

BLUESTONE WIND

PRE-CONSTRUCTION SOUND LEVEL IMPACT ASSESSMENT



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1.0 EXECUTIVE SUMMARY

The proposed Bluestone Wind project will be located in Broome County, NY. The project is expected to be approximately 124 MW using 33 wind turbines and ancillary structures. This report is a noise impact assessment required under section 1001.19 as part of the NY State Article 10 process.

This document contain(s) confidential commercial information, trade secrets, and/or proprietary information and as such is entitled to confidential treatment under Section 87(2) of the New York State Public Officers Law and the Commission's regulations (16 NYCRR 6-1). An un-redacted version of this document has been submitted under separate cover pursuant to 16 NYCRR 6-1.4.

Noise Standards and Design Goals

The project will be located within two towns, both of which have local noise standards. In Sanford, sound levels generated by wind turbines are limited to 50 dBA measured at a non-participating residence. This standard applies day or night. The Town of Windsor has a noise ordinance but has confirmed and agreed to in stipulations that it is not applicable to this facility.

As part of the project, noise design goals were developed based on a literature review of health-based standards, guidelines on sound and annoyance, and previous Siting Board proceedings in order to balance reasonable development and minimize potential impacts from the Facility. These design goals include a 45 dBA nighttime limit at a non-participating residence. This is guided by the World Health Organization's (WHO) eight-hour guideline for sleep disturbance. A nighttime design goal of 55 dBA is established for a participating residence. Another design goal for non-participating residences is to prohibit a "pure tone" in accordance with ANSI S12.9 Part 3/Annex B Section B.1, or impose a 5 dBA penalty to the broadband limit if a pure tone occurs.

Wind turbines produce infrasound but these levels are well below human thresholds of audibility. However, infrasound and low frequency energy can result in airborne vibration within homes if the levels are high enough. American National Standard ANSI S12.9-2005/Part 4 identifies that low frequency sound annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each less than 65 dB. These levels will be design goals at the exterior of a home to conservatively assess the potential for low frequency annoyance.

An annual nighttime level of 40 dBA ($L_{eq, \text{night, outside}}$) at a non-participating residence is another design goal consistent with the Certificate conditions of Cassadaga Wind (case #14-F-0490). This covers all the eight-hour nighttime periods over the course of an entire year (365 days). This same annual nighttime design goal is 50 dBA at a participating residence.

Other design goals include meeting the NYS DEC Noise Policy at locations on DEC lands, limiting 1-hour sound levels to 55 dBA or less at non-participating property lines, 50 dBA at non-residential receptors (i.e. historic venues, cemeteries, playgrounds), and no perceptible indoor vibrations at non-participating residences.

Existing Condition Sound Monitoring

Consistent with Stipulation 19(b) agreed to by the parties in this proceeding, existing condition sound levels were measured at seven locations in and around the project site during both summer and winter seasons. Sound levels were measured for two weeks collecting both broadband (dBA) and one-third octave band data, as well as ground-level and hub-height wind speeds. Additional infrasound measurements were also collected at one location in each season. All data were processed to remove invalid, intermittent, and seasonal noise in order to calculate the L_{eq} and L_{90} ambient sound levels required in the Article 10 regulations.

Future Sound Modeling

Consistent with Stipulation 19, the expected future sound levels from the project were modeled at all sensitive sound receptors identified in the project area. Sound power levels from four potential wind turbine models under maximum sound power conditions were used in the model, plus a 2 dB manufacturer's uncertainty factor. The first round of modeling estimated the highest 1-hour L_{eq} from the project. This was done using the ISO 9613-2 propagation standard and every wind turbine was assumed to be operating simultaneously at maximum sound level. The second round of modeling also used the ISO 9613-2 propagation standard but included adjustments to the maximum sound power levels using one year of on-site meteorological data to calculate an estimated worst-case (L_{10}), typical (L_{50}), and annual nighttime ($L_{eq, \text{night- outside}}$) sound level at each receptor. Sound levels from construction activities at the most potentially impacted areas were modeled for the major phases of construction.

Conclusions

The detailed analyses presented in this report confirm that the Facility construction and operation has been designed to comply with the noise and vibration design goals and applicable standards. Table ES-1 summarizes each of the eleven design goals and standards, and indicates the compliance status of the project with each one.

As detailed below, two potential wind turbine models meet the annual $L_{eq, \text{night- outside}}$ design goal and two potential wind turbine models do not meet this goal. In addition, a few non-participating locations show modeled 16 Hz levels slightly above the design goal under all four potential wind turbine models, and these locations are addressed through the minimization and mitigation measures identified below. The final analysis will be refined to model only the selected wind turbine model. Therefore, at this stage of permitting,

adverse impacts from noise and vibration from the construction and operation of the Bluestone Wind project have been avoided or mitigated to the maximum extent practicable.

Table ES-1 Summary of Compliance with Sound Standards and Design Goals – Bluestone Wind

#	Municipality or Organization	Sound Level Limit	Assessment Location	Noise descriptor	Period of Time	Participant Status	Comply?
1	Town of Sanford Renewable Energy Systems §1402.5(A)(5)	50 dBA	Exterior wall of the nearest non-participating residence	Not stated (assumed Leq)	Not stated (assumed 1-hour); day or night	Non-participant	Yes
2	Program Policy Assessing and Mitigating Noise Impacts issued by the New York State Department of Environmental Conservation (NYSDEC), Feb. 2001	6 dBA increase over ambient	Areas of human use	L90	Not stated	NYS DEC lands	Yes
3	Design goal (1999 WHO Guidelines)	45 dBA ¹	At residence	Leq	8-hour; nighttime	Non-participant	Yes
4	Design goal (1999 WHO Guidelines)	55 dBA	At residence	Leq	8-hour; nighttime	Participant	Yes
5	Design goal	55 dBA	Property line and lands except wetlands	Leq	1-hour; day or night.	Non-participant	Yes
6	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	40 dBA	At residence	Leq, night, outside	Annual; nighttime	Non-participant	Yes (Vestas; Senvion) No (GE; Nordex)

¹ Subject to a 5 dBA penalty if a prominent tone occurs. See goal 9 for details.

Table ES-1 Summary of Compliance with Sound Standards and Design Goals – Bluestone Wind (Continued)

#	Municipality or Organization	Sound Level Limit	Assessment Location	Noise descriptor	Period of Time	Participant Status	Comply?
7	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	50 dBA	At residence	Leq, night, outside	Annual; nighttime	Participant	Yes
8	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	65 dB at 16, 31.5, 63 Hz	At residence	Leq	1-hour; day or night	Non-participant	No (16 Hz) Yes (31.5; 63 Hz)
9	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	No pure tone or 5 dBA penalty if a prominent tone occurs	At residence	Leq	1-hour; day or night	Non-participant	Yes
10	Design goal (ANSI/ASA S12.9-2007/Part 5)	50 dBA	Non-residential (historic venues; cemeteries; playgrounds; etc.)	Leq	1-hour	Non-participant	Yes
11	Design goal for vibrations.	Not perceptible indoor vibrations	At residence	See ANSI S 2.71-1983 (R August 6/2012) for details	See ANSI S 2.71-1983 (R August 6/2012) for details	Non-Participant	Yes

2.0 INTRODUCTION

This report is a pre-construction noise impact assessment (PNIA) of the proposed Bluestone Wind required under section 1001.19 as part of the NY State Article 10 process.

The Bluestone Wind Project is a proposed 124-megawatt (MW) project located within the Towns of Windsor and Sanford, Broome County, New York. The proposed Facility consists of the construction and operation of a commercial-scale wind power project, including the installation and operation of up to 33 wind turbines, together with the associated collection lines, access roads, meteorological towers, and operation and maintenance (O&M) building. These turbines and related facilities will be sited within privately-owned leased land within an approximately 5,700-acre Facility Site. To deliver electricity to the New York State power grid, the Applicant proposes to construct a collection substation, and a point of interconnect substation including a battery storage facility, which will interconnect with NYSEG's existing Afton to Stilesville 115 kV transmission line, in the Town of Sanford.

The PNIA was conducted in accordance with the Article 10 regulations and the stipulations among the parties. The report includes the following elements:

- ◆ Project description
- ◆ Discussion of sound level limits, regulations, guidelines, and goals for the project
- ◆ Discussion of human response to wind turbine noise, including annoyance
- ◆ Description of existing condition sound level measurement program
- ◆ Sound level measurement results from two seasons of monitoring
- ◆ Sound level propagation modeling procedures
- ◆ Sound level modeling results
- ◆ Wind shear and turbulence intensity
- ◆ Construction sound level procedures and results
- ◆ Other potential community noise impacts
- ◆ Detailed appendices of model inputs and results tables
- ◆ Glossary of terms

3.0 PROJECT DESCRIPTION

The proposed Bluestone Wind Project (the “Project”) is being developed by Bluestone Wind, LLC (the “Applicant”) an indirect subsidiary of Calpine Wind Holdings, LLC. The Project is a proposed 124-megawatt (MW) project located within the Towns of Windsor and Sanford, Broome County, New York.

The proposed Facility consists of the construction and operation of a commercial-scale wind power project, including the installation and operation of up to 33 wind turbines, together with the associated collection lines, access roads, meteorological (“met”) towers, and one operation and maintenance (O&M) building. These turbines and related facilities will be sited within privately-owned leased land within an approximately 5,700-acre Facility Site.

To deliver electricity to the New York State power grid, the Applicant proposes to construct a collection substation, and a point of interconnect substation including a battery storage facility, which will interconnect with NYSEG’s existing Afton to Stilesville 115 kV transmission line, in the Town of Sanford. The interconnect substation will be the typical three ring break configuration, will not contain any new noise sources, and thus was not included in the noise study. A 10 MW battery storage component is included as part of the project, and will be located adjacent to the collector substation.

The Applicant is considering a range of turbine models for the Facility. For this PNIA, four (4) wind turbine generators (WTGs) were analyzed²:

- ◆ General Electric (GE) 3.8-137; hub height (HH) of 131 meters
- ◆ Vestas V150-4.2; HH = 127 meters
- ◆ Nordex N149/4500; HH = 125 meters
- ◆ Senvion 4.2M148; HH = 130 meters

The collector substation will contain a single 34.5/115 kV step-up transformer rated at up to 222 MVA. 392 discrete receptors were analyzed for the project. These include 97 seasonal residences, 276 year-round residences, 4 public places, and 15 unknown (not verifiable) receptors. All unknown receptors were conservatively assumed to be residences.

² A fifth WTG is also under consideration, the Siemens Gamesa Renewable Energy (SGRE) SG4.2-145; HH = 127 meters. However, no sound power level data were available for this WTG at the time of submission.

4.0 REGULATIONS, GUIDELINES, AND EVALUATION CRITERIA

4.1 Local Regulations

Bluestone Wind is located within the Towns of Sanford and Windsor, Broome County, NY. Broome County does not have any noise regulations applicable to wind turbine operation. In Sanford, Local Law #1-1992 was amended by Local Law #1 of 2017 to add a new Article XIV entitled “Renewable Energy Systems.” Section 1402.5(A)(5) limits sound levels generated by operation of WECS (Wind Energy Conversion Systems) to 50 dBA measured from the exterior wall at a non-participating residence. This standard applies day or night. Neither the metric nor the time period of evaluation is stated in the standard. For purposes of this assessment, a one-hour Leq (day or night) was assumed consistent with NYS DEC solid waste noise limits [Part 360-1.14(p)].

In Windsor, Local Law No. 1 of 2016 amended Chapter 68 “Noise Control.” Section 68-8 contains daytime and nighttime maximum permissible continuous sound levels based on land use (Residential; Business; Commercial). However, Section 68-9(17) states that the provisions of Section 68-8 do not apply to projects under the purview of Article 10. Therefore, the Town of Windsor local limits will not be evaluated for this Project.

4.2 New York State

This project falls under the jurisdiction of the NY State Board on Electric Generation Siting and the Environment “Article 10” regulations. Part 1001.19 “Exhibit 19: Noise and Vibration” contains the required elements of the regulation. These regulations do not list quantitative sound limits applicable to this project, but rather all the factors that must be considered in the noise study. . In a previous proceeding for the siting of a wind project, the Siting Board established standards and design goals at nonparticipating residential receptors as a condition to the operation of the facility. (See Application of Cassadaga Wind LLC, *Order Granting Certificate of Environmental Compatibility and Public Need, With Conditions*, Case No. 14-F-0490, dated January 17, 2018; Conditions 70-73; 80-83).

The NYSDEC has published a guidance document³ for assessing noise impacts (NYSDEC, 2001). This DEC policy states that the US EPA “Protective Noise Levels” guidance found that an annual sound level of 55 dBA L_{dn} was sufficient to protect the public health and welfare, and in most cases, did not create an annoyance. A 55 dBA L_{dn} would be equivalent to a daytime sound level of 55 dBA, and a nighttime sound level of 45 dBA, or a continuous level of approximately 49 dBA. The guidance document states that the addition of any noise source, in a non-industrial setting, should not raise the ambient noise level above a maximum of 65 dBA. This guidance document also states that sound level

³ Program Policy Assessing and Mitigating Noise Impacts issued by the New York State Department of Environmental Conservation (NYSDEC), Feb. 2001

increases from 0-3 dBA should have no appreciable effect on receptors, increases from 3-6 dBA may have potential for adverse noise impact only in cases where the most sensitive of receptors are present, and increases of more than 6 dBA may require a closer analysis of impact potential depending on existing sound levels and the character of surrounding land use and receptors. An increase of 10 dBA deserves consideration of avoidance and mitigation measures in most cases. The DEC policy will be used to evaluate any NYS DEC lands within one mile a wind turbine.

4.3 Federal Guidelines

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

4.4 World Health Organization Guidelines

A useful guideline for putting sound levels in perspective is the “Guideline for Community Noise” (World Health Organization, Geneva, 1999). Table 4.1 in this document states that daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. At night, sound levels at the outside facades of the living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open. The time base for these World Health Organization (WHO) sound levels is 16 hours for daytime and 8 hours for nighttime. In other words, they are not 10-minute averages but over a longer period of time. The 16-hour and 8-hour timeframes are considered short-term time periods.

In 2009 the WHO released another report entitled “Night Noise Guidelines for Europe.” The 2009 WHO report recommends a Night Noise Guideline (NNG) of 40 dBA. However, the 40 dBA guideline is an “ $L_{eq, night, outside}$ ” descriptor, which is NOT the same as a short-term measurement. $L_{eq, night, outside}$ is defined as the A-weighted long-term average sound level determined over all the night periods of a year; in which the night is eight hours (23:00 to 07:00 local time). Thus, the $L_{eq, night, outside}$ is an annual average, and is not an appropriate descriptor to use for evaluating a permit’s compliance criteria. An annual design goal is not a standard and should not be a permit condition given the complexity of measuring sound over the course of 365 nights.

Since $L_{eq, night, outside}$ considers 365 nights of operation, there will be some nights the wind turbines do not operate at all and many others where they will operate at a level below maximum sound level. Therefore, the $L_{eq, night, outside}$ sound level will always be lower than the worst-case (highest) short-term sound level measured on a given night. In other words, the $L_{eq, night, outside}$ guideline of 40 dBA, is not a 10-minute or 1-hour sound level, but is an average annual level.

It is important to note that the 1999 and 2009 WHO guidelines were developed with a focus on transportation sound and were not developed specifically for wind turbines.

4.5 National Association of Regulatory Utility Commissioners Report

The National Association of Regulatory Utility Commissioners (NARUC) Grants & Research Department published a report entitled “Wind Energy & Wind Park Siting and Zoning—Best Practices and Guidance for States” (January 2012). Part of the report presents guidelines for wind power development, including recommended approaches to several critical issues such as noise. The 2012 NARUC study concluded that, for long-term mean sound levels, a planning guideline of 40 dBA is an ideal design goal, and 45 dBA is an appropriate regulatory limit outside a residence at night. The report does not provide a recommendation for an annual average.

Details behind the sound level recommendations in the 2012 NARUC report are found in an October 2011 NARUC report.⁴ It is important to note that the 40 dBA and 45 dBA targets listed above are long-term mean sound levels, from data collected over a period of “several weeks.” In other words, these are not short-term maximum sound levels and are not directly comparable to the short term or annual average design goals established for this Facility. For example, the NARUC modeling methodology does not add the wind turbine manufacturer uncertainty, or “K” factor, which is typically 2 dBA. Therefore, a NARUC modeled result of 45 dBA would be the same as a 47 dBA modeled result when the “K” factor is included. This modeling study incorporates the “K” factor in the model.

According to the report, these sound levels were based on experience with wind turbine project operation and sound monitoring and were intended to minimize adverse reaction and sleep disturbance. Of course, the report notes that these levels do not mean the project sound will be inaudible or completely insignificant, only that its noise would generally be low enough that it would probably not be considered objectionable by the vast majority of neighbors. Another reason these numerical values cannot be compared with the proposed design goals for the Facility are that the NARUC report notes that the L₉₀ statistical measure should be used to determine sound levels from wind turbines instead of the L_{eq} as the L₉₀ captures the consistently present sound level during relatively quiet periods between identifiable noise events like car passbys or planes flying overhead. However, the L_{eq} is used to evaluate project sound levels since the design goals and criteria are stated in terms of an L_{eq}.

4.6 Wind Turbine Sound Annoyance and Complaint Studies

The frequency range 20 – 20,000 Hertz (Hz) is commonly described as the range of “audible” noise. The frequency range of low frequency sound is generally from 20 Hz to 200 Hz, and the range below 20 Hz is often described as “infrasound”.

⁴ Assessing Sound Emissions from Proposed Wind Farms & Measuring the Performance of Completed Projects, NARUC, prepared by Hessler Associates, Inc., October 2011.

4.6.1 Audible Sound

Several studies of human response to wind turbine sound were conducted in Europe in the early 2000s. Pedersen and Waye performed a cross-sectional study in Sweden in 2000.⁵ A dose-response relationship between calculated A-weighted sound levels from wind turbines and noise annoyance was found. Noise annoyance was related to other subjective factors such as attitude and sensitivity. Attitude towards the visual aspect of wind turbines was strongly correlated to annoyance. In other words, if an individual did not like the way a wind turbine appeared, they were more likely to be annoyed by the turbine as compared with being annoyed by the sound generated by a turbine.

Another detailed field study was conducted in the Netherlands in 2007 through the use of calculated sound levels and a questionnaire.⁶ A dose-response relationship between A-weighted sound levels and reported perception and annoyance was found. However, the study found that high turbine visibility enhances negative response, and having wind turbines visible from a dwelling significantly increases the risk of annoyance. Annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study also found that people who benefit economically from wind turbines have a significantly decreased risk of annoyance, even at the same sound levels. From that same study, it was found that of all sound sources that might disturb sleep in rural areas, 70% were not disturbed, 12% were disturbed by people/animals, 12% were disturbed by traffic/mechanical sounds, and 6% were disturbed by wind turbines.⁷

Observations of neighbors' reactions to newly operational wind farms suggest that it is not necessary to rigidly impose a maximum noise level of 40 dBA in order to avoid complaints. The NARUC document recommends 40 dBA as an *ideal* design goal, if it can reasonably be achieved, but 45 dBA as an appropriate regulatory limit. Adverse reactions to wind turbine noise between 40 and 45 dBA is still quite low, at roughly 2 percent of wind-park neighbors, even in rural environments with low background levels.⁸

⁵ *Perception and annoyance due to wind turbine noise—a dose-response relationship*, E. Pedersen and K.P. Waye, Goteborg University, Sweden, J. Acoust. Soc. Am. 116(6), December 2004.

⁶ *Response to noise from modern wind farms in The Netherlands*, E. Pedersen et al, J. Acoust. Soc. Am. 126(2), August 2009.

⁷ *Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress*, RH Bakker et al, Sci Total Environ, 2012.

⁸ Wind Energy & Wind Park Siting and Zoning Best Practices and Guidance for States, NARUC, prepared by National Regulatory Research Institute, January 2012.

In 2014 McCunney et al did a detailed literature search and concluded that “Annoyance associated with living near wind turbines is a complex phenomenon related to personal factors. Noise from turbines plays a minor role in comparison with other factors in leading people to report annoyance in the context of wind turbines.”⁹

Health Canada, in collaboration with Statistics Canada, conducted one of the most extensive studies to understand the impacts of wind turbine noise to-date.¹⁰ A cross-section epidemiological study was carried out in 2013 in the provinces of Ontario and Prince Edward Island (PEI) on randomly selected participants living near and far from operating wind turbines. Calculated outdoor wind turbine sound levels were up to 46 dBA. Note that these sound levels represent typical worst-case long term (one year) average sound levels.

Many peer-reviewed publications have been written based on the Health Canada research, including an analysis of annoyance. For example, Michaud et al report annoyance toward several wind turbine features increased with increasing sound levels, including the following noise, blinking lights, shadow flicker, visual impacts, and vibrations. In the entire study, approximately 7% reported a high level of annoyance from wind turbine noise. In the homes within the 40-46 dBA wind turbine noise area, approximately 13% reported a high level of annoyance. Annoyance was significantly higher in Ontario versus PEI at comparable sound levels.¹¹

Another publication from the Health Canada study found that the association between wind turbine noise levels and annoyance was found to be rather weak ($R^2 = 9\%$). The R^2 improved after considering annoyance due to other wind turbine related features such as visibility, blinking lights on the nacelle, the perception of vibrations during wind turbine operation, and physical safety.¹² This is consistent with the Pedersen research.

In 2015, the U.S. Department of Energy funded Lawrence Berkeley National Laboratory (LBNL) to lead a 4-year project collecting data from a broad-based and representative sample of individuals living near U.S. wind power projects.¹³ The aim was to broaden the

⁹ *Wind Turbines and Health: A Critical Review of the Scientific Literature*, R. McCunney et al, Journal of Occupational and Environmental Medicine, 56(11), November 2014.

¹⁰ Health Canada website: <http://www.hc-sc.gc.ca/ewh-semt/noise-bruit/turbine-eoliennes/summary-resume-eng.php>

¹¹ *Exposure to wind turbine noise: Perceptual responses and reported health effects*, D. Michaud et al, J. Acoust. Soc. Am. 139(3), March 2016.

¹² *Personal and situational variables associated with wind turbine noise annoyance*, D. Michaud et al, J. Acoust. Soc. Am. 139(3), March 2016.

¹³ *National Survey of Attitudes of Wind Power Project Neighbors: Summary of Results*, B. Hoen et al, US Department of Energy, Lawrence Berkeley National Laboratory, January 2018.

understanding of how U.S. communities are reacting to the deployment of wind turbines, and to provide insights to those communities considering wind projects. Results of this work are now available as presentations or manuscripts, and are in the process of being submitted for peer reviewed publication in scientific journals.

Survey data were collected from 1,705 residents across 24 states who were living within 5 miles of 250 U.S. wind power projects. A 50-question multi-mode (phone, mail, and internet) survey was distributed to each homeowner in the sample, eliciting information on attitudes, stress reactions, perceived fairness of the process, relationship to the project, attitudes, and demographic information. Regarding attitude toward the wind project, 8% responded either very negative or negative, while the remaining 92% were neutral or positive. For just the respondents within 0.5 mile of a wind turbine, 25% were very negative or negative, and 75% were neutral or positive. Regarding annoyance, 5.6% of all respondents reported being somewhat, moderately, or very annoyed by the wind project. For the respondents within 0.5 mile of a wind turbine, 30% reported being somewhat, moderately, or very annoyed by the wind project.

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

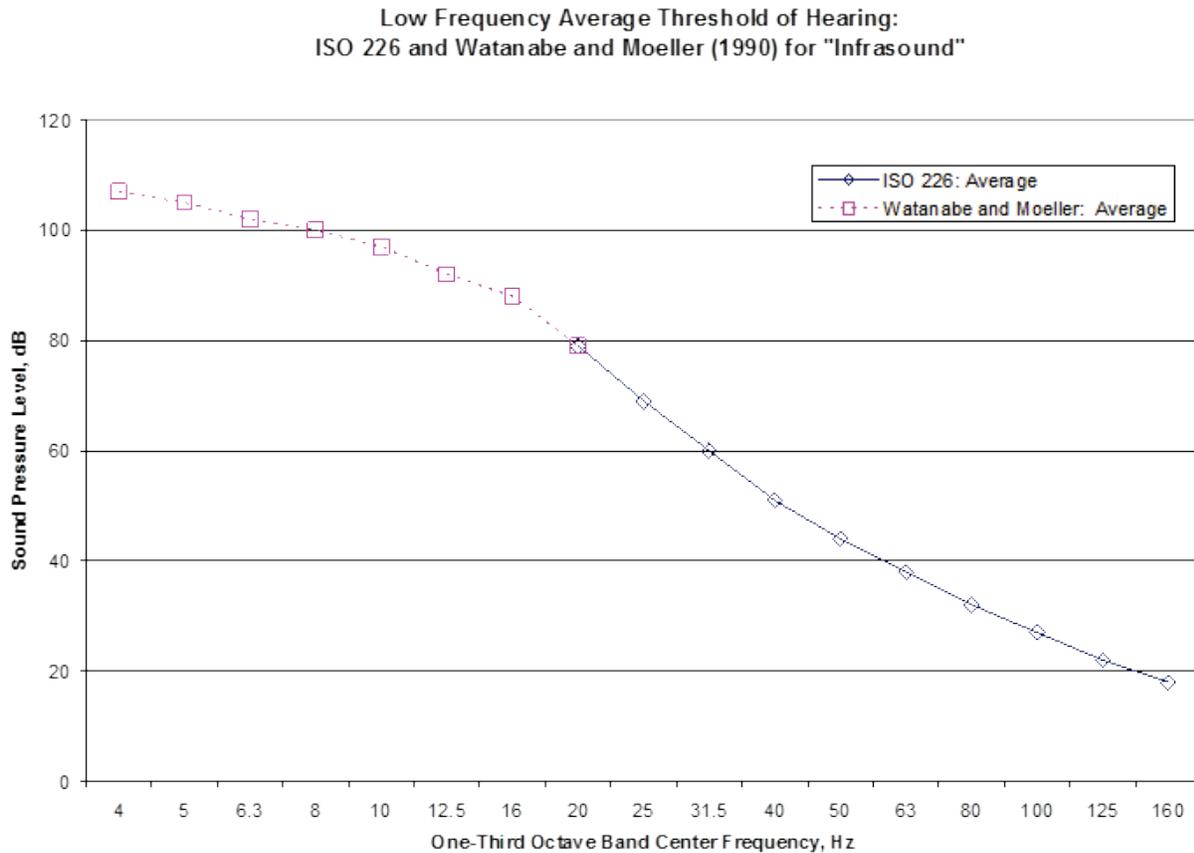
4.6.2 *Infrasound and Low Frequency*

The frequency range of low frequency sound is generally from 20 Hz to 200 Hz, and the range below 20 Hz is often described as "*infrasound*". However, audibility can extend to frequencies below 20 Hz if the energy is high enough. Since there is no sharp change in hearing at 20 Hz, the division between "low-frequency sound" and "infrasound" should only be considered "practical and conventional." The threshold of hearing is standardized for frequencies down to 20 Hz.¹⁴ Based on extensive research and data, Watanabe and Moeller have proposed normal hearing thresholds for frequencies below 20 Hz.¹⁵ Figure 4-1 shows these sound levels as a function of frequency.

¹⁴ Acoustics - Normal equal-loudness-level contours, International Standard ISO 226:2003, International Organization for Standardization, Geneva, Switzerland, (2003).

¹⁵ T. Watanabe, and H. Moeller, "Low Frequency Hearing Thresholds in Pressure Field and in Free Field", J. Low Frequency Noise and Vibration, 9(3), 106-115, (1990).

Figure 4-1 Low Frequency Average Threshold of Hearing



The results of Epsilon Associates, Inc. research indicate that there is no audible infrasound either outside or inside homes at 1,000 feet from a wind turbine. Sound levels meet the ANSI standard for low frequency noise in bedrooms, classrooms, and hospitals, meet the ANSI standard for thresholds of annoyance from low frequency noise, and there should be no window rattles or perceptible airborne induced vibration of light-weight walls or ceilings within homes. In homes there may be slightly audible low frequency noise beginning at around 50 Hz (depending on other sources of low frequency noise); however, the levels are below criteria and recommendations for low frequency noise within homes. ¹⁶

Annex D in the American National Standard ANSI S12.9-2005/Part 4¹⁷ identifies that low frequency sound annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each less than 65 dB. According to the standard, annoyance to sounds

¹⁶ *Low frequency noise and infrasound from wind turbines*, R. O'Neal et al, Noise Control Engineering J., 59(2), 2011.

¹⁷ American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound – Part 4: Noise Assessment and Prediction of Long-term Community Response, American National Standards Institute ANSI S12.9-2005/Part 4, Acoustical Society of America, New York, (2005).

with strong low frequency content is virtually only an indoor issue. Table 4-1 summarizes these levels.

Section 6 of the American National Standard ANSI/ASA S12.2-2008¹⁸ discusses criteria for evaluating indoor low frequency room noise. These criteria assess the potential to cause perceptible airborne induced vibration and rattles. Outdoor low frequency sounds that are high enough can cause building walls to vibrate and windows to rattle. Window rattles are not low frequency noise, but may be caused by low frequency noise. ANSI/ASA S12.2 presents limiting levels at low frequencies (16, 31.5, 63 Hz) for assessing (a) the probability of *clearly* perceptible acoustically induced vibration and rattles in lightweight wall and ceiling constructions, and (b) the probability of *moderately* perceptible acoustically induced vibration in similar constructions. See Table 4-2 below. Research has found that reduction of sound from outside to inside at these low frequencies is modest but not zero. Typical reductions with windows open are 3 dB, 6 dB, and 9 dB at 16, 31.5, and 63 Hz respectively.¹⁹ Table 4-3 summarizes the equivalent outdoor sound levels with this level of attenuation included.

As noted in the 2011 NARUC report, “the widespread belief that wind turbines produce elevated or even harmful levels of low frequency and infrasonic sound is utterly untrue as proven repeatedly and independently by numerous investigators.”

Table 4-1 Low frequency levels at which annoyance is minimal. [ANSI S12.9-2005/Part 4]

Condition	Octave-band center frequency (Hz)		
	16	31.5	63
Minimal annoyance levels	65 dB	65 dB	65 dB

Table 4-2 Measured interior sound pressure levels for perceptible vibration and rattle in lightweight wall and ceiling structures. [ANSI/ASA S12.2-2008]

Condition	Octave-band center frequency (Hz)		
	16	31.5	63
Clearly perceptible vibration and rattles likely	75 dB	75 dB	80 dB
Moderately perceptible vibration and rattles likely	65 dB	65 dB	70 dB

18 American National Standard Criteria for Evaluating Room Noise, American National Standards Institute ANSI/ASA S12.2-2008, Acoustical Society of America, New York, (2008).

19 Low frequency noise and infrasound from wind turbines, R. O’Neal et al, Noise Control Engineering J., 59(2), 2011.

Table 4-3 *Equivalent outdoor sound pressure levels for perceptible vibration and rattle in lightweight wall and ceiling structures.*

Condition	Octave-band center frequency (Hz)		
	16	31.5	63
Clearly perceptible vibration and rattles likely	78 dB	81 dB	89 dB
Moderately perceptible vibration and rattles likely	68 dB	71 dB	79 dB

4.7 Ground-Borne Vibration

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

Gastmeier & Howe measured vibration at a residence 325 meters (1,066 feet) from several 1.8 MW wind turbines and found vibration levels were well below the perception limits found in ISO 2631-2 (“Evaluation of human exposure to whole-body vibration Part 2”).²⁰

The Massachusetts Department of Environmental Protection (MA DEP) and the Massachusetts Department of Public Health commissioned an expert panel who found that seismic motion from wind turbines is so small that it is difficult to induce any physical or structural response.²¹ Two reports cited in the MA DEP review (Styles 2005²²; Schofield 2010²³) indicate that at 100 meters from a wind turbine the maximum motion that is induced is 120 nanometers (at about 1 Hz). A nanometer is 10^{-9} meter. So this is 1.2×10^{-7} meter of ground displacement. Extremely sensitive measuring devices have been used to detect this slight motion. To put the motion in perspective, the diameter of a human hair is on the order of 10^{-6} meter. The Schofield measurements were conducted on a Vestas V-47 with a maximum rotational rate of 29 rpm (blade pass frequency of 1.47 Hz).

Ground-borne vibration measurements were made by Epsilon from Siemens 2.3 and GE 1.5sle wind turbines in Texas.²⁴ The maximum ground-borne vibration RMS particle

²⁰ *Recent Studies of Infrasonic from Industrial Sources*, W. Gastmeier & B. Howe, Canadian Acoustics, 36(3), 2008.

²¹ *Wind Turbine Health Impact Study: Review of Independent Expert Panel*, Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health, January 2012.

²² *Microseismic and Infrasonic Monitoring of Low Frequency Noise and Vibration from Windfarms*, P. Styles et al, Keele University, 18 July 2005.

²³ *Seismic Measurements at the Stateline Wind Project*, R. Schofield, University of Oregon, 2010.

²⁴ *A Study of Low Frequency Noise and Infrasonic from Wind Turbines*, Epsilon Associates, Inc., prepared for NextEra Energy Resources, LLC, July 2009.

velocities were 0.071 mm/second (0.71×10^{-4} meters/second) in the 8 Hz one-third octave band. This was measured 1,000 feet downwind from a GE 1.5sle WTG under maximum power output and high wind at the ground. The background ground-borne vibration RMS particle velocity at the same location was 0.085 mm/sec. Both of these measurements meet ANSI S2.71-1983²⁵ recommendations for perceptible vibration in residences during night time hours of 1.0×10^{-4} meters/second at 8 Hz. Soil conditions were soft earth representative of an active agricultural use. No perceptible vibration was felt from operation of the wind turbines. The GE 1.5sle has a maximum rotation rate of 20 rpm (blade pass frequency of 1 Hz), and the Siemens 2.3 has a maximum rotation rate of 15.4 rpm (blade pass frequency of 0.77 Hz).

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

²⁵ *Guide to the Evaluation of Human Exposure to Vibration in Buildings*, ANSI/ASA S2.71-1983 (R August 6, 2012).

Table 4-4 Base response one-third octave band RMS velocity ratings for the three biodynamic vibration axes and combined axis (From ANSI S2.71-1983 (R2006))

One-Third Octave band center frequency, Hz	Velocity (RMS), m/s		
	z axis	x, y axis	Combined axis
1	1.6×10^{-3}	5.7×10^{-4}	5.7×10^{-4}
1.25	1.1×10^{-3}	4.6×10^{-4}	4.6×10^{-4}
1.6	8.0×10^{-4}	3.6×10^{-4}	3.6×10^{-4}
2	5.6×10^{-4}	2.9×10^{-4}	2.9×10^{-4}
2.5	4.0×10^{-4}	2.9×10^{-4}	2.4×10^{-4}
3.15	2.9×10^{-4}	2.9×10^{-4}	2.1×10^{-4}
4	2.0×10^{-4}	2.9×10^{-4}	1.7×10^{-4}
5	1.6×10^{-4}	2.9×10^{-4}	1.4×10^{-4}
6.3	1.3×10^{-4}	2.9×10^{-4}	1.2×10^{-4}
8	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
10	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
12.5	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
16	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
20	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
25	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
31.5	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
40	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
50	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
63	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}
80	1.0×10^{-4}	2.9×10^{-4}	1.0×10^{-4}

Finally, the Ministry for the Environment, Climate and Energy of the Federal State of Baden-Wuerttemberg, Germany published a detailed study on infrasound and vibration from wind turbines.²⁶ The results found that vibration velocity levels from a 2.4 MW Nordex N117 wind turbine at distances of less than 300 meters (~1,000 feet) were less than 0.1×10^{-4} meters/sec. Therefore, ground-borne vibration can be detected by instruments but is no different than the ever-present background vibration and not a concern.

The information from some of the references cited above is summarized in Table 4-5 below. No information is publicly available about the soil type, foundation, or vibration isolation characteristics of the cited examples. The maximum frequency of rotation for the GE 3.8-137 wind turbine is 13.6 rpm. The maximum frequency of rotation for the Vestas V150-4.2 wind turbine is 12.0 rpm. The maximum frequency of rotation for the Nordex N149/4500 wind turbine is 12.25 rpm. The maximum frequency of rotation for the Senvion 4.2M148 wind turbine is 10.5 rpm. With regard to the mass of rotation, a single blade for the GE 3.8-137 weighs 40,124 pounds, a single blade for the Vestas V150-4.2 weighs 38,005 pounds, a single blade for the Nordex N149/4500 weighs 43,872 pounds, and a single blade for the Senvion 4.2M148 weighs 46,297 pounds. Blade weights for the other wind turbines in Table 4-5 were not available.

Table 4-5 Summary of Ground-Borne Vibration Information

Reference	Power output of WTGs	Distance to vibration measurements	Frequency of rotation
Gastmeier & Howe (2008)	1.8 MW	1,066 feet	17 rpm
MA DEP/Styles et al (2005)	450 kW	328 feet	33 rpm
MA DEP/Schofield (2010)	660 kW	80 feet	29 rpm
Epsilon/NextEra (2009)	1.5 MW	1,000 feet	20 rpm
Epsilon/NextEra (2009)	2.3 MW	1,000 feet	15.4 rpm
LUBW Ministry for Environment	2.4 MW	1,000 feet	13.2 rpm

4.8 Project Noise Standards and Design Goals

As noted in the NARUC 2012 report, a balance must be struck between avoiding or minimizing potential impacts from wind turbine generated sound while not imposing regulatory standards which are so stringent that they do not afford additional benefits but instead are prohibitive to project viability. Regulatory limits for other power generation and

²⁶ Low-frequency sound noise incl. infrasound from wind turbines and other sources, LUBW Ministry for the Environment, Climate and Energy of the Federal State of Baden-Wuerttemberg, Germany, November 2016.

mechanical processes never seek inaudibility but rather to limit noise from a source to a reasonably acceptable level. The project noise standards and design goals have been grouped into ones that can reasonably be verified through post-construction sound level measurements (see Table 4-6A), and those that are evaluated through the use of detailed computer modeling (see Table 4-6B). The eleven standards and design goals for this project are described in more detail below.

The project will be located within two towns, both of which have local noise standards. In Sanford, the local wind law states a 50 dBA standard measured at a non-participating residence. This standard applies day or night (Goal #1). The Town of Windsor has a noise ordinance but has confirmed and stipulated that it is not applicable to this facility because the project is proceeding under PSL Article 10.

As part of the project, noise design goals were developed based on a literature review in order to balance reasonable development and minimize annoyance to the community. These include a 45 dBA Leq nighttime limit at a non-participating residence (Goal #3). This is based on the World Health Organization's (WHO) eight-hour guideline to minimize sleep disturbance. A nighttime design goal of 55 dBA is established for a participating residence and is also based on the WHO guideline (Goal #4). Another design goal for non-participating residences is to prohibit a "pure tone" in accordance with ANSI S12.9 Part 3/Annex B Section B.1, or impose a 5 dBA penalty to the broadband limit if a pure tone occurs (Goal #9).

Wind turbines produce infrasound but these levels are well below human thresholds of audibility. However, infrasound and low frequency energy can result in airborne vibration within homes if the levels are high enough. American National Standard ANSI S12.9-2005/Part 4 identifies that low frequency sound annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each 65 dB or less (Goal #8).

An annual nighttime level of 40 dBA ($L_{eq, \text{night, outside}}$) at a non-participating residence is another design goal as put forth by the WHO (Goal #6). This covers all the eight-hour nighttime periods over the course of an entire year (365 days). This same annual nighttime design goal is 50 dBA at a participating residence (Goal #7).

As discussed in Section 4.4, the WHO notes daytime and evening outdoor living area sound levels at a residence should not exceed an L_{eq} of 55 dBA to prevent serious annoyance and an L_{eq} of 50 dBA to prevent moderate annoyance from a steady, continuous noise. Since a property line is not a "living area", or even an area where people routinely spend extended time, limiting 1-hour sound levels to 55 dBA or less at non-participating property lines is a reasonable design goal (Goal #5). Other design goals include meeting the NYS DEC Noise Policy at locations on DEC lands (Goal #2), and 50 dBA at non-residential receptors (Goal #10).

Since ground-borne vibration from a wind farm is not a demonstrated issue to people in their homes, ground-borne vibration has a design goal but will only be analyzed through the post-construction complaint resolution program, if necessary (Goal #11).

Table 4-6A Summary of Measured Sound Standards or Design Goals – Bluestone Wind

#	Municipality or Organization	Sound Level Limit	Assessment Location	Noise descriptor	Period of Time	Participant Status
1	Town of Sanford Renewable Energy Systems §1402.5(A)(5)	50 dBA	Exterior wall of the nearest non-participating residence	Not stated (assumed Leq)	Not stated (assumed 1-hour); day or night	Non-participant
3	Design goal (1999 WHO Guidelines)	45 dBA	At residence	Leq	8-hour; nighttime	Non-participant
4	Design goal (1999 WHO Guidelines)	55 dBA	At residence	Leq	8-hour; nighttime	Participant
8	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	65 dB at 16, 31.5, 63 Hz	At residence	Leq	1-hour; day or night	Non-participant
9	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	No pure tone or 5 dBA penalty if a prominent tone occurs	At residence	Leq	1-hour; day or night	Non-participant

Table 4-6B Summary of Modeled Design Goals – Bluestone Wind

#	Municipality or Organization	Sound Level Limit	Assessment Location	Noise descriptor	Period of Time	Participant Status
2	Program Policy Assessing and Mitigating Noise Impacts issued by the New York State Department of Environmental Conservation (NYSDEC), Feb. 2001	6 dBA increase over ambient	Areas of human use	L90	Not stated	NYS DEC lands
5	Design goal	55 dBA	Property line and lands except wet-lands	Leq	1-hour; day or night	Non-participant
6	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	40 dBA	At residence	Leq, night, outside	Annual; nighttime	Non-participant
7	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	50 dBA	At residence	Leq, night, outside	Annual; nighttime	Participant
10	Design goal (ANSI/ASA S12.9-2007/Part 5)	50 dBA	Non-residential (historic venues; cemeteries; playgrounds; etc.)	Leq	1-hour	Non-participant
11	Design goal for vibrations.	Not perceptible indoor vibrations	At residence	See ANSI S 2.71-1983 (R August 6/2012) for details	See ANSI S 2.71-1983 (R August 6/2012) for details	Non-Participant

5.0 WIND TURBINE NOISE

5.1 Sources of Sound from Wind Turbines

A wind turbine produces noise mechanically and aerodynamically. Mechanical noise sources include the gearbox, generator, yaw drives, cooling fans, and auxiliary equipment such as hydraulics. Advances in gearboxes and yaw systems have decreased these noise sources over the years. Direct drive systems, such as those proposed for the turbines under consideration for this Facility, will improve this even more. In addition, utility scale wind turbines are usually insulated to prevent mechanical noise from proliferating outside the nacelle or tower.

Aerodynamic sound is generated due to complex fluid-structure interactions occurring on the blades. Of these mechanisms, the most persistent and often strongest source of aerodynamic sound from modern wind turbines is the trailing edge noise. As a turbine blade rotates through a changing wind stream, the aerodynamics change, leading to differences in the boundary layer and thus to differences in the trailing edge noise. Also, the direction in which the blade is pointing changes as it rotates, leading to differences in the directivity of the noise from the trailing edge. This noise source leads to what some people call the “whooshing” sound.²⁷

Most modern turbines use pitch control for a variety of reasons. One of the reasons is that at higher wind speeds, when the control system has the greatest impact, the pitch controlled turbine is quieter than a comparable stall-regulated turbine. In other words, once sound levels have reached their maximum level, typically at around wind speeds of 8-10 m/s at hub height, sound levels do not continue to increase even when wind speeds increase beyond 8-10 m/s. The wind turbines proposed for this project use pitch control.

5.2 Noise Abatement Measures

Noise from wind turbines can be reduced using either factory-installed technology, proper siting, or possibly through energy reduction measures after construction. Given the large distances between wind turbines and sensitive receptors in this project, noise abatement measures should not be necessary.

5.2.1 Pre-Construction

Modern utility-scale wind turbines are all horizontal axis, upwind, 3-blade designs. The upwind design means the rotor and blades always face into the wind. The older downwind

²⁷ *Wind Turbine Health Impact Study: Review of Independent Expert Panel*, Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health, January 2012.

design is obsolete and could cause some noise issues due to the blades passing through the wake created by the wind hitting the tower.

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

The design of the wind turbine blades has an impact on sound levels. Blade manufacturers are researching and testing ways to reduce sound levels from various tip shapes. In addition, there are low noise trailing edge (LNTE) or serrated trailing edge (STE) options available for some wind turbine models (terminology depends on the manufacturer but the intent is the same). These are essentially metal sawtooth serrations that can be affixed to the edge of a blade to reduce blade trailing edge noise. General Electric estimates that the LNTE option reduces sound levels 2-4 dBA as compared to unserrated blades.²⁸

5.2.2 Construction

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

- ◆ Blasting is likely at this site. Blasting will be limited to daytime hours and conducted in accordance with the Bluestone Wind Preliminary Blasting Plan included elsewhere in the Article 10 Application.
- ◆ Pile driving is possible at this site. If pile driving is required, it will be limited to daytime hours.
- ◆ Utilizing construction equipment fitted with exhaust systems and mufflers that have the lowest associated noise whenever those features are available.

²⁸ *Wind Turbine Blade Noise Mitigation Technologies*, B. Petitjean et al., presented at Fourth International Meeting on Wind Turbine Noise, Rome, Italy, 2011.

- ◆ Maintaining equipment and surface irregularities on construction sites to prevent unnecessary noise.
- ◆ Configuring, to the extent feasible, the construction in a manner that keeps loud equipment and activities as far as possible from noise-sensitive locations.
- ◆ Using back-up alarms with a minimum increment above the background noise level to satisfy the performance requirements of the current revisions of Standard Automotive Engineering (SAE) J994 and OSHA requirements.
- ◆ Develop a staging plan that establishes equipment and material staging areas away from sensitive receptors when feasible.
- ◆ Contractors shall use approved haul routes to minimize noise at residential and other sensitive noise receptor sites on the mainland.

5.2.3 *Operations*

The Complaint Resolution Plan provided with this Application contains the procedures to be followed in the event of a noise complaint during operations. The noise emitted by a wind turbine is predominantly determined by the aerodynamic broadband noise of the rotor blades, which is directly dependent on the circumferential or blade tip speed. Blade noise increases with increasing wind speed until rated electrical power is reached. The sound power level can be lowered by reducing the rotor speed through blade pitch adjustments, thus lowering and limiting the tip speed. The rated electrical power level is reduced accordingly through earlier blade pitching. Therefore, there is some loss in energy yield because of the reduction in power level.

Most modern wind turbine manufacturers offer an option called noise-reduced operating mode (NRO = Noise-Reduced Operation). With the aid of the control system the turbine can be switched to noise-reduced mode, based on pre-determined parameters such as the time of day, wind direction, wind speed, etc. NRO can be implemented on an “as needed” basis through the use of software programming.

Due to the inherent size of wind turbines, typical barrier structures are not practical to reduce sound. Sound barriers are used as needed around a substation if the transformer is identified as a sound source requiring noise control. At a noise-sensitive receptor, interior sound levels can be reduced through the use of better doors, windows, and/or insulation.

6.0 BASELINE SOUND LEVEL MONITORING PROGRAM

To characterize the existing soundscape of the Project area, an ambient (baseline) monitoring program was conducted in accordance with the NYS Article 10 Exhibit 19 requirements and Stipulation 19(b). This section outlines the structure of the ambient program.

Details of the winter monitoring program were presented in the “Sound Level Measurement Protocol—Winter Season” and was attached to the Facility’s Preliminary Scoping Statement, dated February 17, 2017. Between the time of the ambient measurement programs and this NIA, the Project Area was reconfigured and shifted to the east. The ambient measurement locations are still representative of the general vicinity of the Project.

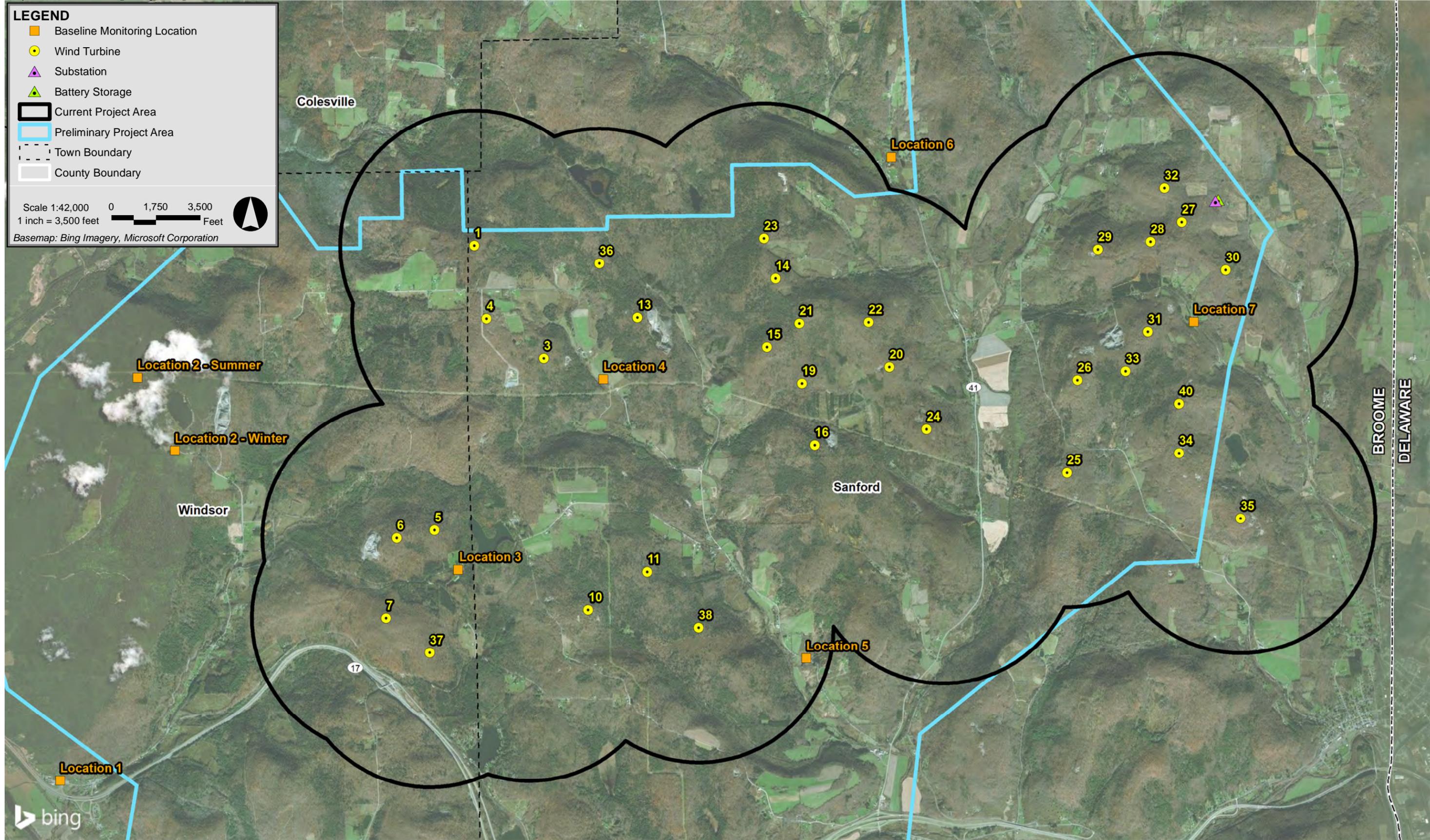
6.1 Sensitive Receptors

All residences [including participating, non-participating, full-time and seasonal], outdoor public facilities and areas, hospitals, schools, care centers, libraries, places of worship, cemeteries, public parks, public campgrounds, summer camps (e.g. YMCA Camp Tuscarora), and any historic resources listed or eligible for listing on the State or National Register of Historic Places and Federal and State lands, if any within one mile of a wind turbine or project-related substation were included as sensitive receptors. Seasonal receptors included cabins and hunting camps identified by property tax codes and any other seasonal residence known to have septic systems or running water. These are shown in Figure 9-1 in accordance with Stipulation 19(a).

