Noise Impact Assessment
Proposed 0.5 MW Solar Array

Maxson Hill Road
AP 4 Lot 38
Hopkinton, Rhode Island

PREPARED FOR:
Centrica Business Solutions
7484 Candlewood Road, Suite T-W
Hanover, MD 21076

PREPARED BY:
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404 Wyman Street, Suite 375
Waltham, Massachusetts 02451

ESS Project No. C642-000

August 13, 2020

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TABLE OF CONTENTS

SECTION **PAGE**

1.0 INTRODUCTION 2

2.0 CONCEPTS OF ENVIRONMENTAL SOUND 2

3.0 APPLICABLE NOISE STANDARDS AND REGULATIONS 3

4.0 ASSESSMENT OF EXISTING ENVIRONMENT 3

5.0 PREDICTIVE MODELING 6
- 5.1 Noise Prediction Model 6
- 5.2 Modeling Inputs 6
- 5.3 Comparison to Estimated Baseline Noise Levels 7

6.0 CONCLUSION 9

TABLES

Table 1 Examples of Common Indoor and Outdoor A-Weighted Sound Pressure Levels
Table 2 Noise Source Inputs to the Cadna-A Model
Table 3 Cadna-A Modeling Result Sound Levels

FIGURES

Figure 1 Site Plan and Topography
Figure 2 Predicted Noise Levels and Isopleths

APPENDICES

Appendix A Equipment Sound Level Documentation

1.0 INTRODUCTION

ESS Group, Inc. (ESS) was contracted by Centrica Business Solutions for professional consulting services related to the permitting of a proposed ±0.5 MW ground mounted Photovoltaic Solar Energy System (PSES) project at Assessor's Plat 4, Lot 38 on Maxson Hill Road in Hopkinton, Rhode Island. The purpose of this assessment was to evaluate the predicted sound levels at the property line as a result of the operation of the PSES. The following sections detail the methodology used and the final results of the project noise impact assessment. Relevant backup documentation supporting these analyses has been included in Appendix A.

2.0 CONCEPTS OF ENVIRONMENTAL SOUND

Sounds are generated by a variety of sources (e.g., a musical instrument, a voice speaking, or an airplane that passes overhead). Energy is required to produce sound and this sound energy is transmitted through the air in the form of sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear. The range of sound pressures that can be detected by a person with normal hearing is very wide, ranging from about 20 micro-pascals (µPa) for very faint sounds at the threshold of hearing to nearly 10 million µPa for extremely loud sounds, such as a jet during take-off at a distance of 300 feet. Because the range of human hearing is so wide, sound levels are reported using "sound pressure levels", which are expressed in terms of decibels. The sound pressure level in decibels is the logarithm of the ratio of the sound pressure of the source to the reference sound pressure of 20 µPa, multiplied by 20.

Table 1 provides some examples of common sources of sound and their sound pressure levels. All sound levels in this assessment are provided in A-weighted decibels, abbreviated "dB(A)" or "dBA." The A-weighted sound level reflects how the human ear responds to sound, by deemphasizing sounds that occur in frequencies at which the human ear is least sensitive to sound (at frequencies below about 100 hertz and above 10,000 hertz) and emphasizing sounds that occur in frequencies at which the human ear is most sensitive to sound (in the mid-frequency range from about 200 to 8,000 hertz). In the context of environmental sound, noise is defined as "unwanted sound."

Table 1: Examples of Common Indoor and Outdoor A-Weighted Sound Pressure Levels

Sound Level dB(A)	Common Indoor Sounds	Common Outdoor Sounds
110	Rock Band	Jet Takeoff at 1000 feet
100	Inside NYC Subway Train	Chain Saw at 3 feet
90	Food Blender at 3 feet	Impact Hammer (Hoe Ram) at 50 feet
80	Garbage Disposal at 3 feet	Diesel Truck at 50 feet
70	Vacuum Cleaner at 10 feet	Lawn Mower at 100 feet
60	Normal Speech at 3 feet	Auto (40 mph) at 100 feet
50	Dishwasher in Next Room	Busy Suburban Area at night
40	Empty Conference Room	Quiet Suburban Area at night
25	Empty Concert Hall	Rural Area at night

Sound pressure levels are typically presented in community noise assessments utilizing the noise metrics described below and expressed in terms of A-weighted decibels.

