manufacturers Association (NEMA), which lists minimum performance specifications for electrical transformers, regulators and reactors, including sound emissions. The standards specify maximum average sound levels for transformers, as measured at a 1 foot distance from the transformer.

(6) Amplitude Modulation Generation Estimates

Amplitude modulation (AM) is a fluctuation in sound level that occurs at the blade passage frequency. At lower magnitudes, this modulation is called “blade swish,” which is a standard characteristic of wind turbine noise. There is no consistent definition how much of a sound level fluctuation is necessary for blade swish to be considered AM, however sound level fluctuations in A-weighted sound level have been found at up to 10 dB. Fluctuations in individual 1/3 octave bands are typically more and can exceed 15 dB, although unusual. Fluctuations in individual 1/3 octave bands can sometimes synchronize and desynchronize over periods, leading to increases and decreases in magnitude of the A-weighted fluctuations. Similarly, in wind farms with multiple turbines, fluctuations can synchronize and desynchronize, leading to variations in AM depth (McCunney et al., 2014). Most AM is in the mid-frequencies and most overall A-weighted AM is less than 4.5 dB in depth (RSG et al., 2016).

There are many confirmed and hypothesized causes of AM including: blade passage in front of the tower, blade tip sound emission directivity, wind shear, inflow turbulence, and turbine blade yaw error. It has recently been noted that although wind shear can contribute to the extent of AM, wind shear does not contribute to the existence of AM in and of itself. Instead, there needs to be detachment of airflow from the blades for wind shear to contribute to AM (Renewable UK, 2013). While factors like the blade passing in front of the tower are intrinsic to wind turbine design, other factors vary with turbine design, local meteorology, topography, and turbine layout. Mountainous areas, for example, are more likely to have turbulent airflow, less likely to have high wind shear, and less likely to have turbine layouts that allow for blade passage synchronization for multiple turbines. AM extent varies with the relative location of a receptor to the turbine. AM is usually experienced most when the receptor is between 45 and 60 degrees from the downwind or upwind position and is experienced least directly with the receptor directly upwind or downwind of the turbines.

In order to determine turbulence intensity conditions present at the site, RSG analyzed one year of meteorological data take from Meteorological Tower 1, at the Facility Site. The wind speed at two anemometer heights (40 meters and 60 meters) and wind speed standard deviation were used to calculate the turbulence intensity present at the site. Turbulence intensity is the ratio of wind speed standard deviation to the wind speed at a given measurement height. Results of the analysis showed that turbulence intensity is higher during the day than at night, but is more variable during the day. Turbulence intensity levels were not higher than levels measured by RSG at other proposed wind energy projects.

Wind shear was also evaluated based on one year of meteorological data from Meteorological Tower 1. The analysis showed that wind shear is generally higher overnight, when the atmosphere is more stable, than it is during the day. In addition, wind shear is highly variable at this site. Wind shear is highest at the cut-in speed for the turbines, (i.e., when sound emissions will be lowest), and decreases with wind speed. A comparison of turbulence intensity and wind shear for the same periods showed that periods of particularly high wind shear and particularly high turbulence intensity do not occur at the same time. This is not surprising since the stable atmosphere required for high wind shear should not also be turbulent.

In summary, the Facility Site does not have higher turbulence intensity, but does have higher wind shear than other projects RSG has worked on, mostly located on ridge tops. However, it is important to note that that most periods with high wind shear do not also simultaneously have high turbulence intensity. As mentioned above, wind shear alone can exacerbate amplitude modulation, but it is not sufficient to cause amplitude modulation, so high wind shear has to be coincident with high turbulence intensity to cause high levels of amplitude modulation, an uncommon condition at the Facility Site.

(f) Predicted Sound Levels Table

The predicted sound levels based on ambient noise monitoring and sound propagation modeling are included in Appendix C of the PNIA. Graphical format sound contours are depicted in 1 dBA increments for representative external property boundaries in Figures 115-118 of Appendix B of the PNIA. Both Tables 30 and 31 (Appendix C), and Figures 119 through 122 (Appendix B) of the PNIA provide sound pressure levels modeled with applied NROs, as described in 19(e)(5).

(g) Applicable Noise Standards

Noise standards applicable to the Facility Site, as well as noise guidelines that are not required but are recommended by various agencies, are described below. More information on these standards is included in Section 4 of the PNIA.

Local Regulations

The Facility is located in three towns with formal quantitative sound level standards: the Towns of Charlotte, Cherry Creek, and Arkwright. The standards in each town are similar, but there are nuances with exceptions, measurements, and other factors that differ in each of the standards. The ordinances in these towns are summarized here, and more detail is provided in the PNIA, attached as Appendix Z. A full discussion of all local ordinances is provided in Exhibit 31. In each town standard, the limit is 50 dBA L10 at non-participating receivers, unless the ambient sound level is above 50 dBA. In that case, the limit is the ambient sound level plus 5 dB. If a facility emits a tonal sound, the sound level limit is reduced by 5 dB. All of the ordinances require the noise evaluation to be conducted by competent acoustical consultant, who shall document the noise levels at property lines and at the nearest residence not on the site. The Charlotte and Arkwright ordinances require post-construction noise testing by qualified independent third-party acoustical measurement consultant, which may be required as often as every two years.