6.2 Sound Level Measurement Locations

In accordance with ANSI S12.9-1992/Part 2 (R2013), the deterministic spatial sampling technique was used to select measurement locations. In other words, sound monitoring locations were selected to be representative of nearby residences in various directions from the wind project. For example, Location 1 represents those receptors near I-86/Old Route 17 which carries 8,000-10,000 vehicles/day, while the remaining locations represent rural residential areas with about 500 vehicles/day or less. Thus, the selected locations are representative of potentially impacted receptors. The program was intended to measure total ambient sound in the area which includes all noise sources.

Two sound level measurement programs were conducted; winter and summer. The measurement locations remained generally consistent between the two programs with the exception of one location for which there was a change in property permissions. Therefore, a different, but nearby, measurement location was utilized in the summer program. Figure 6-1 shows the measurement locations for both measurement programs and identifies the one location that was changed between the seasons overlaid upon an aerial photograph. Each sound level monitoring location is described in the following subsections. The



Bluestone Wind Broome County, New York

coordinates for the sound level measurement locations are listed in Table 6-1, which are slightly adjusted from the field-measured Global Positioning System (GPS) points for refined accuracy.

The NYS DOT website was checked for Annual Average Daily Traffic (AADT) counts in the vicinity of the sound level meters (SLM). The section of Interstate 86 (I-86; State Route 17) immediately south of the Project had an AADT ranging from 8,294 to 10,834 vehicles in 2015, Route 41 in the eastern portion of the Project Area had an AADT ranging from 524 to 714 vehicles in 2015, and Route 233 in the western portion of the Project Area had an AADT of 562 in 2015.²⁹ Other roads in the Project Area generally carry less traffic than these roads.

Table 6-1 GPS Coordinates – Sound Level Measurement Locations

Location	Latitude	Longitude
Location 1	42.05627°	-75.61497°
Location 2 – Winter	42.09161°	-75.59784°
Location 2 – Summer	42.09951°	-75.60313°
Location 3	42.07848°	-75.55710°
Location 4	42.09877°	-75.53576°
Location 5	42.06845°	-75.50690°
Location 6	42.12226°	-75.49370°
Location 7	42.10409°	-75.45022°

6.2.1 Location 1

One continuous programmable, unattended sound level meter was placed near Old Route 17 in the Town of Windsor, New York. The meter was placed approximately 15 meters north of the road and is representative of existing sound levels along Old Route 17 and in near proximity to I-86. Refer to Figures 6-2 and 6-3 for a photo of the monitoring setup during the winter and summer³⁰ seasons, respectively.

²⁹ <https://www.dot.ny.gov/tdv>. Accessed in May 2018.

³⁰ Sound level meter placement at the precise winter location during the summer season was not physically possible due to overgrown vegetation; however, a representative location was selected.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 10:00 a.m. Thursday, March 2 until 4:20 p.m. Friday, March 17, 2017 for a total of 2,040³¹ 10-minute measurement periods, and from 10:20 a.m. Thursday, August 10 until 12:30 p.m. Thursday, August 24, 2017 for a total of 2,022 10-minute measurement periods during the summer season.

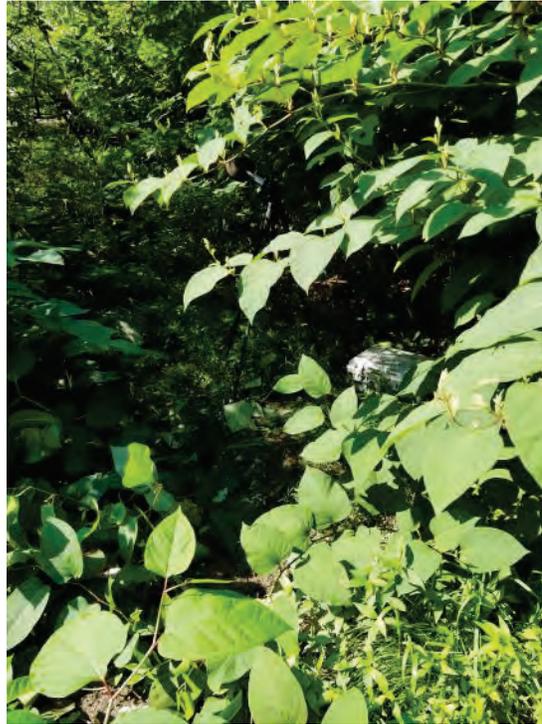
Upon the mid-term check on the equipment during the winter season, the extension cable from the microphone to the SLM was declared to be faulty and required replacement. Therefore, the meter did not measure sound levels for 158 10-minute periods while no extension cable was present in the setup. The sound data collected during the first week of the program with the original extension cable were reviewed and appear to be unaffected by the cable.

Figure 6-2 Location 1, Sound Level Meter, Winter



³¹ There was a total of 158 10-minute periods when the SLM was not collecting data due to an extension cable replacement during the mid-term check.

Figure 6-3 Location 1, Sound Level Meter, Summer



6.2.2 Location 2

Measurement Location 2 was selected to be representative of the northwestern vicinity of the Project. Permission had been granted at a residential property along Ostrander Road in the Town of Windsor, NY for the first monitoring season (winter). Permission was not granted several months later to monitor at the property for the summer monitoring program; therefore, an alternate location was selected for the summer to be similarly representative of the northwestern vicinity of the Project.

6.2.2.1 Location 2 – Winter

One continuous programmable, unattended sound level meter was placed at the Weaver residence on Ostrander Road in the Town of Windsor, NY. The meter was placed approximately 20 meters southwest of the road in an open field. This location is representative of existing sound levels in the northwestern vicinity of the Project along Ostrander Road. Refer to Figure 6-4 for the monitoring setup during the winter season.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 11:20 a.m. Thursday, March 2 until 9:40 a.m. Friday, March 17, 2017 for a total of 2,143 10-minute measurement periods.

Figure 6-4 Location 2 - Winter, Sound Level Meter

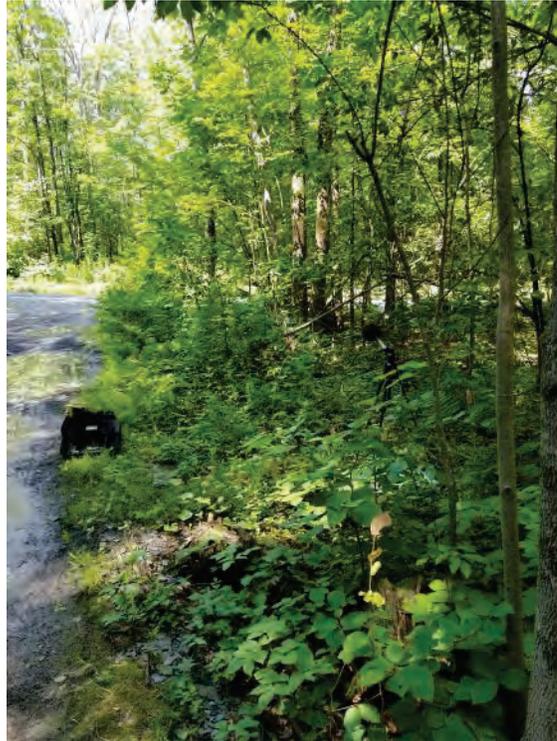


6.2.2.2 Location 2 – Summer

One continuous programmable, unattended sound level meter was placed at the Goodspeed residence on Cresson Hill Road in the Town of Windsor, NY. The meter was placed approximately 15 meters south of the road. This location is representative of existing sound levels in the northwestern vicinity of the Project. Refer to Figure 6-4 for the monitoring setup during the summer season.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the summer season from 2:40 p.m. Wednesday, August 9 until 10:00 a.m. Thursday, August 24, 2017 for a total of 2,121 10-minute measurement periods.

Figure 6-5 Location 2 - Summer, Sound Level Meter



6.2.3 Location 3

One continuous programmable, unattended sound level meter was placed at the Sky Lake Camp property on Sky Lake Road in the Town of Windsor, NY. The meter was placed approximately 25 meters south of Sky Lake Road. This location is representative of receptors in the west-central area of the Project. Refer to Figures 6-6 and 6-7 for a photo of the monitoring setup during the winter and summer seasons, respectively.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 12:30 p.m. Thursday, March 2 until 10:40 a.m. Friday, March 17, 2017 for a total of 2,143 10-minute measurement periods and from 4:50 p.m. Wednesday, August 9 until 10:40 a.m. Thursday, August 24, 2017 for a total of 2,115 10-minute measurement periods during the summer season. In addition to sound data collection, continuous ground-level wind speed and direction were made at this location during both monitoring programs. During the summer program, temperature, relative humidity, and precipitation measurement data were also collected. The meteorological equipment setup is shown in Figure 6-8 and 6-9 for the respective seasons.

Figure 6-6 Location 3, Sound Level Meter, Winter



Figure 6-7 Location 3, Sound Level Meter, Summer

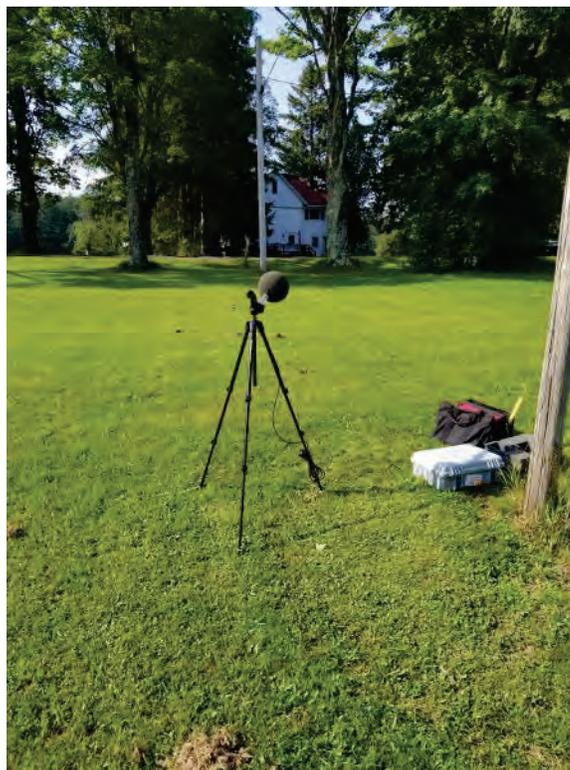


Figure 6-8 Location 3, Meteorological Tower, Winter



Figure 6-9 Location 3, Meteorological Tower, Summer



6.2.4 Location 4

One continuous programmable, unattended sound level meter was placed on Pazzelli Road in the Town of Sanford, NY. The meter was placed approximately 15 meters southwest of Pazzelli Road in a field. This location is representative of receptors in the central vicinity of the Project Area. Refer to Figures 6-10 and 6-11 for a photo of the monitoring setup during the winter and summer seasons, respectively.

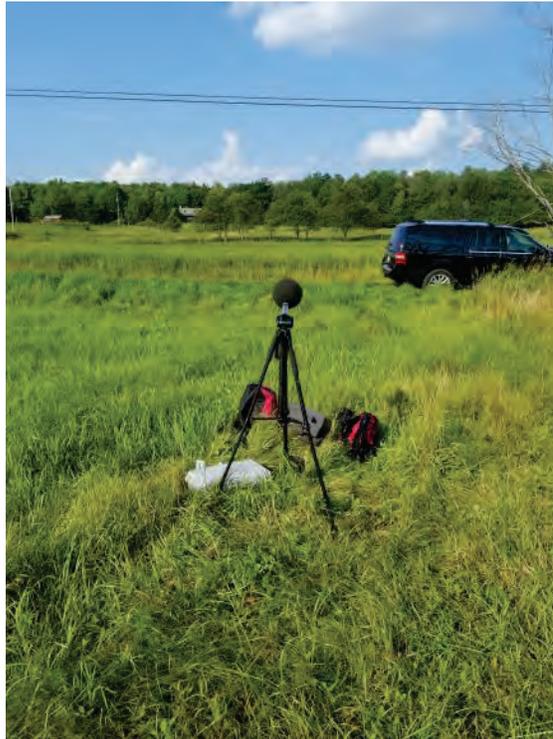
The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 12:50 p.m. Friday, March 3 until 3:00 p.m. Friday, March 17, 2017 for a total of 1,795 10-minute measurement periods and from 5:30 p.m. Wednesday, August 9 until 11:00 a.m. Thursday, August 24, 2017 for a total of 2,115 10-minute measurement periods during the summer season.

Upon the mid-term check during the winter season, the 7-inch windscreen was found on the ground near the SLM. A review of the sound levels from the first week of the program indicate that the windscreen was displaced for most, if not all, of the monitoring duration, rendering those periods (788) invalid. The windscreen was replaced by Epsilon personnel; however when the location was checked several hours later, the windscreen was missing, likely due to high winds. The meter began collecting sound level data with a replacement windscreen on the microphone at 3:10 p.m. on March 10, 2017.

Figure 6-10 Location 4, Sound Level Meter, Winter



Figure 6-11 Location 4, Sound Level Meter, Summer



6.2.5 Location 5

One continuous programmable, unattended sound level meter was placed along the eastern side of Farnham Road in the Town of Sanford, NY. The meter was positioned approximately 15 meters from Farnham Road. This location is representative of receptors in the southeast area of the Project. Refer to Figures 6-12 and 6-13 for a photo of the monitoring setup during the winter and summer seasons, respectively.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 5:30 p.m. Thursday, March 2 until 12:20 p.m. Friday, March 17, 2017 for a total of 2,127 10-minute measurement periods and from 11:20 a.m. Thursday, August 10 until 1:20 p.m. Thursday, August 24, 2017 for a total of 2,025 10-minute measurement periods during the summer season.

Figure 6-12 Location 5, Sound Level Meter, Winter



Figure 6-13 Location 5, Sound Level Meter, Summer



6.2.6 Location 6

One continuous programmable, unattended sound level meter was placed along Mooney Pond Road, to the east of Parker Road in the Town of Sanford, NY. The meter was positioned approximately 15 meters east of Parker Road. This location is representative of receptors in the northern area of the Project. Refer to Figures 6-14 and 6-15 for a photo of the monitoring setup during the winter and summer³² seasons, respectively.

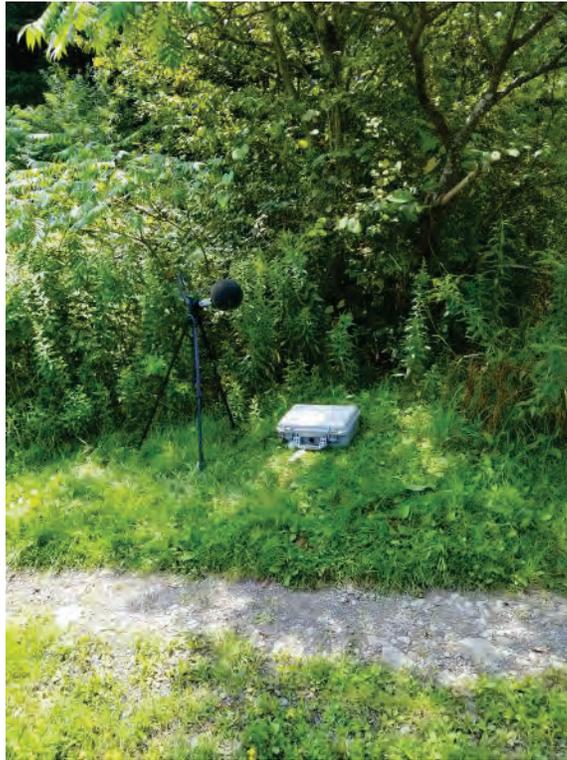
The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 6:30 p.m. Thursday, March 2 until 2:10 p.m. Friday, March 17, 2017 for a total of 2,129 10-minute measurement periods and from 11:50 a.m. Thursday, August 10 until 2:00 p.m. Thursday, August 24, 2017 for a total of 2,018 10-minute measurement periods during the summer season.

Figure 6-14 Location 6, Sound Level Meter, Winter



³² Sound level meter placement at the precise winter location during the summer season was not physically possible due to overgrown vegetation; however, a representative location was selected.

Figure 6-15 Location 6, Sound Level Meter, Summer



6.2.7 Location 7

One continuous programmable, unattended sound level meter was placed along Loomis Hill Road, in the Town of Sanford, NY. The meter was positioned approximately 15 meters southwest of Loomis Hill Road. This location is representative of receptors within the eastern portion of the Project Area. Refer to Figures 6-16 and 6-17 for a photo of the monitoring setup during the winter and summer seasons, respectively.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 2:50 p.m. Thursday, March 2 until 1:00 p.m. Friday, March 17, 2017 for a total of 2,143 10-minute measurement periods, and from 6:40 p.m. Wednesday, August 9 until 11:40 a.m. Thursday, August 24, 2017 for a total of 2,108 10-minute measurement periods during the summer season. In addition to sound data collection, continuous ground-level wind speed measurements were made at this location during both monitoring programs utilizing equipment shown in Figures 6-18 and 6-19 for the respective seasons.

Figure 6-16 Location 7, Sound Level Meter, Winter



Figure 6-17 Location 7, Sound Level Meter, Summer



Figure 6-18 Location 7, Meteorological Tower, Winter



Figure 6-19 Location 7, Meteorological Tower, Summer



6.3 Sound Level Measurement Instrumentation

Each of the monitoring locations utilized either a Larson Davis (LD) model 831³³ sound level meter (SLM) to measure both A-weighted (dBA) and one-third octave bands from 20 Hz to 10,000 Hz. Each instrument was equipped with a LD PRM831 preamplifier and a PCB 377B20 or 377C20 half-inch microphone, or a Norsonic model Nor140³⁴ SLM equipped with a Norsonic Nor1209 preamplifier and a G.R.A.S. 40AN half-inch microphone along with an environmental protection kit. The kit included an untreated ACO 7-inch diameter 20 ppi (pores per inch) open cell foam windscreen to reduce wind-induced noise over the microphone. Windscreen insertion loss data by one-third octave band is found in Table B.2 of ANSI/ASA S12.9-2016/Part 7.³⁵ This shows windscreen insertion loss of 0.1 dB or less in the low frequency and infrasound range, less than 1.0 dB from 200 Hz to 4000 Hz, and up to 2 dB from 5000 Hz to 10,000 Hz. A summary of these insertion losses is included in this report as Appendix A. Each microphone was tripod-mounted at a height of approximately four feet (1.2 meters) above ground level in accordance with ANSI S12.9-1992/Part 2 (R2013). Horizontal microphone placements near roadways were in accordance with ANSI S12.9-1992/Part 2 (R2013) for open land.

The LD831 and Nor140 meters meet Type 1 ANSI/ASA S1.4, ANSI S1.43-1997 (R2007), and IEC 61672 Class 1 standards for sound level meters and were calibrated and certified as accurate to standards set by the National Institute of Standards and Technology. The octave band filters for all instrumentation meet ANSI S1.11-2004 (R2009). These calibrations were conducted by an independent laboratory within 12 months of field placement and certificates of calibration are provided in Appendix B. All measurement equipment was calibrated in the field before and after the surveys with the manufacturer's acoustical calibrator which meets the standards of IEC 60942-2003 Class 1L and ANSI/ASA S1.40-2006 (R2016).

6.4 Meteorological Instrumentation

6.4.1 Ground Level Winds

Wind speed can have a strong influence on ambient sound levels. In order to understand how the existing sound levels are influenced by wind speed, HOBO H21-002 micro-

³³ Noise floor specified in manufacturer's manual with use of PRM831 preamplifier and 377B02 microphone for A-weighted sound pressure levels is 18 dB at a 0 dB gain and 17 at a 20 dB gain. Noise floor specified for Z-weighted sound pressure levels is 23 dB at a 0 dB gain and 21 at a 20 dB gain.

³⁴ Noise floor specified in manufacturer's manual A-weighted sound pressure levels is 25 dB with self-noise of the SLM at 15 dB. Preamplifier and microphone are not stated.

³⁵ Quantities and Procedures for Description and Measurement of Environmental Sound, Part 7: Measurement of Low-frequency Noise and Infrasound Outdoors and in the Presence of Wind and Indoors in Occupied Spaces, ANSI/ASA S12.9-2016/Part 7, American National Standards Institute, Inc., 2016.

weather stations (manufactured by Onset Computer Corporation) with tripods and data loggers were used to record continuous wind speed data at Locations 3 and 7 during both seasons. The wind instruments have a measurement range of 0 to 44 m/s (99 mph) or 0 to 45 m/s (100 mph) and an accuracy of +/- 0.5 m/s (1.1 mph) or +/- 1.1 m/s (2.4 mph). The starting threshold is 0.5 m/s (1.1 mph) or ≤ 1.0 m/s (2.2 mph). The wind direction measurement range is 0 to 358 degrees (2-degree dead band) or 0 to 355 degrees (5-degree dead band), with an accuracy of +/- 5 degrees.

6.4.2 *Hub Height Winds*

Hub height wind speeds during the ambient programs were calculated based on measurements from an on-site 60-meter meteorological tower. The wind speed sensor mounted at 59 meters was used to extrapolate wind speeds up to the 130 meter hub height by Bluestone Wind meteorologists and provided to Epsilon.

6.4.3 *Precipitation, Temperature, and Relative Humidity*

Meteorological data from the New York State Mesonet system was used for both the winter and summer measurements. The New York State Mesonet consists of 125 state-of-the-art environmental monitoring stations and serves as the foundation of an Early Warning Severe Weather Detection network for the entire State of New York. The New York State Mesonet was developed by research scientists at the State University of New York (SUNY) at Albany's Atmospheric Sciences Research Center, and Department of Atmospheric and Environmental Sciences. Mesonet sites are distributed statewide with every county across New York having at least one or more sites. The Mesonet collects measurements of a number of surface and atmospheric variables, such as temperature, relative humidity, wind speed and direction, surface pressure, soil moisture, soil temperature, solar radiation, and precipitation amounts for rainfall and snow accumulation. These data are archived and available to the public.

The Deposit Mesonet station is located approximately 4 miles from the closest Bluestone measurement location. This location began operation on August 23, 2016. As this is the closest Mesonet station, and has elevation comparable to the Project site, this location was selected as a source of precipitation, relative humidity, and temperature data for both the winter and summer measurements.

The SUNY Mesonet data from Deposit are provided in Appendix C of this report.

One hour of data was missing from the SUNY Mesonet data during the winter monitoring program. National Weather Service data from Binghamton was used during this period. This station is approximately 25 miles west of the Bluestone site.

6.5 Infrasonic Monitoring

Infrasound was measured during both seasons at Location 5, using the Norsonic Nor140 SLM equipped with a Norsonic Nor1209 preamplifier, a G.R.A.S. 40AN half-inch microphone. The G.R.A.S. 40AN microphone is designed to measure audible frequencies as well as infrasound frequencies down to 1 Hz (+/- 1 dB) and 0.5 Hz (+/- 2 dB). The infrasound SLM utilized the same environmental protection kit as the other SLMs with an ACO 7-inch diameter windscreen to reduce wind-induced noise over the microphone that was tripod-mounted approximately 4 feet above ground level. The infrasound meter collected continuous broadband and one-third octave-band ambient sound pressure level data. The meter logged data every 10 minutes with statistical data for the following parameters: L_{eq} , L_{10} , L_{50} , L_{90} , L_{max} , and L_{min} . A one-second time history data collection using the "fast" response setting was also implemented.

7.0 BASELINE SOUND LEVEL MONITORING RESULTS

This chapter discusses the results from the detailed ambient (baseline) monitoring program outlined in the previous chapter. Specifically, the logic for data validity, hub-height wind speed data during monitoring, and sound level result descriptions for the monitoring locations are explained.

7.1 Data Formatting Overview

Sound level data were collected at 10-minute intervals³⁶ at seven strategically selected locations around the proposed wind energy Project during a winter and a summer season. Monitoring periods that experienced elevated ground-level wind speeds or precipitation were excluded from the data analysis per Method #1 in ANSI S12.18-1994. According to this standard, “No sound level measurement shall be made when the average wind velocity exceeds 5 m/s when measured at a height of 2 ± 0.2 m above the ground”. In addition, “Measurement during precipitation [...] is highly discouraged”. Precipitation events identified at the SUNY MesoNet station in Deposit, NY defined periods for which sound level data were excluded from the analysis for the both the winter and summer measurement programs.

The sound level equipment used in ambient monitoring have specifications regarding operative ranges under certain air conditions, e.g., temperature and relative humidity.^{37,38} Data from the Deposit MesoNet station were additionally referenced for the range exceedances during all measurement timeframes. Sound levels during these exceedances were excluded from further processing.

As per Stipulation 19(b)(9), seasonal noise shall be removed from the ambient sound level measurements regardless of season. A high-frequency natural sound (HFNS) filter was therefore applied to the measured one-third octave-band data from which a broadband sound level was calculated for both the summer and winter monitoring seasons. This technique removes all sound energy above the 1,250 Hertz frequency band. The methodology for the filtration process is as specified in ANSI/ASA S12.100-2014 and the

³⁶ It should be noted that all sound level instrumentation data, ground level meteorological instrumentation data, on-site meteorological tower data, and National Weather Service data records were all time-correlated for appropriate alignment of 10-minute periods. Daylight Savings Time adjustments were also made for the winter 2017 monitoring period, specifically.

³⁷ Periods measured outside the temperature range of 14°F to 122°F were considered invalid due to the Larson Davis Model 831 and Norsonic Nor140 SLM specifications.

³⁸ Periods measured outside the relative humidity range of 1 to 99% were considered invalid based on microphone specifications. The accuracy of sound levels measured with a Larson Davis Model 831 SLM outside the relative humidity range of 25% to 90% is unknown; however, the data are not considered invalid and are included in the data summaries. The same is relevant for sound levels measured with a Norsonic Nor140 SLM outside the range of 5% to 90% relative humidity.

sound pressure levels presented in this report using this methodology are indicated as ANS-weighted levels (presented in dBA). The calculated broadband ANS-weighted (dBA) average L_{eq} and L_{90} ambient sound levels are presented for the winter and summer seasons for each location in following subsections.

As per the Exhibit 19 regulations 1001.19(f)(1) daytime is defined as the period from 7 a.m. to 10 p.m. Respectively, nighttime is defined as the period from 10 p.m. to 7 a.m. (1001.19(f)(2)).

7.2 Hub Height Winds

Wind speed data from a 60-meter on-site tower and extrapolated hub height wind speeds were provided to Epsilon for the ambient monitoring periods. Extrapolated hub height wind speed and wind direction data are displayed as wind roses for the winter and summer monitoring seasons in Figures 7-1, and 7-2 [REDACTED], respectively. These data are used for a comparison of hub height wind speeds (relevant to wind turbine operation) versus ambient sound levels in Chapter 8 of this report. Hub height wind speeds that produce the maximum sound power levels vary by wind turbine manufacturer, which is reflected in the binning of the wind speeds in Figures 7-1 and 7-2.

7.3 Location 1

Sound levels at Location 1 were influenced by vehicular traffic on Old Route 17 and Interstate 86, occasional rattling from a nearby sign, machinery noise from an auto body shop, birds, and occasional aircraft. Sound level-versus-time graphs are provided in this section. This includes L_{eq} and L_{90} sound pressure levels and ground-level wind speeds measured at Location 3. Data that were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation and instrumentation operative exceedances as recorded at the Deposit MesoNet station are identified in the figures.

7.3.1 *Winter Monitoring*

The ranges of measured A-weighted sound levels during the winter season are summarized below and presented graphically in Figure 7-3. A total of 636 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1398 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 22 to 58 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 25 to 69 dBA.

The ranges of calculated ANS-weighted sound levels during the winter season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 21 to 57 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 24 to 65 dBA.

7.3.2 Summer Monitoring

The ranges of measured A-weighted sound levels during the summer season are summarized below and presented graphically in Figure 7-4. A total of 113 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 1909 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 38 to 61 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 48 to 66 dBA.

The ranges of calculated ANS-weighted sound levels during the summer season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 23 to 59 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 34 to 65 dBA.

7.3.3 Spectral Sound Level Data

In addition to broadband sound levels, spectral sound level data were measured during each 10-minute period at Location 1 for both the winter and summer measurement periods. Using only valid measurement periods, octave-band and one-third octave-band data are summarized in Figures 7-5 and 7-6, respectively, as logarithmic averages of the equivalent (L_{eq}) sound levels; separated by daytime and nighttime. Octave-band levels are displayed from 31.5 Hz to 16,000 Hz in Figure 7-5 for both L_{eq} and L_{90} . The one-third octave-band data in Figure 7-6 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones³⁹. The logarithmically averaged one-third octave-

³⁹ Prominent discrete tones as defined by the ANSI S12.9 Part 3 standard. The lowest frequency in the Annex B.1 tone test is 25 Hz. 20 Hz data are presented for informational purposes.

band ambient sound levels demonstrate no existing tones in the winter season. Pure tones were present at the 5,000 Hz frequency for the summer season, likely due to bird and insect activity.

7.4 Location 2

Placement of the Location 2 monitor changed between the winter and summer measurement programs due to change of permission. Sound levels at the Winter Location 2 monitor were influenced by wind, birds, vegetation rustle, occasional trains, and distant traffic. Sound levels at the Summer Location 2 monitor were influenced by birds, owls, insects, and distant vehicles. Sound level-versus-time graphs are provided in this section. This includes L_{eq} and L_{90} sound pressure levels and measured ground-level wind speeds at Location 3. Data that were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation and instrumentation operative exceedances as recorded at the Deposit MesoNet station are identified in the figures.

7.4.1 *Winter Monitoring*

The ranges of measured A-weighted sound levels during the winter season are summarized below and presented graphically in Figure 7-7. A total of 601 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,536 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 17 to 50 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 18 to 64 dBA.

The ranges of calculated ANS-weighted sound levels during the winter season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 14 to 48 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 16 to 63 dBA.

7.4.2 *Summer Monitoring*

The ranges of measured A-weighted sound levels during the summer season are summarized below and presented graphically in Figure 7-8. A total of 173 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 1,948 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 24 to 67 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 27 to 72 dBA.

The ranges of calculated ANS-weighted sound levels during the summer season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 12 to 61 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 15 to 66 dBA.

7.4.3 Spectral Sound Level Data

In addition to broadband sound levels, spectral sound level data were measured during each 10-minute period at Location 2. Using only valid measurement periods, octave-band and one-third octave-band data are summarized in Figures 7-9 and 7-10, respectively, as logarithmic averages of the equivalent (L_{eq}) sound levels; separated by daytime and nighttime. Octave-band levels are displayed from 31.5 Hz to 16,000 Hz in Figure 7-9 for both L_{eq} and L_{90} . The one-third octave-band data in Figure 7-10 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones⁴⁰. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter season. A pure tone exists at 5,000 Hz for the summer season, likely due to insect activity.

7.5 Location 3

Sound levels at Location 3 were influenced by rustling vegetation, overhead planes, audible wind, birds, insects, faint Interstate 86 traffic, and the occasional car on William Law Road. Sound level-versus-time graphs are provided in this section. This includes L_{eq} and L_{90} sound pressure levels and measured ground-level wind speeds that were measured at this location. Data that were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation and instrumentation operative exceedances as recorded at the Deposit MesoNet station are identified in the figures.

7.5.1 Winter Monitoring

The ranges of measured A-weighted sound levels during the winter season are summarized below and presented graphically in Figure 7-11. A total of 594 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,543 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 17 to 53 dBA;

⁴⁰ Prominent discrete tones as defined by the ANSI S12.9 Part 3 standard. The lowest frequency in the Annex B.1 tone test is 25 Hz. 20 Hz data are presented for informational purposes.

- ◆ The valid equivalent level (L_{eq}) measurements ranged from 19 to 65 dBA.

The ranges of calculated ANS-weighted sound levels during the winter season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 13 to 52 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 17 to 60 dBA.

7.5.2 Summer Monitoring

The ranges of measured A-weighted sound levels during the summer season are summarized below and presented graphically in Figure 7-12. A total of 158 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 1,957 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 20 to 63 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 22 to 79 dBA.

The ranges of calculated ANS-weighted sound levels during the summer season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 14 to 62 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 18 to 78 dBA.

7.5.3 Spectral Sound Level Data

In addition to broadband sound levels, spectral sound level data were measured during each 10-minute period at Location 3. Using only valid measurement periods, octave-band and one-third octave-band data are summarized in Figures 7-13 and 7-14, respectively, as logarithmic averages of the equivalent (L_{eq}) sound levels; separated by daytime and nighttime. Octave-band levels are displayed from 31.5 Hz to 16,000 Hz in Figure 7-13 for both L_{eq} and L_{90} . The one-third octave-band data in Figure 7-14 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones⁴¹. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones.

⁴¹ Prominent discrete tones as defined by the ANSI S12.9 Part 3 standard. The lowest frequency in the Annex B.1 tone test is 25 Hz. 20 Hz data are presented for informational purposes.

7.6 Location 4

Sound levels at the Location 4 monitor were influenced by wind, occasional vehicle traffic on Pazzelli Road, overhead planes, rustling vegetation, birds, faint stream noise, and occasional farm animals. Sound level-versus-time graphs are provided in this section. This includes L_{eq} and L_{90} sound pressure levels and measured ground-level wind speeds that were measured at Location 3. Data that were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation and instrumentation operative exceedances as recorded at the Deposit MesoNet station are identified in the figures.

7.6.1 *Winter Monitoring*

The ranges of measured A-weighted sound levels during the winter season are summarized below and presented graphically in Figure 7-15. A total of 366 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 635 10-minute periods of valid data. The winter data at this location were truncated as there were technical issues during the first week of measurements.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 18 to 48 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 18 to 58 dBA.

The ranges of calculated ANS-weighted sound levels during the winter season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 14 to 47 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 16 to 58 dBA.

7.6.2 *Summer Monitoring*

The ranges of measured A-weighted sound levels during the summer season are summarized below and presented graphically in Figure 7-16. A total of 162 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 1,951 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 23 to 60 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 24 to 69 dBA.

The ranges of calculated ANS-weighted sound levels during the summer season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 12 to 51 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 14 to 69 dBA.

7.6.3 Spectral Sound Level Data

In addition to broadband sound levels, spectral sound level data were measured during each 10-minute period at Location 4. Using only valid measurement periods, octave-band and one-third octave-band data are summarized in Figures 7-17 and 7-18, respectively, as logarithmic averages of the equivalent (L_{eq}) sound levels; separated by daytime and nighttime. Octave-band levels are displayed from 31.5 Hz to 16,000 Hz in Figure 7-17 for both L_{eq} and L_{90} . The one-third octave-band data in Figure 7-18 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones⁴². The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter season. Pure tones are present in the summer data at the 5,000 Hz and 10,000 Hz frequencies, likely due to insect or bird activity.

7.7 Location 5

Sound levels at the Winter Location 5 monitor were influenced by distant traffic noise from Interstate 86, occasional aircraft, stream noise⁴³, bird, insects, and vehicles along Farnham Road. Sound level-versus-time graphs are provided in this section. This includes L_{eq} and L_{90} sound pressure levels and measured ground-level wind speeds that were measured at Location 3. Data that were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation and instrumentation operative exceedances as recorded at the Deposit Mesonet station are identified in the figures.

7.7.1 Winter Monitoring

The ranges of measured A-weighted sound levels during the winter season are summarized below and presented graphically in Figure 7-19. A total of 578 10-minute periods were

⁴² Prominent discrete tones as defined by the ANSI S12.9 Part 3 standard. The lowest frequency in the Annex B.1 tone test is 25 Hz. 20 Hz data are presented for informational purposes.

⁴³ The measurement Protocol states that the microphone was to be placed 15 meters (~ 50 feet) from the centerline of the nearest traffic lane, and if this was not possible or practical that the microphone setback from the road would be comparable to the setback of a sensitive receptor. Specific microphone placement at this location was designed to avoid stream noise as much as possible while following the Protocol and with the limitation of the parcel boundary.

excluded from the winter season. The resulting dataset includes a total of 1,543 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 21 to 55 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 21 to 64 dBA.

The ranges of calculated ANS-weighted sound levels during the winter season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 17 to 54 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 20 to 63 dBA.

7.7.2 Summer Monitoring

The ranges of measured A-weighted sound levels during the summer season are summarized below and presented graphically in Figure 7-20. A total of 166 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 1,859 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 25 to 64 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 30 to 69 dBA.

The ranges of calculated ANS-weighted sound levels during the summer season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 17 to 60 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 19 to 67 dBA.

7.7.3 Spectral Sound Level Data

In addition to broadband sound levels, spectral sound level data were measured during each 10-minute period at Location 5. Using only valid measurement periods, octave-band and one-third octave-band data are summarized in Figures 7-21 and 7-22, respectively, as logarithmic averages of the equivalent (L_{eq}) winter and summer sound levels; separated by daytime and nighttime. Octave-band levels are displayed from 31.5 Hz to 16,000 Hz in Figure 7-21 for both L_{eq} and L_{90} . The one-third octave-band data in Figure 7-22 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete

tones⁴⁴. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter monitoring period. A pure tone was present at 5,000 Hz during the summer program, likely due to insect activity.

7.8 Location 6

Sound levels at the Location 6 monitor were influenced by occasional traffic from Route 41 to the west, wind, rustling vegetation, stream noise⁴⁵, insects, birds and a neighborhood dog barking. Sound level-versus-time graphs are provided in this section. This includes L_{eq} and L_{90} sound pressure levels and measured ground-level wind speeds that were measured at Location 7. Data that were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation and instrumentation operative exceedances as recorded at the Deposit MesoNet station are identified in the figures.

7.8.1 Winter Monitoring

The ranges of measured A-weighted sound levels during the winter season are summarized below and presented graphically in Figure 7-23. A total of 694 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,429 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 25 to 55 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 27 to 69 dBA.

The ranges of calculated ANS-weighted sound levels during the winter season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 23 to 53 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 26 to 66 dBA.

⁴⁴ Prominent discrete tones as defined by the ANSI S12.9 Part 3 standard. The lowest frequency in the Annex B.1 tone test is 25 Hz. 20 Hz data are presented for informational purposes.

⁴⁵ The measurement Protocol states that the microphone was to be placed 15 meters (~50 feet) from the centerline of the nearest traffic lane, and if this was not possible or practical that the microphone setback from the road would be comparable to the setback of a sensitive receptor. Specific microphone placement at this location was designed to avoid stream noise as much as possible while following the Protocol and with the limitation of the parcel boundary.

7.8.2 Summer Monitoring

The ranges of measured A-weighted sound levels during the summer season are summarized below and presented graphically in Figure 7-24. A total of 72 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 1,946 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 32 to 62 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 34 to 74 dBA.

The ranges of calculated ANS-weighted sound levels during the summer season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 25 to 60 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 27 to 73 dBA.

7.8.3 Spectral Sound Level Data

In addition to broadband sound levels, spectral sound level data were measured during each 10-minute period at Location 6. Using only valid measurement periods, octave-band and one-third octave-band data are summarized in Figures 7-25 and 7-26, respectively, as logarithmic averages of the equivalent (L_{eq}) winter sound levels; separated by daytime and nighttime. Octave-band levels are displayed from 31.5 Hz to 16,000 Hz in Figure 7-25 for both L_{eq} and L_{90} . The one-third octave-band data in Figure 7-26 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones⁴⁶. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones for the winter season. Pure tones exist at the 5,000 Hz and 8,000 Hz frequencies for the summer season likely due to birds and insect activity.

7.9 Location 7

Sound levels at the Winter Location 7 monitor were influenced by wind noise, vegetation rustle, birds, sounds from nearby residences, and insects. Sound level-versus-time graphs are provided in this section. This includes L_{eq} and L_{90} sound pressure levels and measured ground-level wind speeds that were measured at this location. Data that were excluded

⁴⁶ Prominent discrete tones as defined by the ANSI S12.9 Part 3 standard. The lowest frequency in the Annex B.1 tone test is 25 Hz. 20 Hz data are presented for informational purposes.

from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation and instrumentation operative exceedances as recorded at the Deposit MesoNet station are identified in the figures.

7.9.1 Winter Monitoring

The ranges of measured A-weighted sound levels during the winter season are summarized below and presented graphically in Figure 7-27. A total of 713 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,424 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 19 to 50 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 19 to 66 dBA.

The ranges of calculated ANS-weighted sound levels during the winter season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 15 to 50 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 17 to 64 dBA.

7.9.2 Summer Monitoring

The ranges of measured A-weighted sound levels during the summer season are summarized below and presented graphically in Figure 7-28. A total of 73 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,035 10-minute periods of valid data.

- ◆ The valid steady-state level (L_{90}) measurements ranged from 20 to 62 dBA;
- ◆ The valid equivalent level (L_{eq}) measurements ranged from 23 to 77 dBA.

The ranges of calculated ANS-weighted sound levels during the summer season are summarized below.

- ◆ The valid, calculated steady-state (L_{90}) ANS-weighted broadband sound levels ranged from 10 to 61 dBA;
- ◆ The valid, calculated equivalent (L_{eq}) ANS-weighted broadband sound levels ranged from 12 to 76 dBA.

7.9.3 Spectral Sound Level Data

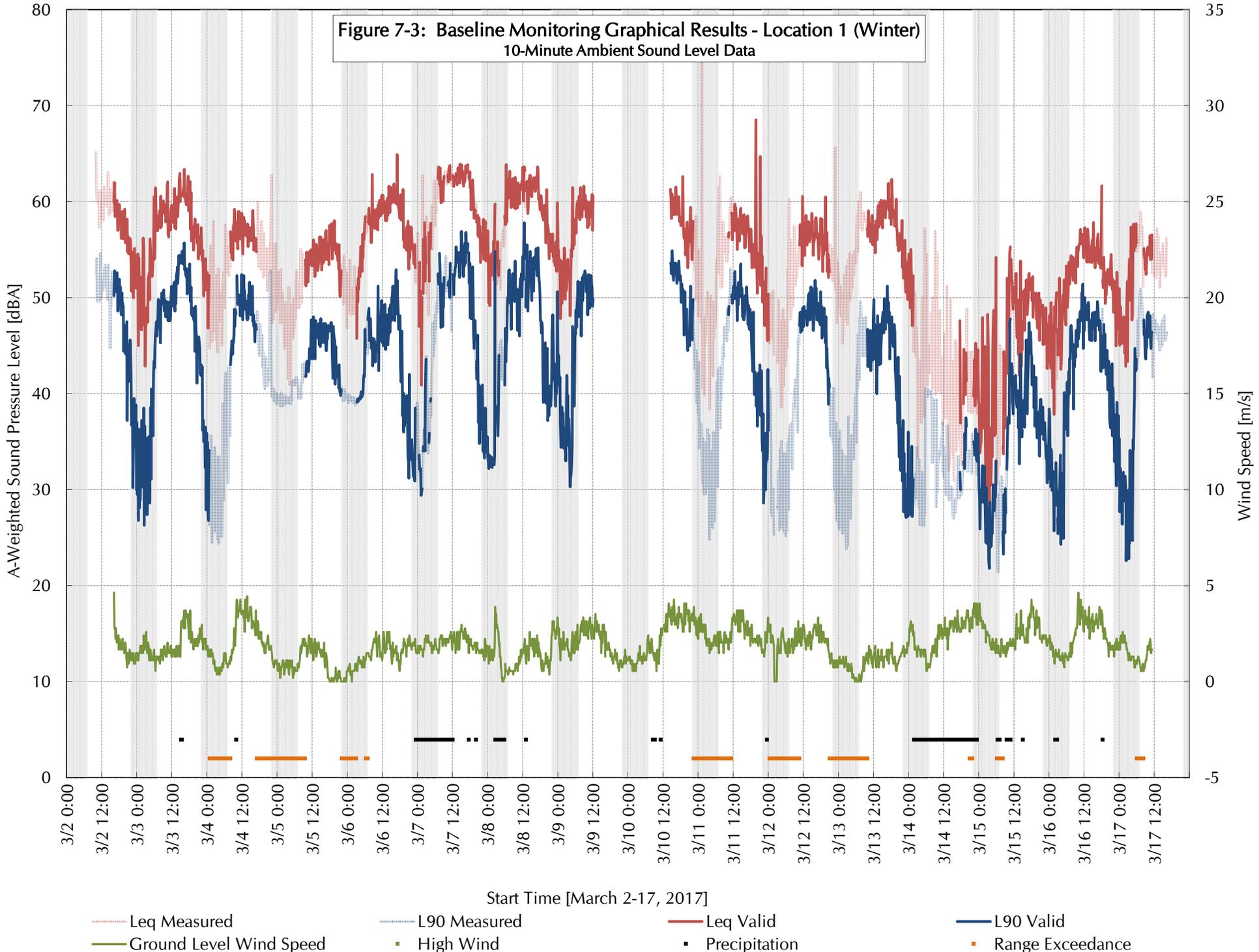
In addition to broadband sound levels, spectral sound level data were measured during each 10-minute period at Location 7. Using only valid measurement periods, octave-band and one-third octave-band data are summarized in Figures 7-29 and 7-30, respectively, as logarithmic averages of the equivalent (L_{eq}) winter and summer sound levels; separated by daytime and nighttime. Octave-band levels are displayed from 31.5 Hz to 16,000 Hz in Figure 7-29 for both L_{eq} and L_{90} . The one-third octave-band data in Figure 7-30 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones⁴⁷. The logarithmically averaged one-third octave-band ambient sound levels demonstrate no existing tones during the winter season. A pure tone was present at 5,000 Hz during the summer season, likely due to insect activity.

⁴⁷ Prominent discrete tones as defined by the ANSI S12.9 Part 3 standard. The lowest frequency in the Annex B.1 tone test is 25 Hz. 20 Hz data are presented for informational purposes.

