BLUEBIRD SOLAR PROJECT

OPERATION NOISE ANALYSIS REPORT

Prepared for
BayWa r.e. Solar Projects LLC
18575 Jamboree Road, Suite 850
Irvine, CA 92612

Prepared by
AZTEC Engineering
501 N 44th Street, Suite 300
Phoenix, AZ 85008

April 2021

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

The Bluebird Solar project is located in Harrison County, approximately one mile east of Leesburg, KY. The majority of the project sits between Highways 62 and 353, with a portion of the project located to the east of Highway 353. The project's southern border is 0.5 mile north of the Harrison County southern boundary line. Figure 1 depicts the project location.

The Bluebird Solar project is a 90 to 100 MWac PV solar farm. The buildable area, of approximately 1000 acres which will be permitted, includes discrete fenced areas of solar panels, laydown areas, landscaping, internal access roads, a project substation, and a utility switchyard. Battery storage is not included. To evaluate the existing and the proposed operation noise impacts from the project to nearby sensitive receptors, AZTEC Engineering was contracted by BayWa to conduct an operation noise impact analysis. This operation noise analysis report was prepared to document the existing noise levels surrounding the project area, predict operation noise levels at sensitive receptors, and determine the operation noise impact.

2.0 NOISE BACKGROUND INFORMATION

Sound is a form of energy that is transmitted by pressure variations that the human ear can detect. Sound levels are expressed in units of decibels (dB). Sound frequency is expressed in units of hertz (Hz). A normal human ear is able to hear sound with frequencies from 20 Hz to 20,000 Hz. Because the human ear does not equally perceive all sound frequencies, people perceive sound in the middle frequency better than sound in the low and high frequencies. As a result, sound levels in some frequency bands are adjusted or weighted to the frequency response of human hearing and the human perception of loudness. The "A"-weighted sound in decibels, or dBA, most closely represents the range of human hearing.

Noise is often called unwanted sound. Each individual perceives noise level changes differently. Generally, a 3 dBA noise change is the smallest change that can be detected by the human ear. A 5 dBA noise change is readily perceivable by most people. An increase of 10 dBA is normally perceived as a doubling of noise loudness. Typical sound levels experienced by people range from the 30s dBA, such as a quiet living room at night, to the 80s dBA, such as a sidewalk adjacent to heavy traffic. Noise levels related to point sources such as pump motors decrease rapidly with a 6 dBA reduction when doubling the distance. Noise levels related to linear sources such as traffic on roadways decrease less rapidly ─ 3 dBA when doubling the distance. Table 1 shows noise levels associated with common sources.

Noise varies in frequency, and its intensity fluctuates over time. Therefore, the A-weighted equivalent steady-state noise level ─ expressed as "L_{Aeq}" ─ is used to represent a single number to describe varying noise levels over a specified period. Another metric used in determining the impact of environmental noise is the differences in response that people have to daytime and nighttime noise levels. During the evening and at night, exterior background noises generally are lower than daytime levels. However, most household noise also decreases at night, and exterior noise becomes more noticeable. Furthermore, most people sleep at night and are sensitive to intrusive noises. The L_{dn} is a noise metric that accounts for the greater annoyance of noise during the nighttime hours (10:00 p.m. to 7:00 a.m.).

