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TECHNICAL REPORT

Title: Existing Conditions Background Sound Survey and Operational Noise Impact Assessment

Project: Hillcrest Solar Farm
Location: Brown County, OH
Prepared For: Hillcrest Solar I, LLC/Open Road Renewables, LLC
Prepared By: David M. Hessler, P.E., INCE
Revision: A
Issue Date: May 2, 2017
Reference No: TM-2028-042117-A

Attachments: **Table T-2028-042017-A** Substation Sound Propagation Calculations

1.0 Introduction

A study has been carried out for Hillcrest Solar I, LLC to evaluate the sound emissions from the proposed Hillcrest Solar Farm located in Brown County, Ohio in order to identify and quantitatively evaluate any potential community noise issues. Compared to other types of power generation facilities, potential noise impacts from a photovoltaic solar energy project are relatively few and relatively mild and, moreover, have the unusual characteristic of only occurring during the daylight hours when noise is much less likely to be an issue in the first place. In this case, any possible concerns about noise are largely confined to the step up transformer in the new substation, electrical inverters within the various solar fields and some short-lived activities during construction. In an effort to methodically evaluate the potential impact of the substation, a field survey was conducted to establish the existing levels of background sound at the nearest residences so that projections of future transformer sound could be evaluated within an appropriate context. This report summarizes the findings from that field survey and discusses the potential noise impacts associated with the project.

1.1 Executive Summary

A six day field survey of the existing ambient sound levels in the immediate vicinity of the future substation associated with the Hillcrest Solar Farm was carried out to establish what the baseline environmental conditions are and determine what effect the sound emissions from the transformers at the existing Duke Energy Hillcrest substation might be having at the nearest residences. The survey results indicate that the sound emissions from the existing substation are largely or totally insignificant during the day at the nearest homes but that the tonal transformer hum tends to become more pronounced and detectable at night. However, nighttime conditions are uniquely irrelevant to a solar energy project, since it is only operational during the day. Consequently, no change or increase in nighttime noise will occur as a result of the planned project. During the day environmental sound levels in the vicinity of the substation are driven by sources unrelated to the existing substation, such as distant traffic, wind rustle, birds, etc.

The sound power level of the step up transformer associated with the proposed substation was calculated from its expected maximum MVA rating of 200 and mathematically projected to the nearest potentially sensitive receptors. This projection indicates that any sound emissions from the new transformer will be significantly lower than the current natural background sound level making it inaudible all of the time at all of the nearest residences - except at the very closest house about 800 ft. south of the existing and proposed substations. At this particular location, it is anticipated that the sounds from the new transformer will be inaudible or inconsequential most or the time during the day when it is in service; however, there may be occasional periods when it is faintly perceptible with careful listening. But, generally speaking, no significant adverse community noise impact is expected from the proposed substation.

Beyond the substation, there will some sound from the electrical inverters distributed throughout the solar fields. While the sound emissions from this equipment are not negligible in overall magnitude and tonal in character close to these units, the higher frequency tonal aspect drops away quickly with distance and field measurements indicate that inverter sound fades to insignificance relative to normal background levels at a distance of 150 ft. Moreover, inverter sound is rarely audible at the perimeter fence of typical solar fields so an adverse noise impact at the nearest residences beyond the project boundary appears to be highly unlikely from this equipment. In any event, options exist to mitigate inverter sound emissions should any problem arise.

In contrast to other forms of power generation, sound emissions during construction are expected to be dramatically lower in magnitude and duration. Some unavoidable disturbance is possible when the mounting posts are driven in but this activity will be short-lived in any particular location. Other sounds from trenching and road building will also be brief in duration and will progress from place to place avoiding prolonged exposure at any specific location.

In general, the potential noise impacts from all aspects of the project are expected to minimal and reasonably acceptable.

2.0 Existing Conditions Sound Survey

A sound level survey was carried out in the vicinity of the proposed substation over a 6 day period from Friday, March 24th through Thursday, March 30th, 2017 using continuously recording sound monitors in general accordance with ANSI S12.9-R2013 "Quantities and Procedures for Description and Measurement of Environmental Sound. Part 2: Measurement of Long-term, Wide-Area Sound". The objective of the survey was to gain an understanding of the existing environmental sound levels at the nearest residences to the planned substation and also, more specifically, to evaluate the current sound emissions from the existing Duke Energy 345 kV Hillcrest Substation, which is located immediately adjacent to the proposed substation site. In effect, the new substation would potentially add sound that is similar in character to what is currently being experienced – as opposed to the introduction of a completely new sound source at a greenfield site. Consequently, the survey was designed to determine just how significant or insignificant this existing sound is and what the effect of the new substation might be in that context.

2.1 Measurement Locations

As illustrated in Figure 2.1.1 on the following page, four monitoring locations were used to evaluate existing sound levels:

- **Position 1** – Control - At the southern fence of the existing substation midway between the two transformers
- **Position 2** – Nearest Residence – At a point along the substation access road the same distance (750 ft.) south of the substation as the nearest residence
- **Position 3** – Nearest Residences on CH 8 – Representative of the homes along County Highway 8 south of the site
- **Position 4** – Nearest Residences on Driver Collins Road - Representative of the homes along Driver Collins Road west of the site

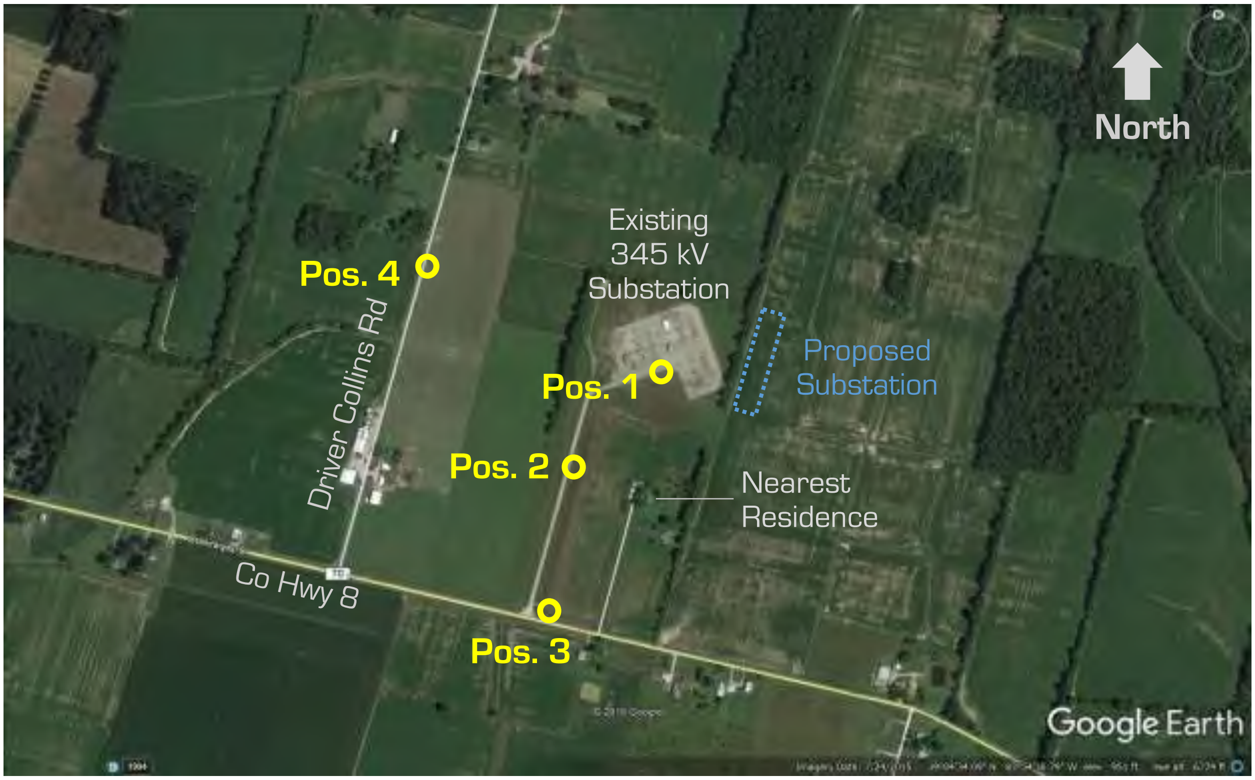

Figure 2.1.1
Site Vicinity Showing Sound Measurement Locations

The specific monitoring locations are described in further detail below.