State Standards

NYSDEC Program Policy

There is no quantitative state noise standard that applies to this Facility. There are, however, guidelines provided by the New York State Department of Environmental Conservation (NYSDEC), in *Assessing and Mitigating Noise Impacts* (NYSDEC, 2000). The document includes information about background sound level measurements, jurisdiction limits of the NYSDEC, and a review of guidelines from the other sources, among other topics. The sound level guidelines are found in Section V.B.1.c. Two types of thresholds are mentioned – one that is relative to existing background sound levels, and the other that is fixed.

Relative to existing background sound levels, the document states that permitted operations should minimize increases in sound pressure levels above ambient levels. Increases below 3 dB are have no appreciable effect on sounds receptors, and increases between 3-6 dBA have potential to cause adverse impacts to only the most sensitive receptors. Sound pressure increases above 6 dB may require a closer analysis of impacts, depending on existing ambient noise. The document states that "in non-industrial settings, the sound pressure level should probably not exceed ambient noise by more than 6 dB(A) at the receptor." Increases approaching an increase in 10 dB result in a perceived doubling of noise levels, which would warrant avoidance and mitigation measures in most cases.

The NYSDEC guidelines suggest that addition of any noise source in a non-industrial setting, should not raise the ambient noise level above 65 dBA, and that 65 dBA represents the upper limit of what would be acceptable noise conditions. Lower maximum sound pressure levels may be more appropriate when there are sensitive receptors nearby. The guidelines state that they do not "supersede any local noise ordinances or regulations."

NYSDPS Article 10

In 2012, the New York Department of Public Services (NYSDPS) revised its rules for electric generation and siting, contained in New York Code, Rules, and Regulations 16, Article 10. Exhibit 19 of these regulations requires "a study of the noise impacts of the construction and operation of the facility, related facilities and ancillary equipment," along with a list of requirements that the Article 10 Exhibit must contain. The Article 10 Regulations do not list a specific sound level limit, but instead describe information requirements and analysis requirements for a permit application. This Application is being prepared in accordance with the Article 10 regulations, and Stipulations agreed upon by DPS and NYSDEC for this Facility.

World Health Organization Guidelines

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

The WHO guidelines suggest a daytime and nighttime protective noise level. During the day, the levels are 55 dBA L_{EQ}(16), that is, an average over a 16-hour day, to protect against serious annoyance and 50 dBA L_{EQ}(16) to protect against moderate annoyance. During the night, the WHO recommends limits of 45 dBA L_{EQ}(8) (the equivalent average sound level, averaged over eight nighttime hours) and an instantaneous maximum of 60 dBA LF_{max} (fast response maximum). These are to be measured outside the bedroom window. These guidelines are based on the assumption that sound levels indoors would be reduced by 15 dBA with windows partially open. So long as the sound levels outside of the house remain at or below 45 dBA, sound levels in the bedroom will generally remain below 30 dBA. Given the climate in the vicinity of the Facility Site, this is essentially a summertime standard, since residents are less likely to have their windows open during other times of the year. By closing windows, an additional ~10 dB of sound attenuation will result. In addition to protection against annoyance, these guidelines are intended to protect against hearing impairment, speech intelligibility, sleep disturbance, and hearing impairment. Of these factors, protection against annoyance and sleep disturbance require the lowest limits.

The WHO suggest that full sentence intelligibility requires a signal to noise ratio of about 15 dB. For speech volume of 50 dBA, this would indicate some speech interference as low as 35 dBA L_{EQ} for "smaller rooms".

The WHO long-term guideline to protect against hearing impairment is 70 dBA $L_{(24)}$ over a lifetime exposure, and higher for occupational or recreational exposure.

The WHO indicate that sound sources with high levels of low frequency can be more intrusive. The guidelines do not include specific limits and instead state:

> "When noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided. For noise with a large portion of low-frequency sound a still lower guideline is recommended."

In October, 2009, WHO Europe conducted an updated literature review and built upon WHO's guidelines for nighttime noise in Europe. They added an annual average nighttime guideline level to protect against adverse effects on sleep disturbance. This guideline is 40 dB L_{night}, measured outside the bedroom window.

Federal Standards and Guidelines

There are no federal standards that apply to wind turbines on private land. Many federal agencies have adopted guidelines and standards that apply to other types of facilities; the Federal Interagency Task Force is set up to develop consistency of noise standards among federal agencies. A summary of some of these standards is provided in the PNIA. Notably, the U.S. Environmental Protection Agency (USEPA) established a guideline to protect public health and welfare with an adequate margin of safety. The maximum noise level recommended in this guideline is 55 dB L_{dn}, which is the A-weighted day-night Leq, where a penalty of 10 dB is applied to nighttime sound. More information on additional guidelines established by federal agencies is included in Section 4.3 of the PNIA.