Figure 1. Vicinity Map

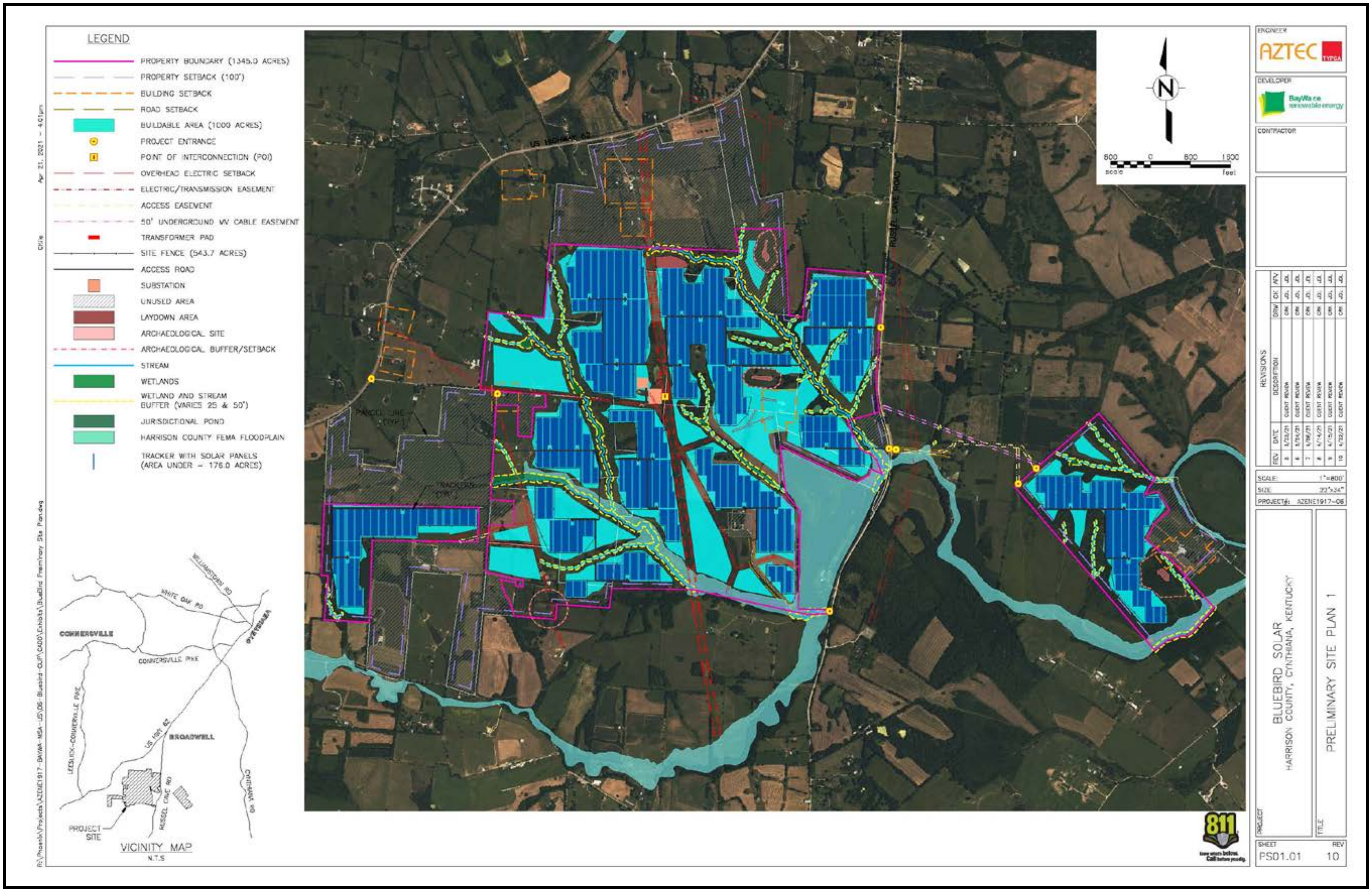


TABLE 1 COMMON NOISE SOURCES AND LEVELS	
Sound Pressure Level (dBA)	**Typical Sources**
120	Jet aircraft takeoff at 100 feet
110	Same aircraft at 400 feet
90	Motorcycle at 25 feet
80	Garbage disposal
70	City street corner
60	Conversational speech
50	Typical office
40	Living room (without TV)
30	Quiet bedroom at night
Source: *Environmental Impact Analysis Handbook* (Rau and Wooten 1980)	

3.0 ENVIRONMENTAL SETTING

3.1 Land Uses and Noise Sensitive Receptors

Noise-sensitive receptors generally are defined as locations where people reside or where the presence of unwanted sound may adversely affect the existing land use. Typically, noise-sensitive land uses include residences, hospitals, places of worship, libraries, performance spaces, offices, and schools, as well as nature and wildlife preserves, recreational areas, and parks.

The project is located in a rural area. Existing land use within the project site is primarily agricultural. Ambient noise is mainly from traffic on Highways 62 and 353 for those sensitive receptors with close proximity. For other sensitive receptors further away from the roadways, ambient noise is composed of farm equipment (e.g., tractors) used to grow and harvest crops and to raise cattle and other farm animals. No commercial or industrial sources were identified in the analysis area.

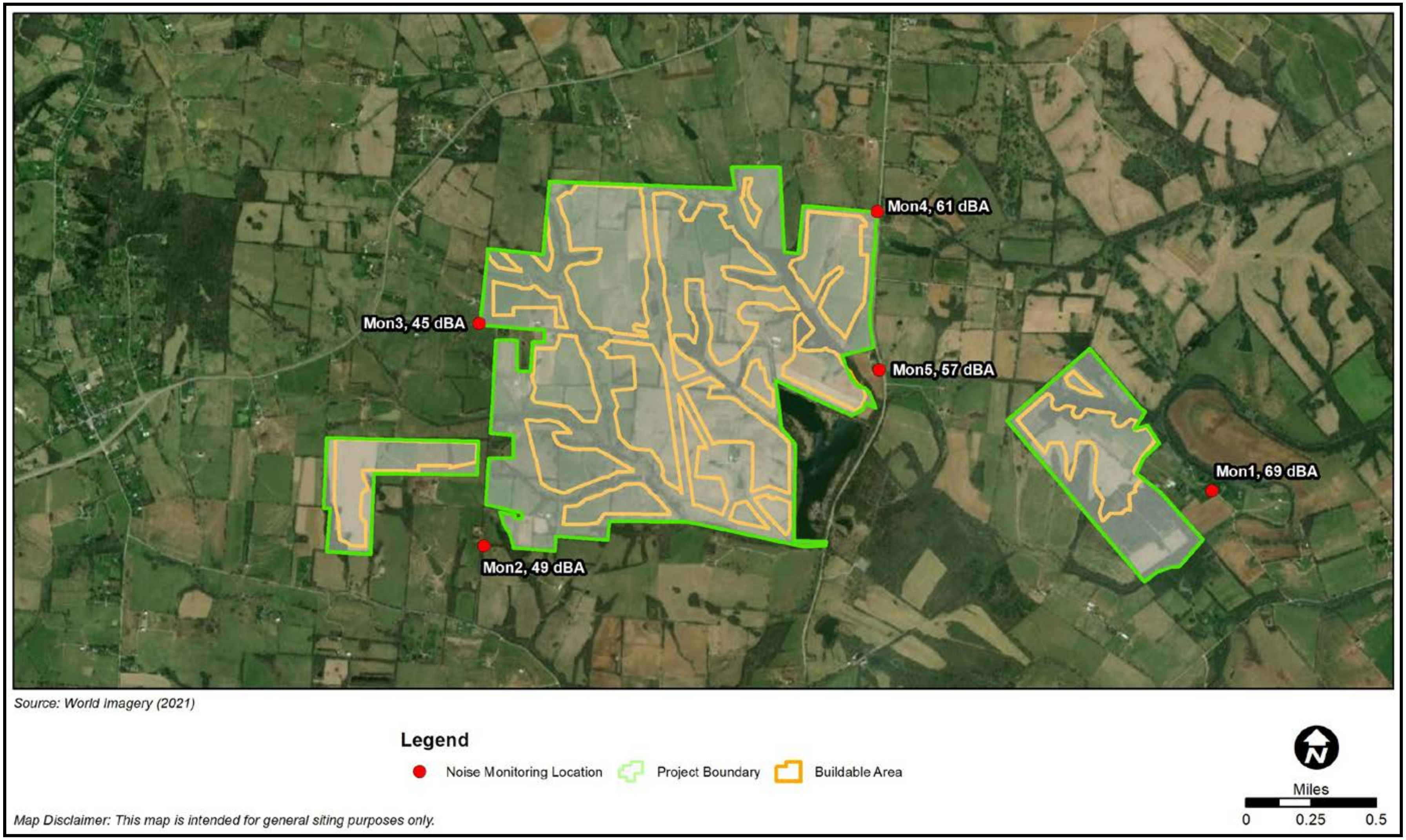
3.2 Existing Noise Conditions

Noise monitoring was conducted at 5 different sites outside the project boundary to document existing noise conditions on April 12, 2021. Each site was monitored for 15 minutes. Weather conditions (temperature, relative humidity, wind speed and direction, and sky condition) were documented. The Larson Davis System 824 with sound level meter and real-time analyzer, which complies with American National Standards Institute (ANSI) S1.4 and Type I Standards, was used to collect the sound. The monitoring results are summarized in Table 2 and Figure 2.