Figure 7-1 On-Site Hub Height Wind Rose – Winter Ambient [REDACTED]

Figure 7-2 On-Site Hub Height Wind Rose – Summer Ambient [REDACTED]

Figure 7-3: Baseline Monitoring Graphical Results - Location 1 (Winter)
 10-Minute Ambient Sound Level Data



- Leq Measured
- L90 Measured
- Leq Valid
- L90 Valid
- Ground Level Wind Speed
- High Wind
- Precipitation
- Range Exceedance

Figure 7-4: Baseline Monitoring Graphical Results - Location 1 (Summer)
10-Minute Ambient Sound Level Data

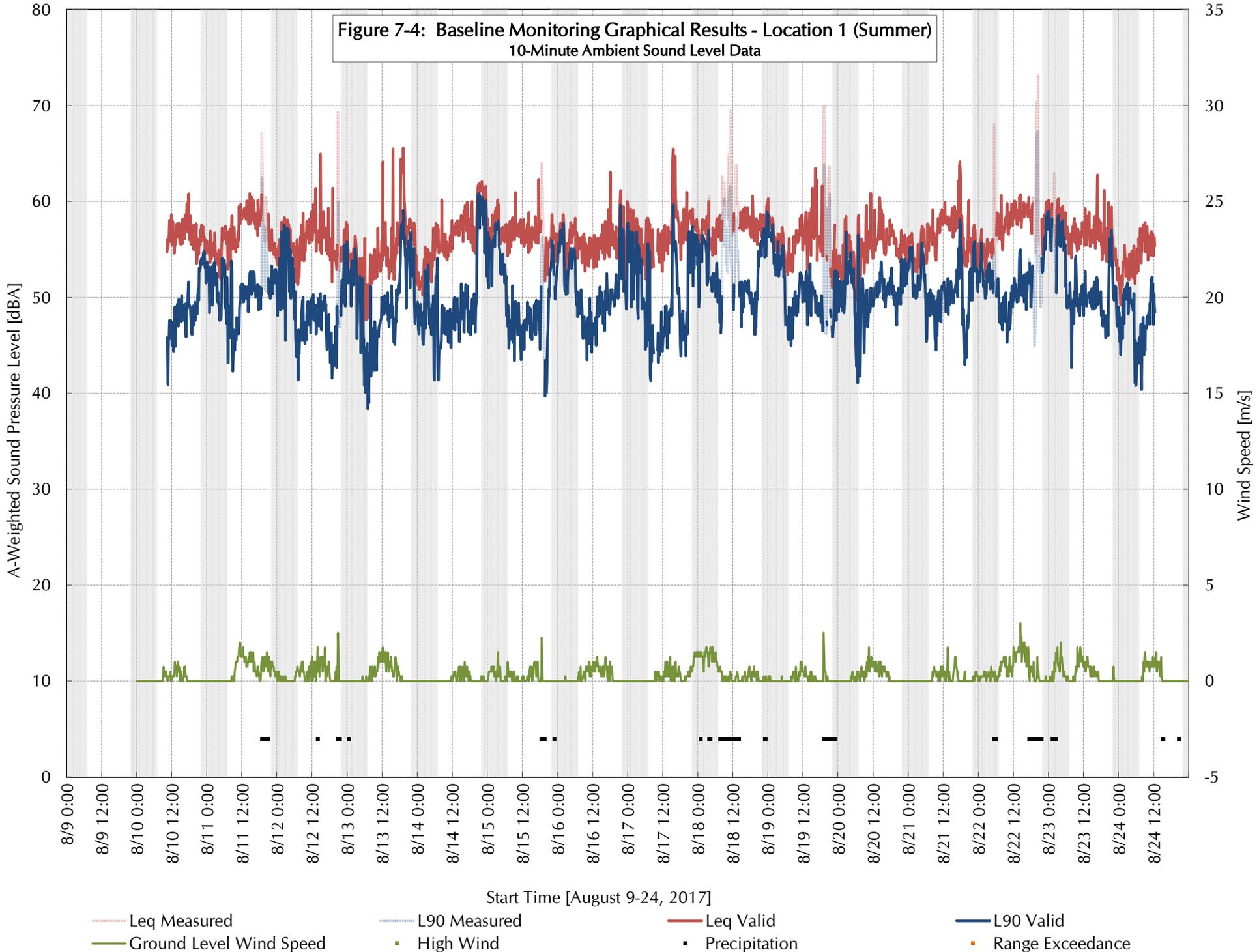


Figure 7-5: Baseline Monitoring Graphical Results - Location 1 Octave Band Sound Pressure Levels
 Average of 10-Minute Sound Pressure Levels

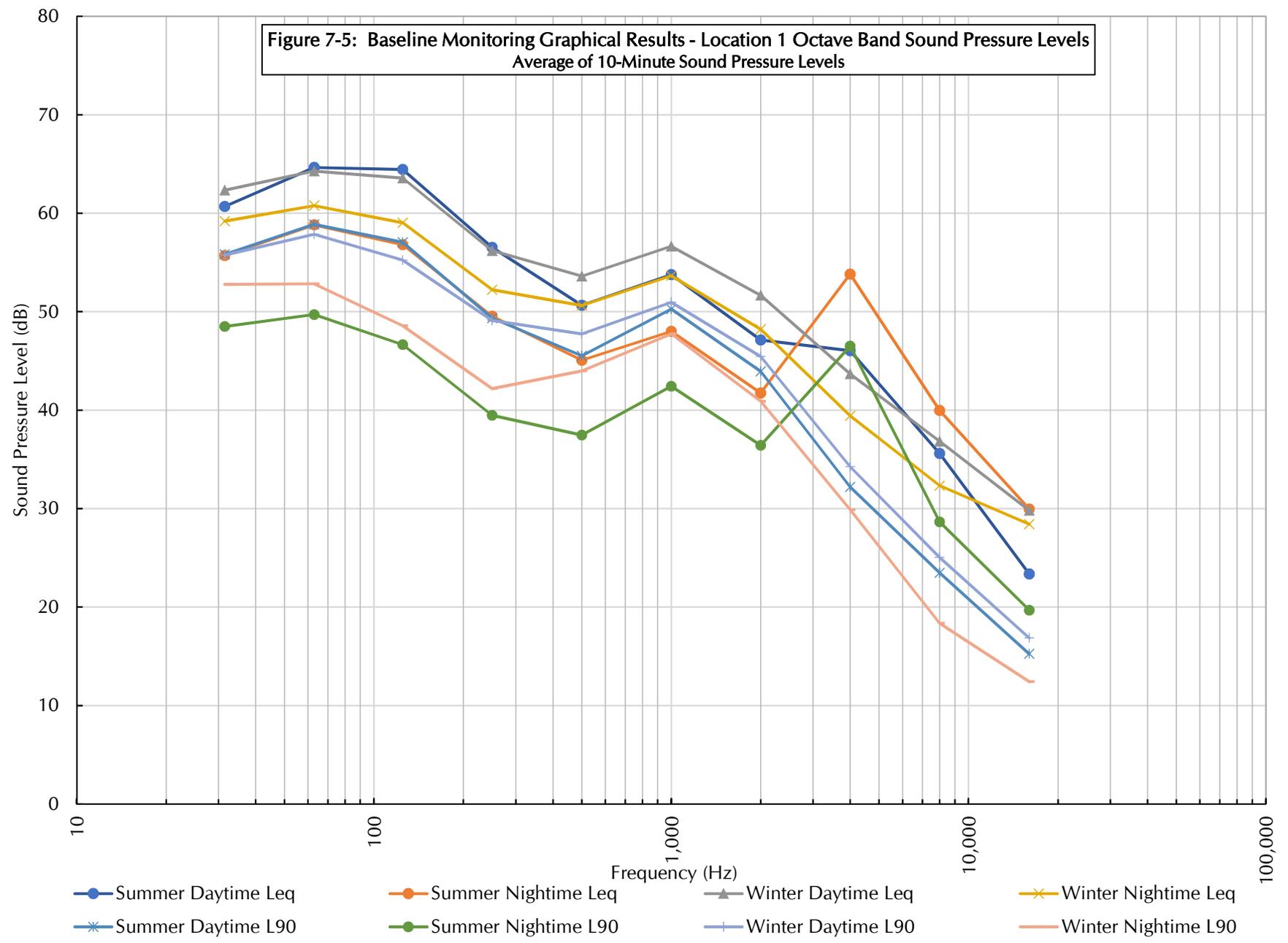


Figure 7-6: Baseline Monitoring Graphical Results - Location 1-Third Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels

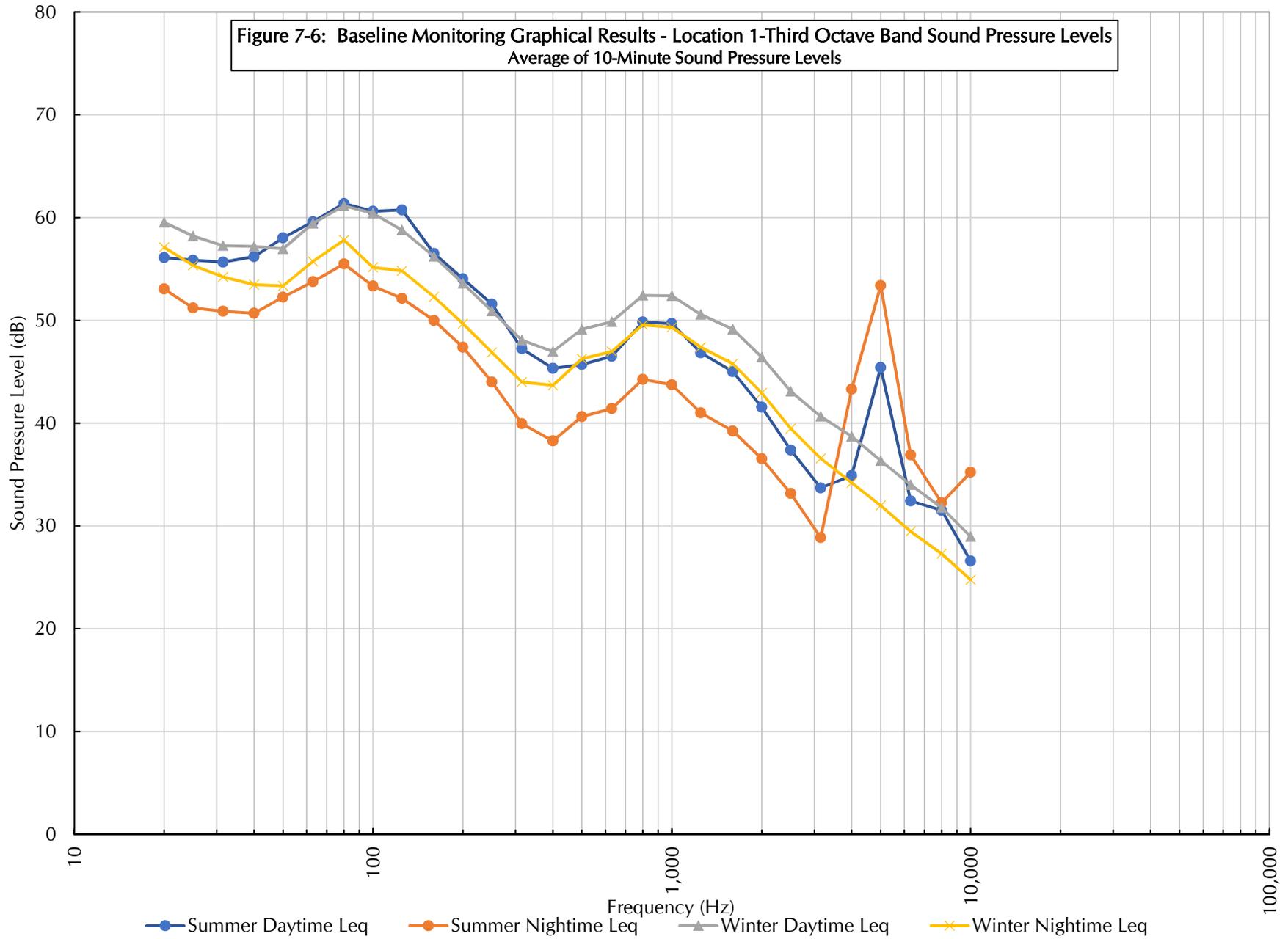


Figure 7-7: Baseline Monitoring Graphical Results - Location 2 (Winter)
 10-Minute Ambient Sound Level Data

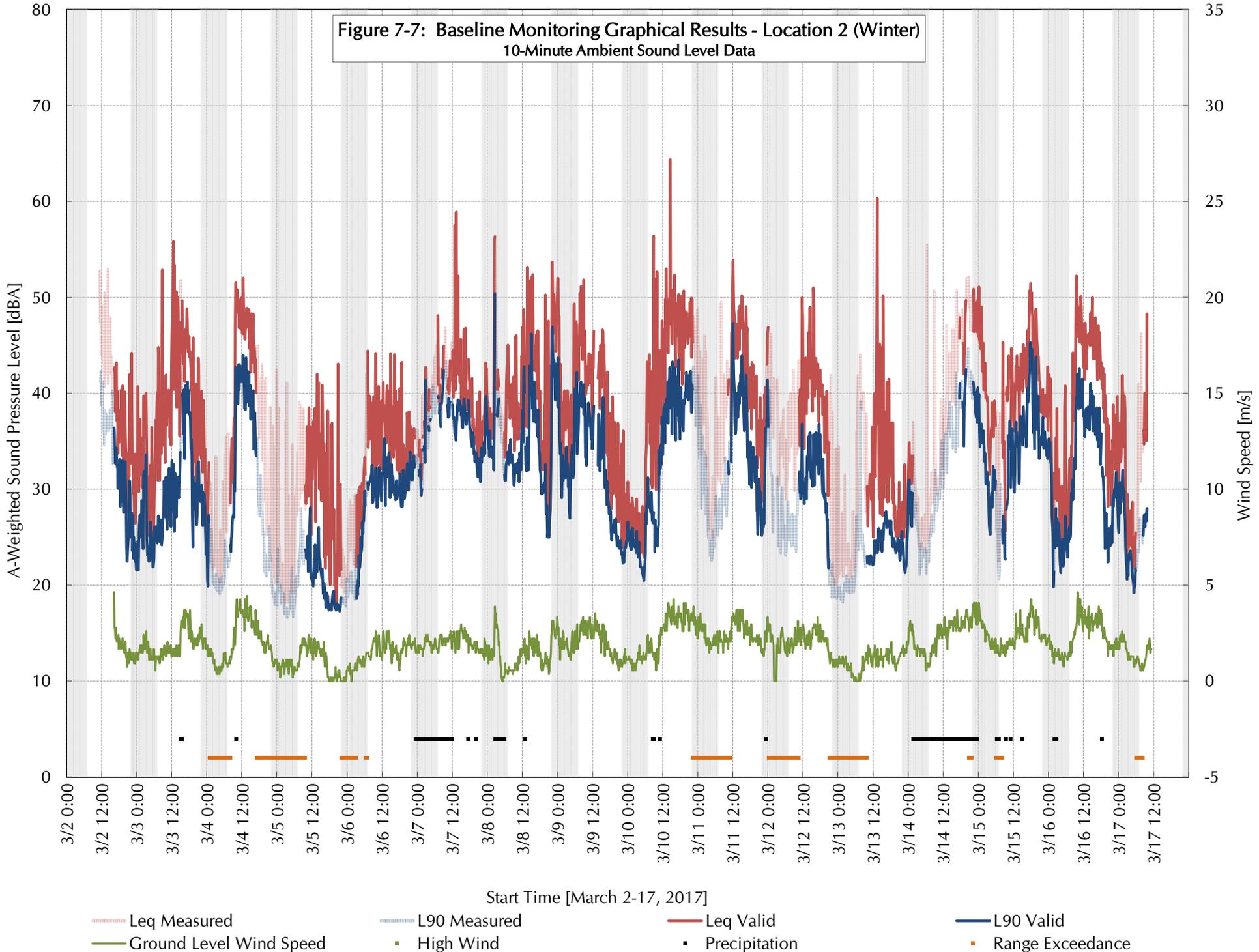
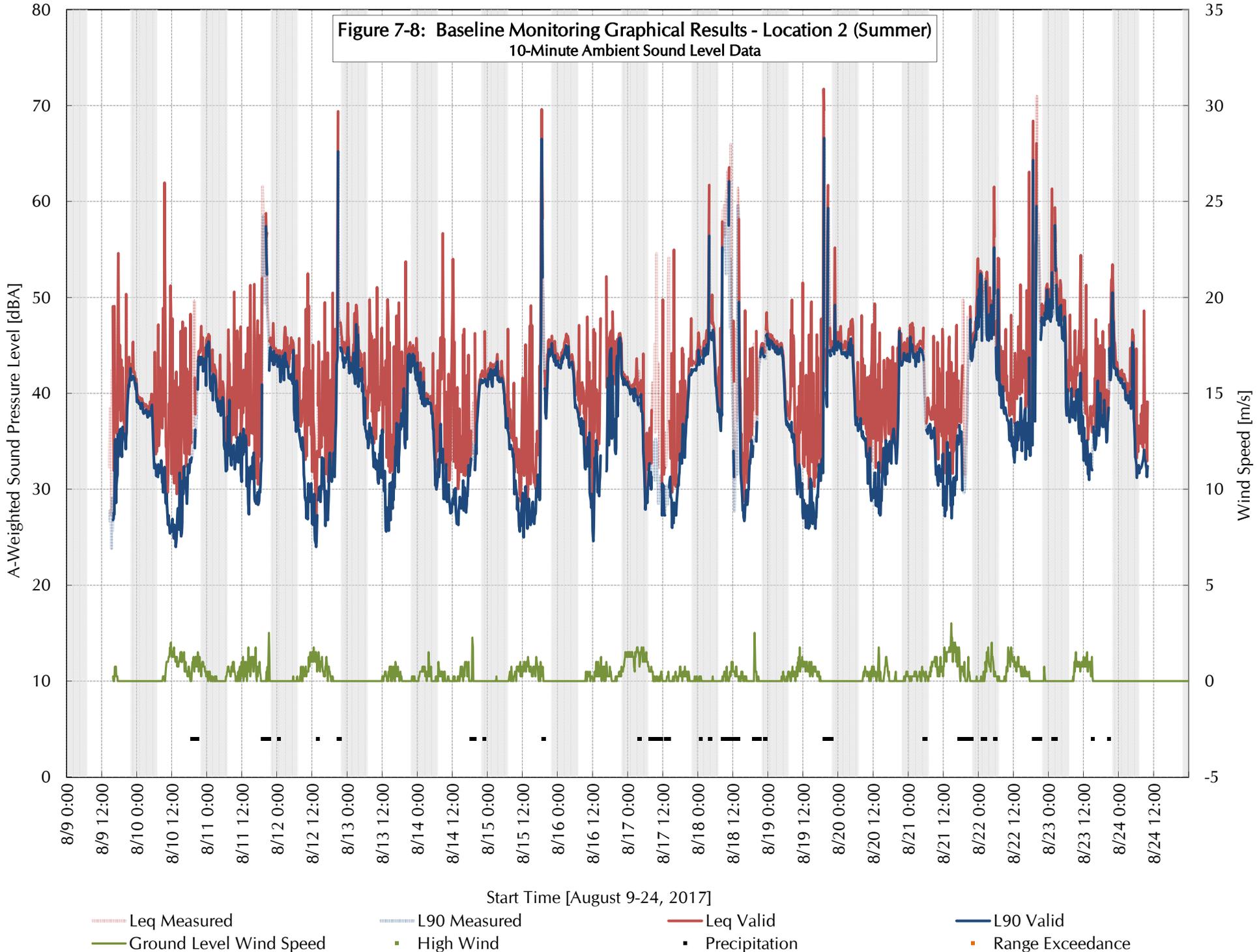
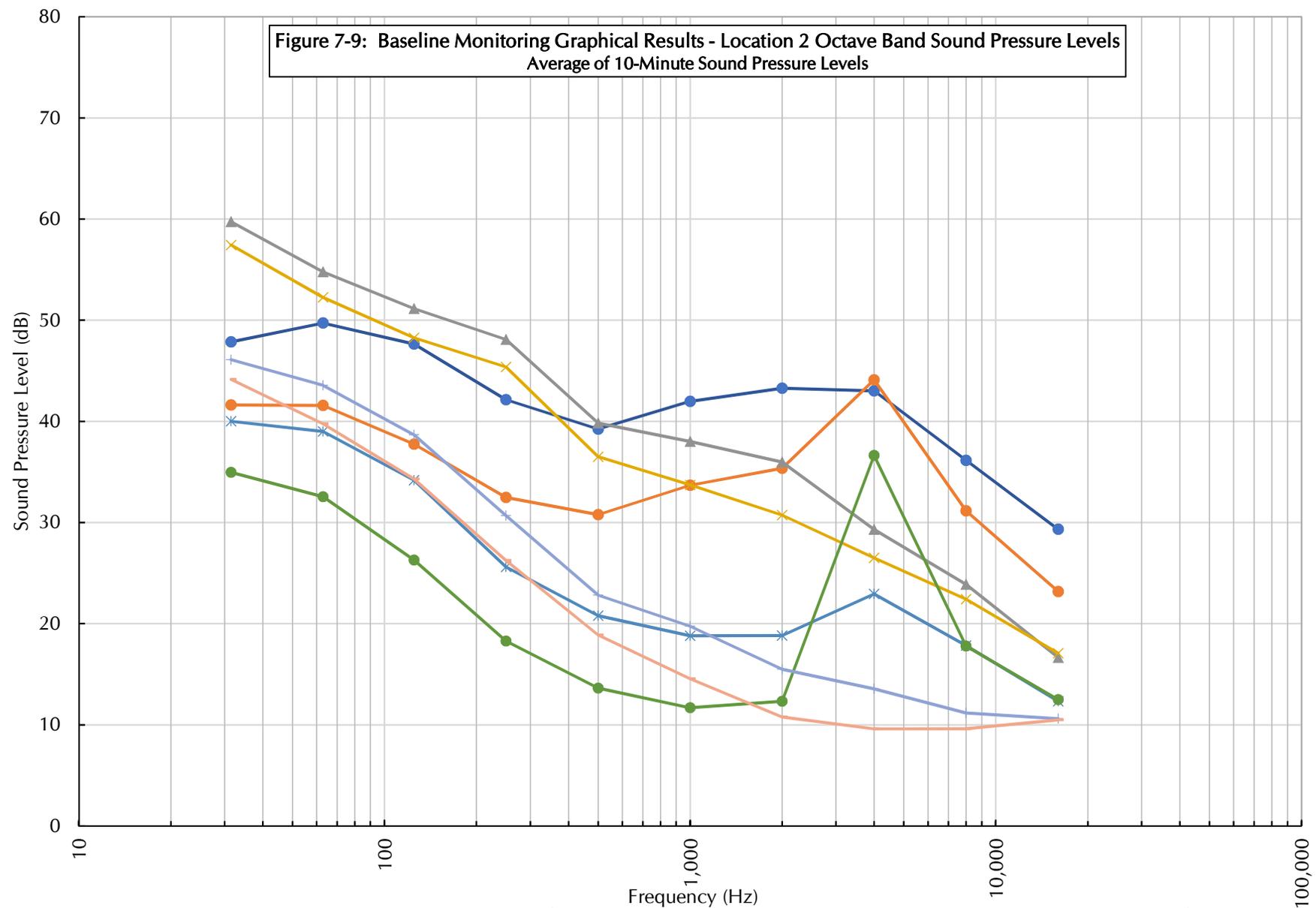


Figure 7-8: Baseline Monitoring Graphical Results - Location 2 (Summer)
10-Minute Ambient Sound Level Data



- Leq Measured
- L90 Measured
- Leq Valid
- L90 Valid
- Ground Level Wind Speed
- High Wind
- Precipitation
- Range Exceedance

Figure 7-9: Baseline Monitoring Graphical Results - Location 2 Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels



- Summer Daytime Leq
- Summer Nighttime Leq
- ▲ Winter Daytime Leq
- ✕ Winter Nighttime Leq
- ✕ Summer Daytime L90
- Summer Nighttime L90
- + Winter Daytime L90
- Winter Nighttime L90

Figure 7-10: Baseline Monitoring Graphical Results - Location 2-Third Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels

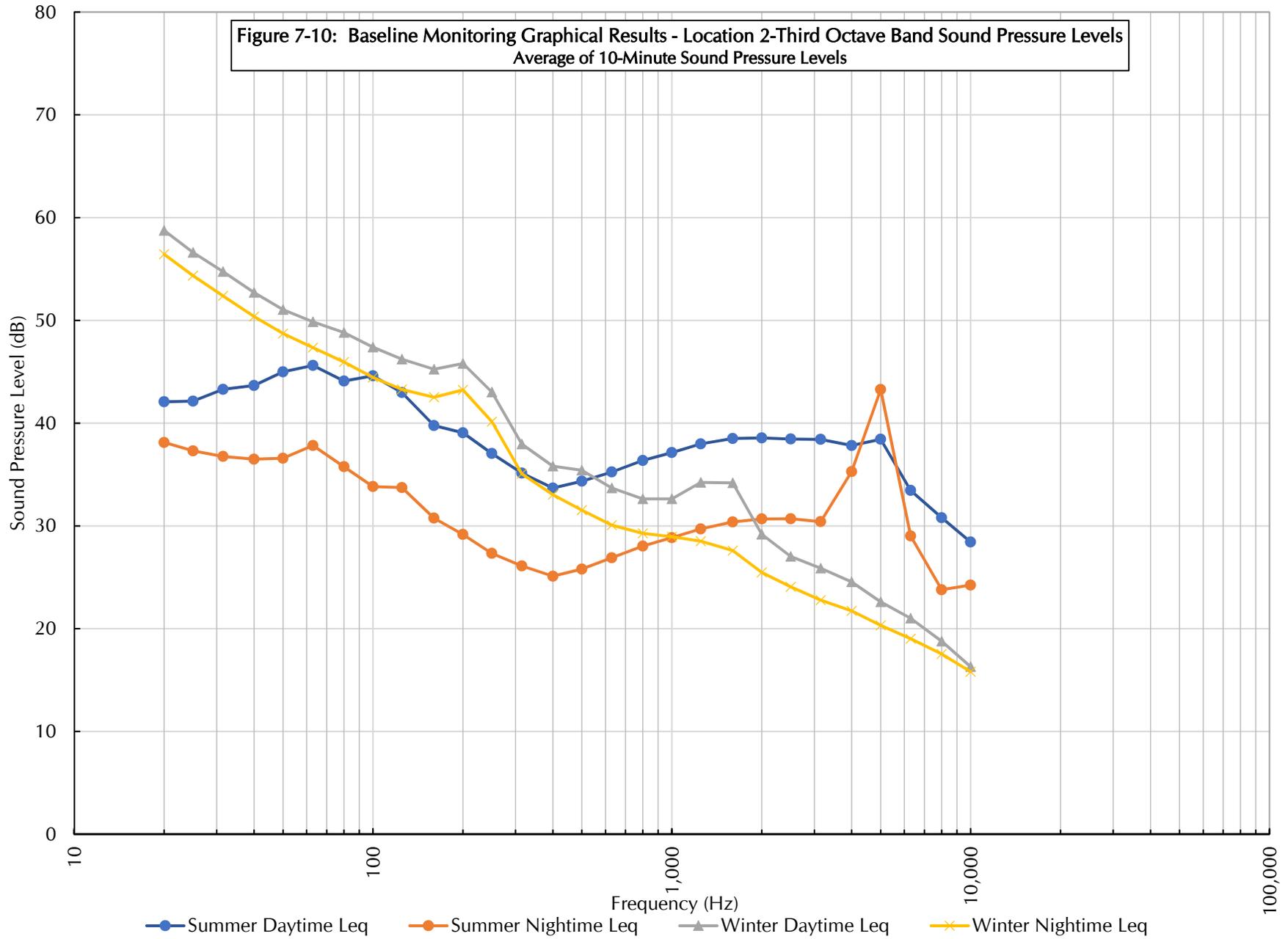


Figure 7-11: Baseline Monitoring Graphical Results - Location 3 (Winter)
 10-Minute Ambient Sound Level Data

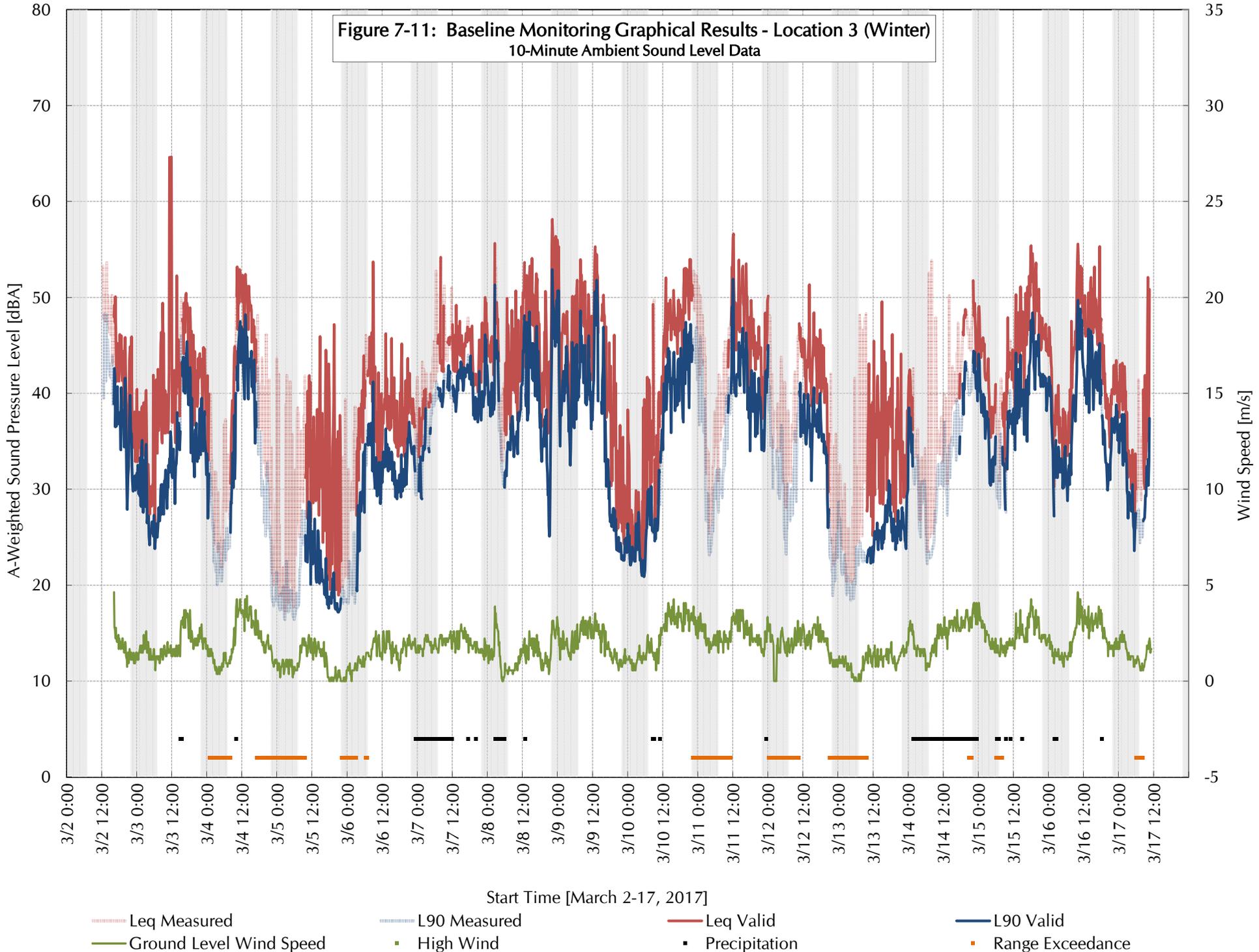


Figure 7-12: Baseline Monitoring Graphical Results - Location 3 (Summer)
 10-Minute Ambient Sound Level Data

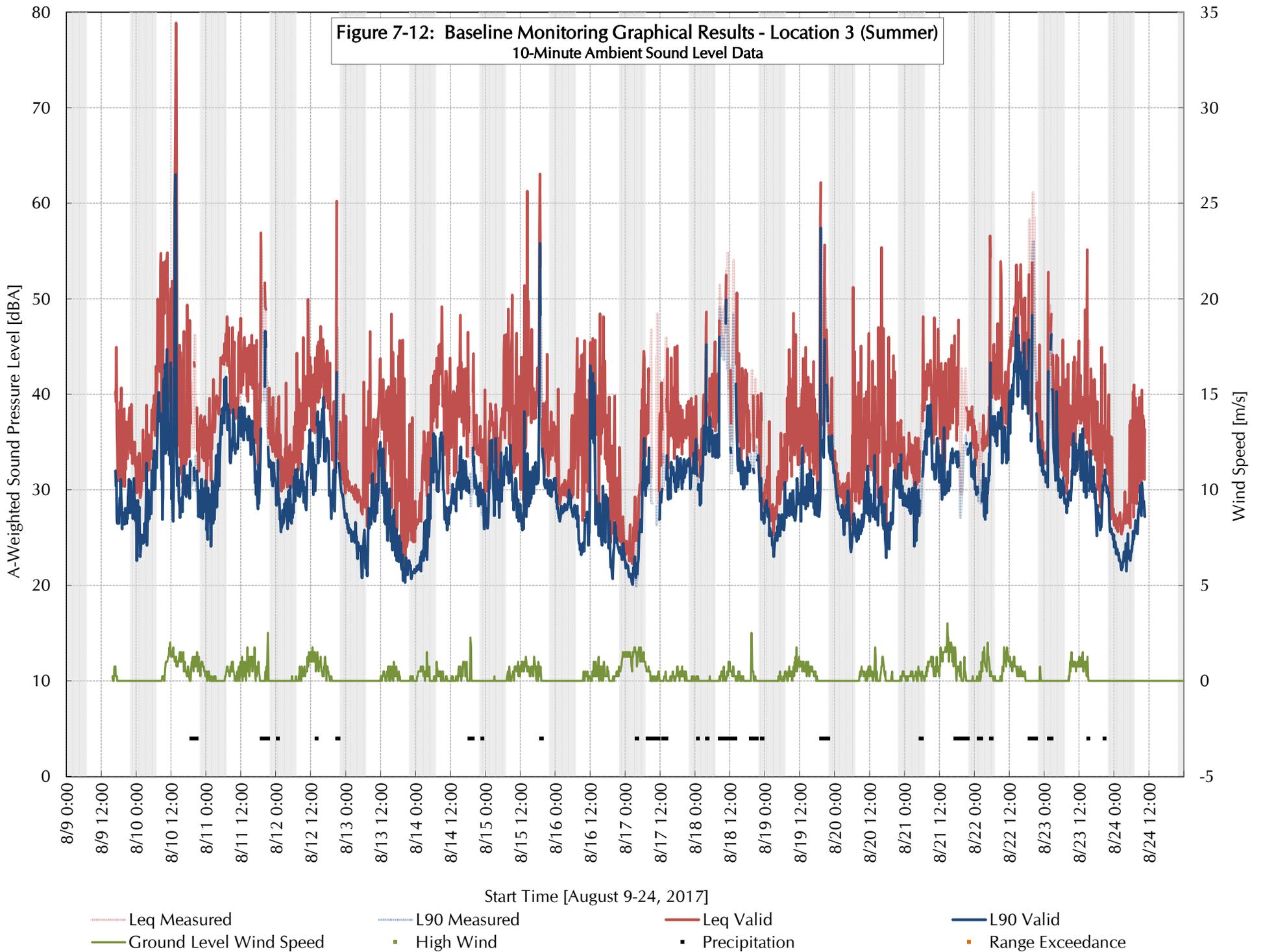
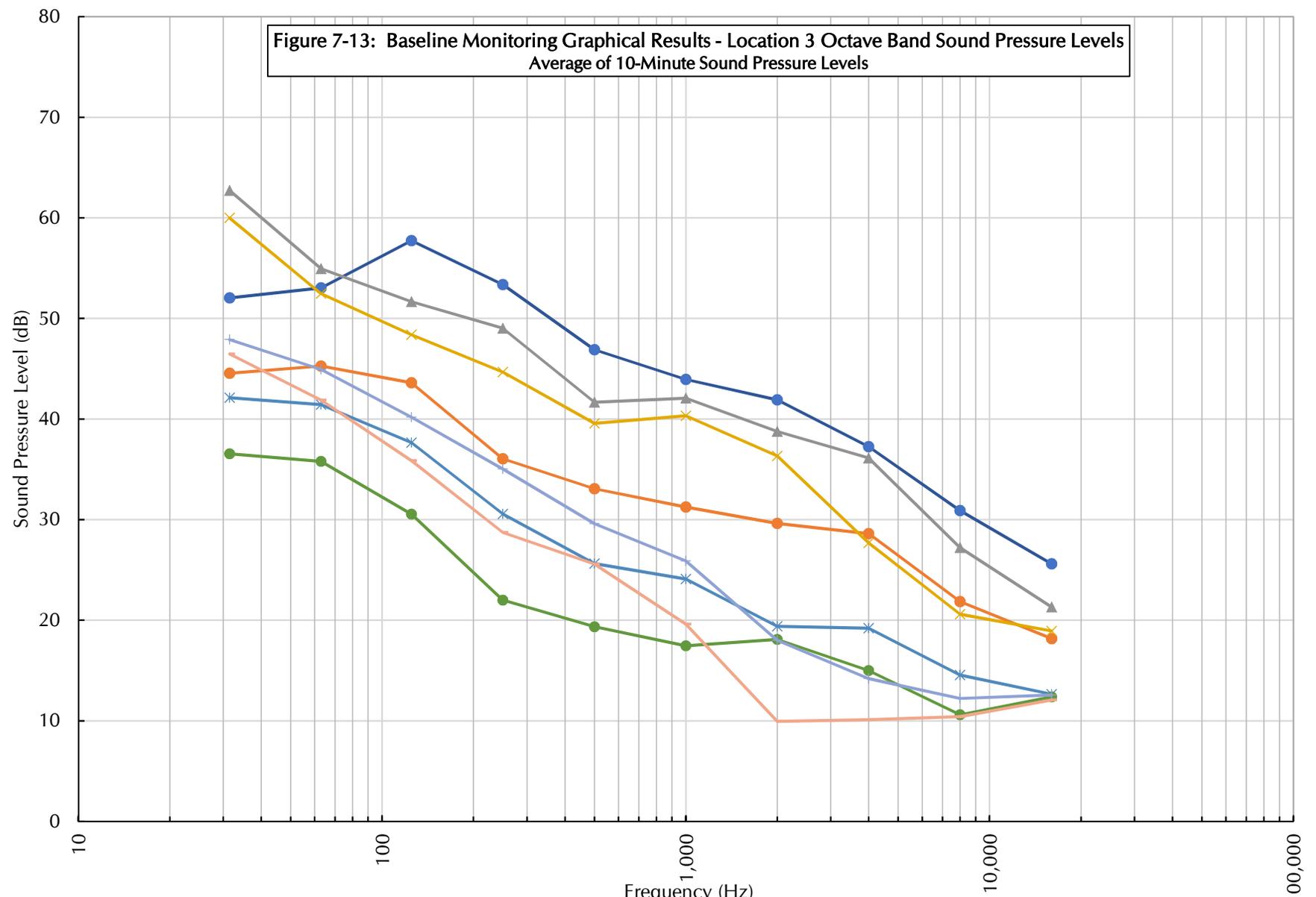


Figure 7-13: Baseline Monitoring Graphical Results - Location 3 Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels



- Summer Daytime Leq
- Summer Nighttime Leq
- Summer Daytime L90
- Summer Nighttime L90
- ▲ Winter Daytime Leq
- ▲ Winter Nighttime Leq
- ▲ Winter Daytime L90
- ▲ Winter Nighttime L90

Figure 7-14: Baseline Monitoring Graphical Results - Location 3-Third Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels

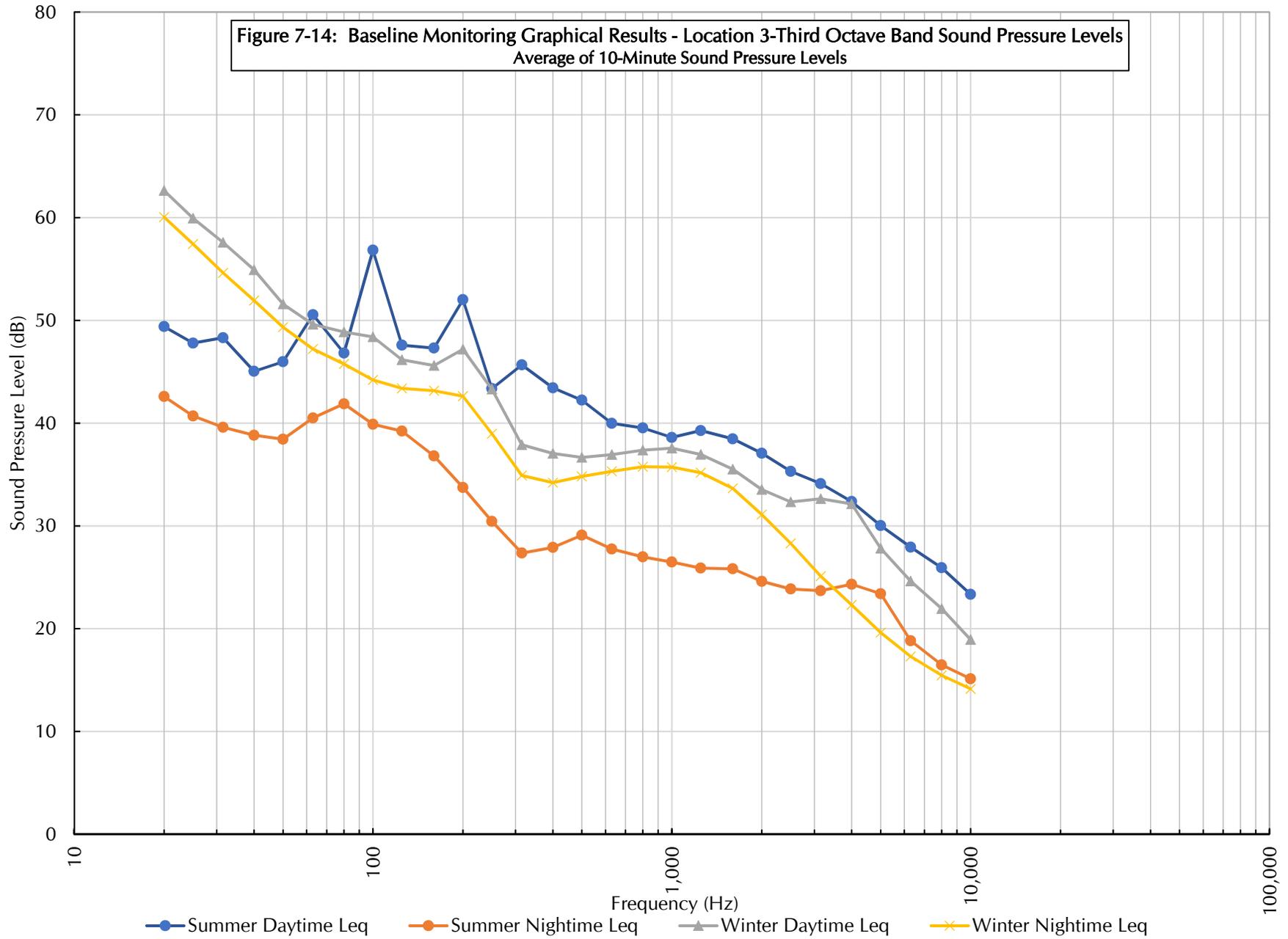
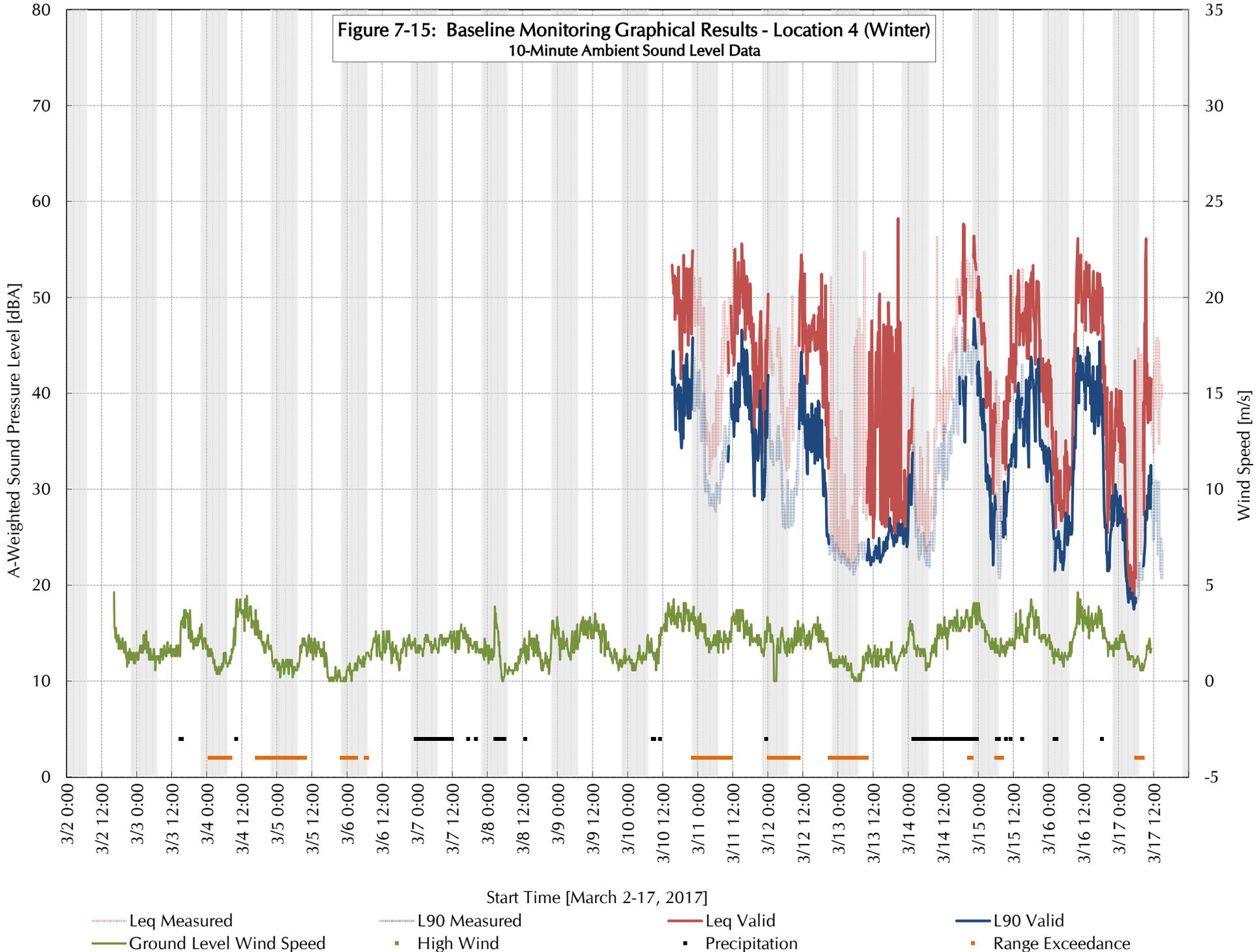


Figure 7-15: Baseline Monitoring Graphical Results - Location 4 (Winter)
 10-Minute Ambient Sound Level Data



- Leq Measured
- L90 Measured
- Leq Valid
- L90 Valid
- Ground Level Wind Speed
- High Wind
- Precipitation
- Range Exceedance

Figure 7-16: Baseline Monitoring Graphical Results - Location 4 (Summer)
 10-Minute Ambient Sound Level Data

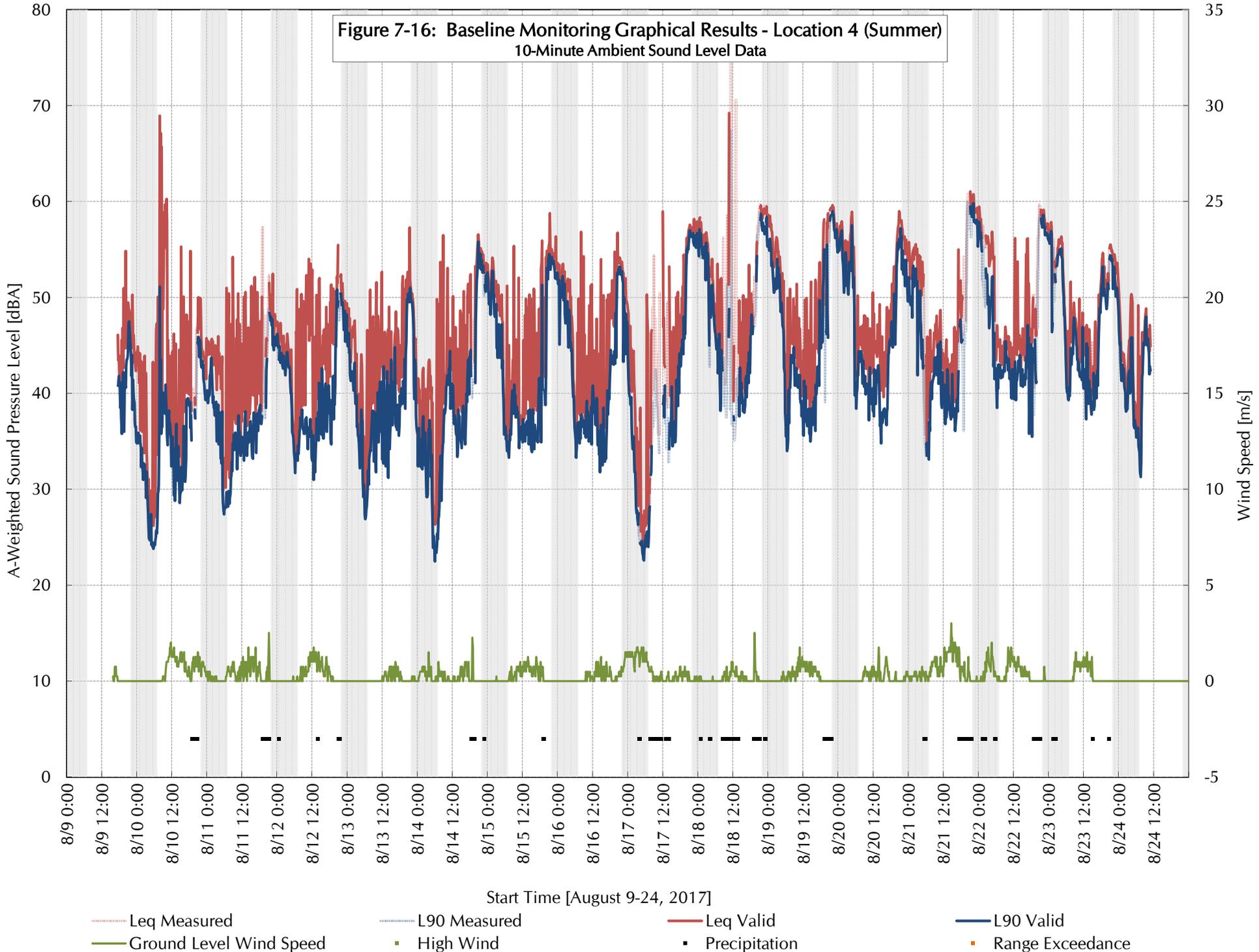
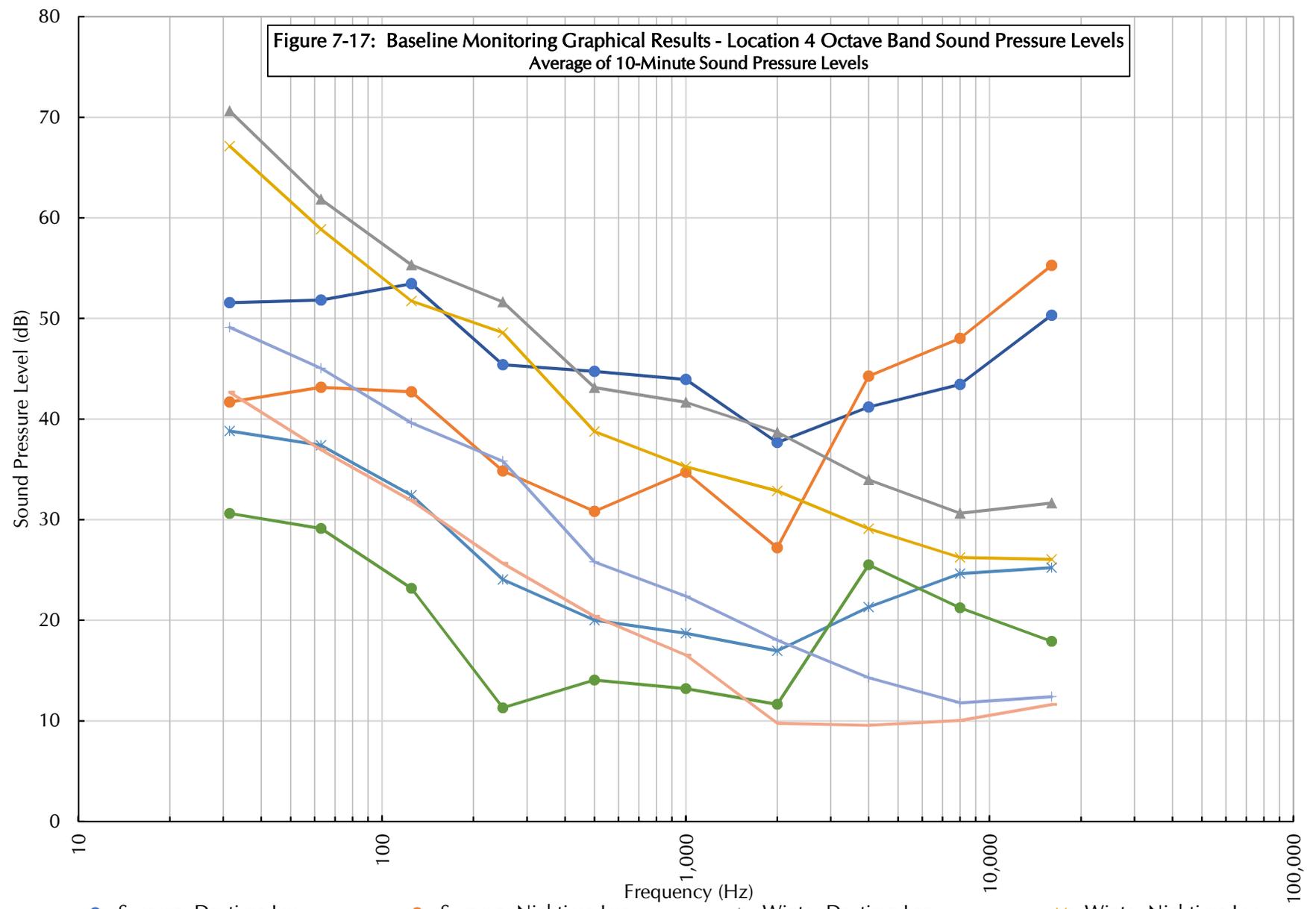