National Academy of Sciences Study

In 2008, the National Research Council of the National Academy of Sciences issued *Environmental Impacts of Wind-Energy Projects*. This report summarized the state of understanding of wind energy projects with respect to its ecological and human impacts, the latter of which includes noise. The report found that noise is typically not an issue for residences over approximately one half a mile because sound propagation is limited by technologies that limit noise impacts. These include upwind turbines, where the rotor is in front of the tower, and variable speed turbines, where rotor speeds are lower at low wind speeds. Variable speed, upwind turbines are proposed for the Cassadaga Wind Project. These will reduce noise impacts as indicated in the National Academy of Sciences Study.

Audible Sound Design Goal

Given the scientific evidence regarding sleep disturbance and other impacts that were reviewed by WHO, the Facility is being designed to not exceed 45 dBA $L_{EQ(8)}$, which is averaged over the entire night (11 pm to 7 am) outside at non-participating permanent residences and the Arkwright, Charlotte, and Cherry Creek noise standards of 50 dBA L_{10} during the day and night. This would not apply to areas that have transient uses such as seasonal homes, camps, driveways, trails, farm fields, and parking areas, which were evaluated to the sound level limits of the town (50 dBA L_{10}). Since the L_{10} sound level is typically less than 2 dB more than the L_{EQ} for a given period, these receptors were evaluated against a 48 dBA $L_{EQ(8)}$ limit. This nighttime noise goal is more stringent than all of the federal guidelines mentioned above and will be well below the level that can cause hearing impairment according to WHO, the EPA, and OSHA. The goal is both protective of human health and hearing loss, and prevents any quality-of-life concerns.

Based on research regarding human response to wind turbine noise (Janssen et al 2011), approximately 5 percent of the population are annoyed indoors and 12 percent outdoors by exterior sound levels of 45 dBA (L_{EQ} at 8 m/s).

Please see 19(e)(4) for information on standards with respect to infrasound.

(h) Noise Standards Comparison Table

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 in compliance with all of the standards and guidelines applicable to the Facility, where applicable. The noise design goal for the Facility is the most conservative of those in the table, the 45 dBA $L_{(8)}$ standard for overnight periods.

Table 19-8. Noise Standards and Degree of Compliance

Municipality/Organization	Standard or Guideline	Overall Level	Metric	Tonal Penalty	Does Facility Comply with Standard or Guideline
Town of Arkwright	Standard	50 dBA or Ambient Sound Level plus 5 dB if the Ambient Sound Level is Above 48 dBA	L_{10}	5 dB	Yes
Town of Charlotte	Standard	50 dBA or Ambient Sound Level plus 5 dB if the Ambient Sound Level is Above 50 dBA	L_{10}	5 dB	Yes
Town of Cherry Creek	Standard	50 dBA or Ambient Sound Level plus 5 dB if the Ambient Sound Level is Above 50 dBA	L_{10}	5 dB	Yes
NYSDEC	Guideline	55 dBA L_{dn}/ Ambient Sound Level plus 6 dB	L_{dn}	-	Yes/Yes[1]
NYSDPS Chapter 10	Guideline	-	-	-	-
Word Health Organization (Night)	Guideline	45 dBA	$L_{(8)}$ - L_{EQ} Averaged Over the Night	-	Yes
World Health Organization (Day)	Guideline	50 dBA for moderate annoyance, 55 dBA for serious annoyance	$L_{(16)}$ - L_{EQ} Averaged Over the Day	-	Yes
Environmental Protection Agency	Guideline	55 dBA	L_{dn} – Annual day-night average	-	Yes

Municipality/Organization	Standard or Guideline	Overall Level	Metric	Tonal Penalty	Does Facility Comply with Standard or Guideline
Federal Interagency Task Force	Guideline	55 to 65 dB	L_{dn} - Annual day-night average	-	Yes

[1]Comparing modeled annual L_{EQ} to monitored overall L_{EQ}.

(i) Noise Abatement Measures for Construction Activities

In addition to the Complaint Resolution Plan for the Facility, which is attached as Appendix T, a Complaint Resolution Plan specific to wind turbine noise is included as Section 3.0 in the Post-Construction Noise Monitoring and Compliance Protocol, which is included in Appendix Z. this plan serves as the noise complaint-handling procedure applicable during both Facility construction and operation. The Applicant takes seriously any complaints that it receives from members of the public. Complaints will be able to be made in person at the Facility's O&M building, via phone, or by writing, and the Applicant will contact the individual within 48 hours of receipt 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.

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:

- Implementing best management practices for sound abatement during construction, including use of appropriate mufflers and limiting hours of construction where practicable, and turning off construction vehicles when not in use.

(j) Noise Abatement Measures for Facility Design and Operation

Due to the inherent size of wind turbines, physical noise control measures, such as noise barriers, active noise control, and tree plantings, are impractical. In-spite of this, some mitigation measures for noise are available. Wind turbine noise can be abated using either factory-installed measures, siting methods implemented during final Facility design, or measures implemented after the Facility is constructed. These methods are described below.