TABLE 2 NOISE LEVEL MEASUREMENTS SUMMARY			
Monitor Number (MON)	**Address/Description**	**Day/ Time**	**Monitoring Result L_{Aeq}, dBA**
1	Property owner driveway approximately 3 feet west of Lail Ln	April 12/ 2:28-2:43 PM	69
2	Road ROW approximately 10 feet east of Allen Pike	April 12/ 12:24-12:39 PM	49
3	Road ROW approximately 12 feet north of Allen Pike	April 12/ 11:42-11:47 AM	45
4	Road ROW approximately 15 feet west of Russel Cave Rd/KY-353	April 12/ 1:37 -1:52 PM	61
5	Property owner driveway approximately 30 feet west of Russel Cave Rd/KY-353	April 12/ 1:01-1:16 PM	57

The monitored noise levels represent the existing baseline noise condition within and adjacent to the project area during daytime hours. The average ambient noise levels from the measurements ranged from 45 dBA to 69 dBA. The lowest monitored noise level was recorded from site MON-3 on the west side of the project boundary approximately 12 feet north of Allen Pike. The highest monitored noise level was recorded from site MON-1 on a private driveway west of Lail Ln. Detailed noise level monitoring information is located in Appendix A of this report.

Figure 2. Noise Monitoring Results



4.0 REGULATORY SETTING

In 1974 the U.S. EPA published "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin on Safety". In this publication, the U.S. EPA evaluated the effects of environmental noise with respect to health and safety and determined an L_{dn} of 55 dBA (equivalent to a continuous noise level of 48.6 dBA) to be the maximum sound level that will not adversely affect public health and welfare by interfering with speech or other activities in outdoor areas.

Since no other local, county, or state thresholds were identified, an L_{dn} of 55 dBA has been used to determine if the project would adversely affect public health and welfare.

5.0 IMPACT ANALYSIS

Potential noise sensitive receptors were selected for noise modeling with up to 3,000-foot buffer from the project boundary. High resolution aerial photography, Google street view photos, and proposed site layouts were analyzed using Google Earth Pro to determine the presence of potential noise sensitive receptors. The selected receptors are all dwelling units. No schools, childcare centers, outdoor recreation, medical centers or other types of noise sensitive receptors were observed. Figure 3 shows the selected receptors to be modeled as noise receivers in the noise model.

The SoundPLAN® computer noise model was used for computing noise levels from the proposed operation noise from the transformers, inverters, and trackers under worst case scenario. An industry standard, SoundPLAN® was developed by Braunstein + Berndt GmbH to provide estimates of sound levels at distances from specific noise sources taking into account the effects of terrain features including relative elevations of noise sources, receivers, and intervening objects (buildings, hills, trees), and ground effects due to areas of hard ground (pavement, water) and soft ground (grass, field, forest). In addition to computing sound levels at specific receiver positions, SoundPLAN® can produce noise contour graphics that show areas of equal and similar sound level.

Analysis Methodology

The sound propagation model within SoundPLAN® that was used for this study was ISO 9613-2 This international standard propagation model is used nearly universally in the U.S. for environmental noise studies, due to its conservative propagation equations. ISO 9613-2 uses "worst-case" downwind propagation conditions in all directions, and accounts for variations in terrain and the effects of ground type.

The equivalent sound pressure level at the receiver, in downwind conditions, is calculated for each point source based on the formula below.

$$L_{eq} = L_w + D_c - A$$

Where:

L_{eq} is the equivalent sound pressure level at the receiver, in downwind conditions,

L_w is the sound power level by the point source,

D_c is the directivity correction that describes the deviation of the sound pressure level in a specific direction from the sound power level,

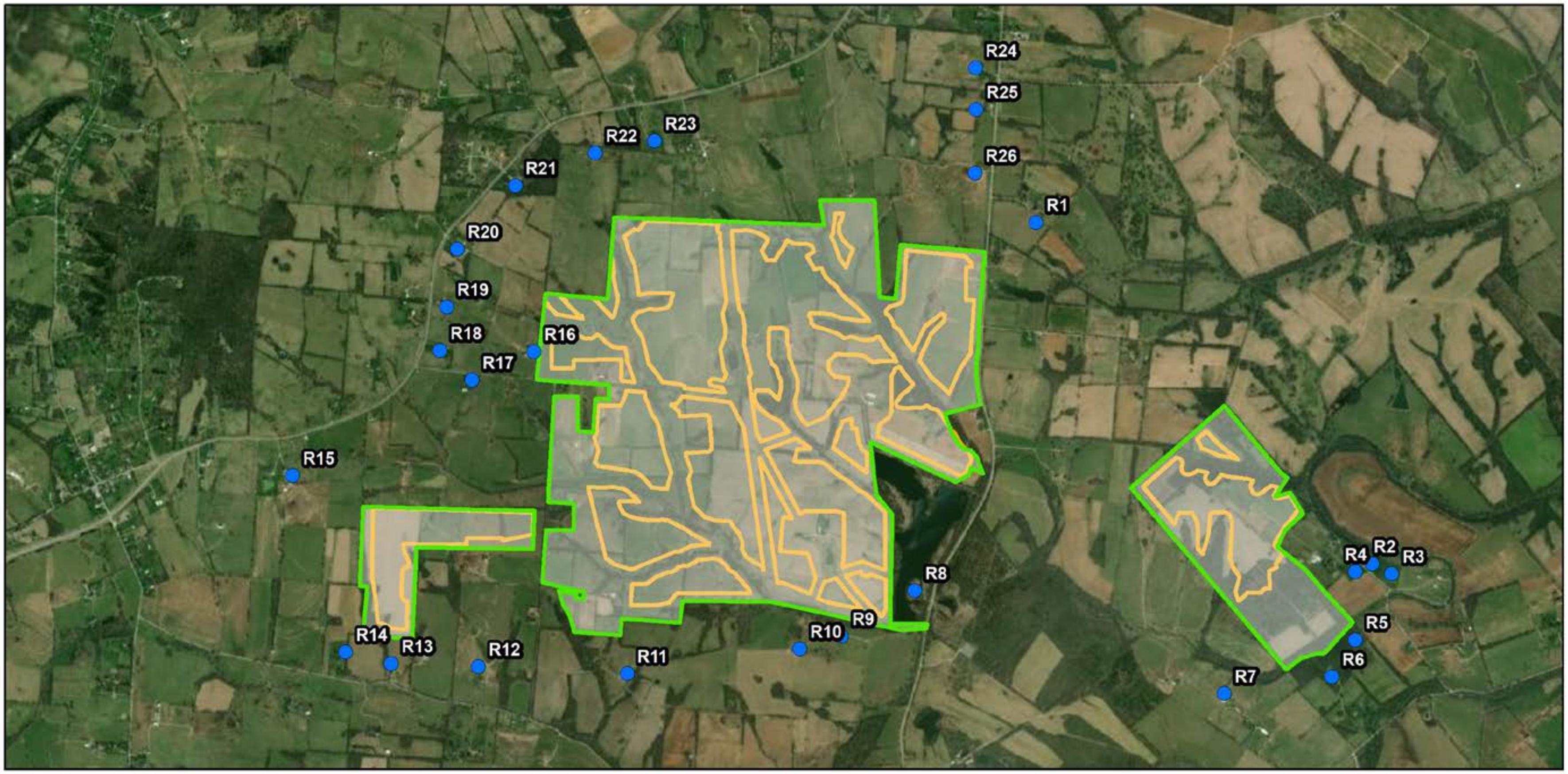
A is the attenuation of the sound propagation. It is a sum of the attenuation due to the geometrical divergence, the ground effect, the atmospheric absorption, the barriers, and miscellaneous other effects.