Figure 7-17: Baseline Monitoring Graphical Results - Location 4 Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels



- Summer Daytime Leq
- Summer Nighttime Leq
- ▲ Winter Daytime Leq
- × Winter Nighttime Leq
- * Summer Daytime L90
- Summer Nighttime L90
- * Winter Daytime L90
- * Winter Nighttime L90

Figure 7-18: Baseline Monitoring Graphical Results - Location 4-Third Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels

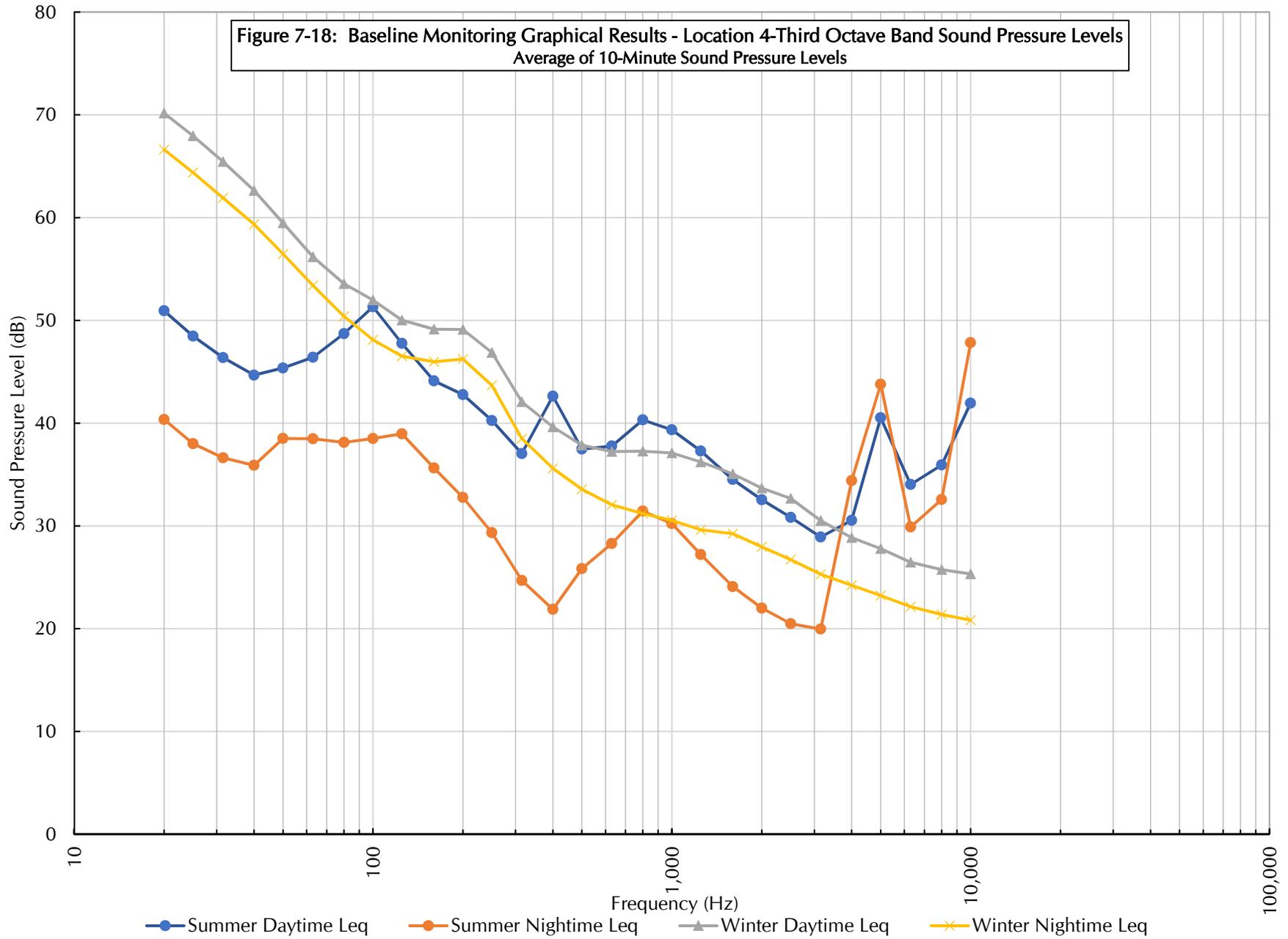
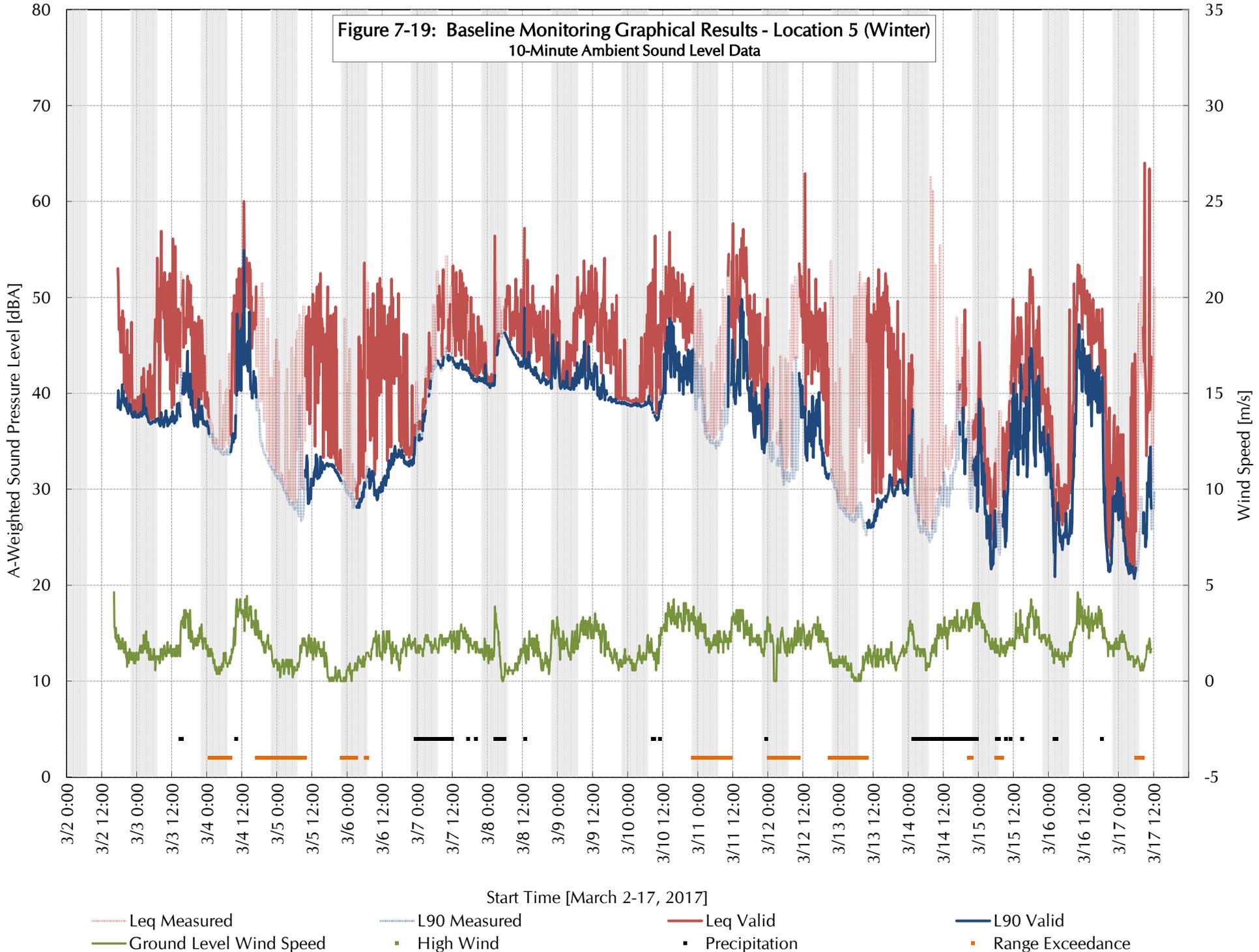
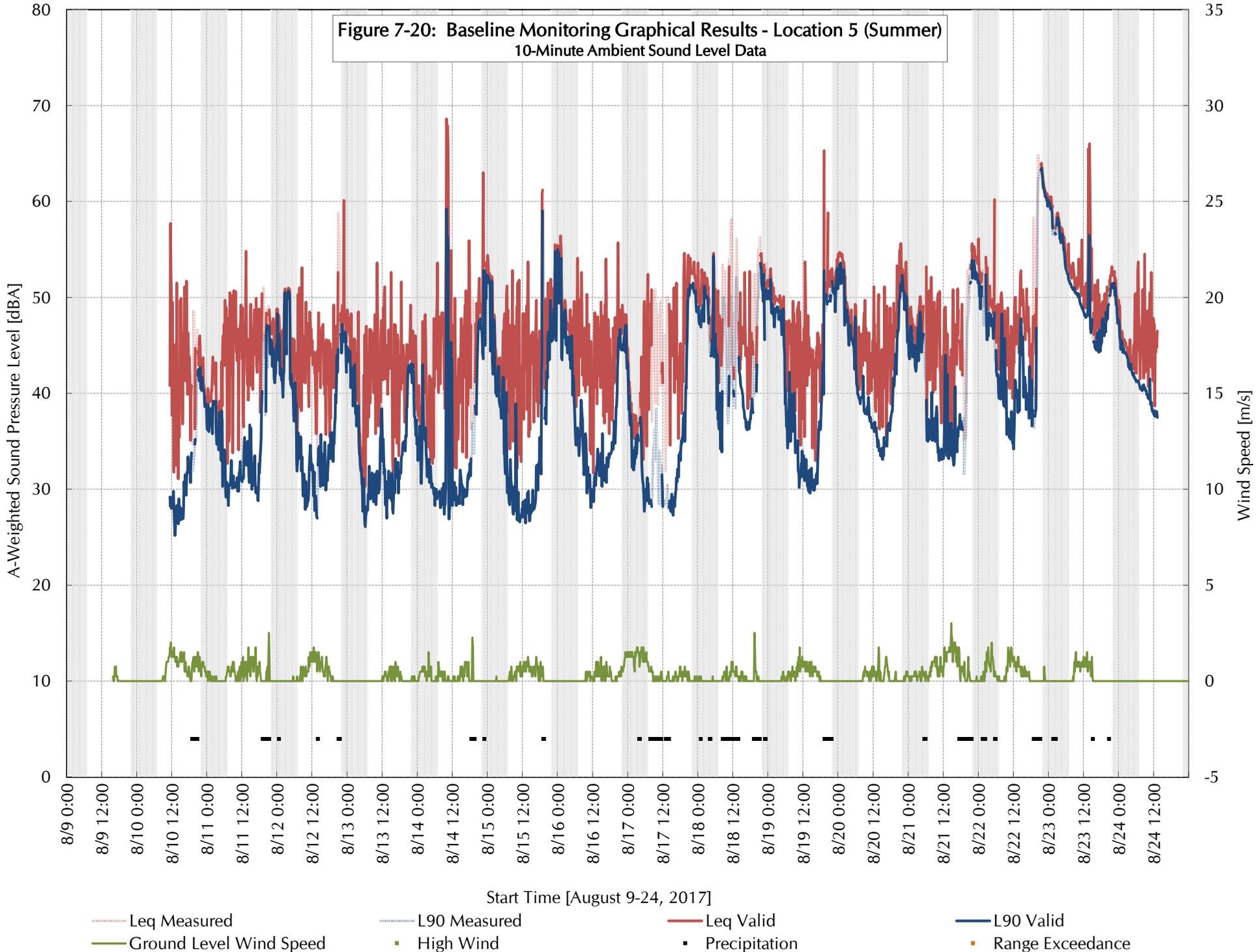


Figure 7-19: Baseline Monitoring Graphical Results - Location 5 (Winter)
 10-Minute Ambient Sound Level Data



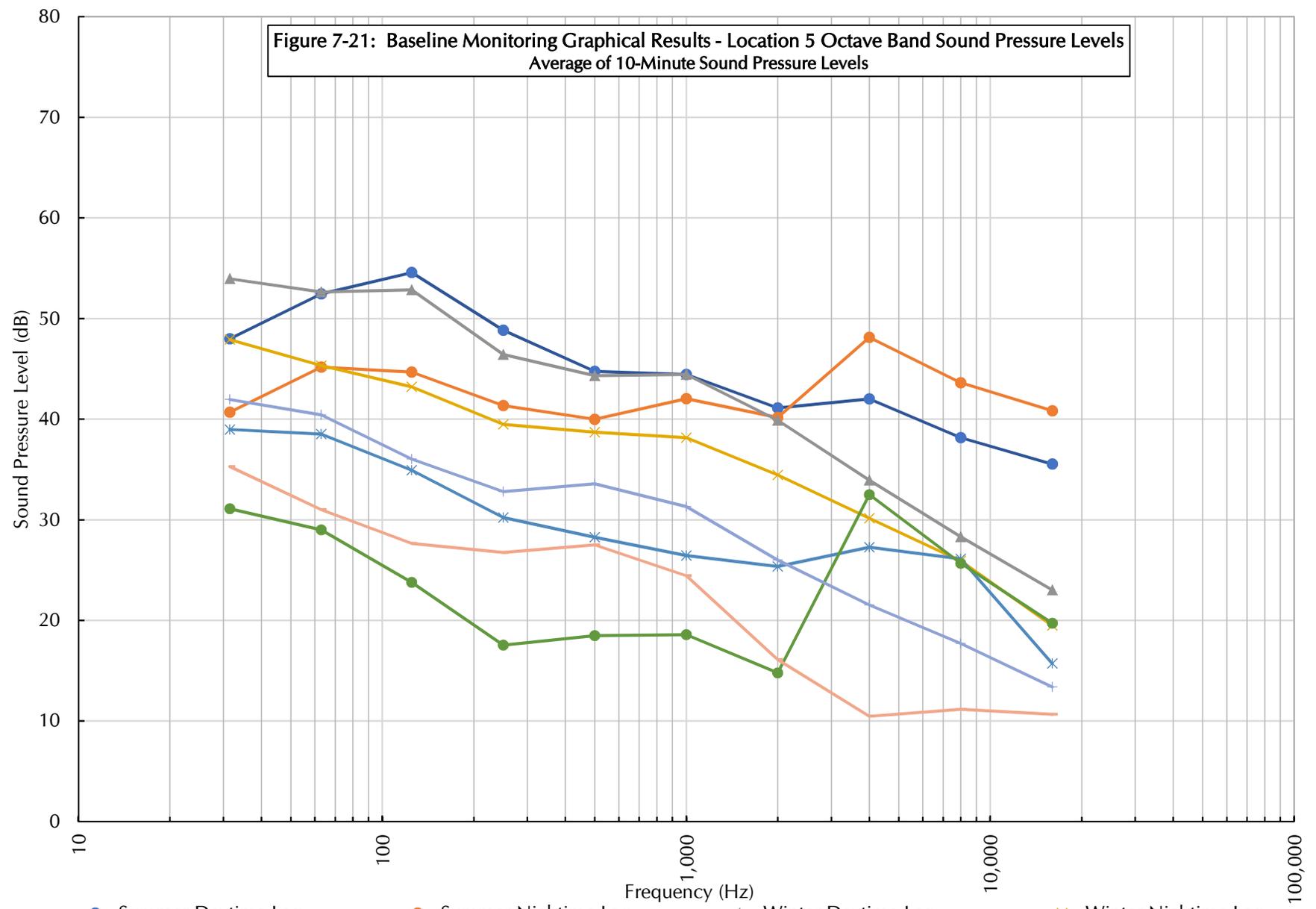
⋯ Leq Measured	⋯ L90 Measured	— Leq Valid	— L90 Valid
— Ground Level Wind Speed	■ High Wind	— Precipitation	■ Range Exceedance

Figure 7-20: Baseline Monitoring Graphical Results - Location 5 (Summer)
 10-Minute Ambient Sound Level Data



----- Leq Measured ----- L90 Measured — Leq Valid — L90 Valid
— Ground Level Wind Speed ■ High Wind ■ Precipitation ■ Range Exceedance

Figure 7-21: Baseline Monitoring Graphical Results - Location 5 Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels



- Summer Daytime Leq
- Summer Nighttime Leq
- ▲ Winter Daytime Leq
- ✕ Winter Nighttime Leq
- * Summer Daytime L90
- Summer Nighttime L90
- + Winter Daytime L90
- + Winter Nighttime L90

Figure 7-22: Baseline Monitoring Graphical Results - Location 5-Third Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels

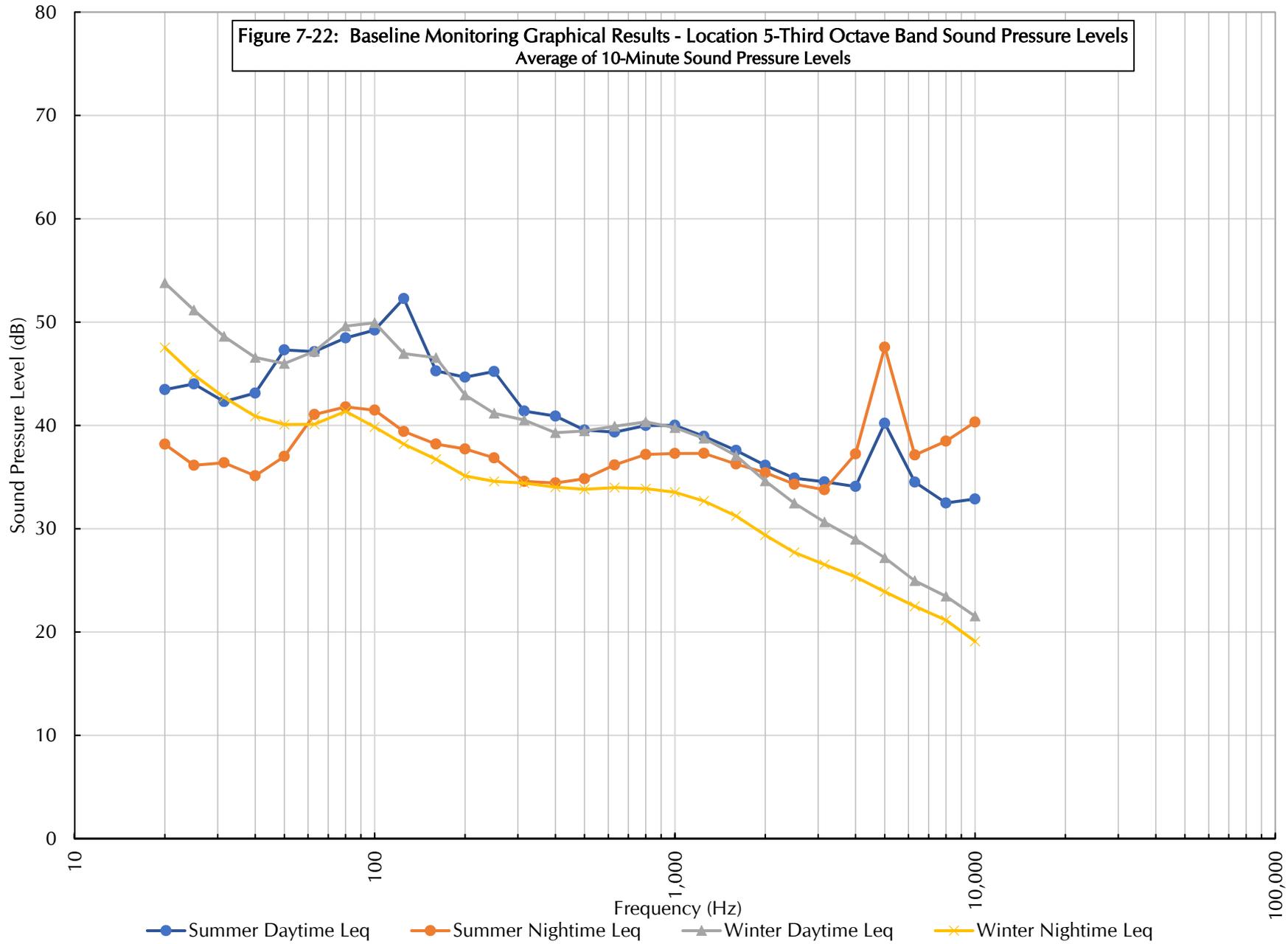
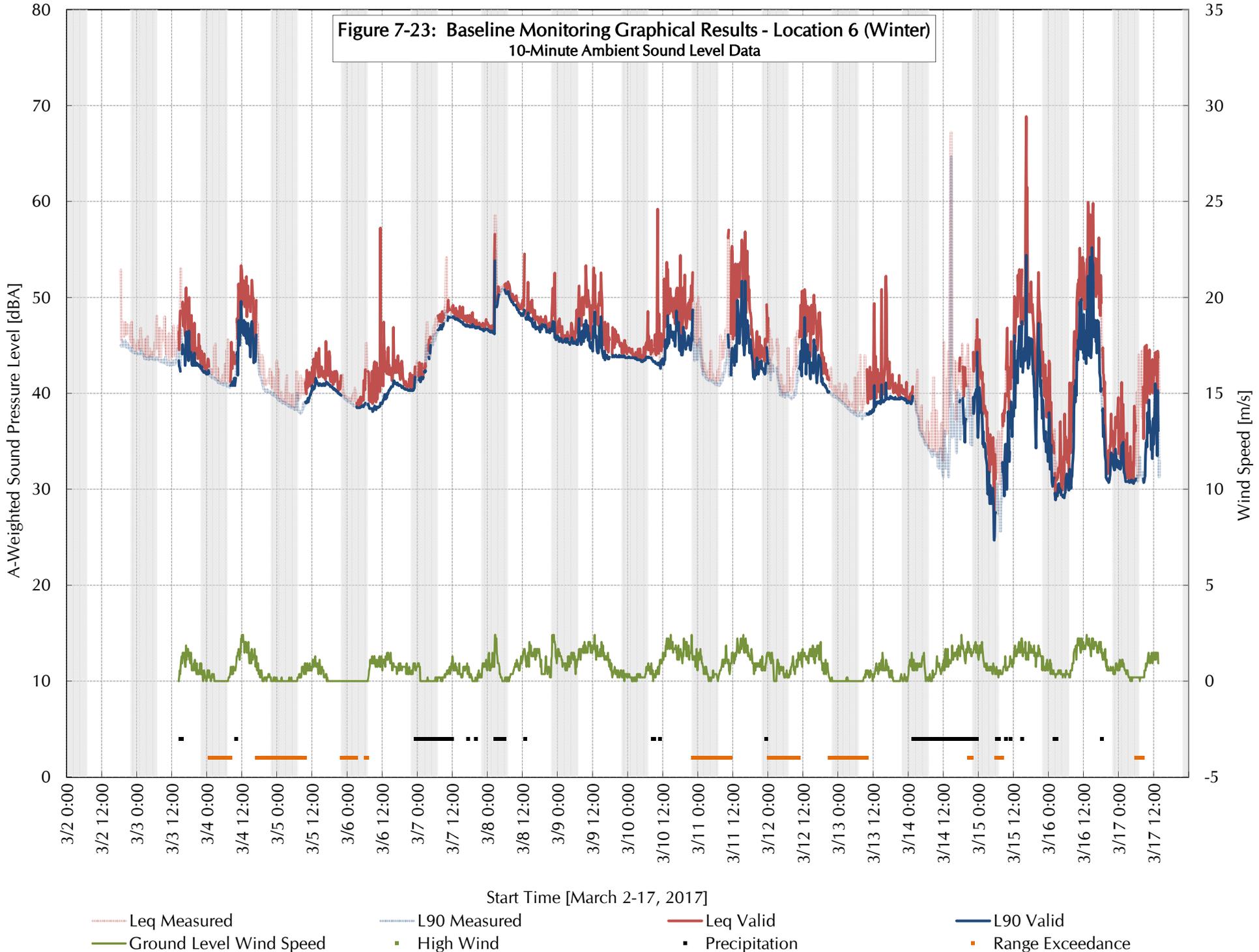


Figure 7-23: Baseline Monitoring Graphical Results - Location 6 (Winter)
 10-Minute Ambient Sound Level Data



--- Leq Measured --- L90 Measured — Leq Valid — L90 Valid
— Ground Level Wind Speed ■ High Wind ■ Precipitation ■ Range Exceedance

Figure 7-24: Baseline Monitoring Graphical Results - Location 6 (Summer)
10-Minute Ambient Sound Level Data

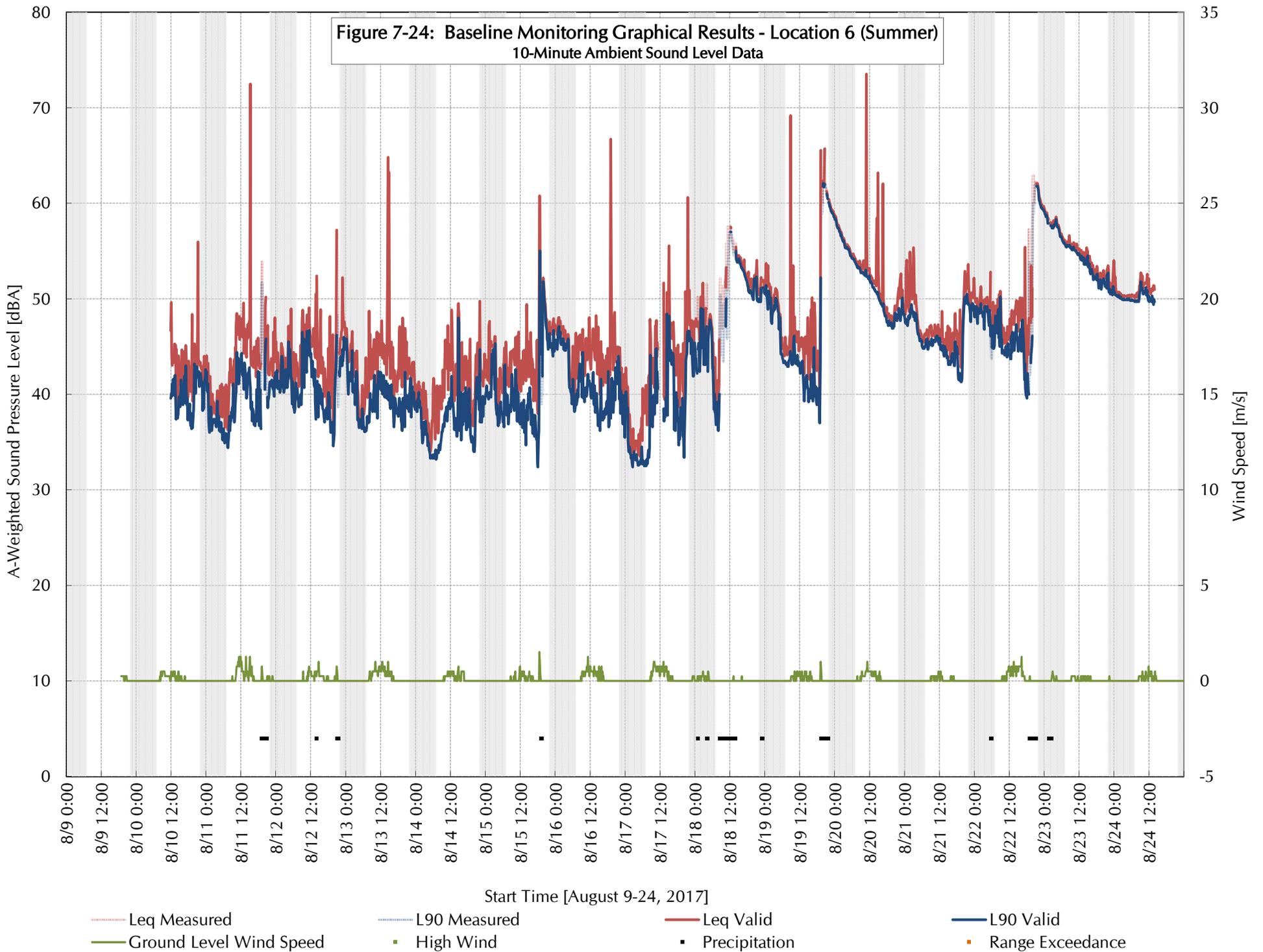
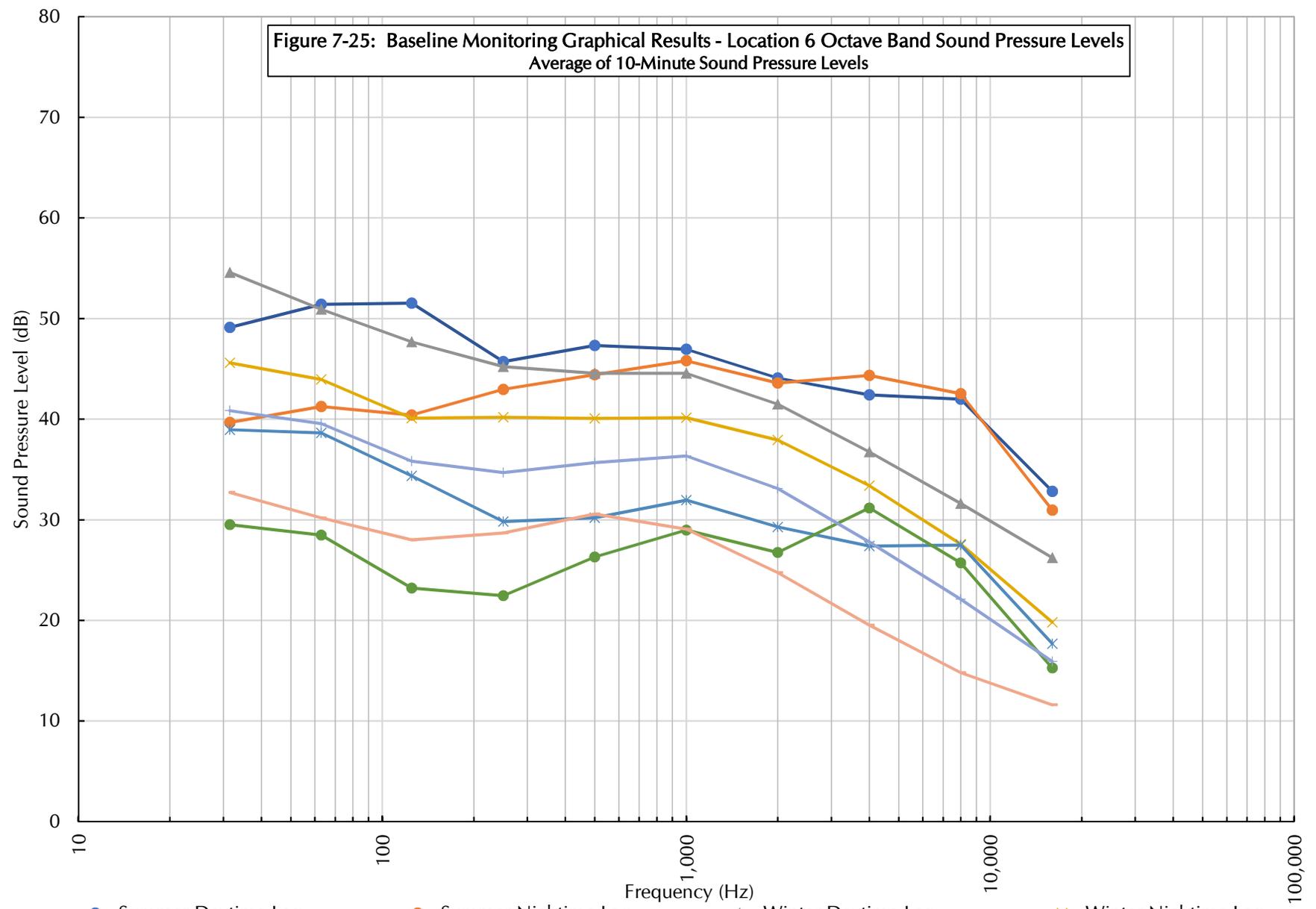


Figure 7-25: Baseline Monitoring Graphical Results - Location 6 Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels



- Summer Daytime Leq
- Summer Nighttime Leq
- ▲ Winter Daytime Leq
- ✕ Winter Nighttime Leq
- ✕ Summer Daytime L90
- Summer Nighttime L90
- + Winter Daytime L90
- Winter Nighttime L90

Figure 7-26: Baseline Monitoring Graphical Results - Location 6-Third Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels

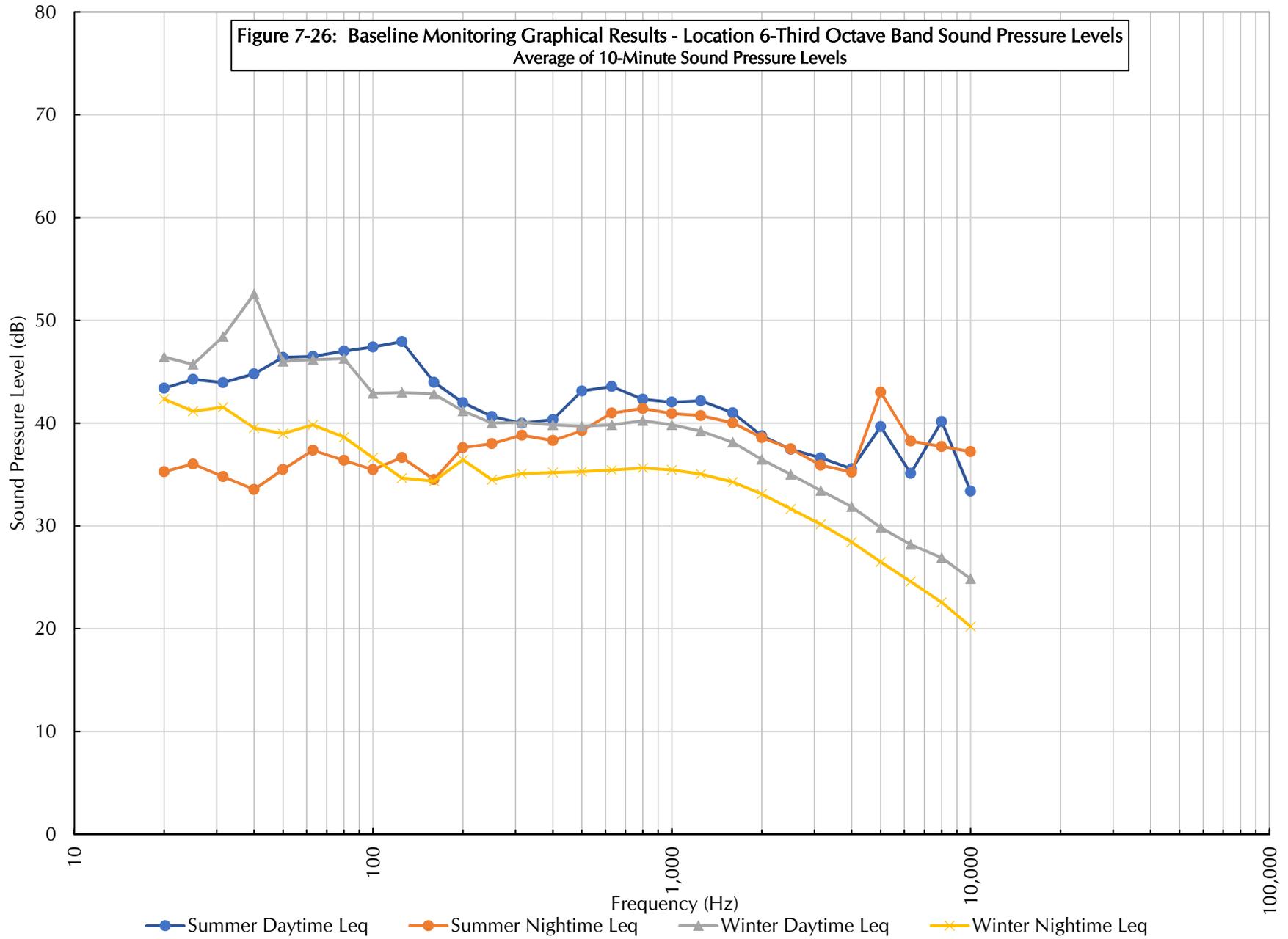


Figure 7-27: Baseline Monitoring Graphical Results - Location 7 (Winter)
 10-Minute Ambient Sound Level Data

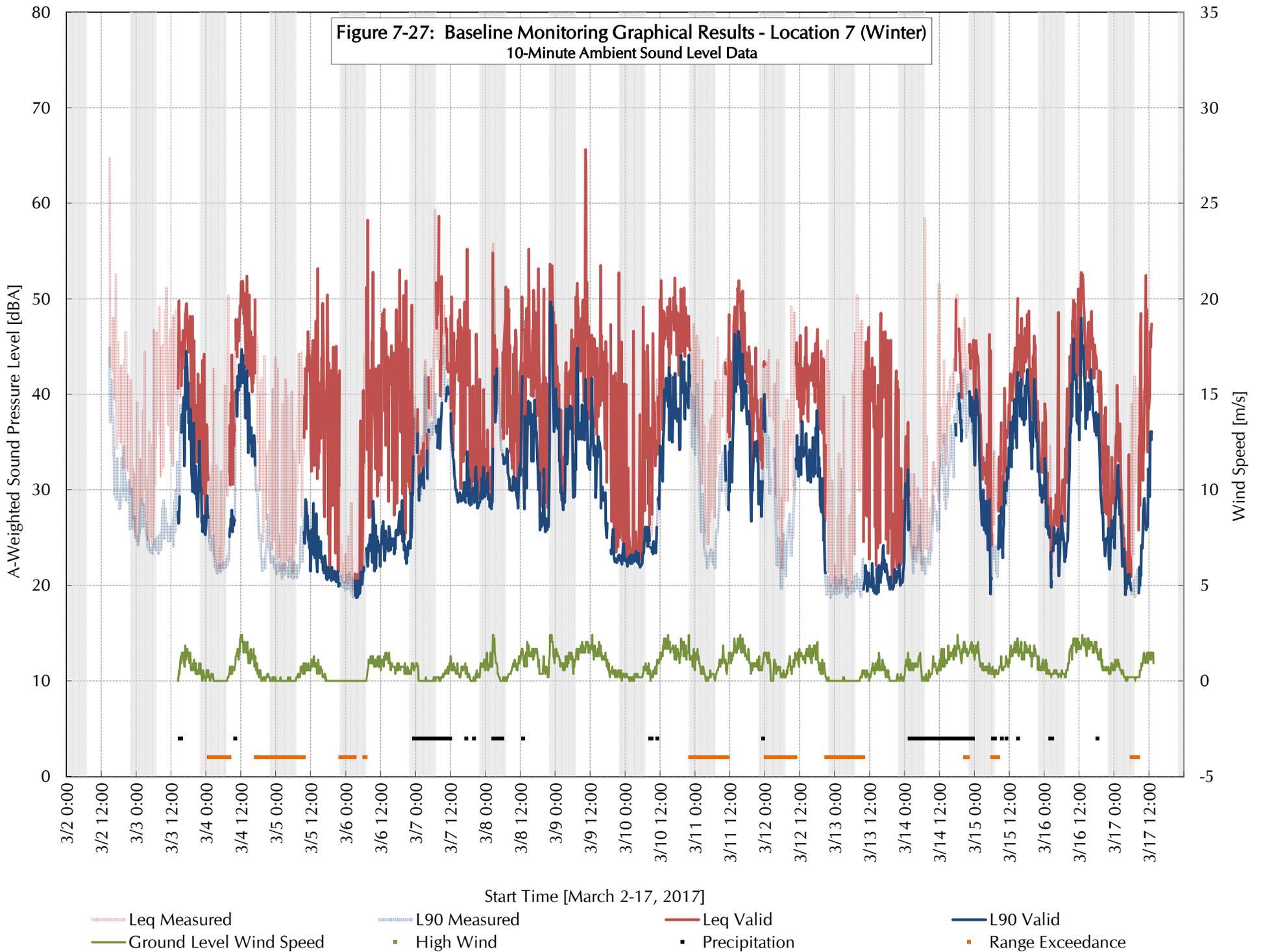


Figure 7-28: Baseline Monitoring Graphical Results - Location 7 (Summer)
 10-Minute Ambient Sound Level Data

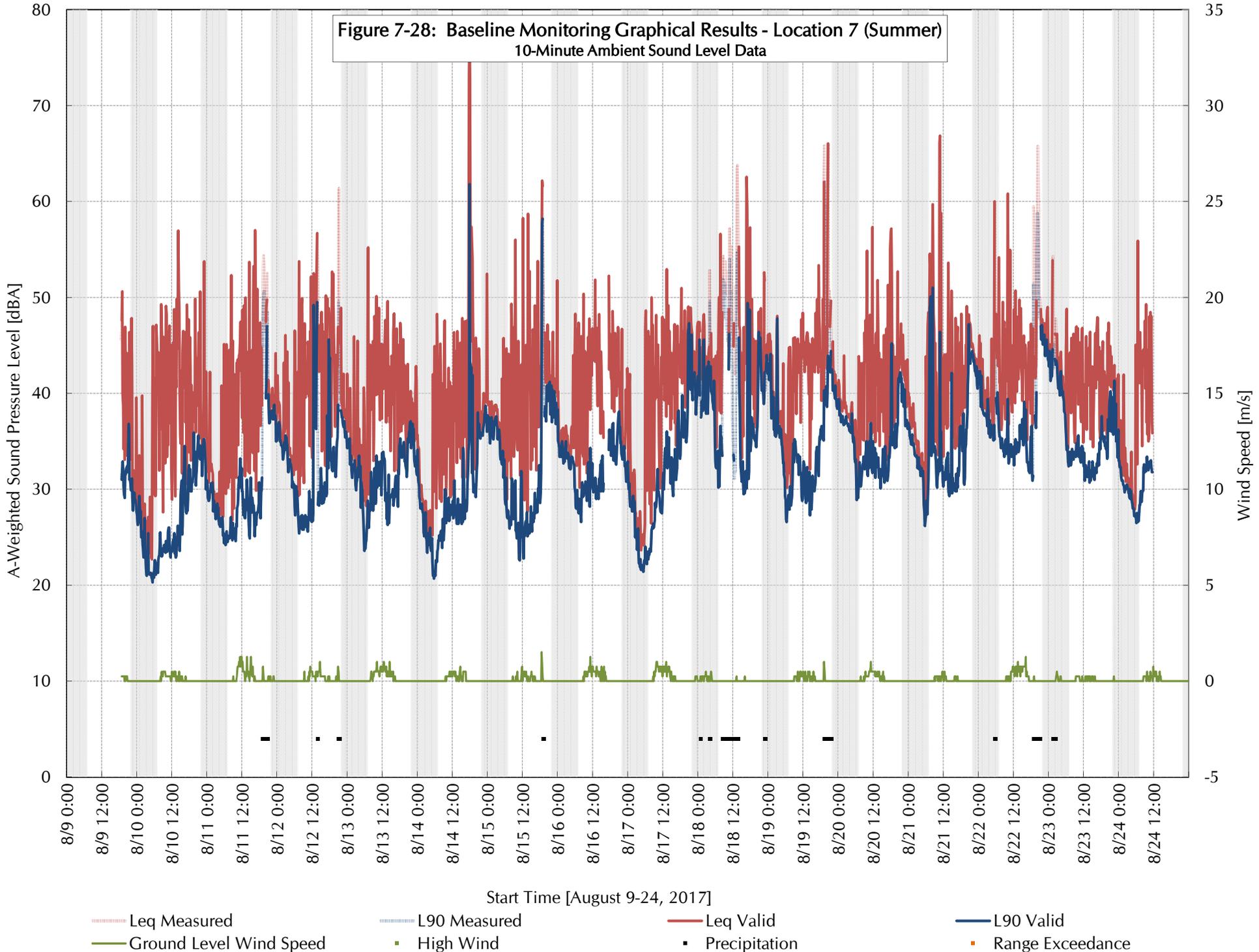
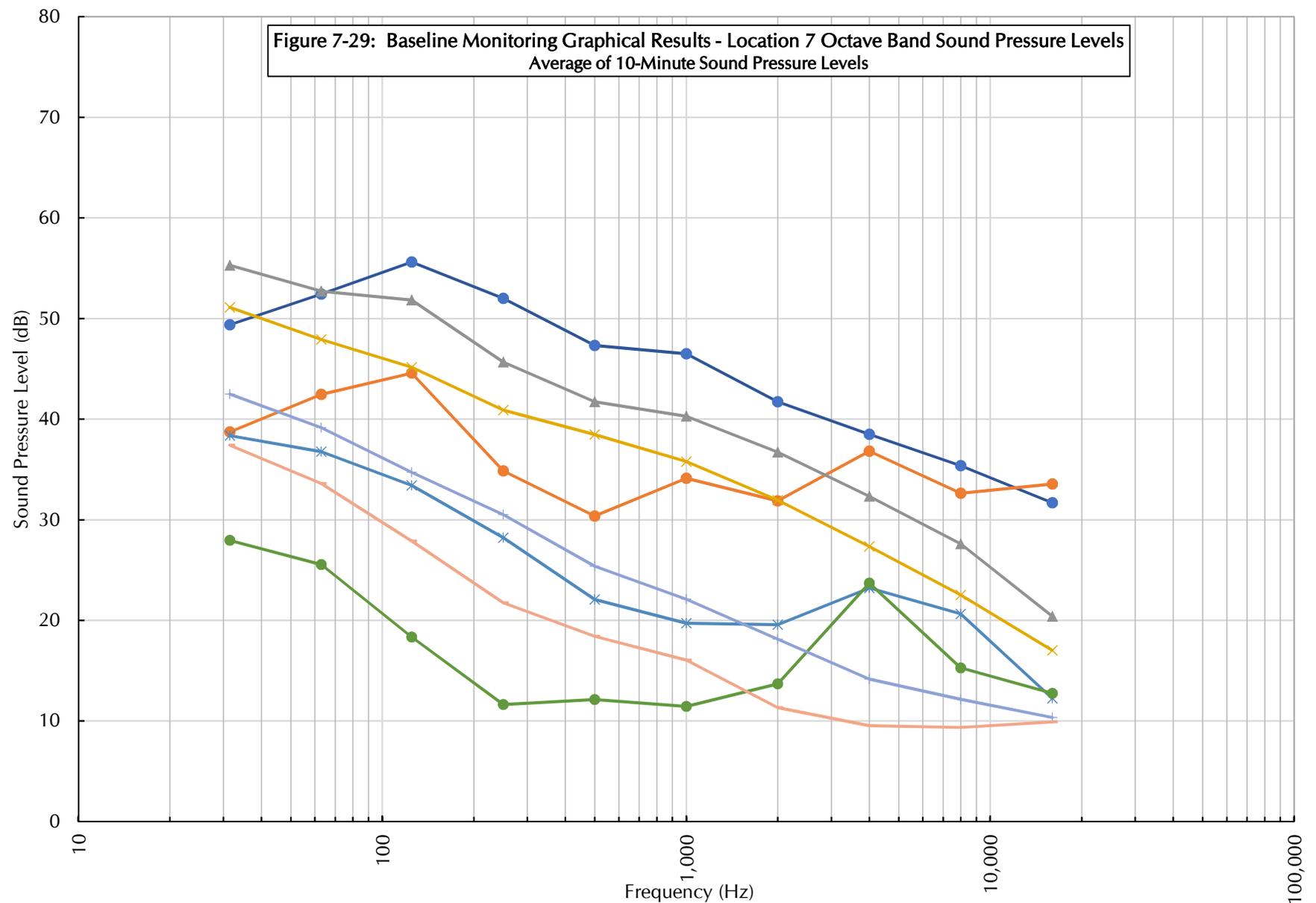
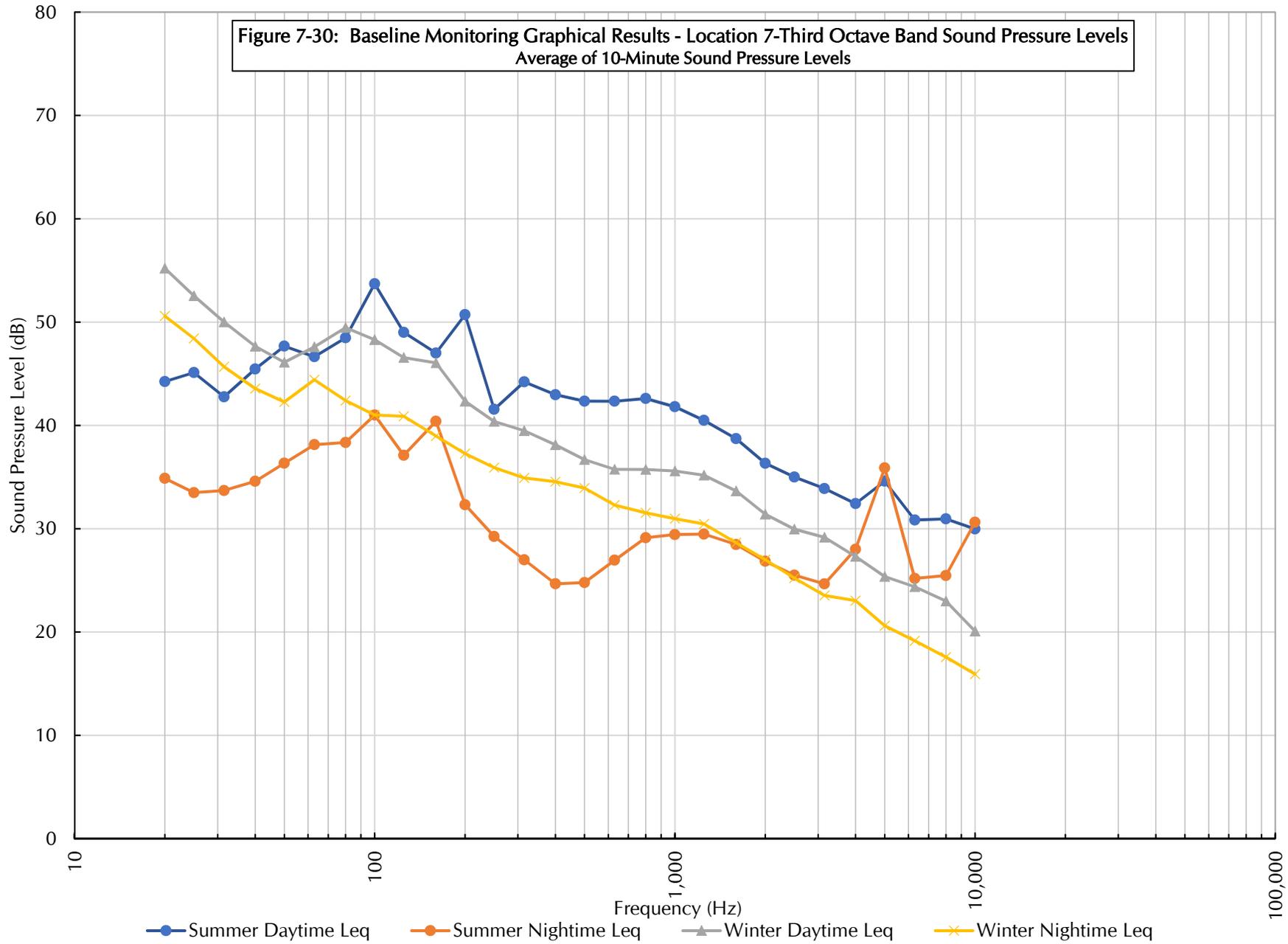


Figure 7-29: Baseline Monitoring Graphical Results - Location 7 Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels



- Summer Daytime Leq
- Summer Nighttime Leq
- ▲ Winter Daytime Leq
- ✕ Winter Nighttime Leq
- ✕ Summer Daytime L90
- Summer Nighttime L90
- + Winter Daytime L90
- Winter Nighttime L90

Figure 7-30: Baseline Monitoring Graphical Results - Location 7-Third Octave Band Sound Pressure Levels
Average of 10-Minute Sound Pressure Levels



8.0 SEASONAL SOUND LEVEL MONITORING SUMMARY

A two-season baseline monitoring program was performed for Bluestone Wind in 2017 to characterize the existing sound level environment around the Project region. The sound levels measured during the winter and summer monitoring periods are summarized in the following subsections as tabular data by location. Respective ANS-weighted broadband sound levels calculated for the desired summary of interest are tandemly provided with the measured broadband levels within each table. Only valid⁴⁸ 10-minute measurement periods are included in the summary tables. Daytime is defined as the period from 7 AM to 10 PM. Nighttime is defined as the period from 10 PM to 7 AM.

