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Subject: ***KN415 Solar Sound Study***
TPE IL KN415, LLC
Kane County, Illinois

Executive Summary

The purpose of this technical memorandum is to summarize the evaluated sound levels associated with the operational equipment located at the proposed KN415 Solar Site in Kane County, IL. The proposed solar photovoltaic project site is approximately 1 mile southwest of Algonquin, approximately 5 miles northwest of downtown Carpentersville, and approximately 3 miles north of downtown Gilberts. The site is generally located south of Huntley Road and east of Galligan Road. The solar site will be located on agricultural land with rural residences north and west of the project area as well as a church to the east. The location of the proposed KN415 Solar Site is shown in **Figure 1**.

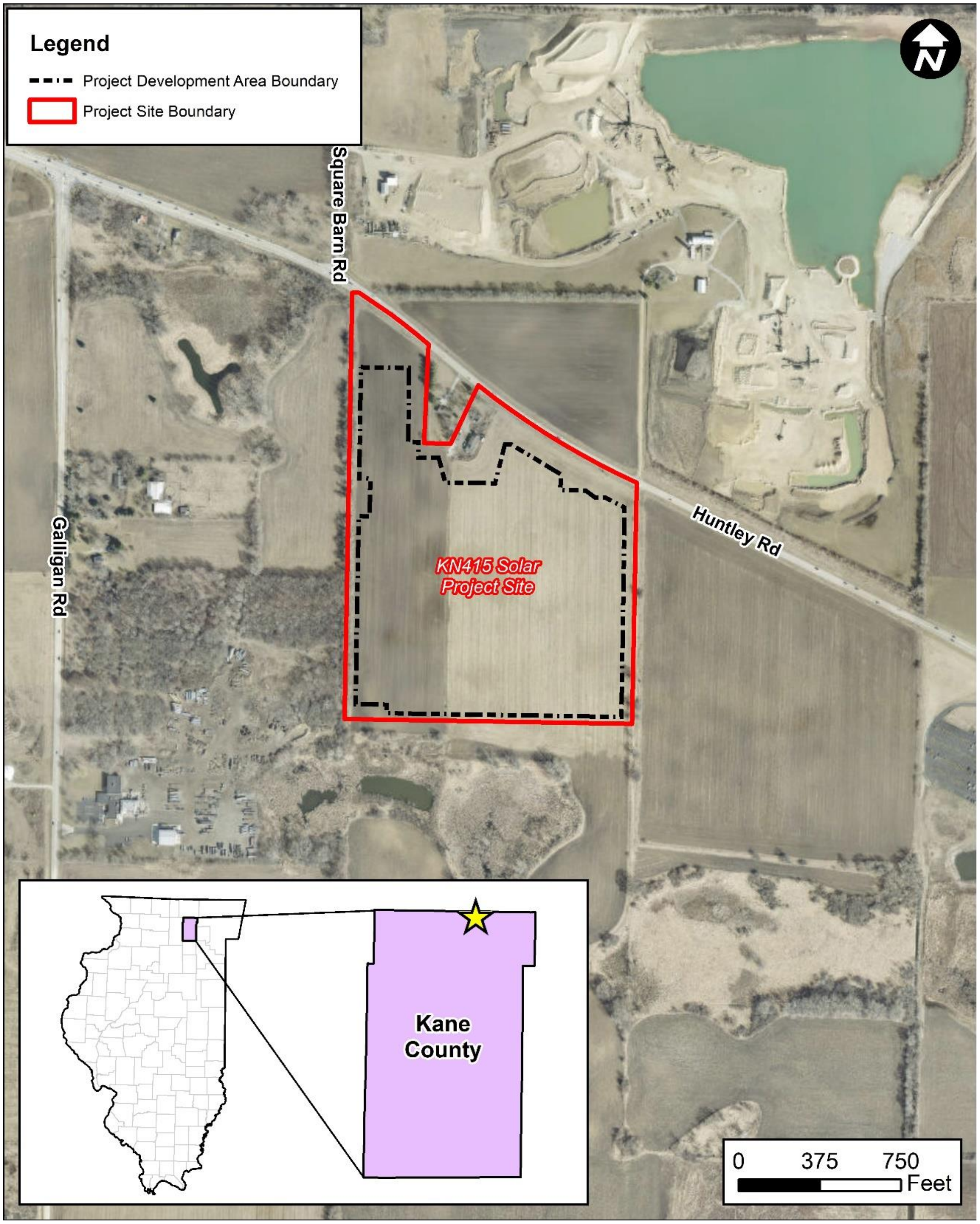
Analysis Findings

- *The solar photovoltaic project will be located on agricultural land with residential land uses north and west of the project area as well as a church to the east. The Illinois Pollution Control Board (IPCB) noise regulations are based on allowable octave band sound pressure levels that vary depending on the category of land the noise is generated from and the category of land the noise is received at. Modeled operational octave band sound pressure levels at surrounding Class A property boundaries (i.e., residences or religious institutions) are not anticipated to exceed the limits established by IPCB; therefore, noise mitigation is not recommended at this time.*

Project Description

The proposed KN415 Solar Site will be developed on approximately 34 acres of an approximately 45-acre parcel of agricultural within an unincorporated portion of Kane County, IL. The solar site will consist of solar arrays with a set of string inverters near the northeastern corner of the site.

Figure 1: Site Location and Vicinity



Characteristics of Noise

Noise is generally defined as unwanted sound. It is emitted from many natural and man-made sources. Sound pressure levels are usually measured and expressed in decibels (dB). The decibel scale is logarithmic and expresses the ratio of the sound pressure unit being measured to a standard reference level. Most sounds occurring in the environment do not consist of a single frequency, but rather a broad band of differing frequencies. The intensities of each frequency add together to generate sound. Because the human ear does not respond to all frequencies equally, the method commonly used to quantify environmental noise consists of evaluating all of the frequencies of a sound according to a weighting system. It has been found that the A-weighted decibel [dB(A)] filter on a sound level meter, which includes circuits to differentially measure selected audible frequencies, best approximates the frequency response of the human ear.

The degree of disturbance from exposure to unwanted sound – noise – depends upon three factors:

1. The amount, nature, and duration of the intruding noise
2. The relationship between the intruding noise and the existing sound environment; and
3. The situation in which the disturbing noise is heard

