HIGH BRIDGE WIND PROJECT
PRE-CONSTRUCTION SOUND LEVEL IMPACT ASSESSMENT

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Chapter 1.0

Executive Summary

1.0 EXECUTIVE SUMMARY

The proposed High Bridge Wind Project will be located in Chenango County, NY. The project is expected to be approximately 100 MW using 25 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 the Town of Guilford which has does not have a numerical sound standard. The Town of Guilford is in the process of drafting a "Renewable Energy Systems Local Law" which would include a standard for wind turbine sound. If and when such local law is adopted, a supplement to the Application will be provided which discusses any applicable noise standards contained therein.

New York state regulations do not list quantitative sound limits applicable to this project. 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 and 50 dBA daytime limit at a non-participating residence. A design goal of 55 dBA, day or night, 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 ($L_{eq,\ night,\ outside}$) 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 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 no perceptible indoor vibrations at non-participating residences, a limit of 55 dBA 1-hour L_{eq} at a non-participating property line, and in order to minimize complaints, the long-term mean sound levels should be limited to 40 dBA (ideal) and 45 dBA (maximum) at a residence outdoors according to NARUC.

Existing Condition Sound Monitoring

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

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 ($L_{eq,\ night\text{-}outside}$) 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 generally comply with the noise and vibration design goals and applicable standards. Table ES-1 summarizes each of the design goals and standards, and indicates the compliance status of the project with each one. As this table shows, the proposed project will meet most design goals and standards. Noise Reduced Operation (NRO) is needed for three manufacturers to meet the short-term sound limit while one does not need NRO. In addition, two manufacturers meet the low frequency design goal while two manufacturers do not. For the long-term annual $L_{night,\ outside}$ design goal at a non-participating residence, one manufacturer meets the limit while the other three do not. These analyses will be refined upon final turbine selection and final layout at which time all regulatory standards will be met.

Therefore, at this stage of permitting, adverse noise and vibration impacts from the construction and operation of the High Bridge Wind Project have been avoided or mitigated to the maximum extent practicable through the use of blade technology and good siting considerations.

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

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

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

#	Design Goal. (Not to exceed)	Assessment Location	Noise descriptor	Period of Time	Participant Status	Design Goals and basis	Comply?
9	40-45 dBA. Ideal and Maximum Design Goals, respectively	At residence, Outdoor	L90 (See NARUC-2011 for details)	Long-term mean as obtained with computer modeling.	Non-participant. (Daytime and nighttime)	Ideal and Maximum Design Goals; National Association of Regulatory Utility Commissioners. NARUC-2011	Yes

Chapter 2.0

Introduction

2.0 INTRODUCTION

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

The High Bridge Wind Project (the "Project") is a proposed 100-megawatt (MW) commercial-scale wind power project located within the Town of Guilford, Chenango County, New York. The Project's turbines and related facilities will be sited within privately-owned leased land within the Project Area.

Epsilon Associates ("Epsilon") conducted the PNIA in accordance with the Article 10 regulations and the Project's understanding of the required DPS scope of studies. 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

Chapter 3.0

Project Description

3.0 PROJECT DESCRIPTION

The proposed Project is being developed by High Bridge Wind, LLC (the "Applicant" or "High Bridge") a wholly-owned subsidiary of Calpine Corporation.

The proposed Facility consists of the construction and operation of a commercial-scale wind power project, including the installation and operation of up to 25 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 28,000-acre Facility Area.

To deliver electricity to the New York State power grid, High Bridge Wind proposes to construct a collection substation, which will include up to 5 MW of battery storage, and a point of interconnection (POI) substation. The collection substation will be located at the end of the Facility's 34.5 kilovolt (kV) collection system and will connect to the POI substation via a short (less than 5-mile) span of overhead 115 kV transmission line. The point of interconnect (POI) substation will interconnect with NYSEG's Jennison to East Norwich 115 kV transmission line in the Town of Guilford. The interconnect substation will not contain any new noise sources, and thus was not included in the PNIA.

The Applicant is considering four wind turbine models for the Facility. For this PNIA, the following wind turbine generators (WTGs) were analyzed:

- GE 158 4.8-5.5; HH = 107.5 meters (m) or 125.4m; RD = 158m
- SGRE 145 4.2-4.8; HH = 107.5m or 127.5m; RD = 145m
- Nordex N149 4.0-4.8; HH = 105m or 125m; RD = 149m
- Vestas V150 5.6; HH = 105m or 125m; RD = 150m

The collector substation will contain two 34.5/115 kV step-up transformers rated at up to 90 MVA and 28 MVA each. 818 discrete receptors were analyzed for the project. These include 706 year-round residences, 68 seasonal residences, 15 public areas, and 29 unknown structures. All "unknown" structures were conservatively assumed to be residences. Of the 818 receptors, 55 were participating, and 763 were non-participating. Of the 706 year-round residences, 41 were participating and 665 were non-participating. Of the 68 seasonal residences, 9 were participating and 59 were non-participating. Of the 15 public areas, 2 were participating and 13 were non-participating. Of the 29 unknown structures, 3 were participating and 26 were non-participating.

Chapter 4.0

Regulations, Guidelines, and Evaluation Criteria

4.0 REGULATIONS, GUIDELINES, AND EVALUATION CRITERIA

4.1 Local Regulations

Chenango County does not have any noise regulations applicable to wind turbine operation. In Guilford, Local Law #2 of 1992 discusses the "Prevention of Unnecessary Noise Law." It is a general nuisance law with no numerical standards, nor is it geared toward wind turbines.

The Town of Guilford is in the process of drafting a "Renewable Energy Systems Local Law" which would include a standard for wind turbine sound. High Bridge Wind will continue to monitor the status of the Town's proposed wind ordinance, and will supplement the Application with any additional information related thereto, including any changes to the above standards in the version of the local law ultimately adopted by the Town of Guilford.

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 document[1] 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 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

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

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.

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.

In 2018, the WHO released another report "Environmental Noise Guidelines for the European Region" (WHO Regional Office for Europe, Copenhagen, Denmark, 2018) which did include guidelines for wind turbines. This document proposes an annual average

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

The key findings of the 2018 WHO report related to health outcomes found either no evidence that wind turbine noise is related to heart disease, hypertension, and sleep disturbance, or low quality evidence regarding wind turbine noise and annoyance. Neither the Wind Turbine Noise and Health Study conducted by Health Canada, nor the 2018 Lawrence Berkeley National Laboratory studies, which found no health impacts from wind turbines, were included in the 2018 WHO report (see Section 4.6 of this PNIA). The 2018 WHO report did note that the latest environmental noise guidelines for the European Region supersede the 1999 WHO guidelines except in the area of indoor guideline values.

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

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

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

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.[2] 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 PNIA incorporates the "K" factor in the modeling results.

According to the NARUC 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 L_{90} statistical measure should be used to determine sound levels from wind turbines instead of the L_{eq} as the L_{90} captures the consistently present sound level during relatively quiet periods between identifiable noise events like passing cars 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*".

4.6.1 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.[3] 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

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

[3] *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.

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.[4] 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.[5]

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.[6]

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."[7]

Health Canada, in collaboration with Statistics Canada, conducted one of the most extensive studies to understand the impacts of wind turbine noise to-date.[8] 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

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

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

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

[7] *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.

[8] Health Canada website: http://www.hc-sc.gc.ca/ewh-semt/noise-bruit/turbine-eoliennes/summary-resume-eng.php

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 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.[9]

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.[10] 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.[11] The aim was to broaden the understanding of how U.S. communities are reacting to the deployment of wind turbines, and to provide insights to those communities considering wind projects. 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.

For the LBNL study, 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 those respondents residing within 0.5 mile of a wind turbine, 25% were very negative or negative, and 75% were neutral or positive.

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

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

[11] *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.

Regarding annoyance, 5.6% of all respondents reported being somewhat, moderately, or very annoyed by the wind project. For the respondents residing 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.[12] Based on extensive research and data, Watanabe and Moeller have proposed normal hearing thresholds for frequencies below 20 Hz.[13] Figure 4-1 shows these sound levels as a function of frequency.

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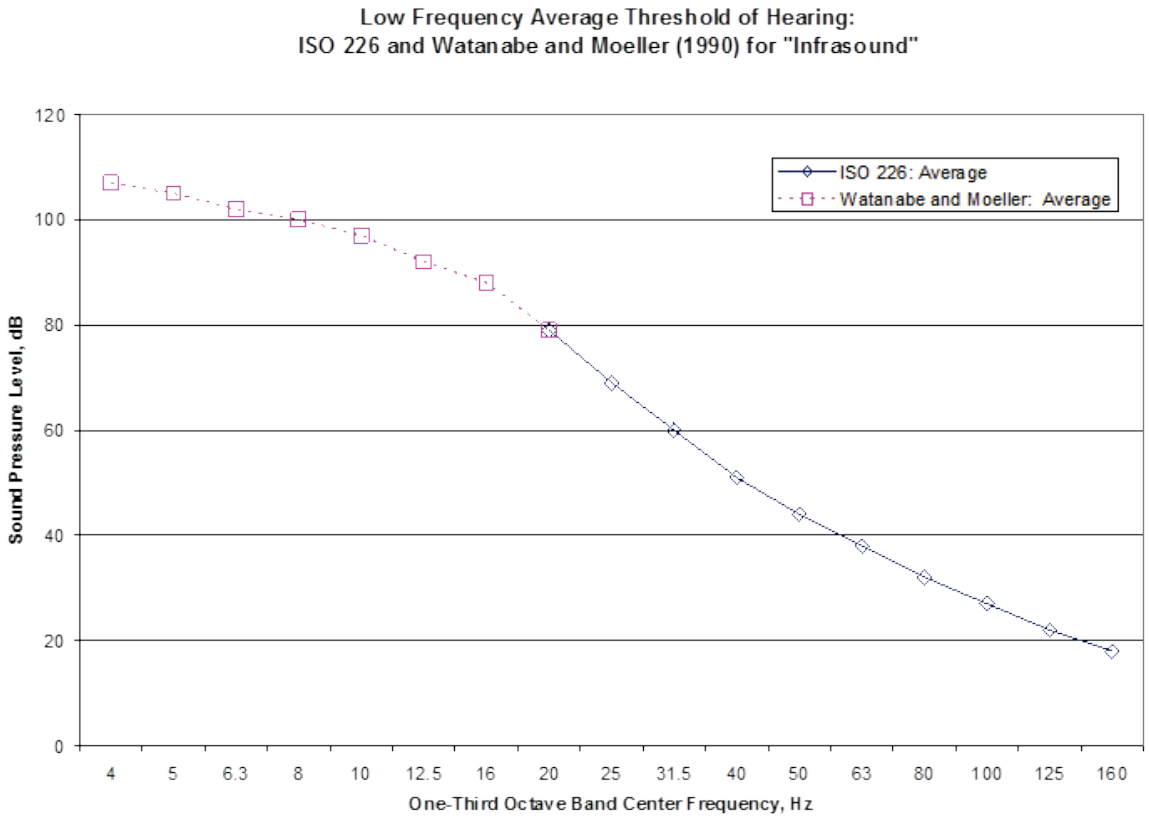
[12] Acoustics - Normal equal-loudness-level contours, International Standard ISO 226:2003, International Organization for Standardization, Geneva, Switzerland, (2003).

[13] 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. [14]

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

Annex D in the American National Standard ANSI S12.9-2005/Part 4[15] identifies that low frequency sound annoyance is minimal when the 16, 31.5 and 63 Hz octave band sound pressure levels are each less than 65 dB. According to the standard, annoyance to sounds with strong low frequency content is virtually only an indoor issue. Table 4-1 summarizes these levels.

Section 6 of the American National Standard ANSI/ASA S12.2-2008[16] 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.[17] 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."

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15 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).

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

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

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

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). [18]

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

[18] *Recent Studies of Infrasound from Industrial Sources,* W. Gastmeier & B. Howe, Canadian Acoustics, 36(3), 2008.

structural response.[19] Two reports cited in the MA DEP review (Styles 2005[20]; Schofield 2010[21]) indicate that at 100 meters from a wind turbine the maximum motion that is induced is 120 nanometers (at about 1 Hz). A nanometer is 10^{-9} meter. This is 1.2×10^{-7} meter of ground displacement. Extremely sensitive measuring devices have been used to detect this slight motion. To put the motion in perspective, the diameter of a human hair is on the order of 10^{-6} meter. The Schofield measurements were conducted on a Vestas V-47 with a maximum rotational rate of 29 rpm (blade pass frequency of 1.47 Hz).

Ground-borne vibration measurements were made by Epsilon from Siemens 2.3 and GE 1.5sle wind turbines in Texas.[22] The maximum ground-borne vibration RMS particle velocities were 0.071 mm/second (0.71×10^{-4} meters/second) in the 8 Hz one-third octave band. This was measured 1,000 feet downwind from a GE 1.5sle WTG under maximum power output and high wind at the ground. The background ground-borne vibration RMS particle velocity at the same location was 0.085 mm/sec. Both of these measurements meet ANSI S2.71-1983[23] 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.

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

[20] *Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibration from Windfarms,* P. Styles et al, Keele University, 18 July 2005.

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

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

[23] *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.[24] 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 proposed project wind turbines are:

- GE 5.5-158 = 10.1 rpm,
- SGRE 4.5-145 = 10.8 rpm,
- Nordex N149/4.8 = 12.3 rpm,
- Vestas V150-5.6 = 12.6 rpm

With regard to the mass of rotation, a single blade for the GE 158 is 50,706 pounds. Blade weights for the other project wind turbines and those 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

[24] 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 or through complaint response measurements (see Table 4-6B). The ten standards and design goals for this project are described in more detail below.

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

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

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

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

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

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

#	Design Goal. (Not to exceed)	Assessment Location	Noise descriptor	Period of Time	Participant Status	Design Goals and basis
1	45 dBA	At residence, Outdoor	Leq	9-hour nighttime	Non-participant	Design Goal; Certificate Condition 80(a) Case 14-F-0490 and WHO-1999
1A	50 dBA	At residence, Outdoor	Leq	15-hour daytime	Non-participant	Design Goal; WHO-1999
2	55 dBA	At residence, Outdoor	Leq	9-hour nighttime	Participant	Design Goal; Certificate Condition 80(a) Case 14-F-0490
2A	55 dBA	At residence, Outdoor	Leq	15-hour daytime	Participant	Design Goal; Certificate Condition 80(a) Case 14-F-0490
5	No audible prominent tones or 5 dBA penalty if they occur.	At residence, Outdoor	Leq	1-hour	Non-participant	Design Goal; Certificate Condition 80(c) Case 14-F-0490
6	65 dB at 16, 31.5, and 63 Hz full-octave bands.	At residence, Outdoor	Leq	1-hour; daytime and nighttime	Non-Participant	Design Goal; Certificate Condition 80(d) Case 14-F-0490

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

#	Design Goal. (Not to exceed)	Assessment Location	Noise descriptor	Period of Time	Participant Status	Design Goals and basis
3	40 dBA	At residence, Outdoor	Lnight-outside (Leq)	Annual; nighttime. (2009-WHO)	Non-participant	Design Goal; Certificate Condition 80(b) Case 14-F-0490 and WHO-2009
4	50 dBA	At residence, Outdoor	Lnight-outside (Leq)	Annual; nighttime. (2009-WHO)	Participant	Design Goal; Certificate Condition 80(b) Case 14-F-0490 and WHO-2009
7	No perceptible vibrations	At residence, Indoor	See ANSI S2.71-1983 (R August 6, 2012).	See ANSI S2.71-1983 (R August 6, 2012).	Non-participant	Design Goal; Certificate Condition 80(e) Case 14-F-0490
8	55 dBA	Property line	Leq	1-hour; daytime and nighttime	Non-participant	Design Goal; Boundary lines and Lands Except Wetlands (WHO 1999)
9	40-45 dBA. Ideal and Maximum Design Goals, respectively	At residence, Outdoor	L90 (See NARUC-2011 for details)	Long-term mean as obtained with computer modeling.	Non-participant. (Daytime and nighttime)	Ideal and Maximum Design Goals; National Association of Regulatory Utility Commissioners. NARUC-2011

Chapter 5.0

Wind Turbine Noise

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.[25]

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.

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

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 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 plastic or metal sawtooth serrations that can be affixed to the blade's rear edge to reduce blade trailing edge noise. General Electric estimates that the LNTE option reduces sound levels 2-4 dBA as compared to unserrated blades.[26] Vendor sound data from other major manufacturers confirms this level of reduction.

5.2.2 Construction

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

- Blasting is anticipated at this site. Blasting will be limited to daytime hours and conducted in accordance with the High Bridge Wind Preliminary Blasting Plan included elsewhere in the Article 10 Application.

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

- Pile driving is not anticipated at this site. If pile driving is required, it will be limited to daytime hours. See the preliminary geotechnical report for more detail.

- Utilizing construction equipment fitted with exhaust systems and mufflers that have the lowest associated noise whenever those features are available.

- Maintaining equipment and surface irregularities on construction sites to prevent unnecessary noise.

- Configuring, to the extent feasible, the construction in a manner that keeps loud equipment and activities as far as possible from noise-sensitive locations.

- Using back-up alarms with a minimum increment above the background noise level to satisfy the performance requirements of the current revisions of Standard Automotive Engineering (SAE) J994 and OSHA requirements.

- Develop a staging plan that establishes equipment and material staging areas away from sensitive receptors when feasible.

- Contractors shall use approved haul routes to minimize noise at residential and other sensitive noise receptor sites.

5.2.3 Operations

The Noise 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.

Chapter 6.0

Baseline Sound Level Monitoring Program

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 the Project's understanding of the required DPS scope of studies. This section outlines the structure of the ambient program.

6.1 Sensitive Receptors

All residences [including participating, non-participating, full-time and seasonal)], outdoor public facilities and areas, State Forest Lands, places of worship, hospitals, schools, cemeteries, campsites, summer camps, Public Parks, Federal and NY 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 the Project's understanding of the required DPS scope of studies.

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. 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 consistent between the two programs. Figure 6-1 shows the measurement locations for both measurement programs. The ambient measurement locations are representative of the general vicinity of the Project. Each sound level monitoring location is described in the following subsections.

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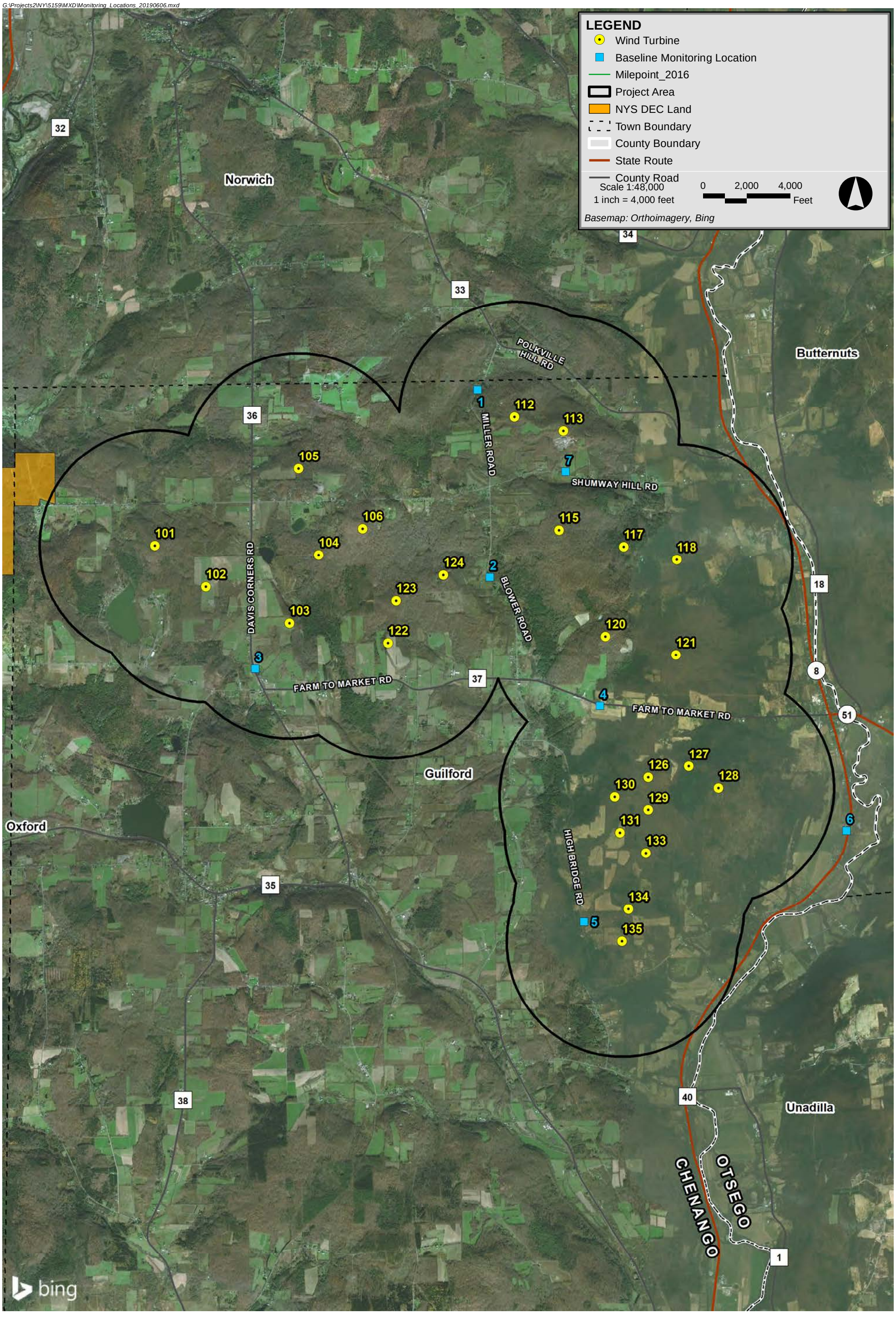


High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 6-1

Baseline Monitoring Locations Locus Map

The coordinates for the sound level measurement locations are listed in Table 6-1, which are slightly adjusted as needed 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 Route 8 through the project had an AADT of 3,169 vehicles in 2015. County Road 36 to the west of the project had an AADT of 1,657 vehicles in 2015, and County Road 35 to the southwest of the project had an AADT of 2,044 vehicles in 2015.[27] 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	42.4671°	-75.4432°
Location 2	42.4436°	-75.441°
Location 3	42.4319°	-75.4807°
Location 4	42.4267°	-75.4208°
Location 5	42.4004°	-75.4247°
Location 6	42.4119°	-75.3803°
Location 7	42.4569°	-75.4282°

6.2.1 Location 1—Miller Road

One continuous programmable, unattended sound level meter was placed near Miller Road in the Town of Guilford. The meter was placed approximately 15 meters west of the road and is representative of existing sound levels in the north area of the Project Site and along Miller Road. Refer to Figures 6-2 and 6-3 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 summer season from 12:30 p.m. Thursday, August 30, 2018 until 11:50 a.m. on Tuesday, September 4, 2018, and from 6:30 p.m. Thursday, September 6, 2018 to 3:10 p.m. Monday, September 17, 2018. Data was unable to be collected from midday on September 4, to the evening of September 6 due to battery issues. In total, 2,280 10-minute measurement periods were recorded during the summer measurement program.

[27] https://gis3.dot.ny.gov/html5viewer/?viewer=tdv Accessed in May 2019.

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. on Tuesday, January 8, 2019 until 10:30 a.m. on Thursday, January 17, 2019 , and from 11:10 a.m. on Thursday, January 17, 2019 until 12:50 p.m. on Friday, January 25, 2019. In total, 2,453 10-minute measurement periods were recorded during the winter measurement program.

In addition to sound data collection, continuous ground-level wind speed data were collected at this location during both monitoring programs. The meteorological equipment setup is shown in Figures 6-4 and 6-5 for the respective seasons.

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

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

Figure 6-4 Location 1- Winter, Meteorological Tower

Figure 6-5 Location 1- Summer, Meteorological Tower

6.2.2 Location 2—Blower Road

One continuous programmable, unattended sound level meter was placed near Blower Road in the Town of Guilford. The meter was placed west of the road and is representative of existing sound levels in the central area of the Project Site and along Blower Road. 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 summer season from 2:00 p.m. Thursday, August 30, 2018 until 7:10 p.m. on Thursday, September 6, and from 7:20 p.m. Thursday, September 6 to 3:30 p.m. Monday, September 17, 2018. In total, 2,600 10-minute measurement periods were recorded during the summer measurement program.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 5:20 p.m. on Tuesday, January 8, 2019 until 11:20 a.m. on Thursday, January 17, and from 11:40 a.m. on Thursday, January 17, 2019 until 10:20 a.m. Friday, January 25, 2019. In total, 2,405 10-minute measurement periods were recorded during the winter measurement program.

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

Figure 6-7 Location 2 - Summer, Sound Level Meter

6.2.3 Location 3 – County Road 36

One continuous programmable, unattended sound level meter was placed near County Road 36 in the Town of Guilford. The meter was placed east of the road and is representative of existing sound levels along in the western area of the Project Site and along County Road 36. Refer to Figures 6-8 and 6-9 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 summer season from 2:30 p.m. Thursday, August 30, 2018 until 5:30 p.m. on Thursday, September 6, and from 5:50 p.m. Thursday, September 6 to 3:50 p.m. Monday, September 17, 2018. In total, 2,598 10-minute measurement periods were recorded during the summer measurement program.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 1:00 p.m. on Tuesday, January 8, 2019 until 4:00 p.m. on Thursday, January 17, and from 4:50 p.m. on Thursday, January 17 until 10:50 a.m. Friday, January 25, 2019. In total, 2,430 10-minute measurement periods were recorded during the winter measurement program.

Figure 6-8 Location 3, Sound Level Meter, Winter

Figure 6-9 Location 3, Sound Level Meter, Summer

6.2.4 Location 4 – County Road 37

One continuous programmable, unattended sound level meter was placed near County Road 37 in the Town of Guilford. The meter was placed approximately 15 meters south of the road and is representative of existing sound levels along in the central area of the Project Site and along County Road 37. 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 summer season from 5:10 p.m. Thursday, August 30, 2018 until 7:30 p.m. on Thursday, September 6, and from 7:50 p.m. Thursday, September 6 to 4:20 p.m. Monday, September 17, 2018. In total, 2,585 10-minute measurement periods were recorded during the summer measurement program.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 10:10 a.m. on Monday, January 9, 2019 until 2:00 p.m. on Thursday, January 17 and from 2:40 p.m. on Thursday, January 17 until 12:30 p.m. Friday, January 25, 2019. In total, 2,314 10-minute measurement periods were recorded during the winter measurement program.

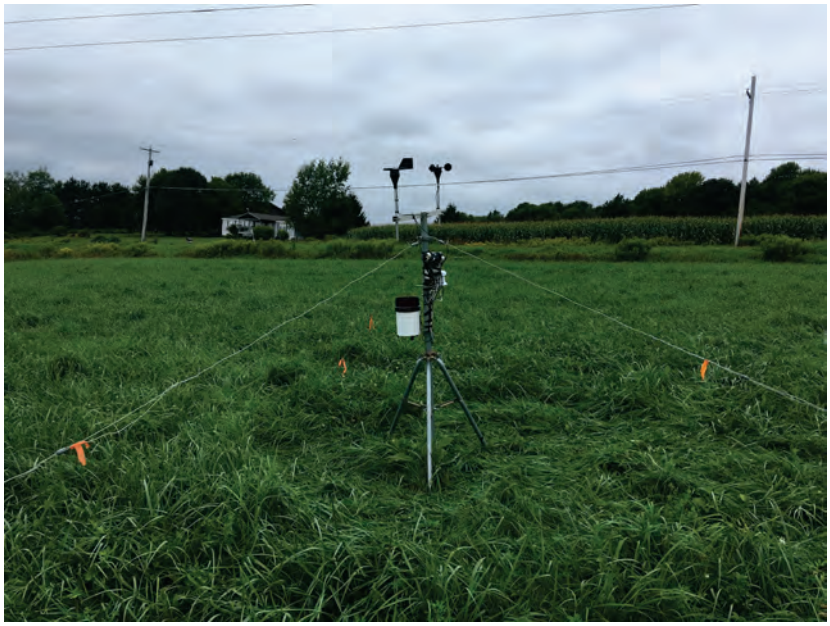
In addition to sound data collection, continuous meteorological data were collected at this location during both monitoring programs including wind speed, precipitation, relative humidity, and temperature. The meteorological equipment setup is shown in Figures 6-12 and 6-13 for the respective seasons.

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

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

Figure 6-12 Location 4- Winter, Meteorological Tower

Figure 6-13 Location 4- Summer, Meteorological Tower



6.2.5 Location 5 – High Bridge Road

One continuous programmable, unattended sound level meter was placed near High Bridge Road in the Town of Guilford. The meter was placed approximately 15 meters east of the road and is representative of existing sound levels along in the southern area of the Project Site and along High Bridge Road. Refer to Figures 6-14 and 6-15 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 summer season from 3:10 p.m. Thursday, August 30, 2018 until 7:50 p.m. on Thursday, September 6, and from 8:10 p.m. Thursday, September 6 to 5:20 p.m. Monday, September 17, 2018. In total, 2,603 10-minute measurement periods were recorded during the summer measurement program.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 4:10 p.m. on Tuesday, January 8, 2019 until 11:50 a.m. on Thursday, January 17, and from 12:50 p.m. on Thursday, January 17 until 11:20 a.m. Friday, January 25, 2019. In total, 2,413 10-minute measurement periods were recorded during the winter measurement program.

Figure 6-14 Location 5, Sound Level Meter, Winter

Figure 6-15 Location 5, Sound Level Meter, Summer

6.2.6 Location 6 – NY Route 8

One continuous programmable, unattended sound level meter was placed along NY Route 8, in the Town of Guilford. The meter was positioned approximately 15 meters west of NY Route 8. This location is representative of receptors in the eastern area of the Project. 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 summer season from 11:20 a.m. Thursday, August 30, 2018 until 8:20 p.m. on Thursday, September 6, and from 8:40 p.m. Thursday, September 6 to 4:50 p.m. Monday, September 17, 2018. In total, 2,623 10-minute measurement periods were recorded during the summer measurement program.

The meter continuously measured and stored broadband (A-weighted) and one-third octave band sound level statistics during the winter season from 9:00 a.m. on Wednesday, January 9, 2019 until 1:00 p.m. on Thursday, January 17, and from 1:50 p.m. on Thursday, January 17 until 11:50 a.m. Friday, January 25, 2019. In total, 2,316 10-minute measurement periods were recorded during the winter measurement program.

In addition to sound data collection, continuous ground-level wind speed data were collected at this location during both monitoring programs. The meteorological equipment setup is shown in Figures 6-18 and 6-19 for the respective seasons.

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

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

Figure 6-18 Location 6- Winter, Meteorological Tower

Figure 6-19 Location 6- Summer, Meteorological Tower

6.2.7 Location 7 – Shumway Hill Road

One continuous programmable, unattended sound level meter was placed along Shumway Hill Road in the Town of Guilford. The meter was positioned approximately 15 meters north of Shumway Hill Road. This location is representative of receptors in the northern area of the Project. Refer to Figures 6-20 and 6-21 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 summer season from 2:00 p.m. Friday, August 31, 2018 until 6:40 p.m. on Thursday, September 6, and from 7:10 p.m. Thursday, September 6 to 2:40 p.m. Monday, September 17, 2018. In total, 2,449 10-minute measurement periods were recorded during the summer measurement program.

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. on Tuesday, January 8, 2019 until 2:40 p.m. on Thursday, January 17, and from 3:40 p.m. on Thursday, January 17 until 10:00 a.m. Friday, January 25, 2019. In total, 2,428 10-minute measurement periods were recorded during the winter measurement program.

Figure 6-20 Location 7, Sound Level Meter, Winter

Figure 6-21 Location 7, Sound Level Meter, Summer

6.3 Sound Level Measurement Instrumentation

Each of the monitoring locations utilized either a Larson Davis (LD) model 831[28] sound level meter (SLM) or a Norsonic model Nor140[29] SLM to measure both A-weighted (dBA) and one-third octave bands from 6.3 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 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.[30] 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

[28] 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.

[29] 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.

[30] 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.

to 2 dB from 5000 Hz to 10,000 Hz. A summary of these insertion losses is included in this report as Appendix A. Since all measured sound level results are presented in terms of ANS-weighting (see discussion in Section 7.1), frequencies above 1250 Hz are not included, and thus the minor microphone insertion loss is irrelevant.

Each microphone was tripod-mounted at a height of approximately five feet (1.5 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-weather stations (manufactured by Onset Computer Corporation) with tripods and data loggers were used to record continuous wind speed data at Locations 1 and 6 during both seasons. Additionally, an ATMOS 41 weather sensor (manufactured by The Meter Group) monitored wind speed, wind direction, precipitation, and relative humidity at Location 4 during both the summer and winter monitoring programs.

The HOBO 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.

The ATMOS 41 wind speed sensor has a measurement range of 0 to 30 m/s (67 mph) with a resolution of 0.01 m/s. The wind direction measurement range is 0 to 359 degrees 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 57 meters was used to extrapolate wind speeds up to both the 105 meter hub height and the 125 meter hub height by High Bridge Wind meteorologists, and provided to Epsilon.

6.4.3 Precipitation, Temperature, and Relative Humidity

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 Sherburne Mesonet station is location approximately 12.9 miles from the closest High Bridge measurement location. The SUNY Mesonet data from the Sherburne station are provided in Appendix C of this report.

Precipitation data from the Sherburne Mesonet station was used for both the summer and winter measurement programs in combination with the precipitation data measured by the ATMOS 41. The ATMOS 41 precipitation sensor has a measurement range of 0 to 400 mm/h with a resolution of 0.017 mm/h and an accuracy of +/-5% for measurements between 0 and 50 mm/h.

Additionally, relative humidity and temperature obtained by the ATMOS were used for both the summer and winter measurement programs in lieu of Mesonet data, due the improved accuracy gained through using on-site meteorological measurements. The ATMOS 41 relative humidity sensor has a measurement range of 0 to 100% with a resolution of 0.1% and an accuracy of +/-3%. The temperature measurement range is -50 to 60 degrees Celsius with a resolution of 0.1 degrees and an accuracy of +/- 0.6 degrees.

6.5 Infrasound Monitoring

Infrasound was measured during both seasons at Location 2, 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.

Chapter 7.0

Baseline Sound Level Monitoring Results

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 intervals[31] 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 the Project's understanding of the required DPS scope of studies. These periods are when the average wind velocity exceeds 5 m/s when measured at a height of 2 ± 0.2 m above the ground or during periods of precipitation. Precipitation events identified at the SUNY MesoNet station in Sherburne, NY defined periods for which sound level data were excluded from the analysis for the summer and winter measurement programs. Further precipitation exclusions were made using the meteorological data recorded by the ATMOS station positioned at Location 4.

The sound level equipment used in ambient monitoring have specifications regarding operative ranges under certain air conditions, e.g., temperature and relative humidity.[32,33] Data from the ATMOS meteorological station were additionally referenced for the range exceedances during all measurement timeframes. Sound levels during these exceedances were excluded from further processing.

As per the Project's understanding of the required DPS scope of studies, intermittent noise was filtered by using the L_{90}. Seasonal noise was 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

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[31] It should be noted that all sound level instrumentation data, ground level meteorological instrumentation data and on-site meteorological tower data records were all time-correlated for appropriate alignment of 10-minute periods.

[32] 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.

[33] 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 true 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., and 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. There are two general proposed hub heights: 105m/107.5m and 125m/127.5m. For analysis purposes, hub height wind speeds were extrapolated to 105m and 125m. Extrapolated hub height wind speed and wind direction data are displayed as wind roses for the both proposed hub heights for winter and summer monitoring seasons in Figures 7-1 through 7-4 [REDACTED]. 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 through 7-4.

7.3 Location 1 Miller Road

Sound levels at Location 1 were influenced by vehicular traffic on Miller Road, vegetation rustle, insects, wind, dogs, a nearby stream, local traffic, 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 1. Data were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation or instrumentation operative exceedances. Precipitation information for Location 1 was obtained from the ATMOS Meteorological Station at Location 4.

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 7-5. A total of 1,324 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,129 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 17 to 49 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 19 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 13 to 47 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 16 to 68 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 7-6. A total of 117 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,130 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 19 to 59 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 21 to 82 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 57 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 14 to 80 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 7-7 and 7-8, 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 7-7 for both L_{eq} and L_{90}. The one-third octave-band data in Figure 7-8 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones[34]. Pure tones were present and were most prominent at 2,500 and 5,000 Hz frequency for the summer nighttime measurement period. The 5,000 Hz frequency tone is likely due to bird and insect activity.

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[34] 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.

7.4 Location 2- Blower Road

Sound levels at the Location 2 monitor were influenced by wind, cars along Blower Road, birds, vegetation rustle, and distant dogs barking. 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 1. Data were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation or instrumentation operative exceedances. Precipitation information for Location 2 was obtained from the ATMOS Meteorological Station at Location 4.

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 7-9. A total of 1,292 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,113 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 17 to 42 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 19 to 56 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 12 to 42 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 17 to 54 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 7-10. A total of 120 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,456 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 31 to 54 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 35 to 61 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 51 dBA;

- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 14 to 60 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 7-11 and 7-12, 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 7-11 for both L_{eq} and L_{90}. The one-third octave-band data in Figure 7-12 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones[35]. Pure tones were present and were most prominent at the 5,000 Hz frequency for the summer season. This is likely due to bird and insect activity.