2.1.1 Position 1 – Control

A 1/3 octave band frequency analyzer was set up as a continuous sound monitor just outside the southern fence of the existing substation at a point equidistant from the two transformers, which were both clearly audible at this short distance, as intended. The purpose of this test location was to create a time history of any variance in the substation's sound emissions over the survey period and to continuously record its frequency spectrum since transformers are tonal sound sources that generate a hum at harmonics of 60 Hz.

Photographs of the instrument set up at Position 1 are shown below.

Figure 2.1.1.1
Measurement Position 1 Looking N towards the Larger Transformer

Figure 2.1.1.2
Measurement Position 1 Looking NW towards the Smaller Transformer

2.1.2 Position 2 – Nearest Residence

A second 1/3 octave band frequency analyzer and another redundant data logger were set up at point along the access road 750 ft. south of the existing transformers to record sound levels representative of those experienced at the nearest residence (without intruding on private property or causing any sort of inconvenience), which is the same distance from the transformers. This home will also be the closest residence to the new substation and, as such, is the principal design and analysis point.

Figure 2.1.2.1
Measurement Position 2 Looking E towards Nearest House

Figure 2.1.2.2
Measurement Position 2 Looking N towards Existing Substation

2.1.3 Position 3 – Nearest Residences Along CH 8

A sound level monitor was set up on a utility pole at the beginning of the access road to capture the sound levels generally experienced at a handful of homes along County Highway 8 south of the current and planned substations.

Figure 2.1.3.1
Measurement Position 3 Looking ESE towards Residences along CH 8

Figure 2.1.3.2
Measurement Position 3 Looking N towards Existing Substation

2.1.4 Position 4 – Nearest Residences on Driver Collins Road

A monitor was set up on a utility pole on Driver Collins Road to measure the sound levels generally experienced at the homes along this road west of the existing and planned substations.

Figure 2.1.4.1
Measurement Position 4 Looking N towards Houses along Driver Collins Road

Figure 2.1.4.2
Measurement Position 4 Looking E towards Existing Substation (Beyond Tree Line)

2.2 Survey Equipment and Measurement Parameters

Norsonic N-140, ANSI S1.4-1983(R2006) Type 1 precision, frequency analyzers were used at the principal locations, Positions 1 and 2, and Rion Model NL-22, ANSI Type 2, environmental sound monitors were used at the remaining locations. Each instrument was field calibrated with a Brüel and Kjær Type 4230, ANSI S1.40-1984(R1990) Type 1 calibrator at the beginning and end of the survey and all instruments exhibited an insignificant drift within the range from -0.1 and +0.4 dB. Weather-treated 3 in. diameter windscreens were used at all positions. As is evident in the photos above, the microphones were fixed to temporary posts at a standard height of 1.2 m above local grade at the locations on the substation property. For security reasons the monitors at Positions 3 and 4 were located about 8 ft. above grade on utility poles.

A variety of statistical sound levels, such as the minimum, average, maximum, etc. were measured in 10 minute increments over the 6 day survey period; however, the parameter of primary relevance and importance to this kind of survey is the L90 percentile level, which is the sound level exceeded 90% of the time over each measurement period. Put another way, this level captures the quietest (not necessarily consecutive) 1 minute of each 10 minute interval, which in this particular environment, tends to capture any momentary lulls in traffic making it a very conservative measure of the near-minimum background sound level.

2.3 Survey Conditions

The general weather parameters over the survey period, as observed in Batavia, OH a few miles west of the project site, are illustrated below.

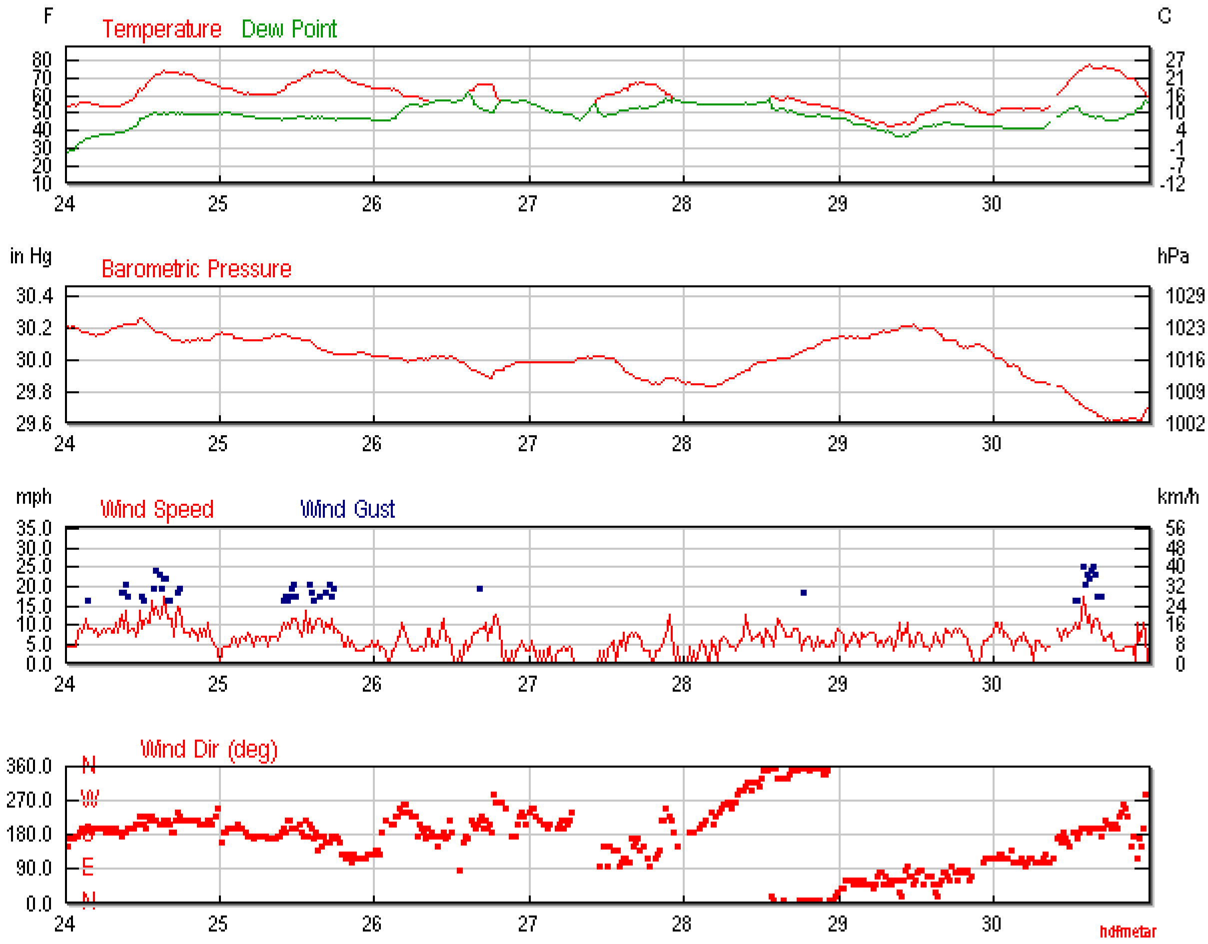

Figure 2.3.1
General Weather Parameters during the Survey Period as Observed in Batavia, OH (weatherundergound.com)

In general, the weather conditions during the survey were unseasonably mild for the season with temperatures close to or above 70 deg. on some days. As can be seen from Figure 2.3.1, it was windy during the daytime hours on March 24, 25 and 30. There was only one period of significant rain: from about 11 a.m. to 1 p.m. on March 26.

3.0 Survey Results

3.1 Control Position and Nearest Residence

The survey results, in terms of the L90(10 min.) sound levels for the two principal test locations, Positions 1 and 2, are plotted below.

