# SOUND LEVEL ANALYSIS REPORT

# 600 Central Street Battery Energy Storage System Project
# Holliston, Massachusetts

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# 1.0 EXECUTIVE SUMMARY

The 600 Central Street Battery Energy Storage Project (the Project) is a proposed energy storage facility with a capacity of approximately 5 megawatts (MW) in Holliston, Massachusetts. The Project is being developed by Blue Wave Solar (Blue Wave). Epsilon Associates Inc. (Epsilon) has been retained by Blue Wave to conduct a sound level analysis for this Project.

The sound level analysis included a baseline measurement program conducted in July 2022 to determine existing sound levels in the vicinity of the Project site and sound level modeling of operational sounds from the proposed facility.

This report presents the findings of the sound level measurement program. Computer modeling was used to predict worst-case future $L_{eq}$ sound levels from the Project. The Project will include 4 battery storage containers and 2 inverters with a proposed sound wall to reduce sound from the Project. The highest predicted Project only $L_{eq}$ sound level at a modeling location is 36 dBA. This location is at the west property line of the Project.

## 2.0 INTRODUCTION

The proposed Project will consist of 4 energy storage containers and 2 inverters and will have a capacity of approximately 5 MW. This report presents the findings of a sound level analysis for the Project including a baseline sound level measurement program and computer modeling to predict sound levels from the Project. The Project components were modeled in CadnaA using sound data provided by Blue Wave.

# 3.0 SOUND TERMINOLOGY

There are several ways in which sound levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The following information defines the sound level terminology used in this analysis.

The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy, but not equal to a doubling in decibel quantity (100 dB). Thus, every 3-dB change in sound level represents a doubling or halving of sound energy. The human ear does not perceive changes in the sound pressure level as equal changes in loudness. Scientific research demonstrates that the following general relationships hold between sound level and human perception for two sound levels with the same or very similar frequency characteristics[1]:

- 3 dB increase or decrease results in a change in sound that is just perceptible to the average person,
- 5 dB increase or decrease is described as a clearly noticeable change in sound level, and
- 10 dB increase or decrease is described as twice or half as loud.

Another mathematical property of decibels is that if one source of sound is at least 10 dB louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter (SLM) that is used to measure sound is a standardized instrument.[2] It contains "weighting networks" (e.g., A-, C-, Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz (Hz), are detailed characterizations of sounds, often addressed in musical terms as "pitch" or "tone". The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies. The A-weighting network is the accepted scale used for community sound level measurements; therefore, sounds are frequently reported as detected with a sound level meter using this weighting. A-weighted sound levels emphasize middle frequency sounds (i.e., middle pitched – around 1,000 Hz) and de-emphasize low and high frequency sounds. These sound levels are reported in decibels designated as "dBA". The C-weighting network has a nearly flat response for frequencies between 63 Hz and 4,000 Hz and is noted as dBC. Z-weighted sound levels are measured sound levels without any weighting curve and are otherwise referred

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1 Bies, David, and Colin Hansen. 2009. *Engineering Noise Control: Theory and Practice*, 4th Edition. New York: Taylor and Francis.