Geometrical divergence refers to the decline in noise level that occurs in association with increased distance from the receptor. Sounds generated from a point source typically attenuate or decrease at a rate of 6 dBA for each doubling of distance. For example, a noise level of 80 dBA measured at a distance of 5 feet from the noise source would be reduced to 74 dBA at 10 feet from the source and be further reduced to 32 dBA at 1280 feet.

The propagation of noise is also affected by the intervening ground, known as ground effect. A hard site (such as parking lots or smooth bodies of water) receives no additional ground attenuation, and the changes in noise levels with distance are simply the geometric spreading from the source, which equates to 6 dBA per doubling distance. A soft site (such as soft dirt, grass, or scattered bushes and trees) provides an additional ground attenuation value of 1.5 dBA per doubling of distance. Thus, a point source over a soft site would drop off at generally 7.5 dBA per doubling of distance. The 7.5 dBA drop off rate is just a rule of thumb for quick noise level estimation. SoundPLAN uses complex formula based on ground absorption coefficient and other factors such as terrain change to calculate noise levels at the receivers. SoundPLAN does not use 7.5 dBA drop off rate directly in the model.

The sound attenuation due to atmospheric absorption is calculated based on the atmospheric absorption coefficient (α). The absorption coefficient is calculated according to the ISO 9613-1 “Acoustics - Attenuation of sound during propagation outdoors - Part 1: Calculation of the absorption of sound by the atmosphere”. It is dependent on the frequency, air pressure, temperature, and relative humidity.

Figure 3. Modeled Noise Receivers



Source: World Imagery (2021)

Legend

Modeled Receivers | Project Boundary | Buildable Area

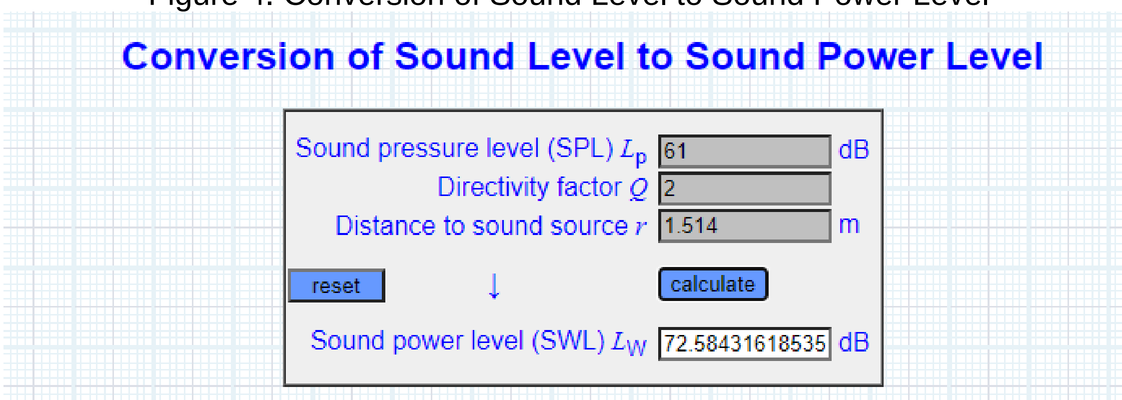
Miles
0 0.25 0.5

Map Disclaimer: This map is intended for general siting purposes only.

Transformer, Inverter, and Tracker Noise

The solar array associated with this project includes tracking panels distributed evenly across the site. Tracking systems involve the panels being driven by small DC motors to track the arc of the sun to maximize each panel's potential for solar absorption. Panels would turn no more than five (5) degrees every 15 minutes and would operate no more than one (1) minute out of every 15-minute period. These tracking motors are a potential source of mechanical noise and are included in this assessment. Because the model of the tracker was not available at the time of this report, it is assumed that the sound typically produced by each panel tracking motor is 61 dBA at 5 feet. For reference, that equates to a sound power level of 73 dBA, see conversion example in figure 4 below. Sound power level is the acoustic energy emitted by a source which produces a sound pressure level at some distance. While the sound power level of a source is fixed, the sound pressure level depends upon the distance from the source and the acoustic characteristics of the area in which it is located. Sound power level of each point source is the input to SoundPLAN.

Figure 4. Conversion of Sound Level to Sound Power Level



Source: www.sengpielaudio.com/calculator-soundpower.htm

This facility will consist of approximately 31 inverters, which are expected to be the loudest noise generating operational equipment. Because the model of the inverter is not available at this time, it is assumed that the sound typically produced by each inverter is 65 dBA at 5 feet. That equates to a sound power level of 77 dBA. In addition, a small-scaled transformer would be used along with the inverter on each transformer pad. It is assumed that the sound typically produced by each small-scaled transformer is 58 dBA at 5 feet; that equates to a sound power level of 70 dBA.

Substation/Switchyard Noise

The proposed project's onsite substation/switchyard will be located in the middle of the project site (please refer to Figure 1). The substation is located more than 3,000 feet from the nearest sensitive noise receptor. It is assumed that a larger transformer at the Substation has a noise level of 71 dBA at a distance of 5 feet, which equates to a sound power level of 83 dBA. To be conservative, a total sound power level of 86 dBA was considered for the substation and switchyard.

The following data was used as input into the model.

- A total of 31-point sources was modeled to represent small-scaled transformers, inverters, and trackers on the transformer pads. A combined sound power level of 79 dBA was assumed for equipment on each transformer pad. The source height was assumed to be 5 feet.
- A point source was modeled to represent a large-scaled transformer for the substation/switchyard. A combined sound power level of 86 dBA was assumed for equipment in the substation and switchyard.
- A total of 26 receivers was modeled to represent sensitive noise receptors. The source height was assumed to be 5 feet.
- Topo contour lines were inputted into the model to consider terrain variation.
- Ground surface was assumed to be soft ground.