7.5 Location 3 – County Road 36

Sound levels at Location 3 were influenced by local traffic, wind , vegetation rustle, insects, passing horse and buggy, and birds. 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 1. Data were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation or instrumentation operative exceedances. Precipitation information for Location 3 was obtained by the ATMOS Meteorological Station at Location 4.

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 7-13. A total of 1,329 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,112 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 15 to 58 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 15 to 73 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 8 to 57 dBA;

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[35] 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, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 9 to 69 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 7-14. A total of 120 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,457 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 21 to 63 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 24 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 11 to 61 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 13 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 7-15 and 7-16, 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 7-15 for both L_{eq} and L_{90}. The one-third octave-band data in Figure 7-16 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones[36]. Pure tones were present and were most prominent at the 6,300 Hz frequency for the summer daytime measurement period and at the 8,000 Hz frequency for the summer nighttime measurement period. These are likely due to bird and insect activity.

[36] 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 – County Road 37

Sound levels at the Location 4 monitor were influenced by vegetation rustle, insects, birds, barking dogs, local traffic, distant truck traffic, and wind. 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 4. Data were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation or instrumentation operative exceedances. Precipitation information for Location 4 was obtained by the ATMOS Meteorological Station at Location 4.

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 7-17. A total of 1,577 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 737 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 15 to 43 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 16 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 9 to 42 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 11 to 68 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 7-18. A total of 120 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,460 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 27 to 52 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 30 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 11 to 50 dBA;

- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 12 to 72 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 7-19 and 7-20, 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 7-19 for both L_{eq} and L_{90}. The one-third octave-band data in Figure 7-20 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones[37]. Pure tones were present and were most prominent at the 5,000 Hz frequency for the summer season. The 5,000 Hz frequency tone is likely due to bird and insect activity.

7.7 Location 5—High Bridge Road

Sound levels at the Location 5 monitor were influenced by vegetation rustle, vehicular traffic, insects, birds, wind, and occasional aircraft overhead. 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 6. Data were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation or instrumentation operative exceedances. Precipitation information for Location 5 was obtained by the ATMOS Meteorological Station at Location 4.

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 7-21. A total of 1,309 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,104 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 21 to 44 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 22 to 62 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 19 to 43 dBA;

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[37] 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, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 20 to 61 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 7-22. A total of 120 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,466 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 25 to 63 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 19 to 48 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 19 to 58 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 7-23 and 7-24, 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 7-23 for both L_{eq} and L_{90}. The one-third octave-band data in Figure 7-24 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones[38]. Pure tones were present and were most prominent at the 8,000 Hz frequency for the summer daytime measurement period and at 3,150 and 5,000 Hz frequency for the summer nighttime measurement period. The 5,000 and 8,000 Hz frequency tones are likely due to bird and insect activity.

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[38] 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.

7.8 Location 6 – NY Route 8

Sound levels at the Location 6 monitor were influenced by traffic along NY Route 8, insects, birds, wind, and farm equipment. 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 6. Data were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation or instrumentation operative exceedances. Precipitation information for Location 6 was obtained by the ATMOS Meteorological Station at Location 4.

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 7-25. A total of 1,209 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,107 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 16 to 50 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 19 to 67 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 12 to 50 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 17 to 66 dBA.

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 7-26. A total of 120 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,463 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 20 to 60 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 21 to 73 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 11 to 50 dBA;

- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 13 to 72 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 7-27 and 7-28, 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 7-27 for both L_{eq} and L_{90}. The one-third octave-band data in Figure 7-28 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones[39]. No prominent discrete tones were observed at this location.

7.9 Location 7 – Shumway Hill Road

Sound levels at the Location 7 monitor were influenced by traffic, distant construction-equipment noise (summer only), insects, vegetation rustle, and wind. 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 6. Data were excluded from further analysis and calculations due to ground-level winds exceeding 5 m/s or due to precipitation or instrumentation operative exceedances. Precipitation information for Location 7 was obtained by the ATMOS Meteorological Station at Location 4.

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 7-29. A total of 1,330 10-minute periods were excluded from the winter season. The resulting dataset includes a total of 1,098 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 17 to 57 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 17 to 63 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 11 to 55 dBA;

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[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.

- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 13 to 62 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 7-30. A total of 120 10-minute periods were excluded from the summer season. The resulting dataset includes a total of 2,329 10-minute periods of valid data.

- The valid steady-state level (L_{90}) measurements ranged from 31 to 70 dBA;
- The valid equivalent level (L_{eq}) measurements ranged from 33 to 93 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 11 to 70 dBA;
- The valid, calculated equivalent (L_{eq}) ANS-weighed broadband sound levels ranged from 13 to 82 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 7-31 and 7-32, 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 7-31 for both L_{eq} and L_{90}. The one-third octave-band data in Figure 7-32 span the audible frequencies from 20 Hz to 10,000 Hz and were analyzed for prominent discrete tones[40]. Pure tones were present and were most prominent at the 4,000, 5,000, and 8,000 Hz frequency, likely caused by insect activity.

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[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.

Figure 7-1 On-Site Hub Height Wind Rose at 105 m – Summer Ambient [REDACTED]

Figure 7-2 On-Site Hub Height Wind Rose at 125 m – Summer Ambient [REDCATED]

Figure 7-3 On-Site Hub Height Wind Rose at 105 m – Winter Ambient [REDACTED]

Figure 7-4 On-Site Hub Height Wind Rose at 125 m – Winter Ambient [REDACTED]

Figure 7-5: Baseline Monitoring Graphical Results - Location 1 (Winter)
10-Minute Ambient Sound Level Data

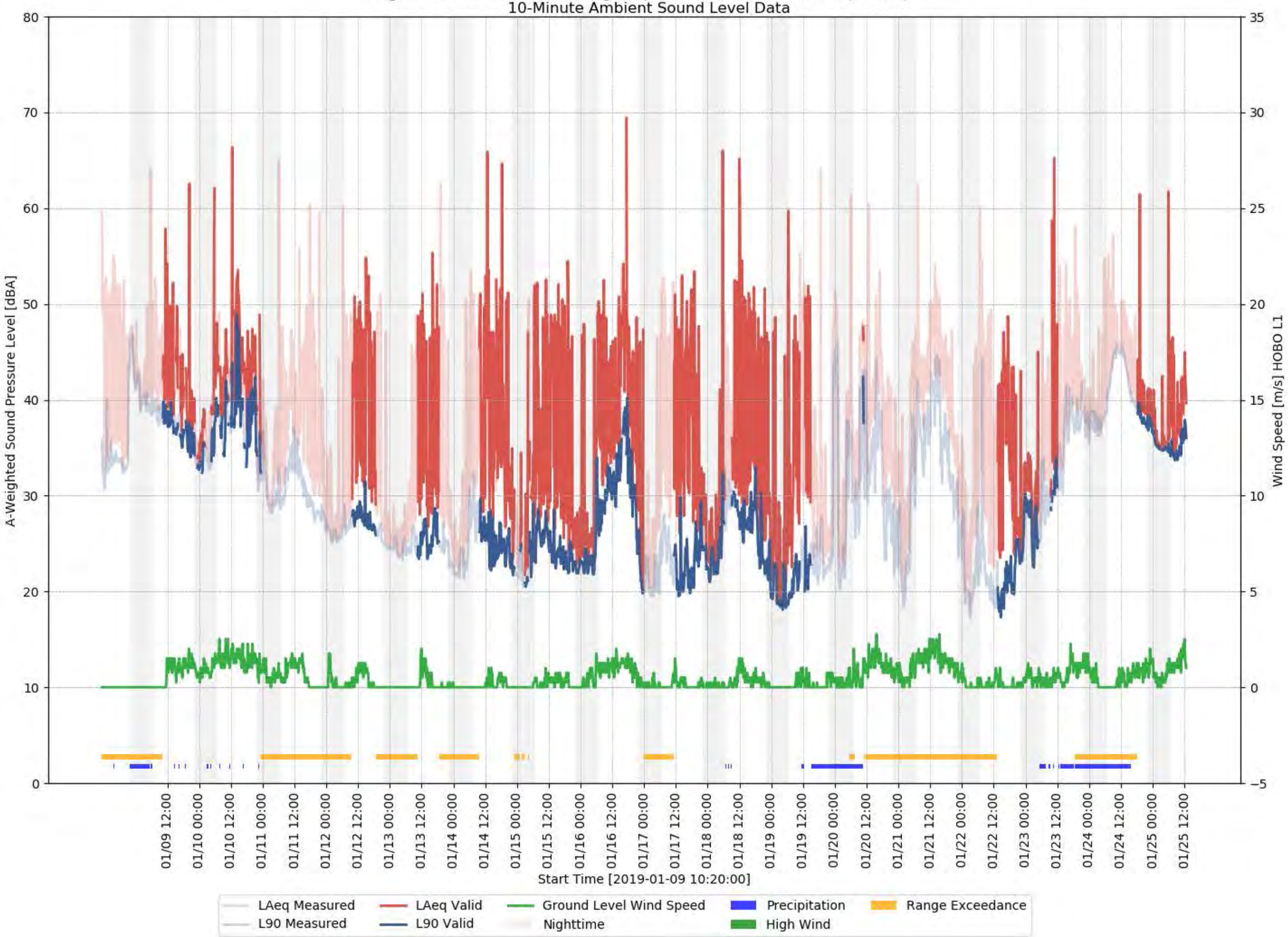


Figure 7-6: Baseline Monitoring Graphical Results - Location 1 (Summer)
10-Minute Ambient Sound Level Data

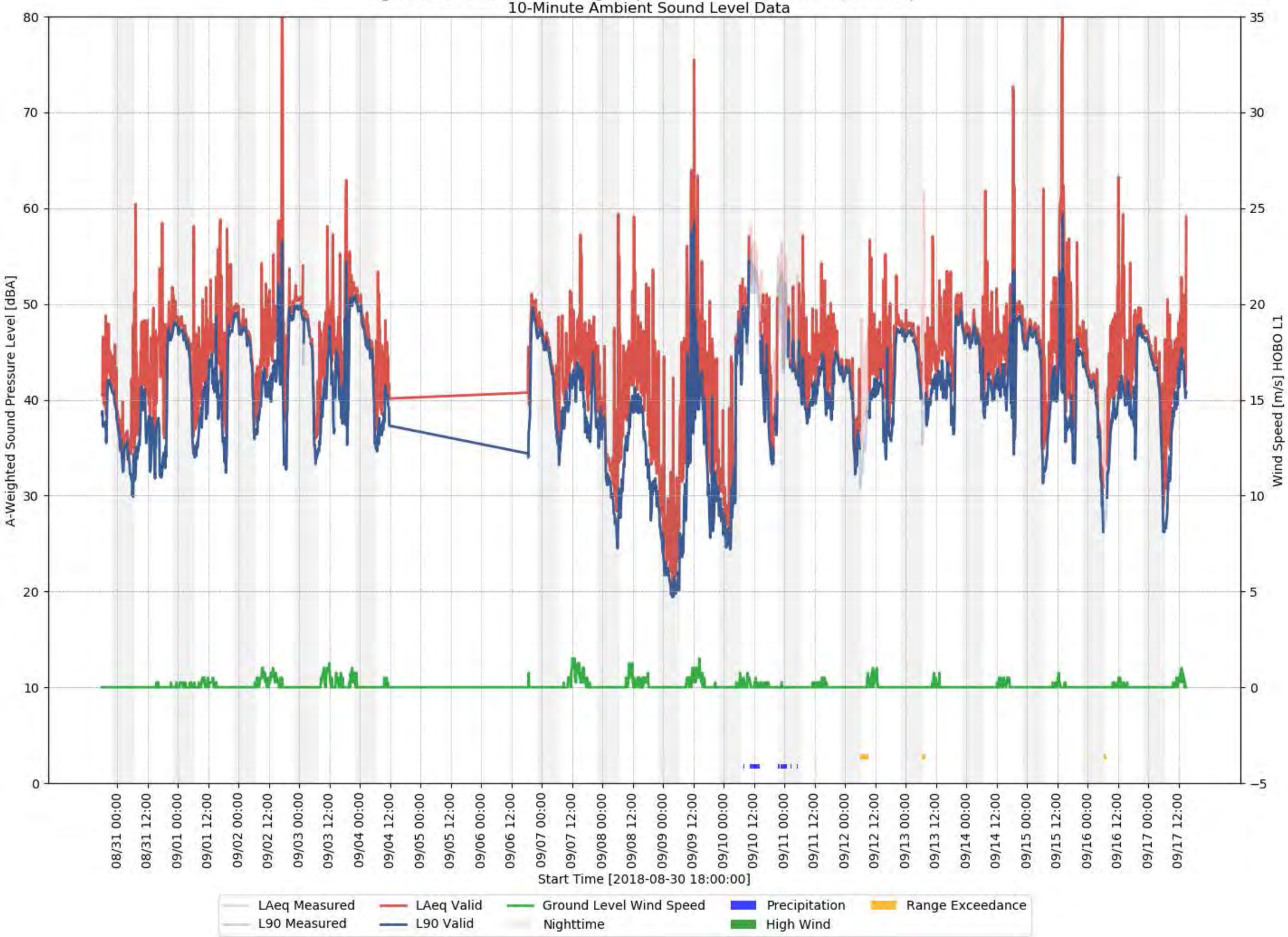


Figure 7-7: Baseline Monitoring Graphical Results - Location 1 - Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

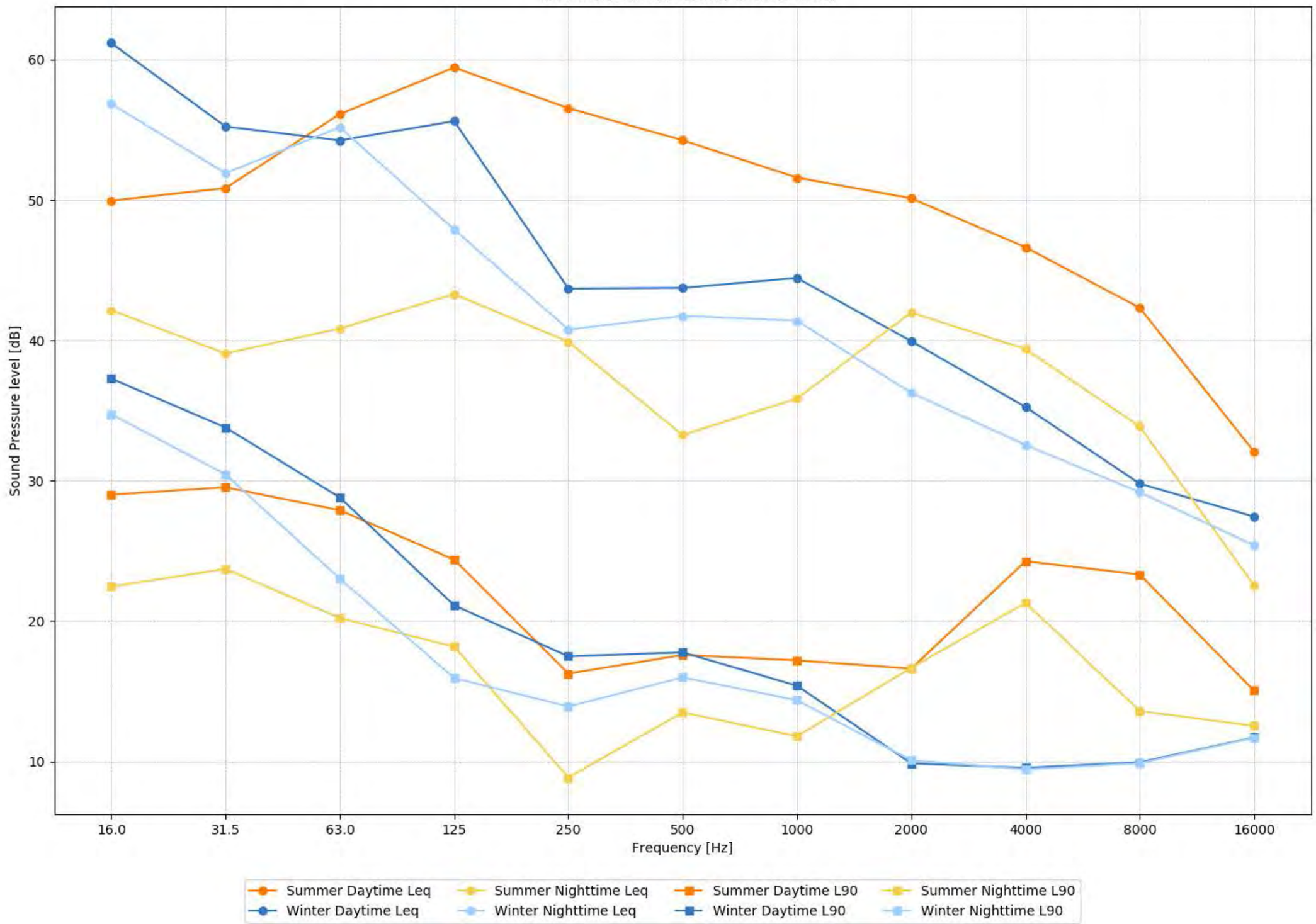


Figure 7-8: Baseline Monitoring Graphical Results - Location 1 - Third Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

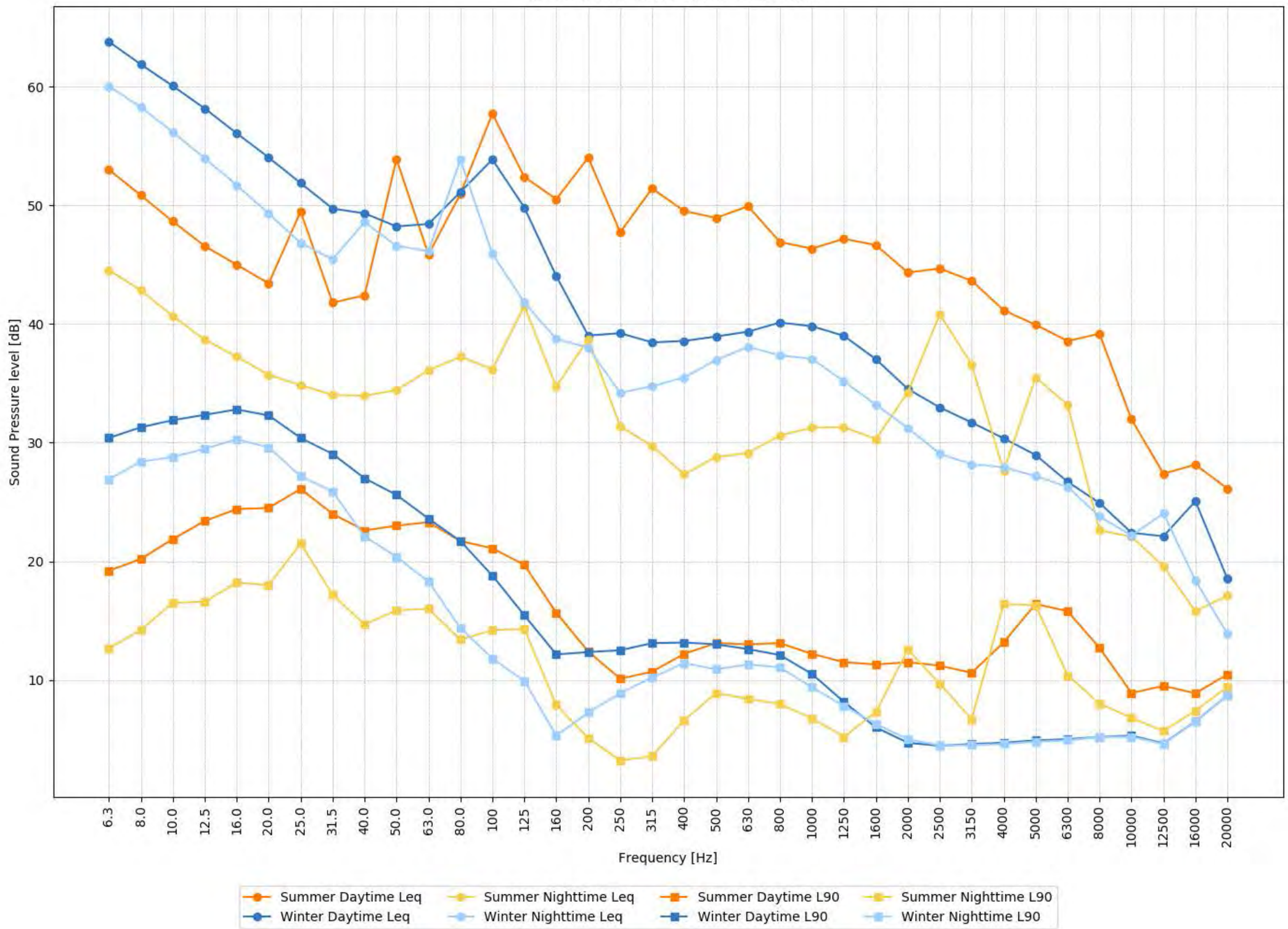


Figure 7-9: Baseline Monitoring Graphical Results - Location 2 (Winter)
10-Minute Ambient Sound Level Data

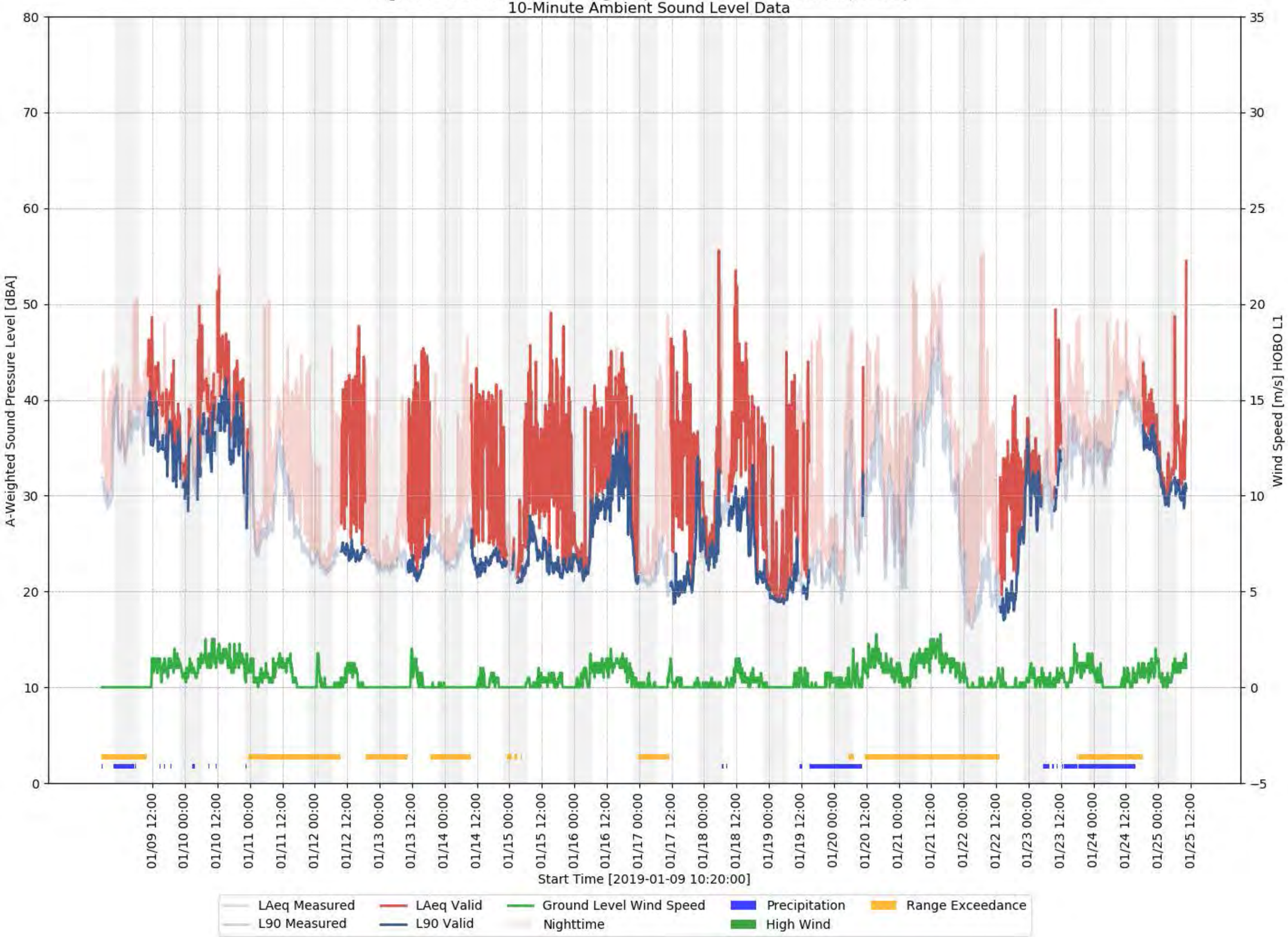


Figure 7-10: Baseline Monitoring Graphical Results - Location 2 (Summer)
10-Minute Ambient Sound Level Data

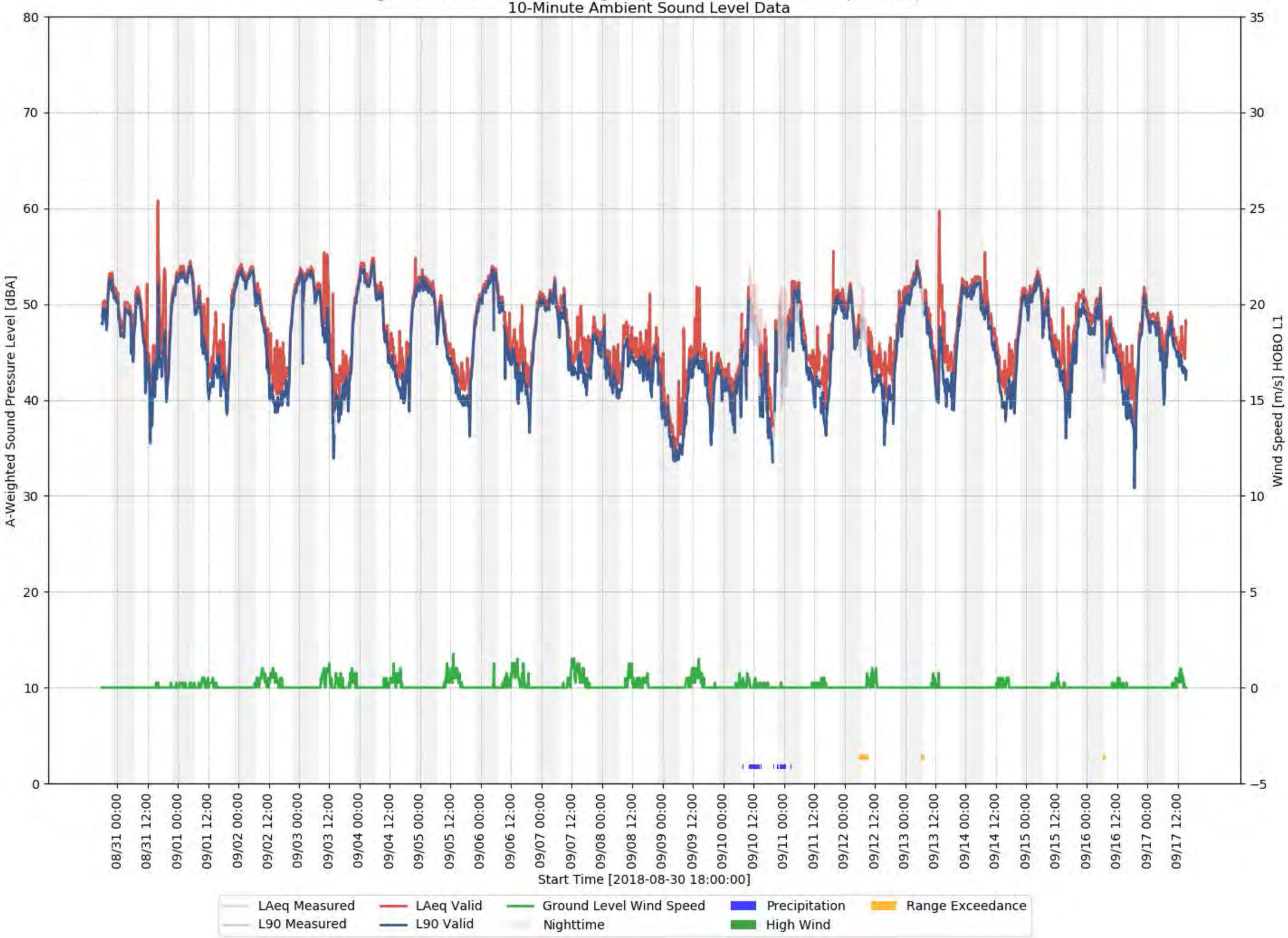


Figure 7-11: Baseline Monitoring Graphical Results - Location 2 - Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

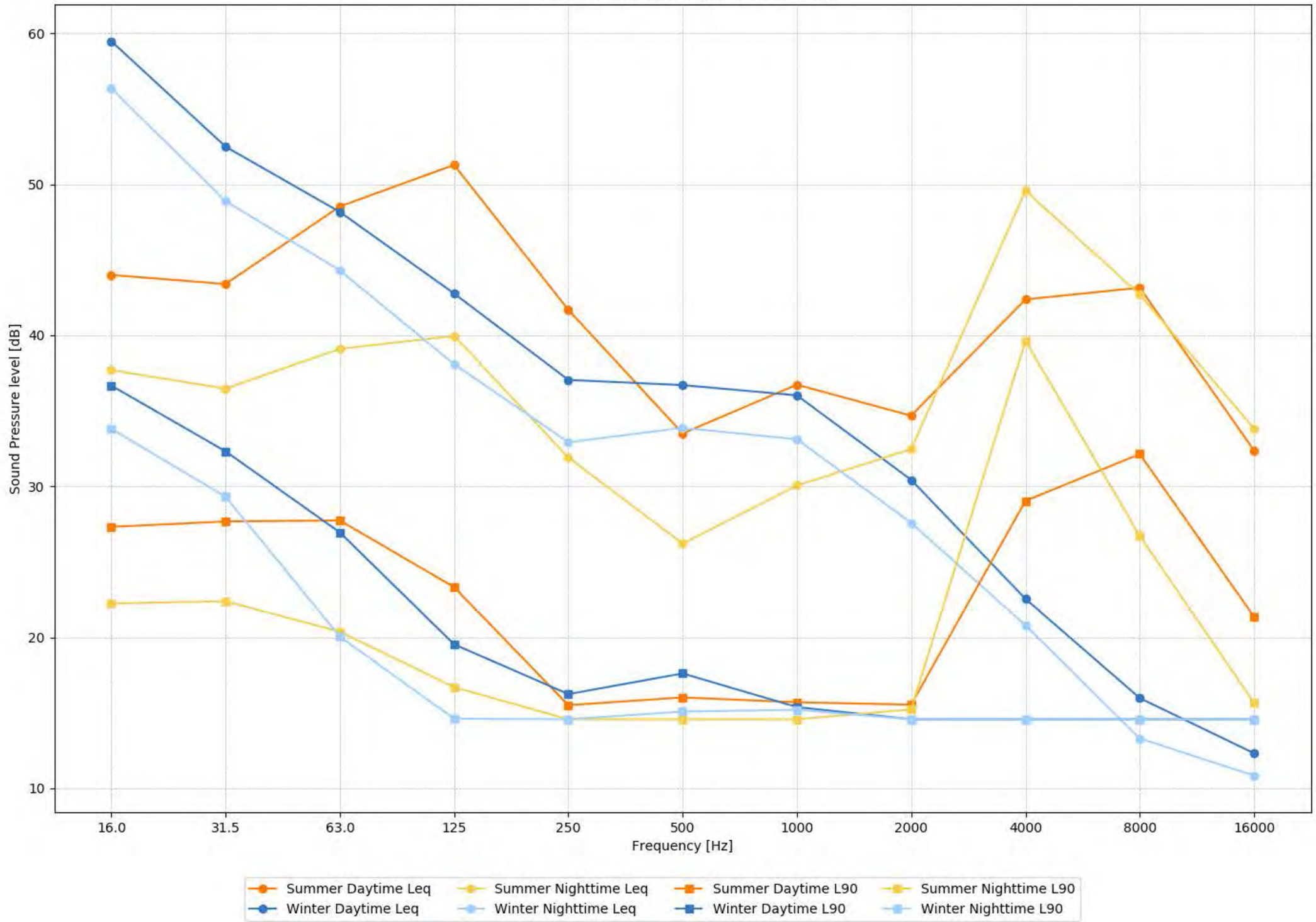


Figure 7-12: Baseline Monitoring Graphical Results - Location 2 - Third Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

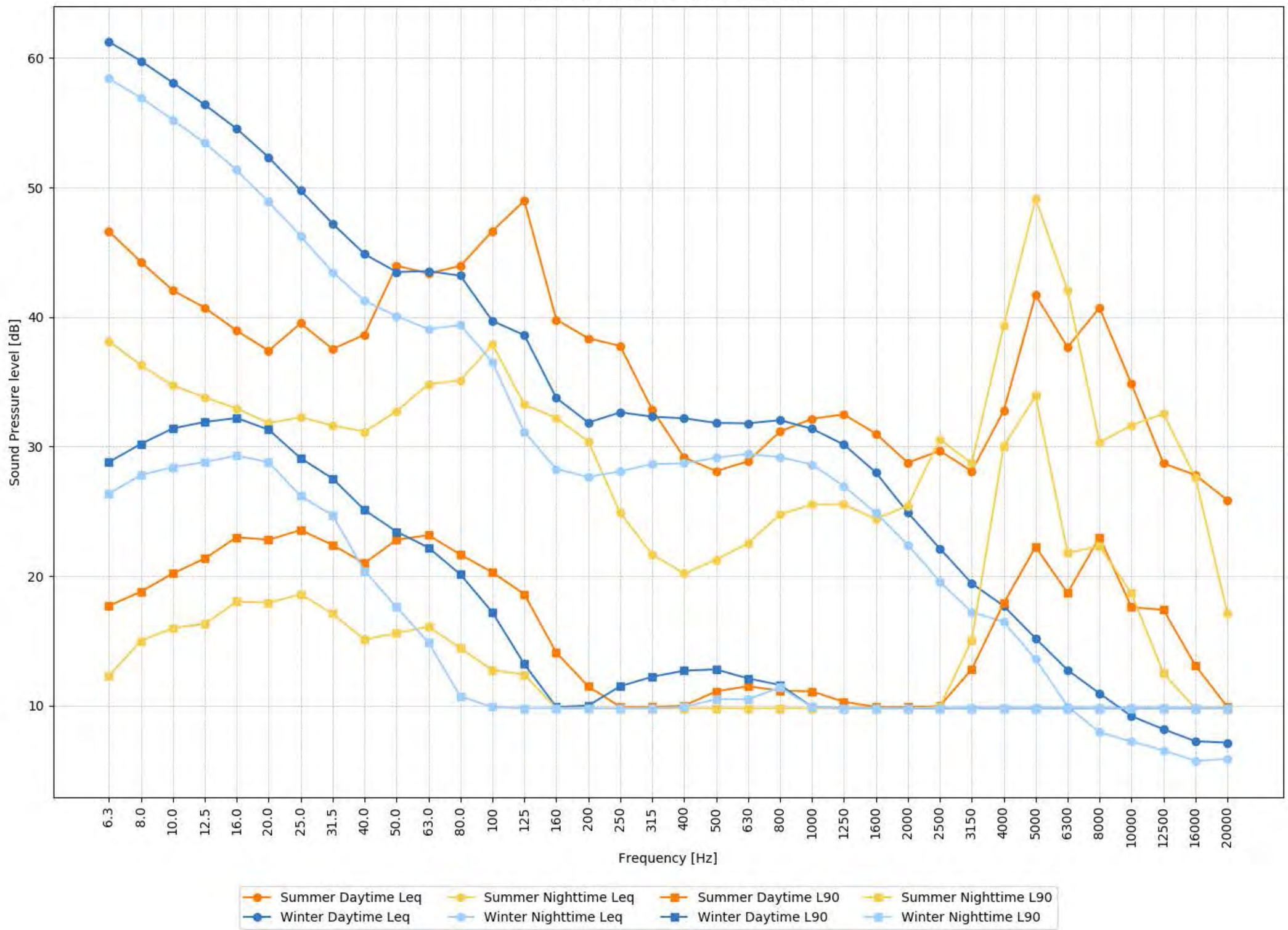


Figure 7-13: Baseline Monitoring Graphical Results - Location 3 (Winter)
10-Minute Ambient Sound Level Data