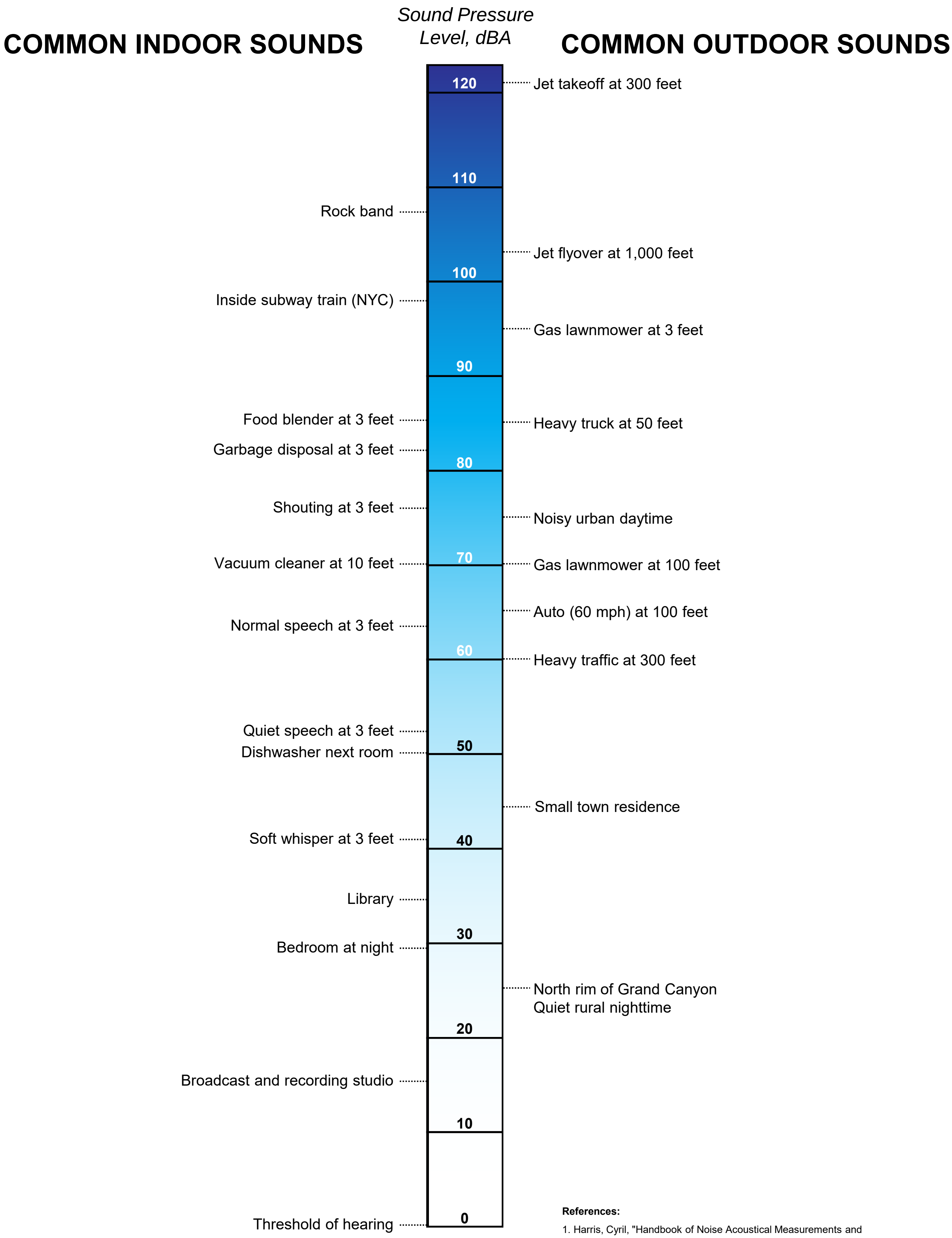
2 *American National Standard Electroacoustics – Sound Level Meters – Part 1: Specifications,* ANSI S1.4-2014 (R2019), published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

to as “unweighted”. Sound pressure levels for some common indoor and outdoor environments are shown in Figure 3-1.

Because the sounds in our environment vary with time, they cannot simply be described with a single number. Two methods are used for describing variable sounds. These are exceedance levels and the equivalent level, both of which are derived from some number of moment-to-moment sound level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated $L_n$, where n can have a value between 0 and 100 in terms of percentage. Two sound level metrics that are commonly reported in community sound studies are described below.

- $L_{90}$ is the sound level exceeded 90 percent of the time during the measurement period. The $L_{90}$ is close to the lowest sound level observed. It is essentially the same as the residual sound level, which is the sound level observed when there are no obvious nearby intermittent sound sources.

- $L_{eq}$, the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.,* the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated $L_{eq}$ and is typically A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with linear mean square sound pressure values, the $L_{eq}$ is mostly determined by loud sounds if there are fluctuating sound levels.