- **Wind Turbine Design –** Horizontal axis wind turbines, with three blades, positioned upwind of the tower are the only type used for utility-scale wind power. Turbines with the blades positioned downwind of the tower are obsolete and cause more noise issues than upwind designs due to the blades passing through the wake of the tower. Vertical axis wind turbines are not available in megawatt scale. The design of the blade can have a substantial impact on noise generation. Some turbine models are available with serrated trailing edge that reduces wind turbine aerodynamic noise by smoothing the flow of air behind the blade, reducing turbulence and therefore noise emissions. Depending on the turbine model selected, serrated trailing edge technology may or may not be available. On some models, serrations can be installed even after the project is constructed.

- **Facility Siting –** Changing of turbine setbacks from residences can be used to decrease sound levels, however wind turbine layouts are chosen to maximize energy production, comply with wind ordinance setback requirements, comply with setback requirements for other environmental conditions (water, flora, fauna, etc.), meet spacing requirements for the turbines themselves, facilitate access, and accommodate landowner preferences. As a result, modification of turbine arrangements to decrease sound pressure levels at receptors can have adverse effects on project performance and feasibility.

- **Noise Reduced Operations (NROs) –** NROs Noise Reduced Operations (NROs) are operational changes to reduce noise generation. NROs are usually accomplished by adjusting turbine blade pitch, slowing the rotor speed of the turbines, which reduces aerodynamic noise produced by the blades. NROs are a readily available technology on most modern wind turbines and may be used to reduce turbine sound power to a level at or below the sound power of the turbine modeled in the Application. NROs can be implemented on an as-needed basis. For example, they can be programmed for selected wind speeds, wind directions, and times of day. The programs can be adjusted at any time after the wind turbines have commenced operations. 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. Please see discussion of NROs above in 19(d) and 19(e)(5).

In addition to the Complaint Resolution Plan for the Facility, which is attached as Appendix T, a Complaint Resolution Plan specific to wind turbine noise is included as Section 3.0 in the Post-Construction Noise Monitoring and Compliance Protocol, which is included in Appendix Z. This plan serves as the noise complaint-handling procedure applicable during both Facility construction and operation. The plan is further described above in 19(i).

(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 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.

The Occupational Safety and Health Administration sets legal limits on noise exposure in the workplace, which are based on a worker's time weighted average over an 8-hour day. OSHA's permissible exposure limit (PEL) is 90 dBA for all workers for an 8-hour period (OSHA, undated); above this level, potential for hearing damage becomes more likely. Sound pressure levels at generated by Facility construction and operation at sensitive receptors will be well 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. The guideline sets an L_{EQ} of 70 dBA or less, averaged over a 40-year period. Because this standard assumes long-term exposure, only operational noise concerns are applicable. With sound propagation modeling using NROs, the highest sound level at a permanent non-participating residence would be 45 dBA $L_{(8)}$. Therefore, the Facility is not expected to result in hearing damage based on USEPA guidelines.

Similar to the USEPA guideline is the WHO long-term guideline to protect against hearing impairment, which establishes a 70 dBA $L_{(24)}$ over a lifetime exposure, with higher levels for occupational or recreational exposure. As described above, the highest construction sound level at a non-participating receptor would be 65 dBA, and the highest operational sound level at a non-participant residence would be 45 dBA $L_{(8)}$. Therefore, the Facility is well in compliance with WHO noise standards for protection against hearing impairment. The Facility is not expected to result in hearing damage based on WHO guidelines.

(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*. This document states that for speech to be intelligible when listening to complicated messages (e.g., at school, listening to foreign languages, telephone conversations), it is recommended that the speech be at least 15 dBA higher than the background ambient noise. The WHO Guidelines present 50 dBA as a casual speech level typical for both men and women, and this recommendation states that background noise not exceed 35 dBA where complicated messages are being relayed. Although speech interference is influenced by the spectrum of the masking sound, no particular guidance is given to adjust the WHO's guidelines for sound sources of different frequency content. Since speech may range from 100 Hz to 6 kHz, there will be overlap between the spectra of wind turbine noise and speech. This guideline is generally intended for classrooms and so includes corrections for the hearing impaired, reverberation, children, and lack of language proficiency. 50 dBA is also a low sound level for speech at close distances, with most normal speech being 60 dBA at close distances, as stated in ANSI 12.65-2011. Assuming that being indoors results in a 15 dBA decrease in sound pressure levels from the outdoors (WHO, 1999, p. 28), areas with outdoor levels of sound measured at 50 dBA or more would comply with this recommendation for indoors. Because all sensitive receptors are predicted to have a maximum operational sound level at 45 dBA $L_{(8)}$, the Facility will not result in interference with indoor speech, according to the WHO's recommendations.