- "L_{10}" is the sound level that is exceeded for 10 percent of the time. This metric is a measure of the intrusiveness of relatively short-duration noise events that occurred during the measurement period.
- "L_{90}" is the sound level that is exceeded for 90 percent of the time and is a measure of the background or residual sound levels in the absence of recurring noise events.
- "L_{eq}" is the is the constant sound level which would contain the same acoustic energy as the varying sound levels during the time period, and is representative of the average noise exposure level for that time period.
- "L_{MAX}" is the instantaneous maximum sound level for the time period.

It is often necessary to combine the sound pressure levels from one or more sources. Because decibels are logarithmic quantities, it is not possible to simply add the values of the sound pressure levels together. For example, if two sound sources each produce 70 dB and they are operated together, their combined impact is 73 dB – not 140 dB as might be expected. Four equal 70 dB sources operating simultaneously result in a total sound pressure level of 76 dB. In fact, for every doubling of the number of equal sources, the sound pressure level goes up another three decibels. A tenfold increase in the number of sources makes the sound pressure level increase by 10 dB, while a hundredfold increase makes the level increase by 20 dB. The logarithmic combination of *n* different sound levels is calculated by the following equation:

$$L_{total}=10*\log_{10}\left(10^{\frac{L_1}{10}}+10^{\frac{L_2}{10}}+\ldots+10^{\frac{L_n}{10}}\right)$$

Perceived changes in sound level can be slightly more subjective; the average person will not notice a change of 1-2 dB, a 3 dB increase is just barely perceptible, while a 5 dB change is clearly noticeable.

3.0 APPLICABLE NOISE STANDARDS AND REGULATIONS

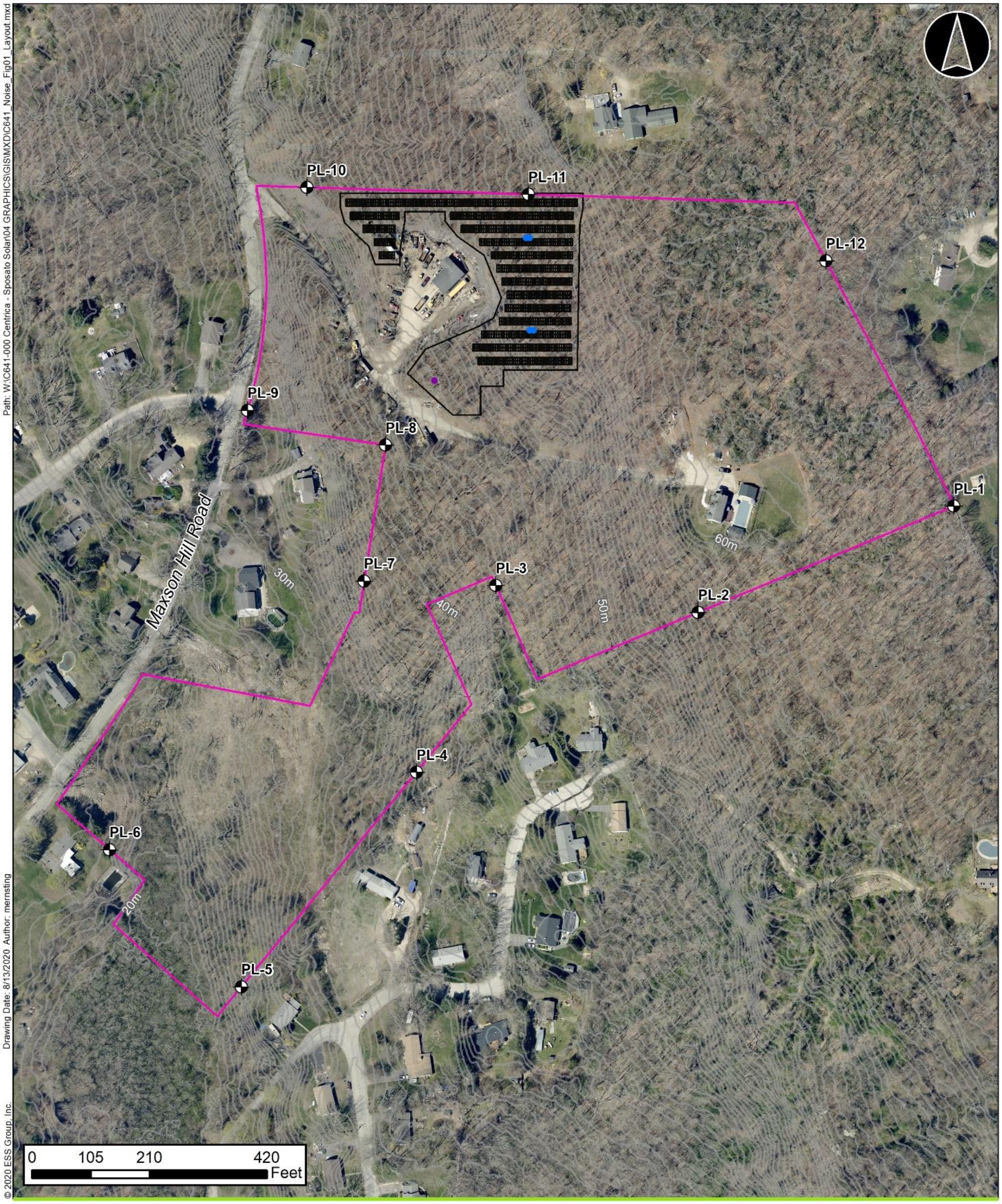
The State of Rhode Island does not have noise regulations that are applicable to the proposed solar array. Applicable noise standards are contained within the ordinances of the Town of Hopkinton.