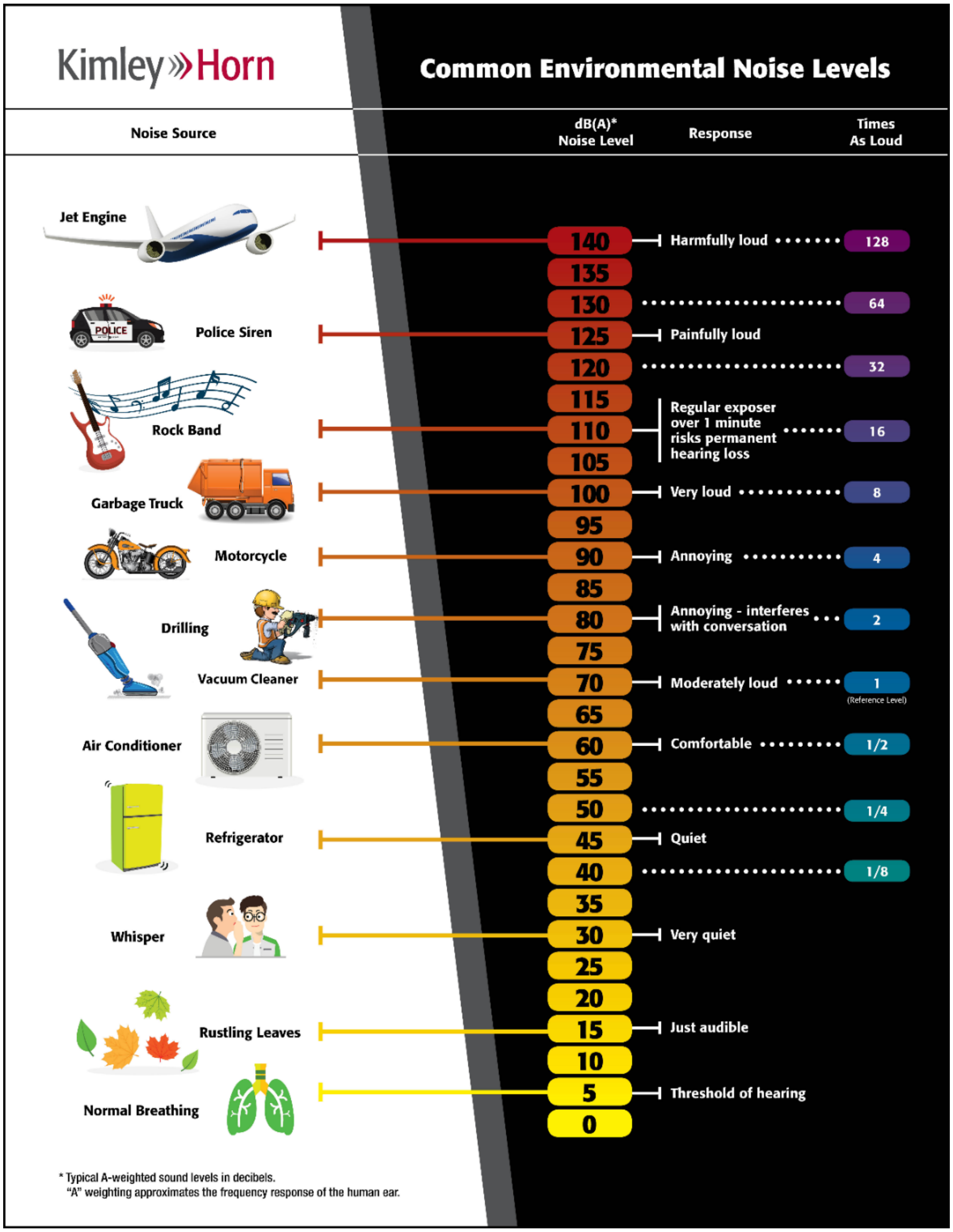
In considering the first of these factors, it is important to note that individuals have varying sensitivity to noise. Loud noises bother some people more than other people, and some individuals become increasingly upset if an unwanted noise persists. The time patterns and durations of noise(s) also affect perception as to whether or not it is offensive. For example, noises that occur during nighttime (sleeping) hours are typically considered to be more offensive than the same noises in the daytime.

With regard to the second factor, individuals tend to judge the annoyance of an unwanted noise in terms of its relationship to noise from other sources (background noise). A car horn blowing at night when background noise levels are low would generally be more objectionable than one blowing in the afternoon when background noise levels are typically higher. The response to noise stimulus is analogous to the response to turning on an interior light. During the daytime an illuminated bulb simply adds to the ambient light, but when eyes are conditioned to the dark of night, a suddenly illuminated bulb can be temporarily blinding.

The third factor – situational noise – is related to the interference of noise with activities of individuals. In a 60 dB(A) environment such as is commonly found in a large business office, normal conversation would be possible, while sleep might be difficult. Loud noises may easily interrupt activities that require a quiet setting for greater mental concentration or rest; however, the same loud noises may not interrupt activities requiring less mental focus or tranquility.

As shown in **Figure 2**, most individuals are exposed to fairly high noise levels from many sources on a regular basis. To perceive sounds of greatly varying pressure levels, human hearing has a non-linear sensitivity to sound pressure exposure. Doubling the sound pressure results in a three decibel change in the noise level; however, variations of three decibels [3 dB(A)] or less are commonly considered “barely perceptible” to normal human hearing. A five decibel [5 dB(A)] change is more readily noticeable. A ten-fold increase in the sound pressure level correlates to a 10 decibel [10 dB(A)] noise level increase; however, it is judged by most people as only sounding “twice as loud”.