In addition, according to WHO (1999), with a raised voice, sentences may be 100% intelligible for background noise levels up to 55 dBA. Using a strained voice, sentences spoken can be 100% intelligible even at background noise levels of 65 dBA. Modeling of sound pressure levels presented in the PNIA was done for outdoor environments, and as previously stated, sound pressure levels are not expected to exceed 45 dBA $L_{(8)}$ at sensitive receptors. Therefore, some receptors will have outdoor noise levels higher than the most conservative noise threshold (see above) under which complicated messages should be relayed (35 dBA), but will not have background noise levels equaling or exceeding the level at which the voice needs to be raised in order for sentences to be 100% intelligible (55 dBA). Therefore, any impacts to outdoor speech resulting from noise generated by the operating Facility are expected to be minor. Please see Figures 115 to 118 of Appendix B of the PNIA to see predicted future noise levels in 1 dBA increments at all outdoor areas in and immediately adjacent to the Facility Site.

In USEPA's *Protective Noise Levels* (1978), the agency sets thresholds above which noise could interfere with indoor and outdoor speech. In the document, USEPA states that "the highest noise level that permits relaxed conversation with 100% sentence intelligibility throughout the room is 45 dBA" (USEPA, 1978). Outdoor noise levels described in the guidelines depend on distance from speaker to listener and whether a raised voice or a normal voice is used, but establishes a 55 dBA conservative threshold, which would guarantee 95% sentence intelligibility outdoors with a normal speaking voice at a distance of three meters, including a 5 dBA safety margin. Because all sensitive receptors were modeled to have the highest operational sound level at 45 dBA (measured outdoors), and because USEPA indicates that sound from the outdoor to the indoor environment attenuates approximately 15 dB with windows partly open, the Facility will not result in interference with indoor or outdoor speech, as defined in USEPA guidelines.

(3) Potential for Annoyance/Complaints

(i) Review of Annoyance Literature

Sound level standards and guidelines such as those published by the World Health Organization are typically based on research conducted for transportation noise. There have been some studies that conclude that wind turbine noise is more intrusive to some listeners than a transportation source of equivalent magnitude. Suggested reasons for increased annoyance include: amplitude modulation, tonality, low frequency content, and the newness of wind turbine noise as an environmental noise source.

Some studies have looked at the response of residents surrounding wind farms relative to the audio frequency (20 Hz to 20,000 Hz) and sound level emitted by the wind turbines. Similar wide-spread studies have not compared annoyance to low frequency or infrasound levels, though there is a high correlation between A- and C-weighted sound levels (Tachibana et al., 2014). The studies that have been performed for human response to low frequency sound and infrasound from wind turbines have largely been laboratory studies.

Response in the Audio Frequency Range

Studies of human response to wind turbine sound were performed in Sweden (in 2000 and 2005) and The Netherlands (2007) by Eja Pederson and other authors (Waye, Lassman, etc.). There have been several papers about these studies, including a summary written by Janssen et al (2011) that included a combined dose response curve. The Pederson studies were performed by sending self-reporting surveys to respondents living in and around wind farms and comparing responses from these surveys to modeled sound levels at those residences. A total of 1,830 people responded to these surveys.

The Janssen dose-response curves shows that for sound at 45 dBA LEQ (calculated outdoors), there is an annoyance rate of approximately 12 percent for residents outdoors and 5 percent for residents indoors. The highly annoyed rate is 5 percent outdoors and 2 percent indoors for this sound level. Note that sound levels were calculated using the equations of the Swedish Environmental Protection Agency and assumes that receptors are always downwind of the source. A common finding among the various studies is that annoyance was lower among residents who benefited economically from the wind turbines. Annoyance also increases with age, visibility of the turbines from the residence, and noise sensitivity.

Health Canada studied health indicators among populations exposed to wind turbine sound (Michaud, 2015). Just as with Pedersen's studies, self-reporting surveys were distributed to participants (1,238 in total). Correlations were found between wind turbine modeled sound levels and annoyance towards noise, shadow-flicker, turbine visibility, blinking lights, and vibration. Although C-weighted sound levels were calculated for the study, A-weighted levels were primarily assessed, due to the high correlation between A-weighted and C-weighted levels (R^2=0.88). The rate of highly annoyed residents due to wind turbine noise was found to be approximately three percent at sound levels between 40 and 46 dBA. This sound level assumes wind turbines emissions at an 8 m/s wind speed measured at a height of 10 meters. Also note, that the Health Canada study assumed a ground absorption factor of G=0.7 with no uncertainty factor added to the wind turbine sound power, so levels modeled by Health Canada will be about 3 dB lower than the equivalent scenario modeled in this report.