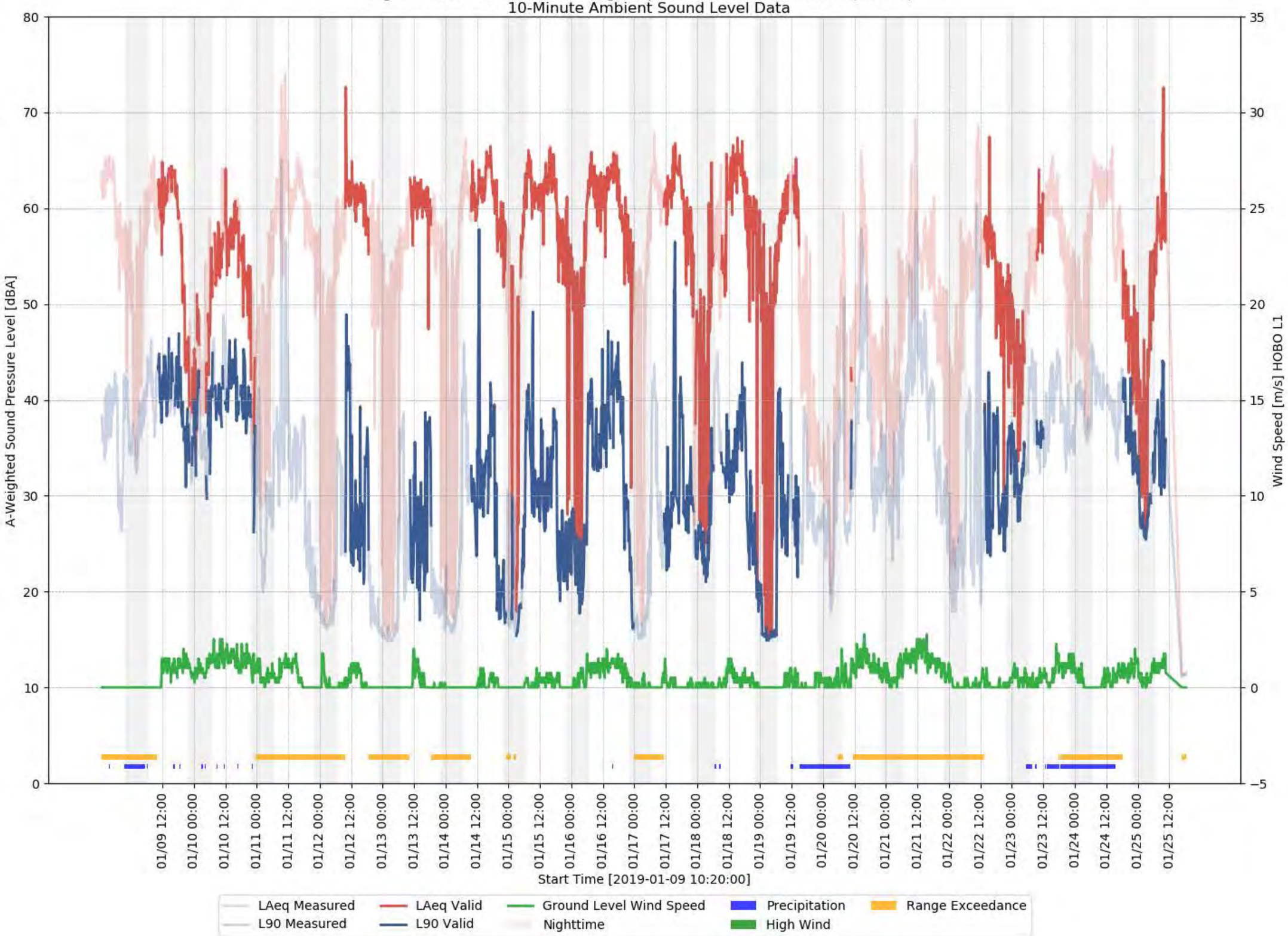


Figure 7-14: Baseline Monitoring Graphical Results - Location 3 (Summer)
10-Minute Ambient Sound Level Data

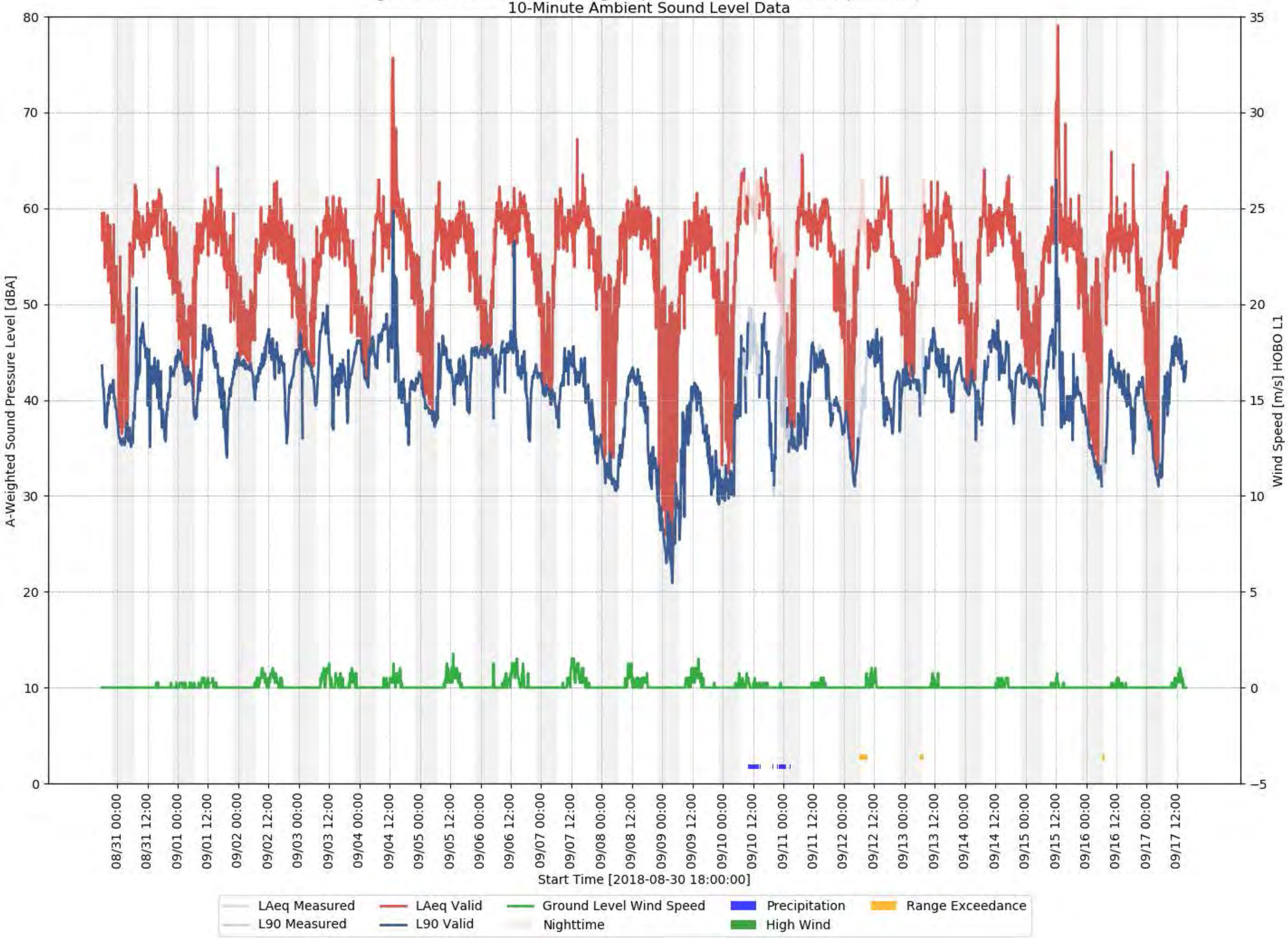


Figure 7-15: Baseline Monitoring Graphical Results - Location 3 - Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

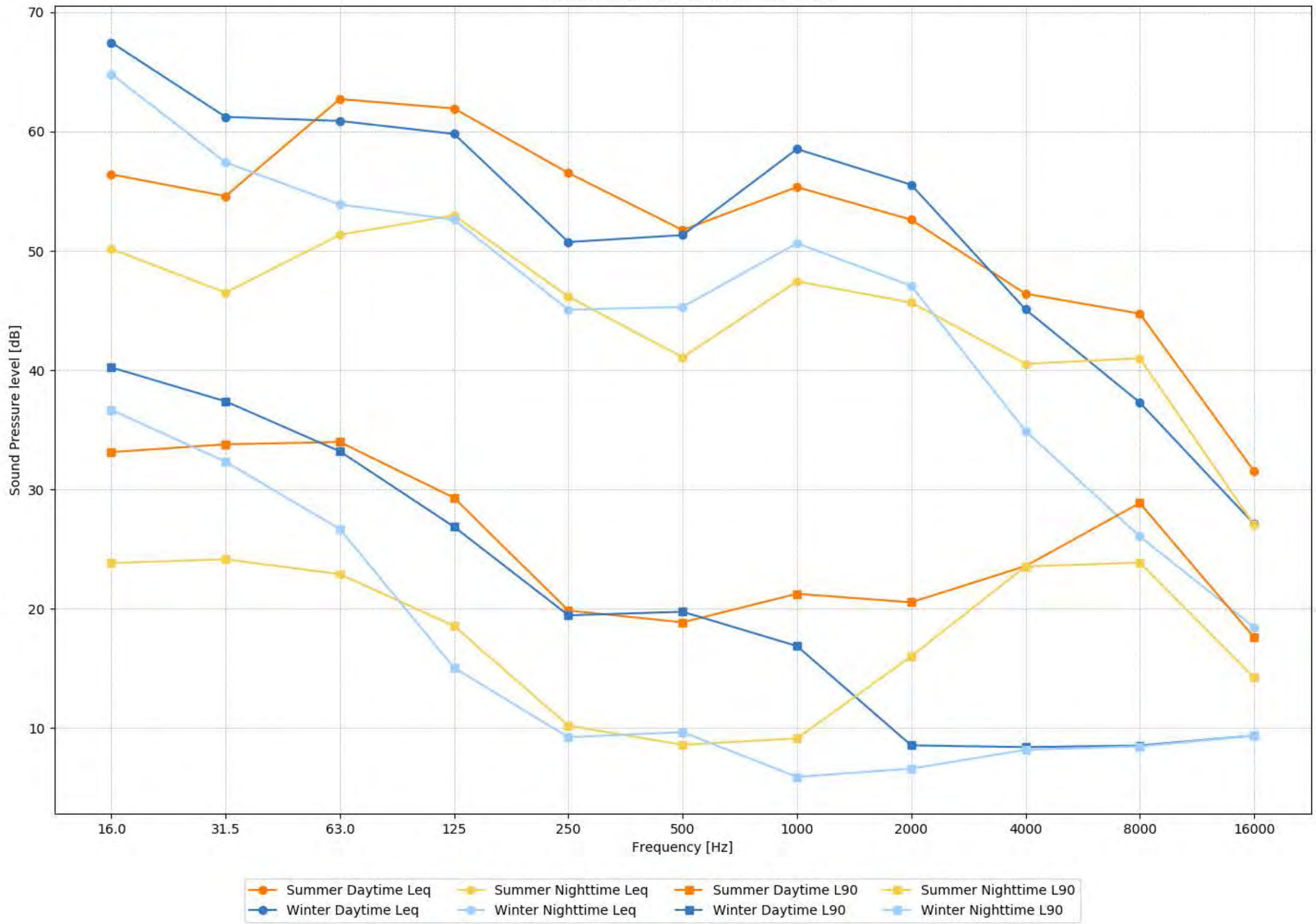


Figure 7-16: Baseline Monitoring Graphical Results - Location 3 - Third Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

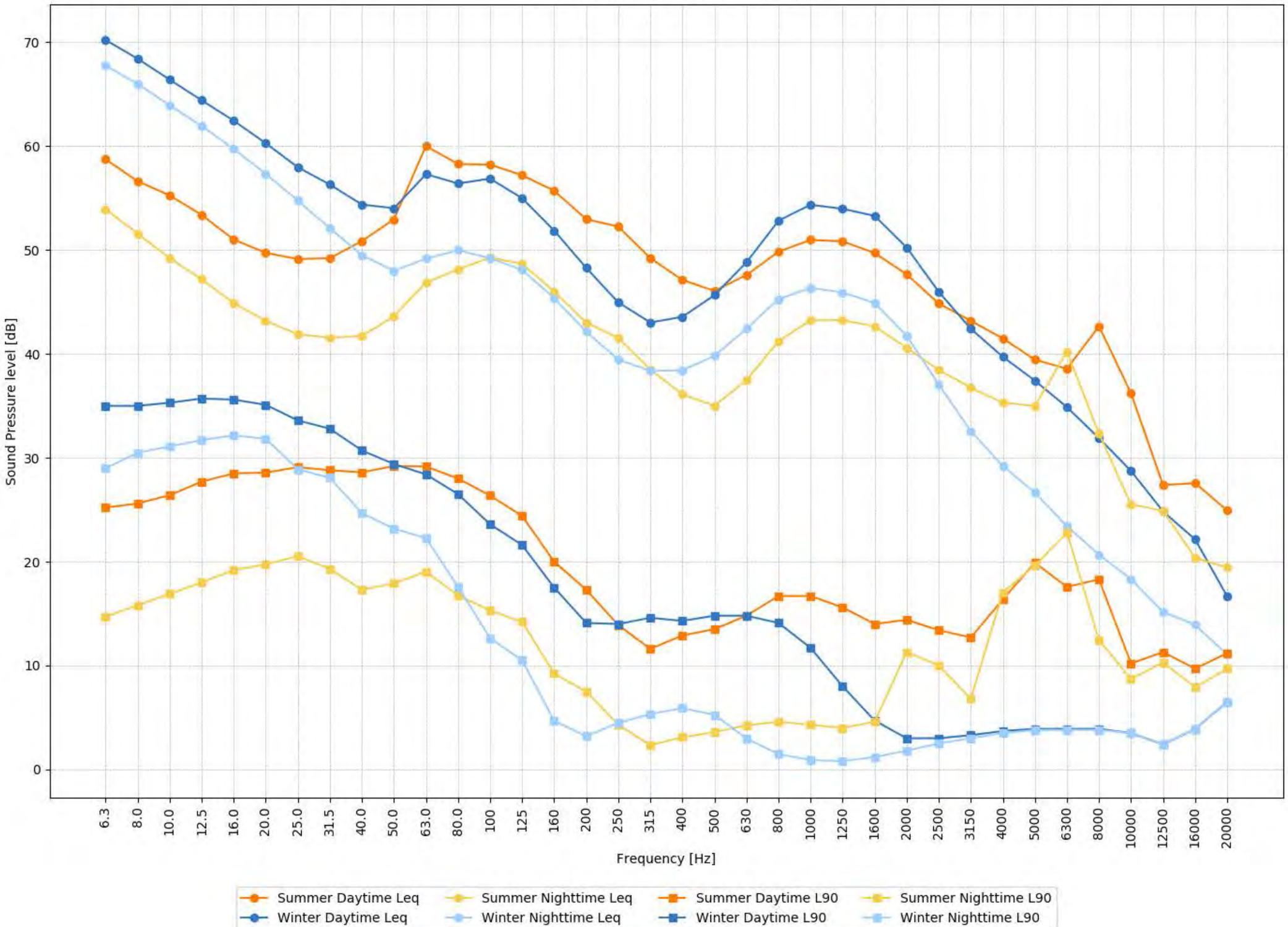


Figure 7-17: Baseline Monitoring Graphical Results - Location 4 (Winter)
10-Minute Ambient Sound Level Data

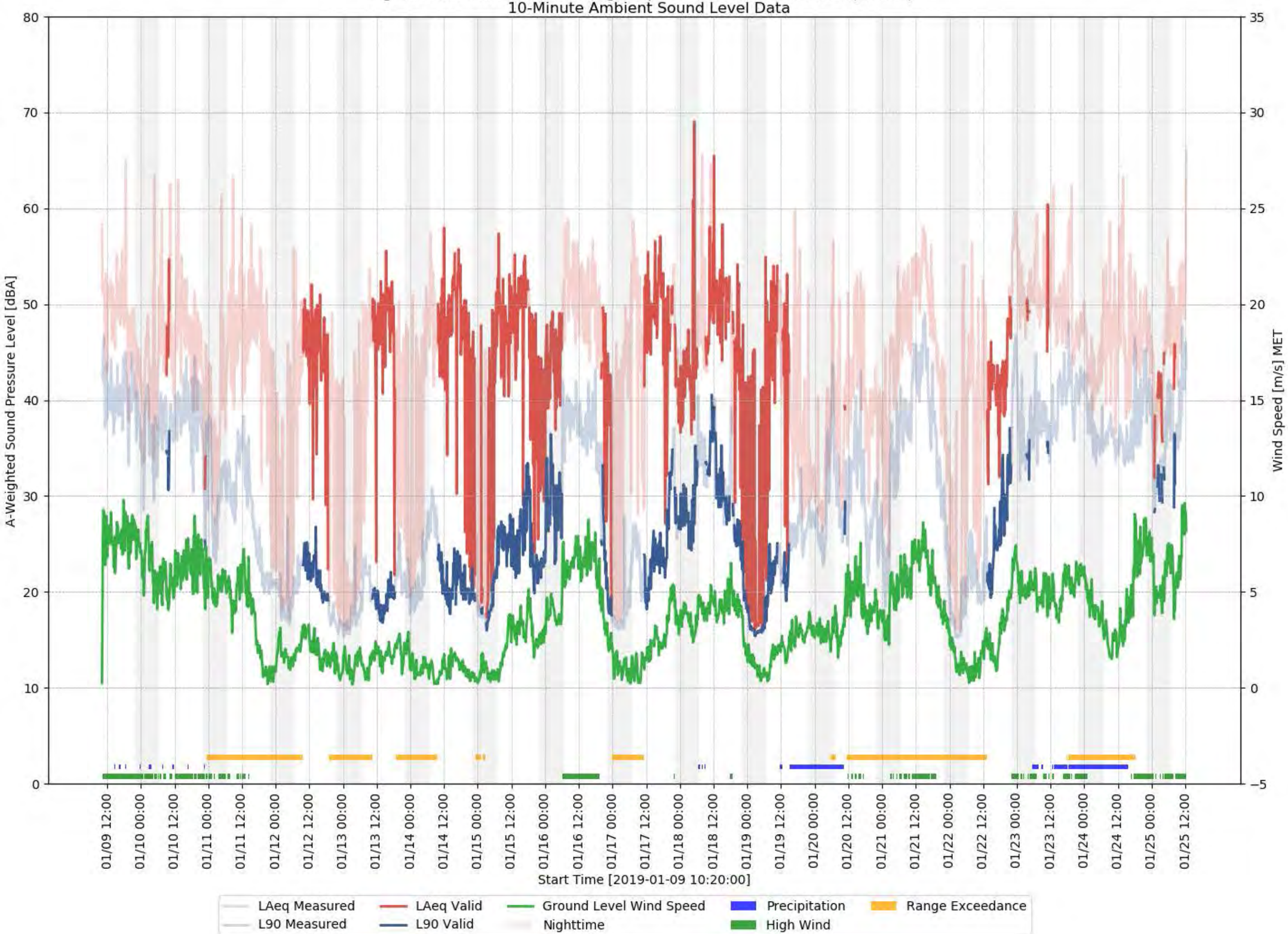


Figure 7-18: Baseline Monitoring Graphical Results - Location 4 (Summer)
10-Minute Ambient Sound Level Data

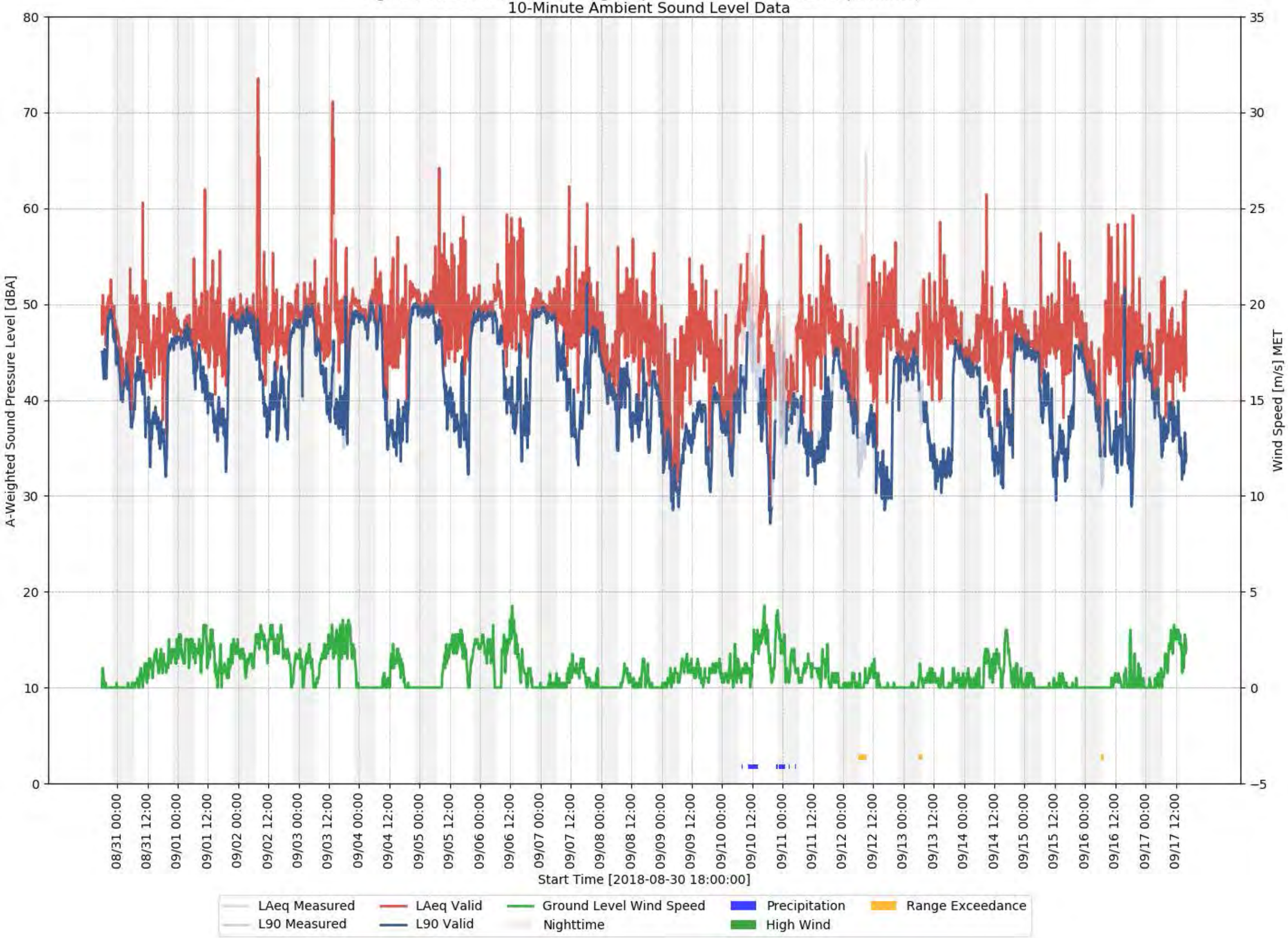


Figure 7-19: Baseline Monitoring Graphical Results - Location 4 - Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

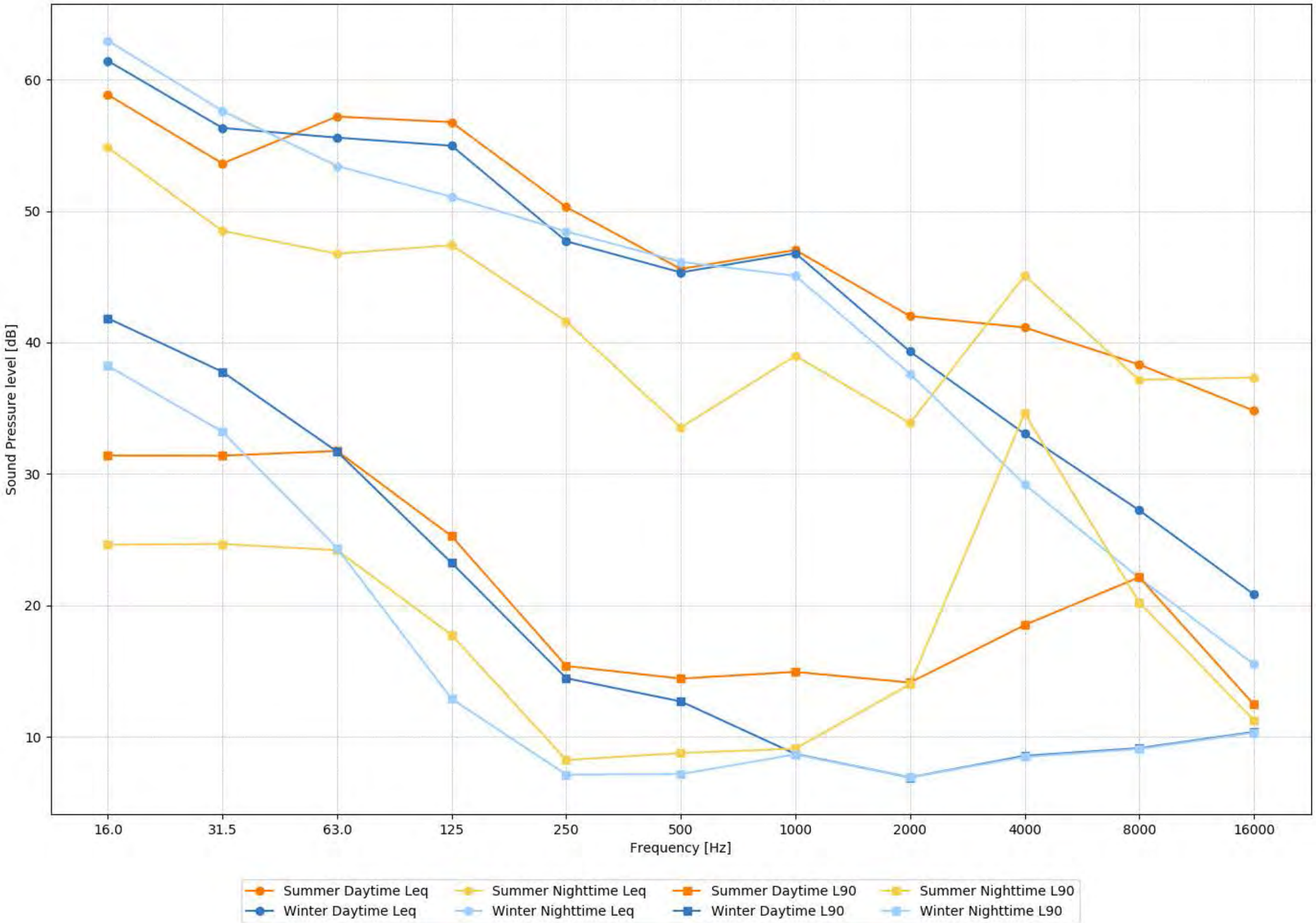


Figure 7-20: Baseline Monitoring Graphical Results - Location 4 - Third Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

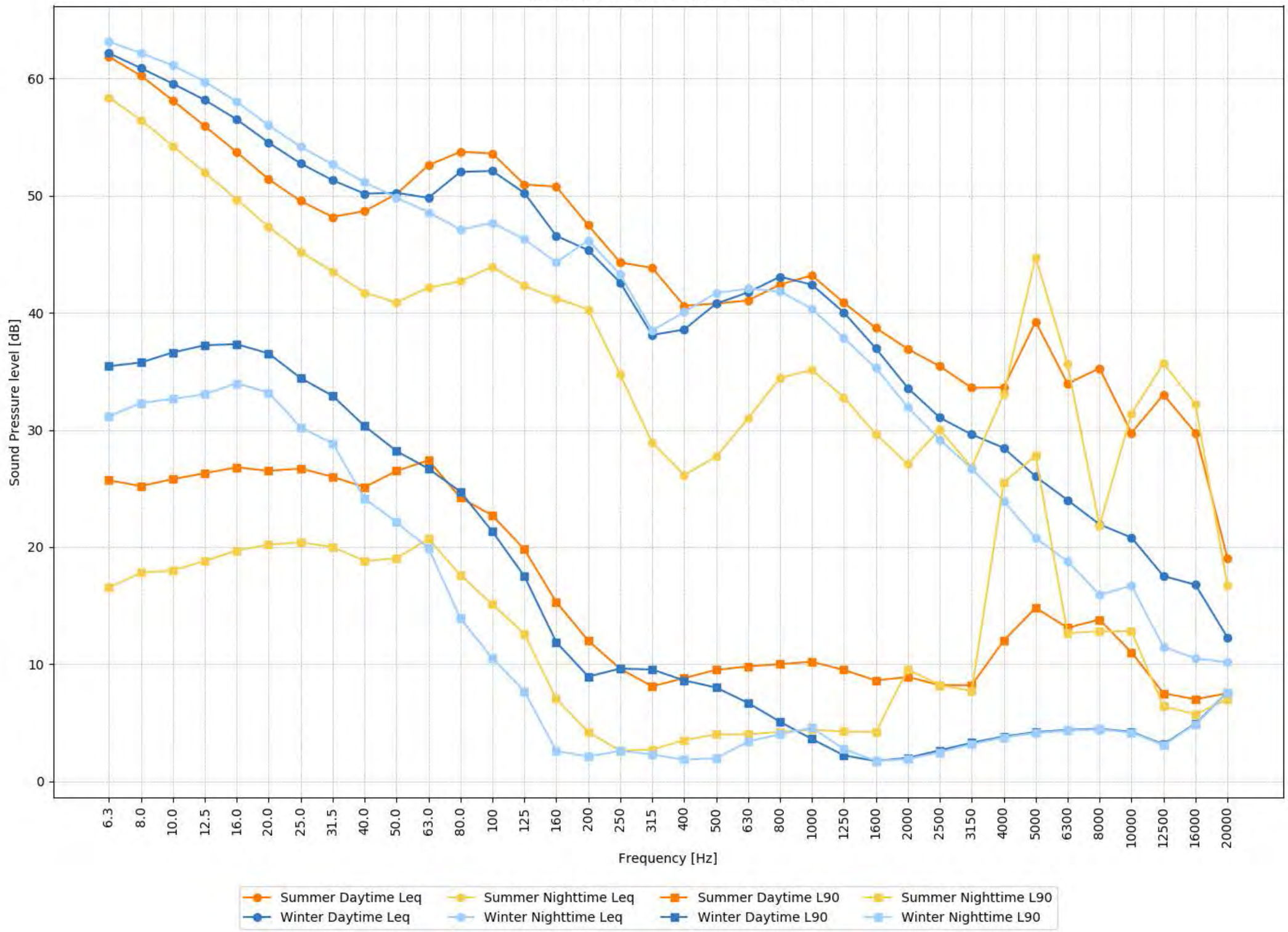


Figure 7-21: Baseline Monitoring Graphical Results - Location 5 (Winter)
10-Minute Ambient Sound Level Data

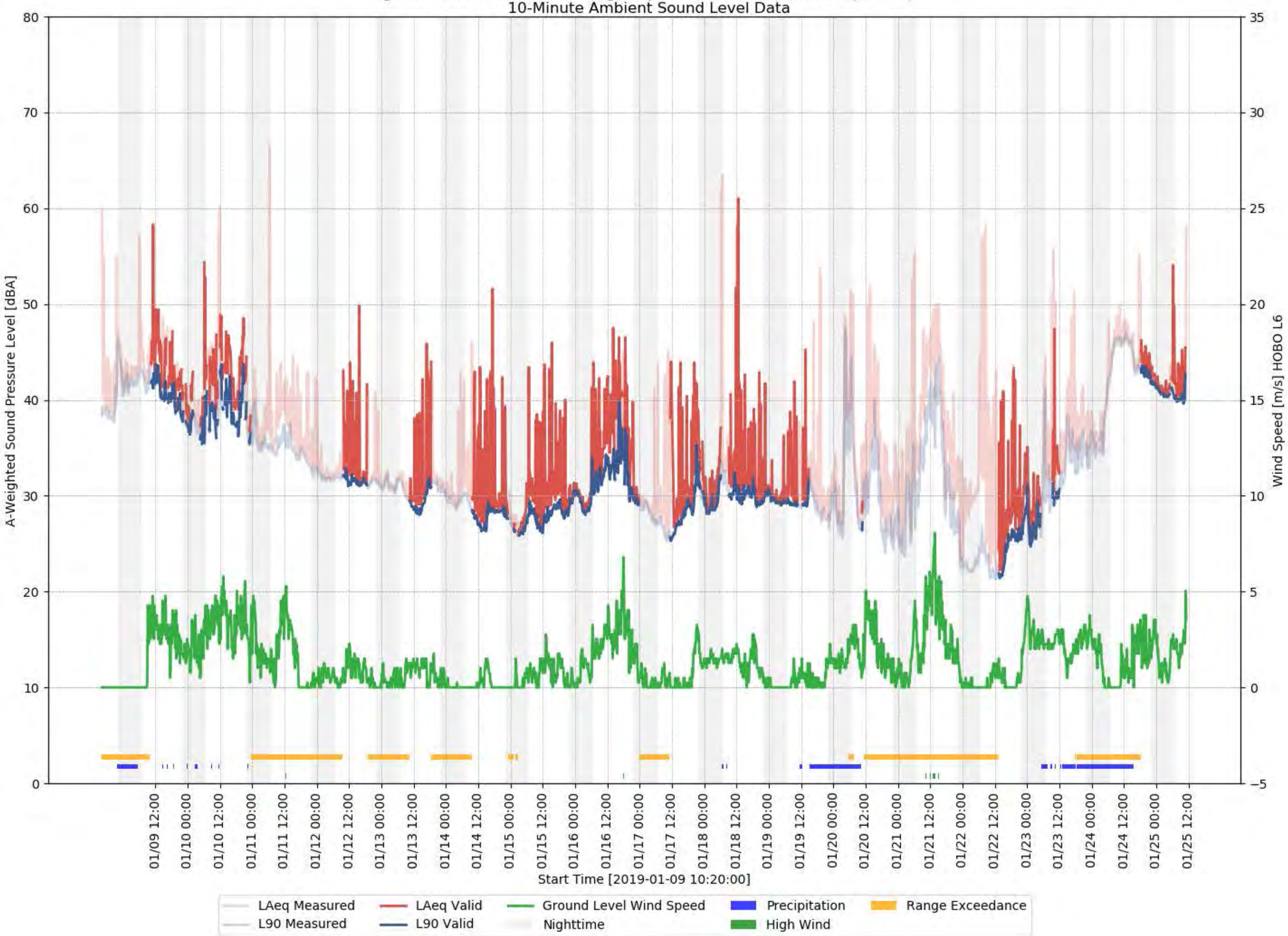


Figure 7-22: Baseline Monitoring Graphical Results - Location 5 (Summer)
10-Minute Ambient Sound Level Data

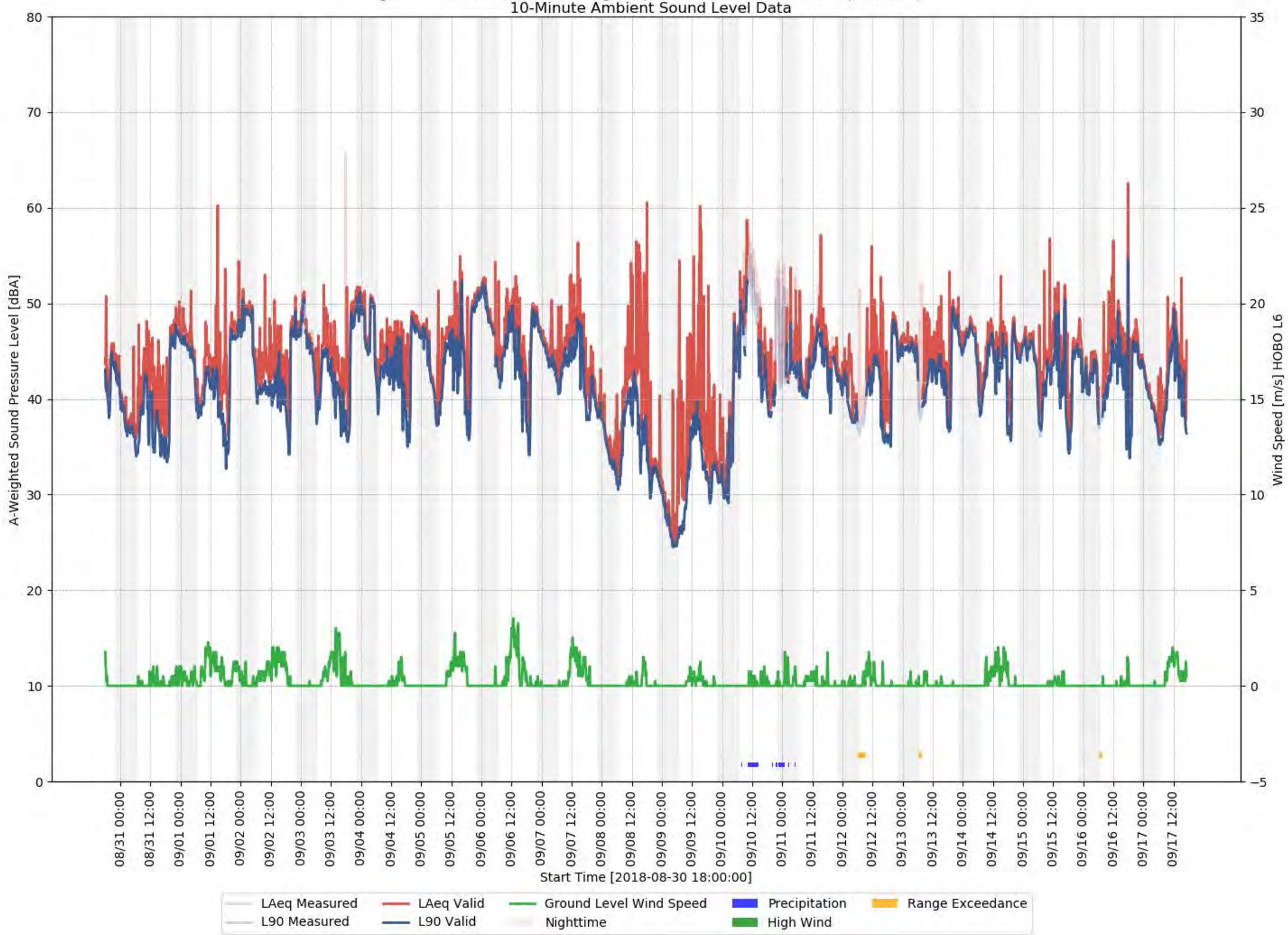


Figure 7-23: Baseline Monitoring Graphical Results - Location 5 - Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