Figure 2: Common Noise Levels



Over time, individuals tend to accept the noises that intrude into their lives on a regular basis. However, exposure to prolonged and/or extremely loud noise(s) can prevent use of exterior and interior spaces and has been theorized to pose health risks.

Local Regulations

The KN415 Solar Site is in Kane County, IL. Chapter 25, Article V, Section 25-5-4-9 of the Kane County Code of Ordinances states that “noise levels from Commercial Solar Energy Facilities shall be in compliance with applicable Illinois Pollution Control Board (IPCB) regulations.”

The Illinois Pollution Control Board (IPCB) noise regulations are based on allowable octave band sound pressure levels during daytime and nighttime hours. According to Title 35 (Environmental Protection), Subtitle H (Noise), Chapter I (Pollution Control Board), Part 901 (Sound Emission Standards and Limitations for Property Line-Noise Sources), a facility operating in an agricultural field (Class C Land) cannot cause an exceedance of sound levels at any point within a residential or religious land use (Class A Land) during daytime hours as shown in **Table 1.**

Table 1: Maximum Allowable Sound Emitted to Class A Land During Daytime Hours

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) of Sound Emitted to any Receiving Class A Land from		
	Class C Land	Class B Land	Class A Land
31.5	**75**	72	72
63	**74**	71	71
125	**69**	65	65
250	**64**	57	57
500	**58**	51	51
1000	**52**	45	45
2000	**47**	39	39
4000	**43**	34	34
8000	**40**	32	32

The IPCB has also established the allowable octave band sound pressure levels for nighttime hours shown in **Table 2**.

Table 2: Maximum Allowable Sound Emitted to Class A Land During Nighttime Hours

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) of Sound Emitted to any Receiving Class A Land from		
	Class C Land	Class B Land	Class A Land
31.5	**69**	63	63
63	**67**	61	61
125	**62**	55	55
250	**54**	47	47
500	**47**	40	40
1000	**41**	35	35
2000	**36**	30	30
4000	**32**	25	25
8000	**32**	25	25

Sound frequencies are reported in units of Hertz (Hz), which correspond to the number of vibrations per second of a given tone. A cumulative 'sound level' is equivalent to ten times the base-10 logarithm of the ratio of the sum of the sound pressures of all frequencies to the reference sound pressure. To simplify the mathematical process of determining sound levels, sound frequencies are grouped into ranges, or 'bands.' Sound levels are then calculated by adding the cumulative sound pressure levels within each band.

The commonly accepted limitation of human hearing to detect sound frequencies is between 20 Hz and 20,000 Hz, and human hearing is most sensitive to the frequencies between 1,000 Hz – 6,000 Hz. Although people are generally not as sensitive to lower-frequency sounds as they are to higher frequencies, most people lose the ability to hear high-frequency sounds as they age. To accommodate varying receptor sensitivities, frequency sound levels are commonly adjusted, or 'filtered', before being logarithmically added and reported as a single 'sound level' magnitude of that filtering scale. The 'A-weighted' decibel filtering scale applies numerical adjustments to sound frequencies to emphasize the frequencies at which human hearing is sensitive, and to minimize the frequencies to which human hearing is not as sensitive.

Table 3 shows the A-weighted adjusted sound levels based on the daytime IPCB frequency limits.

Table 3: Frequency Scaling for Sound Emitted to Class A Land During Daytime Hours

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) to any Receiving Class A Land from Class C Land	A-weighted Adjustment[1]	Adjusted Frequency Sound Levels (A-weighted)
31.5	**75**	-39.53	35.47
63	**74**	-26.22	47.78
125	**69**	-16.19	52.81
250	**64**	-8.67	55.33
500	**58**	-3.25	54.75
1000	**52**	0.00	52.00
2000	**47**	1.20	48.20
4000	**43**	0.96	43.96
8000	**40**	-1.14	38.86
Overall Sound Level			***60.61 dB(A)***[2]