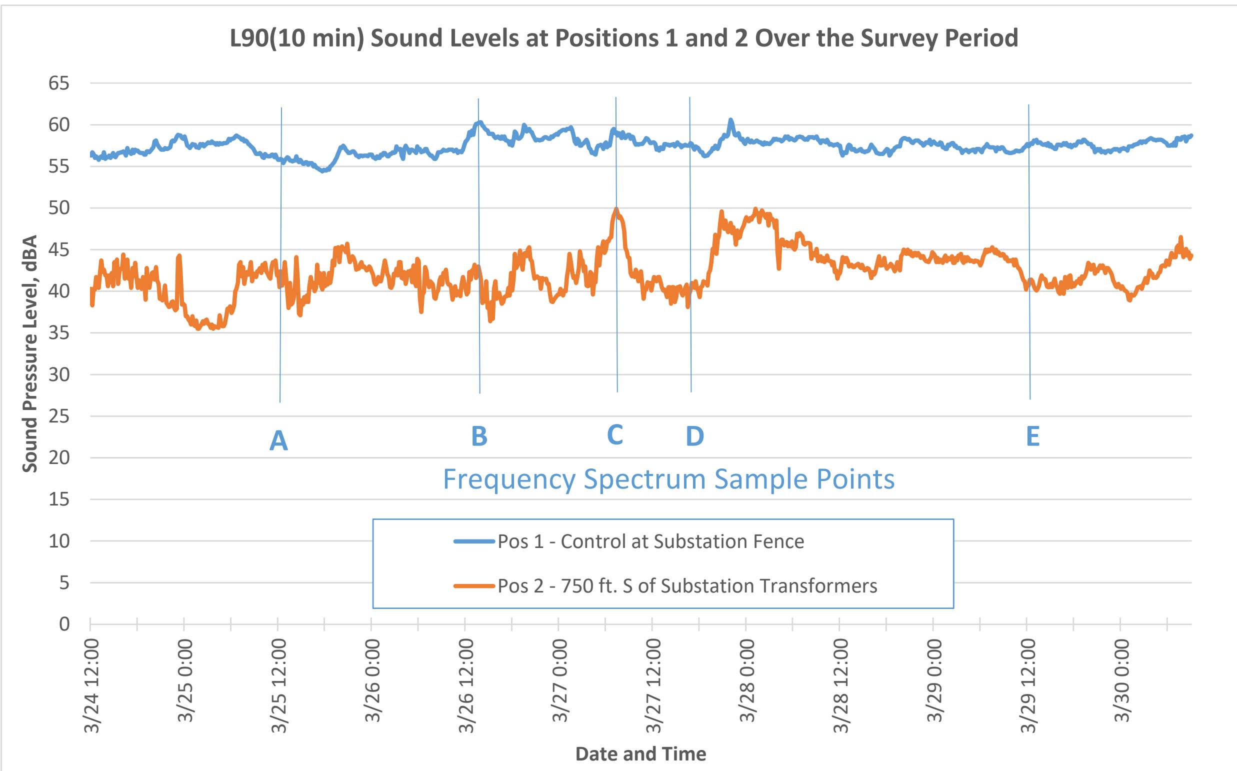

Figure 3.1.1

What these results generally show is that the sound emissions from the existing substation are largely constant and do not vary to any significant degree with time of day or night or, apparently, any other factor. What this consistency implies is that the ups and downs that are evident in the sound level 750 feet away (representative of the nearest home) are not attributable to the substation, but rather are driven by other, unrelated environmental influences, such as distant traffic volumes, wind, birds, man-made sounds, etc.

In order to further investigate the link, or lack thereof, between the sound emissions from the substation and what is actually heard at the nearest residence, a series of frequency spectrum comparisons are plotted below. These samples, taken at the points designated as A through E in Figure 3.1.1, were randomly selected for different days during the daytime hours because any sound emissions from the new substation will only be a daytime occurrence. These plots are A-weighted, which means, in simple terms, that the highest or peak values in each spectrum represent the frequencies that are the most perceptible to the human ear, while the lower values are generally insignificant or completely inaudible. In general, these frequency cross-sections show that at the control position the existing transformers produce their most dominant sound at the harmonics of 360 and 480 Hz, while the fundamental tone at 120 Hz is clearly present but relatively subdued in magnitude. The important take-away from these graphics is that these dominant frequencies, that are so prominent at the substation fence, are almost entirely or completely absent from the spectra at the nearest residence. This indicates that the transformers, at least during the day, are mostly or completely imperceptible at the house. Data from some nighttime periods indicate that transformer hum can become significantly more perceptible at night; however, nighttime circumstances are uniquely irrelevant to the sound emissions from a solar energy facility.