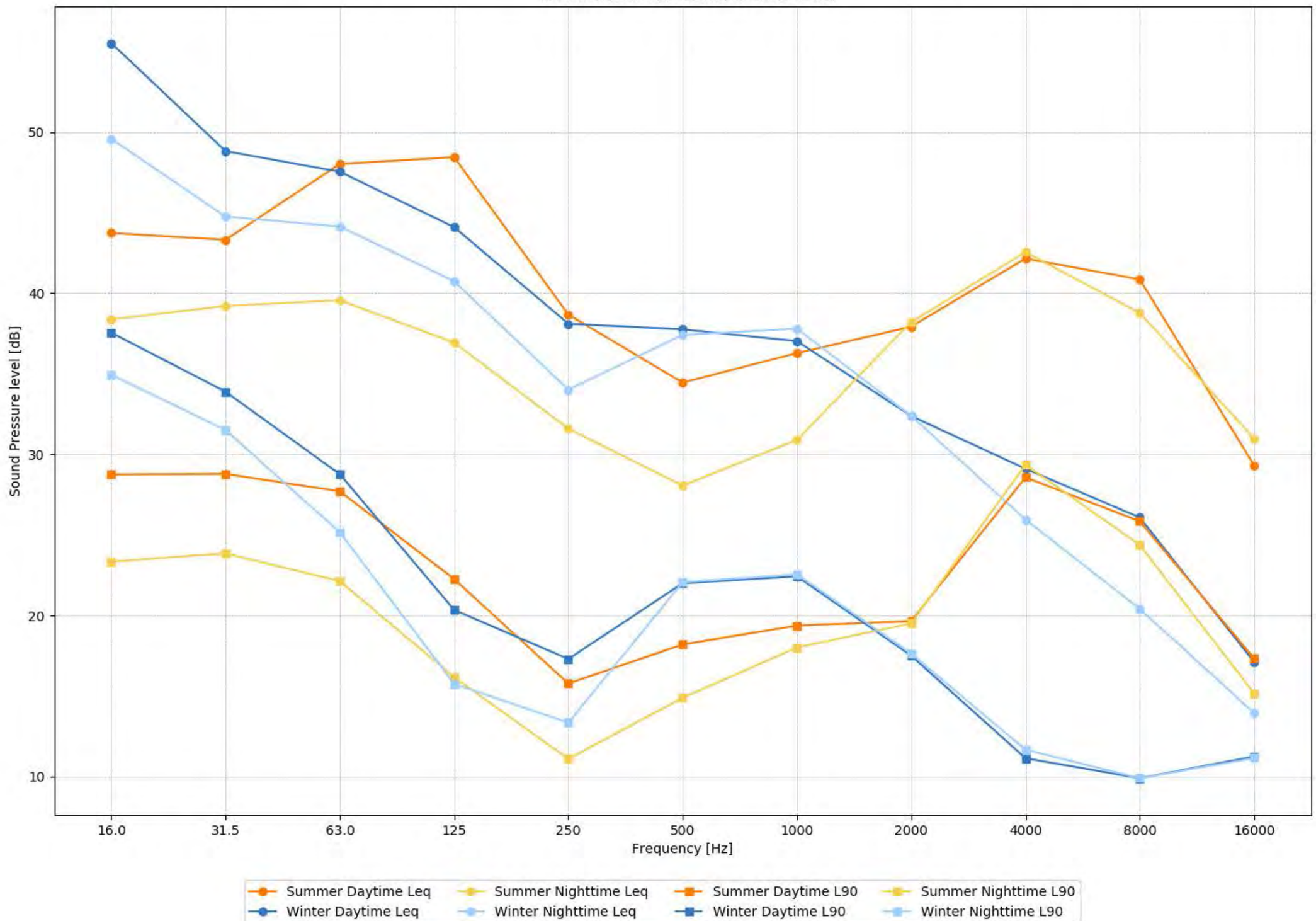


Figure 7-24: Baseline Monitoring Graphical Results - Location 5 - Third Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

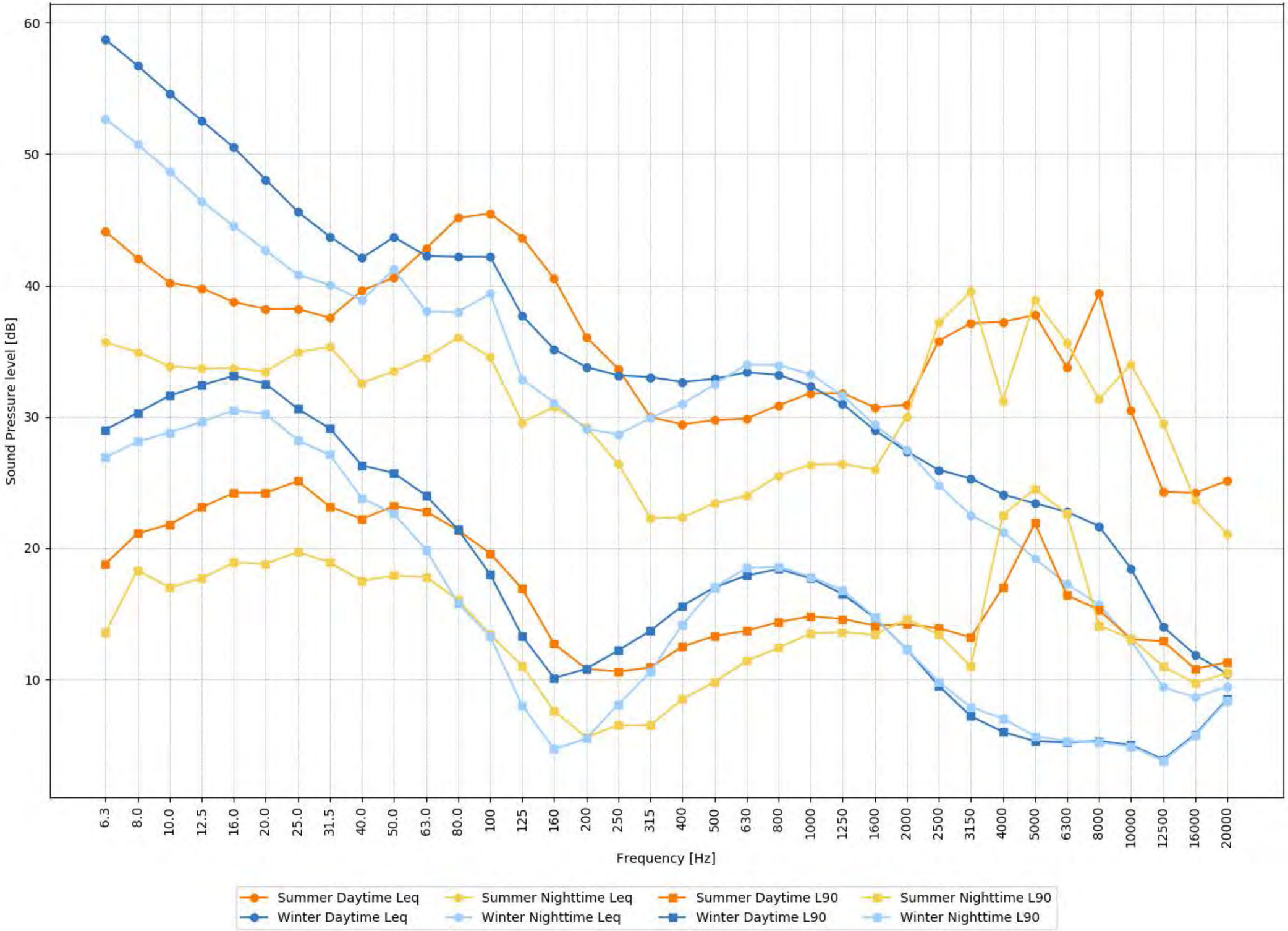


Figure 7-25: Baseline Monitoring Graphical Results - Location 6 (Winter)
10-Minute Ambient Sound Level Data

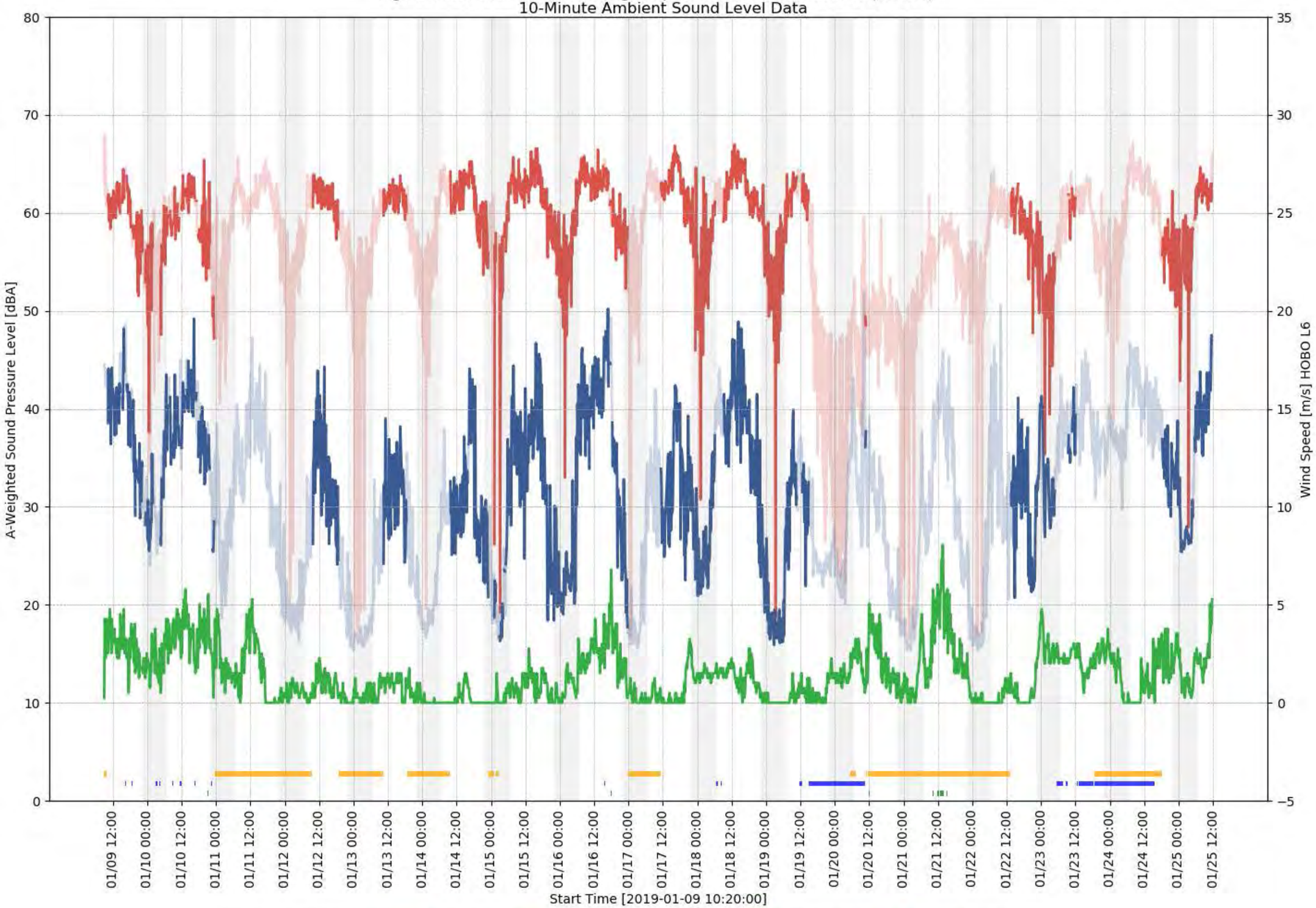


Figure 7-26: Baseline Monitoring Graphical Results - Location 6 (Summer)
10-Minute Ambient Sound Level Data

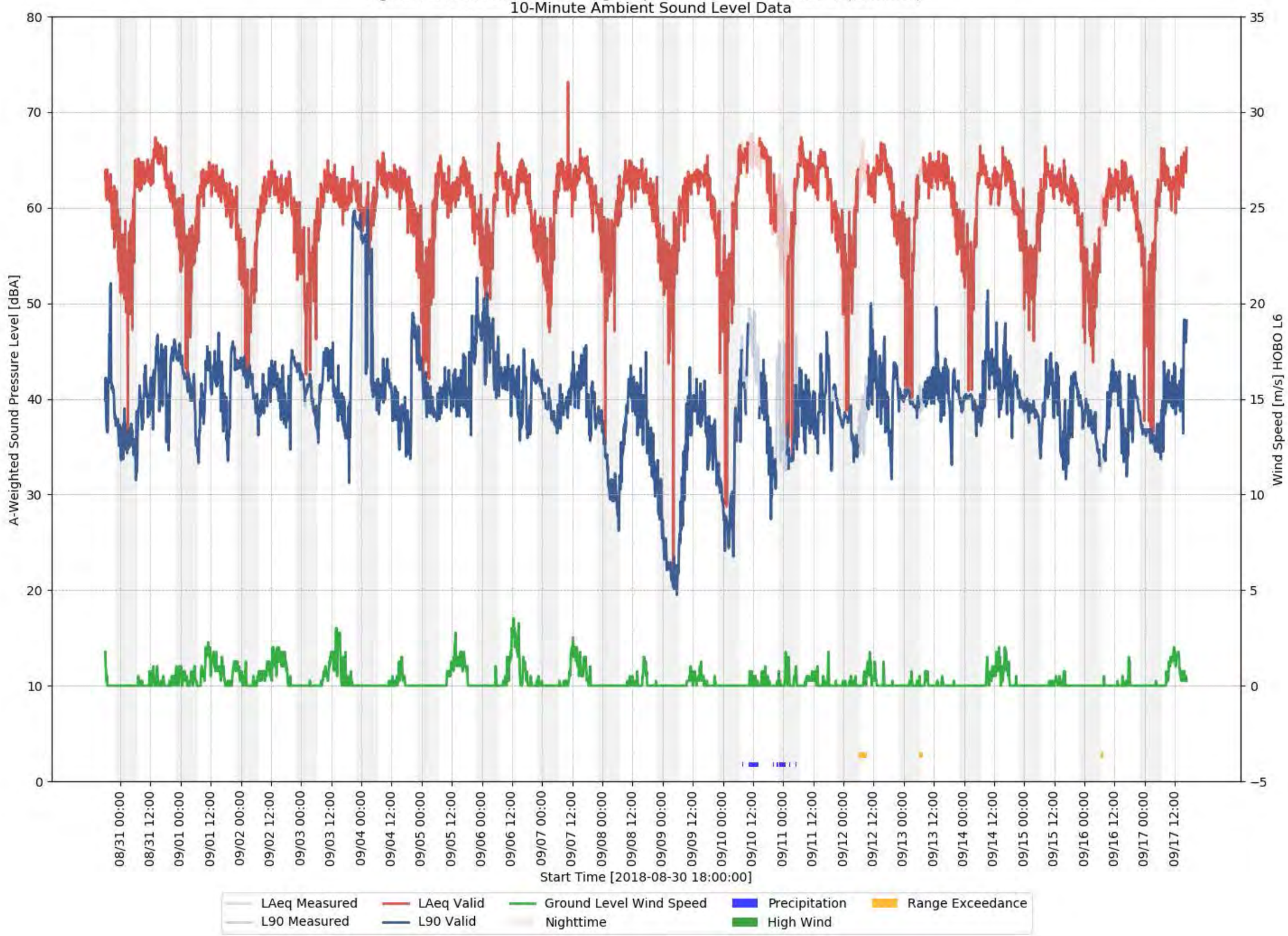


Figure 7-27: Baseline Monitoring Graphical Results - Location 6 - Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

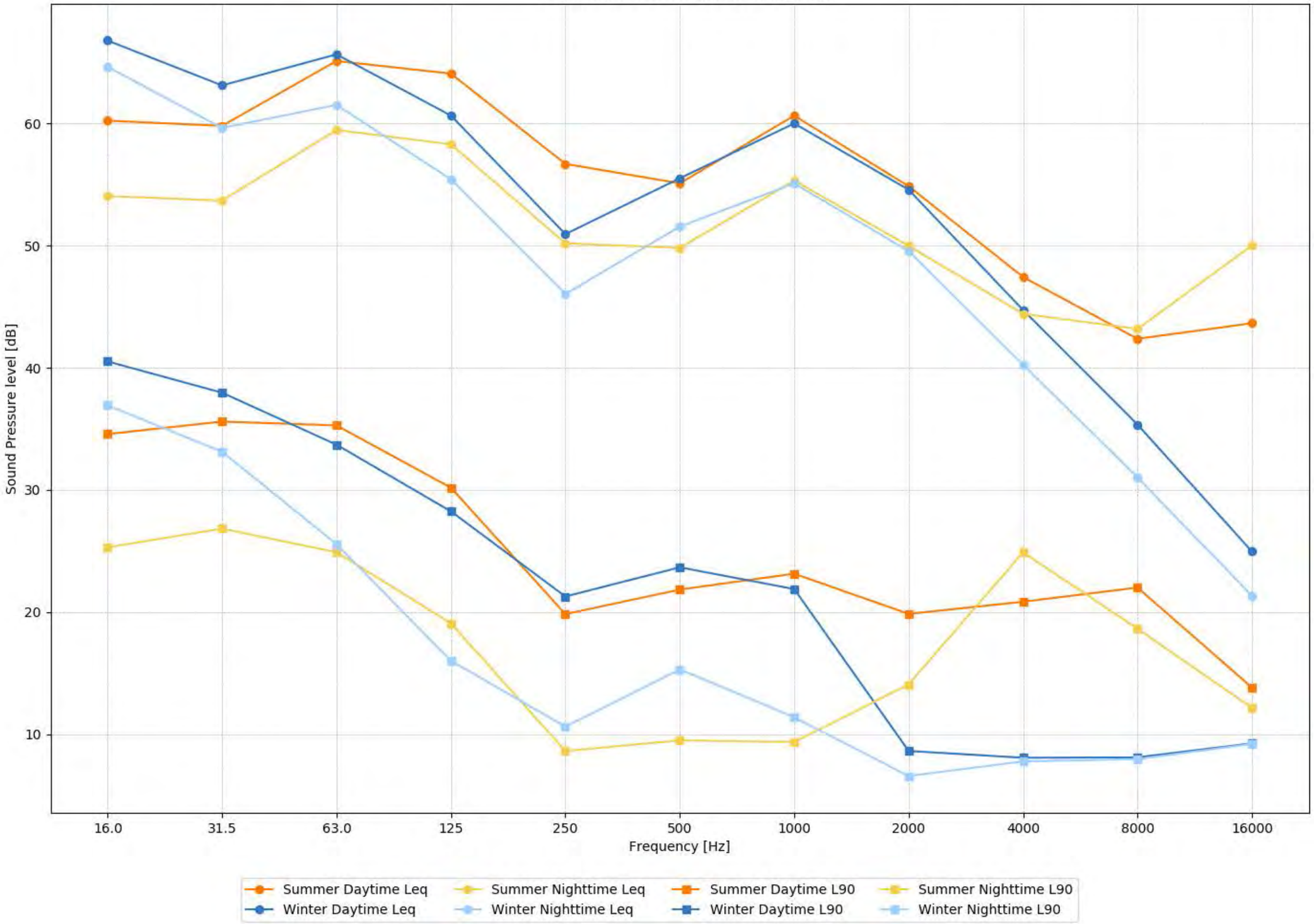


Figure 7-28: Baseline Monitoring Graphical Results - Location 6 - Third Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

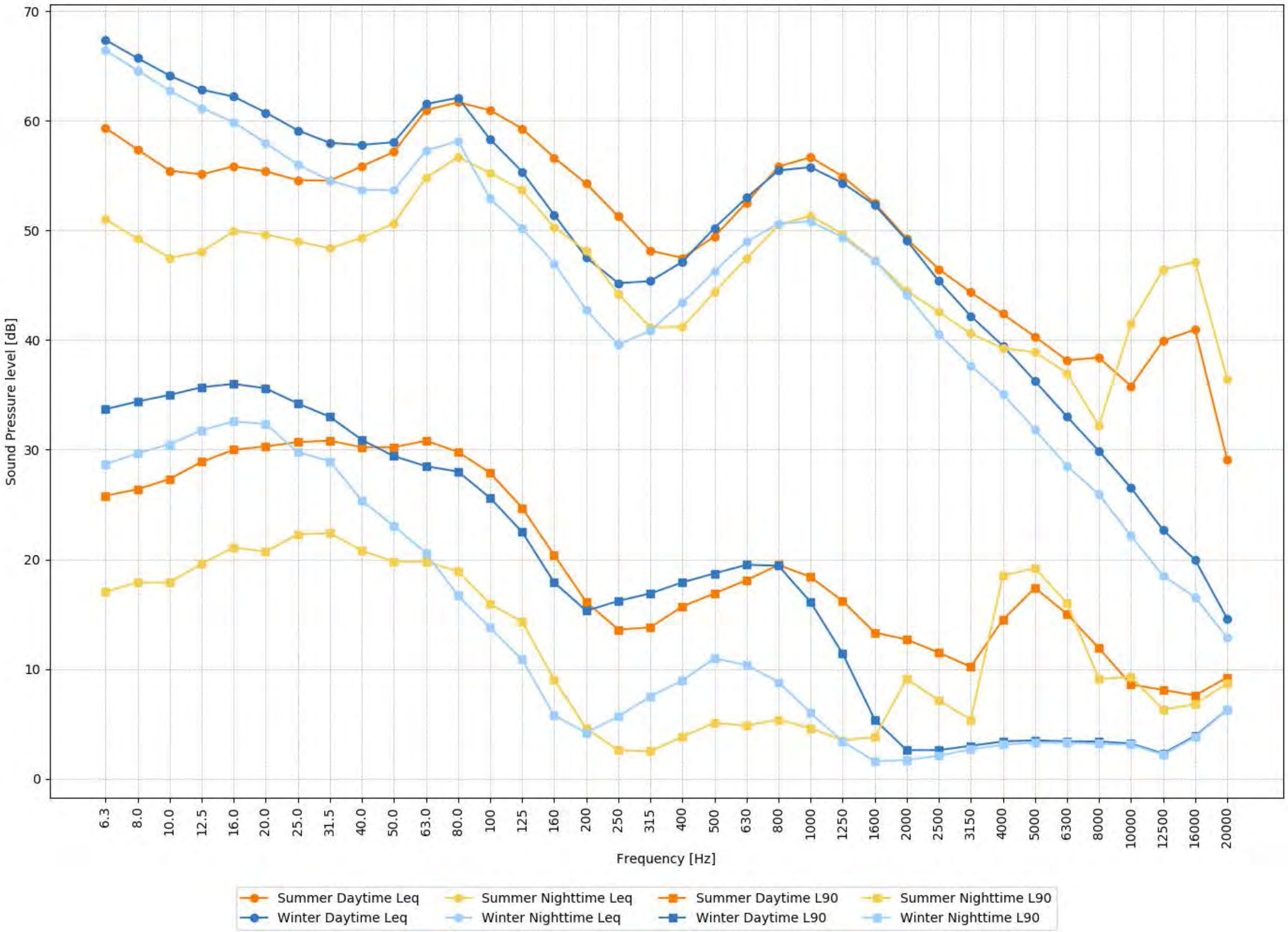


Figure 7-29: Baseline Monitoring Graphical Results - Location 7 (Winter)
10-Minute Ambient Sound Level Data

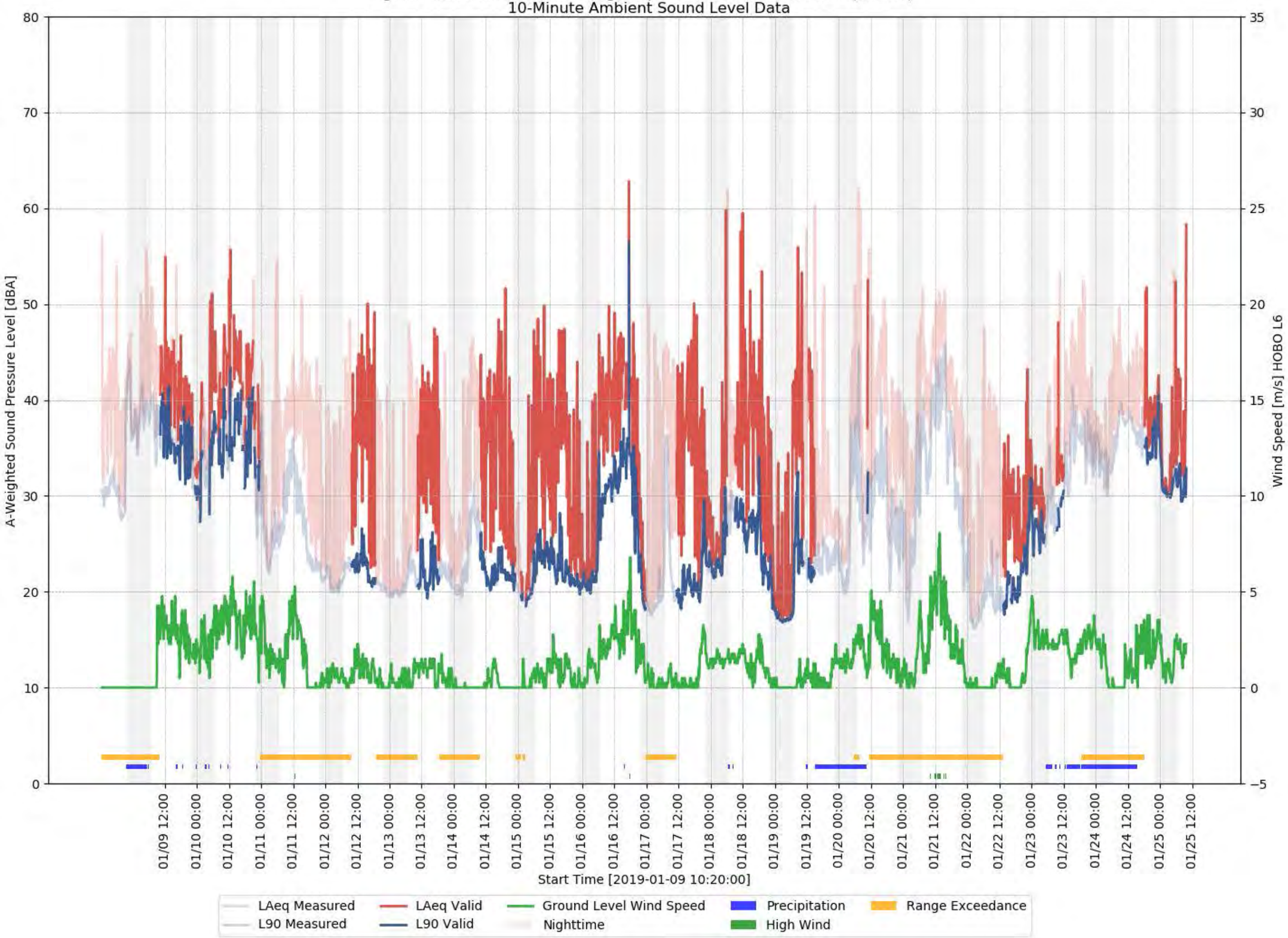


Figure 7-30: Baseline Monitoring Graphical Results - Location 7 (Summer)
10-Minute Ambient Sound Level Data

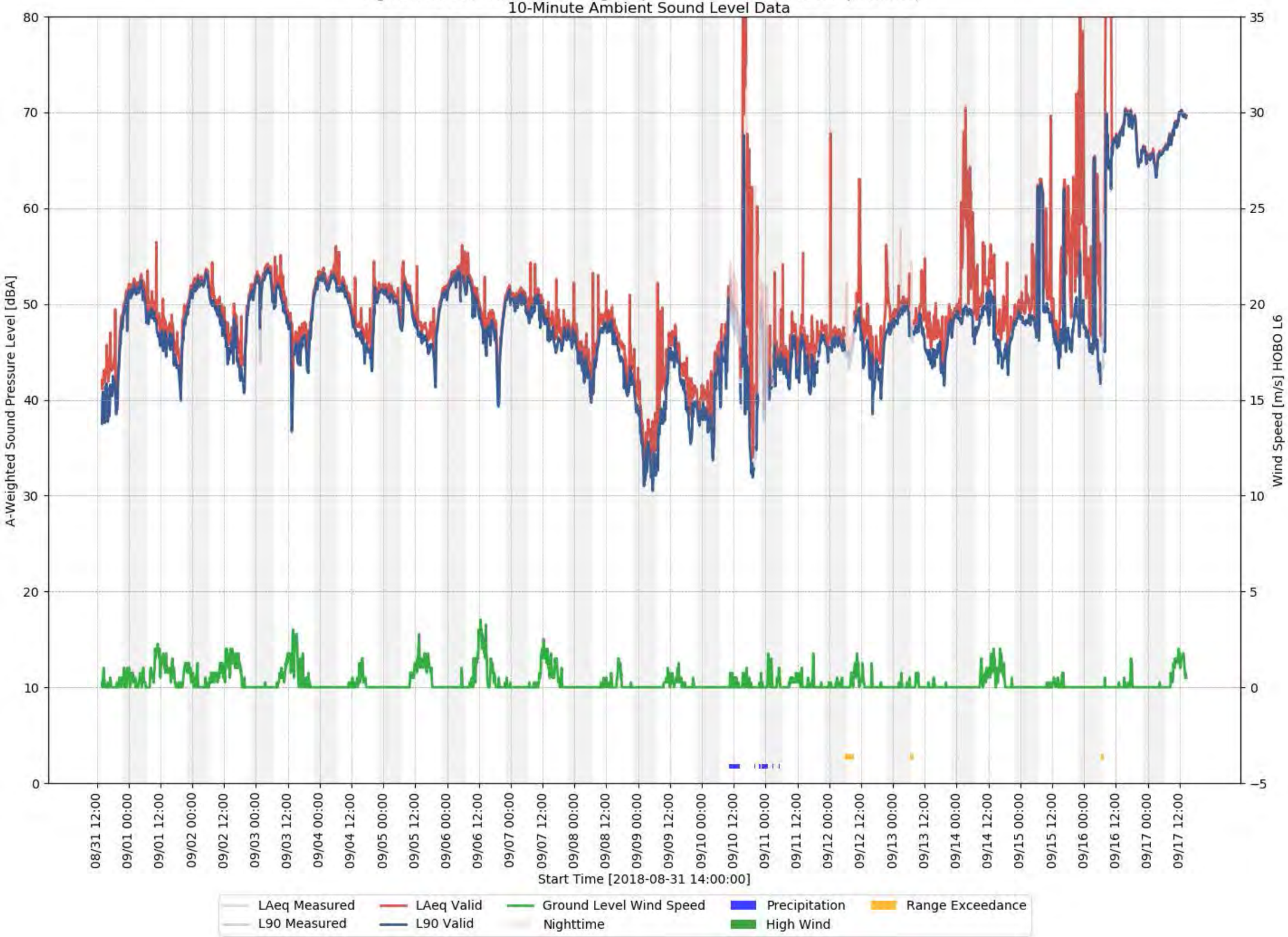


Figure 7-31: Baseline Monitoring Graphical Results - Location 7 - Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data

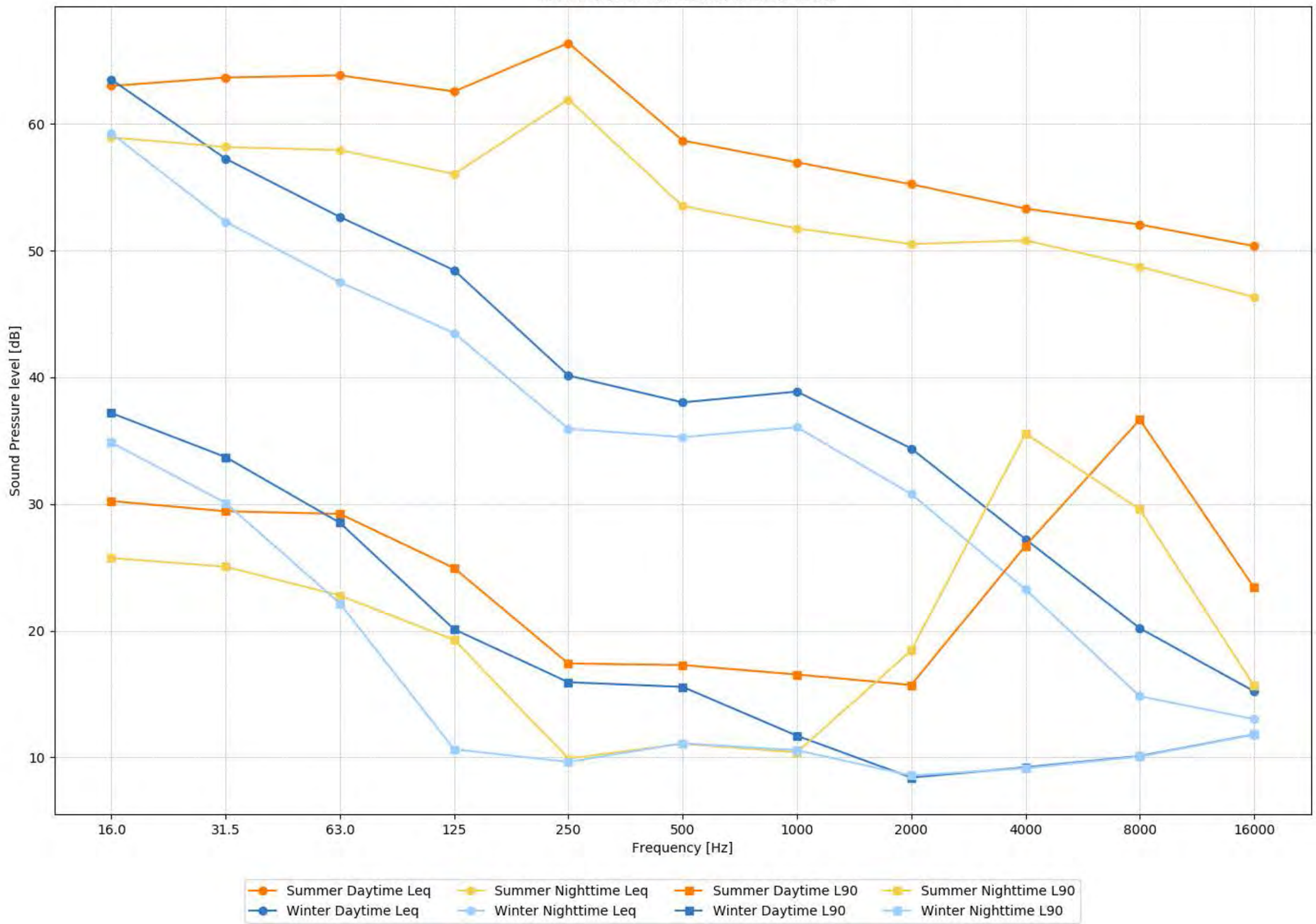
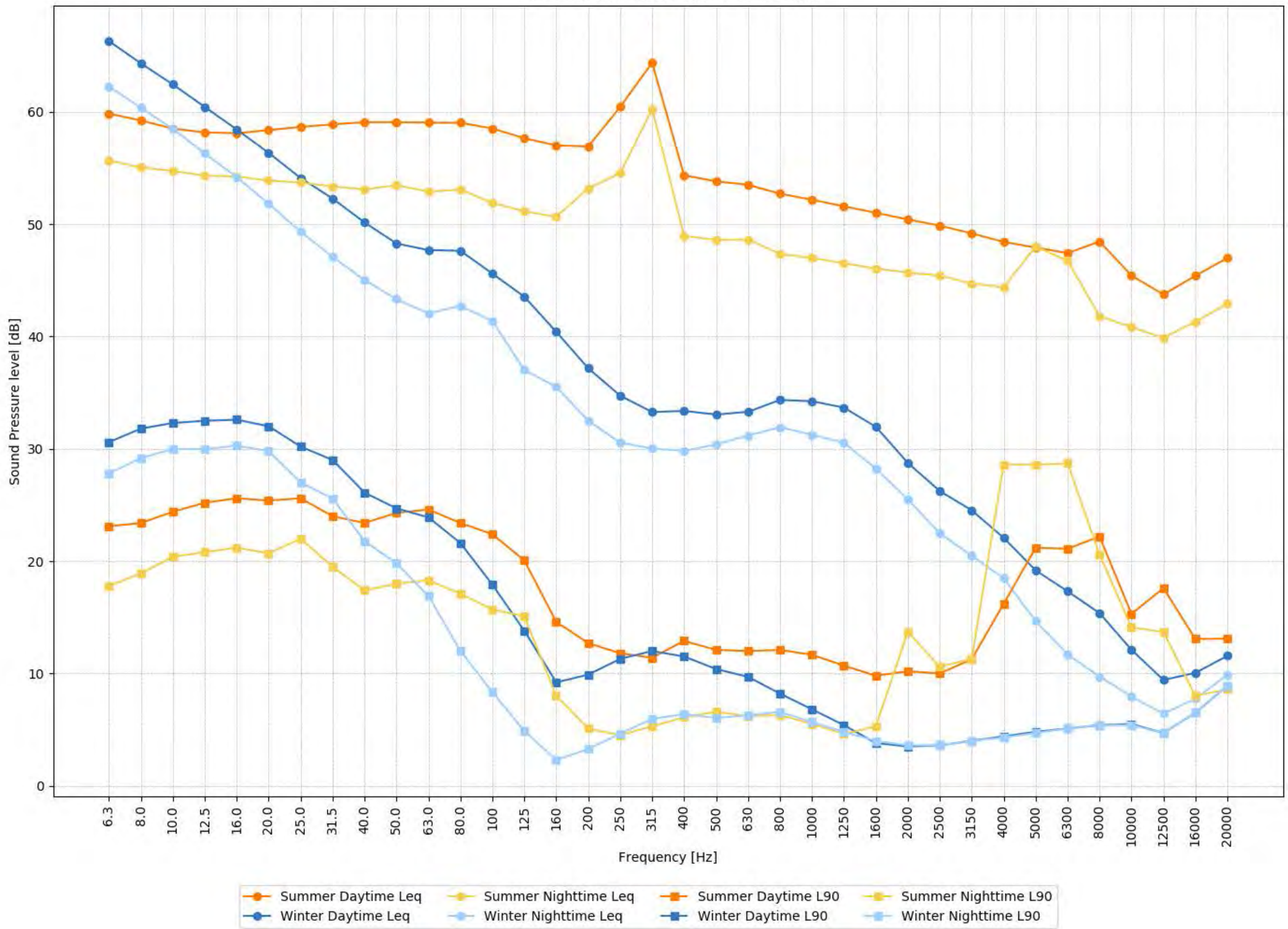


Figure 7-32: Baseline Monitoring Graphical Results - Location 7 - Third Octave Band Sound Pressure Levels
10-Minute Ambient Sound Level Data



Chapter 8.0

Seasonal Sound Level Monitoring Summary

8.0 SEASONAL SOUND LEVEL MONITORING SUMMARY

A two-season baseline monitoring program was performed for High Bridge Wind in 2018 and 2019 to characterize the existing sound level environment around the Project area. 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 "as-measured" broadband levels within each table. Only valid[41] 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 L_{90} sound levels are shown below in Table 8-1, as per the Project's understanding of the required DPS scope of studies. Values are separated by monitoring season as well as for both seasons combined. These values represent the L_{90} of the measured L_{90} values.