Table 3 shows the predicted project operation noise levels in hourly L_{Aeq} and L_{dn} for all selected receivers under the worst case scenario. Figure 5 shows operation noise contours of 20 dBA and 30 dBA L_{Aeq} generated by the noise model. As indicated, operation noise contours of 30 dBA L_{Aeq} were confined within the project site itself. Because all the solar equipment were considered point sources and they are located far away from the sensitive receptors, the equipment noise energy dissipated rapidly before reaching to the receptors. Figure 6 shows operation noise grid map within the project area. Operation noise would be masked by background ambient noise.

As can be seen from Table 3 below, predicted operation noise level are below 20 dBA L_{dn} at all sensitive receivers. Therefore, the proposed project operation will comply with EPA standard of 55 dBA L_{dn} as identified in Section 4. No future noise mitigation is needed for the project.

TABLE 3
Predicted Operation Noise Levels

Receiver ID	Noise Levels (L_{Aeq}, dBA)	Noise Levels (L_{dn}, dBA)	Receiver ID	Noise Levels (L_{Aeq}, dBA)	Noise Levels (L_{dn}, dBA)
R1	16.0	14.6	R14	16.3	14.8
R2	14.6	13.4	R15	15.1	13.8
R3	13.3	12.3	R16	19.0	17.3
R4	15.8	14.4	R17	17.3	15.7
R5	13.7	12.6	R18	15.9	14.5
R6	13.0	12.1	R19	15.3	14.0
R7	14.0	12.9	R20	14.5	13.3
R8	17.5	15.9	R21	14.9	13.6
R9	16.8	15.3	R22	16.2	14.7
R10	16.9	15.4	R23	16.9	15.4
R11	16.2	14.7	R24	12.2	11.5
R12	15.5	14.1	R25	13.5	12.5
R13	16.4	14.9	R26	15.9	14.5

Note:
1. Solar facility would not operate during night time hours and thus would not generate noise.

Vehicular Traffic

The solar facility is expected to have up to two technicians visiting the site daily for daily operations and maintenance activities. Other professionals will visit the site on an as-needed basis. Weekend work is not anticipated but may be required upon any component outages that may impact energy production from the site. Asides from the scenarios mentioned, vehicular traffic onsite will be limited to typical weekday business hours. Technicians will drive mid- or full-sized trucks and will not contribute noticeably to the existing traffic noise levels.

Maintenance Activities

Typical maintenance activities may include inspection, minor repair and maintenance on the solar panels, the tracking system, wiring, and/or inverters. Ground maintenance will include periodic inspection of the vegetative buffers, boundary fencing, and vegetation control through mowing and herbicide applications. Technicians will be on site Monday to Friday. Noise from maintenance activities will not contribute noticeably to the nearest sensitive receptors as they are similar to the background agricultural noise characteristics.

Figure 5. Operation Noise Contour Map

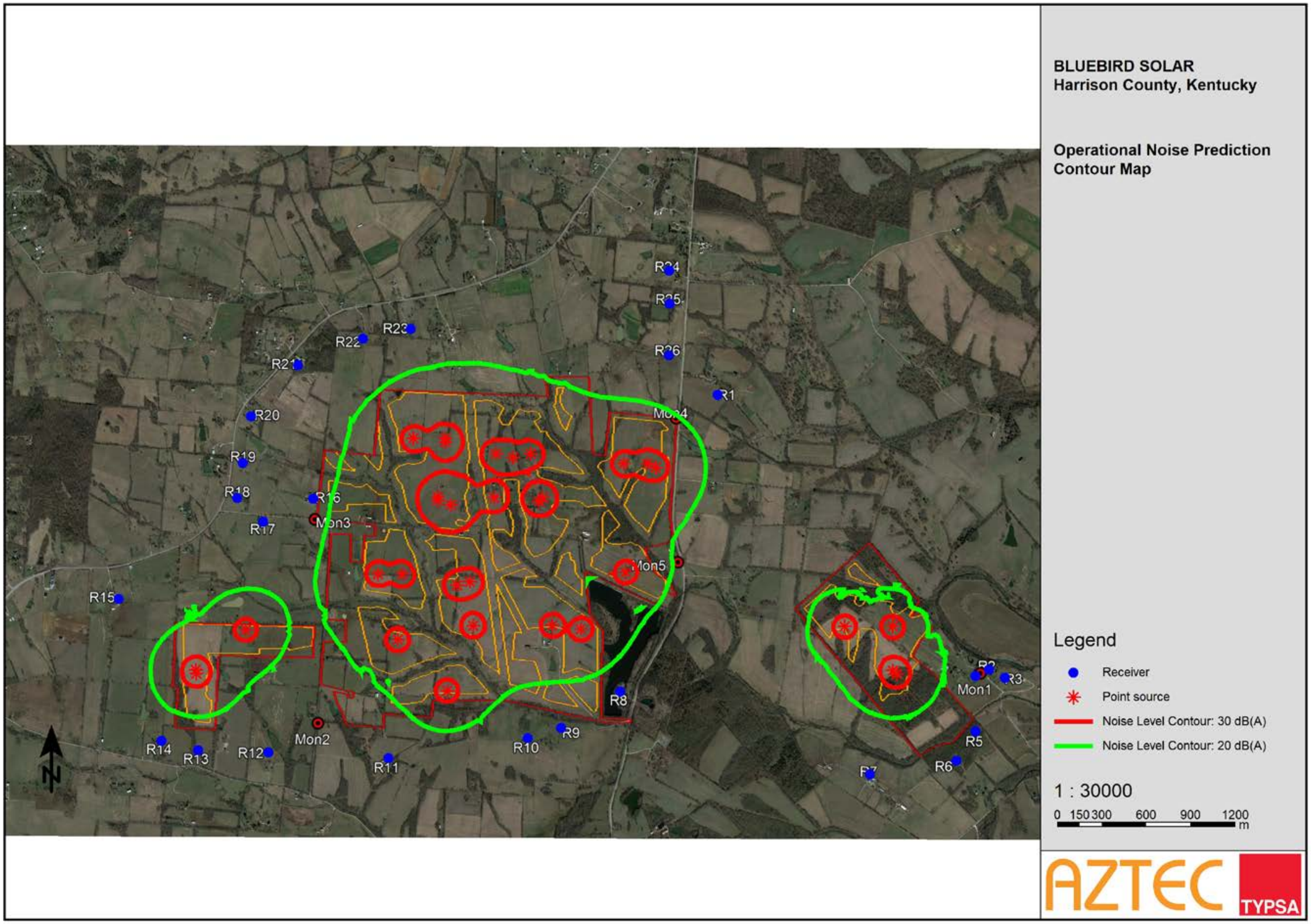
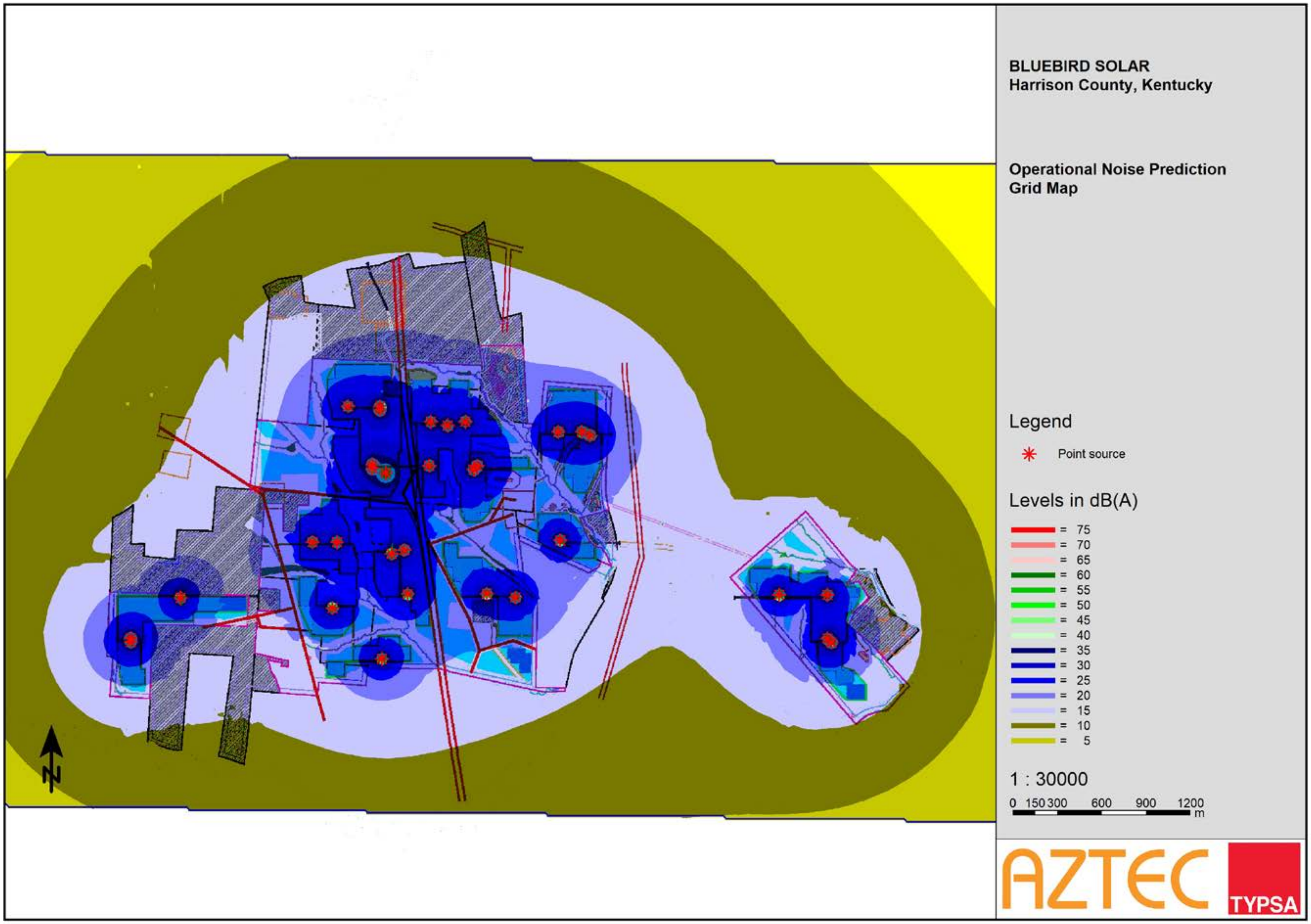