**References:**


1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998




**Figure 3-1**

*Common Indoor and Outdoor Sound Levels*

# 4.0 NOISE REGULATIONS

## 4.1 Federal Regulations

There are no federal community noise regulations applicable to this Project.

## 4.2 Massachusetts State Regulations

The MassDEP has the authority to regulate noise under 310 CMR 7.10, which is part of the Commonwealth's air pollution control regulations. Those regulations apply to "suppressible and preventable industrial and commercial sources of sound" and include the following:

> *No person owning, leasing, or controlling a source of sound shall willfully, negligently, or through failure to provide necessary equipment, service, or maintenance or to take necessary precautions cause, suffer, allow, or permit unnecessary emissions from said source of sound that may cause noise,*

where noise is defined as causing a nuisance, being injurious, or unreasonably interfering with the comfortable enjoyment of life and property or the conduct of business. The MassDEP administers this regulation through its Noise Policy DAQC 90-001, dated February 1, 1990. The Noise Policy limits a source to a 10-dBA increase above the ambient sound measured (the L90 sound level) at the property line for the site and at the nearest residences. According to the MassDEP, "Noise levels that exceed the criteria at the source's property line by themselves do not necessarily result in a violation or a condition of air pollution under MassDEP regulations (see 310 CMR 7.10). The agency also considers the effect of noise on the nearest occupied residence and/or building housing sensitive receptors."[3] In addition, "…[a] new noise source that would be located in an area in which housing or buildings containing other sensitive receptors could be developed in the future may be required to mitigate its noise impact in these areas."

MassDEP's Noise Policy further prohibits "pure tone" conditions where the sound pressure level in one octave band is 3 dB or more than the sound levels in each of the two adjacent octave bands. A qualitative example of a source emitting a "pure tone" is a fan with a bad bearing that is producing an objectionable squealing sound.

## 4.3 Local Regulations

The City of Holliston Zoning By-Laws include a performance standard pertaining to noise that is consistent with the MassDEP noise regulation. Therefore, compliance with the MassDEP regulations will also result in compliance with the City by-laws.

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3 Energy and Environmental Affairs. Noise Pollution Policy Interpretation | MassDEP. https://www.mass.gov/files/documents/2018/01/31/noise-interpretation.pdf. Accessed April 2022.

# 5.0 EXISTING SOUND LEVELS

## 5.1 Overview

The proposed Project site is located at 600 Central Street, west of an existing power line right of way, in Holliston, MA. An ambient sound level survey was conducted to characterize the existing acoustical environment in the Project area. Existing sound sources around the Project area include: vehicular traffic (including large trucks) along Central Street, insects, rustling vegetation, birds, youth camp activity, and occasional aircraft.

## 5.2 Measurement Methodology

A comprehensive sound level measurement program was developed to quantify the existing ambient sound levels around the proposed Project. The program consisted of one sound level monitor and a weather station. Sound level data were collected for approximately seven days from Tuesday, July 26, 2022, to Wednesday, August 3, 2022.

Sound levels were measured on the proposed Project site at a height of five feet (1.5 meters) above ground level. Meteorological data were collected on-site to determine periods of invalid sound data based on high winds or precipitation.

## 5.3 Measurement Location

The selection of the sound monitoring location was based upon a review of the Project plans and neighboring properties near the Project. The measurement location is shown in Figure 5-1 and described below. The coordinates for the sound level measurement location are shown in Table 5-1.

- **Location 1** (L1) is located near 600 Central Street and is representative of the residential receptors to the west of the facility along Pilgrim Road.