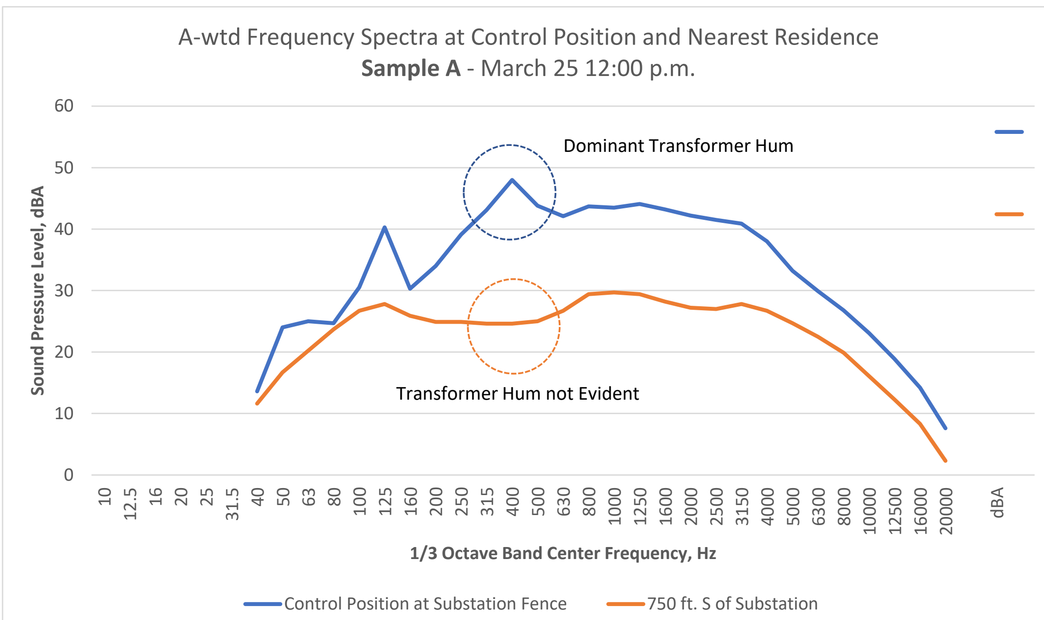

Figure 3.1.2

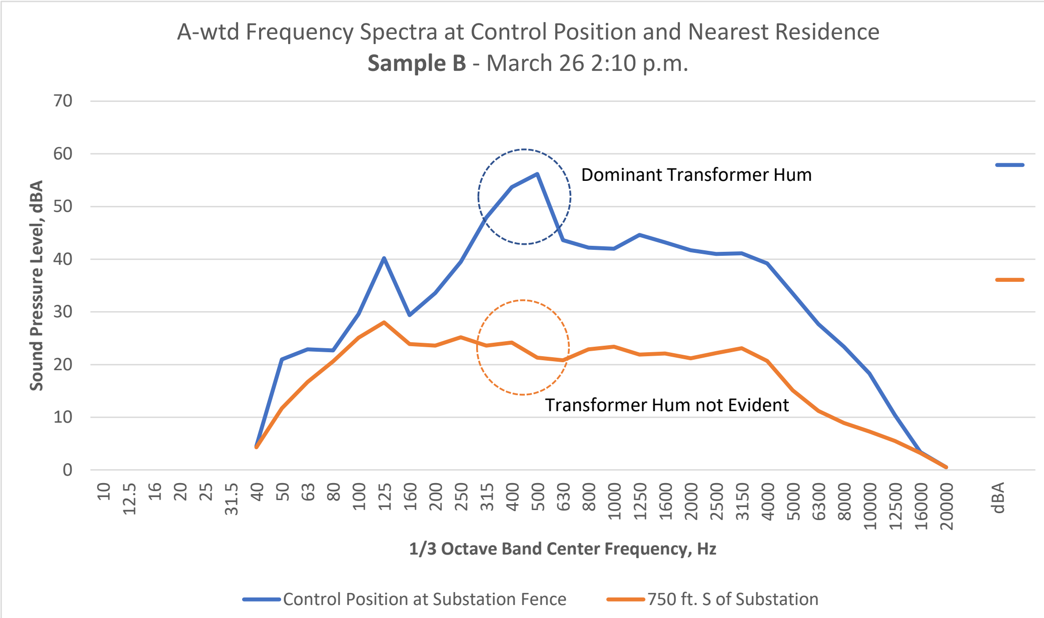

Figure 3.1.3

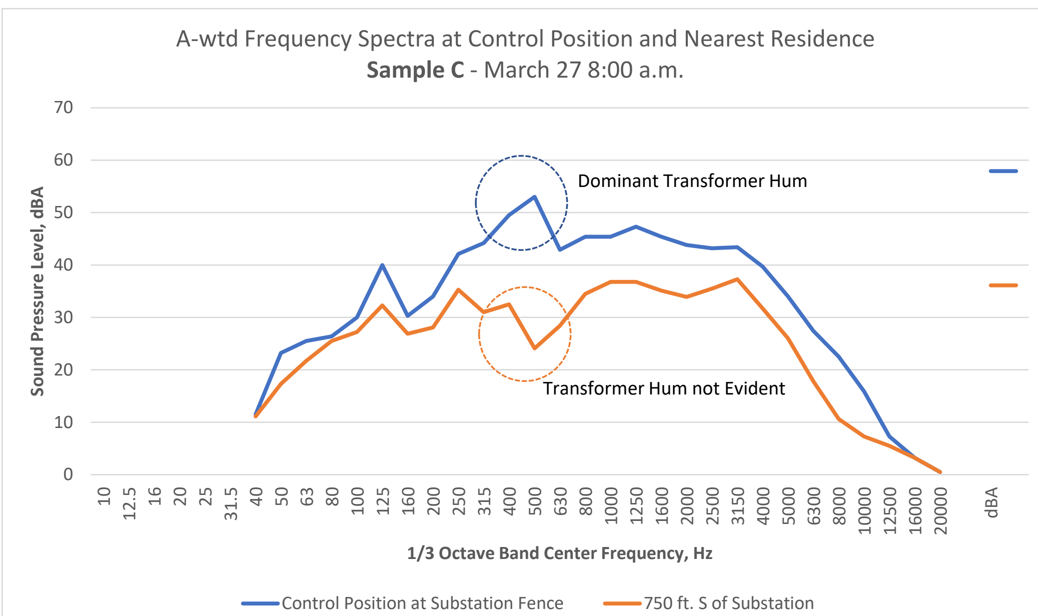

Figure 3.1.4

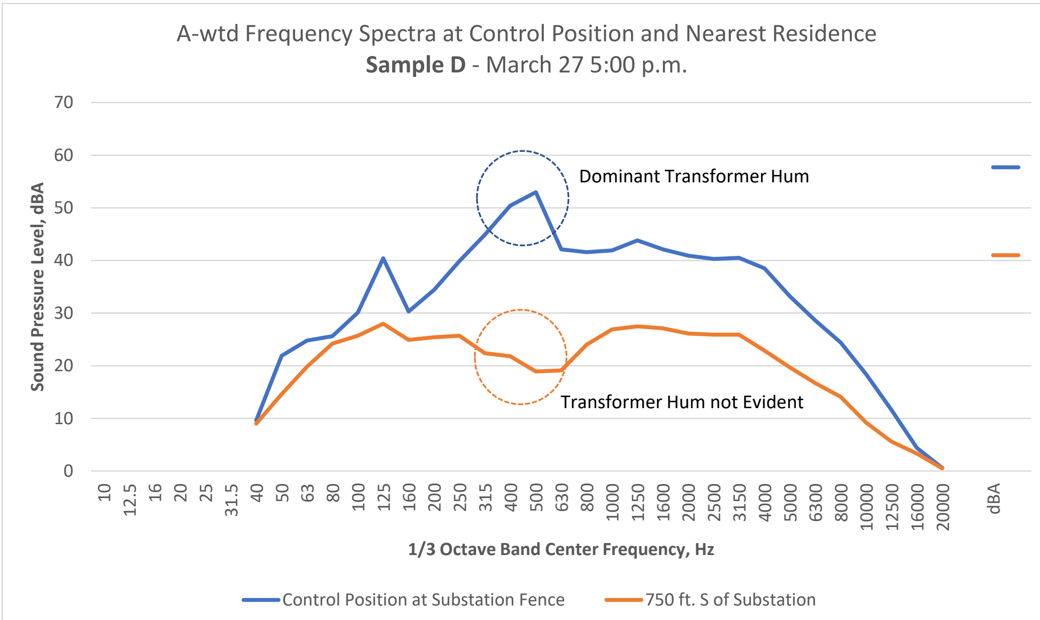

Figure 3.1.5

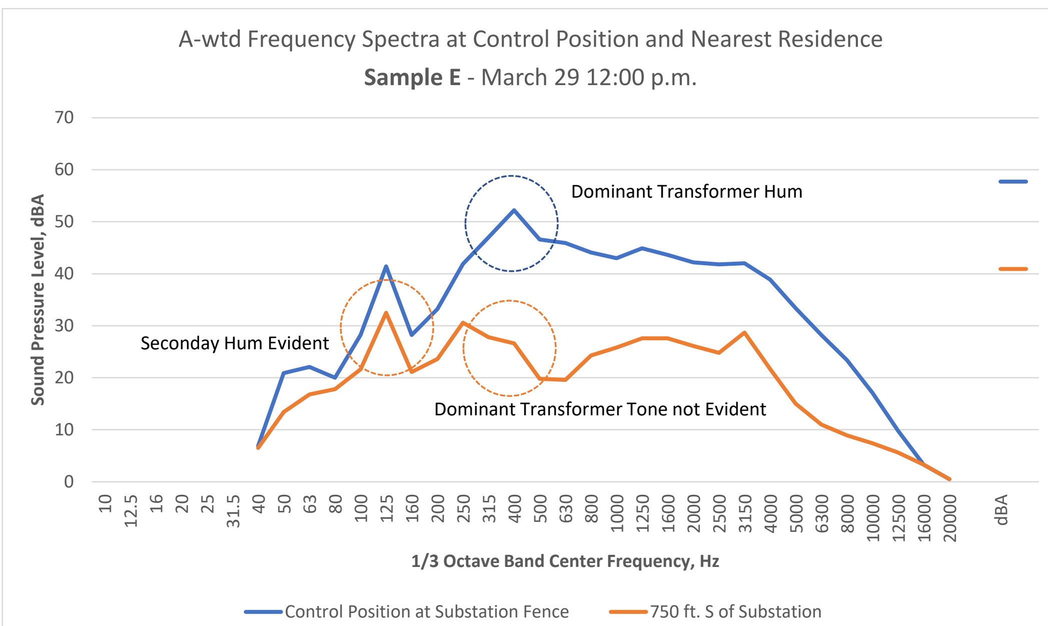

Figure 3.1.6

This last plot shows that a hum at 120 Hz may have been slightly perceptible on that particular day at that particular time; however, in that region of the frequency spectrum a prominence of about 15 dB above the adjacent bands is required to be considered a “prominent discrete tone”. In this case, the prominence of about 10 to 11 dB suggests that the sound at 120 Hz may have been barely perceptible with careful listening, but certainly not obvious. By and large, though, the survey data generally indicate that the sound emissions from the existing substation are mostly inconsequential during the day – and that other natural and man-made sounds are dominant.

3.2 Overall Results at All Positions

The survey results at all the test positions are shown below in Figure 3.2.1. Since the levels at Positions 2, 3 and 4 are often similar despite the fact that Positions 3 and 4 are substantially further from the existing substation than Position 2, it follows that the sound levels near the houses on CH 8 and along Driver Collins Road are driven by widespread, general environmental sources that are unrelated to the substation. In other words, the sound levels at Positions 2, 3 and 4 essentially quantify the macro-ambient, or the typical sound level throughout the entire area.