A Japanese study also looked at the relative annoyance of residents surrounding wind farms, compared with the $L_{EQ,n}$, or average of the A-weighted 10-minute sound levels from each hour over the night with the wind turbine(s) at their rated capacity (Kuwano et al., 2014).The $L_{EQ,n}$ measured by the study is lower, on average, than the sound level downwind with the ten meter wind speed at eight m/s, due to the directionality of turbines. Due to differences in wind farm layouts (single turbine, grid layout, ridgeline layout, etc.), this difference was not readily determined. The authors estimated that, on average, the $L_{EQ,n}$ will be about 6 dB less than the L_{dn}. Using this assumption, the authors found that wind turbine noise is between 6 and 9 dB more annoying than road traffic noise. The study found that between 41 and 45 dB $L_{EQ,n}$ approximately 14 percent of respondents were extremely annoyed and 19 percent were moderately annoyed (Yano et al., 2013). Other findings included that visual disturbance was well correlated with wind turbine noise disturbance, and that insomnia, though low in incidence overall, was more prevalent near wind turbine sites. Insomnia was also found to be related to visual disturbance. Wind turbine noise was also found to have an effect on sleep disturbance for a small portion of respondents, when audible.

Response in the Infrasound Frequency Range

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.

Measurements of infrasound at distances from wind turbines typical of their nearest residential neighbors have consistently found that infrasound levels are below published audible human perception limits. O'Neal et al. (2011) measured sound from wind projects that used the GE 1.5 sle and Siemens SWT 2.3-93 model wind turbines. They found that at typical receptor distances away from a wind turbine, more than 1,000 feet away, wind turbine sound is typically audible starting at 50 Hz.

Tachibana et al. (2014) measured sound levels from 34 wind projects around Japan over a three-year period. They found that infrasound levels were “much lower than the criterion curve” proposed by Moorehouse et al. (2009). RSG et al. (2016) studied infrasound levels at two wind turbine projects in the northeastern U.S. Both indoor and outdoor measurements were made. Comparisons between turbine-on periods and adjacent turbine shutdown periods indicated the presence of wind-turbine-generated infrasound, but well below ISO 389-7 (ISO, 2013) and Wattanabe et al (1990) perception limits. In their review of several wind turbine measurement studies (including O’Neal et al. (2011) and Tachibana et al. (2014)), McCunney et al. (2014) did not find evidence of audible or perceptible infrasound levels at typical residential distances from wind projects.

Authors Salt and Huller (2010), Pierpont (2009), and Schomer et al. (2015) have theorized that infrasound from wind farms can be perceived by humans and cause adverse reactions, even when it is below measured audibility thresholds. Some of these theories have focused on the human vestibular system, hypothesizing that sub-audible infrasound could stimulate the vestibular system, upsetting the human body’s manner of determining balance and causing symptoms such as dizziness, nausea, and headaches, along with disruptions in sleep. In response, McCunney et al. (2014) and Leventhall (2013) contend that there has been no demonstration that humans can perceive sub-audible infrasound, citing the relative insensitivity of the inner ear (where the vestibular system is located) to airborne sound and the presence of other low to moderate magnitude infrasound sources in the body and the environment.

Yokoyama et al. (2014) conducted laboratory experiments with subjects exposed to synthesized infrasound from wind turbines. In one experiment, he filtered synthesized wind turbine sound to eliminate high frequency sound at ten different cutoff frequencies from 10 Hz to 125 Hz. The results indicate that when all sound above 20 Hz was filtered out, none of the respondents could hear or sense the wind turbine sound. In a second experiment correlating the subject response of wind turbine sound to different frequency weighting schemes, they found that the subjective loudness of wind turbine sound was best described by the A-weighted sound level rather than other weightings that focused on low-frequency sound or infrasound.

Hansen et al. (2015) compared subject response to infrasound and “sham” infrasound. In one case, recordings of wind turbine noise, filtered to exclude sound above 53 Hz, were presented to subjects with the infrasonic content present, with only the infrasonic content present, and with the infrasonic content removed. Results showed that adverse response to the sound, was determined by the low frequency, not infrasonic content of the sound. A study by Walker and Celano (2015) found that feelings of nausea and annoyance were more correlated with audible range blade swish than infrasonic components.

Research by Tonin, et al. (2015) found that response to infrasound was more determined by information the subject had received than the presence of infrasound in a sound signal.

(ii) Evaluation of Potential for Complaints/Annoyance

Modified Composite Noise Rating

Potential for community annoyance and complaints was resulting from noise generated by the Facility was determined using the Modified Composite Noise Rating (CNR) methodology (Bolt Beranek and Newman Inc., 1984). The end result of the CNR is a letter-grade which provides an estimate of the community response to the noise. The grades go from "A" to "I", with "A", "B", and "C" being no community reaction, "D" being sporadic complaints to "I" being vigorous community action. CNR methodology takes into account level and spectral shape of noise source, level and spectral shape of background sound, character of the sound (i.e., low frequency, tonal, impulsive), seasonality, time of day, intermittency, and previous exposure/community attitude. In this case, because turbines will operate day and night, in all seasons, temporal factors and seasonality was not taken into account. Also, although noise generated from the turbines reaching sensitive receptors is not tonal, does not contain low frequencies, and is not impulsive, turbine noise was assigned a penalty because some sources show that people find wind turbine noise more annoying than other common sound sources, like traffic. Therefore, a +1 penalty to wind turbine noise was applied. Because there are other wind farms nearby, the community has had some exposure to wind turbine sound. Therefore, a -1 correction to the wind turbine noise was applied. Further detail on CNR methodology is included in Section 11.4 of the PNIA.