1. Based on the ISO 226:2003 standard for normal equal-loudness contours, the A-weighted decibel network filtering scale is defined for a frequency, f, by the equation: $20 \times \log_{10} (A(f) / A(1000))$, where $A(f) = [12{,}200^2 \times f^4] / [(f^2 + 20.6^2) \times (f^2 + 12{,}200^2) \times (f^2 + 107.7^2)^{0.5} \times (f^2 + 737.9^2)^{0.5}]$.
2. Based on the frequency limits, the sound level would be perceived as a sound level of 60.61 dB(A) by human hearing due to the decreased sensitivity of human hearing to lower sound frequencies.

Table 4 shows the A-weighted adjusted sound levels based on the nighttime IPCB frequency limits.

Table 4: Frequency Scaling for Sound Emitted to Class A Land During Nighttime Hours

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) to any Receiving Class A Land from Class C Land	A-weighted Adjustment[1]	Adjusted Frequency Sound Levels (A-weighted)
31.5	**69**	-39.53	29.47
63	**67**	-26.22	40.78
125	**62**	-16.19	45.81
250	**54**	-8.67	45.33
500	**47**	-3.25	43.75
1000	**41**	0.00	41.00
2000	**36**	1.20	37.20
4000	**32**	0.96	32.96
8000	**32**	-1.14	30.86
Overall Sound Level			***51.13 dB(A)***[2]

1. Based on the ISO 226:2003 standard for normal equal-loudness contours, the A-weighted decibel network filtering scale is defined for a frequency, f, by the equation: $20 \times \log_{10} (A(f) / A(1000))$, where $A(f) = [12{,}200^2 \times f^4] / [(f^2 + 20.6^2) \times (f^2 + 12{,}200^2) \times (f^2 + 107.7^2)^{0.5} \times (f^2 + 737.9^2)^{0.5}]$.
2. Based on the frequency limits, the sound level would be perceived as a sound level of 51.13 dB(A) by human hearing due to the decreased sensitivity of human hearing to lower sound frequencies.

The allowable octave band sound pressure levels result in overall A-weighted sound pressure levels at Class A land uses of approximately 60 dB(A) during daytime hours and 51 dB(A) during nighttime hours.

Noise Analysis

Sound levels from the proposed KN415 Solar Site were evaluated using SoundPLAN. This program computes predicted sound levels at noise-sensitive areas through a series of adjustments to reference sound levels. SoundPLAN can also account for topography, groundcover type, and intervening structures. Sound levels generated from inverters are anticipated to be the main source of sound from the proposed solar photovoltaic project site.

It should be noted that noise from surrounding roadways was not modeled in this analysis, although Huntley Road, Square Barn Road, Galligan Road, and other rural roadways are anticipated to contribute to the ambient noise environment throughout the entire day.

Inverters

Photovoltaic (PV) inverter equipment generates steady, unvarying sound that can create issues when located near noise-sensitive areas. It was assumed that forty (40) PV inverters would be located near the northeastern corner of the site. Based on noise emission levels for string inverter equipment, a reference sound level of 65 dB(A) at 1 meter for each inverter was used. The sound from the simultaneous operation of the inverter equipment was calculated at the property boundaries of the closest noise-sensitive receptors surrounding the project area using SoundPLAN.