Article III- Noise, Section 10-51 prohibits "the creating of any unreasonable loud, disturbing and unnecessary noise within the limits of the town," and Section 10-52 additionally prohibits "noise of such character, intensity or duration as to be detrimental to the life or health of any individual, or in disturbance of the public peace and welfare."

The project is regulated by the revised Chapter 246 of the Hopkinton, Rhode Island Code of Ordinances, "Non-Residential Photovoltaic Solar Energy Systems," adopted on January 22, 2019. Section A, Item 14 of Chapter 246, "Non-Residential Photovoltaic Solar Energy Systems," requires that a noise study be conducted to assess potential impacts on nearby receptors and demonstrate that the PSES "does not yield a noise level that exceeds forty (40) decibels at the property line."

4.0 ASSESSMENT OF EXISTING ENVIRONMENT

The 25± acre property is located off of Maxson Hill Road in Hopkinton, RI. It is identified as Assessor's Plat 4, Lot 38 and is zoned Residential, Farming, and Rural-80 (RFR-80). Currently, the Site consists of vacant wooded land, with the exception of a cleared area associated with a residential development in the northern to northeastern portion of the lot. The surrounding area is mostly wooded and undeveloped or low-density residential use. The topography of the Site primarily slopes downward to the southwest from a maximum elevation of approximately 211 feet above sea level at the northeast corner to 63 feet above sea level at the far southwest corner. The solar array will be located on an area in the northern portion of the site approximately 400 feet long and 400 feet wide, surrounding an existing building, with an average elevation of 168 feet above sea level and an average slope of approximately 11 percent. The proposed solar array layout and topography is shown in Figure 1 on the next page.



Maxson Hill Road Solar Array
Hopkinton, Rhode Island

1 inch = 233 feet

Source: 1) ESS, Sound Contours, 2019
2) NAIP, Imagery, 2016
3) ESRI, Transportation, 2019

Legend
- Inverters
- Transformer
- Property Line

Site Layout

Figure 1

5.0 PREDICTIVE MODELING

This section describes the methods, assumptions, and results of the Cadna-A® noise modeling used to predict future sound levels resulting from the operation of the proposed solar array at the property line.

5.1 Noise Prediction Model

The Cadna-A® computer noise model was used to predict future sound pressure levels from the operation of the proposed solar array at the property line and at the nearest noise-sensitive areas. An industry standard, Cadna-A® was developed by DataKustik GmbH to provide an estimate of sound levels at distances from specific noise sources. This model takes into account:

- Sound power levels from stationary and mobile sources;
- The effects of terrain features including relative elevations of noise sources;
- The locations of noise-sensitive land use;
- Intervening objects including buildings and sound barrier walls; and
- Ground effects due to areas of pavement and unpaved ground.

Cadna-A® accounts for shielding and reflections due to intervening buildings or other structures in the propagation path, as well as diffracted paths around and over structures, which tend to reduce computed noise levels. The shielding effects due to intervening terrain are included in the model. The shielding effects due to the proposed photovoltaic solar panels, and existing off-site buildings and ground vegetation were excluded from the model to provide a level of conservatism to the analysis.