**Table 5-1 GPS Coordinates – Sound Level Measurement Location**

| Location | Latitude | Longitude |
|---|---|---|
| L1 | 42.1990299° | -71.4041044° |


**600 Central Street Holliston, Massachusetts**

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**Figure 5-1**

*Sound Level Measurement Location*

## 5.4 Measurement Equipment

One Larson Davis Model 831 sound level meter equipped with a PCB PRM 831 preamplifier, a PCB 377B20 half-inch microphone and an environmental windscreen was used to collect background sound pressure level data at the measurement location. All instrumentation meets the "Type 1 - Precision" requirements set forth in ANSI S1.4 for acoustical measuring devices. The measurement equipment was field calibrated before and after the survey with a Larson Davis CAL200 acoustical calibrator which meets the standards of IEC 942 Class 1L and ANSI S1.40. Statistical descriptors (e.g., $L_{eq}$, $L_{90}$, etc.) were measured for each 1-hour sampling period.

Onsite weather conditions were recorded using an ATMOS 41 weather station and EM60 data logger (manufactured by Meter Group, Inc.). The weather station has a wind speed measurement range of 0 to 30 m/s (67 mph) and an accuracy of ±0.3 m/s (0.67 mph).

## 5.5 Ambient Sound Levels

Hourly A-weighted sound pressure level data from the continuous ambient monitor at the measurement location is shown graphically in Figure 5-2. The data shown are ANS-weighted which means they have been processed using a high-frequency noise filter to remove high-frequency noise that is typically due to seasonal insects. The figure includes periods of precipitation measured at the onsite weather station. To be consistent with ANSI S12.18, all hourly periods of precipitation (10 hours) were excluded from the analysis. The average ground-level wind speed did not exceed 5 m/s during the measurement program, so no additional data were excluded due to high wind speed.

Valid equivalent broadband ANS-weighted sound levels ($L_{eq}$) ranged from 23 to 48 dBA over the 7-day period. The valid measured residual background ($L_{90}$) broadband ANS-weighted sound levels ranged from 20 to 39 dBA over the 7-day period between. The $L_{90}$ is often used to represent constant background sources. Daytime hours are defined as 7 am to 10 pm, and nighttime hours are defined as 10 pm to 7 am, consistent with the definition used by MassDEP.

**Table 5-2 Summary of Averaged ANS-Weighted Ambient Sound Levels**

| Measurement Location | Daytime Maximum Sound Level (dBA) | | Daytime Minimum Sound Level (dBA) | | Nighttime Maximum Sound Level (dBA) | | Nighttime Minimum Sound Level (dBA) | |
|---|---|---|---|---|---|---|---|---|
| | $L_{eq}$ | $L_{90}$ | $L_{eq}$ | $L_{90}$ | $L_{eq}$ | $L_{90}$ | $L_{eq}$ | $L_{90}$ |
| L1 | 48 | 39 | 30 | 24 | 40 | 36 | 23 | 20 |