Table 19-9, below, shows the predicted CNR for the Facility, modeled under quietest times (L_{90}), typical times (L_{50}), and average times (L_{EQ}). The background sound level correction for the quietest periods, based on the overall L_{90}, is +2 for each monitoring location. Thus, the lowest possible Rank for any receptor is "C" in this case. Under this scenario, most of the non-participating receptors (68%) are ranked as CNR "C", with 29% at "D", and 3% in "E". See Table 19-9, below.

However, RSG believes that this is somewhat misleading, since the quietest periods represented by the L_{90} are also correlated with the lowest wind speeds when the wind turbines are operating at lower sound powers, or are not operating at all. Due to low L_{90} sound levels in the Facility Site, it is impossible for the Facility to receive a rating of less than “C”, even with Facility-only sound levels below the threshold of hearing. Therefore, RSG also calculated the CNR based on the L_{50} and L_{EQ}, or the median and energy average sound levels in the area. Under the L_{50} scenario, 90% are ranked as CNR “C”, with 10% at “D” (Table 19-9). Under the L_{EQ} scenario, 93% are at CNR “A”, 5% are at CNR “B”, and 3% are at CNR “C”.

Table 19-9. Composite Noise Rating at Non-Participating Receptors

Rank	Percent of Homes		
	Quiet Times (L_{90})	Typical Times (L_{50})	Overall (L_{EQ})
A	0%	0%	93%
B	0%	0%	5%
C	68%	90%	3%
D	29%	10%	0%
E	3%	0%	0%
F	0%	0%	0%

Annoyance Based on Janssen et al. (2011) Dose Response Curve

Future noise modeling results of 659 sensitive receptors was evaluated using the Janssen et al. (2011) dose response curves (described above in this section under the heading “Response in the Audio Frequency Range”) in order to predict the number of receptors that would be highly annoyed indoors and outdoors. Each residence was calculated individually, but the total population of the receptors (i.e., as individuals) was not estimated. Results are shown below in Table 19-10. Based on the Janssen et al. (2011) dose response curves, approximately three receptors will be highly annoyed indoors and seven outdoors based on the mitigated configuration. It should be noted that the Janssen et al. (2011) dose response curve was generated using survey data from Sweden and the Netherlands, and does not account for factors such as background noise levels specific to the community in the vicinity of the proposed Facility. The CNR methodology (described above), which does take community-specific factors in to account found that for L_{EQ} sound levels, the proposed Facility is not expected to illicit a reaction from any non-participating receptor.

Table 19-10. Estimated Highly Annoyed Receptors

Sound Pressure Level (1-hour L_{EQ} - dBA)	Number of Receptors	Percent Highly Annoyed Indoors	Percent Highly Annoyed Outdoors	Receptors Highly Annoyed Indoors	Receptors Highly Annoyed Outdoors
30	15	-	-	0.0	0.0
31	16	-	-	0.0	0.0
32	28	-	-	0.0	0.0
33	39	-	0.0	0.0	0.0
34	21	0.0	0.2	0.0	0.0
35	60	0.2	0.2	0.1	0.1
36	55	0.2	0.3	0.1	0.2
37	62	0.3	0.5	0.2	0.3
38	72	0.3	0.6	0.2	0.4
39	59	0.4	0.9	0.2	0.5
40	51	0.4	1.2	0.2	0.6
41	40	0.5	1.6	0.2	0.6
42	56	0.7	2.2	0.4	1.2
43	42	0.9	2.9	0.4	1.2
44	35	1.2	3.8	0.4	1.3
45	8	1.6	4.9	0.1	0.4
46	0	2.1	6.2	0.0	0.0
47	0	2.8	7.8	0.0	0.0
48	0	3.6	9.6	0.0	0.0
49	0	4.6	11.6	0.0	0.0
50	0	5.8	14.0	0.0	0.0
Total	**659**			**2.6**	**7.0**

(4) Potential for Sound-Induced Vibration and Annoyance

A discussion of the potential for sound induced vibration and annoyance resulting from the operating Facility is provided above in 19(e)(4). The potential for the Facility to result in perceptible vibrations was evaluated against ANSI S12.2 low frequency criteria to prevent “clearly perceptible” and “moderately perceptible” vibration and rattles in lightweight wall and ceiling structures. The Facility was also evaluated against annoyance criteria outlined in ANSI S12.9 Part 4 Annex D, which establishes a standard for minimal annoyance due to vibrations resulting from low frequency noise and infrasound. Table 19-7, above in 19(e)(4) shows the modeled (and for infrasound, extrapolated) sound pressure levels for each of the following 1/1 octave band center frequencies: 16 Hz, 31.5 Hz, 63 Hz. The Facility will fall below thresholds for clearly perceptible vibration and rattles, moderately perceptible vibration and rattles, and annoyance from vibration and rattles at the worst-case non-participant Therefore, the Facility is not expected to result in perceptible vibration or rattles or annoyance from vibration and rattles.