For ground effects, the reflectivity of the surface is described by a “ground factor” variable (G), which ranges from 0 for ‘hard’ ground (paved surfaces, concrete, etc.) and 1 for “porous” ground (grassland and other vegetated areas). The model used a “porous” ground absorption factor (G) of 1.0 to represent typical ground conditions, since the ground beneath and around the solar arrays will remain vegetated.

The International Standards Organization current standard for outdoor sound propagation (ISO 9613 Part 2 – “Attenuation of sound during propagation outdoors”) was used within Cadna-A®. This standard provides a method for calculating environmental noise in communities from a variety of sources with known emission levels. The method contained within the standard calculates the attenuation over the entire sound path under weather conditions that are favorable for sound propagation, such as for downwind propagation or “under a well-developed moderate ground-based temperature inversion.” Application of conditions that are favorable for sound propagation yields conservative estimates of operational noise levels in the surrounding area.

5.2 Modeling Inputs

Based on the proposed site design of the proposed solar array, the noise-producing sources on the site during operation will be the power inverters and the transformer. Seventeen three-phase inverters were modeled, arranged in rows of 8 and 9, mounted vertically behind the photovoltaic panels along the center of the array, as well as the electrical distribution transformer toward the western side of the site, south of the solar arrays. The location of these sources is shown on Figure 1.

The source model inputs were based on the electrical equipment specifications provided by Centrica. The inverter sound level was based on the SolarEdge SE100KUS inverter, which has a manufacturer sound specification of <60 dBA at 1 meter. The transformer sound level was based on a 500kVA Cooper Power Systems wet-type transformer with a NEMA TR-1 rating of 57 dBA at 1 meter. Since the sound-producing equipment were assumed to be continuously operating, the L_{90} (background level) and L_{EQ} (equivalent constant level) of the proposed equipment are the same for the purposes of this assessment.

Table 2: Noise Source Inputs to the Cadna-A Model

Name	Source Height*	Octave Band Sound Power Levels (dB)									Total (dBA)
		31.5	63	125	250	500	1000	2000	4000	8000	
Inverter (4)	1 m	24.6	37.8	47.9	55.4	60.8	64.0	65.2	65.0	62.9	71.0
Transformer (1)	1 m	21.6	34.8	44.9	52.4	57.8	61.0	62.2	62.0	59.9	68.0

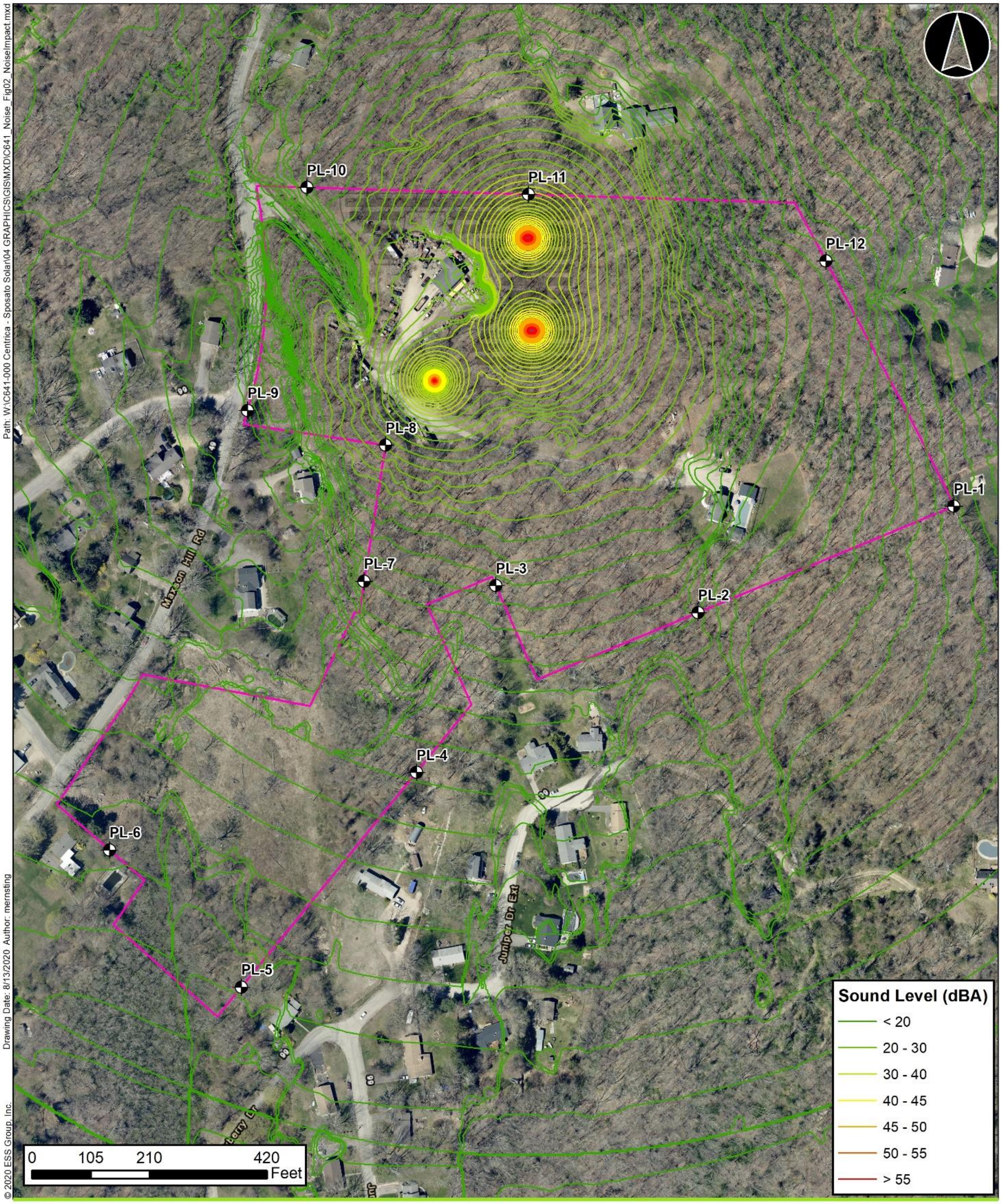
* Heights based on component dimensions and mounting orientation, assumed ground-mounted inverters and pad-mounted transformer. Source levels are extrapolated from manufacturer-provided sound pressure level specifications at 1 meter.