Table 8-1 Daytime Ambient L_{90} (dBA) Sound Pressure Level Summary

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

8.2 Nighttime Ambient – Lower Tenth Percentile

Measured nighttime ambient L_{90} sound levels are presented below in Table 8-2, as per the Project's understanding of the required DPS scope of studies for summer and winter. Values are separated by monitoring season as well as for both seasons combined. These values represent the L_{90} of the measured L_{90} values.

[41] Refer to Chapter 7 for details concerning valid periods.

Table 8-2 Nighttime Ambient L_{90} (dBA) Sound Pressure Level Summary

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

8.3 Daytime Ambient - Average

Measured daytime average ambient levels are presented in Table 8-3, as per the Project's understanding of the required DPS scope of studies. 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 L_{eq} (dBA) Sound Pressure Level Summary

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

8.4 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	45.9	40.7
Location 2	49.7	33.3
Location 3	52.2	49.6
Location 4	47.8	43.1
Location 5	45.1	35.8
Location 6	57.8	56.2
Location 7	58.4	56.1

8.5 Comparison of Sound Levels to Wind Speed

8.5.1 Hub Height Wind Speed

Ten-minute monitored L_{90} and L_{eq} sound levels at Location 2 and corresponding on-site hub height wind speed data are presented in Figures 8-1 and 8-2 [REDACTED]. Location 2 was chosen due to its centralized location and elevation, and since it had infrasound data down to 0.5 Hz. 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. Figure 8-2 shows a similar trend with the L_{eq} values, however, there is a lot of scatter in the sound levels over the same hub height wind speeds. This scatter generally ranges from 25-45 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 2 for both summer and winter monitoring periods combined. The maximum, minimum, and average sound levels are plotted using 0.5 m/s binned ground level wind speeds. Some inverse correlation between ground level wind speed and L_{90} sound levels are seen with a slight decrease in L_{90} as wind speeds increase. On-site ground-level wind speeds did not exceed 2.5 m/s for either season at this location.

8.5.3 Wind Speed at 10 meters

The sound level measurement standard used by all wind turbine manufacturers reports sound power level data as a function of hub height wind speed and a reference height of 10 meters above ground level (AGL).[42] 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 L_{90} 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

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[42] *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 L_{90} 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	15	22.99	1.56	1.79	Class A	Normal
Location 2	18	22.57	1.87	2.23	Class B	Normal
Location 3	18	26.73	1.74	2.04	Class B	Normal
Location 4	18	22.35	1.95	2.35	Class B	Normal
Location 5	18	27.18	2.3	2.88	Class B	Normal
Location 6	18	28.69	1.63	1.88	Class A	Normal
Location 7	18	49.70	13.32	23.70	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	16	21.59	3.08	4.17	Class C	Normal
Location 2	18	20.89	2.29	2.85	Class B	Not Normal
Location 3	18	19.7	3.17	4.3	Class C	Normal
Location 4	18	18.88	2.81	3.7	Class C	Normal
Location 5	18	26.24	2.54	3.26	Class C	Normal
Location 6	18	16.28	1.78	2.1	Class B	Normal
Location 7	17	39.20	10.76	18.96	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	10	27.74	4.83	7.67	Worse than Class C	Normal
Location 2	10	26.62	5.62	9.44	Worse than Class C	Normal
Location 3	10	30.66	5.3	8.72	Worse than Class C	Normal
Location 4	7	19.93	3.14	4.22	Class C	Normal
Location 5	10	31.22	4.16	6.26	Worse than Class C	Normal
Location 6	10	29.7	3	4.02	Class C	Normal
Location 7	10	25.81	4.91	7.86	Worse than 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	26.78	6.15	11.05	Worse than Class C	Normal
Location 2	7	25.32	5.51	9.41	Worse than Class C	Normal
Location 3	7	28.01	8.85	18.55	Worse than Class C	Normal
Location 4	4	21.84	10.21	24.58	Worse than Class C	Normal
Location 5	7	32.03	5.36	9.04	Worse than Class C	Normal
Location 6	7	24.39	5.52	9.43	Worse than Class C	Normal
Location 7	7	24.97	6.04	10.77	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	25	24.97	2.01	2.45	Class B	Not Normal
Location 2	28	24.02	2.18	2.69	Class B	Normal
Location 3	28	28.15	2.05	2.49	Class B	Normal
Location 4	25	21.78	1.65	1.93	Class A	Normal
Location 5	28	28.86	2.15	2.64	Class B	Normal
Location 6	28	29.06	1.43	1.63	Class A	Normal
Location 7	28	41.88	8.42	12.96	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	23	23.58	2.95	3.89	Class C	Normal
Location 2	25	22.35	2.25	2.8	Class B	Not Normal
Location 3	25	22.51	3.44	4.68	Class C	Normal
Location 4	22	19.46	2.69	3.49	Class C	Normal
Location 5	25	28.44	2.57	3.29	Class C	Normal
Location 6	25	19.4	2.33	2.91	Class B	Normal
Location 7	24	35.07	7.47	11.64	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	15	53.4	4.44	6.65	Worse than Class C	Normal
Location 2	18	40.04	1.55	1.77	Class A	Normal
Location 3	18	56.95	0.99	1.06	Class A	Not Normal
Location 4	18	49.25	1.46	1.65	Class A	Normal
Location 5	18	39.15	1.13	1.22	Class A	Normal
Location 6	18	61.61	0.34	0.34	Class A	Normal
Location 7	18	61.6	9.78	16.74	Worse than Class C	Not 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	16	38.27	2.5	3.2	Class C	Normal
Location 2	18	32.29	1.71	2	Class B	Normal
Location 3	18	48.69	0.59	0.61	Class A	Normal
Location 4	18	40.81	0.68	0.7	Class A	Normal
Location 5	18	32.93	1.91	2.29	Class B	Normal
Location 6	18	56.28	0.62	0.64	Class A	Normal
Location 7	17	57.25	9.99	17.42	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	10	46.85	2.49	3.14	Class C	Normal
Location 2	10	38.77	2.02	2.41	Class B	Normal
Location 3	10	59.19	1.55	1.74	Class A	Normal
Location 4	7	48.86	2.38	2.91	Class B	Normal
Location 5	10	39.5	2.95	3.93	Class C	Normal
Location 6	10	60.79	0.88	0.91	Class A	Normal
Location 7	10	41.85	3.35	4.67	Class C	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	44.67	5.17	8.58	Worse than Class C	Normal
Location 2	7	35.88	3.86	5.62	Worse than Class C	Normal
Location 3	7	51.73	3.24	4.41	Class C	Normal
Location 4	4	47.64	7.91	16.14	Worse than Class C	Normal
Location 5	7	40.36	6.82	12.81	Worse than Class C	Normal
Location 6	7	56.15	1.23	1.31	Class A	Normal
Location 7	7	38.81	4.74	7.57	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	25	51.02	2.82	3.68	Class C	Normal
Location 2	28	39.62	1.2	1.34	Class A	Normal
Location 3	28	57.87	0.91	0.98	Class A	Normal
Location 4	25	49.15	1.18	1.3	Class A	Normal
Location 5	28	39.29	1.2	1.34	Class A	Normal
Location 6	28	61.34	0.39	0.4	Class A	Normal
Location 7	28	55.54	6.33	9.43	Worse than Class C	Not 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	23	40.95	2.64	3.39	Class C	Normal
Location 2	25	33.51	1.68	1.96	Class A	Normal
Location 3	25	49.63	0.95	1.01	Class A	Normal
Location 4	22	42.39	1.37	1.55	Class A	Normal
Location 5	25	35.41	2.36	2.97	Class B	Normal
Location 6	25	56.25	0.53	0.54	Class A	Normal
Location 7	24	52.55	7.11	11.01	Worse than Class C	Normal

8.7 Infrasound and Low Frequency

Infrasound and low frequency sound pressure levels were measured at Location 2 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 averaging[43] sound level data from all valid[44] 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 2 are presented in Figure 8-10.

[43] Logarithmic (energy) average of equivalent (Leq) sound pressure levels.

[44] Refer to Chapter 7 for details concerning valid periods.

Figure 8-1 Monitored L_{90} Compared to Hub Height Wind Speed, Location 2, All Seasons [REDACTED]

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

Figure 8-3: Measured L90 Sound Level vs. Ground Level Wind Speed
Location 2 All Seasons

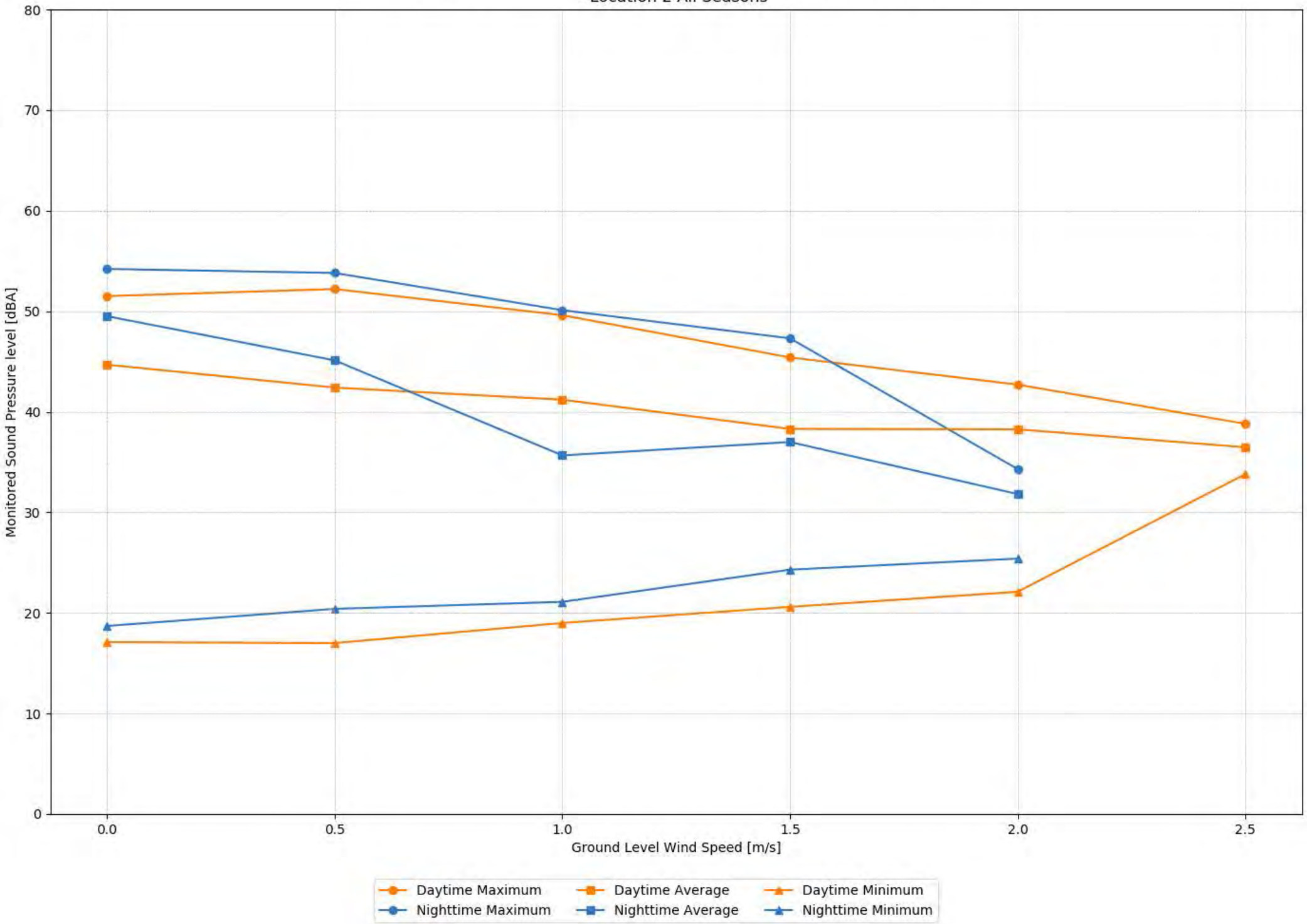


Figure 8-4 Measured L_{90} Sound Level vs. Normalized Wind Speed – Winter Overall Survey Period [REDACTED]

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

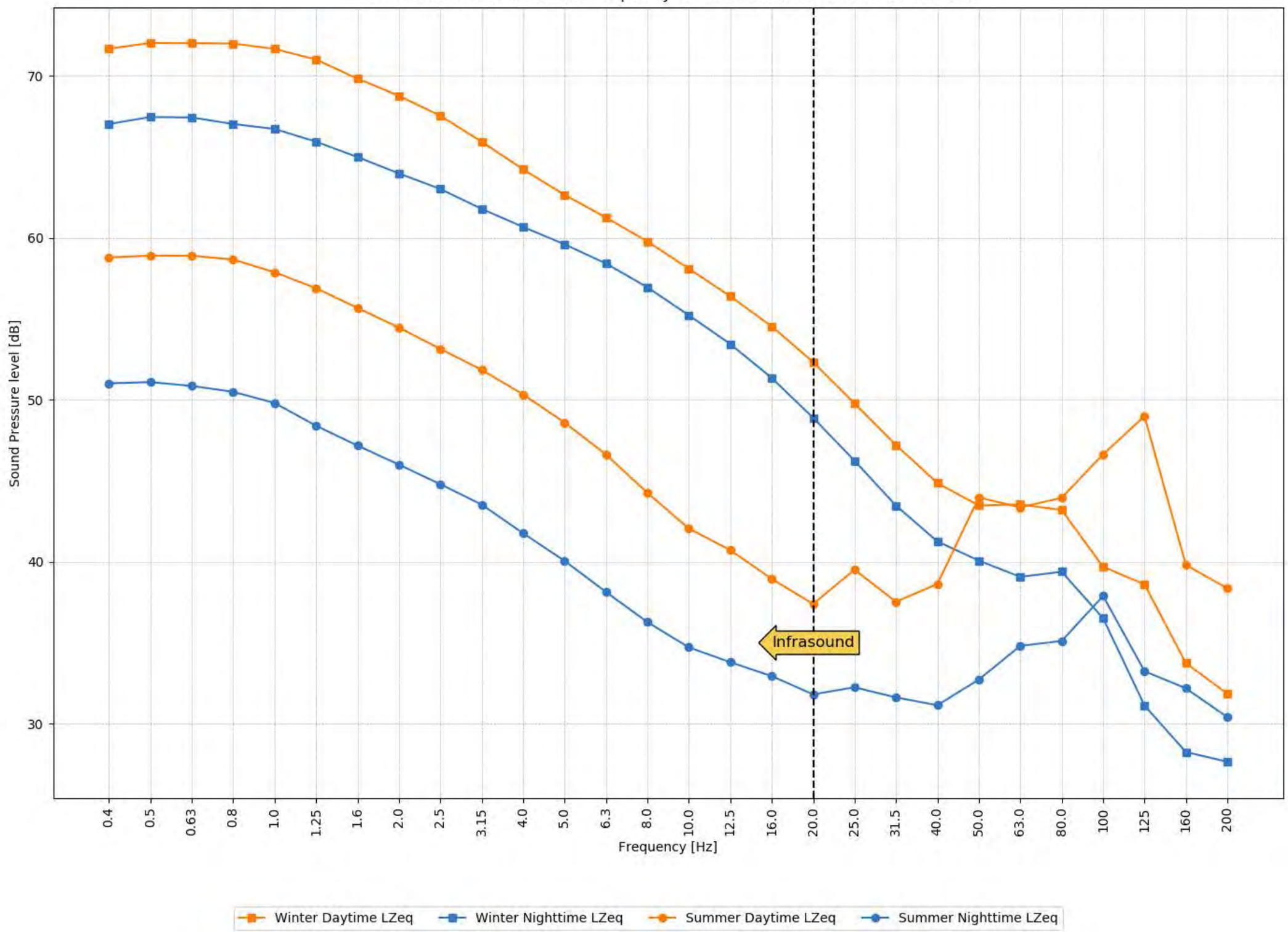
Figure 8-6 Measured L_{90} Sound Level vs. Normalized Wind Speed – Winter Overall Survey Period – Night [REDACTED]

Figure 8-7 Measured L_{90} Sound Level vs. Normalized Wind Speed – Summer Overall Survey Period [REDACTED]

Figure 8-8 Measured L_{90} Sound Level vs. Normalized Wind Speed – Summer Overall Survey Period – Day [REDACTED]

Figure 8-9 Measured L_{90} Sound Level vs. Normalized Wind Speed – Summer Overall Survey Period – Night [REDACTED]

Figure 8-10 Baseline Monitoring Graphical Summary – Location 2
One-Third Octave-Band Low Frequency and Infrasound Sound Pressure Levels



Chapter 9.0

Future Sound 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 25 wind turbines. There are four wind turbine manufacturers being considered in this PNIA. 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 include 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)	Range of Rotor Speed (rpm)
General Electric	GE5.5-158	5,500	107.4 or 125.4	158	6.0-10.1
Nordex	N149/4.8	4,800	105 or 125	149	6.4-12.3
Siemens Gamesa	SG4.5-145	4,500	107.5 or 127.5	145	0*-10.8
Vestas	V150-5.6	5,600	105 or 125	150	4.9-12.6

* = actual lower rpm is unknown.

Of the four wind turbine manufacturers, the hub height that resulted in the highest broadband sound levels, was determined for each manufacturer. Of all the manufacturer's; GE was the only one to provide differing broadband A-weighted sound power levels dependent on the hub height. As a result, the GE5.5-158 with a hub height of 125.4 meters was analyzed further, due to it resulting in higher broadband sound levels than the 107.4 meter hub height. The N149/4.8 with a hub height of 105 meters was analyzed, due to it resulting in higher broadband sound levels than the 125 meter hub height. The SG4.5-145 with a hub height of 107.5 meters was analyzed, due to it resulting in higher broadband sound levels than the 127.5 meter hub height. The V150-5.6 with a hub height of 105

meters was analyzed, due to it resulting in higher broadband sound levels than the 125 meter hub height.

Technical reports from GE[45], Nordex[46], Siemens Gamesa[47], and Vestas[48] were provided by the Applicant, which documented the expected sound power levels associated with each of the wind turbines. Of the four wind turbine options, the SG4.5-145 has the highest broadband A-weighted sound power level, and therefore modeling results of this turbine result in the highest broadband sound levels. Table 9-2 shows the broadband sound power levels as a function of wind speed from these technical reports. Under peak sound level producing conditions the GE5.5-158 wind turbine has an A-weighted sound power level of dBA. The Nordex N149/4.8 wind turbine has an A-weighted sound power level of dBA. The Siemens Gamesa SG4.5-145 wind turbine has an A-weighted sound power level of dBA. The Vestas V150-5.6 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 9-3A (A-weighted) and Table 9-3B (unweighted). 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.

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	>10
GE5.5-158 HH-125.4m Broadband Sound Power Level (dBA)									
Nordex N149/4.8 HH-105m Broadband Sound Power Level (dBA)									
Siemens Gamesa SG4.5-145 HH-107.5m Broadband Sound Power Level (dBA)									
Vestas V150-5.6 HH-105m Broadband Sound Power Level (dBA)									

Notes: 1. Sound power level is constant from the respective wind speed to the cut-out wind speed.

[45] GE Renewable Energy, Technical Documentation Wind Turbine Generation Systems 5.x-158 -60 Hz with LNTE, Rev. 01 -EN 2019-04-02.

[46] Nordex, Third Octave Sound Power Levels Nordex N149/4.0-4.5 Variable Power Curve Modes, Rev. 02, 2019-01-15.

[47] Siemens Gamesa Renewable Energy, SG 4.5-145 Noise Emission Analysis, GN381009-en.

[48] Vestas Wind Systems A/S, V150-5.6 MW Third Octave Noise Emission, T05 0079-5099 V01.

Table 9-3A Wind Turbine Maximum Octave Band Sound Power Levels (dBA) [REDACTED]

Wind Turbine Type	Sound Power Levels per Octave-Band Center Frequency (Hz)									
	16	31.5	63	125	250	500	1k	2k	4k	8k
GE5.5-158										
N149/4.8										
SG4.5-145										
V150-5.6										

Table 9-3B Wind Turbine Maximum Octave Band Sound Power Levels (dB) [REDACTED]

Wind Turbine Type	Sound Power Levels per Octave-Band Center Frequency (Hz)									
	16	31.5	63	125	250	500	1k	2k	4k	8k
GE5.5-158										
N149/4.8										
SG4.5-145										
V150-5.6										

9.2.2 Collection Substation

In addition to the wind turbines, there will be a collector substation located within the Project area. Two step-up transformers rated at 90 MVA and 28 MVA are proposed for the substation. Since source-specific sound data are not yet available, Epsilon estimated the broadband sound power level and octave band sound level 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 dB	63 dB	125 dB	250 dB	500 dB	1k dB	2k dB	4k dB	8k dB
90	97.7	94	100	102	97	97	91	86	81	74
28	90.4	87	93	95	90	90	84	79	74	67

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 5 MW x 20 MWH battery storage system is planned to be co-located with the collector substation. For acoustic modeling, the battery storage facility consisted of 8 battery containers, 8 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 High Bridge Wind[49]. Similarly, broadband and octave band sound level information for the HVAC systems was provided from the Applicant[50]. 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.

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 dB	63 dB	125 dB	250 dB	500 dB	1k dB	2k dB	4k dB	8k 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

9.2.4 Emergency Generator

There may be an emergency generator located adjacent to the O&M building in the event utility-supplied power is temporarily unavailable. This piece of equipment will run in emergencies and for periodic daytime-only testing as directed by the manufacturer. The unit is expected to range from 60 kW to 125 kW in output. For these reasons, sound levels from the operation of the emergency generator were not included in the site-wide model.

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 May 23, 2019 (Layout 20190523). The 25 proposed wind turbines were input into the model. The substation location was provided by the Applicant to the Project team on March 12, 2019. For the modeling analysis, it was assumed that

[49] Via email from Applicant. Battery storage container acoustic emissions 80 dBA at 1 meter.

[50] Via email from Applicant. SPL = 54 dBA at 10 meters.

the collector substation transformer would be located at the center of the substation pad. The proposed wind turbines and substation 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 March 26, 2019. The 818 receptors from this dataset were input into the Cadna/A model. These receptors include the sensitive receptors identified in Section 6.1 above. The 818 receptors are a combination of both participating and non-participating sound sensitive locations within at least 1 mile from the Project boundary. 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 represented an additional 0.0 to 0.5 dBA of conservatism to model results depending on the wind turbine manufacturer.

- 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.

Use of the 1.5m receptor height, coupled with the other conservative modeling assumptions discussed in Section 9.3, has proven to be an accurate predictor of actual sound levels in the real world. For example, the Massachusetts Clean Energy Center "Massachusetts Study on Wind Turbine Acoustics" (February 2016) showed 1-hour

measured L_{eq} sound levels matched well with modeled values at this height. Four seasons of sound level measurements at a ridgeline wind farm in Maine using a 1.5-meter receptor height were likewise less than pre-construction modeled sound levels ("Regulating and predicting wind turbine sound in the U.S."; Kaliski, Bastasch, and O'Neal, presented at INTER-NOISE 2018, Chicago, IL, 2018). In addition, a receptor height of 1.5 meters is the recommended height in the NARUC-2011 document as required in the Project's understanding of the required DPS scope of studies.

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 this modeling scenario, the octave band data for both wind turbine types were 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. Seven bodies of water with moderate width (greater than 500 feet) were identified within the Project area, including North Pond. These seven areas were set to G = 0 representing completely reflective surfaces. This is the most conservative setting available.

- 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,[51] "The ISO 9613-2 model with mixed ground (G = 0.5) with + 2 dB added to the results was most precise and accurate at modeling the hourly L_{eq}, as compared to individual five-minute periods." A recent post-construction measurement program conduction by Epsilon in the Rocky Mountain region found measured sound levels met the regulatory sound level limit under worst-case operating conditions at locations modeled to be at the regulatory limit.

A closer examination of the topography was made between the wind turbines and receptors where modeled results were within 4 dBA of the design goal. A look at the terrain profiles indicate a valley, stretching north to south across a portion of the project area, creating concave geometry as described in Evans and Cooper.[52] The remaining project area indicated gently sloping or steady-sloping terrain. In total, 75 receptors were identified to have met the concave topography criterion. Receptors that were identified to have concave geometry, are in Table E-5 of Appendix E. For this analysis a concavity factor of 2.0 dBA was assumed and added to the broadband sound pressure level received by each modeled wind turbine at each of these receptors. This is in addition to the "K" factor.

Sound pressure levels due to operation of all 25 wind turbines, the collector substation transformers, and the battery storage facility were modeled at all 818 receptors within and surrounding the Project area. The sound levels calculated are 1-hour L_{eq} sound levels. A review of 8,760 hours (one year) of on-site wind speed data found that some of the 365 nights in an entire year maintained a hub height wind speed high enough for all 9 hours of the night to produce the highest sound level from a wind turbine for those 9 consecutive hours. Therefore, on those nights, the sound level would be equal to the highest Leq-1-hour. On all other nights, the Leq-9-hour sound level will be less than the sound levels calculated by the Leq-1-hour.

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. Tabular results and sound level isolines were calculated and generated for the entire Project area.

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 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

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

[52] 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.

adjustments to the calculations. Sound power levels related to the hub height wind speeds presented in Table 9-2 were used in the calculations.

A full year of 2018 on-site meteorological data from tower 1003 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 [REDACTED] 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 93% of the year (8,188 hours) with a 105m hub height or 94% of the year (8,257 hours) with a 125m hub height. The hourly wind speeds drive the resultant sound power level of the wind turbines. Using these data, the sound level exceeded for 10% of the time over the course of one year (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 [REDACTED], and the associated sound power levels for each wind turbine under consideration, are shown in Table 9-8 [REDACTED]. The sound power levels in Table 9-8 do not include any uncertainty factor.

The same full year of on-site wind speed data were used to calculate an equivalent sound level for all nighttime hours in one year ($L_{eq,\ night,\ outside}$). This was done using the percent time matched to sound power level at a given wind speed and was calculated on an energy basis for all wind turbines under consideration. These calculations were done for two scenarios: all hours in a year (including hours below cut-in wind speed), and only those hours in a year above cut-in speed. There were zero hours above cut-out speed. The associated sound power levels for each wind turbine under consideration, are shown in Table 9-9 [REDACTED]. The sound power levels in Table 9-9 do not include any uncertainty factor. Details of data and calculations are in spreadsheet format and will be filed with the Hearing Examiner and treated by the Records Access Officer or other presiding officer as confidential.

Table 9-6 Summary of Annual On-Site Hub Height Wind Speeds (2018) [REDACTED]

	105m Hub Height	125m Hub Height
Total hours of operation	8,188	8,257

Table 9-7 Summary of Annual On-Site Hub Height Wind Speed Statistics (2018) [REDACTED]

Scenario	L10 Wind Speed (105m)	L10 Wind Speed (125m)	L50 Wind Speed (105m)	L50 Wind Speed (125m)
Operational				
All hours				

Table 9-8 Summary of L_{10}, L_{50} Annual Sound Power Levels (dBA) [REDACTED]

Wind Turbine	L_w, All Hours (dBA)	Lw, Operational Hours (dBA)
GE5.5-158 (HH-125.4m), L_{10}		
GE5.5-158 (HH-125.4m), L_{50}		
N149/4.8 (HH-105m), L_{10}		
N149/4.8 (HH-105m), L_{50}		
SG4.5-145 (HH-107.5m), L_{10}		
SG4.5-145 (HH-107.5m), L_{50}		
V150-5.6 (HH-105m), L_{10}		
V150-5.6 (HH-105m), L_{50}		

Notes: 1. The Nordex N149/4.8 model represents the worst case L_{50} annual sound level for both scenarios (with and without non-operational hours).

2. The Siemens Gamesa SG4.5-145 model represents the worst case L_{10} 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
GE5.5-158 (HH-125.4m)		
N149/4.8 (HH-105m)		
SG4.5-145 (HH-107.5m)		
V150-5.6 (HH-105m)		

Notes: 1. The Nordex N149/4.8 model represents the worst case annual nighttime L_{EQ} sound level for both scenarios (with and without non-operational hours).

9.4 Modeling Results

Since the ISO 9613-2 standard does not include the 16 Hz frequency, results at the 16 Hz octave band for each receptor and for each wind turbine manufacturer were extrapolated from the 31.5 Hz results. The extrapolation is the difference between the specific manufacturer's sound power data at 16 Hz and the sound power data at 31.5 Hz used for modeling as presented in Table 9-3B. For example, the GE5.5-158 has a sound power level of 123.1 dB at 16 Hz and 120.3 dB at 31.5 Hz. Thus the 31.5 Hz modeled results for this wind turbine were scaled up by 2.8 dB (123.1 dB -120.3 dB) to calculate the expected sound levels at 16 Hz.

9.4.1 Short-Term – GE5.5-158, HH-125.4m

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 GE5.5-158 turbine model at a hub height of 125.4 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 818 receptors included in the analysis. The broadband sound levels range from 24 to 49 dBA. Six non-participating receptors would be over the design goal of 45 dBA (five at 46 dBA; one at 47 dBA). As discussed previously, the 1-hour L_{eq} is equivalent to the nighttime 9-hour L_{eq} and to the daytime 15-hour L_{eq}.

In order to demonstrate compliance at all non-participating receptors, due to exceedances and concave geometry, this wind turbine model requires an NRO mode to be placed on multiple turbines. The necessary NRO modes are as follows:

- WTG105 must have a 2 dBA reduction, down to a broadband SPL of 105.5 dBA.
- WTG112 must have a 2 dBA reduction, down to a broadband SPL of 105.5 dBA.
- WTG131 must have a 1 dBA reduction, down to a broadband SPL of 106.5 dBA.
- WTG135 must have a 1 dBA reduction, down to a broadband SPL of 106.5 dBA.

Specific mitigation measures will be presented in the compliance filing report upon selection of a final wind turbine manufacturer. Results for the GE5.5-158 wind turbine are presented in this report without taking credit for NRO.

Table 9-10 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 35 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. The highest non-participating receptor is predicted to be receptor #338 at 47 dBA. The highest participating receptor is predicted to be receptor #166 at 49 dBA.

Table 9-10 Participating and Non-Participating Receptors Modeled at 35 dBA or Greater—GE5.5-158

Modeled Leq Sound Level (dBA)[1]	# of Receptors						
	Participating-Year-Round Residence	Non-Participating-Year-Round Residence	Participating-Seasonal Residence	Non-Participating - Seasonal Residence	Participating-Unknown	Non-Participating-Unknown	Non-Participating - Public
50	0	0	0	0	0	0	0
49	0	0	0	0	1	0	0
48	2	0	0	0	0	0	0
47	3	1	0	0	0	0	0
46	1	4	0	0	0	1	0
45	8	14	0	0	0	0	0
44	6	9	1	0	1	1	0
43	8	32	0	13	0	4	0
42	4	24	0	6	0	2	0
41	2	25	0	12	0	1	1
40	6	30	0	3	0	2	0
39	2	20	0	3	0	0	0
38	1	36	0	3	0	0	0
37	1	46	0	2	0	0	0
36	2	43	0	16	1	2	0
35	3	68	0	2	0	2	1

Notes: 1. Rounded to the nearest whole decibel.

9.4.2 Short-Term – N149/4.8, HH-105m

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 N149/4.8 turbine model at a hub height of 105 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 818 receptors included in the analysis. The broadband sound levels range from 22 to 48 dBA. One non-participating receptor would be over the design goal of 45 dBA. As discussed previously, the 1-hour L_{eq} is equivalent to the nighttime 9-hour L_{eq} and to the daytime 15-hour L_{eq}.

In order to demonstrate compliance at all non-participating receptors, due to exceedances, this wind turbine model requires an NRO mode to be placed on one turbine. The necessary NRO mode are as follows:

- WTG112 must have Mode 2.a in place, for a broadband SPL of 105.3 dBA.

Specific mitigation measures will be presented in the compliance filing report upon selection of a final wind turbine manufacturer. Results for the N149/4.8 wind turbine are presented in this report without taking credit for NRO.

Table 9-11 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 35 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. The highest non-participating receptor is predicted to be receptor #338 at 46 dBA. The highest participating receptor is predicted to be receptor #166 at 48 dBA.

Table 9-11 Participating and Non-Participating Receptors Modeled at 35 dBA or Greater—N149/4.8

Modeled Leq Sound Level (dBA)[1]	# of Receptors						
	Participating-Year-Round Residence	Non-Participating-Year-Round Residence	Participating-Seasonal Residence	Non-Participating - Seasonal Residence	Participating-Unknown	Non-Participating-Unknown	Non-Participating - Public
50	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0
48	0	0	0	0	1	0	0
47	2	0	0	0	0	0	0
46	2	1	0	0	0	0	0
45	2	2	0	0	0	1	0
44	5	16	0	0	0	0	0
43	8	6	1	0	1	0	0
42	8	28	0	11	0	5	0
41	5	30	0	7	0	1	0
40	2	20	0	10	0	2	1
39	6	29	0	6	0	2	0
38	1	25	0	3	0	0	0
37	2	31	0	2	0	0	0
36	1	46	0	3	0	0	0
35	2	43	0	16	1	2	0

Notes: 1. Rounded to the nearest whole decibel.

9.4.3 Short-Term – SG4.5-145, HH-107.5m

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 SG4.5-145 turbine model at a hub height of 107.5 meters. Table E-2.1 presents the same data sorted by sound level from high to low. The tables present modeled 1-hour L_{eq} sound levels at the 818 receptors included in the analysis. The broadband sound levels range from 24 to 49 dBA. Four non-participating receptors would be over the design goal of 45 dBA (three at 46 dBA; one at 47 dBA). As discussed previously, the 1-hour L_{eq} is equivalent to the nighttime 9-hour L_{eq} and to the daytime 15-hour L_{eq}.

In order to demonstrate compliance at all non-participating receptors, due to exceedances and concave geometry, this wind turbine model requires an NRO mode to be placed on multiple turbines. The necessary NRO modes are as follows:

- WTG105 must have Mode AM-3 in place, for a broadband SPL of 106.9 dBA.
- WTG112 must have Mode N1 in place, for a broadband SPL of 105.7 dBA.
- WTG131 must have Mode N1 in place, for a broadband SPL of 105.7 dBA.
- WTG135 must have Mode AM-2 in place, for a broadband SPL of 107.2 dBA.

Specific mitigation measures will be presented in the compliance filing report upon selection of a final wind turbine manufacturer. Results for the SG4.5-145 wind turbine are presented in this report without taking credit for NRO.

Table 9-12 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 35 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. The highest non-participating receptor is predicted to be receptor #338 at 47 dBA. The highest participating receptor is predicted to be receptor #166 at 49 dBA.