8.1 Daytime Ambient – Lower Tenth Percentile

Measured daytime ambient L₉₀ sound levels are shown below in Table 8-1, as per Stipulation 19 (f)(1). Values are separated by monitoring season as well as for both seasons combined. These values represent the L₉₀ of the measured L₉₀ values.

Table 8-1 Daytime Ambient L₉₀ (dBA) Sound Pressure Level Summary

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

8.2 Nighttime Ambient – Lower Tenth Percentile

Measured nighttime ambient L₉₀ sound levels are presented below in Table 8-2, as per Stipulation 19 (f)(2) and (f)(3). Values are separated by monitoring season as well as for both seasons combined. These values represent the L₉₀ of the measured L₉₀ values.

⁴⁸ Refer to Chapter 7 for details concerning valid periods.

Table 8-2 Nighttime Ambient L₉₀ (dBA) Sound Pressure Level Summary

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

8.3 Daytime Ambient - Average

Measured daytime average ambient levels are presented in Table 8-3, as per Stipulation 19 (f)(7). The daytime ambient average noise level was calculated by logarithmically averaging sound pressure levels (Leq) (after exclusions) from the background sound level measurements over the daytime period at each monitoring location. These calculations include both summer and winter data combined.

Table 8-3 Daytime Ambient Leq (dBA) Sound Pressure Level Summary

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

8.4 Nighttime Ambient - Average

Measured nighttime average ambient levels are presented in Table 8-4. The nighttime ambient average noise level was calculated by logarithmically averaging sound pressure levels (Leq) (after exclusions) from the background sound level measurements over the nighttime period at each monitoring location. These calculations include both summer and winter data combined.

Table 8-4 Nighttime Ambient L_{eq} (dBA) Sound Pressure Level Summary

Location	Overall (dBA)	
	Measured	ANS
Location 1	55	51
Location 2	45	38
Location 3	41	40
Location 4	52	39
Location 5	49	43
Location 6	43	39
Location 7	50	46

8.5 Comparison of Sound Levels to Wind Speed

8.5.1 Hub Height Wind Speed

Ten-minute monitored L_{eq} and L_{90} sound levels at Location 3 and corresponding on-site hub height wind speed data are presented in Figures 8-1 and 8-2 [REDACTED]. These data are inclusive of both the winter and summer monitoring seasons and are separated into daytime and nighttime values.

All hub height wind speeds were plotted, even those below the cut-in turbine wind speed. Figure 8-1 shows some correlation between L_{90} levels and hub height wind speed, which improves as the wind speed increases. This correlation is more pronounced during the nighttime hours. Figure 8-2 shows a similar trend with the L_{eq} values. There is a lot of scatter in the sound levels over the same hub height wind speeds. This scatter generally ranges from 20-25 dBA but decreases as wind speeds increase.

8.5.2 Ground Level Wind Speed

Figure 8-3 shows on-site ground level wind speeds against ten-minute L_{90} sound levels at Location 3 for both summer and winter monitoring periods combined. The maximum⁴⁹, minimum, and average sound levels are plotted using 0.5 m/s binned ground level wind speeds. Some correlation between ground level wind speed and L_{90} sound levels are also shown here; improving as wind speeds increase. On-site wind speeds did not exceed 4 m/s for either season.

⁴⁹ The period during which the maximum sound level occurred within the 1.5 m/s ground level wind speed bin was reviewed. The sound level data suggest that a loud event was occurring during that hour in the early afternoon during the summer. Location 3 was an active youth camp during the summer monitoring program.

8.5.3 *Wind Speed at 10 meters*

The sound level measurement standard used by all wind turbine manufacturers reports sound level data as a function of hub height wind speed and a reference height of 10 meters above ground level (AGL).⁵⁰ No direct measurement of wind speed at 10 meters AGL was available during the existing condition measurement program. However, the hub height wind speed collected by the on-site meteorological towers was extrapolated down to 10 meters using the technique in IEC 61400-11. The resultant 10 meter AGL wind speeds were then plotted against the valid, ANS-corrected 10-minute L₉₀ sound levels measured during each program (summer and winter). Figure 8-4 [REDACTED] shows the results for the daytime and nighttime periods combined during the winter program, while Figures 8-5 and 8-6 [REDACTED] show the winter day and winter night periods broken out. Figures 8-7, 8-8, and 8-9 [REDACTED] show the same analyses for the summer measurement program.

8.6 Temporal Accuracy

The temporal accuracy section of the ANSI S12.9-1992/Part 2 document requires that the data collection must be long enough to achieve the desired confidence interval. The goal of the sound measurement program is to achieve a 95% confidence interval which would allow for a statement of 95% confidence that the true long-term average sound level falls within the given interval. The size of this confidence interval places the data set into one of three categories referred to as Class A, Class B, and Class C, listed here from most precise to least precise.

To determine the temporal accuracy, the mean square average sound level must be obtained using equation 2 of section 9.5 of the ANSI S12.9-1992/Part 2 document. In this equation, the sample standard deviation and average are used to determine the mean square average. These pieces of information are then combined with the information presented in Table 1 of section 9.5 of the standard to determine the upper and lower bounds of the 95% confidence interval. The equations for the upper and lower bound of the confidence interval are equations 3 and 4 of section 9.5 of the standard respectively. If there are data sets where the number of samples was outside the range covered by the information in Table 1, the source data presented in the Crow et al. document cited in the standard is used to calculate the necessary 'k1' and 'k2' values. A two-tailed 't' interval function is used to generate the necessary 't' value.

To use the equations in the Temporal Accuracy section, the raw data set must be shown to be approximately normal. This can be obtained by following the directions laid out in Appendix D of the standard. The method used in the standard is the Kolmogorov-Smirnov

⁵⁰ *Wind turbines—Part 11: Acoustic noise measurement techniques*, International Electrotechnical Commission IEC 61400-11, Edition 3.0, Geneva, Switzerland, 2012.

test for normality of data. In general, the Kolmogorov-Smirnov test takes the actual repetition of a measurement and compares it to the expected repetition based on the average and standard deviation of the sample. The difference between the actual and expected recurrence is then compared to a critical value that is based on the number of samples and desired confidence level. If any measured value has a difference between expected and actual recurrence that exceeds the critical value, the data shall not be approximated as normal.

Tables 8-5 through 8-10 present the 95% CI of the valid measured L₉₀ sound level data at each site for Summer Daytime, Summer Nighttime, Winter Daytime, Winter Nighttime, Yearly Daytime, and Yearly Nighttime periods, respectively. The “Yearly Daytime” and “Yearly Nighttime” are composed of the summer and winter data combined for each time period (day or night). Each sample represents one full daytime (7 a.m. – 10 p.m.) or nighttime (10 p.m. – 7 a.m.) period in which more than 50% of the 10-minute records were valid. The same information is presented in Tables 8-11 to 8-16 for the measured L_{eq} sound levels at each site. All sound levels in Tables 8-5 to 8-16 are ANS-filtered.

Table 8-5 Temporal Accuracy Summary – Summer Daytime L90

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	14	41.70	0.83	0.86	Class A	Normal
Location 2	14	23.36	2.15	2.63	Class B	Normal
Location 3	14	28.46	2.98	4.00	Class C	Normal
Location 4	14	22.48	2.19	2.69	Class B	Normal
Location 5	14	28.93	3.49	4.90	Class C	Normal
Location 6	14	18.49	1.43	1.60	Class A	Normal
Location 7	14	37.79	3.94	5.75	Worse than Class C	Normal

Table 8-6 Temporal Accuracy Summary – Summer Nighttime L90

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	14	27.19	1.66	1.99	Class A	Normal
Location 2	15	20.83	3.14	4.27	Class C	Normal
Location 3	15	23.07	2.14	2.63	Class B	Normal
Location 4	15	24.12	3.69	5.26	Worse than Class C	Normal
Location 5	14	34.85	7.32	12.55	Worse than Class C	Normal
Location 6	15	18.04	2.76	3.62	Class C	Normal
Location 7	14	45.75	7.5	12.84	Worse than Class C	Normal

Table 8-7 Temporal Accuracy Summary – Winter Daytime L90

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	12	42.48	2.82	3.72	Class C	Normal
Location 2	13	27.80	2.88	3.82	Class C	Normal
Location 3	13	34.01	4.82	7.50	Worse than Class C	Normal
Location 4	5	29.56	5.98	10.60	Worse than Class C	Normal
Location 5	13	35.00	3.80	5.50	Worse than Class C	Normal
Location 6	12	40.07	3.12	4.25	Class C	Normal
Location 7	12	25.14	2.84	3.76	Class C	Normal

Table 8-8 Temporal Accuracy Summary – Winter Nighttime L90

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	7	29.40	3.17	4.27	Class C	Normal
Location 2	8	27.96	4.61	7.27	Worse than Class C	Normal
Location 3	8	31.11	4.44	6.89	Worse than Class C	Normal
Location 4	3	24.65	14.01	38.99	Worse than Class C	Normal
Location 5	8	37.15	8.35	16.66	Worse than Class C	Normal
Location 6	7	41.48	8.24	16.79	Worse than Class C	Normal
Location 7	7	24.98	3.69	5.28	Worse than Class C	Normal

Table 8-9 Temporal Accuracy Summary – Yearly Daytime L90

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	26	42.04	1.26	1.40	Class A	Normal
Location 2	27	25.84	1.90	2.29	Class B	Normal
Location 3	27	31.28	2.77	3.59	Class C	Normal
Location 4	19	25.10	2.53	3.23	Class C	Normal
Location 5	27	32.74	2.96	3.89	Class C	Normal
Location 6	26	40.25	7.16	10.93	Worse than Class C	Normal
Location 7	26	35.28	4.03	5.63	Worse than Class C	Normal

Table 8-10 Temporal Accuracy Summary – Yearly Nighttime L90

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	21	27.96	1.45	1.64	Class A	Normal
Location 2	23	24.55	3.17	4.25	Class C	Normal
Location 3	23	27.03	2.64	3.39	Class C	Normal
Location 4	18	24.01	3.22	4.38	Class C	Normal
Location 5	22	35.81	5.60	8.45	Worse than Class C	Normal
Location 6	22	35.05	7.71	12.24	Worse than Class C	Normal
Location 7	21	43.03	6.89	10.86	Worse than Class C	Normal

Table 8-11 Temporal Accuracy Summary - Summer Daytime Leq

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	14	56.23	0.45	0.45	Class A	Normal
Location 2	14	44.01	2.65	3.44	Class C	Normal
Location 3	14	45.83	3.96	5.77	Worse than Class C	Normal
Location 4	14	46.73	2.79	3.68	Class C	Normal
Location 5	14	47.30	2.06	2.50	Class B	Normal
Location 6	14	50.18	3.96	5.78	Worse than Class C	Normal
Location 7	14	45.95	4.74	7.28	Worse than Class C	Normal

Table 8-12 Temporal Accuracy Summary - Summer Nighttime Leq

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	14	50.15	1.03	1.10	Class A	Normal
Location 2	15	35.16	3.53	4.96	Class C	Normal
Location 3	15	35.53	0.84	0.88	Class A	Normal
Location 4	15	36.40	1.17	1.27	Class A	Normal
Location 5	14	42.53	2.79	3.67	Class C	Normal
Location 6	15	46.85	6.01	9.84	Worse than Class C	Normal
Location 7	14	34.40	4.66	7.09	Worse than Class C	Normal

Table 8-13 Temporal Accuracy Summary - Winter Daytime Leq

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	12	57.45	2.11	2.56	Class B	Normal
Location 2	13	44.06	2.69	3.50	Class C	Normal
Location 3	13	46.31	2.63	3.40	Class C	Normal
Location 4	5	46.82	2.29	2.68	Class B	Normal
Location 5	13	47.20	1.22	1.32	Class A	Normal
Location 6	12	47.37	2.30	2.86	Class B	Normal
Location 7	12	44.32	1.59	1.81	Class A	Normal

Table 8-14 Temporal Accuracy Summary - Winter Nighttime Leq

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	7	53.84	4.94	8.04	Worse than Class C	Normal
Location 2	8	41.30	5.27	8.77	Worse than Class C	Normal
Location 3	8	44.07	5.25	8.73	Worse than Class C	Normal
Location 4	3	45.35	18.14	61.66	Worse than Class C	Normal
Location 5	8	40.85	3.62	5.16	Worse than Class C	Normal
Location 6	7	43.02	4.40	6.80	Worse than Class C	Normal
Location 7	7	41.33	5.18	8.60	Worse than Class C	Normal

Table 8-15 Temporal Accuracy Summary - Yearly Daytime Leq

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	26	56.77	0.90	0.96	Class A	Normal
Location 2	27	43.96	1.79	2.13	Class B	Normal
Location 3	27	46.14	2.37	2.97	Class B	Normal
Location 4	19	46.79	2.07	2.52	Class B	Normal
Location 5	27	47.24	1.15	1.26	Class A	Normal
Location 6	26	48.78	2.22	2.75	Class B	Normal
Location 7	26	45.31	2.52	3.20	Class C	Normal

Table 8-16 Temporal Accuracy Summary - Yearly Nighttime Leq

Location	# of Samples	95% CI Mean (dBA)	Lower CI (dBA)	Upper CI (dBA)	Measurement Class	Normality
Location 1	21	51.32	1.50	1.72	Class A	Normal
Location 2	23	38.10	3.28	4.42	Class C	Normal
Location 3	23	39.13	2.05	2.49	Class B	Normal
Location 4	18	37.86	1.80	2.13	Class B	Normal
Location 5	22	41.88	2.09	2.55	Class B	Normal
Location 6	22	45.40	3.99	5.67	Worse than Class C	Normal
Location 7	21	38.62	4.50	6.52	Worse than Class C	Normal

8.7 Infrasound and Low Frequency

Infrasound and low frequency sound pressure levels were measured at Location 5 in both the summer and winter seasons. The frequency range of these data is from 0.5 Hz to 200 Hz. The sound levels were summarized by averaging⁵¹ sound level data from all valid⁵² winter daytime hours, winter nighttime hours, summer daytime hours, and summer nighttime hours within each one-third octave band. Winter and summer infrasound data collected at Location 5 are presented in Figure 8-10.

⁵¹ Logarithmic (energy) average of equivalent (Leq) sound pressure levels.

⁵² Refer to Chapter 7 for details concerning valid periods.

Figure 8-1 Monitored L_{90} Compared to Hub Height Wind Speed, Location 3, All Seasons [REDACTED]

Figure 8-2 Monitored L_{eq} Compared to Hub Height Wind Speed, Location 3, All Seasons [REDACTED]

Figure 8-3: Monitored L90 Against Ground Level Wind Speed, Location 3All Seasons

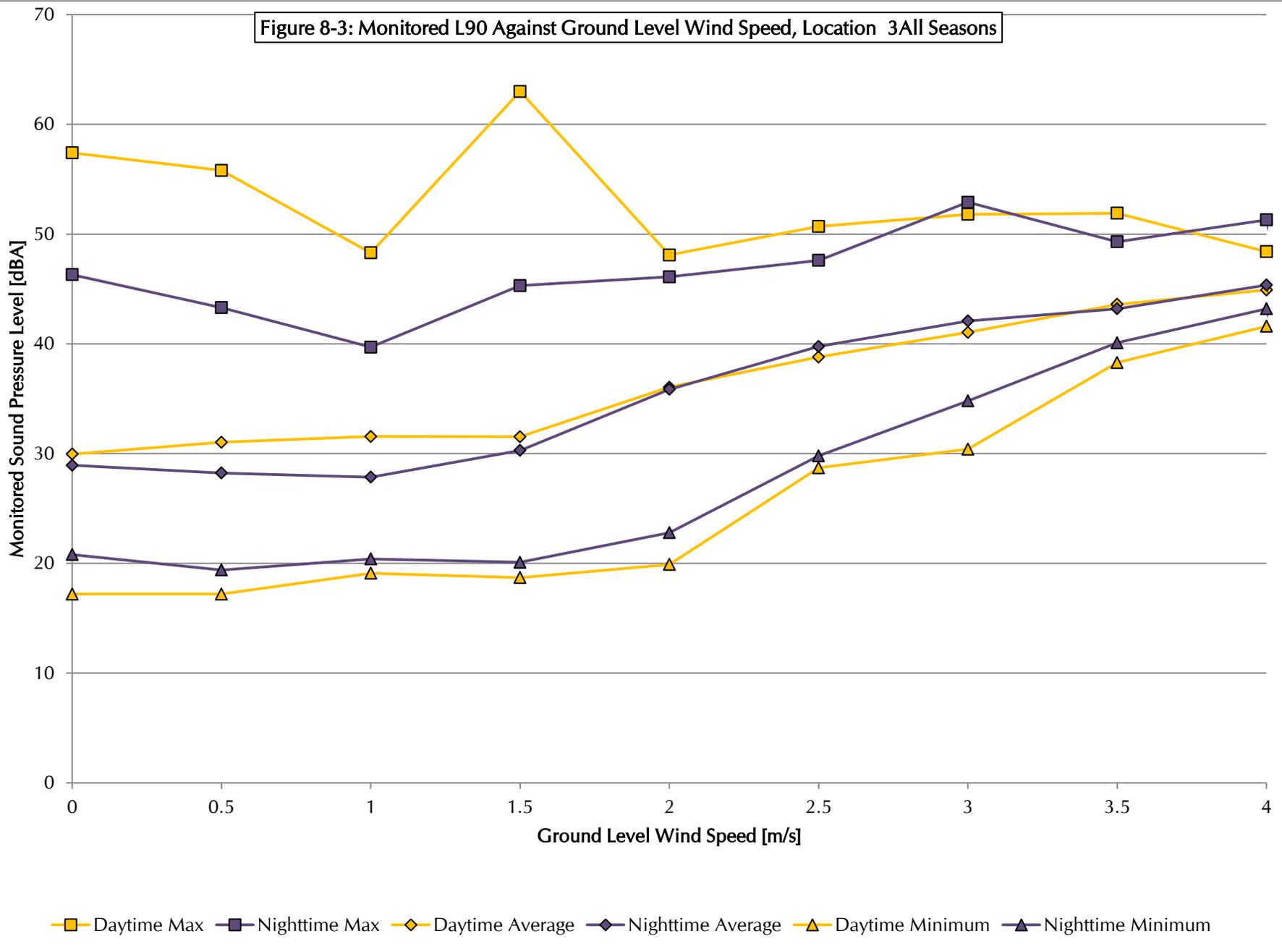


Figure 8-4 Regression Analysis of Measured L_{90} Sound Level vs. Normalized Wind Speed – Winter Overall Survey Period [REDACTED]

Figure 8-5 Regression Analysis of Measured L_{90} Sound Level vs. Normalized Wind Speed – Winter Overall Survey Period – Day [REDACTED]

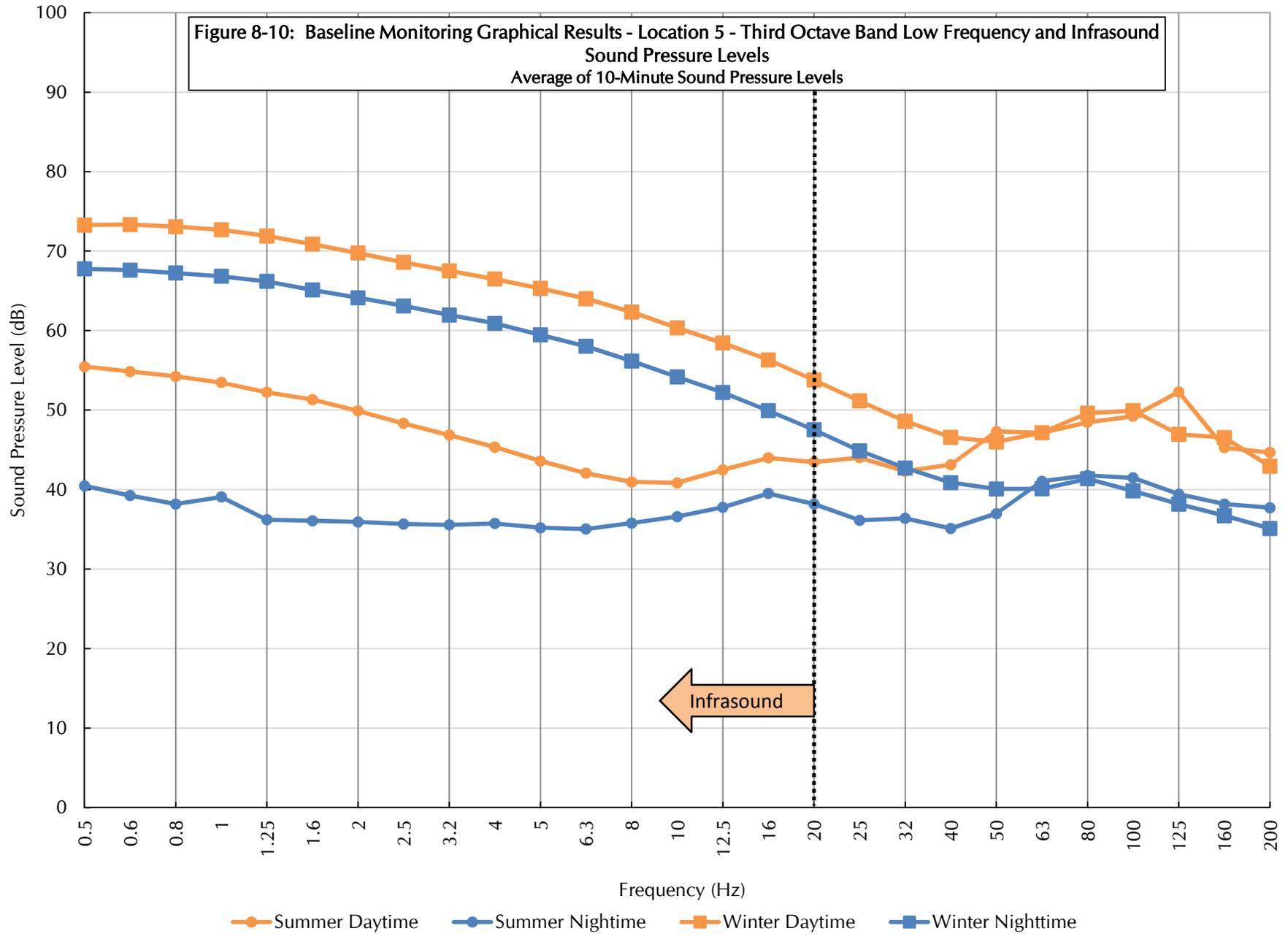
Figure 8-6 Regression Analysis of Measured L₉₀ Sound Level vs. Normalized Wind Speed – Winter Overall Survey Period – Night [REDACTED]

Figure 8-7 Regression Analysis of Measured L₉₀ Sound Level vs. Normalized Wind Speed – Summer Overall Survey Period [REDACTED]

Figure 8-8 Regression Analysis of Measured L₉₀ Sound Level vs. Normalized Wind Speed – Summer Overall Survey Period – Day [REDACTED]

Figure 8-9 Regression Analysis of Measured L₉₀ Sound Level vs. Normalized Wind Speed – Summer Overall Survey Period – Night [REDACTED]

Figure 8-10: Baseline Monitoring Graphical Results - Location 5 - Third Octave Band Low Frequency and Infrasound
 Sound Pressure Levels
 Average of 10-Minute Sound Pressure Levels



9.0 FUTURE SOUND LEVELS

9.1 Sound Propagation

The noise impacts associated with the proposed Project were predicted using the Cadna/A noise calculation software developed by DataKustik GmbH. This software implements the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple reflections, drop-off with distance, and atmospheric absorption. The Cadna/A software allows for octave band calculation of sound from multiple sources as well as computation of diffraction.

9.2 Equipment and Operating Conditions

9.2.1 *Wind Turbines*

The sound level analysis includes 33 wind turbines. There are four wind turbine manufacturers being considered in this NIA. The list of wind turbine manufacturers, hub heights, and rotor diameters examined for this assessment are presented below in Table 9-1. Each of the turbine options includes low-noise blades, sometimes referred to as serrated trailing edge, or low-noise trailing edge blades.

Table 9-1 Wind Turbines Analyzed for Sound Level Assessment

Manufacturer	Wind Turbine Model	Maximum Electrical Power (kW)	Hub Height (m)	Rotor Diameter (m)	Maximum Rotor Speed (rpm)
General Electric	GE 3.8-137	3,830	131	137	13.6
Vestas	V150-4.2	4,200	130	150	12.0
Nordex	N149/4500	4,500	125	149	12.25
Senvion	4.2M148	4,200	130	148	10.5

Of the four wind turbine options, the GE 3.8-137 has the highest broadband A-weighted sound power level, and therefore modeling results of this turbine result in the highest broadband sound levels. Technical reports from GE⁵³, Vestas⁵⁴, Nordex⁵⁵, and Senvion⁵⁶ were provided by the Applicant which documented the expected sound power levels associated with each of the wind turbines. Table 9-2 shows the broadband sound power

⁵³ General Electric Company, Technical Documentation Wind Turbine Generator Systems 3.8-137 – 50/60 Hz Product Acoustic Specifications, 2017.

⁵⁴ Vestas Wind Systems A/S, V150-4.0/4.2 MW Third octave noise emission, DMS 0067-4767 V04.

⁵⁵ Nordex Energy GmbH, Third octave sound power levels, Nordex N149/4.0-4.5 Revision 00, 2018-03-29.

⁵⁶ Senvion 4.2M148 Power Curve and Sound Power Levels, C-3.52-BL.LK.04-B-C.

levels as a function of wind speed from these technical reports. Under peak sound level producing conditions the GE 3.8-137 wind turbine has an A-weighted sound power level of dBA. The Vestas V150-4.2 wind turbine has an A-weighted sound power level of dBA. The Nordex N149/4500 wind turbine has an A-weighted sound power level of dBA, and the Senvion 4.2M148 wind turbine has an A-weighted sound power level of dBA. The maximum octave band sound power levels for each wind turbine type are presented in Table 9-3. For each octave band, the highest sound power level published by the manufacturer has been used and input to the Cadna model, regardless of the wind speed at which they occur. The sound power levels presented in both tables do not include an uncertainty factor. No 16 Hz data were provided for the Senvion wind turbine. A detailed discussion of the 16 Hz modeling is provided in Section 12.6.

Table 9-2 Wind Turbine Broadband Sound Power Levels vs. Wind Speed [REDACTED]

Hub Height Wind Speed (m/s)	3	4	5	6	7	8	9	10
GE 3.8-137 Broadband Sound Power Level (dBA)								
Vestas V150-4.2 Broadband Sound Power Level (dBA)								
Nordex N149/4500 Broadband Sound Power Level (dBA)								
Senvion 4.2 M148 Broadband Sound Power Level (dBA)								

Notes: 1. Sound power level is constant from the respective wind speed to the cut out wind speed. ND = No data. The manufacturer does not present sound levels at this wind speed.

Table 9-3 Wind Turbine Maximum Octave Band Sound Power Levels [REDACTED]

Wind Turbine Type	Sound Power Levels per Octave-Band Center Frequency (Hz)									
	16 dBA	31.5 dBA	63 dBA	125 dBA	250 dBA	500 dBA	1k dBA	2k dBA	4k dBA	8k dBA
GE 3.8-137										
Vestas V150-4.2										
Nordex N149/4500										
Senvion 4.2 M148										

9.2.2 Collection Substation

In addition to the wind turbines, there will be a collector substation located within the Project area. One step-up transformer rated at 222 MVA is proposed for the substation. A sound level test report indicating the broadband sound power level for the substation was

provided by Bluestone Wind⁵⁷. Epsilon estimated the octave band sound emissions using the techniques in the Electric Power Plant Environmental Noise Guide (Edison Electric Institute), Table 4.5 Sound Power Levels of Transformers. Table 9-4 summarizes the sound power level data used in the modeling.

Table 9-4 Collector Substation Transformer Sound Power Levels

Maximum Rating MVA	Broadband Sound Power Level dBA	Sound Power Levels per Octave-Band Center Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
		dB	dB	dB	dB	dB	dB	dB	dB	dB
222	99.4	96	102	104	99	99	93	88	83	76

9.2.3 Battery Storage

In addition to the wind turbines, and collector substation, there will be a battery storage facility located within the Project area. A 10 MW x 40 MWH battery storage system is planned to be co-located with the collector substation. For acoustic modeling, the battery storage facility consisted of 16 battery containers, 16 HVAC units (1 per container) and one auxiliary transformer rated at 1 MVA. Broadband sound level information for the battery storage containers from GE was provided by Bluestone Wind⁵⁸. Similarly, broadband and octave band sound level information for the HVAC systems was provided via email from the Applicant⁵⁹. Epsilon estimated the octave band sound emissions for the containers and the transformer based on professional experience with other battery storage facilities, and the techniques in the Electric Power Plant Environmental Noise Guide (Edison Electric Institute), Table 4.5 Sound Power Levels of Transformers. Table 9-5 summarizes the sound power level data used for each battery storage component in the modeling.

⁵⁷ Test Report – Sound Level, Report No. 0076-01 Page 23 of 91. Test Condition: 100% ONAF Id=2 A-Wt P N N

⁵⁸ Via email June 6, 2018. Battery storage container acoustic emissions 80 dBA at 1 meter.

⁵⁹ Via email from Applicant June 26, 2018. SPL = 54 dBA at 10 meters.

Table 9-5 Battery Storage Facility Components Sound Power Levels

Component	Broadband Sound Power Level dBA (per unit)	Sound Power Levels per Octave-Band Center Frequency (Hz)								
		31.5	63	125	250	500	1k	2k	4k	8k
		dB	dB	dB	dB	dB	dB	dB	dB	dB
Battery Container	88.2	85	91	93	88	88	82	77	72	65
Container HVAC	83.8	60	60	70	74	79	81	75	73	69
Aux Transformer	69.4	66	72	74	69	69	63	58	53	46

9.3 Modeling Inputs and Scenarios

9.3.1 Common Modeling Inputs

Inputs and significant parameters employed in the model common to all modeling scenarios for this Project are described below:

- ◆ *Project Layout:* A wind turbine layout was provided by the Applicant to the Project team on June 22, 2018 (Layout 20180622). The 33 proposed wind turbines were input into the model. The substation and battery storage location was provided by the Applicant to the Project team via email on June 12, 2018. For the modeling analysis, it was assumed that the collector substation transformer would be located at the center of the substation pad. The battery storage facility was assumed to be co-located on the pad with the collector substation. The proposed wind turbines, substation and battery storage for the Project are shown in Figure 9-1. All point sources in the model, including their coordinates, are presented in Tables D-1 through D-4 in Appendix D representing the four different turbine model options.
- ◆ *Receptor Locations:* A modeling receptor dataset was provided by the Applicant to the Project team on June 12, 2018. The 392 receptors from this dataset were input into the Cadna/A model. These receptors include the sensitive receptors identified in Section 6.1 above. The 392 receptors are a combination of both participating and non-participating sound sensitive locations within at least 1 mile from the Project boundary. One receptor within NYSDEC land was identified within the project area (ID #438). This is the area of most frequent human use (campsite; campfire area). These receptors were modeled as discrete points at a height of 1.5 meters AGL to mimic the ears of a typical standing person. These locations are shown in Figure 9-1. The modeling receptors, including their coordinates, participation status, and receptor type are listed in tabular form in Table D-5 in Appendix D.

- ◆ *Terrain Elevation:* Elevation contours for the modeling domain were directly imported into Cadna/A which allowed for consideration of terrain shielding where appropriate. The terrain height contour elevations for the modeling domain were generated from elevation information derived from the National Elevation Dataset (NED) developed by the U.S. Geological Survey. The site topography is gently sloping or steady-sloping from the wind turbines to the sensitive receptors.
- ◆ *Uncertainty factor:* Some wind turbine manufacturers provided a K (uncertainty) factor for the sound power levels presented in the technical documents. Typically uncertainty factors for wind turbines are 2 decibels or less. For this analysis an uncertainty factor of 2.0 dBA was assumed and added to the sound power level for each modeled wind turbine.
- ◆ The highest sound power level for each octave band was input to the model regardless of what wind speed generated this sound level. When combined into an overall A-weighted sound level, this represents an additional 0.0 to 0.4 dBA of conservatism to model results depending on the wind turbine vendor.
- ◆ The meteorological correction term (Cmet) was set to zero.
- ◆ No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

9.3.2 *Short-Term Modeling Scenarios - ISO 9613-2*

Short-term sound level modeling was conducted using the Cadna/A noise calculation software which incorporates the ISO 9613-2 international standard for sound propagation. For these modeling scenarios, the octave band data for the highest wind turbine sound power level was input into Cadna/A to calculate wind turbine generated sound pressure levels during conditions when worst-case sound power levels are expected. Modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by Epsilon, were implemented in the Cadna/A software for this modeling scenario to ensure conservative results (i.e., higher sound levels), and are described below:

- ◆ *Ground Attenuation:* Spectral ground absorption was calculated using a G-factor of 0.5 which corresponds to “mixed ground” consisting of both hard and porous ground cover. This is consistent with the modeling guidelines of NARUC 2011. Four bodies of water with moderate width (greater than 500 feet) were identified within the Project area. These four areas were set to G=0 representing completely reflective surfaces. This is the most conservative setting available.
- ◆ As per ISO 9613-2, the model assumed favorable conditions for sound propagation, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night or equivalently downwind propagation.

- ◆ All modeled sources were assumed to be operating simultaneously and at the design wind speed corresponding to the greatest sound level impacts.
- ◆ Meteorological conditions assumed in the model (temperature = 10°C & relative humidity = 70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1000 Hz octave bands where the human ear is most sensitive.

The conservative set of modeling assumptions for this analysis is consistent with the modeling recommendations in NARUC 2011 with the exception that NARUC does not include the uncertainty factor “K”, and the modeling for this project does add the “K” factor. Thus these model results are more conservative (higher) than what NARUC would predict. In addition, the use of these model inputs has been verified through post-construction sound level measurement programs at operating wind energy facilities. According to the Massachusetts Study on Wind Turbine Acoustics,⁶⁰ “The ISO 9613-2 model with mixed ground (G=0.5) with +2 dB added to the results was most precise and accurate at modeling the hourly L_{eq} , as compared to individual five minute periods.” A recent post-construction measurement program conducted by Epsilon in the Rocky Mountain region found measured sound levels met the regulatory sound level limit under worst-case operating conditions at locations modeled to be at the regulatory limit.

A closer examination of the topography was made between the wind turbines and receptors where modeled results were within 3 dBA of the design goal. A look at the terrain profiles indicate gently sloping or steady-sloping terrain, and no instances of the concave geometry as described in Evans and Cooper.⁶¹

Sound pressure levels due to operation of all 33 wind turbines, collector substation transformer, and battery storage components were modeled at 392 receptors within and surrounding the Project area. The sound levels calculated are 1-hour L_{eq} sound levels. In addition to modeling at discrete points, sound levels were also modeled throughout a large grid of receptor points, each spaced 20 meters apart to allow for the generation of sound level isolines. Although tabular results of each of the four turbine models were calculated, sound level isolines were only generated for the GE turbine model, because it has the highest A-weighted sound power level.

9.3.3 Long-Term Modeling Scenarios – ISO 9613-2 Annual Sound Level Metrics

Over the course of a year, sound levels associated with the operation of wind turbines will at times be less than the modeled worst-case / short-term sound levels. In order to quantify

⁶⁰ RSG et al, “Massachusetts Study on Wind Turbine Acoustics,” Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016.

⁶¹ Evans, T. and J. Cooper, “Comparison of Predicted and Measured Wind Farm Noise Levels and Implications for Assessments of New Wind Farms,” *Acoustics Australia*, Vol. 40, No. 1, April 2012.

this reduction, differences in the wind turbine sound power levels due to changes in hub height wind speeds were addressed in the sound level modeling meteorological adjustments to the calculations. Sound power levels related to the hub height wind speeds presented in Table 9-1 were used in the calculations.

A full year of 2017 on-site meteorological data from tower 1001 were used to calculate the hub height wind speed and related sound power levels for each hour of the year (8760 hours). Table 9-6 summarizes the wind speeds for the year in terms of hours below cut-in speed, above cut-out speed, and missing data. From these data, it can be seen that the wind turbines would be expected to operate at some level approximately 91% of the year (7,935 hours). The hourly wind speeds drive the resultant sound power level of the wind turbines. Using these data, the sound level exceeded for 10% of the time over the course of one year (L_{10}) was calculated, as well as the sound exceeded for 50% of the time over the course of one year (L_{50}). These calculations were done for two scenarios: all hours in a year (including hours below cut-in speed and above cut-out wind speed), and only those hours in a year above cut-in speed and below cut-out wind speed. The L_{10} and L_{50} wind speed results are summarized in Table 9-7, and the associated sound power levels for each wind turbine are shown in Table 9-8.

The same full year of on-site wind speed data were used to calculate an equivalent sound level for all nighttime hours in one year ($L_{eq, night, outside}$). This was done using the percent time matched to sound power level at a given wind speed, and was calculated on an energy basis for each wind turbine under consideration. These calculations were done for two scenarios: all hours in a year (including hours below cut-in wind speed), and only those hours in a year above cut-in speed. There were only four hours above cut-out speed. These were included as operational but make no difference in the calculated $L_{eq, night, outside}$. Details of data and calculations are in spreadsheet format and will be filed with the Hearing Examiner and treated by the Records Access Officer or other presiding officer as confidential.

Table 9-6 Summary of Annual On-Site Hub Height Wind Speeds (2017) [REDACTED]

Table 9-7 Summary of Annual On-Site Hub Height Wind Speed Statistics (2017) [REDACTED]

Scenario	L10 Wind Speed	L50 Wind Speed

Table 9-8 Summary of L₁₀, L₅₀ Annual Sound Power Levels (dBA) [REDACTED]

Wind Turbine	L _w , All Nighttime Hours (dBA)	L _w , Operational Nighttime Hours (dBA)
GE 3.8-137, L ₁₀		
GE 3.8-137, L ₅₀		
Vestas V150-4.2, L ₁₀		
Vestas V150-4.2, L ₅₀		
Nordex N149/4500, L ₁₀		
Nordex N149/4500, L ₅₀		
Senvion 4.2M148, L ₁₀		
Senvion 4.2M148, L ₅₀		

- (1) The GE 3.8-137 model represents the worst case L₁₀ annual sound level for both scenarios (with and without non-operational hours).
- (2) The Nordex N149/4500 model represents the worst case L₅₀ annual sound level for both scenarios (with and without non-operational hours).

Table 9-9 Summary of L_{EQ}, Night, Outside Sound Power Levels (dBA) [REDACTED]

Wind Turbine	All Nighttime Hours	Operational Nighttime Hours
GE 3.8-137		
Vestas V150-4.2		
Nordex N149/4500		
Senvion 4.2M148 ⁽⁴⁾		

- (3) The Nordex N149/4500 model represents the worst case annual nighttime L_{EQ} sound level.
- (4) No sound power level data provided below 6 m/s so these values may be low. However, the Senvion model would still be lower than the highest one (Nordex) and thus the worst-case L_{EQ}, night, year scenario remains the Nordex model.

9.4 Modeling Results

9.4.1 Short-Term – ISO 9613-2 (GE 3.8-137, HH = 131m)

Table E-1 in Appendix E shows the predicted “Project-Only” short-term broadband (dBA) and octave band (dB) sound levels under conditions specified in Section 9.3.2 sorted by modeling receptor ID for the GE 3.8-137 turbine model at a hub height of 131 meters. Table E-1.1 presents the same data sorted by sound level from high to low. The tables present modeled 1-hour L_{eq} sound levels at the 392 receptors included in the analysis. The broadband sound levels range from 28 to 50 dBA. In addition to these discrete modeling points, sound level contours generated from the modeling grid are presented in an overview figure, Figure 9-2, accompanied by a series of inset maps that provide a higher level of detail at all modeled receptors. The sound contour figure set for short-term sound level results was generated only for the GE turbine model, because it has the highest A-weighted sound power level. The contour maps for the other turbine models will show lower impacts. The results in Figure 9-2 include the effects of NRO where applicable (see text below).

In order to demonstrate compliance at all non-participating receptors, this wind turbine model requires some of the wind turbines to be placed in Noise Reduced Operating (NRO) mode. There are multiple NRO mode options to reach 45 dBA at all non-participating receptors. Specific mitigation measures will be presented in the compliance filing report upon selection of a final wind turbine vendor. Results for the GE 3.8-137 wind turbine presented in this report have assumed two wind turbines to be placed in NRO modes. Wind Turbine 1 is assumed to be NRO mode 106⁶², and Wind Turbine 27 is assumed to be

⁶² NRO mode 106 for the GE 3.8-137 represents a 1 dBA reduction for this wind turbine.

NRO mode 103⁶³. Under normal operation, this wind turbine can produce up to 3,830 kW of electricity. Under NRO mode 106, the maximum power output is 3,735 kW, and under NRO mode 103, the maximum power output is 3,185 kW.

Table 9-10 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 40 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. All receptors are residential land use.

Table 9-10 Participating and Non-Participating Receptors Modeled at 40 dBA or Greater (GE 3.8-137)

Modeled Leq Sound Level (dBA) ¹	# of Receptors	
	Participating	Non-Participating
50	1	0
49	1	0
48	1	0
47	0	0
46	5	0
45	11	5
44	11	6
43	4	8
42	2	4
41	3	8
40	5	17

Notes: 1. Rounded to the nearest whole decibel.

9.4.2 Short-Term – ISO 9613-2 (Vestas V150-4.2, HH = 130m)

Table E-2 in Appendix E shows the predicted “Project-Only” short-term broadband (dBA) and octave band (dB) sound levels under conditions specified in Section 9.3.2 sorted by modeling receptor ID for the Vestas V150-4.2 turbine model at a hub height of 130 meters. Table E-2.1 presents the same data sorted by sound level from high to low. The tables present modeled 1-hour Leq sound levels at the 392 receptors included in the analysis. The broadband sound levels range from 29 to 50 dBA.

Table 9-11 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 40 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. All receptors are residential land use.

⁶³ NRO mode 103 for the GE 3.8-137 represents a 4 dBA reduction for this wind turbine.

Table 9-11 Participating and Non-Participating Receptors Modeled at 40 dBA or Greater (Vestas V150-4.2)

Modeled Leq Sound Level (dBA) ¹	# of Receptors	
	Participating	Non-Participating
50	1	0
49	0	0
48	2	0
47	0	0
46	0	0
45	3	1
44	11	3
43	12	7
42	4	8
41	3	4
40	4	9

Notes: 1. Rounded to the nearest whole decibel.

9.4.3 Short-Term – ISO 9613-2 (Nordex N149/4500, HH = 125m)

Table E-3 in Appendix E shows the predicted “Project-Only” short-term broadband (dBA) and octave band (dB) sound levels under conditions specified in Section 9.3.2 sorted by modeling receptor ID for the Nordex N149/4500 turbine model at a hub height of 125 meters. Table E-3.1 presents the same data sorted by sound level from high to low. The tables present modeled 1-hour L_{eq} sound levels at the 392 receptors included in the analysis. The broadband sound levels range from 29 to 51 dBA.

In order to demonstrate compliance at all non-participating receptors, this wind turbine model requires some of the wind turbines to be placed in Noise Reduced Operating (NRO) mode. There are multiple NRO mode options to reach 45 dBA at all non-participating receptors. Specific mitigation measures will be presented in the compliance filing report upon selection of a final wind turbine vendor. Results for the Nordex N149/4500 wind turbine presented in this report have assumed two wind turbines to be placed in NRO modes. Wind Turbine 1 is assumed to be NRO mode 1⁶⁴, and Wind Turbine 27 is assumed to be NRO mode 2⁶⁵. Under normal operation, this wind turbine can produce up to 4,500 kW of electricity. Under NRO mode 1, the maximum power output is 4,380 kW, and under NRO mode 2, the maximum power output is 4,280 kW.

⁶⁴ NRO mode 1 for the Nordex N149/4500 represents a 0.8 dBA reduction for this wind turbine.

⁶⁵ NRO mode 2 for the Nordex N149/4500 represents a 1.3 dBA reduction for this wind turbine.

Table 9-12 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 40 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. All receptors are residential land use.

Table 9-12 Participating and Non-Participating Receptors Modeled at 40 dBA or Greater (Nordex N149/4500)

Modeled Leq Sound Level (dBA) ¹	# of Receptors	
	Participating	Non-Participating
51	1	0
50	0	0
49	1	0
48	1	0
47	0	0
46	4	0
45	10	4
44	12	6
43	4	8
42	3	4
41	3	9
40	5	20

Notes: 1. Rounded to the nearest whole decibel.

9.4.4 Short-Term – ISO 9613-2 (Senvion M148-4.2, HH = 130m)

Table E-4 in Appendix E shows the predicted “Project-Only” short-term broadband (dBA) and octave band (dB) sound levels under conditions specified in Section 9.3.2 sorted by modeling receptor ID for the Senvion M148-4.2 turbine model at a hub height of 130 meters. Table E-4.1 presents the same data sorted by sound level from high to low. The tables present modeled 1-hour L_{eq} sound levels at the 392 receptors included in the analysis. The broadband sound levels range from 28 to 50 dBA.

Table 9-13 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 40 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. All receptors are residential land use.

Table 9-13 Participating and Non-Participating Receptors Modeled 40 dBA or Greater (Senvion M148-4.2)

Modeled Leq Sound Level (dBA) ¹	# of Receptors	
	Participating	Non-Participating
50	1	0
49	0	0
48	2	0
47	0	0
46	0	0
45	3	1
44	11	2
43	10	5
42	6	9
41	2	4
40	2	9

Notes: 1. Rounded to the nearest whole decibel.

9.4.5 Long-Term – ISO 9613-2 L₁₀, L₅₀, and Nighttime L_{EQ} Annual Sound Level Results

A full year of 2017 on-site meteorological data was used to determine the equivalent L₁₀, L₅₀ and nighttime L_{EQ} sound power levels for each wind turbine type as described in Section 9.3.3. The long-term sound levels have been analyzed using two methodologies. The first method, “Method 1” (no zeros), includes only periods when the wind turbines are expected to be operating based on the annual meteorology (i.e., above cut-in wind speed). This is conservative in that there will be periods during the year when the sound level associated with the wind turbines will be zero as they will not be operating. These periods have the potential to reduce the sound levels for the various metrics presented in this analysis. The second method, “Method 2” (with zeros), includes all hours (both operational and non-operational periods) in the calculation. This is more representative of long-term/annual conditions as there will be periods during a year when the wind turbines are not operating. For each of these long-term scenarios, the wind turbine with the highest resulting sound power level has been modeled. All other wind turbines being considered would result in lower long-term sound level impacts.

For annual L₁₀ modeling, the wind turbine with the highest equivalent sound power level was the GE 3.8-137, as shown in Table 9-8. For annual L₅₀ modeling, the wind turbine with the highest equivalent sound power level was the Nordex N149, as shown in Table 9-8. For annual nighttime L_{eq, night, outside} modeling, the wind turbine with the highest equivalent sound power level was the Nordex N149, as shown in Table 9-9.

Using the highest resulting sound power levels from Table 9-8, the annual Project L₁₀ and L₅₀ sound level at each noise sensitive location has been calculated. Using the highest resulting sound power levels from Table 9-9, the annual L_{EQ} nighttime noise level (L_{Eq, night, outside}) has been calculated at each of the modeled noise sensitive locations. L_{Eq, night, outside} is the equivalent continuous sound level determined over all nighttime periods during the year with the Exhibit 19 regulations defining nighttime as the period from 10 p.m. to 7 a.m. (1001.19(f)(2)). The definition, as presented in the 2009 WHO document, refers to ISO 1996-2: 1987 and identifies night as an eight hour period. The more recent ISO 1996-1:2016 (Acoustics – description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures) defines L_{Eq, night, outside} and provides various time frames for a nighttime period. In order to remain consistent with the 2009 WHO document, a night for L_{Eq, night, outside} will be defined as an 8-hour period.