The conceptual site layout and existing topography was used to create a terrain model that represents the topography during operation of the proposed facility. Figure 1 shows the proposed topography within the site. The inputs to the model are 0.5-meter contours, based on existing LIDAR data from RIGIS and the conceptual site plan. The model assumed continuous and simultaneous operation of all sound-producing equipment. This was a conservative assumption, since not all equipment will be operating continuously at full load. A search radius of 500 meters from each receptor was used in the model to ensure that all noise sources contributing to the predicted facility noise level were modeled at every noise-sensitive receptor.

5.3 Comparison to Estimated Baseline Noise Levels

Cadna-A® allows the user to place receptors at selected locations and predicts sound levels at those specific receptor locations. For this analysis, specific receptors were placed at property line locations only.

Table 3 presents the predicted sound levels resulting solely from the operation of the proposed solar array along with the range of typical background noise levels (conservative values for a typical L_{90} measurement). The model also calculated sound levels for the surrounding area, using a 1-meter receptor grid, with a receptor height of 1.55 meters (representative of average ear height). This data is displayed in the isopleths on Figure 2, which show lines of equal sound level at the site and the surrounding area.



Maxson Hill Road Solar Array
Hopkinton, Rhode Island

1 inch = 233 feet

Source: 1) ESS, Sound Contours, 2020
2) RIGIS, Imagery, 2019
3) ESRI, Transportation, 2019

Legend

- Receptor Location
- Inverters
- Transformer
- Property Line

Noise Impacts

Figure 2

Table 3: Cadna-A Modeling Result Sound Levels

Site ID	Solar Array Noise Level (dBA)	Assumed Background Noise Level (dBA)	Maximum Permitted Noise (dBA)
PL-1	6.2	30-35	40
PL-2	14.3	30-35	40
PL-3	17.7	30-35	40
PL-4	11.2	30-35	40
PL-5	4.2	30-35	40
PL-6	7.2	30-35	40
PL-7	16.0	30-35	40
PL-8	24.2	30-35	40
PL-9	12.9	30-35	40
PL-10	18.4	30-35	40
PL-11	34.5	30-35	40
PL-12	12.4	30-35	40

6.0 CONCLUSION

The results of this Noise Impact Assessment conducted for the proposed 0.5 MW ground-mounted PSES project at Assessor's Plat 4, Lot 38 on Maxson Hill Road in Hopkinton, Rhode Island demonstrate that the maximum predicted sound levels from the proposed photovoltaic solar array will likely not be perceptible above existing ambient sound levels at the property line or at any point beyond the property line, and will be well below the newly established local noise ordinance threshold for PSES installations (40 dBA).