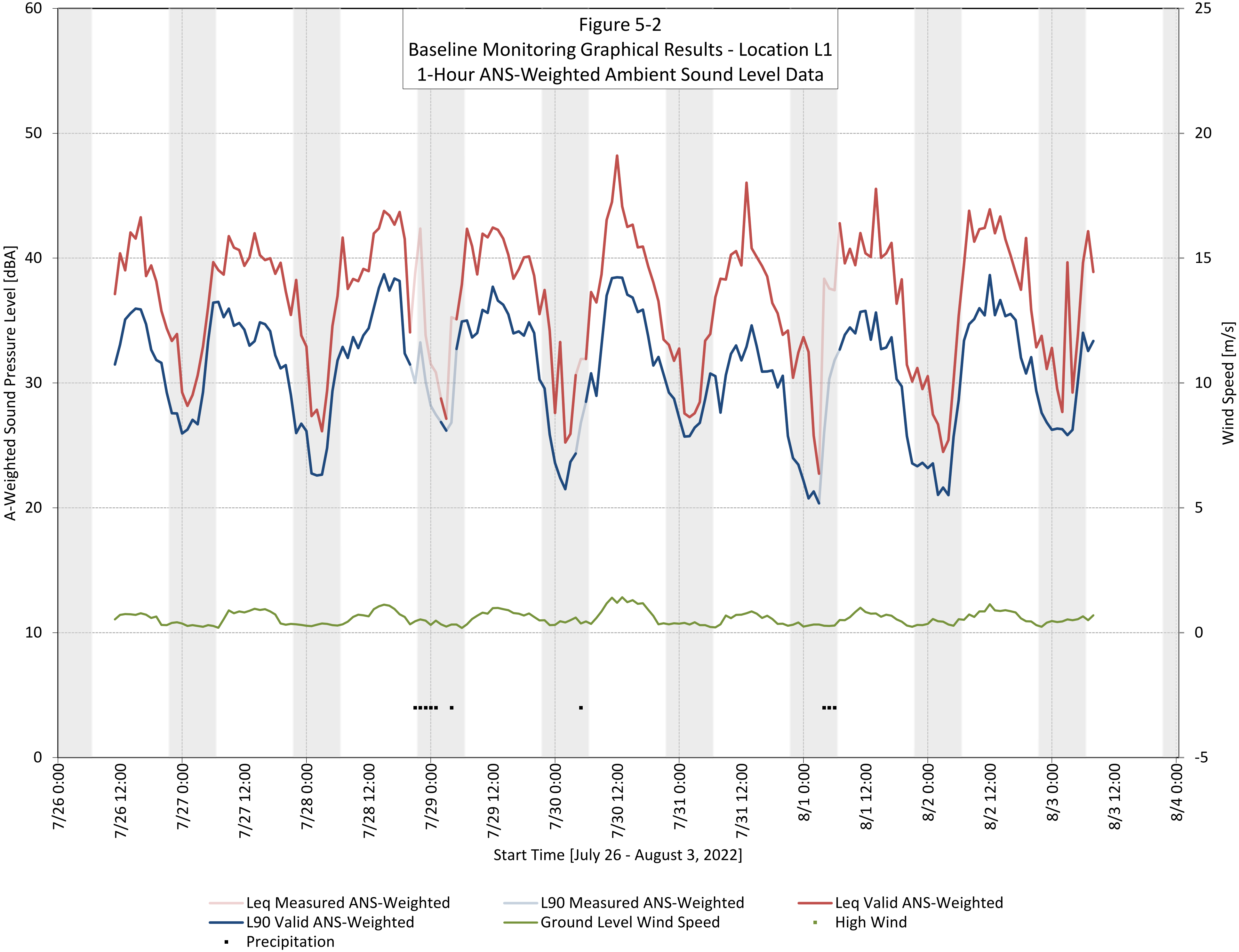
Figure 5-2
Baseline Monitoring Graphical Results - Location L1
1-Hour ANS-Weighted Ambient Sound Level Data
A-Weighted Sound Pressure Level [dBA]
Wind Speed [m/s]
60
50
40
30
20
10
0
25
20
15
10
5
0
-5
7/26 0:00
7/26 12:00
7/27 0:00
7/27 12:00
7/28 0:00
7/28 12:00
7/29 0:00
7/29 12:00
7/30 0:00
7/30 12:00
7/31 0:00
7/31 12:00
8/1 0:00
8/1 12:00
8/2 0:00
8/2 12:00
8/3 0:00
8/3 12:00
8/4 0:00
Start Time [July 26 - August 3, 2022]
Leq Measured ANS-Weighted
L90 Measured ANS-Weighted
Leq Valid ANS-Weighted
L90 Valid ANS-Weighted
Ground Level Wind Speed
High Wind
Precipitation

# 6.0 MODELED SOUND LEVELS

## 6.1 Sound Sources and Noise Controls

The sources of sound from the Project will be the inverters and battery storage containers. Sound power level data for this equipment was provided by Blue Wave. Sound source information and source quantities are presented in Table 6-1.

The Project is proposed to include a sound wall to reduce Project sound level impacts. The sound wall is approximately 400 feet in length with a height of 20 feet above ground and runs along the Project perimeter as shown in Figure 6-1. The modeled sound wall is absorptive[4] on the interior-facing façade and reflective[5] on the exterior-facing façade. The model assumes the wall material is sufficiently dense that sound transmission through it is negligible and that any access gates in the walls are closed.