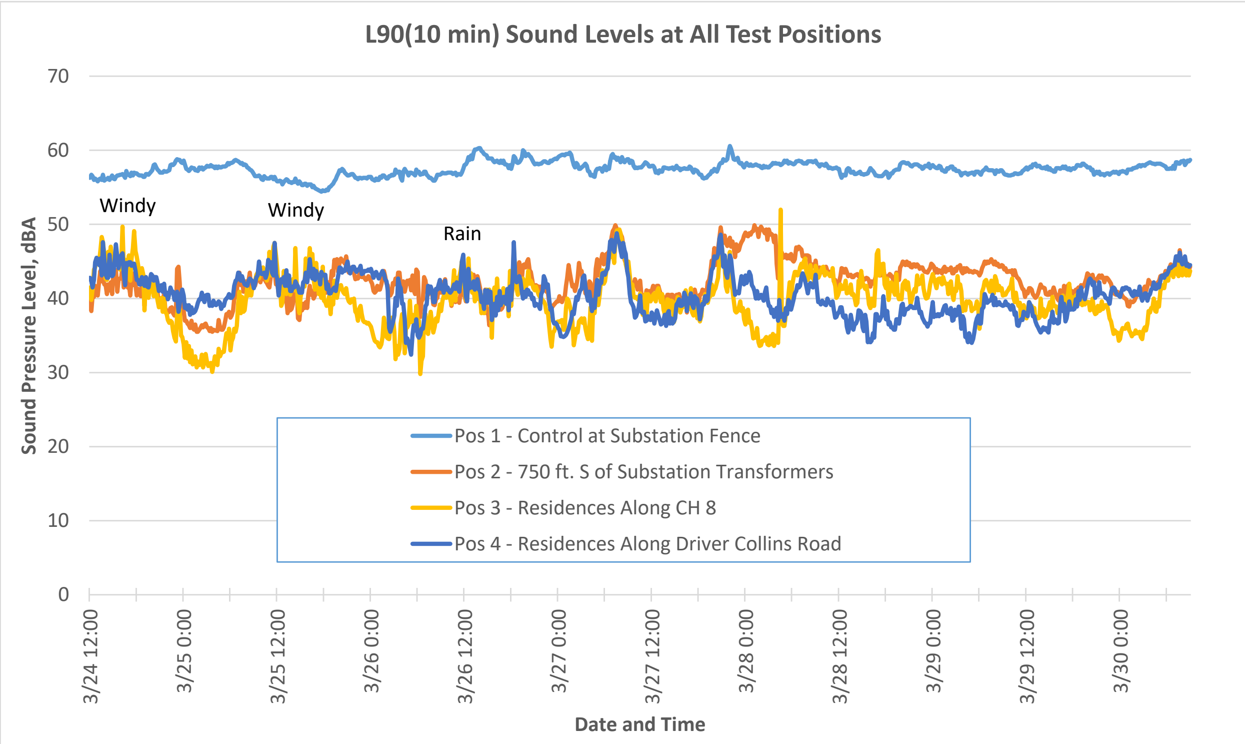

Figure 3.2.1

In summary, the survey results essentially show that the sound emissions from the existing substation transformers, while quite prominent and rich in tones at the fence, do not propagate very well to the nearest homes and are only faintly perceptible at best at the nearest house during the day. Indications are that the transformer tones are more readily audible at night; however, this circumstance is not particularly germane to the analysis of the solar project substation, which will only be active during the day. The only real relevance of this intermittent audibility is that the community will have had previous exposure to this type of sound, meaning that if anything is ultimately audible from the new substation it is unlikely to be regarded as a new or strange sound.

4.0 Sound Emissions from the New Substation

4.1 Transformer Sound Level

The only noise source of any potential consequence in the new substation is the step up transformer. Any crackle from the electric lines is something that's only noticeable in or immediately around the substation itself and therefore of no significance at the nearest residences many hundreds of feet away.

The input sound power level for this transformer has been very conservatively estimated in octave bands in **Table T-2085-042017-0** based on the unit's maximum expected megavolt ampere (MVA) rating of 200 using empirically derived algorithms from the "Electric Power Plant Environmental Noise Guide[1]" published by the Edison Electric Institute (EEI). Numerous transformers over a wide range of sizes and manufacturers were measured in the EEI study to develop a formulaic relationship between the MVA rating and sound power. The precise transformer model, rating and manufacturer for this project have not yet been finalized, but the best estimate at this time is for a 200 MVA unit.

For this size transformer, the EEI methodology predicts a near field sound pressure level of 83 dBA and an associated sound power level (Lw) of 103 dBA re 1 pW[2]. The calculated octave band frequency spectrum that is associated with this is tabulated below.

Table 4.1.1
Calculated 200 MVA Transformer Sound Power Level (Lw) Spectrum per EEI Guide

OBCF, Hz	31.5	63	125	250	500	1k	2k	4k	8k	**dBA**
Lw, dB re 1 pW	99	105	107	102	102	96	91	86	79	**103**

[1] "Electric Power Plant Environmental Noise Guide", Prepared by Bolt Beranek and Newman for the Edison Electric Institute, 2nd Ed., 1984.

[2] Sound power level is an essentially intangible quantity, used only for modeling purposes, that is calculated from the measured sound pressure level and the radiating wave front area at the point of the measurement. It is expressed in units of Watts and the designation "re 1 pW", or 'with reference to one picoWatt', is used by convention to distinguish power levels from pressure levels, which are measured in units of pressure, Pascals.

4.2 Sound Propagation Calculations

Based on the sound power level spectrum above, the sound emissions from the substation have been calculated at the nearest potentially sensitive receptors (residences) in strict accordance with ISO 9613-2 *Acoustics –Attenuation of Sound during Propagation Outdoors*[3].

In this instance, a mid-range, somewhat conservative ground absorption coefficient (Ag from ISO 9613-2) of 0.5 (on a scale of 0 to 1) has been used to represent the site vicinity, which consists of open fields. There are no appreciable undulations in the area topography so a flat plane is assumed along with ISO "standard day" conditions (10 deg C/70% RH).

4.3 Substation Sound Levels at the Design Points

The nearest residences to the proposed new substation are illustrated in Figure 4.3.1 and designated as Design Points 1 through 4.

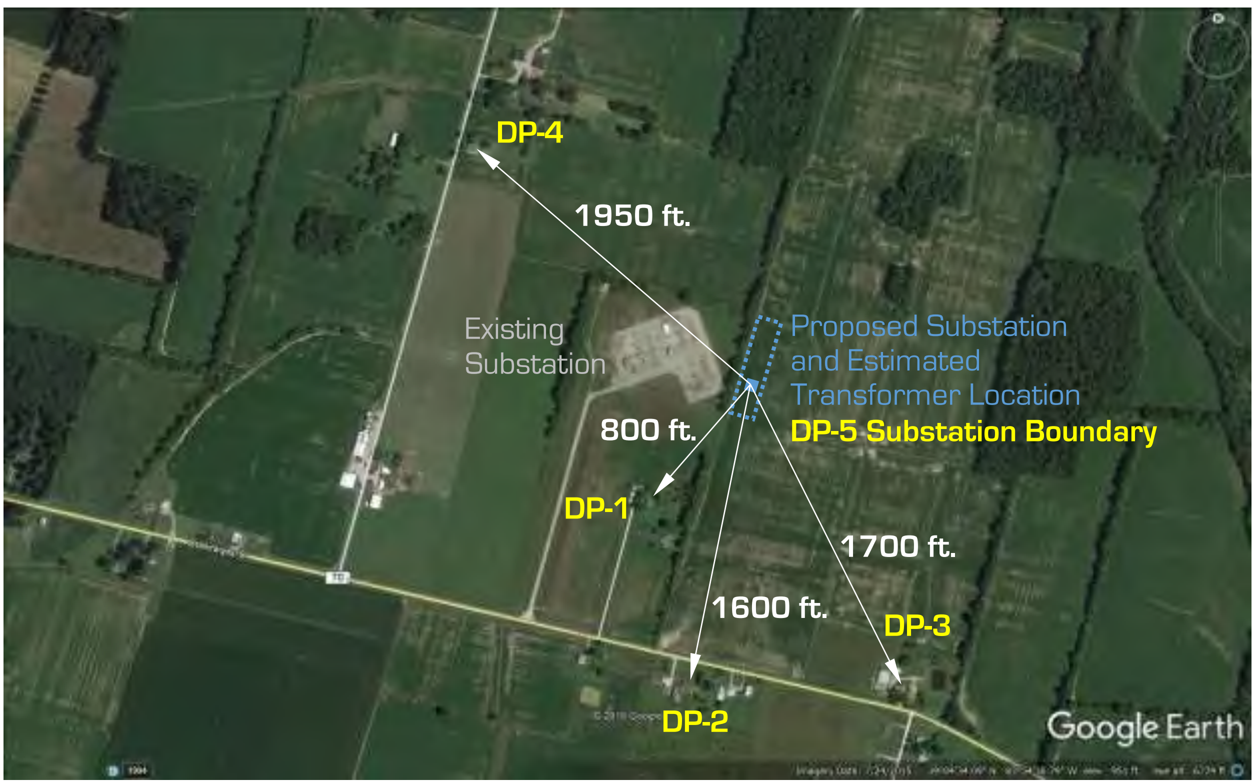

Figure 4.3.1
Substation Vicinity Showing Distances to Nearest Residences

[3] *Acoustics – Attenuation of Sound during Propagation Outdoors*, Part 2, "A General Method of Calculation," ISO 9613-2, International Organization for Standardization, Geneva, Switzerland, 1989.