Table 9-12 Participating and Non-Participating Receptors Modeled at 35 dBA or Greater—SG4.5-145

Modeled Leq Sound Level (dBA)[1]	# of Receptors						
	Participating-Year-Round Residence	Non-Participating-Year-Round Residence	Participating-Seasonal Residence	Non-Participating - Seasonal Residence	Participating-Unknown	Non-Participating-Unknown	Non-Participating - Public
50	0	0	0	0	0	0	0
49	0	0	0	0	1	0	0
48	2	0	0	0	0	0	0
47	3	1	0	0	0	0	0
46	3	2	0	0	0	1	0
45	7	16	0	0	1	0	0
44	5	8	1	0	0	1	0
43	8	32	0	13	0	4	0
42	4	25	0	6	0	2	0
41	2	22	0	12	0	1	1
40	6	33	0	3	0	2	0
39	1	20	0	3	0	0	0
38	2	35	0	3	0	0	0
37	1	45	0	2	0	0	0
36	2	44	0	16	1	2	0
35	3	56	0	2	0	2	1

Notes: 1. Rounded to the nearest whole decibel.

9.4.4 Short-Term – V150-5.6, HH-105m

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 V150-5.6 turbine model at a hub height of 105 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 818 receptors included in the analysis. The broadband sound levels range from 22 to 47 dBA. All non-participating receptors meet the design goal of 45 dBA. As discussed previously, the 1-hour L_{eq} is equivalent to the nighttime 9-hour L_{eq} and to the daytime 15-hour L_{eq}.

Table 9-13 presents the number of sensitive noise receptors that have been modeled to experience a worst-case sound level of 35 dBA or greater. Modeled sound levels have been rounded to the nearest integer and presented in 1 dBA increments by receptor participation status. The highest non-participating receptor is predicted to be receptor #338 at 45 dBA. The highest participating receptor is predicted to be receptor #166 at 47 dBA.

Table 9-13 Participating and Non-Participating Receptors Modeled at 35 dBA or Greater—V150-5.6

Modeled Leq Sound Level (dBA)[1]	# of Receptors						
	Participating-Year-Round Residence	Non-Participating-Year-Round Residence	Participating-Seasonal Residence	Non-Participating - Seasonal Residence	Participating-Unknown	Non-Participating-Unknown	Non-Participating - Public
50	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0
47	0	0	0	0	1	0	0
46	2	0	0	0	0	0	0
45	2	1	0	0	0	0	0
44	2	2	0	0	0	1	0
43	5	16	0	0	0	0	0
42	9	7	1	0	1	1	0
41	8	33	0	12	0	4	0
40	4	26	0	6	0	2	0
39	4	25	0	12	0	2	1
38	4	29	0	4	0	1	0
37	1	21	0	3	0	0	0
36	2	39	0	3	0	0	0
35	1	49	0	2	0	0	0

Notes: 1. Rounded to the nearest whole decibel.

9.4.5 Long-Term – ISO 9613-2 L_{10}, L_{50}, and Nighttime L_{EQ} Annual Sound Level Results

A full year of 2018 on-site meteorological data was used to determine the equivalent L_{10}, L_{50} and nighttime L_{EQ} sound power levels for each wind turbine type over an entire year 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 realistic 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 L_{10} modeling, the wind turbine with the highest equivalent sound power level was the SG4.5-145 with a hub height of 107.5 meters, as shown in Table 9-8. For annual L_{50} modeling, the wind turbine with the highest equivalent sound power level was the Nordex N149/4.8, 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 N149/4.8, as shown in Table 9-9.

Using the highest resulting sound power levels from Table 9-8, the annual Project L_{10} and L_{50} sound level at each noise sensitive location has been calculated. Using the highest resulting sound power levels 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.

$L_{eq,\ night,\ outside}$ Project sound levels range from 19 to 45 dBA for "Method 1" (no zeros) and 19 to 45 dBA for "Method 2" (with zeros) calculations. The highest $L_{eq,\ night,\ outside}$ level at a non-participating receptor is 43 dBA (Receptor ID 338). 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 N149/4.8 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 L_{10} sound levels range from 22 to 47 dBA for both the "Method 1" (no zeros) calculations and the "Method 2" (with zeros) calculations. The highest L_{10} level at a non-participating receptor is 45 dBA (Receptor ID 338).

Annual Project L_{50} sound levels range from 20 to 46 dBA for both the "Method 1" (no zeros) calculations and the "Method 2" (with zeros) calculations. The highest L_{50} level at a non-participating receptor is 44 dBA (Receptor ID 338).

The annual L_{10}, L_{50}, 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 L_{EQ}-night-outside—GE5.5-158

Modeled Leq Sound Level (dBA)[1]	Method 1 – Without Zeros # of Receptors		Method 2 – With Zeros # of Receptors	
	Participating	Non-Participating	Participating	Non-Participating
50	0	0	0	0
49	0	0	0	0
48	0	0	0	0
47	0	0	0	0
46	0	0	0	0
45	0	0	0	0
44	1	0	1	0
43	1	0	1	0
42	2	2	2	1
41	4	4	3	4
40	10	3	10	4

Notes: 1. Rounded to the nearest whole decibel.

Table 9-15 Number of Receptors Modeled at 40 dBA or Greater for L_{EQ}-night-outside—N149/4.8

Modeled Leq Sound Level (dBA)[1]	Method 1 – Without Zeros # of Receptors		Method 2 – With Zeros # of Receptors	
	Participating	Non-Participating	Participating	Non-Participating
50	0	0	0	0
49	0	0	0	0
48	0	0	0	0
47	0	0	0	0
46	0	0	0	0
45	1	0	1	0
44	1	0	1	0
43	0	1	0	1
42	4	3	3	2
41	5	5	5	4
40	9	1	8	2

Notes: 1. Rounded to the nearest whole decibel.

Table 9-16 Number of Receptors Modeled at 40 dBA or Greater for L_{EQ}-night-outside—SG4.5-145

Modeled Leq Sound Level (dBA)[1]	Method 1 – Without Zeros # of Receptors		Method 2 – With Zeros # of Receptors	
	Participating	Non-Participating	Participating	Non-Participating
50	0	0	0	0
49	0	0	0	0
48	0	0	0	0
47	0	0	0	0
46	0	0	0	0
45	1	0	0	0
44	0	0	1	0
43	1	0	1	0
42	3	2	2	1
41	3	5	3	4
40	10	2	10	4

Notes: 1. Rounded to the nearest whole decibel.

Table 9-17 Number of Receptors Modeled at 40 dBA or Greater for L_{EQ}-night-outside—V150-5.6

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

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 sound power levels for the Siemens Gamesa SG 4.5-145, 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 47 dBA 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). 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 22 to 47 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). 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 23 to 47 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). The L_{50} statistical noise descriptor corresponds to estimates for one year of operation using the sound power levels for the Nordex N149/4.8, as presented in Table 9-8. 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 39 to 61 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 from 12.5 Hz to 10,000 Hz for the GE 5.5-158, Siemens Gamesa provides one-third octave band sound power level data from 10 Hz to 10,000 Hz for the SG4.5-145, Nordex provides one-third octave band sound power level data from 10 Hz to 10,000 Hz for the N149/4.8, and Vestas provides one-third octave band sound power level data from 6.3 Hz to 10,000 Hz for the V150-5.6. 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.[53] 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,[54] and Health Canada[55] 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:

- 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. These ten receptor locations were scattered throughout the wind farm and were at a diverse assortment of locations throughout the wind farm, thus providing a good mix of worst-case conditions.

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-

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

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

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

third octave bands and full octave bands at each of the ten locations analyzed. The results in Table 9-20 show the cumulative impact of infrasound from multiple wind turbines at a given location.

Predicted infrasound levels at the nearest non-participating receptor (#338) 337 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	*122.3*
0.63	*121.9*
0.8	*121.6*
1	*121.3*
1.25	*120.9*
1.6	*120.6*
2	*120.3*
2.5	*119.9*
3.15	*119.6*
4	*119.3*
5	*118.9*
6.3	118.6
8	117.5
10	119.4
12.5	118.8
16	118.5
20	117.5
25	116.4
31.5	115.4
40	114.5
50	113.3
63	112.2
80	110.5
100	108.8
125	107.3
160	105.6
200	104.3

Note: italicized sound levels are extrapolated.

Table 9-19 Locations Analyzed for Infrasound & LFN

Receptor ID	Wind Turbine ID	Approximate Distance to Receptor (meters)
3	131	742
	126	1026
	130	511
	129	987
	133	1203
25	102	491
	101	1396
	104	1523
	103	875
	106	2236
34	122	494
	104	1930
	124	1672
	123	1093
	103	1502
123	106	1060
	103	1848
	102	1842
	105	310
	104	946
166	124	1274
	123	1234
	104	959
	106	254
	105	1242
173	123	1219
	122	1555
	124	538
	115	1301
	106	1817
254	129	1008
	127	536
	128	1048
	130	1038
	126	566
338	124	2171
	112	337
	106	2300
	115	1711
	113	992

Table 9-19 Locations Analyzed for Infrasound & LFN (Continued))

Receptor ID	Wind Turbine ID	Approximate Distance to Receptor (meters)
340	121	1326
	120	1753
	115	2154
	118	459
	117	1220
366	134	884
	133	1644
	135	504
	131	1952
	129	2244

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 #3	64	63	63	63	62	62	62	61	61	61	60	60	59	61	60	60	59	58	57	56	55	53	52	50	48	46	45
Octave bands				67			66			65			65			64			62			58			53		
ID #25	63	63	62	62	62	61	61	61	60	60	60	59	58	60	59	59	58	57	56	55	54	53	51	49	47	45	44
Octave bands				67			66			65			64			64			61			57			52		
ID #34	63	62	62	62	61	61	61	60	60	60	59	59	58	60	59	59	58	57	56	55	54	52	50	48	47	45	44
Octave bands				66			65			64			64			63			61			57			52		
ID #123	66	65	65	65	64	64	64	63	63	63	62	62	61	63	62	62	61	60	59	58	57	55	54	52	50	49	47
Octave bands				69			68			67			67			66			64			60			55		
ID #166	67	67	66	66	66	65	65	65	64	64	64	63	62	64	64	63	62	61	60	59	58	57	55	53	52	50	49
Octave bands				71			70			69			68			68			65			62			57		
ID #173	62	62	62	61	61	61	60	60	60	59	59	59	57	59	59	58	57	56	55	54	53	52	50	48	47	45	44
Octave bands				66			65			64			63			63			60			57			52		

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 #254	64	64	63	63	63	62	62	62	61	61	61	60	59	61	61	60	59	58	57	56	55	54	52	50	49	47	46
Octave bands				68			67			66			65			65			62			59			54		
ID #338	65	64	64	64	63	63	63	62	62	62	61	61	60	62	61	61	60	59	58	57	56	55	53	51	49	48	46
Octave bands				69			68			67			66			66			63			59			54		
ID #340	63	63	62	62	62	61	61	61	60	60	60	59	58	60	59	59	58	57	56	55	54	53	51	49	47	45	44
Octave bands				67			66			65			64			64			61			57			52		
ID #366	63	62	62	62	61	61	61	60	60	60	59	59	58	60	59	59	58	57	56	55	54	52	50	48	47	45	44
Octave bands				66			65			64			64			63			61			57			52		

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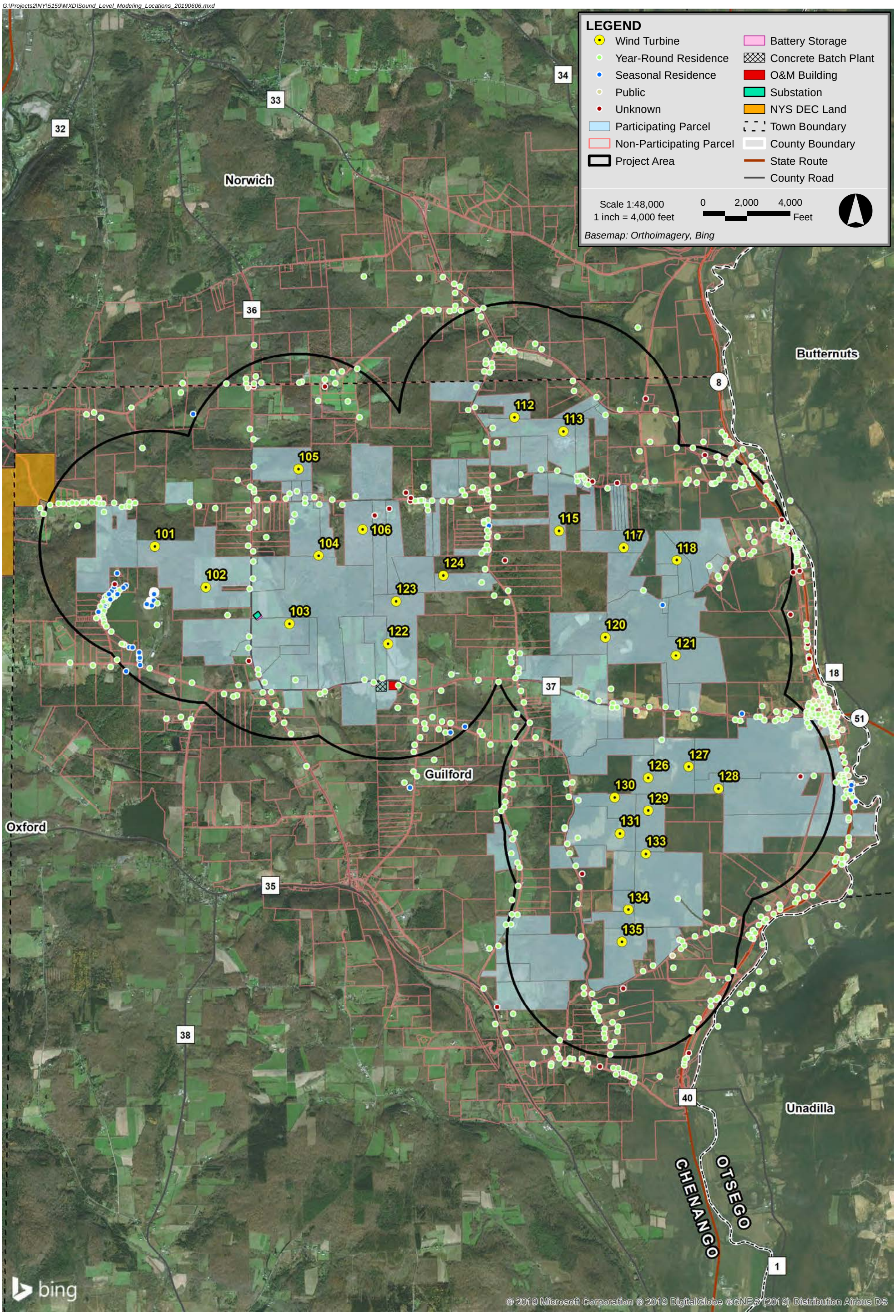

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-1
Sound Level Modeling Locations

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High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 1 of 16

Short Term Sound Level Modeling Results

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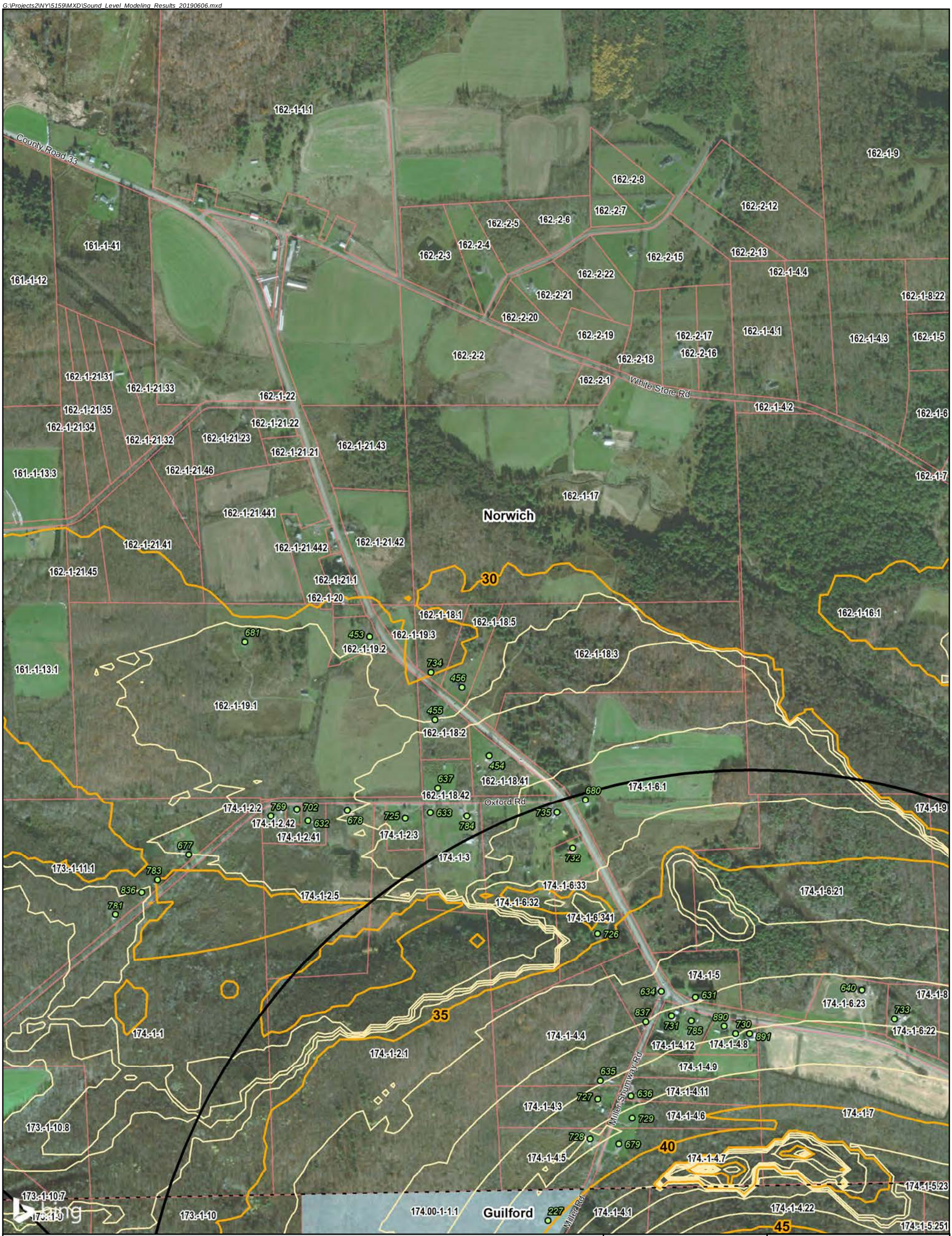

SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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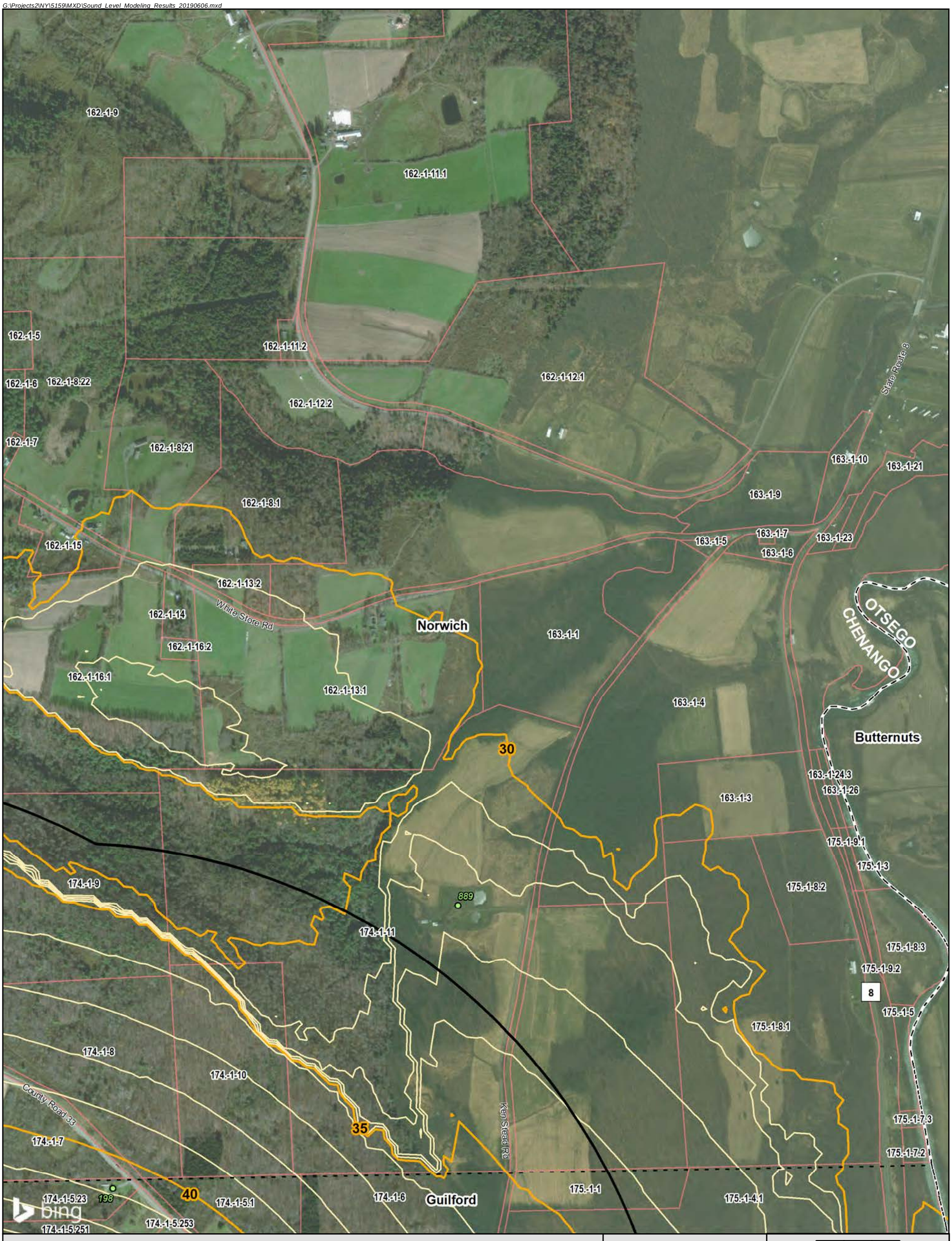
1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 2 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



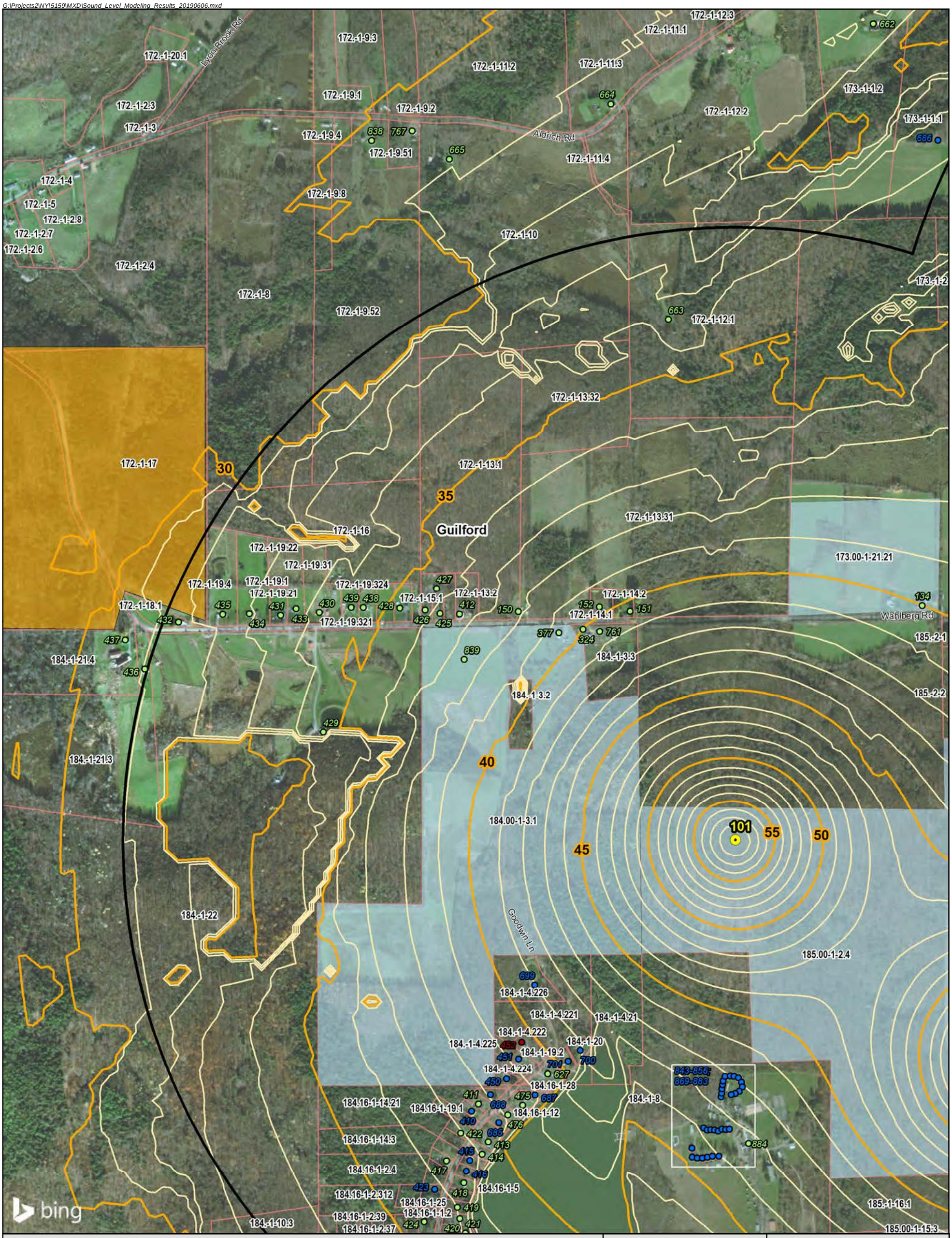
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 3 of 16

Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



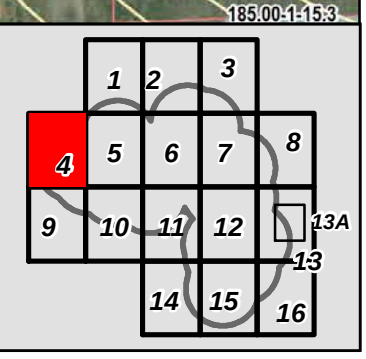
SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

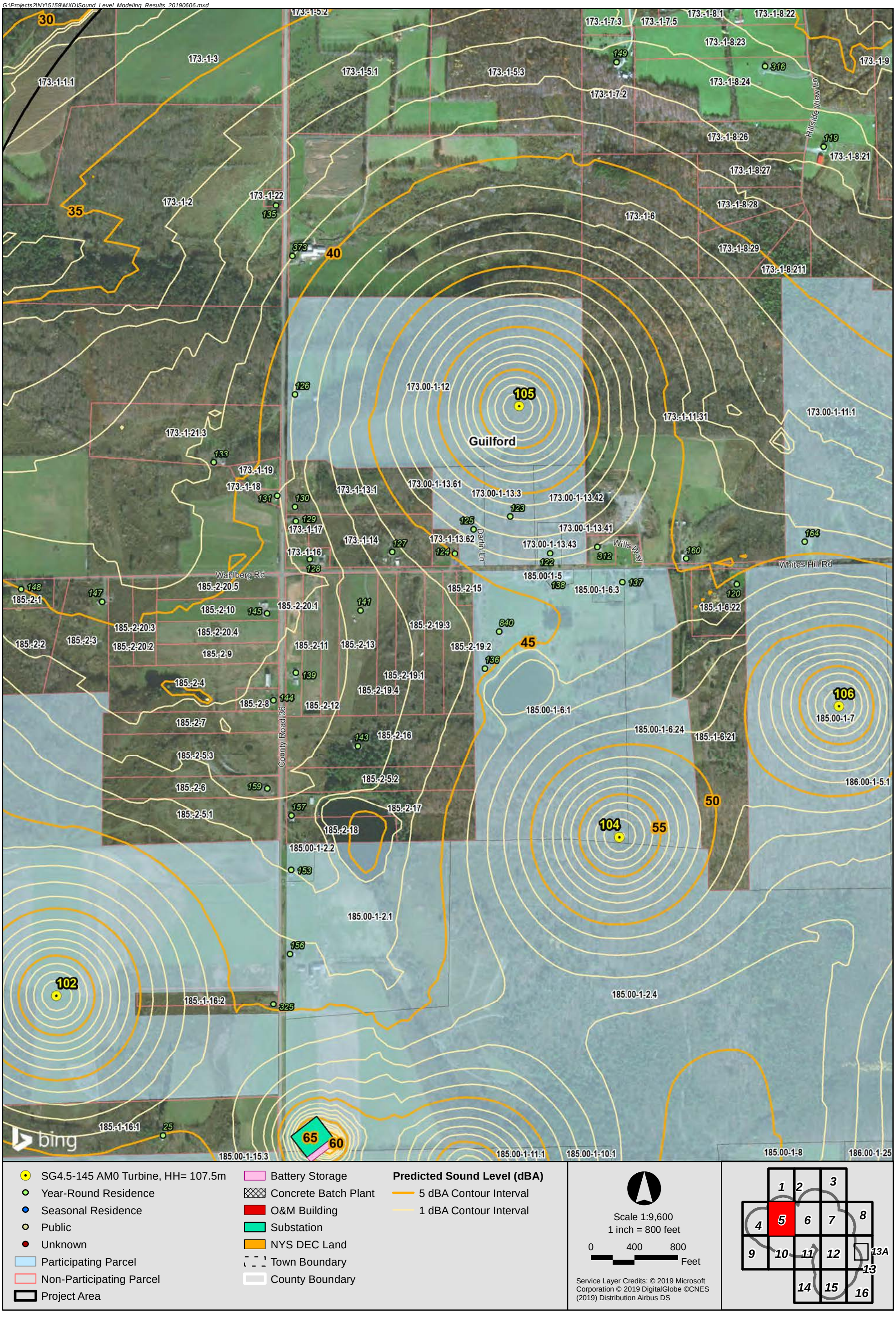


High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 4 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

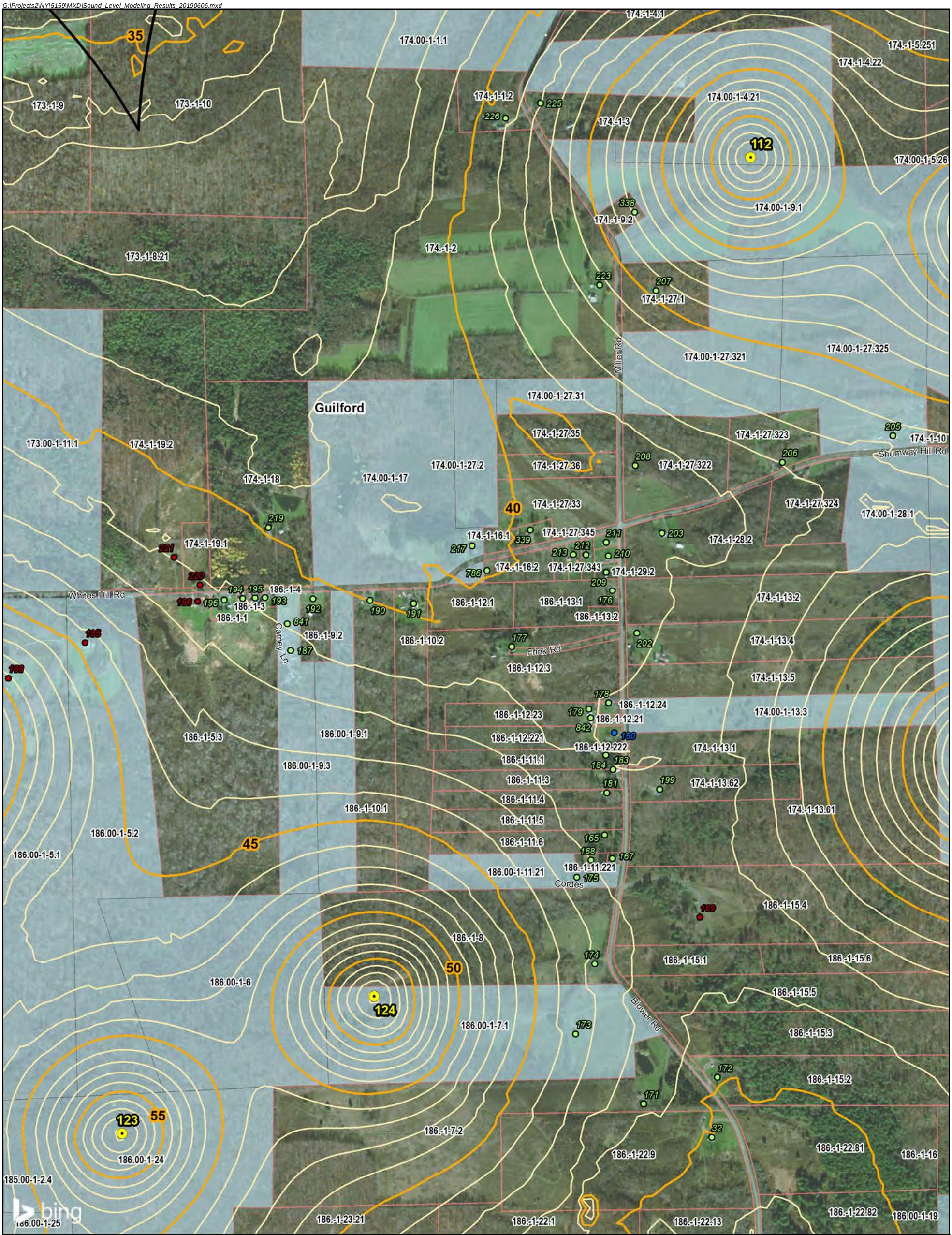
1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 5 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

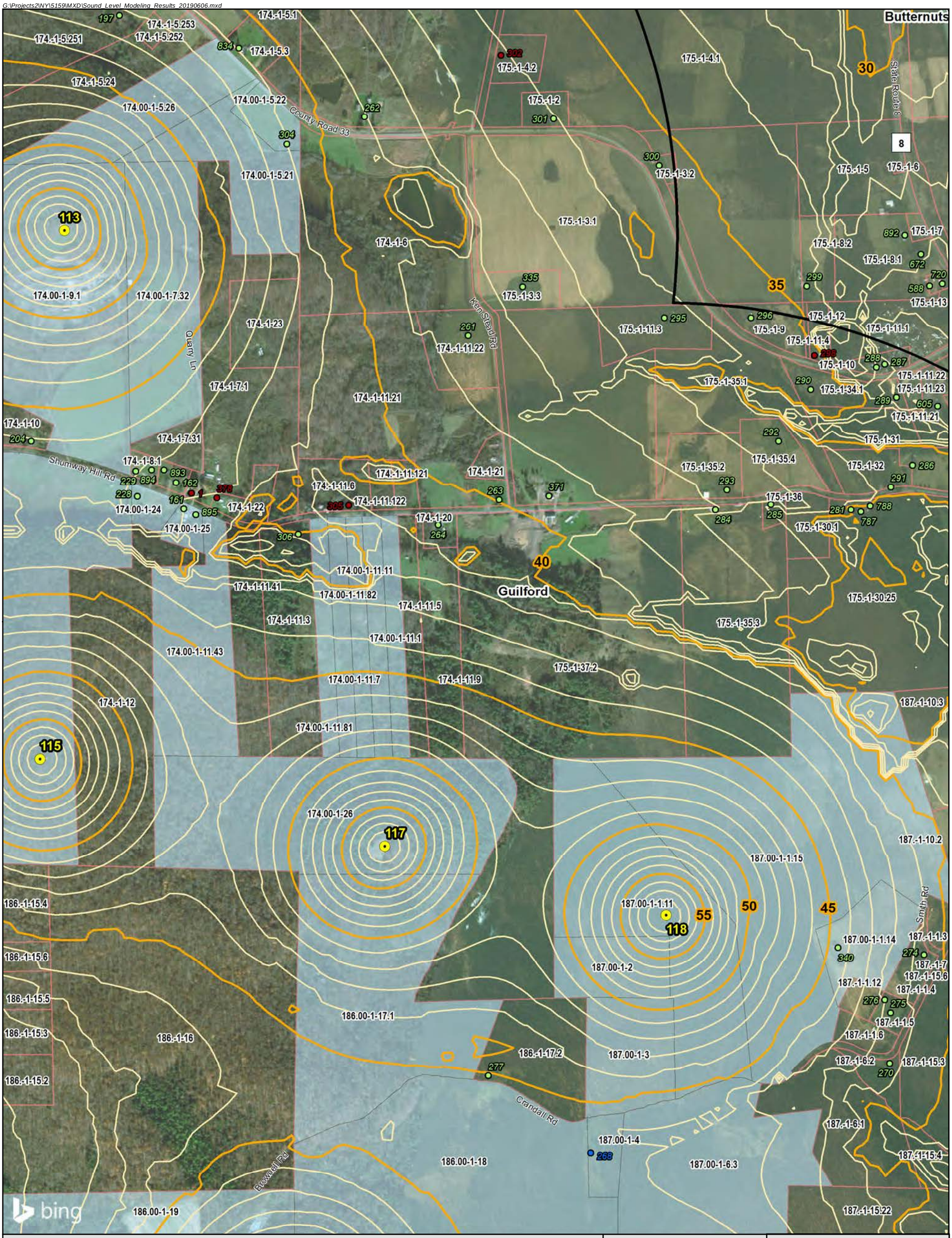
1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind Chenango County, New York

Epsilon Associates Inc.