**Table 6-1 Modeled Sound Levels per Sound Source**

| Sound Source | Model | Sound Power Level, dBA | Number of Units Modeled |
|---|---|---|---|
| Inverter | EPC Power CAB 1000 PCS | 86 | 2 |
| Battery Storage Container | AESI TeraStor ESS | 93 | 4 |

## 6.2 Modeling Methodology

The sound levels due to the Project were predicted using the CadnaA sound level calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation.[6] The software accounts for topography, ground attenuation, multiple building reflections (if applicable), drop-off with distance, and atmospheric absorption. The CadnaA software allows for octave band calculation of sound from multiple sources as well as computation of diffraction.

Inputs and significant parameters employed in the model are described below.

- *Project Layout:* The analysis is for the Project layout dated August 2023. The proposed Project layout and sound walls are shown in Figure 6-1.

- *Modeling Locations:* Epsilon selected six property line modeling locations based on the project layout. Nine additional residential building centroids near the Project were identified by Epsilon based on aerial imagery and modeled as well. All modeling locations were modeled as discrete

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4 Absorption coefficient of 0.84

5 Absorption coefficient of 0.21

6 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation,* International Standard ISO 9613-2:1996 (International Organization for Standardization, Geneva, Switzerland, 1996).

points at a height of 1.5 meters above ground level to approximate ear height of a typical standing adult.

- *Modeling Grid:* Sound levels were calculated over a modeling grid with 10-meter spacing over the region surrounding the Project. Levels were calculated at a height of 1.5 meters above ground level to be consistent with the modeling locations. The resulting sound isopleths are shown in Figure 6-2.

- *Terrain Elevation:* Elevation contours for the modeling domain were imported into CadnaA 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.

- *Source Sound Levels:* Sound power levels used in the model are described in Section 6.1.

- *Ground Attenuation:* Consistent with the aforementioned international standard, the model allows inputs between 0 (hard ground) and 1 (porous ground). Spectral ground absorption was calculated using a G-factor 0.5 for the entire modeling domain. An absorption of 0.5 corresponds to "mixed ground" consisting of both hard and porous ground cover and is appropriate for the crushed stone yard surface as well as the agricultural-residential land surrounding the Project.

Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by Epsilon, were implemented in the CadnaA model to ensure conservative results (i.e., higher sound levels), and are described below:

- The model includes 2 dB of uncertainty for all sources.

- All modeled sources were assumed to be operating simultaneously and at their maximum load corresponding to the greatest sound level impacts.

- 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.

- Meteorological conditions assumed in the model (T=10°C/RH=70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive.

No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

*Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services*


**600 Central Street** **Holliston, Massachusetts**

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**Figure 6-1**

*Sound Level Modeling Locations*

## 6.3 Sound Level Modeling Results

### *6.3.1 Broadband Evaluation*

The modeled Project-only sound levels at each of the modeling locations are shown in Table 6-2. The nighttime ambient sound levels in the Project area can be very low as shown in Table 5-2. Therefore, the predicted Project-only sound levels have been evaluated against the representative daytime $L_{90}$ sound level and the Project operating hours should be restricted to daytime only (7 am to 10 pm).