Figure 6. Operation Noise Grid Map



Conclusion

Based on background noise monitoring and noise analysis for the project operation, it is expected that the ambient noise levels in the project vicinity could be low in the 40s dBA L_{dn}. The project generated noise from equipment within the site is less than 30 dBA L_{dn} and less than 20 dBA L_{dn} at the sensitive receptors, which are far below ambient noise levels. Noise from project generated vehicular traffic and maintenance activities are minimal and will not contribute noticeably to the nearby sensitive receptors. In conclusion, the project operation noise complies with EPA standard of 55 dBA L_{dn} threshold and no noise impact would occur.

REFERENCE

Code of Federal Regulations, Title 24. Part 51.103, Revised April 1, 2005

John G. Rau and David C. Wooten, *Environmental Impact Analysis Handbook*, 1980

Environmental Protection Authority, *Environmental Criteria for Road Traffic Noise*, 1999

Ldn Consulting Inc, *Noise Assessment Centinela Solar Energy Project County of Imperial*, September 6, 2011

Stantec Consulting Services, Inc, *Noise Assessment Ashwood 86MW Solar Facility*, December 11, 2020

APPENDIX A

Noise Level Monitoring Results

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

ENVIRONMENTAL
NOISE LEVEL MEASUREMENT DATA SHEET

Project Number/Name: BLUEBIRD SOLAR PROJECT **Date:** 4/12/2021

Site Number/Description: MON 1, (Lat/Long: 33.290644, -84.339009)