L_{Eq, night, outside} Project sound levels range from 26 to 50 dBA for “Method 1” (no zeros) and 25 to 50 dBA for “Method 2” (with zeros) calculations. The highest L_{Eq, night, outside} level at a non-participating receptor is 42 dBA (Receptor IDs 133 and 207). In addition to these discrete modeling points, sound level contours generated from the modeling grid are presented in an overview figure, Figure 9-3, accompanied by a series of inset maps that provide a higher level of detail at all modeled receptors. This sound contour figure set for L_{Eq, night, outside} Project sound levels was generated only for the Nordex N149 wind turbine model, because it has the highest A-weighted sound power level for this metric. Tables 9-14 to 9-17 summarize the number of receptors equal to or greater than 40 dBA for the L_{Eq, night, outside} modeling for each of the four wind turbines under consideration.

Annual Project L₁₀ sound levels range from 26 to 50 dBA for both the “Method 1” (no zeros) calculations and the “Method 2” (with zeros) calculations. The highest L₁₀ level at a non-participating receptor is 44 dBA (Receptor IDs 133 and 207).

Annual Project L₅₀ sound levels range from 27 to 50 dBA for both the “Method 1” (no zeros) calculations and the “Method 2” (with zeros) calculations. The highest L₅₀ level at a non-participating receptor is 44 dBA (Receptor ID 133).

The annual L₁₀, L₅₀, and nighttime L_{EQ} (L_{Eq, night, outside}) values for all receptors are presented in Table F-1 (Method 1 – No Zeros) and Table F-2 (Method 2 – With Zeros) in Appendix F.

Table 9-14 Number of Receptors Modeled at 40 dBA or Greater for LEQ -night-outside—GE 3.8-137

Modeled Leq Sound Level (dBA) ¹	Method 1 – Without Zeros		Method 2 – With Zeros	
	# of Receptors		# of Receptors	
	Participating	Non-Participating	Participating	Non-Participating
50	1	0	1	0
49	0	0	0	0
48	0	0	0	0
47	1	0	1	0
46	0	0	0	0
45	1	0	0	0
44	0	0	1	0
43	0	0	0	0
42	4	1	0	0
41	9	4	8	4
40	10	4	9	4

Notes: 1. Rounded to the nearest whole decibel.

Table 9-15 Number of Receptors Modeled at 40 dBA or Greater for LEQ -night-outside—Vestas V150-4.2

Modeled Leq Sound Level (dBA) ¹	Method 1 – Without Zeros		Method 2 – With Zeros	
	# of Receptors		# of Receptors	
	Participating	Non-Participating	Participating	Non-Participating
50	1	0	1	0
49	0	0	0	0
48	0	0	0	0
47	1	0	1	0
46	0	0	0	0
45	0	0	0	0
44	0	0	0	0
43	1	0	1	0
42	0	0	0	0
41	1	0	1	0
40	6	4	4	3

Notes: 1. Rounded to the nearest whole decibel.

Table 9-16 Number of Receptors Modeled at 40 dBA or Greater for LEQ-night-outside–Nordex N149/4500

Modeled Leq Sound Level (dBA) ¹	Method 1 – Without Zeros		Method 2 – With Zeros	
	# of Receptors		# of Receptors	
	Participating	Non-Participating	Participating	Non-Participating
50	1	0	1	0
49	0	0	0	0
48	0	0	0	0
47	1	0	1	0
46	0	0	0	0
45	1	0	1	0
44	0	0	0	0
43	2	1	1	0
42	11	1	8	2
41	10	7	11	7
40	7	6	9	5

Notes: 1. Rounded to the nearest whole decibel.

Table 9-17 Number of Receptors Modeled at 40 dBA or Greater for LEQ-night-outside–Senvion M148-4.2

Modeled Leq Sound Level (dBA) ¹	Method 1 – Without Zeros		Method 2 – With Zeros	
	# of Receptors		# of Receptors	
	Participating	Non-Participating	Participating	Non-Participating
50	1	0	1	0
49	0	0	0	0
48	0	0	0	0
47	1	0	1	0
46	0	0	0	0
45	0	0	0	0
44	1	0	0	0
43	0	0	1	0
42	0	0	0	0
41	5	3	1	0
40	10	3	2	3

Notes: 1. Rounded to the nearest whole decibel.

9.5 Total Sound Levels - Modeled Combined with Ambient

9.5.1 *Assignment of Ambient Sound Levels to Modeling Locations*

Measured ambient data were assigned to each modeling receptor based on proximity between measurement points and the similarity of the soundscape between the evaluated position and the location where the ambient noise levels were measured. Assumptions regarding the similarities of soundscapes were based on personal observations at each of the sound level measurement locations and on a review of the aerial imagery for the area. The modeling receptors were not visited during the measurement program to confirm/deny assumptions made regarding the soundscapes. Table G-1 in Appendix G presents the sound level modeling locations with their assigned ambient measurement location.

9.5.2 *Future Total Sound Levels*

The worst-case future noise level during the daytime period at all receptors has been determined by logarithmically adding the daytime ambient sound level (L_{90}), calculated from background sound level monitoring in the summer and winter, to the modeled upper tenth percentile sound level (L_{10}) of the Project as per Exhibit 19 (f)(4). The L_{10} statistical noise descriptor corresponds to estimates for one year of operation using the wind turbine model with the highest sound power level (GE 3.8-137), as presented in Table 9-8. These worst-case future noise levels during the daytime period are presented in Table G-2A (Method 1 – No Zeros) and Table G-2B (Method 2 – With Zeros) in Appendix G. Worst case future daytime noise levels range from 27 to 50 for the Method 1 and the Method 2 calculations.

The worst case future noise level during the summer nighttime period at all receptors has been determined by logarithmically adding the summer nighttime ambient sound level (L_{90}), calculated from background sound level monitoring, to the modeled upper tenth percentile sound level (L_{10}) of the Project as per Exhibit 19 (f)(5) using the wind turbine model with the highest sound power level (GE 3.8-137). The L_{10} statistical noise descriptor corresponds to estimates for summer nighttime period for one year of operation. These worst case future noise levels during the summer nighttime period are presented in Table G-2A (Method 1) and Table G-2B (Method 2) in Appendix G. Worst case future total summer nighttime noise levels range from 26 to 50 dBA for the Method 1 and the Method 2 calculations.

The worst case future total noise level during the winter nighttime period at all receptors has been determined by logarithmically adding the winter nighttime ambient sound level (L_{90}), calculated from background sound level monitoring, to the modeled upper tenth percentile sound level (L_{10}) of the Project as per Exhibit 19 (f)(6) using the wind turbine model with the highest sound power level (GE 3.8-137). The L_{10} statistical noise descriptor corresponds to estimates for winter nighttime period for one year of operation. These worst

case future noise levels during the winter nighttime period are presented in Table G-2A (Method 1) and Table G-2B (Method 2) in Appendix G. Worst case future winter nighttime noise levels range from 27 to 50 dBA for the Method 1 and the Method 2 calculations.

The typical Project daytime noise level at all receptors with has been determined by logarithmically adding the daytime equivalent average sound level (L_{eq}) calculated from background sound level monitoring, to the modeled median Project sound pressure level (L_{50}) as per Exhibit 19 (f)(9) using the wind turbine model with the highest sound power level (Nordex N149). The L_{50} statistical noise descriptor corresponds to estimates for one year of operation. These typical Project daytime noise levels are presented in Table G-2A (Method 1) and Table G-2B (Method 2) in Appendix G. Typical Project daytime noise levels range from 44 to 52 dBA for the Method 1 and Method 2 calculations.

9.6 Infrasound and Low Frequency Sound

GE provides one-third octave band sound power level data down to 12.5 Hz for the GE 3.8-137, Vestas provides one-third octave band sound power level data from 6.3 Hz to 10,000 Hz for the V150-4.2. Nordex provides one-third octave band sound power level data down to 10 Hz for the N149-4500, and Senvion provides one-third octave band sound power level data down to 20 Hz for the 4.2M148. No reference sound power level data below 6.3 Hz are available from any of the manufacturers. Therefore, sound power level data were extrapolated from each manufacturer's lowest published octave band down to 0.5 Hz. The extrapolation process assumed a 1 dB per octave increase in sound power levels from the lowest published value to 0.5 Hz as shown in the research.⁶⁶ The infrasound and low frequency sound power levels are shown in Table 9-18, and represent the highest sound level under any wind speed from any turbine model for each one-third octave band.

Research by Hubbard and Shepherd,⁶⁷ and Health Canada⁶⁸ has shown that within approximately the first 1000 meters of a wind turbine, infrasound and low frequency sound levels decrease according to spherical spreading (-6 dB per doubling of distance). At distances beyond approximately 1000 meters, the one-third octave band levels below ~70 Hz propagate cylindrically at closer to 3 dB per doubling of distance. Therefore, infrasound and low frequency levels for the Project were calculated assuming the following:

⁶⁶ *Massachusetts Study on Wind Turbine Acoustics*, Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, RSG et al., 2016.

⁶⁷ *Aeroacoustics of large wind turbines*, H. Hubbard. And K. Shepherd, J. Acoust. Soc. Am. 89(6), June 1991.

⁶⁸ *Wind turbine sound pressure level calculations at dwellings*, S. Keith et al, J. Acoust. Soc. Am. 139(3), March 2016.

- ◆ 80 Hz and above – decrease spherically at all distances
- ◆ 63 Hz and below – decrease spherically from 0 to 1000 meters; decrease cylindrically beyond 1000 meters

Using these parameters, infrasound and low frequency sound levels were calculated using a spreadsheet approach for the nearest ten receptors to any wind turbine. These receptors included non-participating and participating locations. Two of the top ten receptors had another receptor that was very similar in distance and influenced by the same wind turbines. Therefore, there were eight unique receptors analyzed. These eight locations were scattered throughout the wind farm, and were at end of wind turbine strings as well as in the middle of a string, thus providing a good mix of worst-case conditions.

If no impacts are shown for these locations, then other more distant locations will show even lower sound levels and thus no impacts as well. Only drop-off with distance and atmospheric absorption were included in the calculations. Atmospheric absorption values were taken from ANSI/ASA S1.26-2014 for a temperature of 10 degrees C and 70% relative humidity. This standard only provides absorption values for one-third octave bands of 50 Hz and above, therefore, no atmospheric absorption occurs below 50 Hz. No ground absorption was assumed.

Table 9-19 presents the receptors, the wind turbines included in the calculations, and the distance from the wind turbine to each receptor. Inclusion of the more distant wind turbines is not necessary since they have a negligible effect on overall values which are controlled by the closest turbine(s). The results are shown in Table 9-20 for both the one-third octave bands and full octave bands at each of the eight locations analyzed.

Predicted infrasound levels at the nearest non-participating receptor 339 meters from a wind turbine are consistent with those measured at 350 meters in the Massachusetts Research Study on Wind Turbine Acoustics.

Table 9-18 Maximum Wind Turbine Sound Power Levels—Infrasound & LFN

One-Third Octave Band	Sound Power Level (dB)
0.5	<i>126.4</i>
0.63	<i>126.0</i>
0.8	<i>125.7</i>
1	<i>125.4</i>
1.25	<i>125.0</i>
1.6	<i>124.7</i>
2	<i>124.4</i>
2.5	<i>124.0</i>
3.15	<i>123.7</i>
4	<i>123.4</i>
5	<i>123.0</i>
6.3	122.7
8	121.1
10	119.4
12.5	118.0
16	116.8
20	115.6
25	114.0
31.5	113.0
40	112.4
50	111.1
63	109.9
80	108.1
100	108.8
125	105.9
160	104.6
200	103.1

Note: italicized sound levels are extrapolated.

Table 9-19 Locations Analyzed for Infrasound & LFN

Receptor ID	Wind Turbine ID	Approximate Distance to Receptor (meters)
#32	26	339
	33	922
	25	1006
	31	1353
#58	36	385
	13	887
	3	942
	4	1149
#116	4	380
	1	694
	3	891
	36	1170
#133	27	436
	30	609
	31	788
	32	893
	29	957
#138	31	441
	27	741
	30	884
	29	893
	33	972
#207	1	331
	4	1151
	36	1400
#268	5	261
	6	424
	7	991
#357	31	428
	29	777
	27	797
	33	918
	30	1038

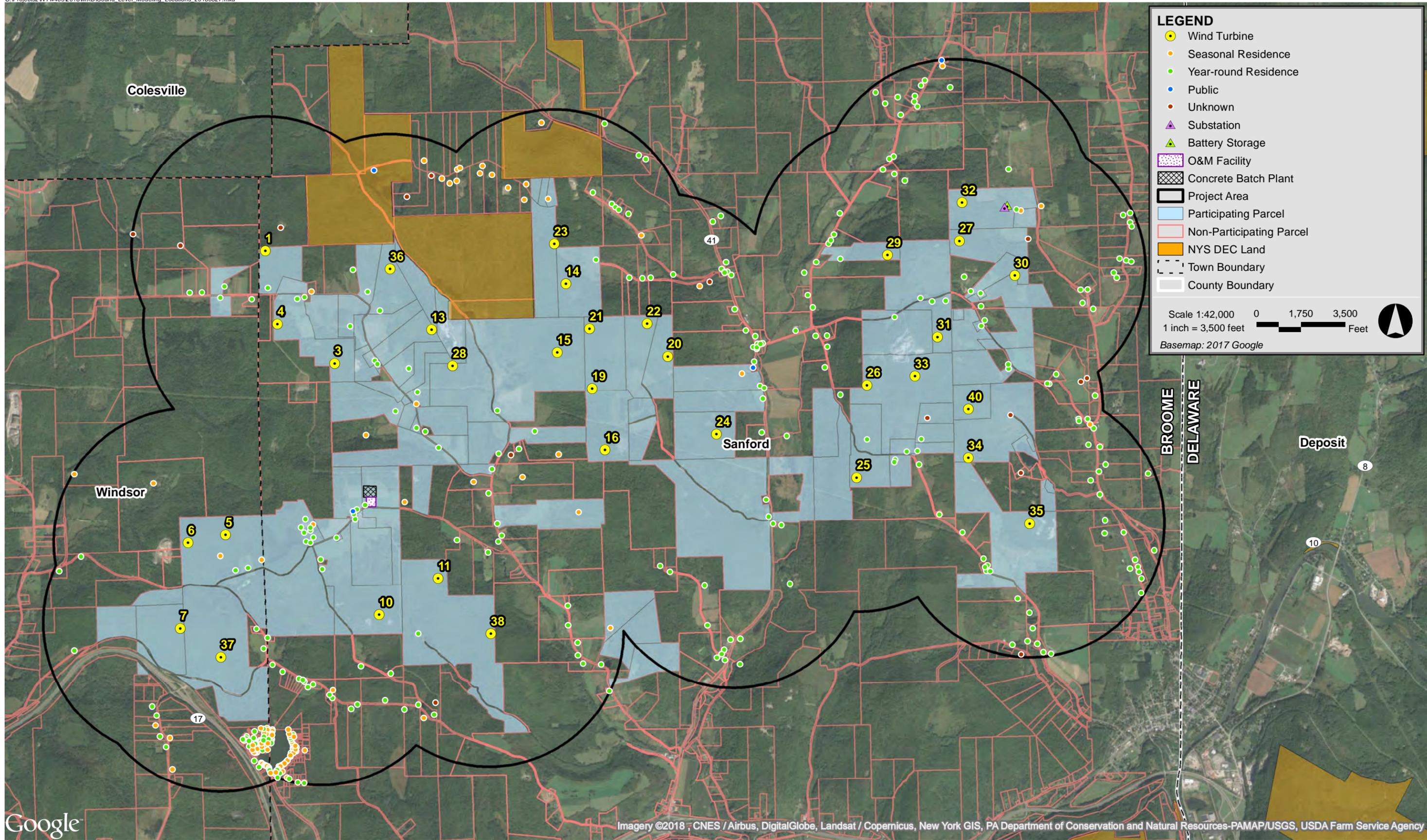
Note: Spectra used for calculations is an aggregate worst case from all four wind turbine models.

Table 9-20 Calculated Sound Levels—Infrasound & LFN

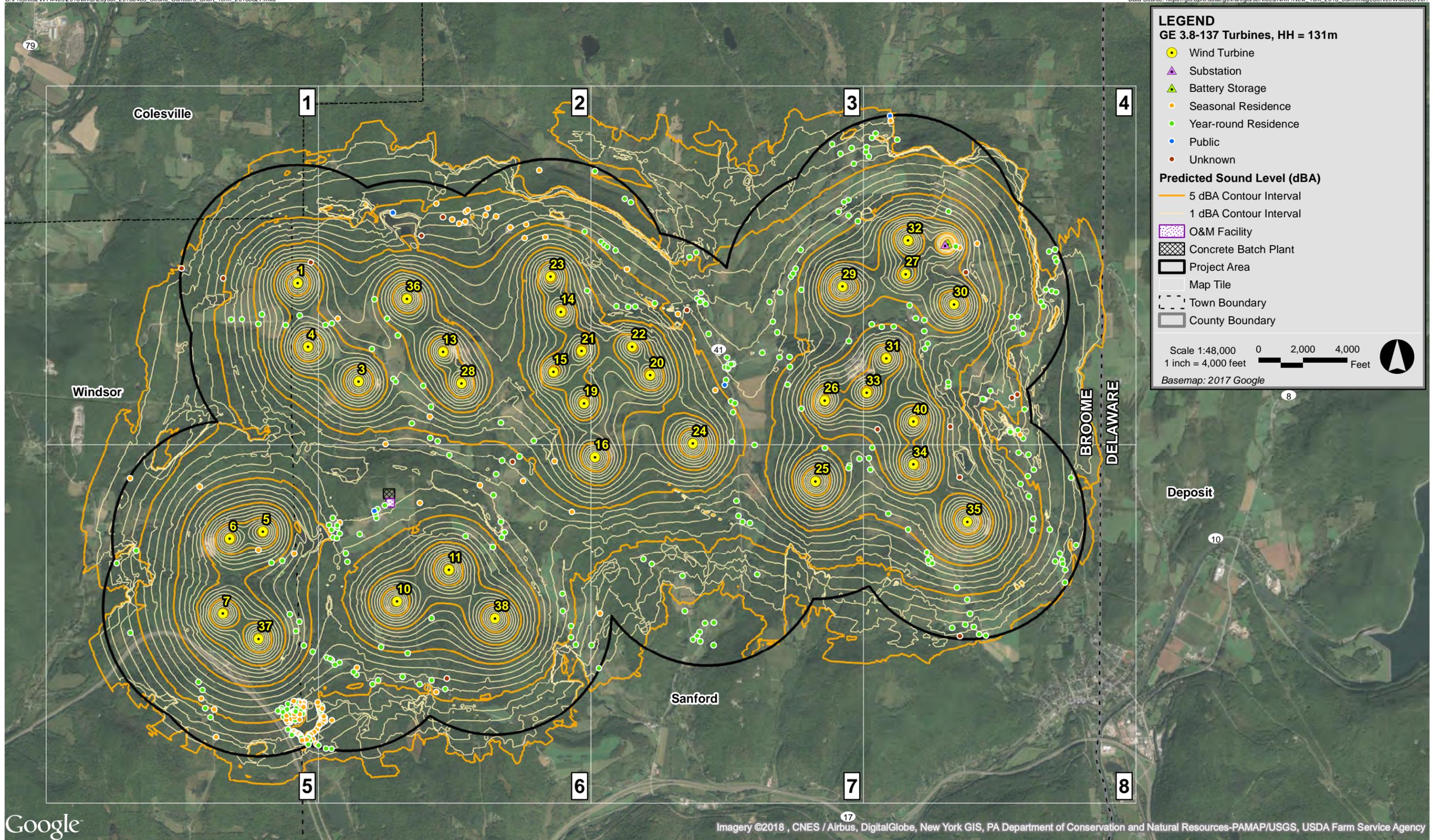
Location	One-Third Octave Band Center Frequency (Hz)																											
	0.5	0.63	0.8	1	1.25	1.6	2	2.5	3.15	4	5	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	
ID #32	69	69	68	68	68	67	67	67	66	66	66	65	64	62	61	59	58	57	56	55	54	53	51	51	48	47	45	
Octave bands				73			72			71			69			64			61			57			54			
ID #58	68	68	68	67	67	67	66	66	66	65	65	65	63	61	60	59	58	56	55	54	53	52	50	51	48	46	45	
Octave bands				72			71			70			68			64			60			57			53			
ID #116	69	68	68	68	67	67	67	66	66	66	65	65	64	62	60	59	58	56	55	55	54	52	51	51	48	47	46	
Octave bands				73			72			71			69			64			60			57			54			
ID #133	69	69	68	68	68	67	67	67	66	66	66	65	64	62	61	60	58	57	56	55	54	53	51	51	48	47	45	
Octave bands				73			72			71			69			64			61			57			54			
ID #138	69	68	68	68	67	67	67	66	66	66	65	65	63	62	60	59	58	56	55	55	53	52	50	51	48	46	45	
Octave bands				72			71			70			68			64			60			57			54			
ID #207	71	70	70	70	69	69	69	68	68	68	67	67	65	64	62	61	60	58	57	57	55	54	52	53	50	49	47	
Octave bands				74			73			72			70			66			62			59			56			

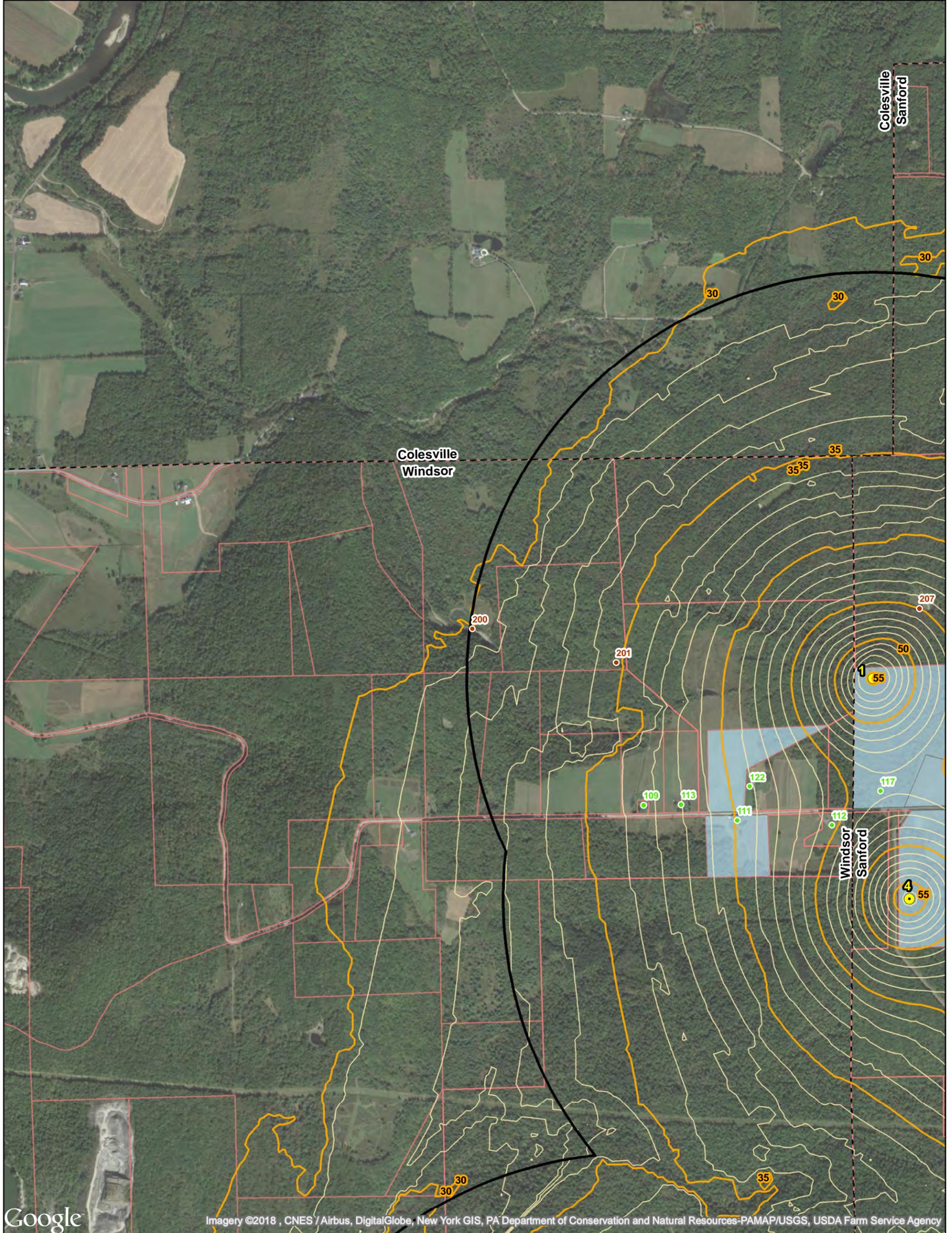
Table 9-20 Calculated Sound Levels—Infrasound & LFN (Continued)

Location	One-Third Octave Band Center Frequency (Hz)																											
	0.5	0.63	0.8	1	1.25	1.6	2	2.5	3.15	4	5	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	
ID #268	72	71	71	71	70	70	70	69	69	69	68	68	66	65	63	62	61	59	58	58	56	55	53	54	51	50	48	
Octave bands				75			74			73			71			67			63			60			57			
ID #357	69	68	68	68	67	67	67	66	66	66	65	65	63	62	60	59	58	56	55	55	53	52	50	51	48	47	45	
Octave bands				73			72			71			68			64			60			57			54			

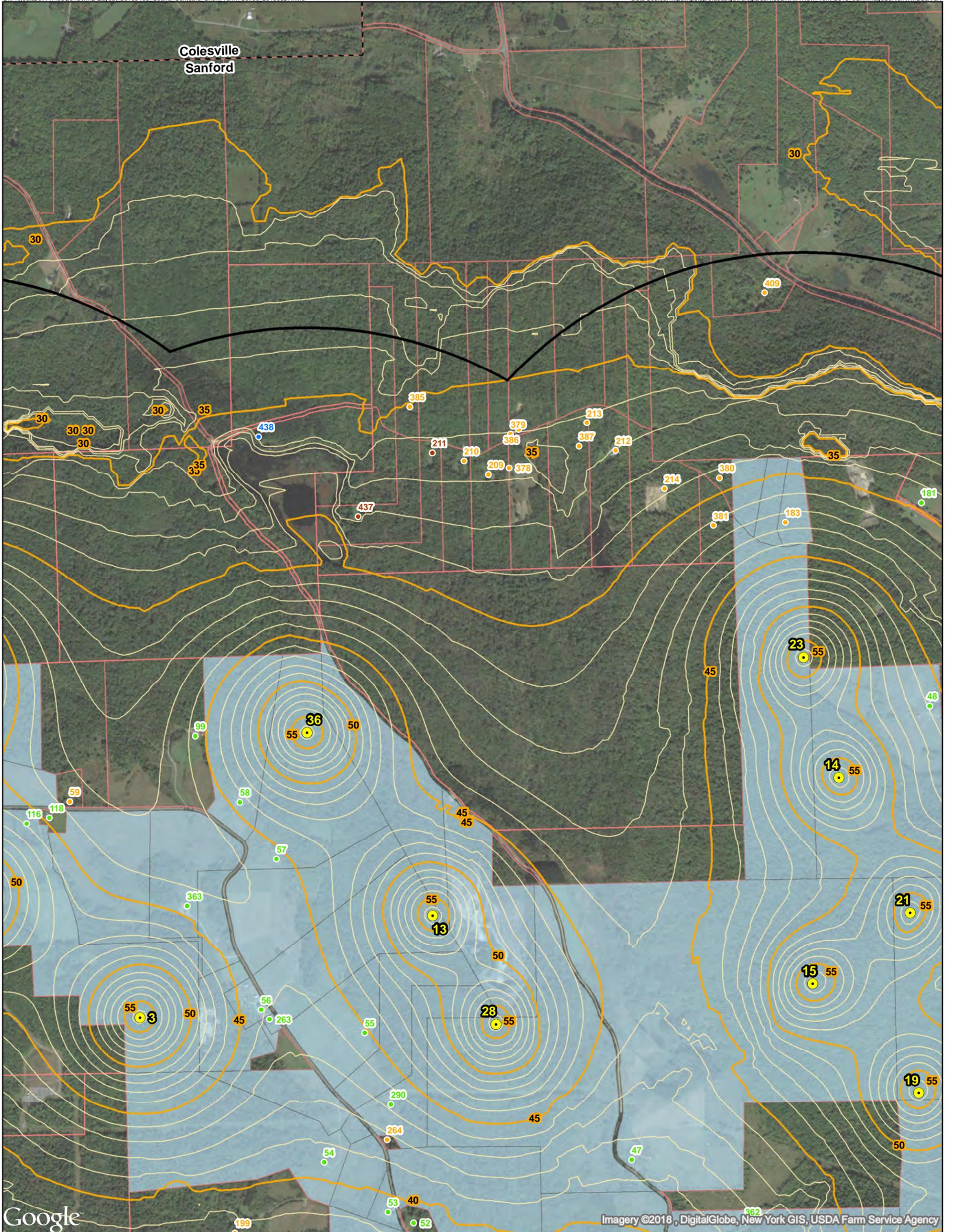


Bluestone Wind Broome County, New York





LEGEND GE 3.8-137 Turbines, HH = 131m ● Wind Turbine - - - Town Boundary □ County Boundary ▲ Substation ▲ Battery Storage		● Seasonal Residence ● Year-round Residence ● Public ● Unknown □ Participating Parcel □ Non-Participating Parcel	□ Project Area □ O&M Facility □ Concrete Batch Plant Predicted Sound Level (dBA) — 5 dBA Contour Interval — 1 dBA Contour Interval	Scale 1:14,400 1 inch = 1,200 feet 0 600 1,200 Feet Basemap: 2017 Google
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LEGEND

GE 3.8-137 Turbines, HH = 131m

- Wind Turbine
- Town Boundary
- County Boundary
- Substation
- Battery Storage

- Seasonal Residence
- Year-round Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel

Project Area

- Project Area
- O&M Facility
- Concrete Batch Plant

Predicted Sound Level (dBA)

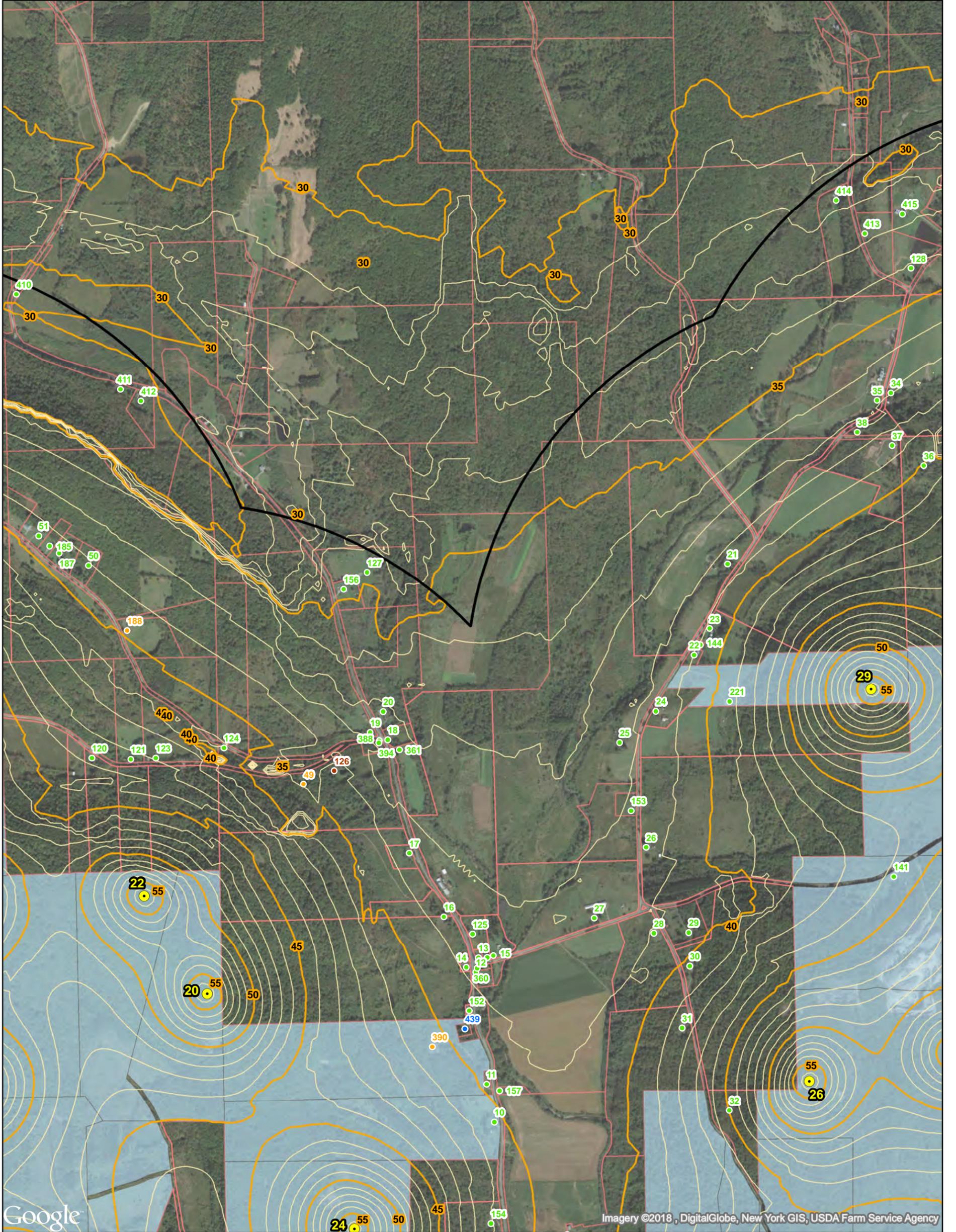
- 5 dBA Contour Interval
- 1 dBA Contour Interval



Scale 1:14,400
1 inch = 1,200 feet



Basemap: 2017 Google



LEGEND

GE 3.8-137 Turbines, HH = 131m

- Wind Turbine
- Town Boundary
- County Boundary
- Substation
- Battery Storage

- Seasonal Residence
- Year-round Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel

Project Area

- O&M Facility
- Concrete Batch Plant

Predicted Sound Level (dBA)

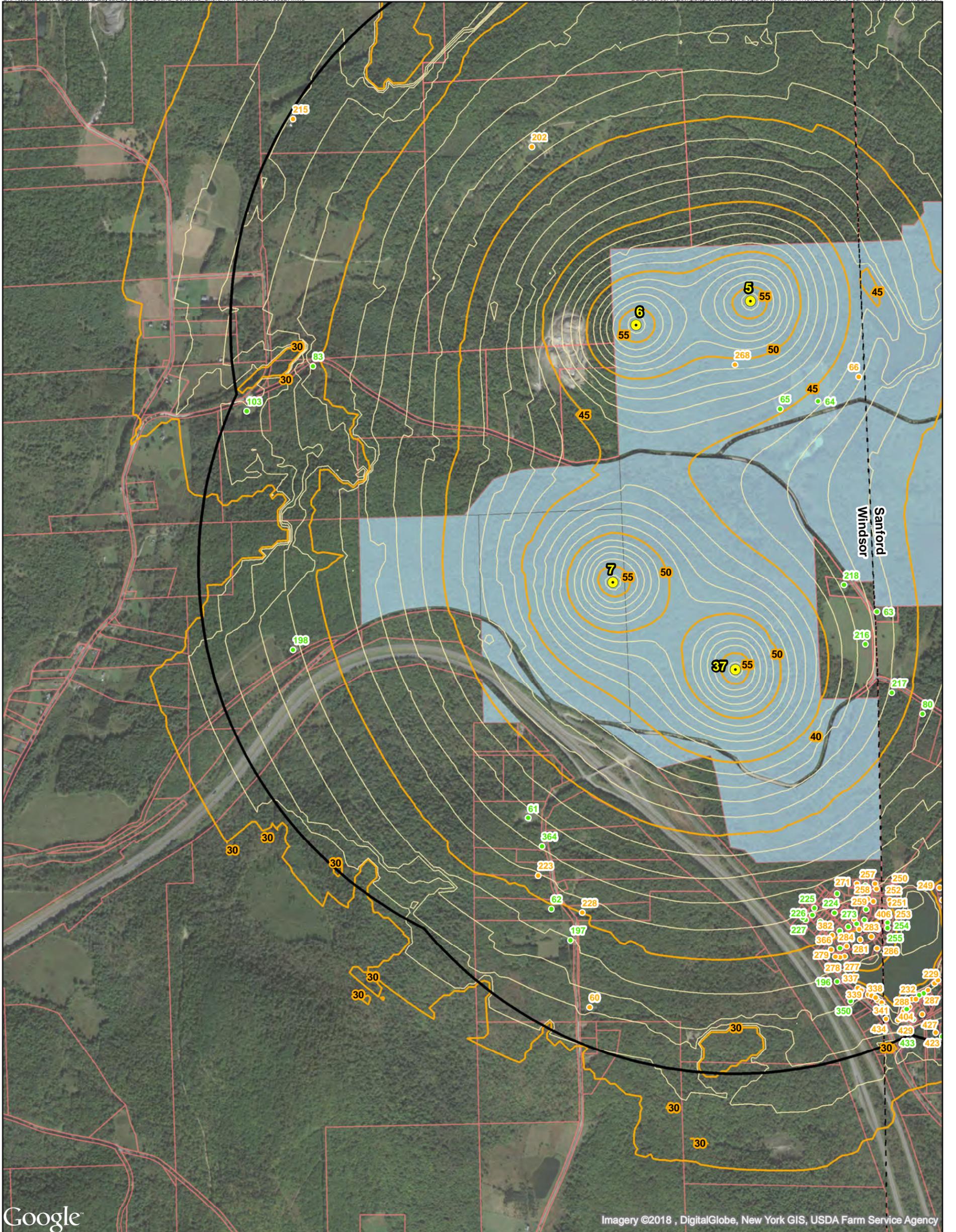
- 5 dBA Contour Interval
- 1 dBA Contour Interval



Scale 1:14,400
1 inch = 1,200 feet



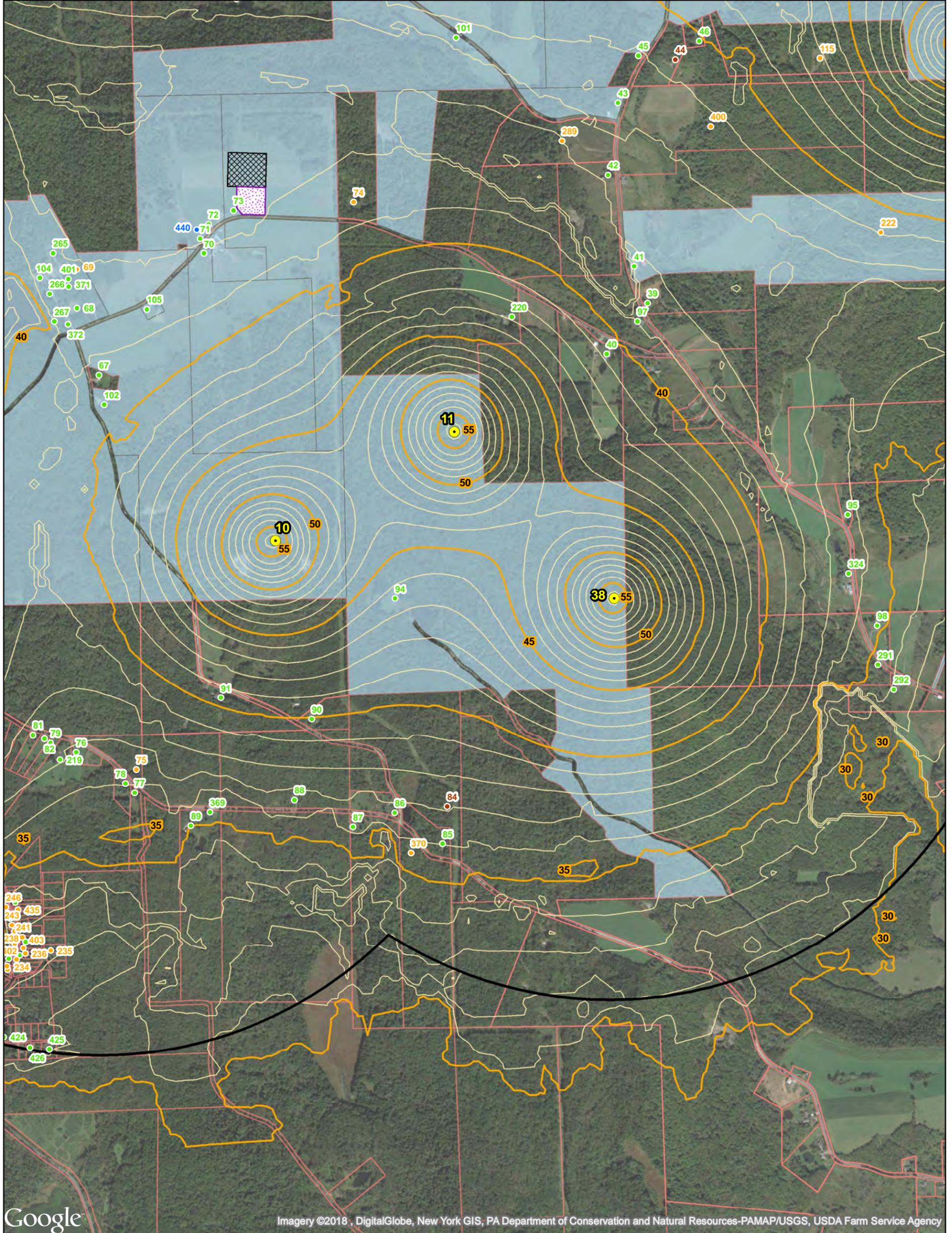
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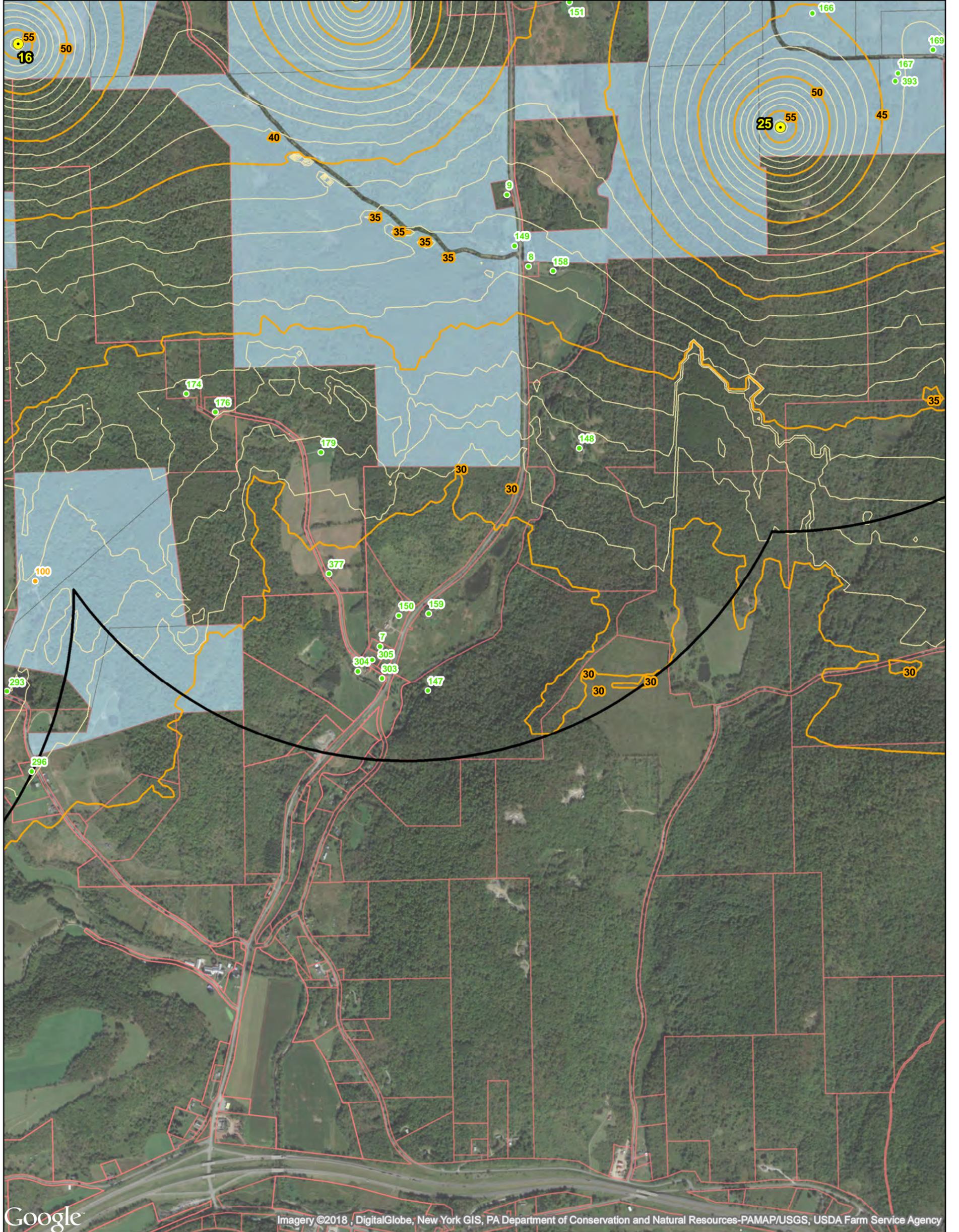
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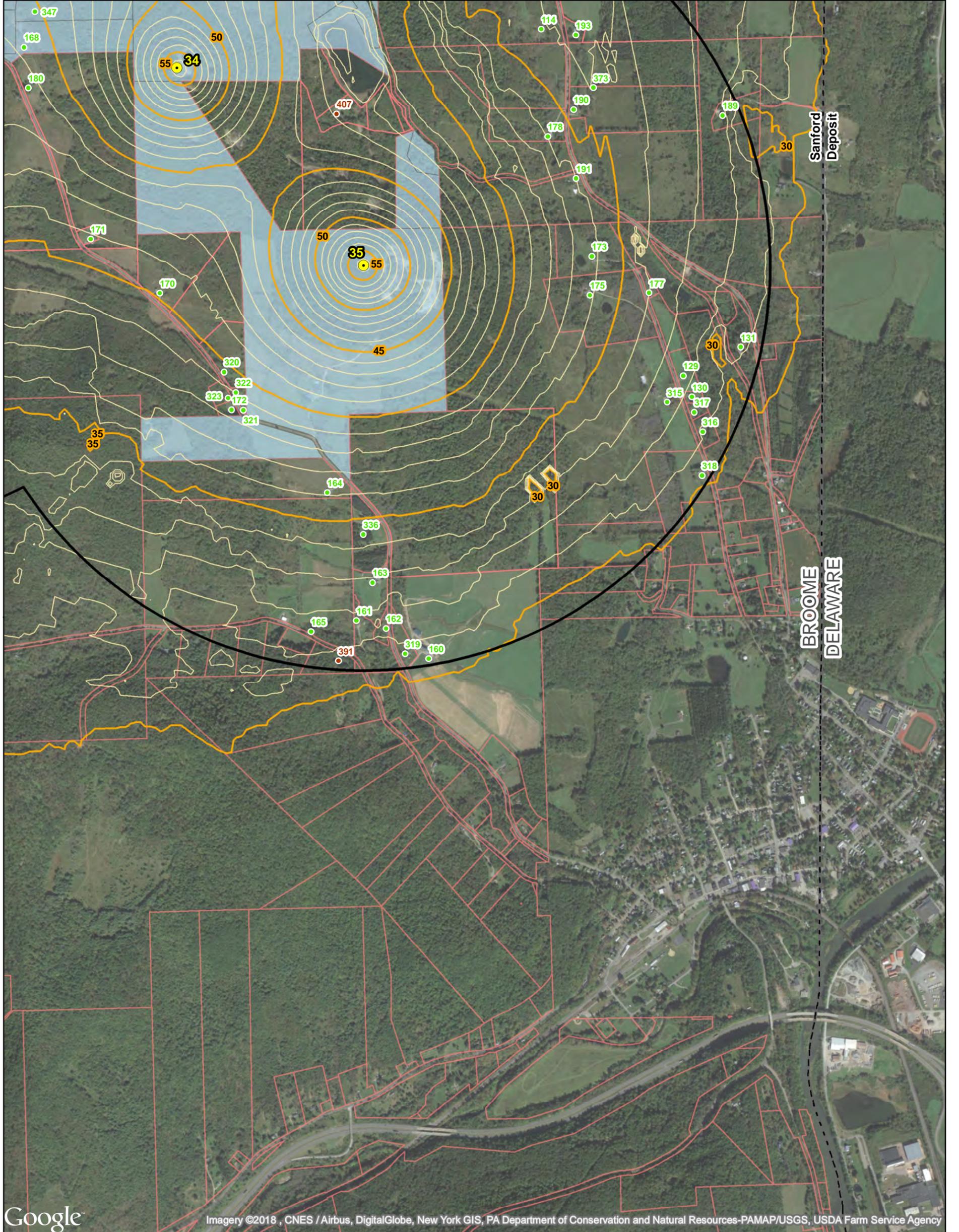
<p>LEGEND</p> <p>GE 3.8-137 Turbines, HH = 131m</p> <ul style="list-style-type: none"> ● Wind Turbine Town Boundary County Boundary ▲ Substation ▲ Battery Storage 		<ul style="list-style-type: none"> ● Seasonal Residence ● Year-round Residence ● Public ● Unknown Participating Parcel Non-Participating Parcel 	<ul style="list-style-type: none"> Project Area O&M Facility Concrete Batch Plant <p>Predicted Sound Level (dBA)</p> <ul style="list-style-type: none"> 5 dBA Contour Interval 1 dBA Contour Interval 	<div style="text-align: center;"> <p>Scale 1:14,400 1 inch = 1,200 feet</p> <div style="display: flex; align-items: center; justify-content: center;"> <div style="width: 100px; border-bottom: 1px solid black; margin-right: 5px;"></div> <div style="margin-right: 5px;">0</div> <div style="margin-right: 5px;">600</div> <div style="margin-right: 5px;">1,200</div> <div style="margin-left: 5px;">Feet</div> </div> <p>Basemap: 2017 Google</p> </div>
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LEGEND GE 3.8-137 Turbines, HH = 131m ● Wind Turbine - - - Town Boundary □ County Boundary ▲ Substation ▲ Battery Storage		● Seasonal Residence ● Year-round Residence ● Public ● Unknown □ Participating Parcel □ Non-Participating Parcel	□ Project Area □ O&M Facility □ Concrete Batch Plant Predicted Sound Level (dBA) — 5 dBA Contour Interval — 1 dBA Contour Interval	📍 Scale 1:14,400 1 inch = 1,200 feet 0 600 1,200 Feet Basemap: 2017 Google
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<p>LEGEND</p> <p>GE 3.8-137 Turbines, HH = 131m</p> <ul style="list-style-type: none"> ● Wind Turbine Town Boundary County Boundary ▲ Substation ▲ Battery Storage 		<ul style="list-style-type: none"> ● Seasonal Residence ● Year-round Residence ● Public ● Unknown Participating Parcel Non-Participating Parcel 	<ul style="list-style-type: none"> Project Area O&M Facility Concrete Batch Plant <p>Predicted Sound Level (dBA)</p> <ul style="list-style-type: none"> 5 dBA Contour Interval 1 dBA Contour Interval 	<div style="text-align: center;"> <p>Scale 1:14,400 1 inch = 1,200 feet</p> <div style="display: flex; align-items: center; justify-content: center;"> <div style="width: 100px; border-bottom: 2px solid black; margin-right: 5px;"></div> <div style="margin-right: 5px;">0</div> <div style="margin-right: 5px;">600</div> <div style="margin-right: 5px;">1,200</div> <div style="margin-left: 5px;">Feet</div> </div> <p>Basemap: 2017 Google</p> </div>
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Google