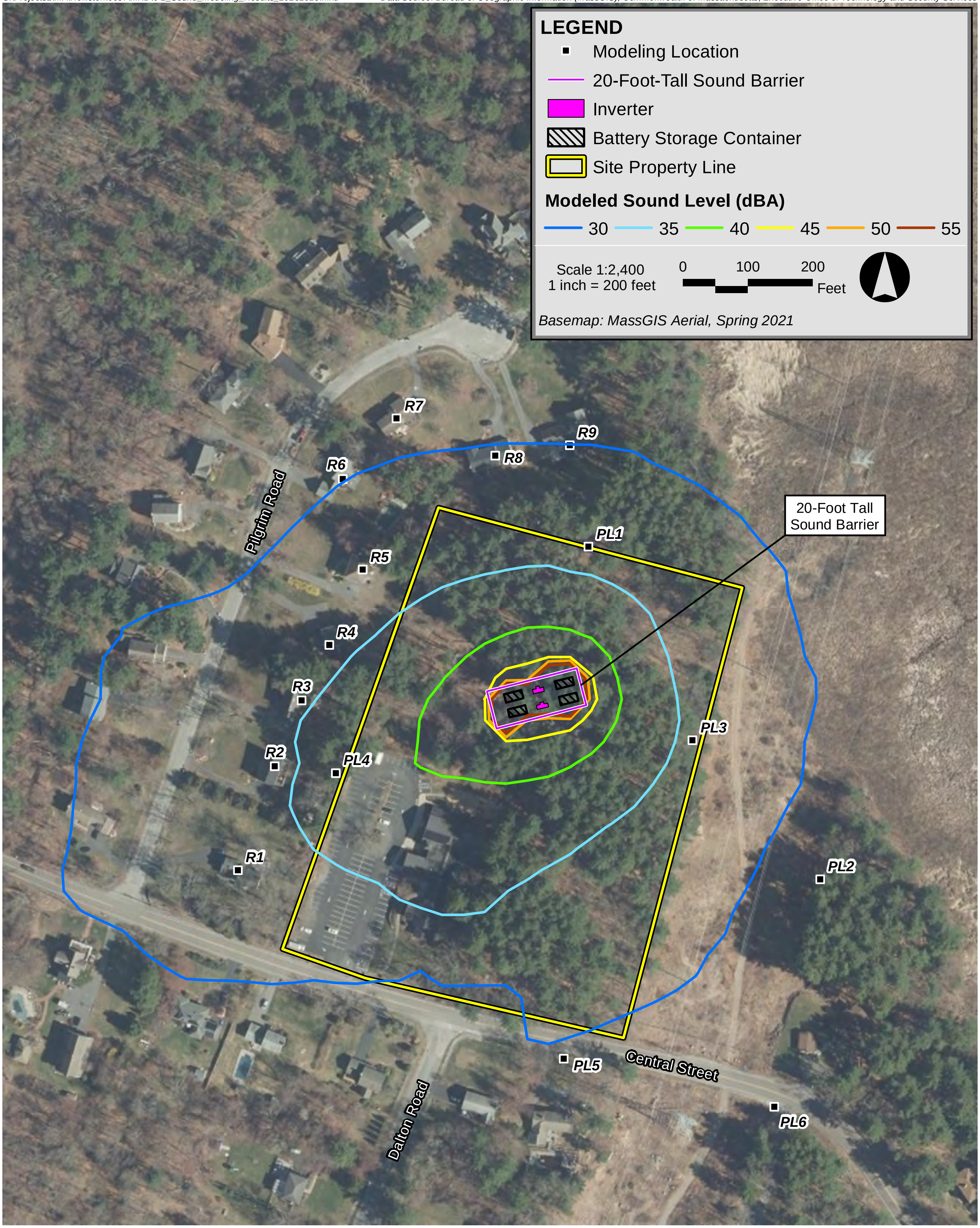
All modeled sound levels, as output from CadnaA, are A-weighted equivalent sound levels ($L_{eq}$, dBA). The predicted barrier mitigated project sound levels at the nearest residences and residential property line receptors are shown in Table 6-2. The predicted sound levels at the 15 modeling locations range from 27 to 37 dBA. The highest predicted Project only $L_{eq}$ sound level is at the west project property line.

As shown in Table 6-2, sound level modeling indicates that the Project will comply with the MassDEP noise policy provided the Project operates during daytime hours only.