The overall A-weighted sound level from the proposed substation transformer at each of these receptors is calculated in Table T-2085-042017-0. These results, assuming operation only during the daylight hours from 7 a.m. to 7 p.m., are plotted graphically below along with the measured existing sound level at each location. Generally speaking, to be clearly audible a sound must exceed the background sound level by about 5 dBA. Anything equal to or below the background is essentially drowned out by it.

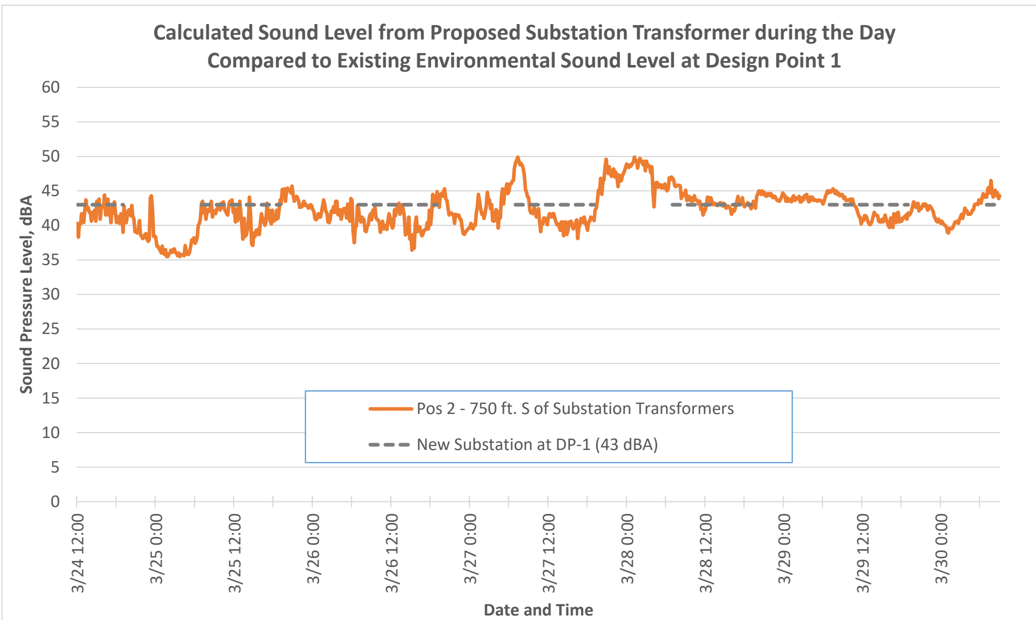

Figure 4.3.1

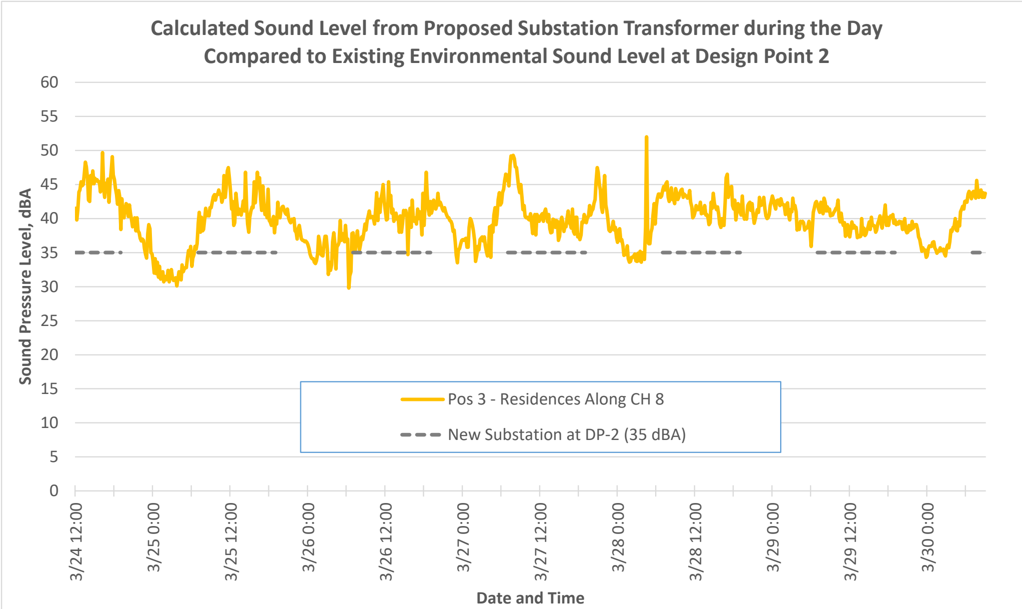

Figure 4.3.2

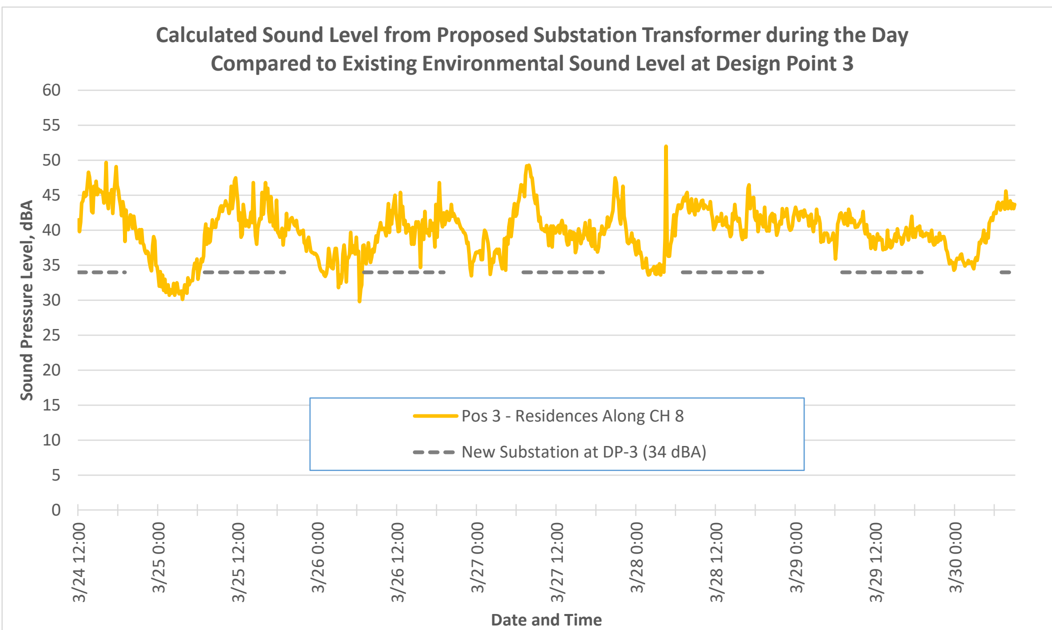

Figure 4.3.3

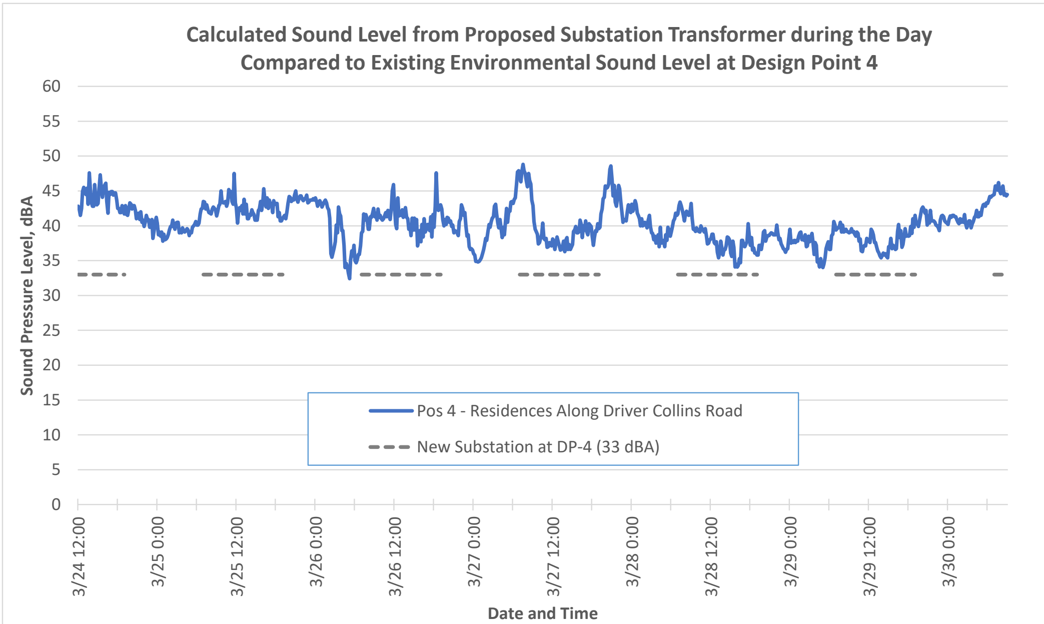

Figure 4.3.4

These plots show that in three out of four cases the substation sound level is well below the background making it impossible to hear. At the closest residence (DP-1, Figure 4.3.1) the data suggest that the transformer could occasionally be about 3 dBA higher than the background, which means that, while it wouldn't be clearly audible or obvious, its tonal sound emissions might be barely perceptible with careful listening for brief periods when all other sounds are momentarily at a minimum.

This projected situation is somewhat similar to the existing situation described in Section 3.1 where the transformer tones from the current substation were utterly undetectable most of the time but did appear, although in a rather subdued manner, on rare occasions, as shown in Figure 3.1.6. In that instance, the prominence of the sound at 120 Hz was not enough to make it clearly perceptible and, in fact, it may not have been audible at all. Since this kind of marginal perceptibility, at best, is currently expected from the new substation, no significant adverse community noise impact is anticipated from this aspect of the project.

At the substation boundary, Design Point 5, a sound level of 61 dBA is calculated assuming a distance of about 100 feet from the transformer. Judging from the level of about 58 dBA that was measured at the fence of the existing 345 kV substation during the baseline survey, this predicted level of 61 dBA appears conservative; i.e. the derivation of the transformer sound power level and the subsequent predictions at all the design points may well be higher than the actual performance.

5.0 Sound Emissions from Other Sources

With the possible exception of substations, photovoltaic power projects generate very little environmental noise. The only other sound sources of any possible significance are the electrical inverters used to convert locally generated DC current into AC power that is then routed to the substation through underground collector cables. Typically these electrical cabinets are situated within and near the center of each solar field, or independent group of solar panels, so they are usually a considerable distance from the perimeter fence and potential neighbors beyond. Generally speaking, these electrical cabinets emit sound levels on the order of 60 to 70 dBA at 10 ft. and, at this very close-in distance, the sound can be characterized as a hum with overlying ringing tones in the high frequencies. Since high frequency sound diminishes rapidly with distance the ringing aspect of the sound dies out very quickly and the sound at any significant distance consists of a low hum, if it is audible at all.

The precise make and model of the inverters for the Hillcrest project has not yet been selected so their sound emissions cannot be modeled or rigorously evaluated at this time. However, a field study of typical inverter sound emissions at several existing large-scale solar facilities - that was carried out for the Massachusetts Clean Energy Center, an agency of the State government, in 2012[4] - indicates that any noise from these cabinets generally drops into the background level and becomes insignificant at a distance of 150 feet and that they are rarely audible at or beyond the perimeter fence. Consequently, it is expected that any conventional solar field layout will result in a situation where inverter noise is inconsequential at the project boundary making any adverse impact on neighbors highly unlikely. Nevertheless, if this sound source were to unexpectedly generate complaints, options, such as cabinet damping and ventilation silencers, would be available to retroactively mitigate noise from these devices and resolve any issue.