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LEGEND

GE 3.8-137 Turbines, HH = 131m

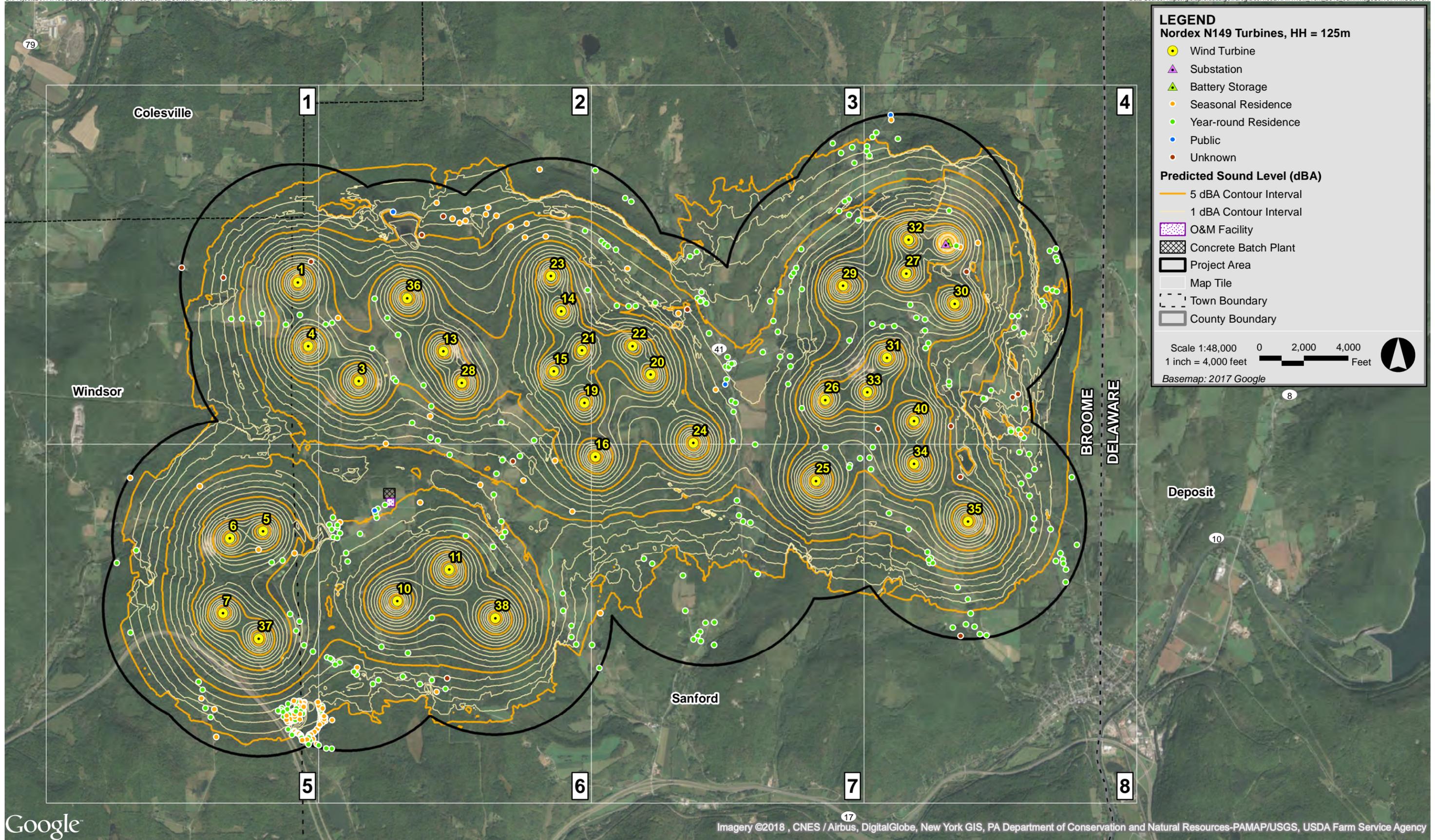
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- Town Boundary
- County Boundary
- Substation
- Battery Storage

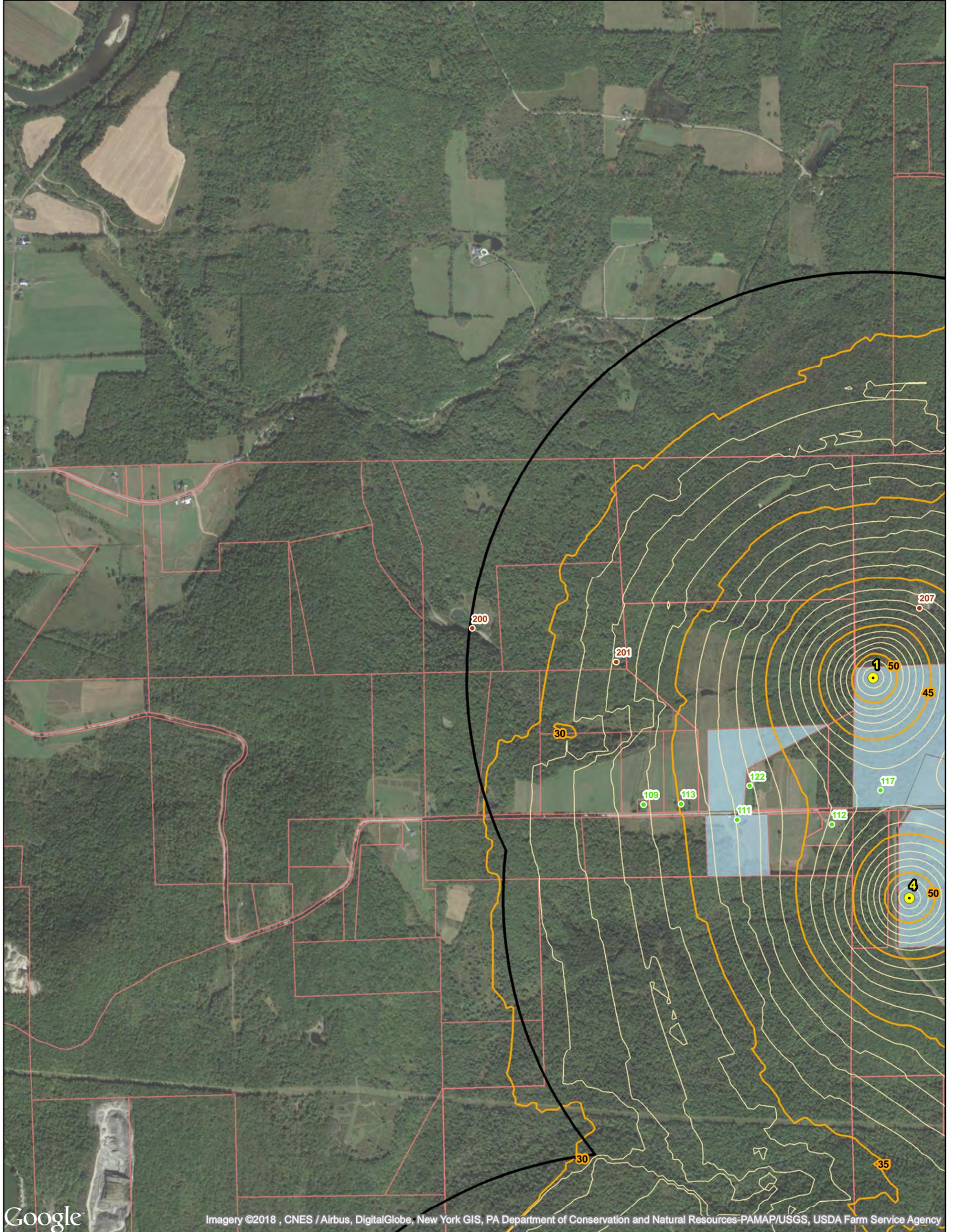
- Seasonal Residence
- Year-round Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel

- Project Area
 - O&M Facility
 - Concrete Batch Plant
- Predicted Sound Level (dBA)**
- 5 dBA Contour Interval
 - 1 dBA Contour Interval

Scale 1:14,400
1 inch = 1,200 feet

Basemap: 2017 Google





Google

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LEGEND

Nordex N149 Turbines, HH = 125m

- Wind Turbine
- Town Boundary
- County Boundary
- Substation
- Battery Storage

- Seasonal Residence
- Year-round Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel

- Project Area
- O&M Facility
- Concrete Batch Plant

Predicted Sound Level (dBA)

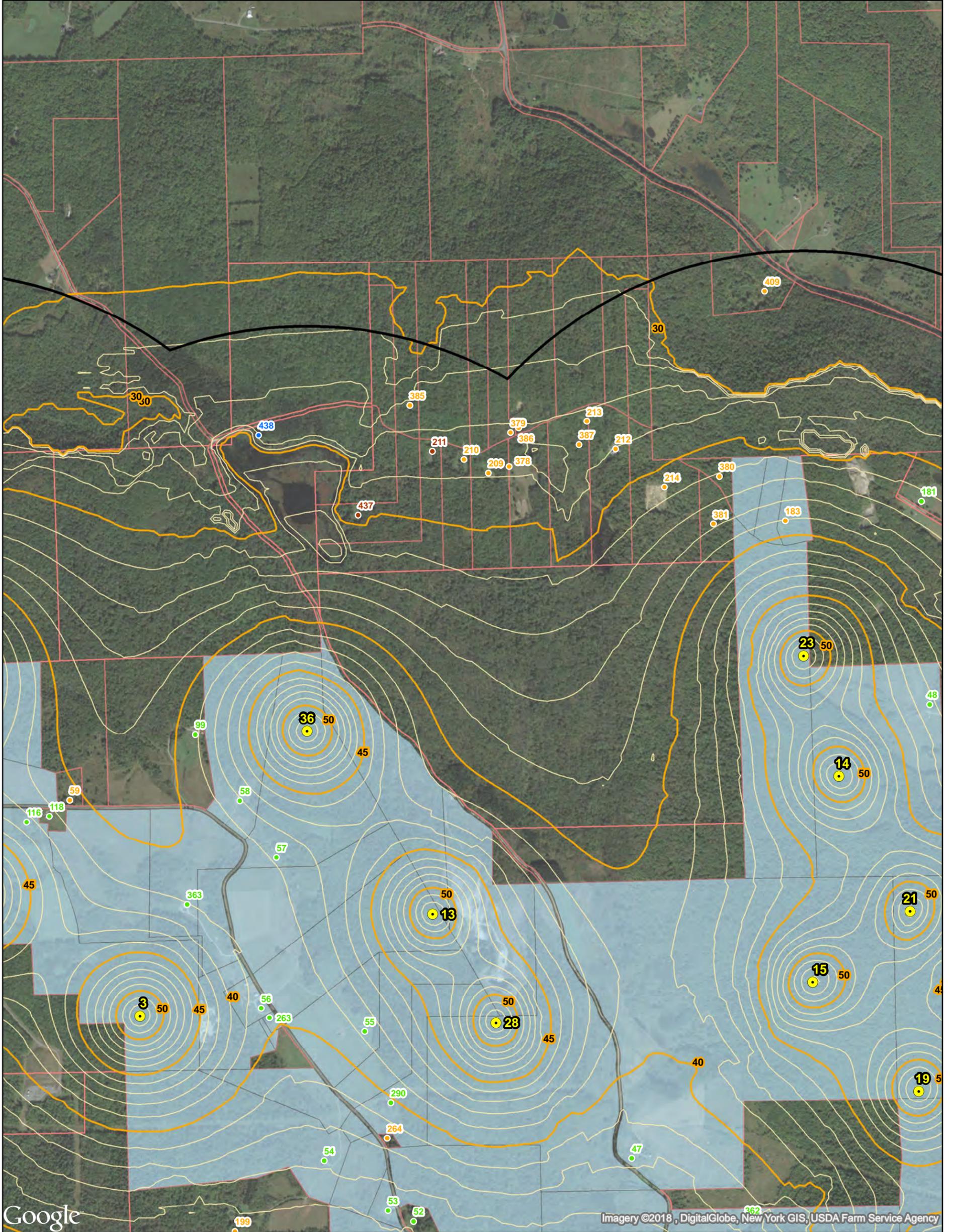
- 5 dBA Contour Interval
- 1 dBA Contour Interval



Scale 1:14,400
1 inch = 1,200 feet



Basemap: 2017 Google



LEGEND

Nordex N149 Turbines, HH = 125m

- Wind Turbine
- Town Boundary
- County Boundary
- Substation
- Battery Storage

- Seasonal Residence
- Year-round Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel

- Project Area
- O&M Facility
- Concrete Batch Plant

Predicted Sound Level (dBA)

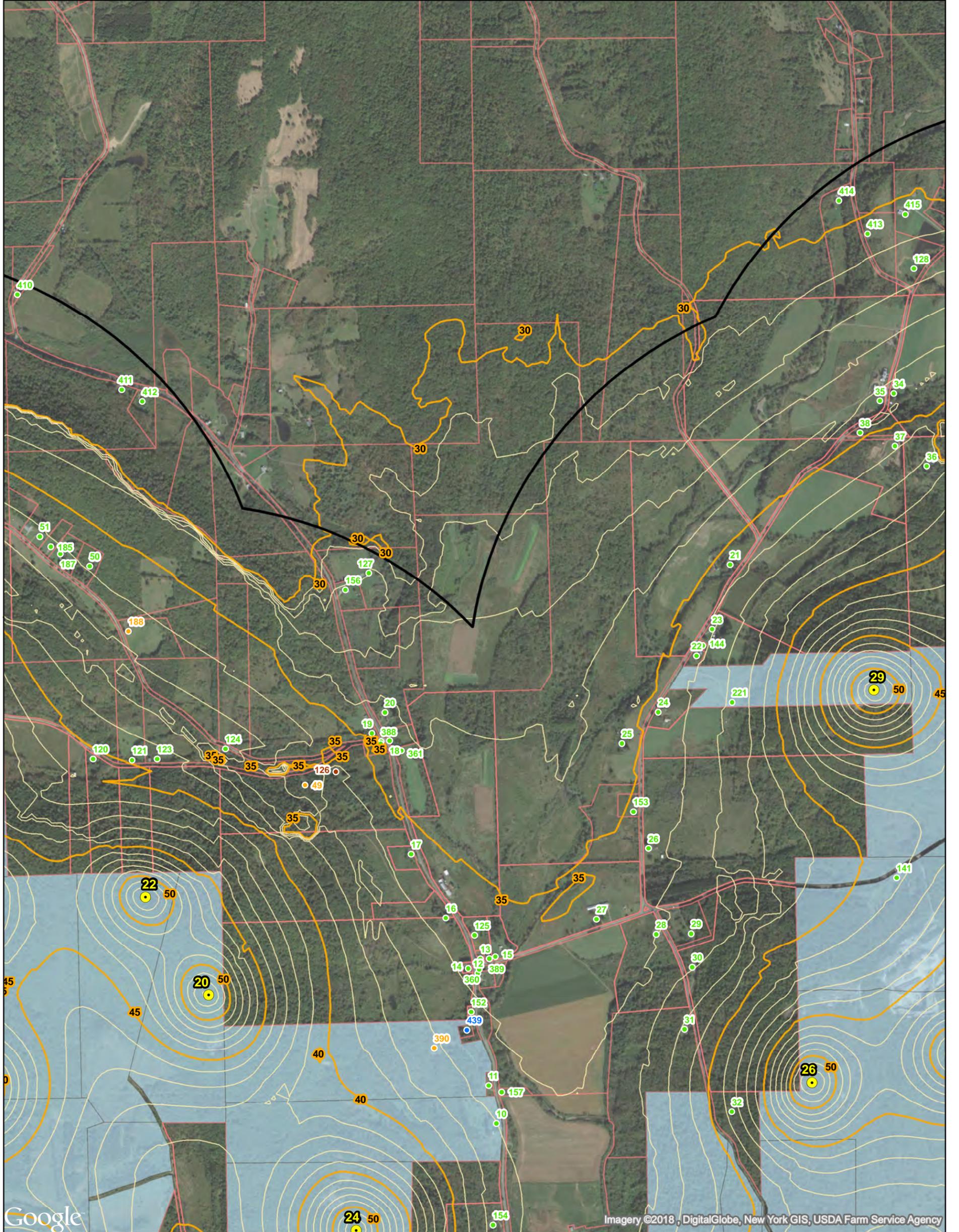
- 5 dBA Contour Interval
- 1 dBA Contour Interval



Scale 1:14,400
1 inch = 1,200 feet



Basemap: 2017 Google



LEGEND

Nordex N149 Turbines, HH = 125m

- Wind Turbine
- Town Boundary
- County Boundary
- ▲ Substation
- ▲ Battery Storage

- Seasonal Residence
- Year-round Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel

- Project Area

- O&M Facility
- Concrete Batch Plant

Predicted Sound Level (dBA)

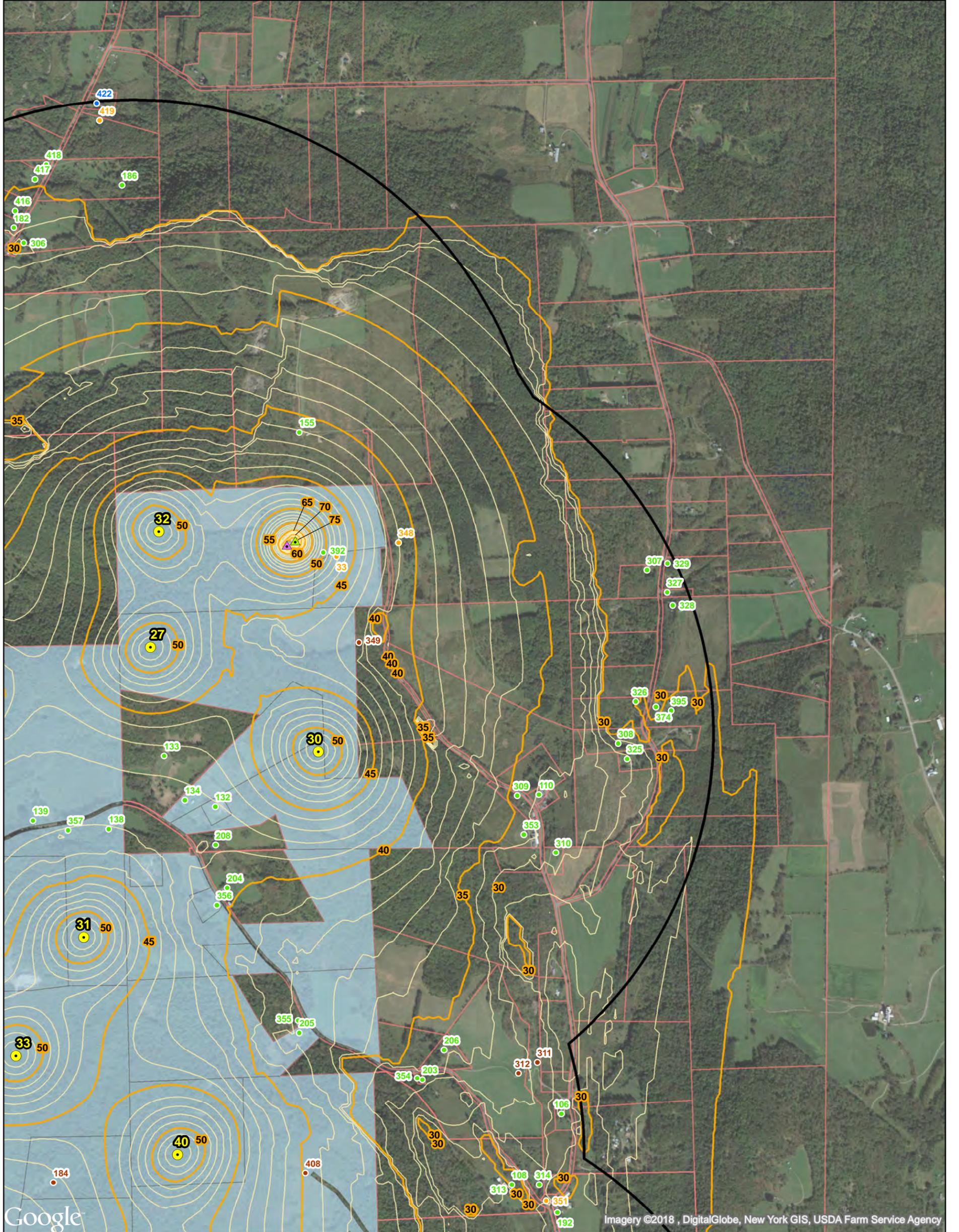
- 5 dBA Contour Interval
- 1 dBA Contour Interval



Scale 1:14,400
1 inch = 1,200 feet



Basemap: 2017 Google

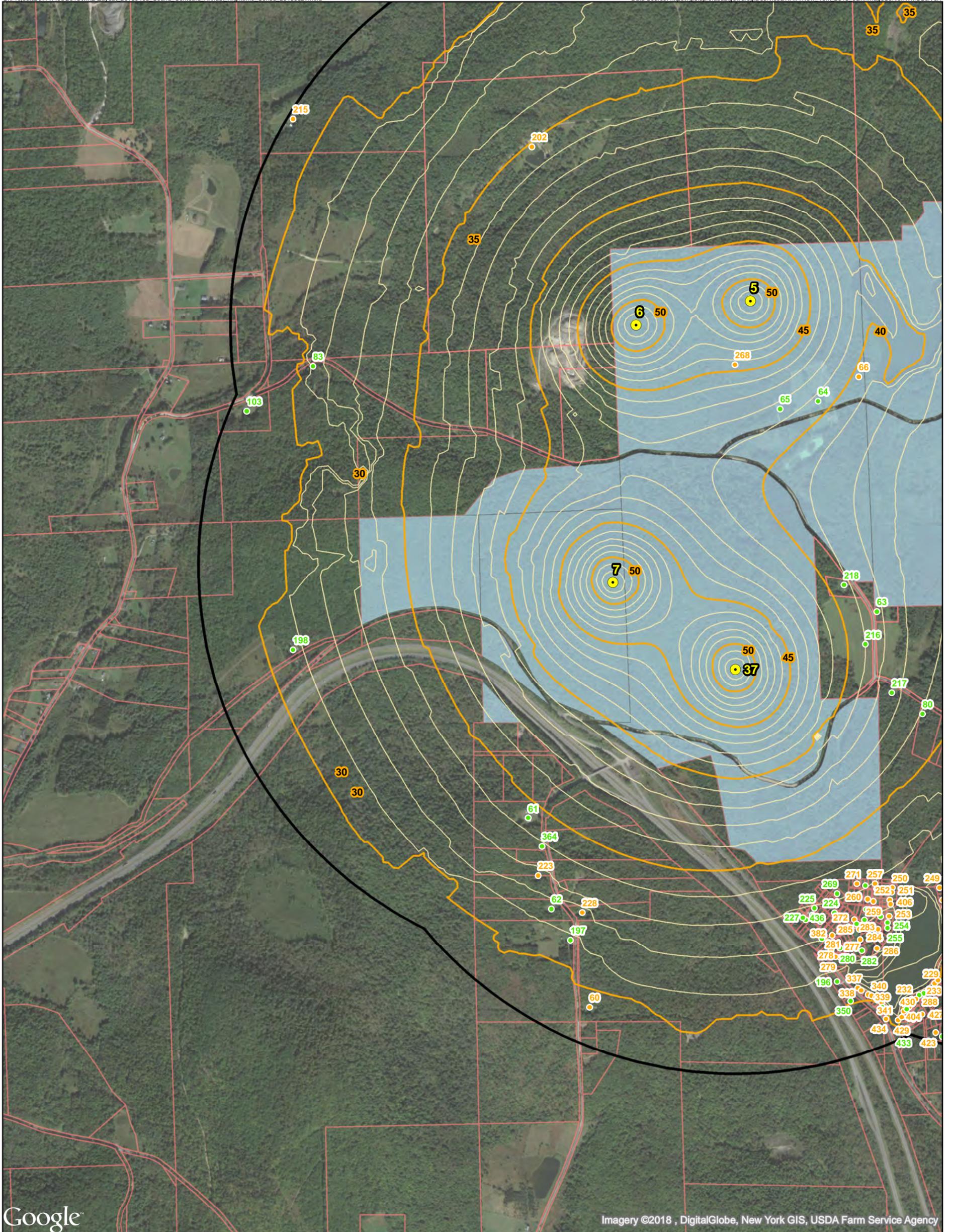


LEGEND			
Nordex N149 Turbines, HH = 125m	● Seasonal Residence	▭ Project Area	 Scale 1:14,400 1 inch = 1,200 feet  0 600 1,200 Feet Basemap: 2017 Google
● Wind Turbine	● Year-round Residence	▭ O&M Facility	
▭ Town Boundary	● Public	▭ Concrete Batch Plant	
▭ County Boundary	● Unknown	Predicted Sound Level (dBA)	
▲ Substation	▭ Participating Parcel	— 5 dBA Contour Interval	
▲ Battery Storage	▭ Non-Participating Parcel	— 1 dBA Contour Interval	

Bluestone Wind Broome County, New York



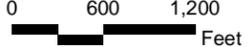
Figure 9-3, Map 4 of 8
Annual Nighttime L_{EQ} Sound Level Modeling Results



LEGEND			
Nordex N149 Turbines, HH = 125m	● Seasonal Residence	▭ Project Area	
● Wind Turbine	● Year-round Residence	▨ O&M Facility	
⋯ Town Boundary	● Public	▩ Concrete Batch Plant	
▭ County Boundary	● Unknown	Predicted Sound Level (dBA)	
▲ Substation	▭ Participating Parcel	— 5 dBA Contour Interval	
▲ Battery Storage	▭ Non-Participating Parcel	— 1 dBA Contour Interval	

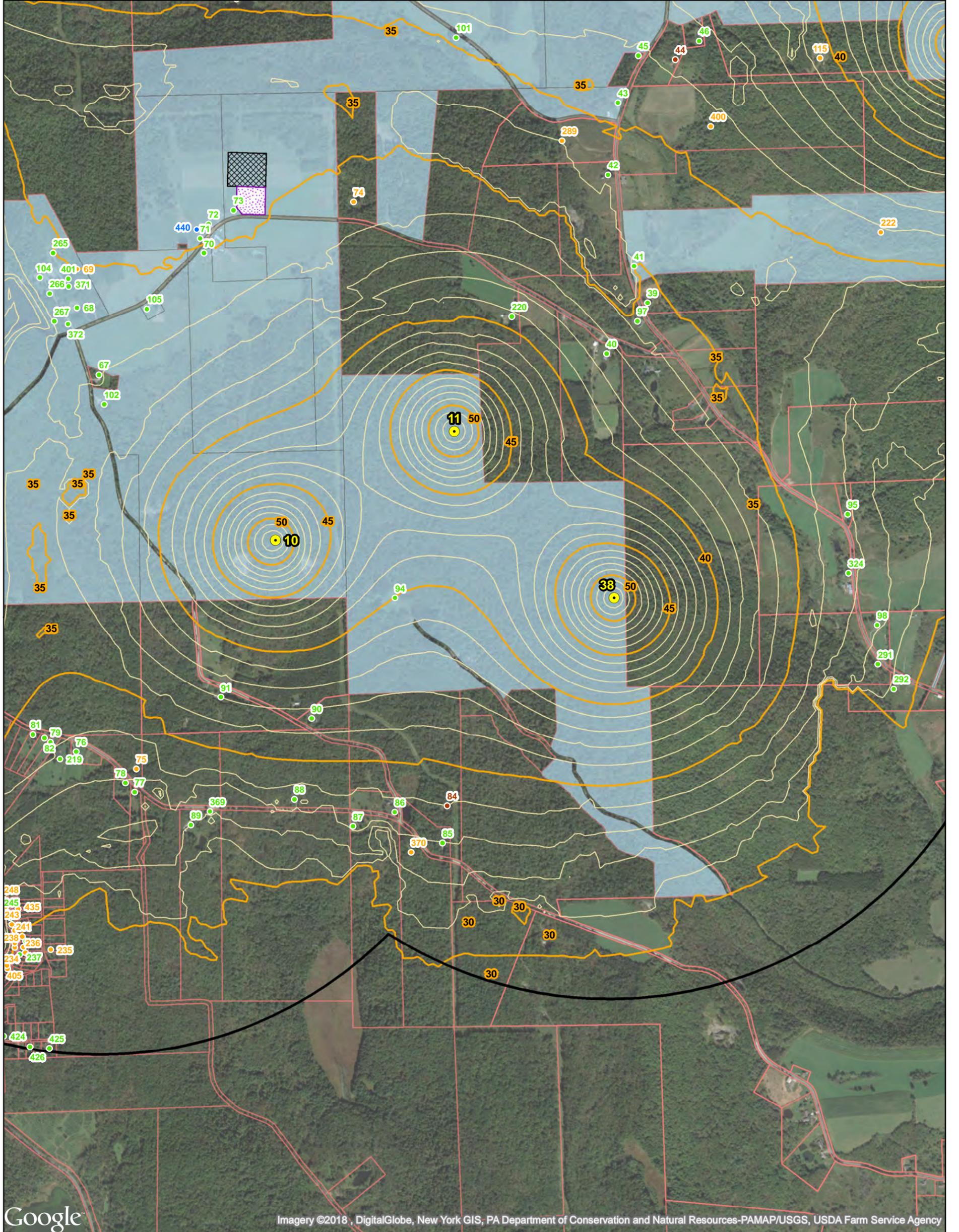


Scale 1:14,400
1 inch = 1,200 feet

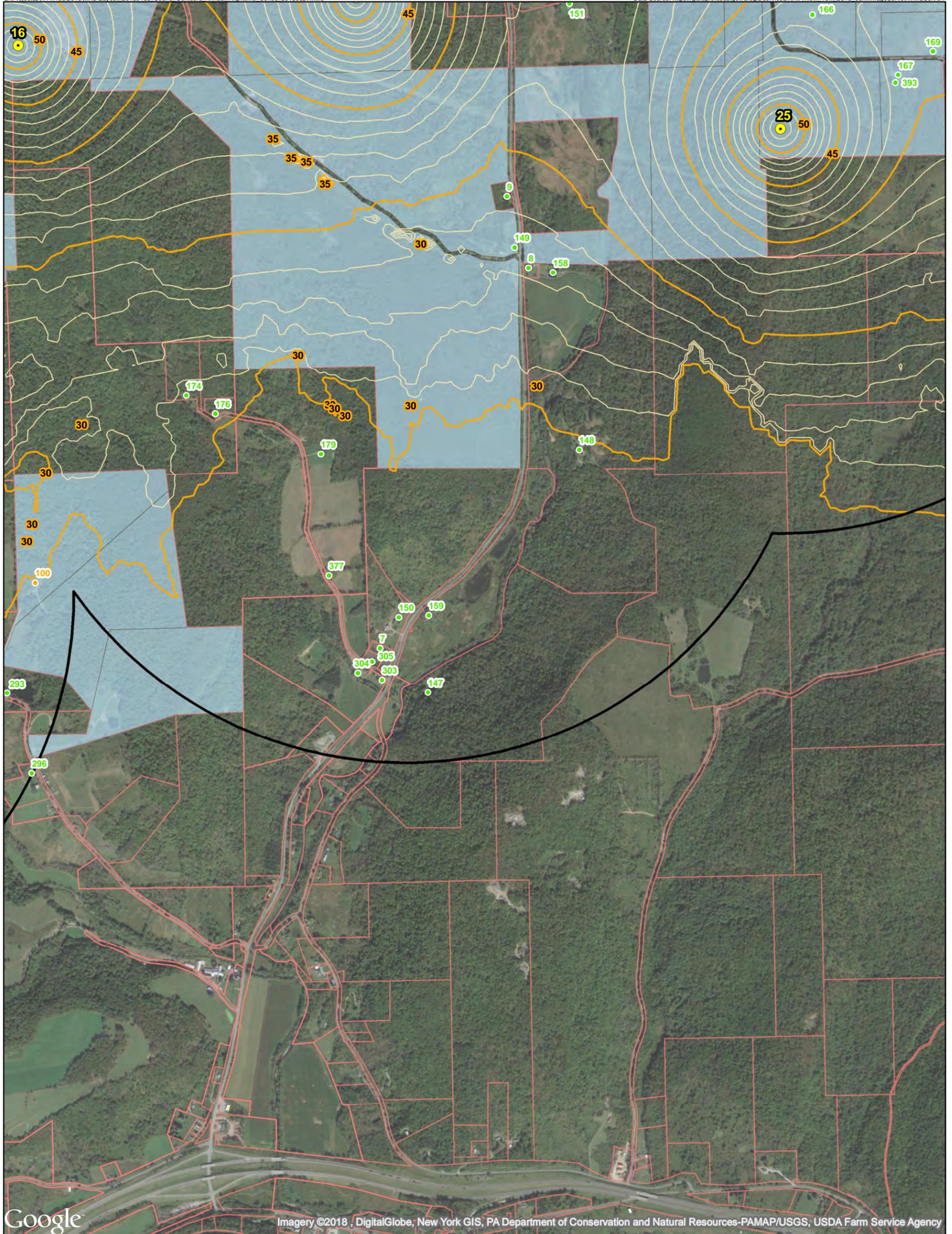


0 600 1,200 Feet

Basemap: 2017 Google



LEGEND Nordex N149 Turbines, HH = 125m ● Wind Turbine - - - Town Boundary □ County Boundary ▲ Substation ▲ Battery Storage		● Seasonal Residence ● Year-round Residence ● Public ● Unknown □ Participating Parcel □ Non-Participating Parcel	□ Project Area □ O&M Facility □ Concrete Batch Plant Predicted Sound Level (dBA) — 5 dBA Contour Interval — 1 dBA Contour Interval	Scale 1:14,400 1 inch = 1,200 feet 0 600 1,200 Feet Basemap: 2017 Google
--	--	---	--	---

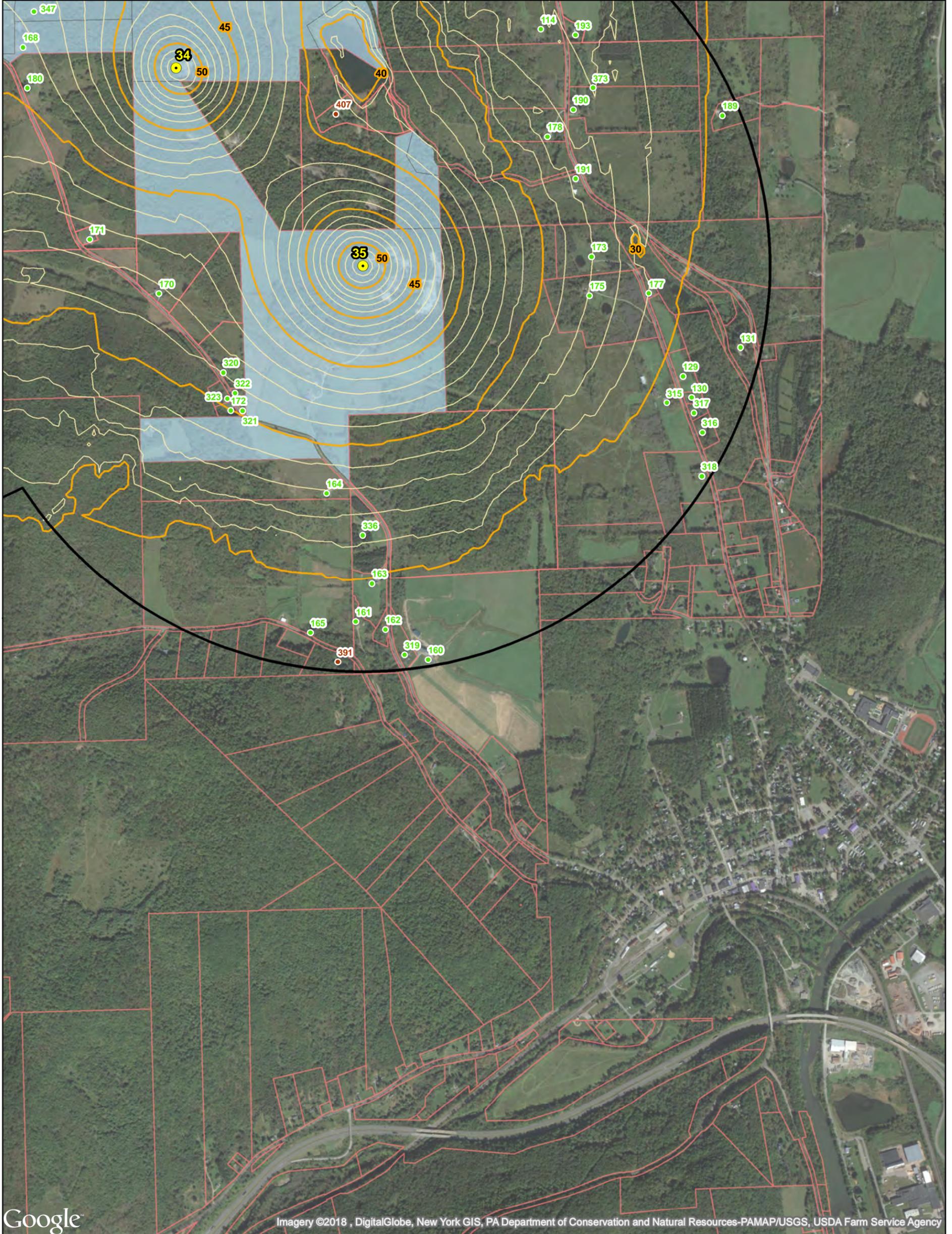


LEGEND Nordex N149 Turbines, HH = 125m ● Wind Turbine - - - Town Boundary □ County Boundary ▲ Substation ▲ Battery Storage			● Seasonal Residence ● Year-round Residence ● Public ● Unknown □ Participating Parcel □ Non-Participating Parcel			□ Project Area □ O&M Facility □ Concrete Batch Plant Predicted Sound Level (dBA) — 5 dBA Contour Interval — 1 dBA Contour Interval			Scale 1:14,400 1 inch = 1,200 feet 0 600 1,200 Feet Basemap: 2017 Google		
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Bluestone Wind Broome County, New York



Figure 9-3, Map 7 of 8
Annual Nighttime L_{EQ} Sound Level Modeling Results



Google

Imagery ©2018, DigitalGlobe, New York GIS, PA Department of Conservation and Natural Resources-PAMAP/USGS, USDA Farm Service Agency

LEGEND

Nordex N149 Turbines, HH = 125m

- Wind Turbine
- Town Boundary
- County Boundary
- Substation
- Battery Storage

- Seasonal Residence
- Year-round Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel

- Project Area
- O&M Facility
- Concrete Batch Plant

Predicted Sound Level (dBA)

- 5 dBA Contour Interval
- 1 dBA Contour Interval



Scale 1:14,400
1 inch = 1,200 feet



Basemap: 2017 Google

10.0 WIND SHEAR AND TURBULENCE INTENSITY

In order to determine wind shear and turbulence intensity conditions, Epsilon obtained one year (8760 hours) of meteorological data collected from an on-site 60-meter meteorological tower (#1001) within the Project site area. The meteorological data measured for calendar year 2017 include wind speed, wind direction, and wind speed standard deviation at multiple heights. The wind speed and wind speed standard deviation data were used for the wind shear and turbulence intensity calculations. Ten minute wind speed data were also used to compute the average hourly wind speed.

Wind shear is the change of wind speed as a function of height above ground. This relationship is typically expressed as a power law of the form:

$$U_z = U_r(Z/Z_r)^\alpha$$

Where

U_z	=	wind speed at height Z
U_r	=	wind speed at height Z_r
α	=	wind shear coefficient

Figure 10-1 [REDACTED] presents the annual average wind shear coefficient by hour for a full year. The overall average wind shear for the year is 0.23, the minimum is -1.15 (wind decreasing with height), and the maximum is 1.99. The wind shear is from a measured height of 32 meters above ground to the tallest expected hub height of 130 meters above ground. Meteorologists from Bluestone Wind provided the extrapolated wind speed data to 130 meters. This figure shows that wind shear at this site is typical which is not surprising considering the combination of land uses (field and forest) in the surrounding area. Wind shear is typically lower during the daytime hours when the atmosphere is less stable as compared to the higher wind shear values at night when the atmosphere is more stable.

Figure 10-1 Average Annual Wind Shear Coefficient by Hour [REDACTED]

As discussed in IEC 61400-11, Annex B turbulence is a natural part of the wind environment. The turbulence intensity is calculated as the average of the ratio of standard deviation of wind speed divided by the average wind speed over a given time period at a certain height. Figure 10-2 [REDACTED] presents the annual average hourly turbulence intensity at this site at a height of 130 meters above ground based on the on-site meteorological tower. The overall average turbulence intensity for the year is 0.13, the minimum is 0.0, and the maximum is 0.82. Results show that turbulence intensity is slightly higher during the day than at night, and can be variable at any time. Figure 10-3 [REDACTED] shows the annual average turbulence intensity by hub height wind speed. These data show that turbulence intensity decreases slightly from cut-in speed to 15 m/s. Wind speeds much above 15 m/s (over 30 mph) are associated with storm conditions and/or high ground level wind speeds, and thus are of less interest to understanding wind turbine only sound levels.

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

Figure 10-2 Annual Average Turbulence Intensity by Hour-Boxes show 90% of data and the whiskers are +5% and -5% outliers [REDACTED]

Figure 10-3 Annual Average Turbulence Intensity by Hub Height Wind Speed--90% of data is Between High and Low Lines; Center Line is Median [REDACTED]

11.0 CONSTRUCTION NOISE

Construction noise modeling was performed for the major phases of construction using the ISO 9613-2 3-D sound propagation standard as implemented in the Cadna/A software package. Settings within Cadna/A were the same as described in Section 9.3. Reference sound source information was obtained from either Epsilon measurements or the FHWA's Roadway Construction Noise Model (RCNM). Modeling and analysis procedures generally followed the guidelines and recommendations of the FHWA Highway Construction Noise Handbook (FHWA-HEP-06-015, U.S. DOT, August 2006).

The majority of the construction activity will occur around each of the wind turbine sites, at the site of the substation, and at the site of the concrete batch plant. By its very nature, construction activity moves around the site. Full construction activity will generally occur at one wind turbine site at a time, although there will be some overlap at adjacent sites for maximum efficiency. For modeling conservatism, it was assumed that full activity was occurring at three sites simultaneously. There are generally three phases of construction for a wind energy project – excavation, foundation work, and turbine erection. Table 11-1 presents the equipment sound levels for the louder pieces of construction equipment expected to be used at this site along with their phase of construction.

Three areas within the Project Area were chosen to calculate representative construction sound levels. The areas and assumed sites of simultaneous construction are:

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

For each of the three areas, cumulative construction sound levels at the ten closest receptors have been calculated. These receptors included both non-participants and participants. The results are shown as maximum 1-second Leq sound levels with all pieces of equipment for each phase operating at the sites. These results overstate expected real-world results since under actual construction conditions, not all pieces of equipment will be operating at the same exact time, and the highest sound levels from every piece of equipment will not tend to occur at the same time as was assumed in the modeling. Figure 11-1 shows the three representative areas of construction activity.

Table 11-1 Sound Levels for Noise Sources Included in Construction Modeling

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

11.1 Area 1 Modeling Results

The cumulative impacts from each of the three main phases of construction (excavation, foundation work, turbine erection) were calculated with the Cadna model for the ten closest receptors to construction activity within Area 1. The loudest phase of construction within this area will be excavation. A sound contour figure of excavation activity occurring simultaneously at the three turbine sites (WTG1, WTG4, and WTG36) is presented in Figure 11-1, Map 1.

The highest sound level at a non-participating receptor within this area is 52 dBA during excavation (Receptor #118), 45 dBA during foundation pouring (Receptors #59 and #118), and 49 dBA during turbine erection (Receptors #59 and #118). The existing condition Leq sound levels measured for this area are 47 dBA (day) and 39 dBA (night) using the ANS-weighted broadband sound level data. Modeling results of construction sound levels within this area are summarized in Table 11-2.

Table 11-2 Construction Noise Modeling Results – Area 1 Construction (dBA)

Receptor ID	Participation Status	Excavation	Foundation	Turbine Erection
57	Participating	48	42	45
58	Participating	50	44	47
59	Non-Participating	51	45	49
99	Non-Participating	50	44	47
111	Participating	46	40	43
112	Non-Participating	50	44	47
116	Participating	52	46	49
117	Participating	54	48	51
118	Non-Participating	52	45	49
122	Non-Participating	48	41	44

11.2 Area 2 Modeling Results

The cumulative impacts from foundation work was calculated with the Cadna model for the ten closest receptors to construction activity within Area 2. A sound contour figure of foundation work occurring simultaneously at the batch plant and the three closest turbine sites (WTG1, WTG4, and WTG36) is presented in Figure 11-1, Map 2.

The highest sound level at a non-participating receptor within this area is 44 dBA during foundation work, at receptors #91 and #220. The existing condition L_{eq} sound levels measured for this area are 48 dBA (day) and 40 dBA (night). Modeling results of foundation work sound levels within this area are summarized in Table 11-3.

Table 11-3 Construction Noise Modeling Results – Area 2 Construction (dBA)

Receptor ID	Participation Status	Foundation
70	Participating	49
71	Participating	50
72	Participating	47
73	Participating	51
74	Non-Participating	43
91	Non-Participating	44
94	Participating	46
102	Participating	42
105	Participating	42
220	Non-Participating	44

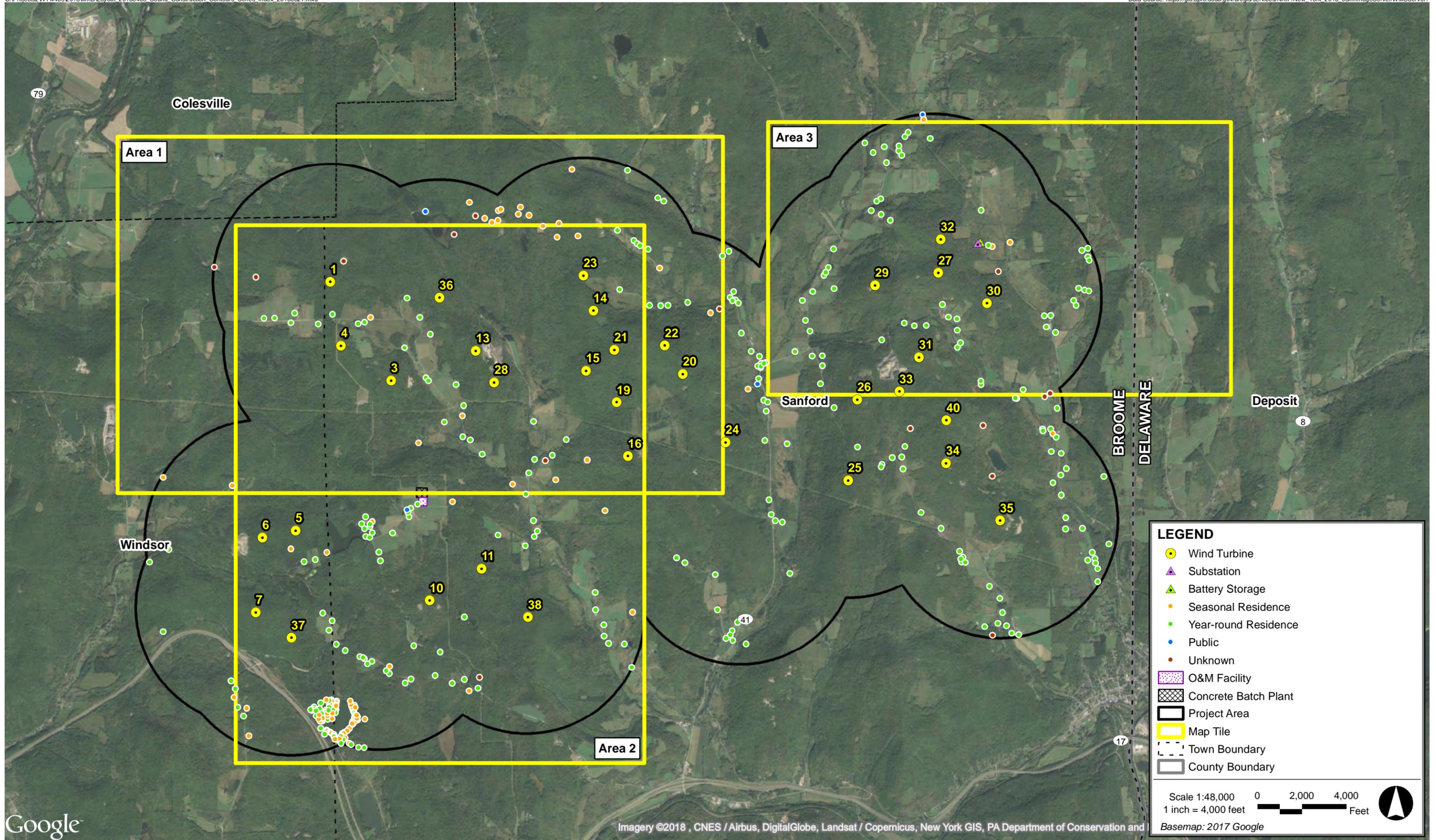
11.3 Area 3 Modeling Results

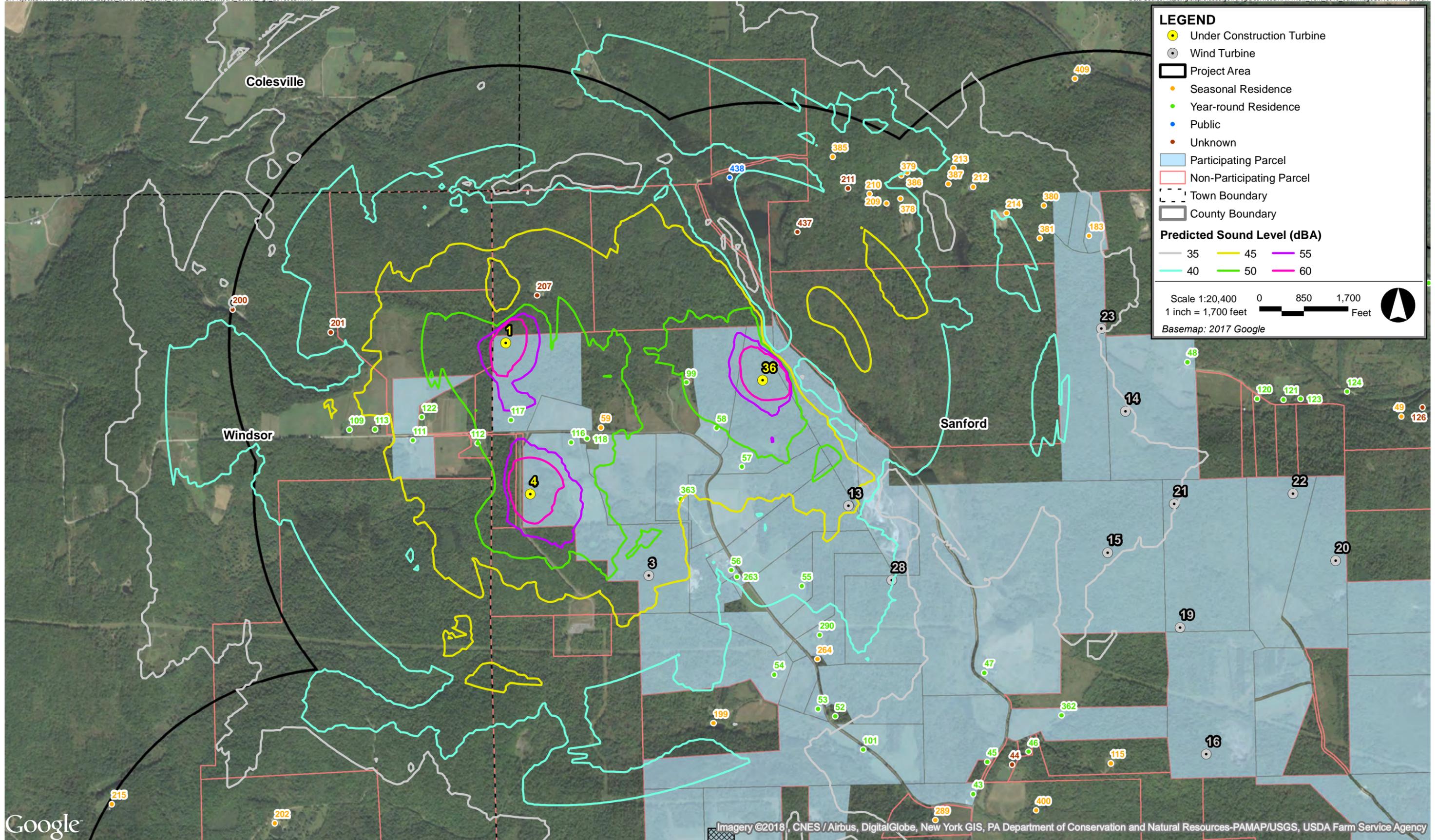
The cumulative impacts from excavation work and foundation work was calculated with the Cadna model for the ten closest receptors to construction activity within Area 3. A sound contour figure of excavation work occurring simultaneously at the substation/battery storage facility and the two closest turbine sites to the substation (WTG27, and WTG32) is presented in Figure 11-1, Map 3.