Figure 9-2, Map 6 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area
Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 7 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd

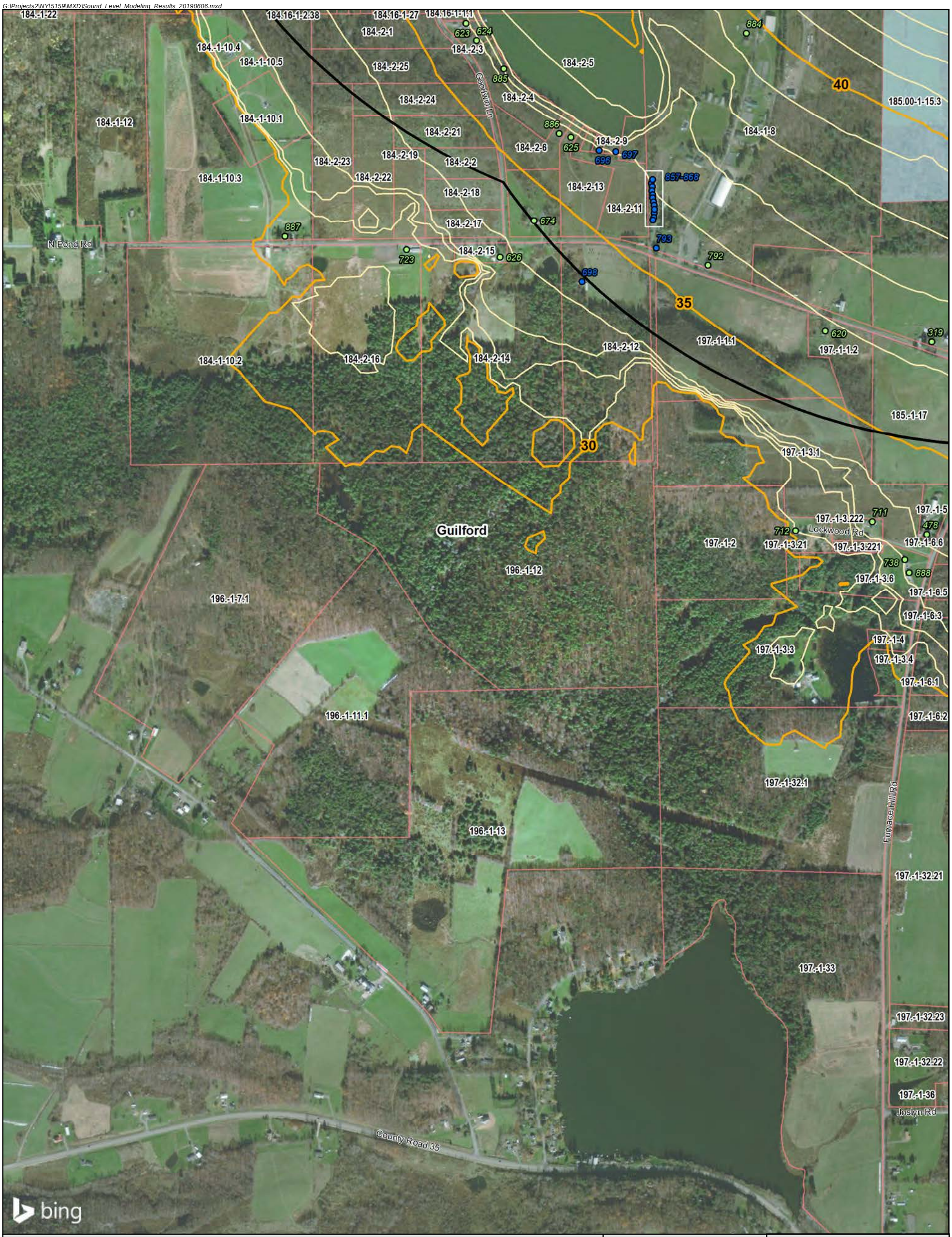
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 8 of 16

Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

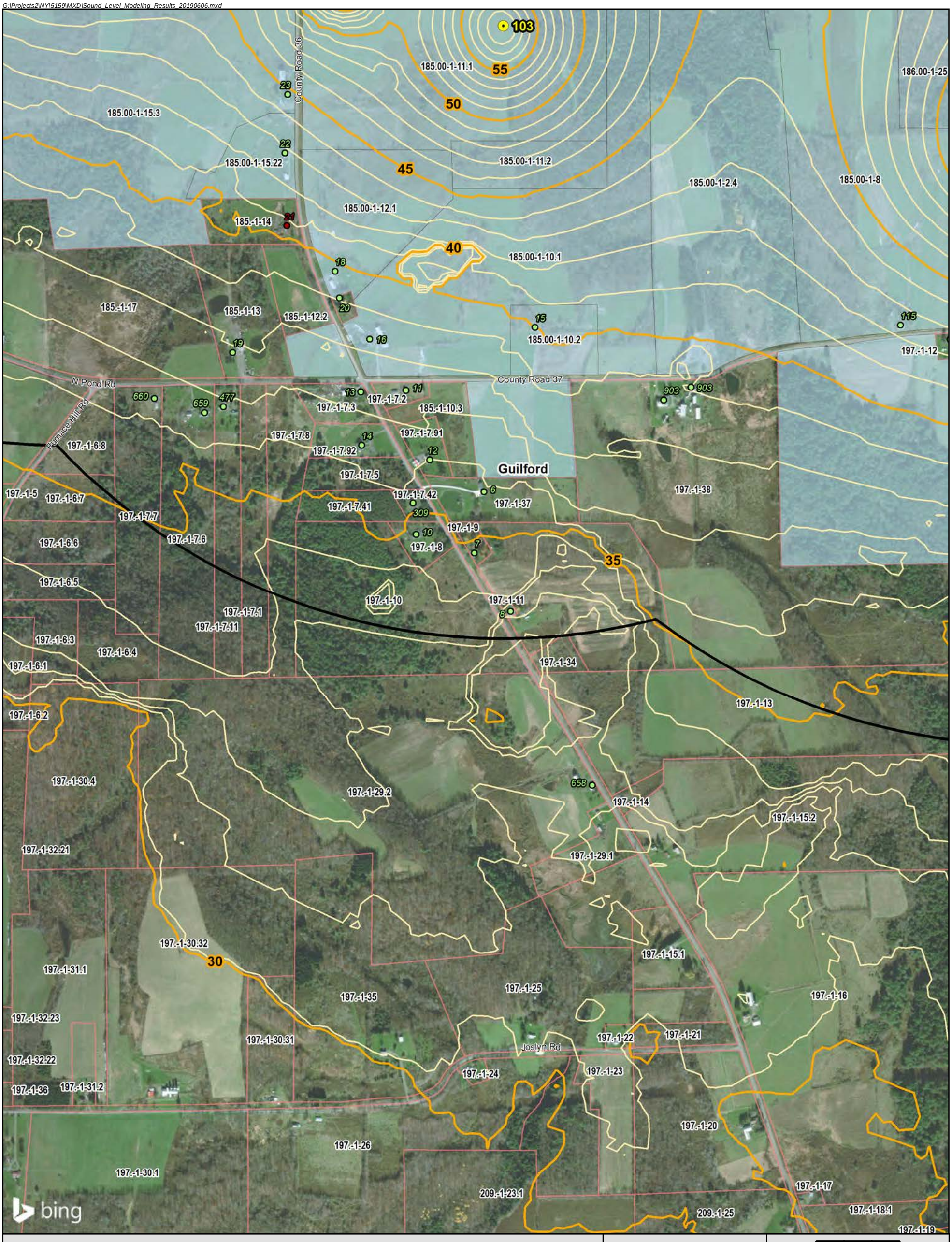
1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 9 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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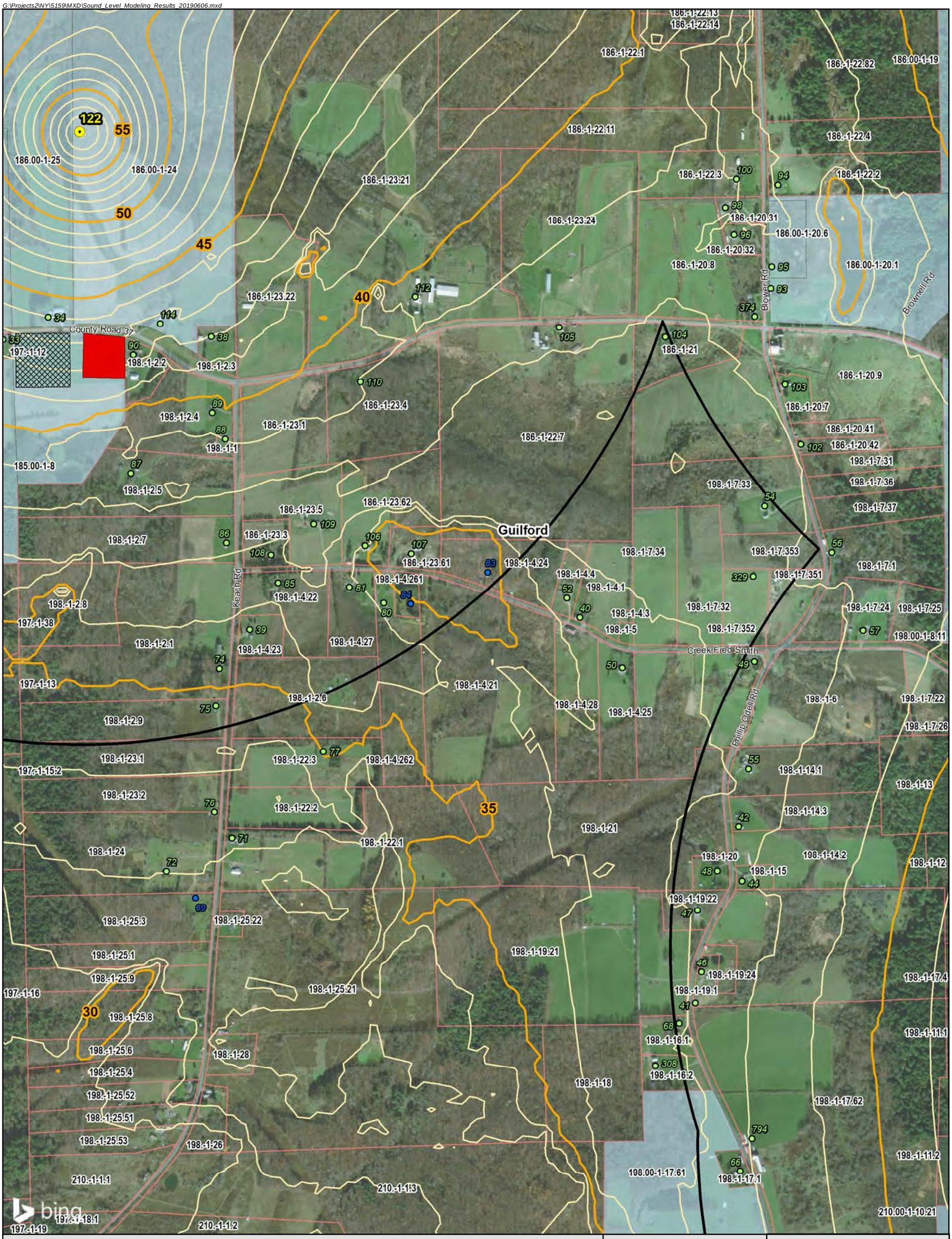
1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 10 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



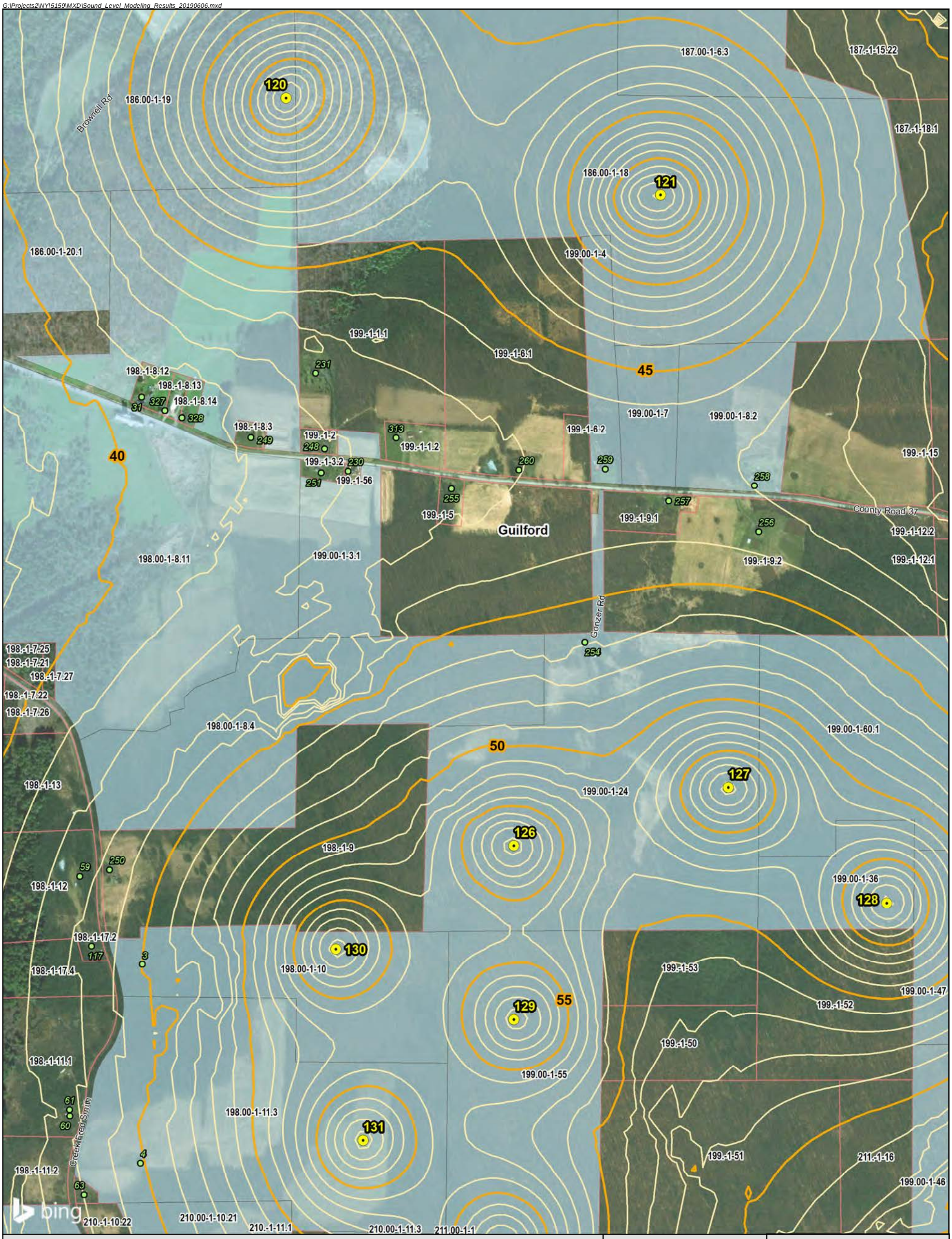
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 11 of 16

Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 12 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd

SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

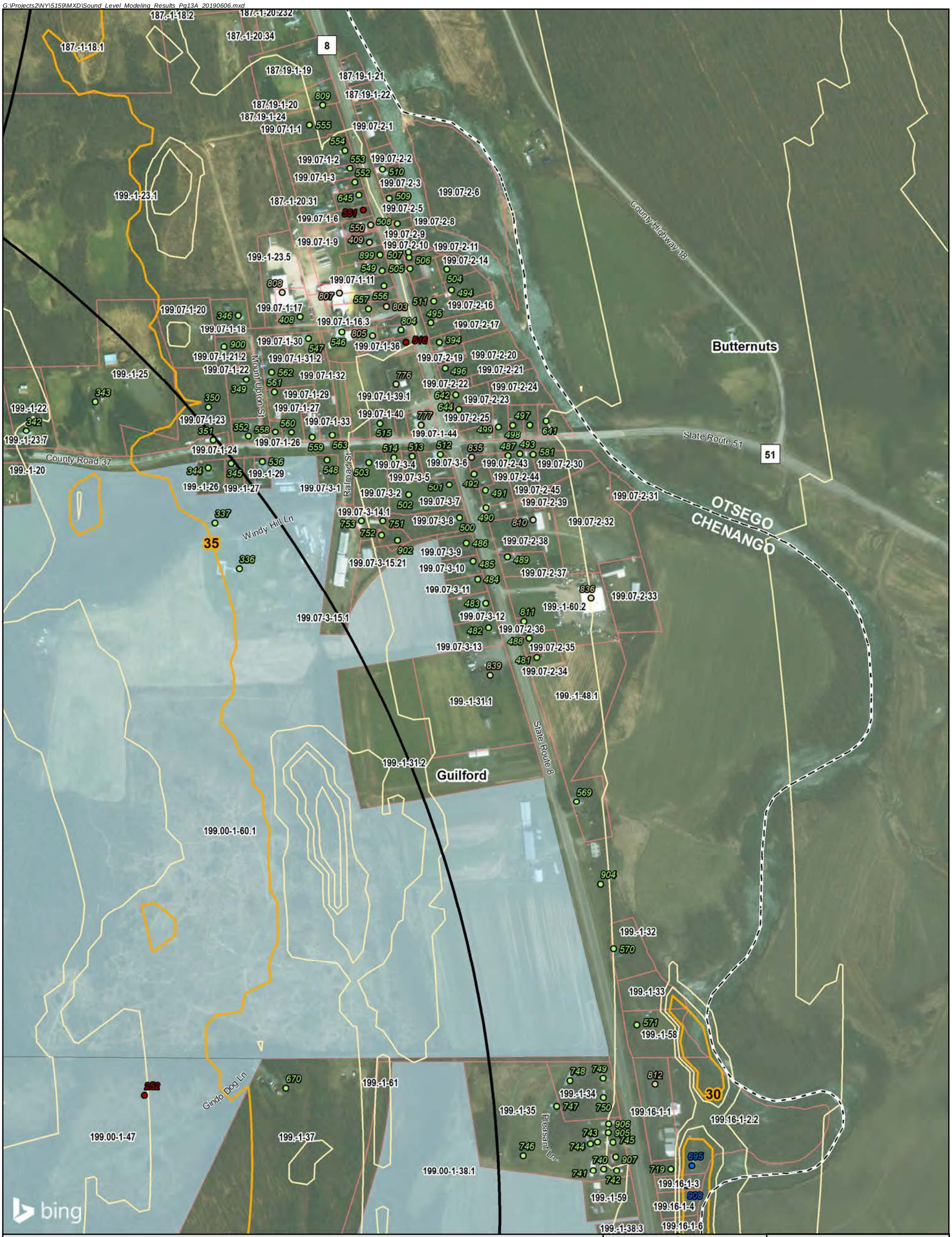
1 2 3 4 5 6 7 8 9 10 11 12 13 13A 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 13 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Pg13A_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m	Battery Storage	**Predicted Sound Level (dBA)**
Year-Round Residence	Concrete Batch Plant	5 dBA Contour Interval
Seasonal Residence	O&M Building	1 dBA Contour Interval
Public	Substation	
Unknown	NYS DEC Land	
Participating Parcel	Town Boundary	
Non-Participating Parcel	County Boundary	
Project Area		

Scale 1:4,800
1 inch = 400 feet
0 200 400 Feet

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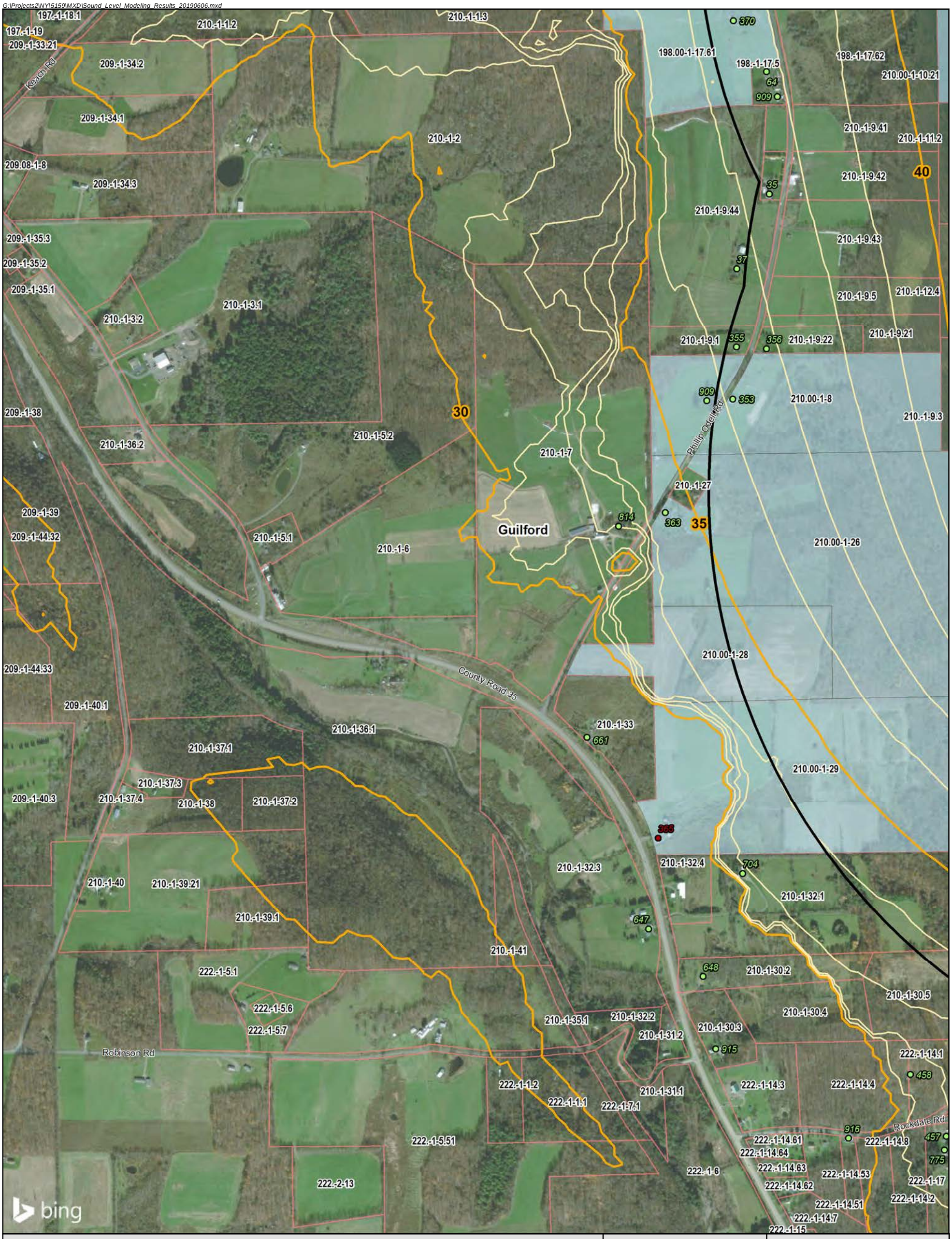
1 2 3 4 5 6 7 8 9 10 11 12 13 13A 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 13A of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m	Battery Storage	**Predicted Sound Level (dBA)**
Year-Round Residence	Concrete Batch Plant	5 dBA Contour Interval
Seasonal Residence	O&M Building	1 dBA Contour Interval
Public	Substation	
Unknown	NYS DEC Land	
Participating Parcel	Town Boundary	
Non-Participating Parcel	County Boundary	
Project Area		

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

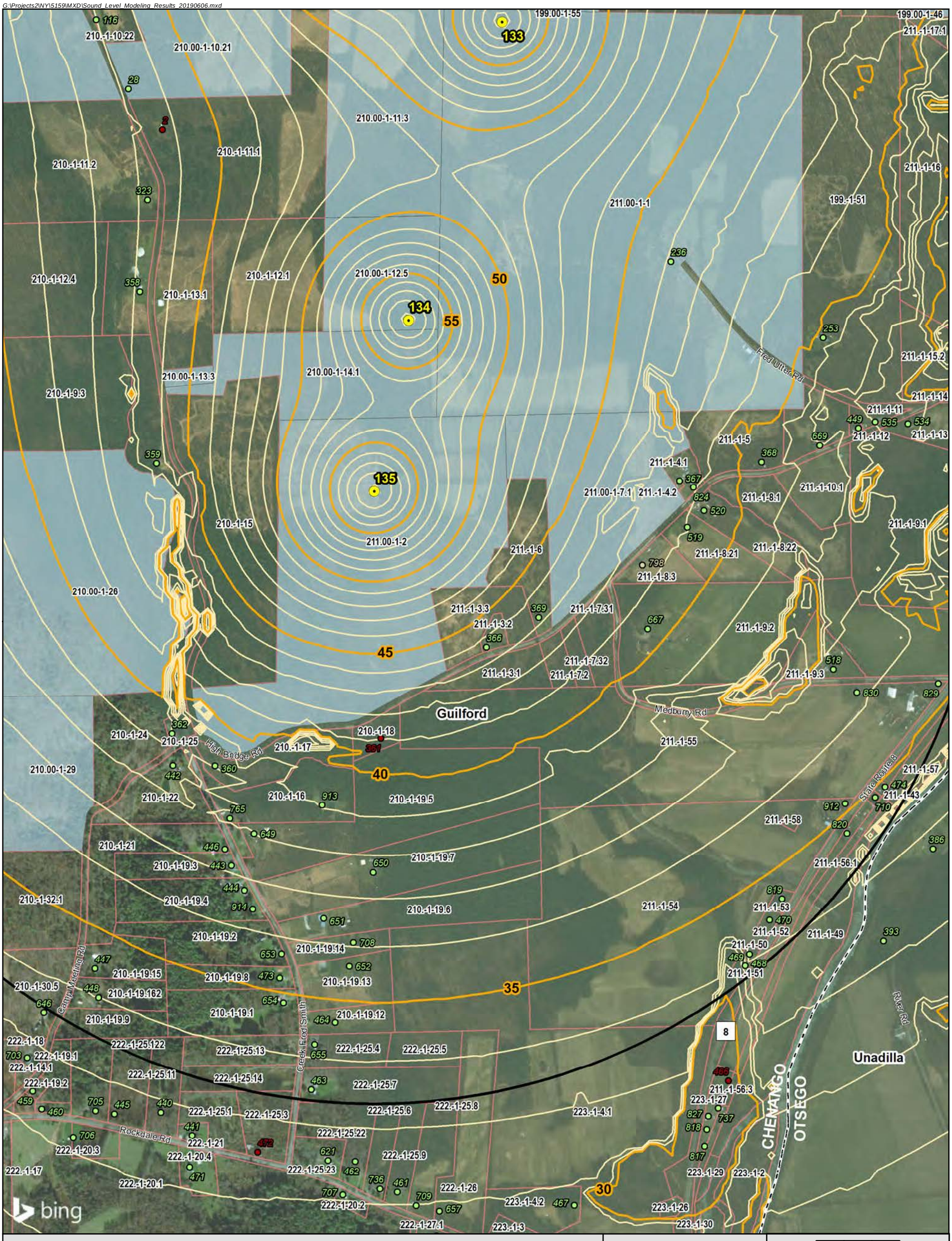
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 14 of 16

Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd



SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 15 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_20190606.mxd

SG4.5-145 AM0 Turbine, HH= 107.5m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-2, Map 16 of 16
Short Term Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd

Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

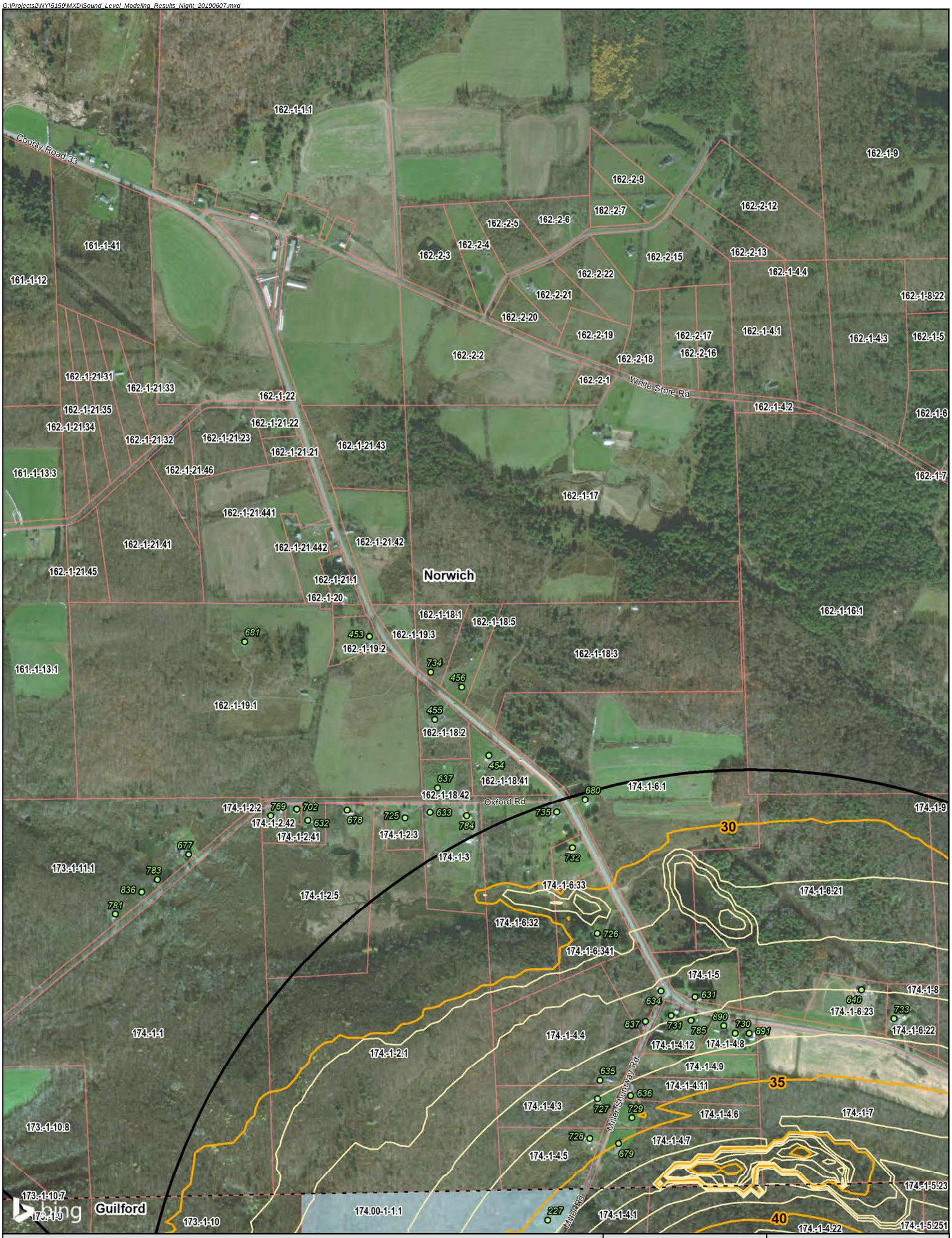
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 1 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



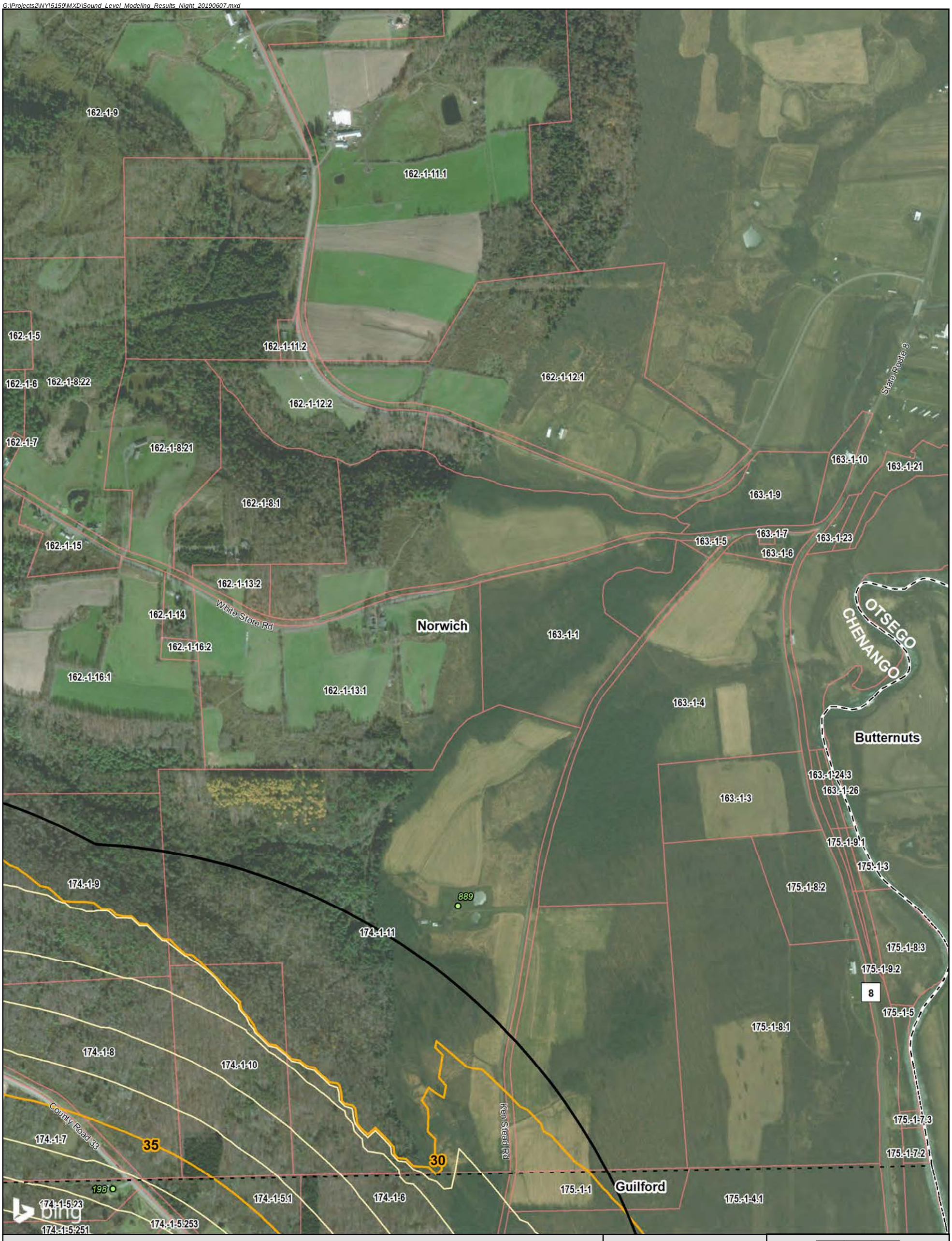
High Bridge Wind **Chenango County, New York**

Epsilon ASSOCIATES INC.

Figure 9-3, Map 2 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



- Nordex N149/4.8, HH = 105m
- Year-Round Residence
- Seasonal Residence
- Public
- Unknown
- Participating Parcel
- Non-Participating Parcel
- Project Area
- Battery Storage
- Concrete Batch Plant
- O&M Building
- Substation
- NYS DEC Land
- Town Boundary
- County Boundary

Predicted Sound Level (dBA)

- 5 dBA Contour Interval
- 1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet

0 400 800 Feet

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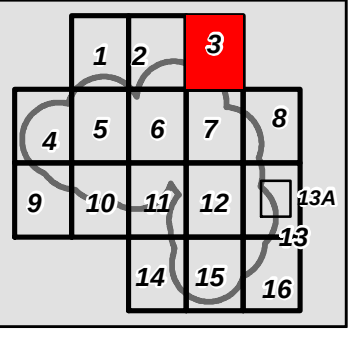


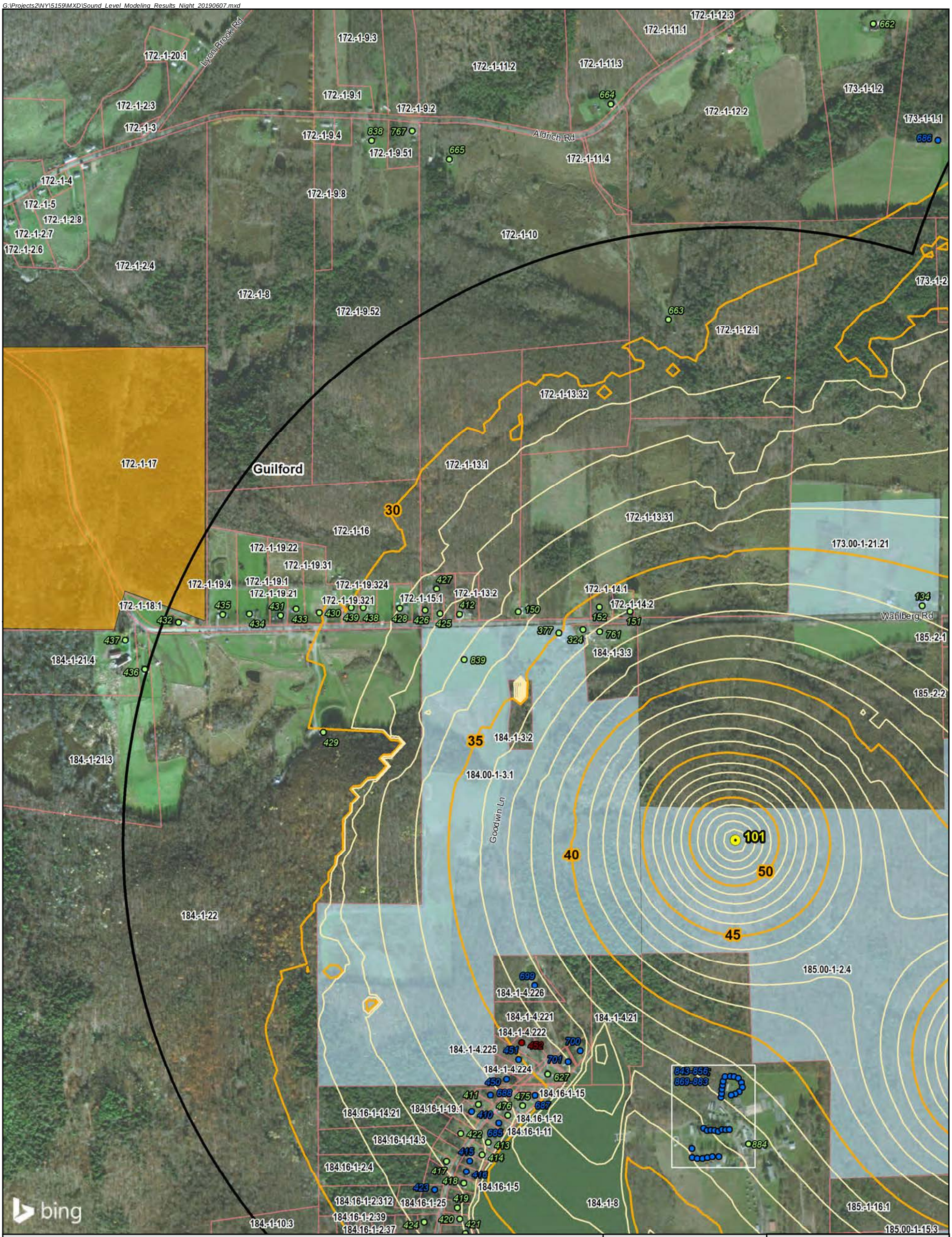
High Bridge Wind **Chenango County, New York**

Epsilon ASSOCIATES INC.