One other possible sound source might be the small motors that (very) slowly rotate the panels so that they track the sun over the course of each day. However, the sound emissions from these motors are thought to be inconsequential even immediately adjacent to them, so no significant community noise impact is anticipated.

During normal operation the facility does not require an operator or any full time staff, so there clearly wouldn't be any noise impacts from traffic. The site would only be occasionally visited by maintenance personnel.

6.0 Sound Emissions during Construction

In contrast to other forms of power generation, the construction phase of a solar energy facility is remarkably short and the activities that generate any significant noise are few. Where a fossil or

[4] Guldberg, P., Tech Environmental, "Study of Acoustic and EMF Levels from Solar Photovoltaic Projects", Prepared for the Massachusetts Clean Energy Center, Boston, Dec. 2012.

wind project would require extensive earthworks and the pouring of massive concrete foundations, a solar plant only involves the installation of the mounting posts for the panel racks, which generally follow the existing topography. No concrete foundations are used for the panel arrays. There are two basic methods of erecting the posts, driving or rotating screw bases. If the posts are driven in, it is essentially a small-scale pile driving operation that produces a repetitive pounding noise, which will be clearly audible for some distance and could cause some unavoidable disturbance. On the other hand, this activity is short-lived and would proceed fairly quickly, only occurring for a period of days or a couple weeks in any one locality. If the posts are screwed in there might be some local noise from the driving apparatus; however, any community impact is likely to be minimal.

In terms of the more traditional construction phases, the table below gives some representative sound levels from construction equipment at 50 feet[5], which, in this case, may be conservatively interpreted as the site property boundary. These sound levels might be temporarily produced very close to where the work is occurring.

Table 6.0.1
Typical Construction Equipment Sound Levels per FHWA by Phase

Equipment Description	Typ. Sound Level at 50 ft., dBA	Est. Maximum Total Level at 50 ft. (Property Boundary) per Phase, dBA*
Blasting		
n/a		n/a
Earthmoving Road Construction and Electrical Line Trenching		
Dozer	85	85
Front End Loader	80	
Grader	85	
Backhoe	80	
Pile (Support Post) Driving		
Piling Auger (Large)	95	95 (Driven Posts)
Drill Rig Truck	84	84 (Screwed Posts)
Truck Traffic Material Delivery		
Flatbed Truck	84	84
Erection Panel Installation		
Mobile Crane	85	85

* Not all vehicles are likely to be in simultaneous operation. Maximum level represents the highest level realistically likely at any given time.

[5] U. S. Dept. of Transportation, Federal Highway Administration, *Roadway Construction Noise Model User's Guide*, Table 1, Jan. 2006.

As indicated in the table, no blasting will be necessary for the project. Additionally, there is no need for concrete pouring throughout the solar fields. The base slabs for the inverters and other electrical equipment will be precast and dropped in place. Concrete pouring is only likely for the transformer base in the substation. A concrete pump truck typically generates a sound level of about 82 dBA at 50 feet[6], or the boundary of the substation. At the nearest house (DP-1) this sound level would decrease to around 56 dBA and occur only intermittently during the day; most likely only for a day or two.

7.0 Conclusions

A six day field survey of the existing ambient sound levels in the immediate vicinity of the future substation associated with the Hillcrest Solar Farm was carried out to establish what the baseline environmental conditions are and determine what effect the sound emissions from the transformers at the existing Duke Energy Hillcrest substation might be having at the nearest residences. The survey results indicate that the sound emissions from the existing substation are largely or totally insignificant during the day at the nearest homes but that the tonal transformer hum tends to become more pronounced and detectable at night. However, nighttime conditions are uniquely irrelevant to a solar energy project, since it is only operational during the day. Consequently, no change or increase in nighttime noise will occur as a result of the planned project. During the day environmental sound levels in the vicinity of the substation are driven by sources unrelated to the existing substation, such as distant traffic, wind rustle, birds, etc.