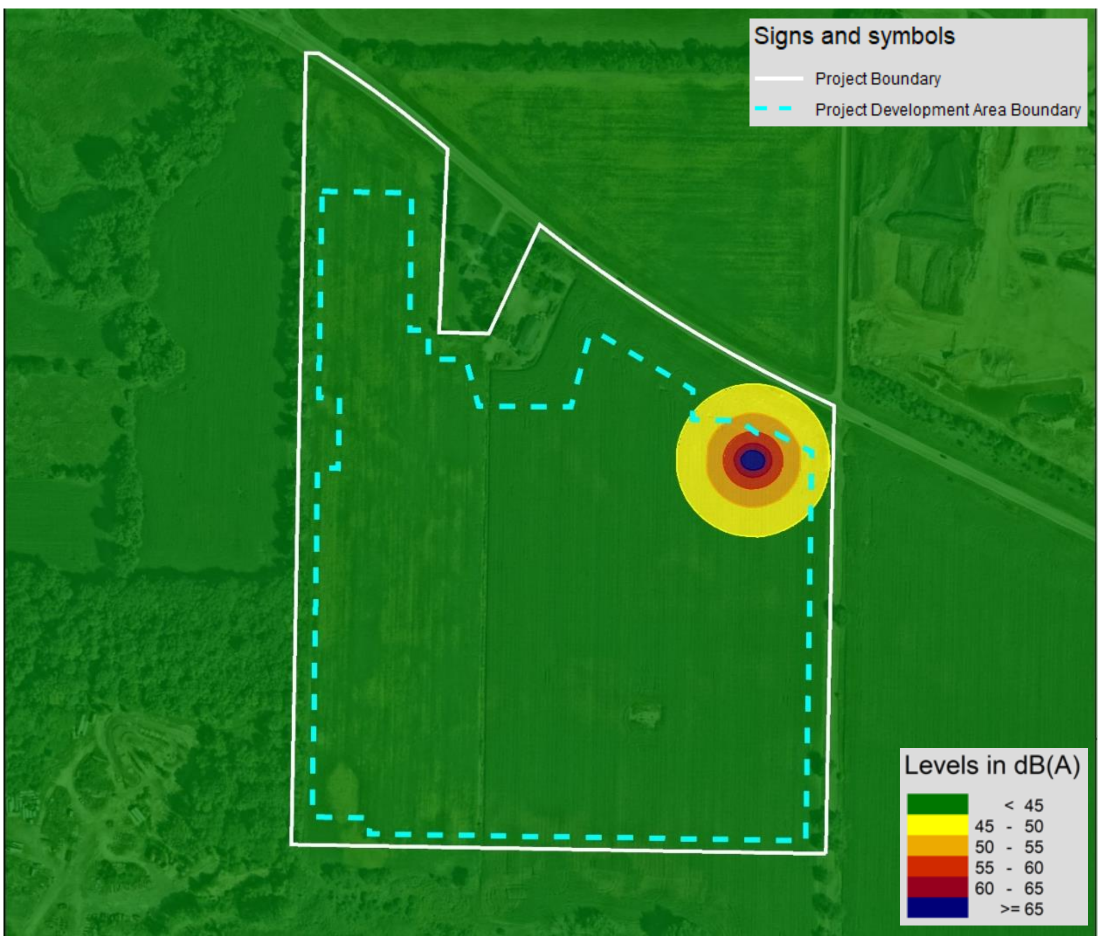
Sound generated by the inverters is not anticipated to significantly contribute to the existing environmental sound levels surrounding the site. Also, sound generated by the inverters is expected to be mitigated by providing offsets between the inverters and surrounding noise-sensitive land uses.

Results

The SoundPLAN-predicted maximum operational sound levels at the property boundary of the closest residential land use to the north are anticipated to be near or below approximately 31 dB(A) and the predicted maximum operational sound levels at the property boundary of the religious land use to the east are anticipated to be near or below approximately 21 dB(A). Both sound levels are below the approximate overall equivalent IPCB permissible sound pressure level limits.

Since the SoundPLAN-predicted maximum noise levels at surrounding Class A property boundaries are not anticipated to exceed the limits established by IPCB, noise mitigation measures do not need to be included in the project design at this time. The anticipated operational sound contours are shown in **Figure 3**.

Figure 3: Operational Sound Contours



Conclusions

The site is generally located south of Huntley Road and west of Galligan Road. The solar site will be located on agricultural land with rural residences north and west of the project area as well as a church to the east.

After modeling and analyzing the anticipated operational sound levels throughout the proposed solar site, it was determined that noise mitigation measures are not needed at this time since the predicted operational sound levels are anticipated to remain below the approximate overall equivalent IPCB permissible sound pressure level limits at Class A land uses.