Figure 9-3, Map 3 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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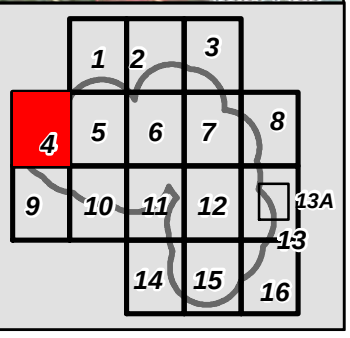


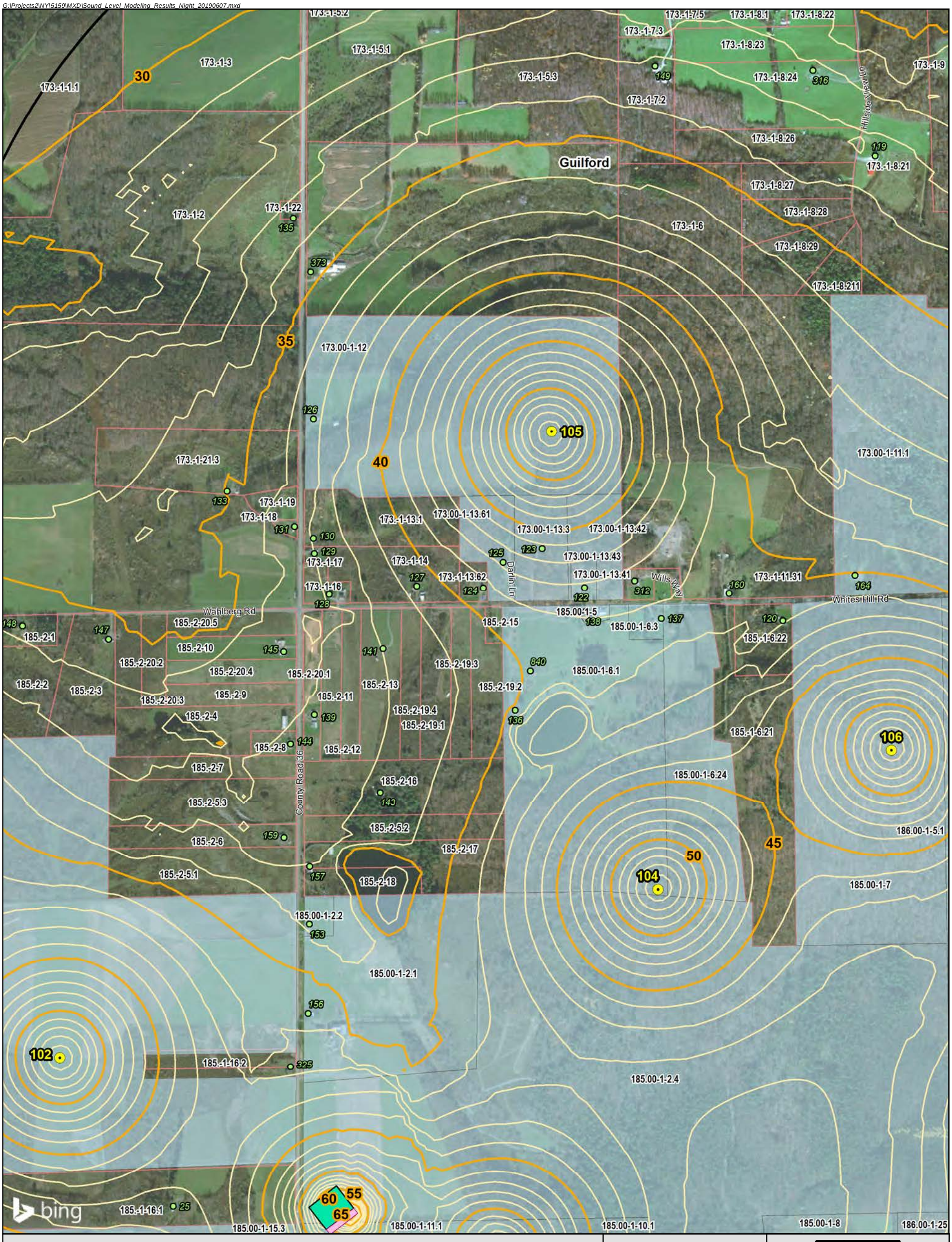
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 4 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

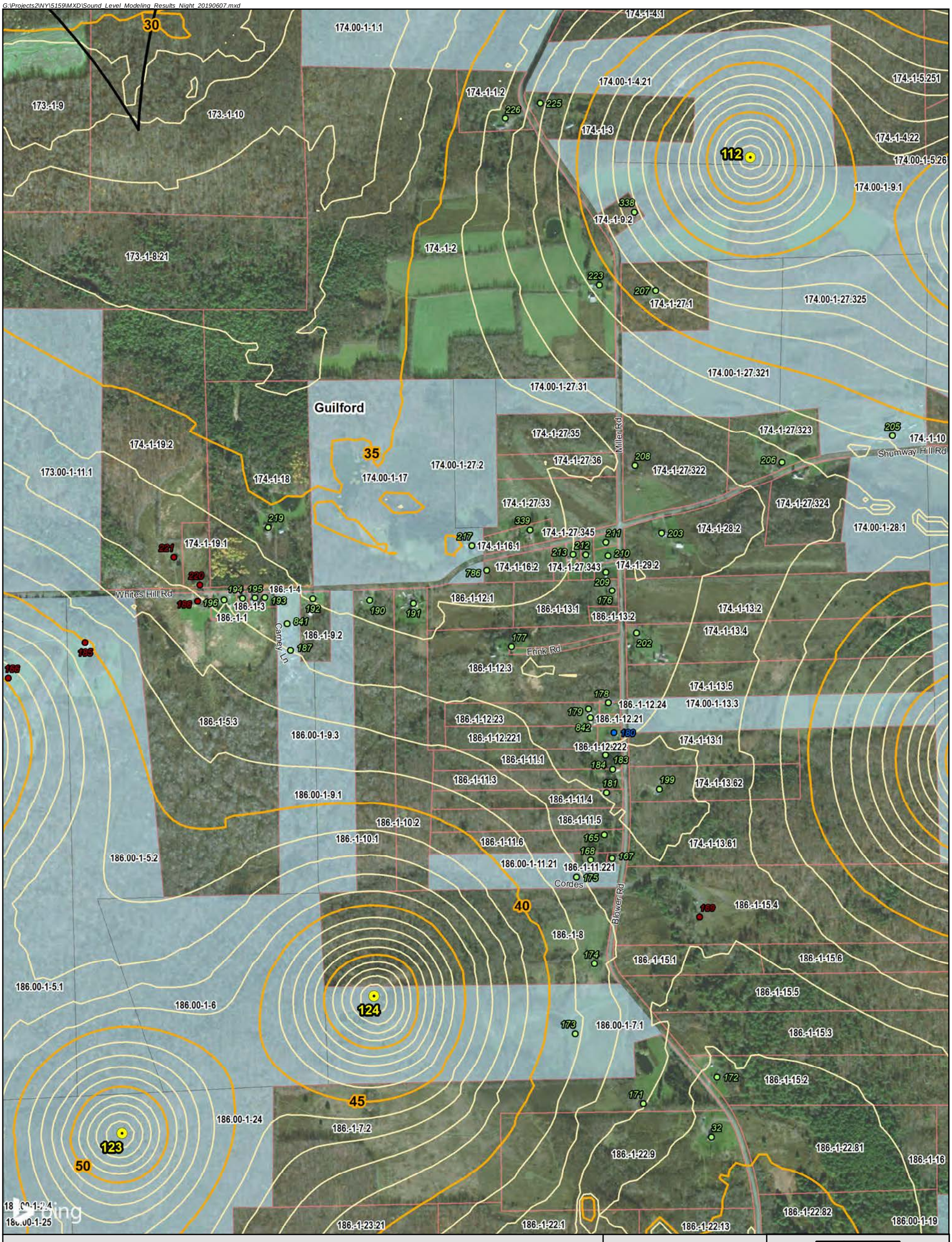
1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 5 of 16
Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



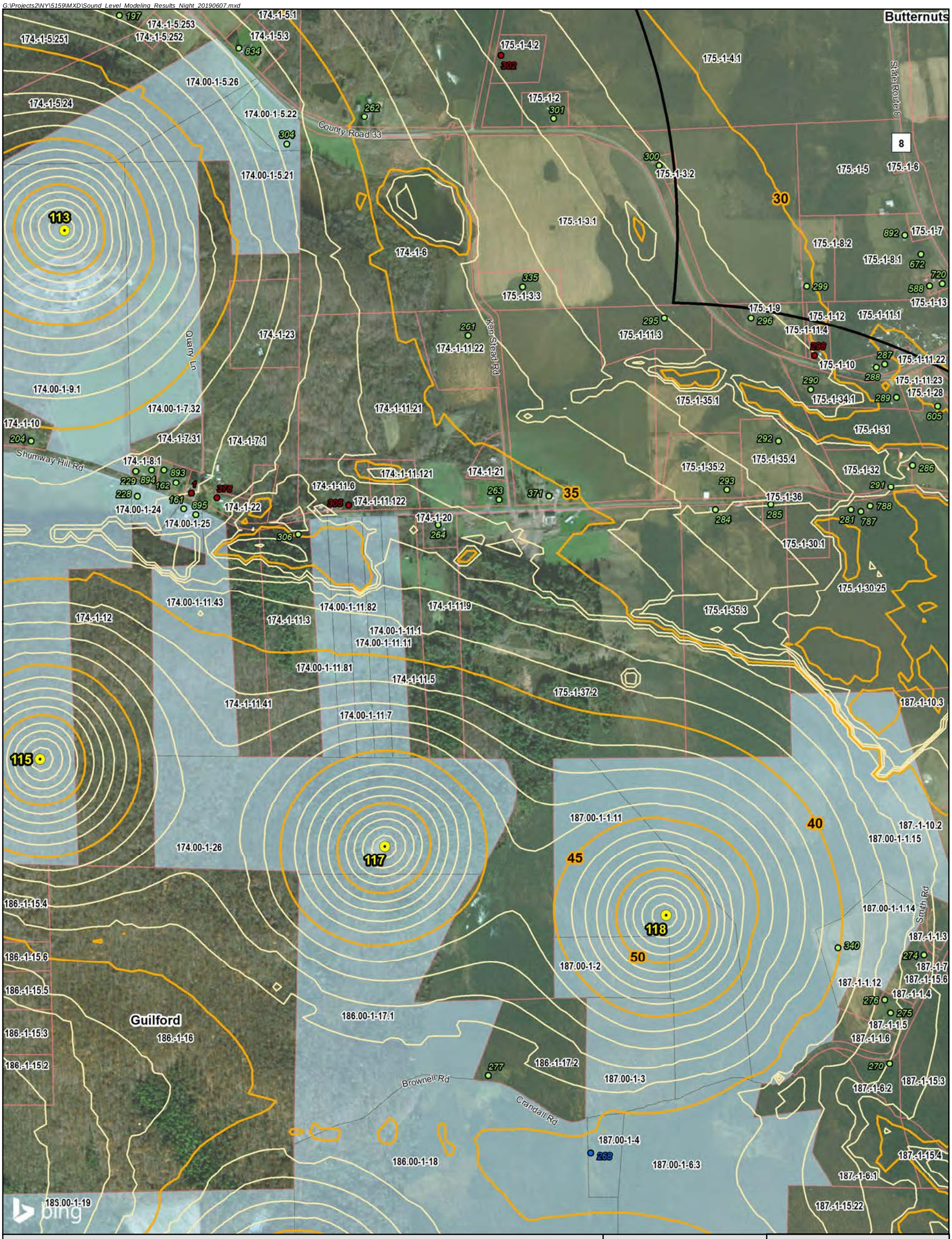
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 6 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 7 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 8 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd

Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

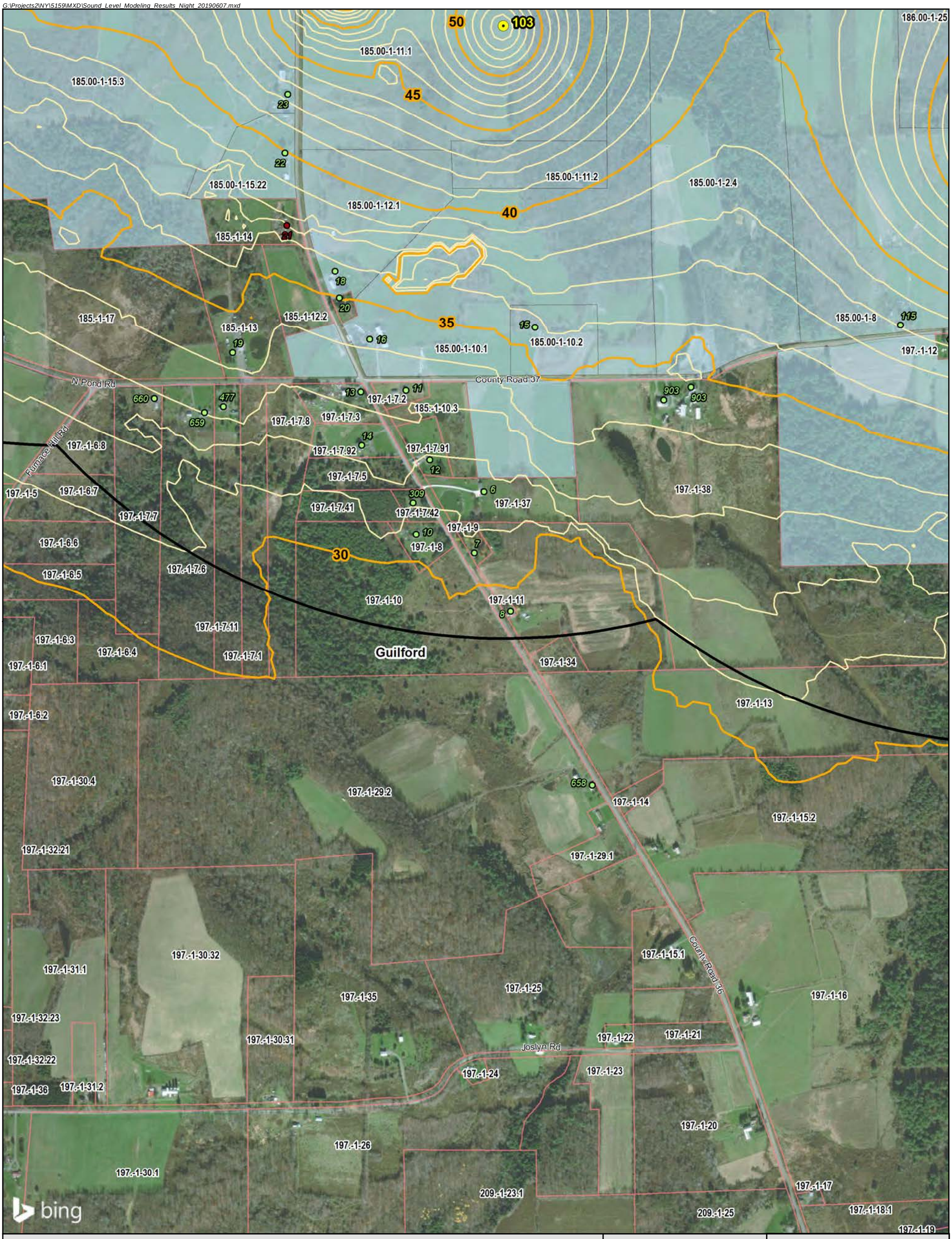
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 9 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

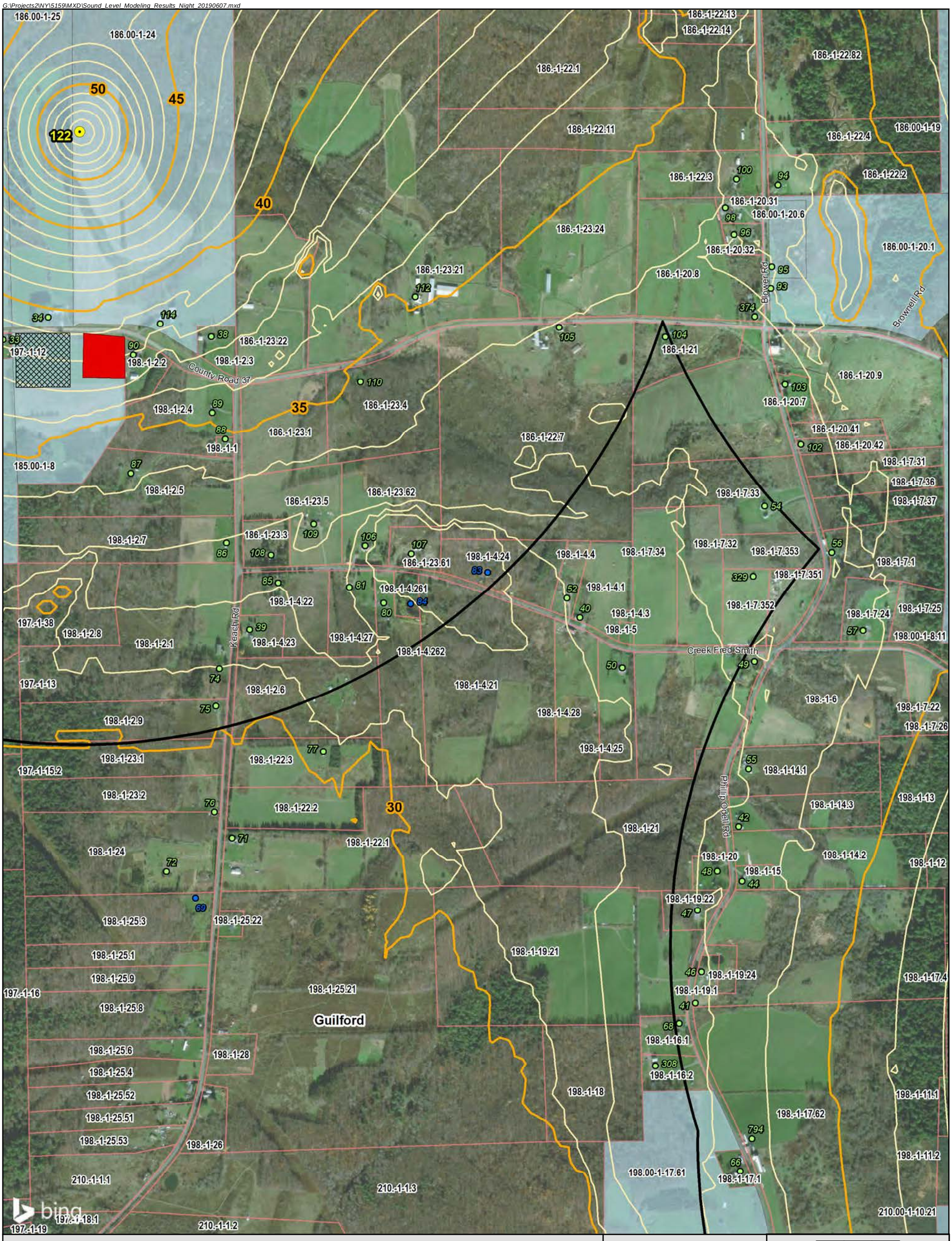
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 10 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

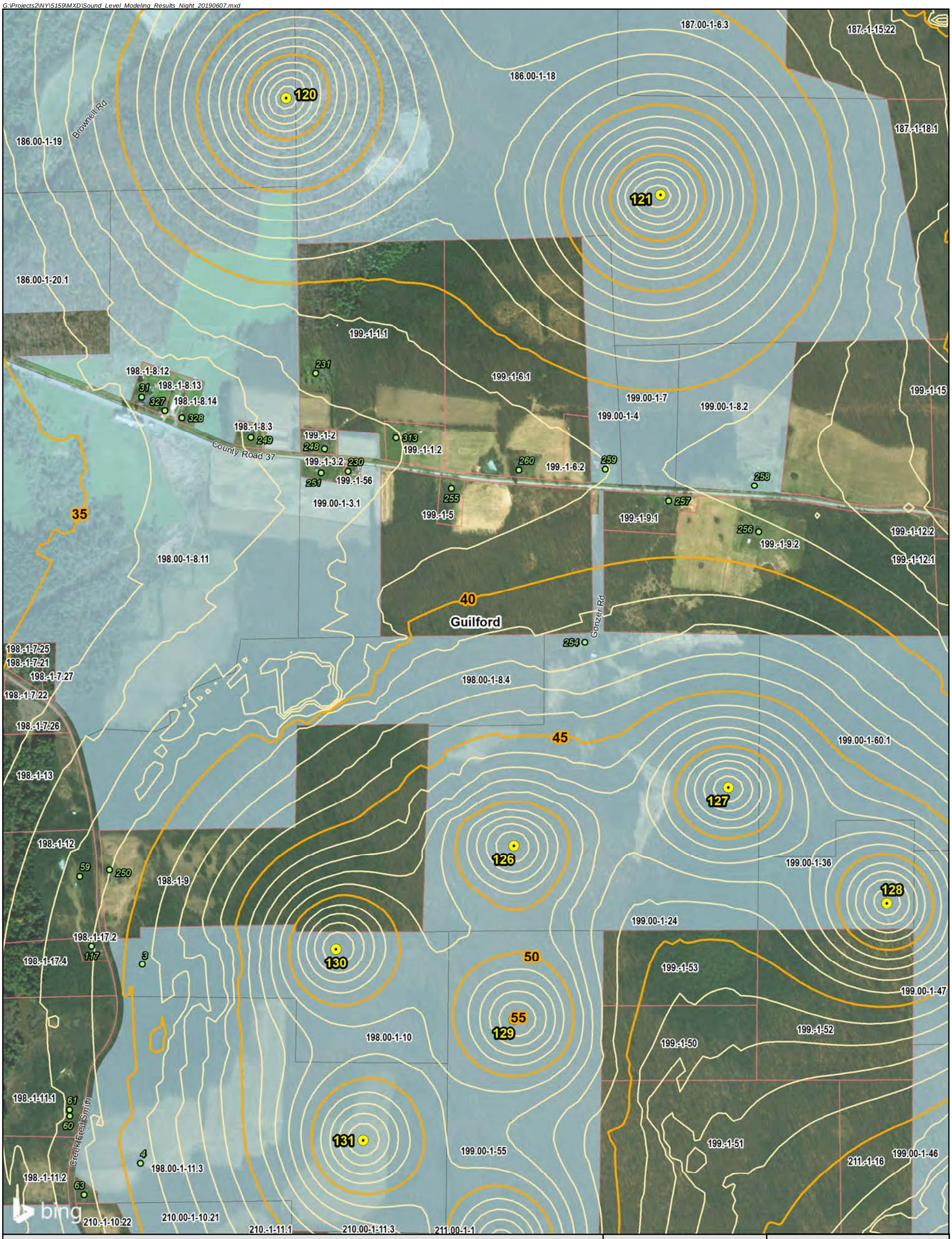
High Bridge Wind **Chenango County, New York**

Epsilon ASSOCIATES INC.

Figure 9-3, Map 11 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

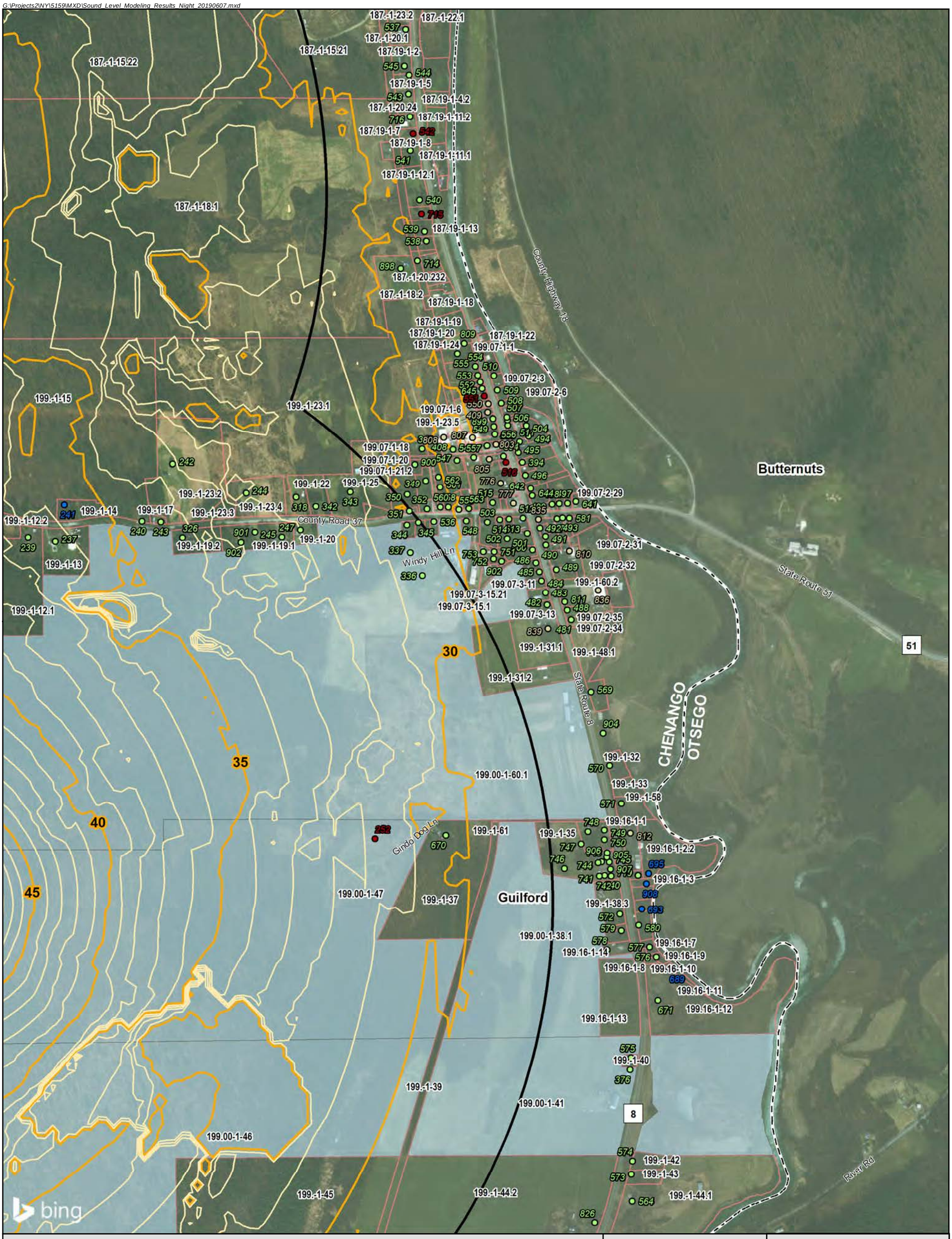
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 12 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area
Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

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1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 13 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_Pg13A_20190607.mxd

Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:4,800
1 inch = 400 feet
0 200 400 Feet

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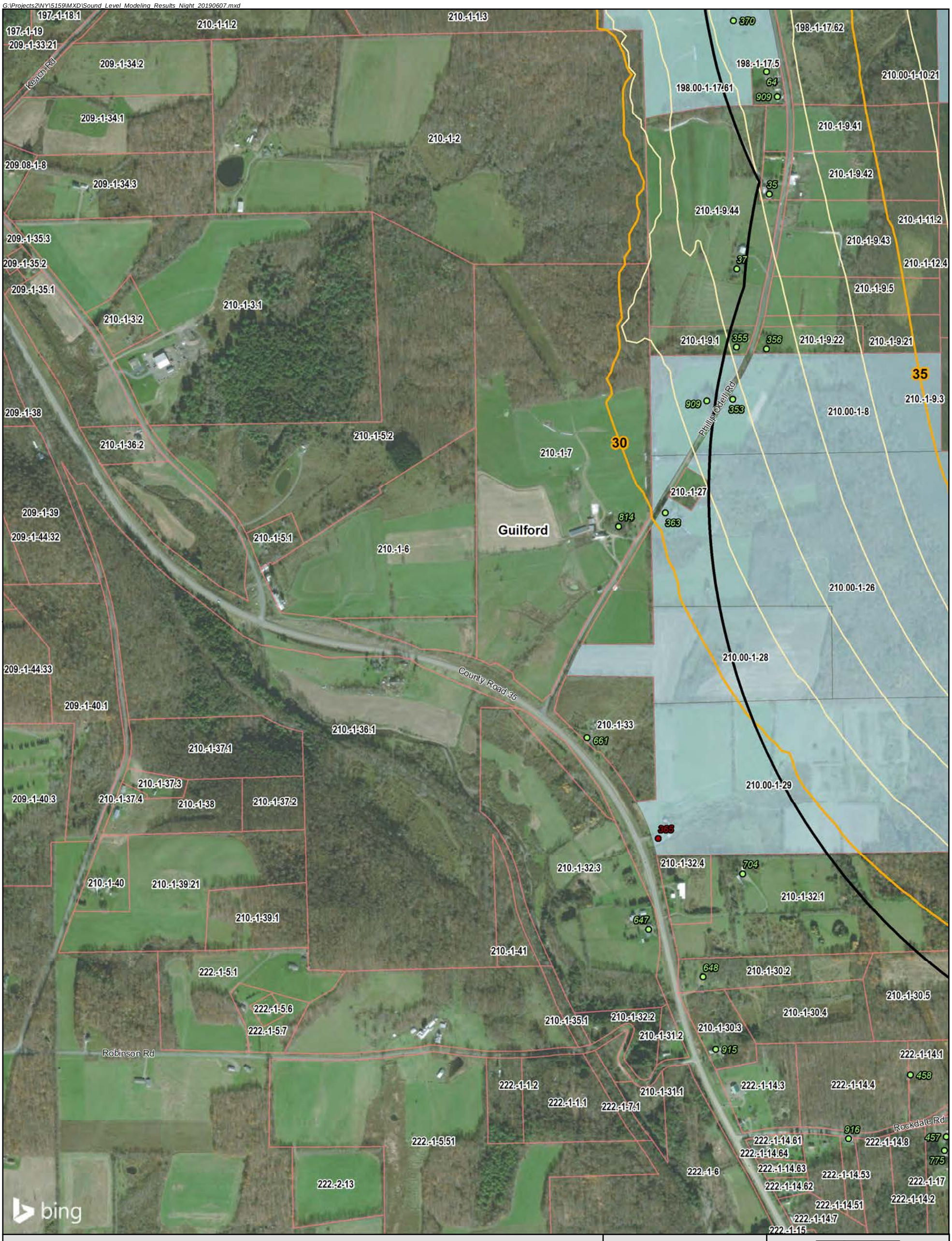
1 2 3 4 5 6 7 8 9 10 11 12 13 13A 14 15 16

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 13A of 16
Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



Nordex N149/4.8, HH = 105m
Year-Round Residence
Seasonal Residence
Public
Unknown
Participating Parcel
Non-Participating Parcel
Project Area

Battery Storage
Concrete Batch Plant
O&M Building
Substation
NYS DEC Land
Town Boundary
County Boundary

Predicted Sound Level (dBA)
5 dBA Contour Interval
1 dBA Contour Interval

Scale 1:9,600
1 inch = 800 feet
0 400 800 Feet

Service Layer Credits: © 2019 Microsoft Corporation © 2019 DigitalGlobe ©CNES (2019) Distribution Airbus DS

1 2 3 4 5 6 7 8 9 10 11 12 13A 13 14 15 16

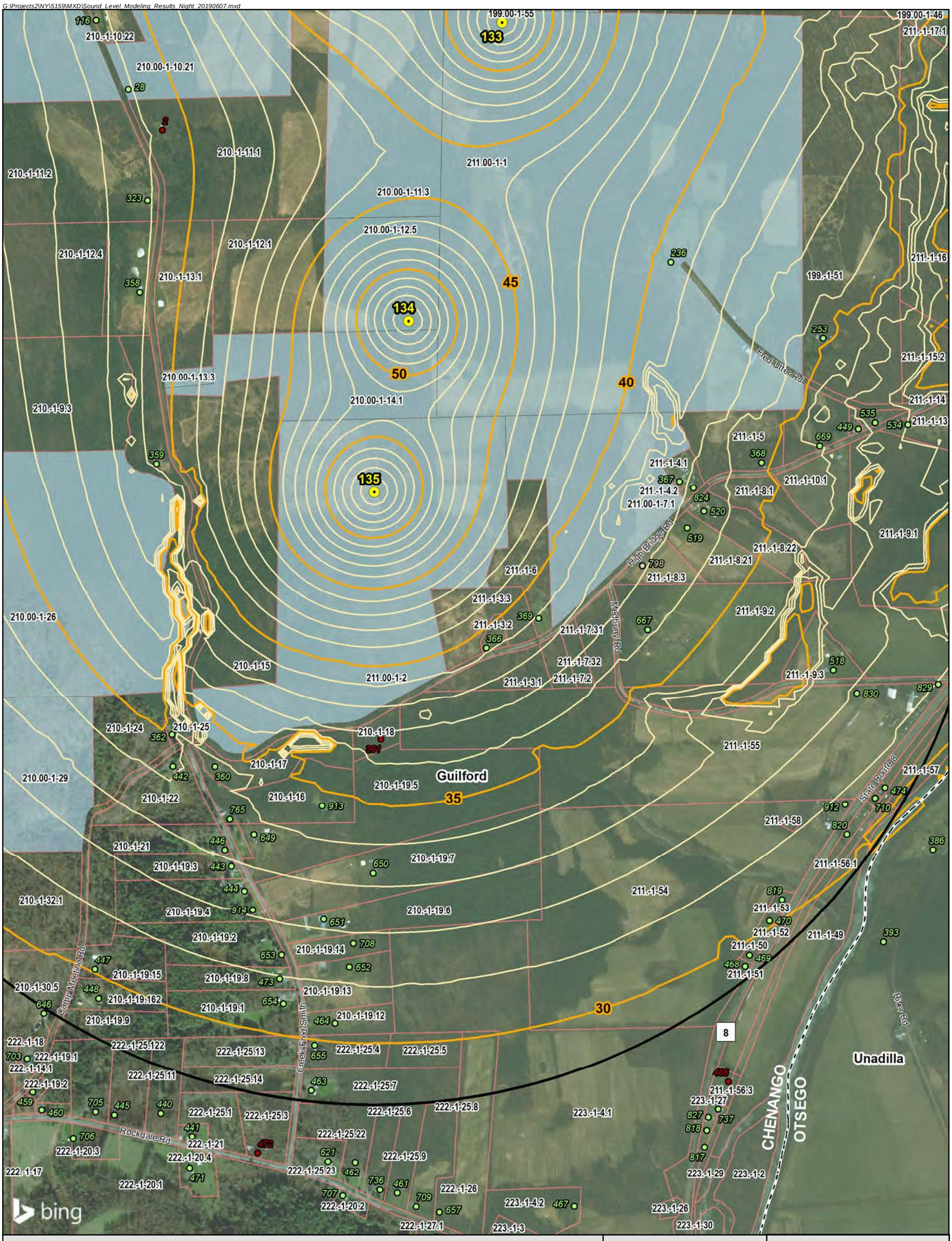
High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 14 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd



High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 15 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results

G:\Projects2\NY\5159\MXD\Sound_Level_Modeling_Results_Night_20190607.mxd

High Bridge Wind **Chenango County, New York**

Epsilon Associates Inc.

Figure 9-3, Map 16 of 16

Annual Nighttime L_{EQ} Sound Level Modeling Results