The sound power level of the step up transformer associated with the proposed substation was calculated from its expected maximum MVA rating of 200 and mathematically projected to the nearest potentially sensitive receptors. This projection indicates that any sound emissions from the new transformer will be significantly lower than the current natural background sound level making it inaudible all of the time at all of the nearest residences - except at the very closest house about 800 ft. south of the existing and proposed substations. At this particular location, it is anticipated that the sounds from the new transformer will be inaudible or inconsequential most or the time during the day when it is in service; however, there may be occasional periods when it is faintly perceptible with careful listening. But, generally speaking, no significant adverse community noise impact is expected from the proposed substation.

Beyond the substation, there will some sound from the electrical inverters distributed throughout the solar fields. While the sound emissions from this equipment are not negligible in overall magnitude and tonal in character close to these units, the higher frequency tonal aspect drops away quickly with distance and field measurements indicate that inverter sound fades to insignificance relative to normal background levels at a distance of 150 ft. Moreover, inverter sound is rarely audible at the perimeter fence of typical solar fields so an adverse noise impact at the nearest

[6] Ibid.

residences beyond the project boundary appears to be highly unlikely from this equipment. In any event, options exist to mitigate inverter sound emissions should any problem arise.

In contrast to other forms of power generation, sound emissions during construction are expected to be dramatically lower in magnitude and duration. Some unavoidable disturbance is possible when the mounting posts are driven in but this activity will be short-lived in any particular location. Other sounds from trenching and road building will also be brief in duration and will progress from place to place avoiding prolonged exposure at any specific location.

In general, the potential noise impacts from all aspects of the project are expected to minimal and reasonably acceptable.

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Table: **T-2085-042017-A**
Title: **Substation Transformer Sound Propagation Calculations**
Project: **ORR Hillcrest Solar**
Revision: **A**
Date: **5/2/17**

1. Sound Power Level Estimate Based on MVA Rating, Assume Standard Core

Descriptor			31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
			Octave Band Center Frequency, Hz										
Maximum Expected MVA Rating	**200**	MVA										102	
Standard NEMA Rating		NEMA = 55 +12 log (MVA), per EEI Guide*										83	
Size Factor (10 log s) Based on MVA												20	
Frequency Adjustment Factors			-3	3	5	0	0	-6	-11	-16	-23		
Near Field Lp Based on NEMA Rating			80	86	88	83	83	77	72	67	60	83	
Lw = NEMA Rating + 10 log s			**99**	**105**	**107**	**102**	**102**	**96**	**91**	**86**	**79**	**103**	

* Edison Electric Institute, "Electric Power Plant Environmental Noise Guide", 2nd Ed., BBN, 1984.

2. Calculated Sound Pressure at DP-1 (Nearest Residence)

Descriptor			31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Path Attenuation:													
Source Receiver Distance	**244**	m		**800** ft.									
Hemispherical Distance Loss, m	244		-56	-56	-56	-56	-56	-56	-56	-56	-56		
Air Absorption (10°C / 70%RH), m	244		0	0	0	0	-1	-1	-2	-5	-13		
Anomalous Attenuation, m	244		0	0	0	-1	-1	-1	-2	-2	-3		
Number of Sources	1		0	0	0	0	0	0	0	0	0		
Ground Attenuation per ISO 9613-2	Ag = 0.5		0	0	-2	-6	-3	-1	-1	-1	-1		
Sum of Path Attenuation:			-56	-56	-58	-63	-60	-59	-61	-64	-73		
Est. Receptor Lp			**43**	**49**	**49**	**40**	**42**	**37**	**31**	**22**	**7**	**43**	

3. Calculated Sound Pressure at DP-2 (Residences on S side of CH 8)

Descriptor			31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Path Attenuation:													
Source Receiver Distance	**488**	m		**1600** ft.									
Hemispherical Distance Loss, m	488		-62	-62	-62	-62	-62	-62	-62	-62	-62		
Air Absorption (10°C / 70%RH), m	488		0	0	0	-1	-1	-2	-4	-10	-25		
Anomalous Attenuation, m	488		0	-1	-1	-1	-2	-2	-4	-5	-6		
Number of Sources	1		0	0	0	0	0	0	0	0	0		
Ground Attenuation per ISO 9613-2	Ag = 0.5		0	0	-3	-6	-3	-1	0	0	0		
Sum of Path Attenuation:			-62	-63	-66	-70	-68	-67	-70	-76	-94		
Est. Receptor Lp			**37**	**43**	**41**	**33**	**35**	**29**	**22**	**10**	**-14**	**35**	

4. Calculated Sound Pressure at DP-3 (Residence on N side of CH 8)

Descriptor			31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
Path Attenuation:													
Source Receiver Distance	**518**	m		**1700** ft.									
Hemispherical Distance Loss, m	518		-62	-62	-62	-62	-62	-62	-62	-62	-62		
Air Absorption (10°C / 70%RH), m	518		0	0	0	-1	-1	-2	-5	-11	-27		
Anomalous Attenuation, m	518		-1	-1	-1	-1	-2	-3	-4	-5	-7		
Number of Sources	1		0	0	0	0	0	0	0	0	0		
Ground Attenuation per ISO 9613-2	Ag = 0.5		0	0	-4	-6	-3	-1	0	0	0		
Sum of Path Attenuation:			-63	-63	-68	-70	-68	-68	-71	-78	-96		
Est. Receptor Lp			**36**	**42**	**40**	**32**	**34**	**28**	**21**	**8**	**-17**	**34**	

Notes:
Lp = Sound Pressure Level, dB re 20 mPa
Lw = Sound Power Level, dB re 1 pW

Hessler Associates, Inc.
WORLDWIDE CONSULTING IN ENGINEERING ACOUSTICS

Table: T-2085-042017-A
Title: Substation Transformer Sound Propagation Calculations
Project: ORR Hillcrest Solar
Revision: A
Date: 5/2/17

Descriptor			31.5	63	125	250	500	1000	2000	4000	8000	dBA	dBC
			Octave Band Center Frequency, Hz										
5. Calculated Sound Pressure at DP-4 (Residence on E side of Driver Collins Road)													
Path Attenuation:													
Source Receiver Distance	**595**	m	**1950** ft.										
Hemispherical Distance Loss, m	595		-63	-63	-63	-63	-63	-63	-63	-63	-63		
Air Absorption (10°C / 70%RH), m	595		0	0	0	-1	-1	-2	-5	-12	-31		
Anomalous Attenuation, m	595		-1	-1	-1	-2	-2	-3	-4	-6	-8		
Number of Sources	1		0	0	0	0	0	0	0	0	0		
Ground Attenuation per ISO 9613-2	Ag = 0.5		0	0	-4	-6	-3	-1	0	0	0		
Sum of Path Attenuation:			-64	-64	-69	-72	-70	-70	-73	-81	-102		
Est. Receptor Lp			**35**	**41**	**38**	**31**	**33**	**27**	**18**	**5**	**-23**	**33**	
6. Calculated Sound Pressure at DP-5 (Substation Boundary)													
Path Attenuation:													
Source Receiver Distance	**30**	m	**100** ft.										
Hemispherical Distance Loss, m	30		-38	-38	-38	-38	-38	-38	-38	-38	-38		
Air Absorption (10°C / 70%RH), m	30		0	0	0	0	0	0	0	-1	-2		
Anomalous Attenuation, m	30		0	0	0	0	0	0	0	0	0		
Number of Sources	1		0	0	0	0	0	0	0	0	0		
Ground Attenuation per ISO 9613-2*	Ag = 1		0	0	-4	-8	-5	-3	-3	-3	-3		
Sum of Path Attenuation:			-38	-38	-42	-46	-43	-41	-41	-42	-43		
Est. Receptor Lp			**62**	**68**	**66**	**57**	**60**	**55**	**50**	**45**	**37**	**61**	

* 100% of propagation path over highly absorptive gravel (Ag = 1)

Notes:
Lp = Sound Pressure Level, dB re 20 mPa
Lw = Sound Power Level, dB re 1 pW