(5) Potential for Structural Damage and Interference Technological, Industrial, or Medical Activities that are Sensitive to Sound

Given that the Facility is not anticipated to result in perceptible noise-induced vibrations or rattles, there is also no potential for structural damage due to vibrations or rattles from operational wind turbines. The PNIA also evaluated whether any infrasound monitoring stations related to the Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) could be impacted by the Facility. The organization runs infrasound monitoring sites that can detect infrasound related to large explosions and other infrasound events. The closest CTBTO monitoring station is in Ottawa, Canada. This station is over 400 km to the northeast of the proposed Facility. Considering this large distance and relatively low infrasound emissions from the Facility, it was determined that there is no potential for impact to the CTBTO's ability to monitor infrasound.

In addition, the Applicant is unaware of any highly sensitive medical equipment that could be affected by infrasound or noise-induced vibration in the vicinity of the Facility.

(l) Post-construction Noise Evaluation Studies

A post-construction noise monitoring and compliance protocol developed by RSG is included in Appendix Z of this Application.

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

The Applicant takes seriously any complaints that it receives from members of the public. In addition to the Complaint Resolution Plan for the Facility, which is attached as Appendix T, a Complaint Resolution Plan specific to wind turbine noise is included as Section 3.0 in the Post-Construction Noise Monitoring and Compliance Protocol, which is included in Appendix Z. this plan serves as the noise complaint-handling procedure applicable during both Facility construction and operation. 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 at the Facility's O&M building, via phone, or by writing. 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 B of the PNIA prepared by RSG. 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.

(1) Comparison of Existing Noise versus Future Noise Levels

Future noise levels of the Facility will be in compliance at all receptors with ordinances established by local laws, noise levels recommended by WHO guidelines (45 dBA $L_{EQ(8)}$, the Facility design goal), and both the noise level threshold and the increase in noise recommended by NYSDEC. Table 19-8 above in 19(h) lists standards applicable to the Facility and compliance with them. Ambient and future sound pressure levels under a variety of conditions and assumptions were modeled for every sensitive sound receptor, and are included in Appendix C of the PNIA.

No applicable annoyance/complaint thresholds or guidelines are specifically established. However, an analysis for annoyance and complaints is provided in 19(k)(3)(ii), and is also discussed below in 19(n)(2).

This Exhibit has been prepared in accordance the requirements of 16 NYCRR § 1001.19.

(2) Impact Estimates

(i) Percentage of the Population Expected to be Impacted by Noise

The Facility has been designed to avoid noise impacts by adhering to established setbacks. In addition, the Applicant will apply appropriate NROs in order to achieve design goals. The design goal (45 dBA $L_{EQ(8)}$), which is the recommended by the WHO for protection against sleep and other disturbance, is more stringent than other all standards applicable to the Facility. All of the non-participating receptors are modeled to at or below this level.

However, despite being in compliance with all applicable ordinances and standards, the Facility may cause some potential for complaints. According to the analysis of potential for annoyance based on the dose response curves developed by Janssen et al. (2011), 0.5% of receptors may be highly annoyed indoors, and about 1.1% of receptors may be highly annoyed outdoors, based on a total of 678 sensitive receptors evaluated in the analysis. However, it should be noted that the results of the CNR methodology (described in 3(i)(2) above) indicate that no reaction to turbine noise is expected from any non-participating receptor during energy average background sound level conditions. Please see 19(k)(3)(ii) for additional information on calculation of potential for annoyance.

(ii) Absolute Value of the Population Expected to be Impacted by Noise

As described above in 19(n)(2)(iii), all of the non-participating sensitive receptors are modeled to be in compliance with the 45 dBA $L_{EQ(8)}$ impact threshold design goal for the Facility.

Despite being in compliance with applicable ordinances and standards, the Facility may cause some potential for complaints. According to the analysis of potential for annoyance based on the dose response curves developed by Janssen et al. (2011), three receptors may be highly annoyed indoors, and about 7 receptors may be highly annoyed outdoors. However, it should be noted that the results of the CNR methodology (described in 3(i)(2) above) indicate that no reaction to turbine noise is expected from any non-participating receptor during average background sound level conditions. A total of 678 receptors were evaluated in this analysis. Please see 19(k)(3)(ii) for additional information on calculation of potential for annoyance.

As stated above, the Applicant takes seriously any complaints that it receives from members of the public. In addition to the Complaint Resolution Plan for the Facility, which is attached as Appendix T, a Complaint Resolution Plan specific to wind turbine noise is included as Section 3.0 in the Post-Construction Noise Monitoring and Compliance Protocol, which is included in Appendix Z. this plan serves as the noise complaint-handling procedure applicable during both Facility construction and operation. 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 at the Facility's O&M building, via phone, or by writing. 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.

Based on the results of the PNIA, which shows adherence of the Facility to appropriate noise guidelines and Town noise ordinances, potential adverse impacts due to sound from the construction and operation of the proposed Facility have minimized to the greatest extent practicable.

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