**Table 6-2 Modeled Broadband Sound Level Compliance Evaluation**

| Modeling Location | Modeled Sound Level, $L_{eq}$ dBA | Ambient Sound Level Between 7 am and 10pm, $L_{90}$ dBA | Total Ambient Plus Project, dBA | Increase above Ambient, dBA |
|---|---|---|---|---|
| R1 | 32 | 27 | 33 | 6 |
| R2 | 33 | 27 | 34 | 7 |
| R3 | 33 | 27 | 34 | 7 |
| R4 | 33 | 27 | 34 | 6 |
| R5 | 31 | 27 | 33 | 5 |
| R6 | 29 | 27 | 31 | 4 |
| R7 | 28 | 27 | 31 | 3 |
| R8 | 29 | 27 | 31 | 4 |
| R9 | 29 | 27 | 31 | 4 |
| PL1 | 33 | 27 | 34 | 7 |
| PL2 | 27 | 27 | 30 | 3 |
| PL3 | 33 | 27 | 34 | 7 |
| PL4 | 36 | 27 | 37 | 9 |
| PL5 | 28 | 27 | 31 | 4 |
| PL6 | 26 | 27 | 30 | 2 |

Sound level isopleths generated from the model are presented in Figure 6-2. The sound levels in Figure 6-2 include the sound level reduction provided by the proposed Project’s 20-foot tall sound wall.




**600 Central Street** **Holliston, Massachusetts**

Epsilon ASSOCIATES INC.

**Figure 6-2**

*Sound Level Modeling Results*

#### 6.3.2 Pure Tone Evaluation

Octave-band sound pressure level modeling indicates that the proposed Project is not expected to create a pure tone condition, as defined by MassDEP, when combined with existing daytime background sound levels at any modeled receptor location. A pure tone evaluation is shown in Table 6-3.

**Table 6-3 Modeled Pure Tone Compliance Evaluation**

| Modeling Location | Ambient Plus Modeled Sound Level (dB) per Octave-Band Center Frequency (Hz)[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 31.5 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| R1 | 42 | 43 | 36 | 34 | 32 | 31 | 25 | 19 | 15 |
| R2 | 43 | 43 | 37 | 35 | 33 | 31 | 26 | 19 | 15 |
| R3 | 43 | 43 | 37 | 36 | 33 | 32 | 26 | 20 | 15 |
| R4 | 43 | 43 | 37 | 35 | 33 | 31 | 26 | 20 | 15 |
| R5 | 43 | 43 | 36 | 34 | 32 | 30 | 25 | 20 | 15 |
| R6 | 42 | 43 | 36 | 33 | 30 | 29 | 24 | 18 | 15 |
| R7 | 42 | 43 | 35 | 32 | 30 | 28 | 23 | 18 | 15 |
| R8 | 42 | 43 | 36 | 33 | 30 | 29 | 24 | 19 | 15 |
| R9 | 42 | 43 | 36 | 33 | 30 | 28 | 24 | 19 | 15 |
| PL1 | 43 | 43 | 37 | 35 | 32 | 30 | 27 | 22 | 16 |
| PL2 | 42 | 43 | 35 | 32 | 30 | 28 | 23 | 18 | 15 |
| PL3 | 43 | 44 | 37 | 35 | 32 | 31 | 27 | 22 | 16 |
| PL4 | 43 | 44 | 38 | 37 | 35 | 34 | 29 | 21 | 15 |
| PL5 | 42 | 43 | 35 | 32 | 30 | 28 | 23 | 18 | 15 |
| PL6 | 42 | 43 | 35 | 31 | 29 | 28 | 22 | 17 | 15 |

1. Calculated from levels with greater precision than shown in this table, and then rounded to the nearest whole decibel.

## 7.0 CONCLUSION

A sound level analysis was conducted for the proposed 600 Central Street Battery Energy Storage Project. The Project consists of four energy storage containers and two central inverters and has a capacity of 5 MW.

Substantial noise mitigation measures have been incorporated into the design of the proposed Project to minimize noise impacts in the community. These mitigation measures include a sound attenuating barrier and nighttime operational restrictions. Should underlying equipment sound data or other operational or site parameters change, the degree of sound mitigation required to achieve compliance may change. If such changes occur, additional sound modeling should be conducted prior to construction to determine the appropriate level of mitigation.

Results of a comprehensive sound level monitoring and modeling analysis indicate that the sound levels from the facility will comply with the requirements set forth in the MassDEP Noise Policy with the mitigation measures described in this report.