Property owner driveway approximately 3 feet west of Lail Ln

Prepared by/Crew: Brynne Taylor

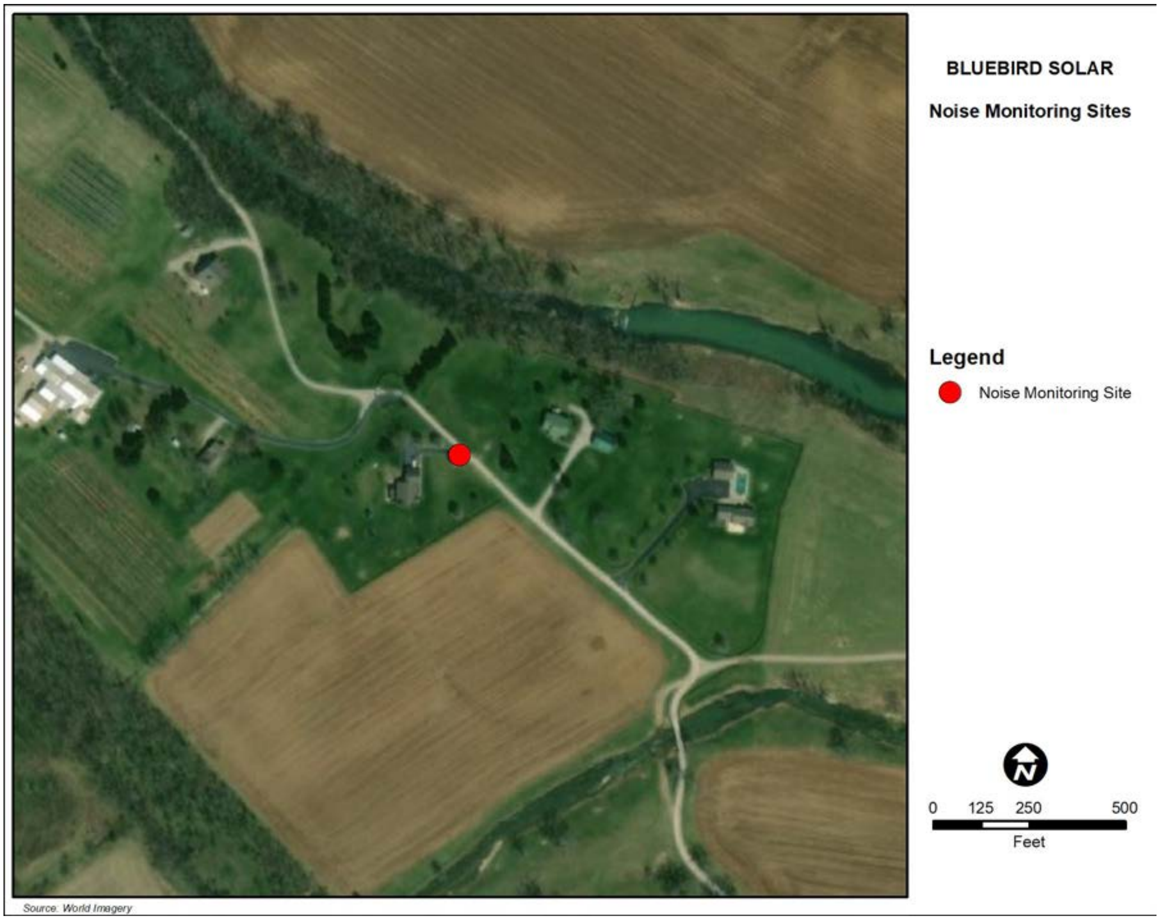
Temperature: 65 ^{o}F **Relative Humidity:** 67 % **Wind & Direction:** 7.2 mph/W **Sky:** Partly Sunny

SLM Make/Model: LDL 824 **Calibration Make/Model:** LDL CA 200 @ 114.00 dB

Calibration: ☒

Posted Speed Limit (mph): 15

Observed Speed (mph): N/A



Sample	Time		Sound Level, dBA			Traffic Count		
	Start	Duration	L_{MIN}	L_{EQ}	L_{MAX}	Auto	Med. Trk.	Hvy. Trk.
1	2:28 PM	15 mins	38.6	69.1	94.8	---	---	---

Several dogs barking and lawn mowers cutting grass on nearby properties while monitoring.

501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

Figure 1. Looking northwest

Figure 2. Looking northeast

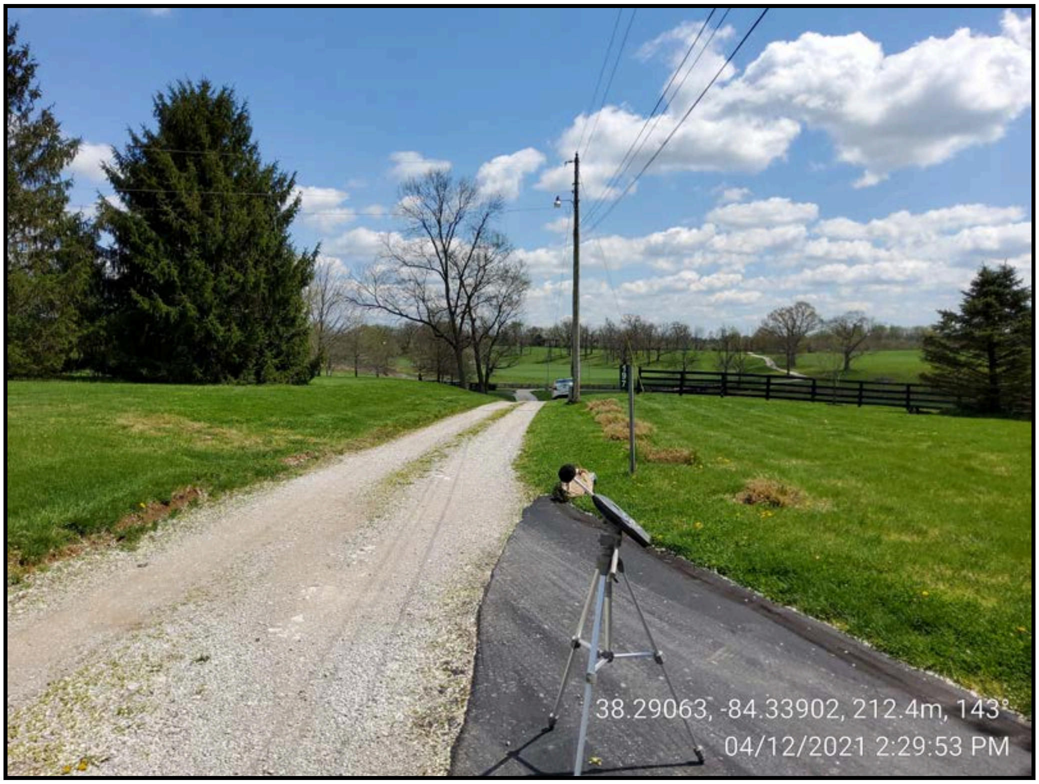


Figure 3. Looking southeast

Figure 4. Looking southwest

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

ENVIRONMENTAL
NOISE LEVEL MEASUREMENT DATA SHEET

Project Number/Name: BLUEBIRD SOLAR PROJECT **Date:** 4/12/2021

Site Number/Description: MON 2, (Lat/Long: 38.287490, -84.390540)

Road ROW approximately 10 feet east of Allen Pike

Prepared by/Crew: Brynne Taylor

Temperature: 61 ºF **Relative Humidity:** 84 % **Wind & Direction:** 8.4 mph/W **Sky:** Partly Sunny

SLM Make/Model: LDL 824 **Calibration Make/Model:** LDL CA 200 @ 114.00 dB

Calibration: ☒

Posted Speed Limit (mph): N/A

Observed Speed (mph): N/A

Sample	Time		Sound Level, dBA			Traffic Count		
	Start	Duration	L_{MIN}	L_{EQ}	L_{MAX}	Auto	Med. Trk.	Hvy. Trk.
1	12:24 PM	15 mins	39.4	48.9	62.0	---	---	---