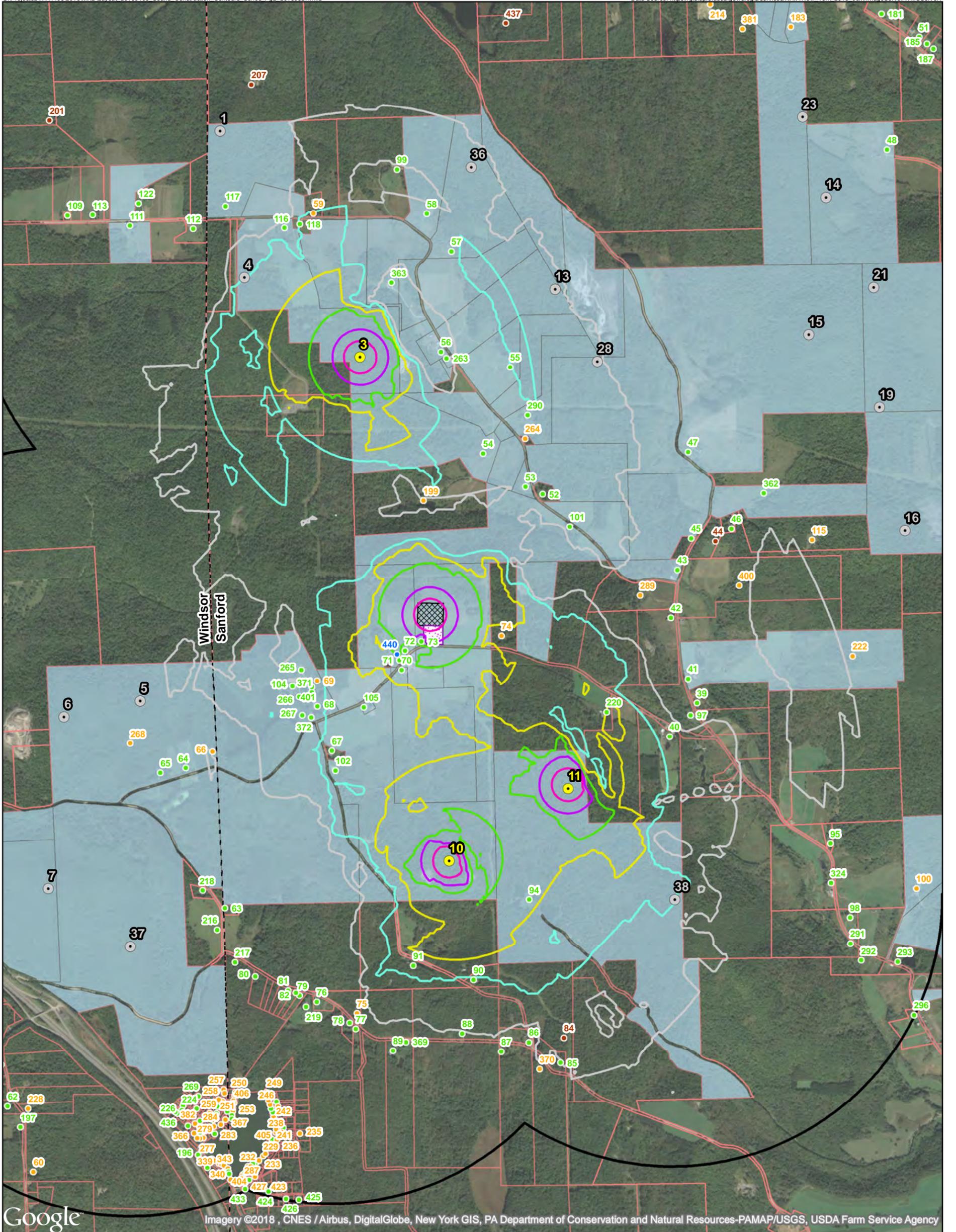
The highest sound level at a non-participating receptor within this area is 54 dBA during excavation, at receptor #155 and #348. The existing condition L_{eq} sound levels measured for this area are 48 dBA (day) and 46 dBA (night). Modeling results of construction sound levels within this area are summarized in Table 11-4.

Table 11-4 Construction Noise Modeling Results – Area 3 Construction (dBA)

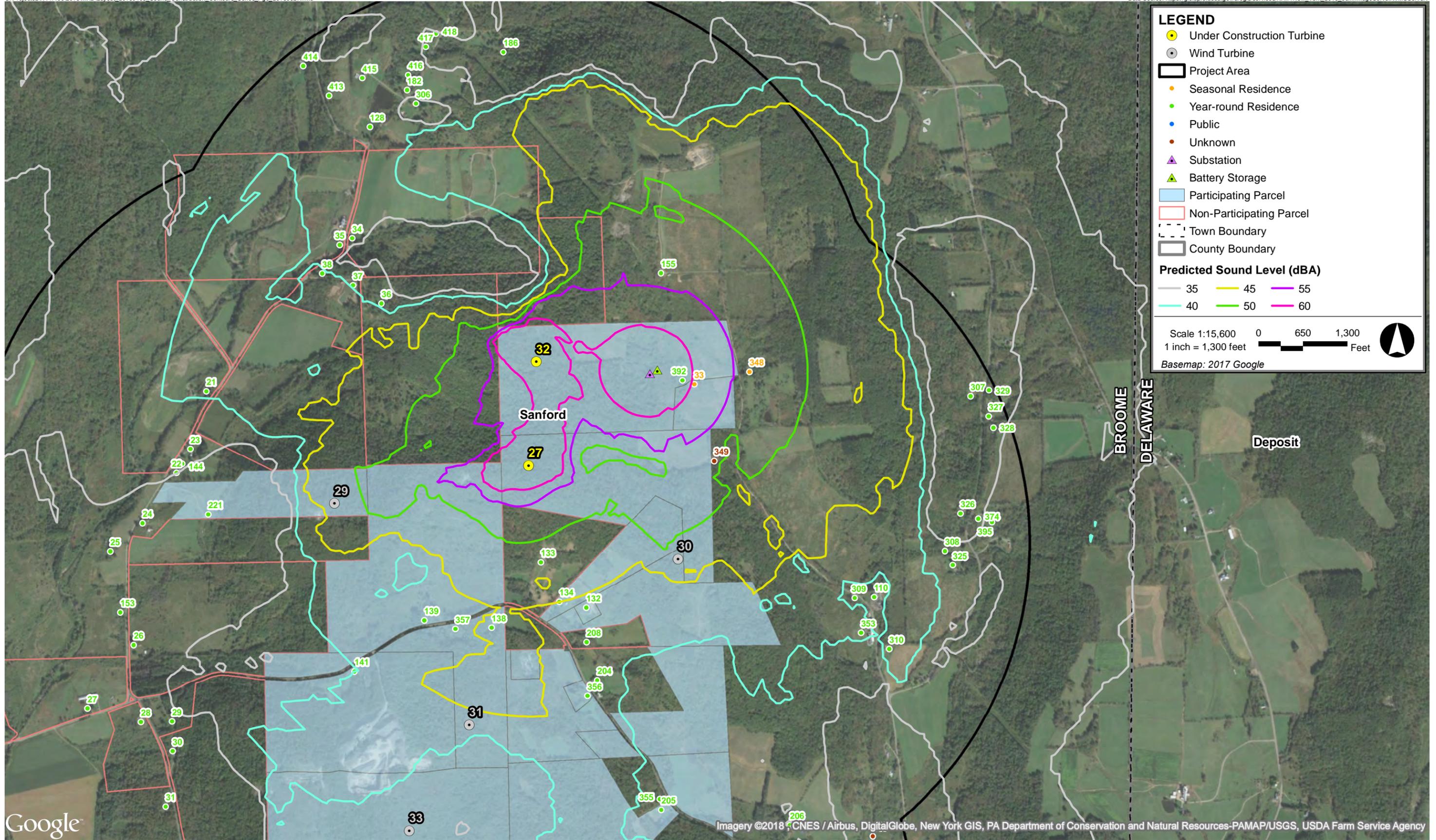
Receptor ID	Participation Status	Excavation	Foundation
392	Participating	62	56
33	Participating	59	53
155	Non-Participating	54	47
348	Non-Participating	54	47
349	Non-Participating	52	46
133	Non-Participating	48	42
138	Participating	46	41
353	Non-Participating	42	35
132	Participating	44	38
110	Non-Participating	39	33







LEGEND <ul style="list-style-type: none"> ● Under Construction Turbine ● Turbine Project Area Town Boundary County Boundary ● Seasonal Residence ● Year-round Residence ● Public ● Unknown Participating Parcel Non-Participating Parcel ▲ Substation ▲ Battery Storage O&M Facility Concrete Batch Plant 		Predicted Sound Level (dBA) <ul style="list-style-type: none"> 35 40 45 50 55 60 	 Scale 1:21,600 1 inch = 1,800 feet  Feet Basemap: 2017 Google
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11.4 Construction Noise Conclusions

Construction is expected to occur from approximately April to November at turbine sites and at the areas of the batch plant, substation, and battery storage facility. Construction of each wind turbine from excavation to foundation pouring to turbine erection is roughly a 90-day process. Excavation work is expected to occur from early morning to the evening. More detail on the expected hours and days of construction can be found elsewhere in the Application. Concrete foundation work and turbine erection work could extend into the overnight hours depending on the weather and timing of a concrete pour which must be continuous.

12.0 OTHER POTENTIAL COMMUNITY NOISE IMPACTS

12.1 Hearing Damage

The Occupational Safety and Health Administration (OSHA) protects against the effects of noise exposure in the workplace through 29CFR1910.95. Permissible noise exposure levels for an 8-hour day are 90 dBA. At sound levels above 85 dBA over an 8-hour workday, employers shall provide hearing protection to employees.

The 1974 U.S. EPA “Levels” document⁶⁹ identifies a sound level of 70 dBA over a 24-hour period as protective against hearing loss from intermittent sources of environmental noise [$L_{eq(24)} = 70$ dBA].

The “Guideline for Community Noise” (World Health Organization, Geneva, 1999) also identifies a sound level of 70 dBA over a 24-hour period as protective against hearing loss from a lifetime exposure to environmental noise [$L_{eq(24)} = 70$ dBA].

According to the WHO 1999 Guidelines, the threshold for hearing impairment is 110 dBA (L_{max} , fast) or 120/140 dBA (peak at the ear) for children/adults. The FHWA Highway Construction Noise Handbook (FHWA-HEP-06-015; August 2006) estimates construction blasting noise levels to be approximately 82 dBA at 200 feet (L_{max}). The closest existing receptor to any wind turbine foundation will be well beyond 200 feet. This would result in an L_{max} sound level of less than 82 dBA at any receptor. These sound levels are well below the WHO hearing impairment threshold.

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

12.2 Speech Interference

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

⁶⁹ Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, U. S. Environmental Protection Agency, 550/9-74-004, March 1974.

The “Guideline for Community Noise” (World Health Organization, Geneva, 1999) recommends an indoor sound level of 35 dBA (L_{eq}) to protect speech intelligibility. This is equivalent to approximately 50 dBA L_{eq} outdoors based on reduction from outside to inside by approximately 15 dBA with windows open, and 25 dBA with windows closed.⁷⁰

12.3 Outdoor Public Facilities

The 1974 U.S. EPA “Levels” document identifies an outdoor level of 55 dBA (L_{dn}) requisite to protect the public health and welfare with an adequate margin of safety. This has a 5 dBA margin of safety – in other words the EPA believes the actual threshold is 60 dBA but has reduced it by 5 dBA. An outdoor L_{dn} is equivalent to a 24-hour sound level of 49 dBA.

12.4 Structural Damage

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

12.5 Ground-Borne Vibration

The nearest operating wind turbine to a non-participating noise-sensitive receptor (#207) is approximately 1,086 feet (331 meters). The frequency of rotation for the GE 3.8-137 wind turbine will range from 6.3 rpm to 13.6 rpm under all operating conditions. This translates to blade pass frequencies of 0.3 Hz to 0.7 Hz. The frequency of rotation for the Vestas V150-4.2 wind turbine will range from 4.9 rpm to 12.0 rpm under all operating conditions. This translates to blade pass frequencies of 0.2 Hz to 0.6 Hz. The frequency of rotation for the Nordex N149/4500 wind turbine will range from 6.4 rpm to 12.3 rpm under all operating conditions. This translates to blade pass frequencies of 0.3 Hz to 0.6 Hz. The frequency of rotation for the Senvion 4.2M148 wind turbine will range from 5.0 rpm to 10.5 rpm under all operating conditions. This translates to blade pass frequencies of 0.3 Hz to 0.5 Hz. Based on the literature findings presented in Section 4.7 where ground-borne vibration was below perceptible thresholds at comparable distances and frequency of rotation, ground-borne vibrations from operation of this project will be below the thresholds as recommended in ANSI S2.71-1983 (R2012).

⁷⁰ Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, U. S. Environmental Protection Agency, 550/9-74-004, March 1974.

12.6 Air-borne Vibration

Table 12-1 shows the low frequency ANSI 12.2-2008 and ANSI S12.9-2005/Part 4 criteria. These data and the modeling procedures were discussed in Section 9.6. Results show that the sound levels from the project will be at or above the minimal annoyance levels at some receptors. As per Stipulation 19(e)(4)(ii), the number of non-participating and participating receptors at or above the 65 dB level for each of the three low frequency octave bands is presented below in Tables 12-2 through 12-5. Table 12-6a (16 Hz) and Table 12.6b (31.5 Hz) list the specific receptor IDs associated with the counts in Tables 12-2 to 12-5. All of the receptors listed in Tables 12.6a and 12.6b are either residential or unknown. The 63 Hz sound levels will not be above 65 dB for any wind turbine under consideration.

Modeling results at the 31.5 Hz and 63 Hz low frequency octave bands have been calculated using Cadna/A acoustic model. Results at the 16 Hz octave band, for each receptor and for each wind turbine manufacturer were extrapolated from the 31.5 Hz results. The extrapolation for each is the difference between the highest manufacturer's sound power data at 16 Hz and the 31.5 Hz sound power data used for computer modeling. For the Senvion wind turbine model, no data was provided at the 16 Hz frequency, and therefore the extrapolation was based upon the highest difference presented by a different manufacturer (GE 3.8-137). Therefore, the analysis for the Senvion is very approximate. Complete octave band sound pressure level results at each receptor for each wind turbine manufacturer is presented in Appendix E.

Table 12-1 ANSI/ASA S12.2-2008 Section 6 and ANSI S12.9-2005/Part 4 Annex D Low Frequency Criteria Compared with Modeled Sound Levels at Worst-Case Receptors

Octave-band center frequency→	16 Hz	31.5 Hz	63 Hz
Low Frequency Guidelines			
Clearly perceptible vibration and rattles likely	75 dB	75 dB	80 dB
Moderately perceptible vibration and rattles likely	65 dB	65 dB	70 dB
Minimal annoyance levels	65 dB	65 dB	65 dB

Table 12-2 Participating and Non-Participating Receptors Modeled 65 dB or Greater for Low Frequency Criteria (GE 3.8-137)

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

Notes: 1. Rounded to the nearest whole decibel. All receptors are either residences or unknown.

Table 12-3 Participating and Non-Participating Receptors Modeled 65 dB or Greater for Low Frequency Criteria (Vestas V150-4.2)

Modeled Leq Sound Level (dB) ¹	16 Hz		31.5 Hz		63 Hz	
	# of Receptors		# of Receptors		# of Receptors	
	Participating	Non-Participating	Participating	Non-Participating	Participating	Non-Participating
71	0	0	0	0	0	0
70	0	0	0	0	0	0
69	1	0	0	0	0	0
68	0	0	0	0	0	0
67	1	1	0	0	0	0
66	17	3	0	0	0	0
65	7	8	0	0	0	0

Notes: 1. Rounded to the nearest whole decibel. All receptors are either residences or unknown.

Table 12-4 Participating and Non-Participating Receptors Modeled 65 dB or Greater for Low Frequency Criteria (Nordex N149/4500)

Modeled Leq Sound Level (dB) ¹	16 Hz		31.5 Hz		63 Hz	
	# of Receptors		# of Receptors		# of Receptors	
	Participating	Non-Participating	Participating	Non-Participating	Participating	Non-Participating
71	0	0	0	0	0	0
70	0	0	0	0	0	0
69	0	0	0	0	0	0
68	1	0	0	0	0	0
67	1	0	0	0	0	0
66	8	1	0	0	0	0
65	14	6	0	0	0	0

Notes: 1. Rounded to the nearest whole decibel. All receptors are either residences or unknown.

Table 12-5 Participating and Non-Participating Receptors Modeled 65 dB or Greater for Low Frequency Criteria (Senvion 4.2M148)

Modeled Leq Sound Level (dB) ¹	16 Hz		31.5 Hz		63 Hz	
	# of Receptors		# of Receptors		# of Receptors	
	Participating	Non-Participating	Participating	Non-Participating	Participating	Non-Participating
71	1	0	0	0	0	0
70	1	1	0	0	0	0
69	12	0	0	0	0	0
68	10	9	0	0	0	0
67	9	7	0	0	0	0
66	4	7	1	0	0	0
65	16	39	0	0	0	0

Notes: 1. Rounded to the nearest whole decibel. All receptors are either residences or unknown.

Table 12-6a Modeled 65 dB or Greater Receptors IDs – 16 Hz

Modeled Leq Sound Level (dB) ¹	GE 3.8-137		Vestas V150-4.2		Nordex N149/4500		Senvion 4.2M148	
	Receptor ID		Receptor ID		Receptor ID		Receptor ID	
	Part.	Non-Part.	Part.	Non-Part.	Part.	Non-Part.	Part.	Non-Part.
71	--	--	--	--	--	--	268	--
70	268	--	--	--	--	--	184	133
69	184	--	268	--	--	--	117; 116;48; 138; 357; 58; 132; 65; 134; 139; 166; 347	--
68	117; 116; 48; 138; 357; 166; 347;	133	--	--	268	--	55; 57; 363; 141; 167; 168; 393; 56; 64; 169	207; 32; 112; 118; 208; 99; 59; 120; 180
67	58; 65; 132; 139; 55; 57; 363; 134; 141; 393; 64; 167; 168; 56; 169	32; 207; 118; 99; 208; 120; 59; 180	184	133	184	--	349; 263; 356; 94; 290; 66; 183; 362; 47	204; 121; 123; 115; 407; 218; 220
66	263; 356; 94; 290; 66; 183; 362	112; 204; 121; 123; 115; 220; 218	117; 116; 48; 138; 357; 58; 132; 134; 139; 166; 65; 347; 55; 57; 363; 141; 168	207; 118; 208	117; 116; 48; 357; 138; 132; 166; 347	133	392; 33; 408; 54	216; 264; 31; 63; 381; 171; 46

Table 12-6a Modeled 65 dB or Greater Receptors IDs – 16 Hz (Continued)

Modeled Leq Sound Level (dB) ¹	GE 3.8-137		Vestas V150-4.2		Nordex N149/4500		Senvion 4.2M148	
	Receptor ID		Receptor ID		Receptor ID		Receptor ID	
	Part.	Non-Part.	Part.	Non-Part.	Part.	Non-Part.	Part.	Non-Part.
65	392; 349; 408; 47; 54	407; 216; 264; 63; 31; 381; 171; 46	393; 167; 56; 64; 169; 263; 66	32; 112; 99; 59; 120; 180; 204; 121	58; 65; 139; 134; 55; 57; 363; 141; 168; 393; 64; 167; 169; 356	207; 32; 118; 208; 99; 180	See Table E-4.1	See Table E- 4.1

Notes: 1. Rounded to the nearest whole decibel. All receptors are residences or unknown.

Table 12-6b Modeled 65 dB or Greater Receptors IDs – 31.5 Hz

Modeled Leq Sound Level (dB) ¹	GE 3.8-137		Vestas V150-4.2		Nordex N149/4500		Senvion 4.2M148	
	Receptor ID		Receptor ID		Receptor ID		Receptor ID	
	Part.	Non-Part.	Part.	Non-Part.	Part.	Non-Part.	Part.	Non-Part.
71	--	--	--	--	--	--	--	--
70	--	--	--	--	--	--	--	--
69	--	--	--	--	--	--	--	--
68	--	--	--	--	--	--	--	--
67	--	--	--	--	--	--	--	--
66	--	--	--	--	--	--	268	--
65	268	--	--	--	--	--	--	--

Notes: 1. Rounded to the nearest whole decibel. All receptors are residences or unknown.

12.7 Potential Interference with Technology

The potential of low-frequency noise including infrasound and vibration from operation of the Project to cause interference with the closest seismological and infrasound stations within 50 miles of the Project site was investigated. The Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) website was reviewed for the nearest location of any infrasound monitoring stations. The nearest ones are in Bermuda (IS51) and Lac du Bonnet, Manitoba, Canada (IS10). Each site is approximately 1,000 miles from Broome County, NY. There are also some auxiliary seismic stations to monitor shock waves in the Earth as part of the CTBTO program. The nearest seismic monitor to Bluestone Wind is located in Sadowa, Ontario, Canada (AS014) which is approximately 258 miles away. Given these large distances and the relatively low levels of infrasound emissions from this project, we conclude there will be no impact to the CTBTO's ability to monitor infrasound. There is one US Geological Survey (USGS) seismological station within 50 miles of the site– Binghamton, NY (BINY) approximately 24 miles to the west. Figure 12-1 shows station BINY in relation to the Project Area. The next nearest USGS stations are, Erie, PA (ERPA) approximately 229 miles to the west, and Lake Ozonia, NY (LONY) approximately 180 miles to the northeast.

The two nearest hospitals to the project are the Barnes Kasson Hospital in Susquehanna, PA approximately nine miles south of the nearest wind turbine, and the Our Lady of Lourdes Memorial Hospital in Binghamton, NY approximately 19 miles to the west of the nearest wind turbine. Distances are “as the crow flies.”

12.8 Amplitude Modulation

The current body of work on amplitude modulation indicates that it is not possible to predict or forecast its occurrence. Design considerations for minimization, and practical post-construction operational mitigation options are in the early phases of development.

The Massachusetts Study on Wind Turbine Acoustics measured amplitude modulation (AM) in detail, and provides a description of the phenomenon.⁷¹ With respect to wind turbines, amplitude modulation is a recurring variation in the overall level of sound over time. The modulation sound is typically broadband, and it comes from interactions of the blade with the atmosphere, wind turbulence, directionality of the broadband sound of the blades, or tower interaction with the wake of the blade. This modulation is not infrasound; rather, it is variation in audible sound that is synchronized to the passage of the turbine blades.

⁷¹ *Massachusetts Study on Wind Turbine Acoustics*, Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, RSG et al., 2016.

The fundamental frequency of the modulations is usually coincident with the rotational speed of the turbine multiplied by the number of blades:

$$\text{Modulation frequency} = (\text{RPM} \times \text{Number of blades}) / 60 \text{ seconds per minute}$$

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

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

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

The primary conclusions with respect to amplitude modulation from the *Massachusetts Study on Wind Turbine Acoustics*⁷² are as follows:

- ◆ Data analyzed for this study indicate that low-frequency sound and infrasound from the wind turbines are not modulated for the most part, and sounds in the frequency range from about 250 Hz to 2 kHz are amplitude-modulated.
- ◆ The technique of calculating a spectrogram from A-weighted sound levels and one-third octave band levels is very effective at revealing the signature of amplitude modulated wind turbine sound. A logging interval of 125 milliseconds or faster is required.
- ◆ The maximum observed increase in modulation depth was at 500 Hz.
- ◆ The measured sound level, wind speed, and distance to turbine have the greatest impact on modulation depth.

⁷² *Massachusetts Study on Wind Turbine Acoustics*, Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, RSG et al., 2016.

- ◆ Approximately 90% of all measured AM depth was 2 dB or less while over 99.9% was 4.5 dB or less.
- ◆ Wind turbulence, wind shear, and yaw error have a lesser, but statistically significant, effect on amplitude modulation depth compared to distance and sound level.
- ◆ The turbulence intensity does not show any trend with respect to the sound levels.

Another reference reviewed for AM in this Application is the “Wind Turbine AM Review: Phase 2 Report”.⁷³ This report reviews research into the effects of and response to the acoustic character of AM. The report notes that “the setting of a threshold for excessive AM is not straightforward. The available research does not identify a clear onset of increased annoyance from AM.” Nonetheless, a proposal is put forth to possibly “control” AM by establishing a “penalty scheme” for excessive AM during periods of complaints. There would be no penalty for AM depths of 0-3 dB, a sliding scale penalty (3-5 dB) for AM depths of 3-10 dB, and a 5 dB penalty for AM depths greater than 10 dB. The report also concludes that “it is not possible to predict whether AM will or will not be present on a site.” This paper does not relate specific levels of wind shear or turbulence to AM levels.

Cooper and Evans analyzed several weeks of sound data approximately 1500 meters from a wind turbine in flat terrain for evidence of AM.⁷⁴ They found zero periods with an amplitude modulation depth of 5 dBA or more which is defined as “excessive” AM in New Zealand. These findings are consistent with the *Massachusetts Study on Wind Turbine Acoustics*. Their data set did not find any significant trend in the level of AM and wind shear.

Research work being sponsored by RenewableUK has identified two possible mitigation options to reduce the AM more often associated with complaints (“thumping”).⁷⁵ They found the thumping occurred under transient stall effects occurring over part of the turbine blade surfaces. Two mitigation measures were tested and found to reduce AM Depth significantly. These two mitigation techniques are a “kit” installed on the blades designed to improve or modify the flow of air on the blades to reduce stall, and a software design change which modified the turbine blade pitch control angle by several degrees under specific wind regime conditions.

⁷³ *Wind Turbine AM Review: Phase 2 Report*, U. K. Department of Energy & Climate Change, prepared by WSP Parsons Brinckerhoff, August 2016.

⁷⁴ Automated detection and analysis of amplitude modulation at a residence and wind turbine, J. Cooper & T. Evans, Proceedings of Acoustics 2013 – Victor Harbor, Australia.

⁷⁵ *Measurements demonstrating mitigation of far-field AM from wind turbines*, M. Cand and A. Bullmore, 6th International Meeting on Wind Turbine Noise, Glasgow, Scotland, April 2015.

Section 10.5 of the IEC standard used for reference sound level measurements of all wind turbines by the manufacturers, notes that amplitude modulation is an optional data element that may be reported during testing.⁷⁶ Annex A and B of this standard also contain a brief mention of AM and its relationship to turbulence conditions.

12.9 Tonality

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

Sound pressure level calculations using the Cadna/A modeling software which incorporates the ISO 9613-2 standard is limited to octave band sound levels; therefore a quantitative evaluation of one-third octave band sound levels using the modeling software was not possible. Instead, one-third octave band sound pressure levels due to the closest wind turbines were calculated at the nearest ten (10) potentially impacted and representative receptor locations using equations accounting for hemispherical radiation and atmospheric absorption. These receptors included both non-participants and participants. Two of the top ten receptors had another receptor that was very similar in distance and influenced by the same wind turbines. Therefore, there were eight unique receptors analyzed for tonality. The calculations at these locations were conducted as discussed in Section 9.6. For these calculations, the turbine manufacturer with the most tonal⁷⁷ one-third octave band spectrum was used, representing the worst case turbine for tonality. The results presented in Table 12-2 show that received sound pressure levels due to the closest wind turbines at each of these locations are not predicted to result in any prominent discrete tones as defined in the stipulations.

⁷⁶ *Wind turbines—Part 11: Acoustic noise measurement techniques*, International Electrotechnical Commission IEC 61400-11, Edition 3.0, Geneva, Switzerland, 2012.

⁷⁷ The Senvion 4.2M148 model wind turbine 1/3 octave bands were used for tonality calculations. This model has the highest delta in adjacent octave bands when compared to the other wind turbine models being considered.

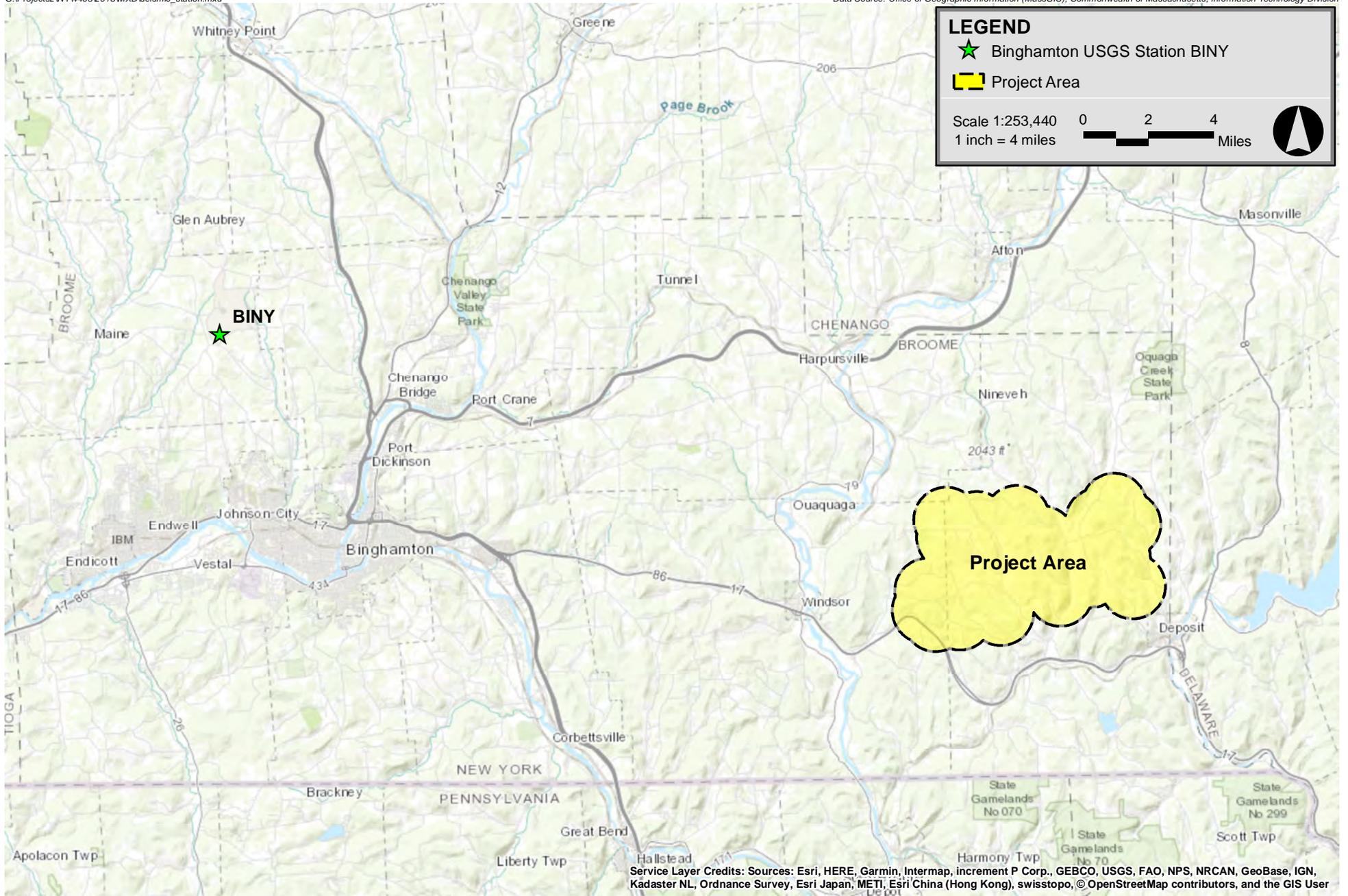
One-third octave band sound power levels for the substation transformer were not supplied by the vendor for the substation equipment; therefore, a quantitative evaluation of one-third octave band sound using the spreadsheet modeling approach was not possible. In general, substation transformers have the potential to create a prominent discrete tone at nearby receptors, specifically during the ONAN (fans off) condition. For this Project the substation is modeled to be less than 36 dBA at all non-participating sensitive receptors. Therefore, prominent discrete tones from the substation are not a concern with this Project.

Table 12-7 Tonal Analysis & Compliance Evaluation: Modeled Sound Pressure Levels

Rec. ID	One-Third Octave Band Center Frequency (Hz)	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
	Tonal Limit	-	15	15	15	15	15	15	15	8	8	8	8	8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	-
32	Received Sound Pressure Level (dB)	56	56	55	54	53	51	50	48	46	44	42	42	40	37	37	36	36	35	34	30	28	27	20	9	0	0	0	
	Average Sound Pressure Level of Contiguous Bands	-	56	55	54	52	51	49	48	46	44	43	41	39	39	36	37	35	35	32	31	29	24	18	10	5	0	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	0	0	-1	1	1	-2	1	-1	0	0	1	-1	0	3	2	-1	-5	0	-	
	Below Tonal Limit?	-	Yes	Yes																									
58	Received Sound Pressure Level (dB)	55	55	54	53	52	50	50	48	45	43	42	42	40	36	37	35	35	34	32	29	27	25	18	6	0	0	0	
	Average Sound Pressure Level of Contiguous Bands	-	55	54	53	52	51	49	47	45	43	42	41	39	38	35	36	34	34	31	30	27	22	16	9	3	0	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	0	0	-1	1	1	-2	1	-1	0	0	1	-1	0	3	2	-3	-3	0	-	
	Below Tonal Limit?	-	Yes	Yes																									
116	Received Sound Pressure Level (dB)	56	55	55	54	52	51	50	48	46	44	43	43	41	37	38	37	37	37	36	34	34	35	32	27	23	17	10	
	Average Sound Pressure Level of Contiguous Bands	-	55.4	54.5	53.6	52.0	51.2	49.4	47.9	46.1	44.2	43.3	41.7	39.9	39.5	37.1	37.6	36.8	36.6	35.3	35.0	34.6	33.0	31.1	27.4	21.8	16.2	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	0	0	-1	1	1	-2	1	-1	0	0	1	-1	-1	2	1	-1	1	0	-	
	Below Tonal Limit?	-	Yes	Yes																									
133	Received Sound Pressure Level (dB)	56	56	55	54	53	51	50	48	46	44	42	42	40	36	37	36	35	34	33	30	28	27	22	16	11	5	0	
	Average Sound Pressure Level of Contiguous Bands	-	56	55	54	52	51	50	48	46	44	43	41	39	39	36	36	35	34	32	30	28	25	21	17	10	6	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	0	0	-1	1	1	-2	1	-1	0	0	1	-1	-1	2	1	-1	1	0	-	
	Below Tonal Limit?	-	Yes	Yes																									
138	Received Sound Pressure Level (dB)	56	55	55	53	52	50	50	48	45	44	43	43	41	37	38	37	37	36	36	34	34	35	32	27	23	16	9	
	Average Sound Pressure Level of Contiguous Bands	-	55	54	53	52	51	49	48	46	44	43	42	40	39	37	38	37	36	35	35	34	33	31	27	22	16	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	-1	0	-1	1	1	-2	1	-1	0	0	1	-1	-1	2	1	-1	1	0	-	
	Below Tonal Limit?	-	Yes	Yes																									
207	Received Sound Pressure Level (dB)	56	55	55	53	52	50	50	48	46	44	42	42	41	37	38	37	37	36	36	34	34	35	32	27	23	16	9	
	Average Sound Pressure Level of Contiguous Bands	-	55	54	53	52	51	49	48	46	44	43	42	40	39	37	37	37	36	35	35	34	33	31	27	22	16	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	0	0	-1	1	1	-2	1	-1	0	0	1	-1	-1	2	1	-1	1	0	-	
	Below Tonal Limit?	-	Yes	Yes																									

Table 12-7 Tonal Analysis & Compliance Evaluation: Modeled Sound Pressure Levels (Continued)

Rec. ID	One-Third Octave Band Center Frequency (Hz)	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	
	Tonal Limit	-	15	15	15	15	15	15	15	8	8	8	8	8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	-
268	Received Sound Pressure Level (dB)	59	58	58	56	55	53	53	51	48	47	45	45	43	40	40	39	39	38	37	34	33	32	26	16	4	0	0	
	Average Sound Pressure Level of Contiguous Bands	-	58	57	56	55	54	52	51	49	47	46	44	42	42	39	40	39	38	36	35	33	29	24	15	8	2	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	0	0	-1	1	1	-2	1	-1	0	0	1	-1	0	3	2	1	-4	-2	-	
	Below Tonal Limit?	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
357	Received Sound Pressure Level (dB)	56	55	55	53	52	50	50	48	45	44	43	43	41	37	38	37	37	37	36	34	34	35	32	27	23	16	9	
	Average Sound Pressure Level of Contiguous Bands	-	55	54	53	52	51	49	48	46	44	43	42	40	39	37	38	37	37	35	35	34	33	31	27	22	16	-	
	Difference between Sound Pressure Level and Contiguous Average	-	0	0	0	0	-1	1	0	-1	0	-1	1	1	-2	1	-1	0	0	1	-1	-1	2	1	-1	1	0	-	
	Below Tonal Limit?	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes



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Bluestone Wind Broome County, New York

13.0 EVALUATION

13.1 Local Laws (Goal #1)

In Sanford, Section 1402.5(A)(5) establishes a standard of 50 dBA for sound levels generated by operation of WECS (Wind Energy Conversion Systems) measured from the exterior wall at a non-participating residence. The short-term ISO 9613-2 model results are presented in terms of a 1-hour L_{eq} . The highest predicted 1-hour L_{eq} sound level in Sanford is 50-51 dBA at receptor #392 (participating) depending on the wind turbine model selected. The highest predicted 1-hour L_{eq} sound level in Sanford at a non-participating residence is 45 dBA at receptors #32, 133, 118, and 112. All predicted L_{eq} sound levels from the Project are 50 dBA or less, therefore, the Project will meet the local sound level limit.

13.2 World Health Organization—Short-Term (Goals #3; #4; #5)

According to the WHO 1999 “Guideline for Community Noise” document, sound levels at the outside facades of living spaces should not exceed an L_{eq} of 45 dBA, so that people may sleep with bedroom windows open. This is an 8-hour average. Since the 8-hour sound level cannot be any higher than the highest 1-hour modeled sound level, the sound levels shown in Appendix E are conservative surrogates for the highest nighttime L_{eq} (8-hour). To further illustrate this point, all 8,760 hours of the on-site hub height wind speeds were analyzed. Only 26 of the 365 nights in an entire year maintained a hub height wind speed high enough for all eight hours of the night to produce the highest sound level from the GE wind turbine for those eight consecutive hours. Likewise, that same analysis of 8,760 hours of wind data found that only six of the 365 days in an entire year maintained a hub height wind speed high enough for all 16 hours of the day to produce the highest sound level from the GE wind turbine for those 16 consecutive hours.

Table 9-10 to Table 9-13 in this PNIA summarize the results applicable to these goals. The results vary by the modeled wind turbine OEM. There are three (3) to eight (8) receptors with L_{eq} (8-hour) sound levels of 46-51 dBA. However, these receptors are Participants in the project, and thus meet the 55 dBA L_{eq} (8-hour) design goal (Goal #4). The highest sound level at a non-participating receptor is 45 dBA, therefore, the Project meets the 45 dBA L_{eq} (8-hour) guideline for non-participants (Goal #3).

A review of the isolines in Figure 9-2 (and all inset maps) shows the external (non-participating) property boundary lines are equal to or less than 55 dBA which meets the design goal of 55 dBA (1-hour L_{eq}) (Goal #5). These are for the worst-case wind turbine under consideration. The other wind turbines evaluated in this PNIA will have lower sound levels at the property lines.

13.3 World Health Organization—Long-Term (Goals #6; #7)

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

The Nordex N149 model was used to evaluate compliance with the design goal of 40 dBA $L_{eq, night, outside}$ because it is considered the “worst-case”. The highest $L_{eq, night, outside}$ level at a non-participating residence is 42 dBA (Receptor IDs 133 and 207). There are nine (9) non-participating residences at 41 dBA or 42 dBA $L_{eq, night, outside}$. All other locations are 40 dBA or less. The GE 3.8-137 had four (4) non-participating residences at 41 dBA $L_{eq, night, outside}$. All other locations are 40 dBA or less using the GE 3.8-137. Modeling for the Vestas V150-4.2 and Senvion M148-4.2 wind turbines showed all non-participating receptors at an $L_{eq, night, outside}$ of 40 dBA or less. Therefore, all non-participating receptors meet the $L_{eq, night, outside}$ design goal of 40 dBA for all wind turbine models except the Nordex N149 which has 9 receptors at 41 dBA or 42 dBA, and the GE 3.8-137 which has 4 receptors at 41 dBA (Goal #6). The highest $L_{eq, night, outside}$ for a participating receptor using any wind turbine is 50 dBA (receptor ID 392). All other locations are 48 dBA or less. Therefore, all participating receptors meet the $L_{eq, night, outside}$ design goal of 50 dBA (Goal #7).

In accordance with Stipulation 19(d)(7), sound level contours generated from the modeling grid are presented in an overview figure, Figure 9-3, accompanied by a series of inset maps that provide a higher level of detail at all modeled receptors. This sound contour figure set for annual nighttime $L_{eq, night, outside}$ Project sound levels was generated only for the Nordex N149 wind turbine model, because it has the highest A-weighted sound power level for the annual nighttime $L_{eq, night, outside}$.

13.4 ANSI S12.9-2005/Part 4 (Goal #8)

Annex D of the American National Standard ANSI S12.9-2005/Part 4 identifies that low frequency sound annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each less than 65 dB. Tables 12-2 to 12-5 show the highest sound level modeled in the 16, 31.5, and 63 Hz octave bands. Results vary by wind turbine

manufacturer but all non-participating residences are below 65 dB at the 31.5 Hz and 63 Hz octave bands.

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

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

13.5 Tonality (Goal #9)

As discussed in Section 12.9, ANSI S12.9 Part 3, Annex B, section B.1 (informative) presents a procedure for testing for the presence of a prominent discrete tone. The results presented in Table 12-2 show that received sound pressure levels due to the closest wind turbines are not predicted to result in any prominent discrete tones at either participating or non-participating residents. For this Project the collector substation is modeled to be less than 36 dBA at all non-participating sensitive receptors. Therefore, prominent discrete tones from the substation are not a concern with this Project. The project thus meets the design goal of no pure tone at any non-participating resident.

13.6 Non-Residential Receptors (Goal #10)

As discussed previously, there are four (4) non-residential receptors among the sensitive receptor set. These receptors are summarized below in Table 13-1 along with the highest 1-hour Leq modeled sound level from each wind turbine under consideration. The highest modeled sound level is 40 dBA. Therefore, the project meets the design goal of 50 dBA Leq 1-hour at any non-residential receptor.

Table 13-1 Non-Residential Receptors—Highest Short-Term Sound Levels (1-hour Leq)

Receptor ID	Participation Status	Description	GE 3.8-137	Vestas V150-4.2	Nordex N149/4500	Senvion 4.2M148
422	Non-Participating	Cemetery	30	30	31	30
438	Non-Participating	Marsh Pond State Forest campsite	36	36	36	35
439	Non-Participating	Sanford Cemetery	40	39	40	39
440	Non-Participating	Alexander Hill Cemetery	38	38	38	37

Notes: 1. Rounded to the nearest whole decibel.

13.7 NYS DEC Lands (Goal #2)

The NYS DEC land nearest to a wind turbine is the Marsh Pond State Forest. Receptor ID #438 represents the area of frequent human use (campsites). Worst-case Leq (1-hour) sound levels are predicted to be 35-36 dBA depending on the wind turbine modeled (see Appendix E). The existing ambient sound levels at ID #438 are represented by measurement Location 4. The quietest daytime summer ambient L90 is 34 dBA (see Table 8-1), and the quietest nighttime summer ambient L90 is 31 dBA (see Table 8-2). Using these data, the worst-case Leq (1-hour) project sound levels are 3-5 dBA above the quietest L90 ambient sound levels. Therefore, the project meets the design goal of a 6 dBA increase over ambient or less.

13.8 Vibration (Goal #11)

As discussed in Section 12.5 of this PNIA, vibration from the proposed wind turbines will not create perceptible vibration thus meeting Goal #11.

13.9 Summary of Compliance

Table 13-2 summarizes all applicable noise standards and design goals applicable to the Bluestone Wind project, and the expected compliance status with said standards and goals.

Table 13-2 Summary of Compliance with Sound Standards and Design Goals - Bluestone Wind

#	Municipality or Organization	Sound Level Limit	Assessment Location	Noise descriptor	Period of Time	Participant Status	Comply?
1	Town of Sanford Renewable Energy Systems §1402.5(A)(5)	50 dBA	Exterior wall of the nearest non-participating residence	Not stated (assumed Leq)	Not stated (assumed 1-hour); day or night	Non-participant	Yes
2	Program Policy Assessing and Mitigating Noise Impacts issued by the New York State Department of Environmental Conservation (NYSDEC), Feb. 2001	6 dBA increase over ambient	Areas of human use	L90	Not stated	NYS DEC lands	Yes
3	Design goal (1999 WHO Guidelines)	45 dBA ⁷⁸	At residence	Leq	8-hour; nighttime	Non-participant	Yes
4	Design goal (1999 WHO Guidelines)	55 dBA	At residence	Leq	8-hour; nighttime	Participant	Yes
5	Design goal	55 dBA	Property line and lands except wet-lands	Leq	1-hour; day or night.	Non-participant	Yes
6	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	40 dBA	At residence	Leq, night, outside	Annual; nighttime	Non-participant	Yes (Vestas; Senvion) No (GE; Nordex)

⁷⁸ Subject to a 5 dBA penalty if a prominent tone occurs. See goal 9 for details.

Table 13-2 Summary of Compliance with Sound Standards and Design Goals - Bluestone Wind (Continued)

#	Municipality or Organization	Sound Level Limit	Assessment Location	Noise descriptor	Period of Time	Participant Status	Comply?
7	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	50 dBA	At residence	Leq, night, outside	Annual; nighttime	Participant	Yes
8	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	65 dB at 16, 31.5, 63 Hz	At residence	Leq	1-hour; day or night	Non-participant	No (16 Hz) Yes (31.5; 63 Hz)
9	Design goal (Permit condition Case 14-F-0490 (Cassadaga Wind))	No pure tone or 5 dBA penalty if a prominent tone occurs	At residence	Leq	1-hour; day or night	Non-participant	Yes
10	Design goal (ANSI/ASA S12.9-2007/Part 5)	50 dBA	Non-residential (historic venues; cemeteries; playgrounds; etc.)	Leq	1-hour	Non-participant	Yes
11	Design goal for vibrations.	Not perceptible indoor vibrations	At residence	See ANSI S 2.71-1983 (R August 6/2012) for details	See ANSI S 2.71-1983 (R August 6/2012) for details	Non-Participant	Yes

14.0 CONCLUSIONS

Potential broadband, octave band, one-third octave band, low frequency, infrasound, and ground-borne vibration impacts from the Bluestone Wind project were examined. Noise design goals for each of these elements were selected based on applicable regulations and guidelines. Based on the detailed analyses presented in this report, the future project sound levels will minimize adverse reaction and prevent sleep disturbance. These levels do not mean the project sound will be inaudible or completely insignificant, only that its noise will generally be low enough that it will probably not be considered objectionable by the vast majority of neighbors. A few non-participating locations show modeled 16 Hz levels slightly above the design goal, as well as a few receptors over the $L_{eq, night, outside}$ goal for some wind turbine models. The final analysis will be refined to model only the selected wind turbine model. Therefore, at this stage of permitting, adverse impacts from noise and vibration from the construction and operation of the Bluestone Wind project have been avoided or mitigated to the maximum extent practicable.