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

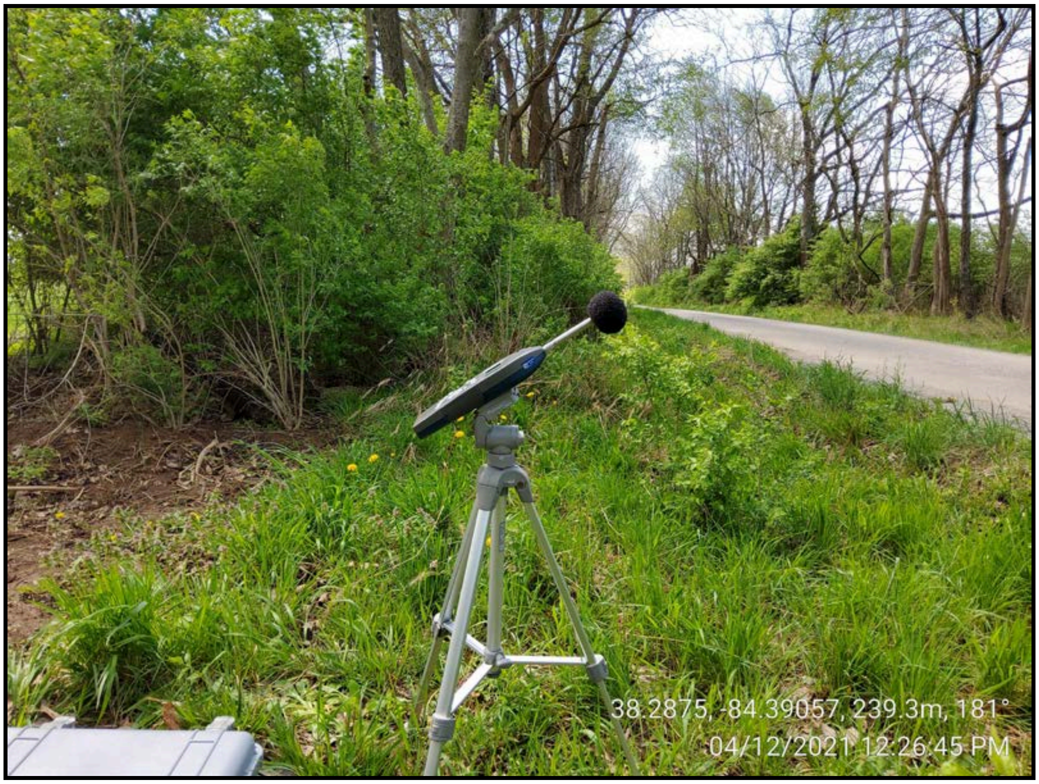


Figure 1. Looking south

Figure 2. Looking west

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

ENVIRONMENTAL
NOISE LEVEL MEASUREMENT DATA SHEET

Figure 3. Looking north

Figure 4. Looking east

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

ENVIRONMENTAL
NOISE LEVEL MEASUREMENT DATA SHEET

Project Number/Name: BLUEBIRD SOLAR PROJECT **Date:** 4/12/2021

Site Number/Description: MON 3, (Lat/Long: 38.299880, -84.390890)

Road ROW approximately 12 feet north of Allen Pike

Prepared by/Crew: Brynne Taylor

Temperature: 59 ºF **Relative Humidity:** 86 % **Wind & Direction:** 7 mph/W **Sky:** Cloudy

SLM Make/Model: LDL 824 **Calibration Make/Model:** LDL CA 200 @ 114.00 dB

Calibration: ☒

Posted Speed Limit (mph): N/A

Observed Speed (mph): N/A

Sample	Time		Sound Level, dBA			Traffic Count		
	Start	Duration	L_{MIN}	L_{EQ}	L_{MAX}	Auto	Med. Trk.	Hvy. Trk.
1	11:42 AM	15 mins	38.4	44.7	53.0	---	---	---

Figure 1. Looking east

Figure 2. Looking south

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

Figure 3. Looking west

Figure 4. Looking north

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

ENVIRONMENTAL
NOISE LEVEL MEASUREMENT DATA SHEET

Project Number/Name: BLUEBIRD SOLAR PROJECT **Date:** 4/12/2021

Site Number/Description: MON 4, (Lat/Long: 38.306144, -84.362672)

Road ROW approximately 15 feet west of Russel Cave Rd/KY-353

Prepared by/Crew: Brynne Taylor

Temperature: 65 °F **Relative Humidity:** 75 % **Wind & Direction:** 7.9 mph/W **Sky:** Partly Sunny

SLM Make/Model: LDL 824 **Calibration Make/Model:** LDL CA 200 @ 114.00 dB

Calibration: ☒

Posted Speed Limit (mph): 55

Observed Speed (mph): 65

Sample	Time		Sound Level, dBA			Traffic Count		
	Start	Duration	L_{MIN}	L_{EQ}	L_{MAX}	Auto	Med. Trk.	Hvy. Trk.
1	1:37 PM	15 mins	35.1	60.5	85.0	---	---	---

501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

Figure 1. Looking north

Figure 2. Looking east

501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

Figure 3. Looking south

Figure 4. Looking west

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

ENVIRONMENTAL
NOISE LEVEL MEASUREMENT DATA SHEET

Project Number/Name: BLUEBIRD SOLAR PROJECT **Date:** 4/12/2021

Site Number/Description: MON 5, (Lat/Long: 38.297383, -84.362496)

Property owner driveway approximately 30 feet west of Russel Cave Rd/KY-353

Prepared by/Crew: Brynne Taylor

Temperature: 63 °F **Relative Humidity:** 82 % **Wind & Direction:** 6.8 mph/W **Sky:** Partly Sunny

SLM Make/Model: LDL 824 **Calibration Make/Model:** LDL CA 200 @ 114.00 dB

Calibration: ☒

Posted Speed Limit (mph): 55

Observed Speed (mph): 65

Sample	Time		Sound Level, dBA			Traffic Count		
	Start	Duration	L_{MIN}	L_{EQ}	L_{MAX}	Auto	Med. Trk.	Hvy. Trk.
1	1:01 PM	15 mins	36.4	57.4	75.2	---	---	---

At one point a donkey was braying and several cows started mooing on the property.

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

Figure 1. Looking north

Figure 2. Looking east

AZTEC TYPSA
501 N 44th St, Suite 300
Phoenix, AZ 85008
Tel: (602) 454-0402
Fax: (602) 458-7465

Figure 3. Looking south

Figure 4. Looking west