ACOUSTICAL STUDY

Windsor Solar One

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Windsor, Connecticut

PREPARED FOR

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March 2024

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1

Introduction

The purpose of this acoustical study is to evaluate the potential noise impacts associated with the operation of the proposed Windsor Solar One Project (the Project) located in at 445 River Street in Windsor, Connecticut. This acoustical assessment evaluated the potential sound levels generated by the mechanical equipment, including the inverters, transformers, and single-axis tracking panel rack systems, that will be part of the Project. The sound levels were compared to the Connecticut Department of Energy and Environmental Protection's (CT DEEP) noise control regulations (Regulations of Connecticut State Agencies (RCSA), Title 22a, Section 22a-69-1 to 22a-69-7).

Project Description

The proposed Project consists of the development of a 3.0-megawatt (MW) alternating current (AC) ground-mounted solar photovoltaic (PV) facility located on a 47.1-acre parcel at 445 River Street in Windsor, CT.

The site of the proposed project is bounded to the west and south by River Street, which contains residential properties. To the east, the site of the proposed project is bounded by a parcel that was recently developed as an Amazon distribution facility. To the north, the site of the proposed project is bounded by residences that could be characterized as either townhomes condominiums.

Fundamentals of Noise

Noise is defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, communication, work, or recreation. How people perceive sound depends on several measurable physical characteristics, which include the following:

- **Intensity** – Sound intensity is often equated to loudness.
- **Frequency** – Sounds are comprised of acoustic energy distributed over a variety of frequencies. Acoustic frequencies, commonly referred to as tone or pitch, are typically measured in Hertz. Pure tones have all their energy concentrated in a narrow frequency range.

Sound levels are most often measured on a logarithmic scale of decibels (dB). The decibel scale compresses the audible acoustic pressure levels which can vary from the threshold of hearing (zero dB) to the threshold of pain (120 dB). Because sound levels are measured in dB, the addition of two sound levels is not linear. Adding two equal sound levels creates a 3 dB increase in the overall level. Research indicates the following general relationships between changes in sound level and human perception:

- A 3 dB increase is a doubling of acoustic energy and is the threshold of perceptibility to the average person.
- A 10 dB increase is a tenfold increase in acoustic energy but is perceived as a doubling in loudness to the average person.

The human ear does not perceive sound levels from each frequency as equally loud. To compensate for this phenomenon in perception, a frequency filter known as A weighted [dB(A)] is used to evaluate environmental noise levels. **Table 1** presents a list of common outdoor and indoor sound levels.

Table 1. Common Outdoor and Indoor Sound Levels

Outdoor Sound Levels	Sound Pressure (μPa)*		Sound Level dB(A)**	Indoor Sound Levels
	6,324,555	-	110	Rock Band at 5 m
Jet Over Flight at 300 m		-	105	
	2,000,000	-	100	Inside New York Subway Train
Gas Lawn Mower at 1 m		-	95	
	632,456	-	90	Food Blender at 1 m
Diesel Truck at 15 m		-	85	
Noisy Urban Area—Daytime	200,000	-	80	Garbage Disposal at 1 m
		-	75	Shouting at 1 m
Gas Lawn Mower at 30 m	63,246	-	70	Vacuum Cleaner at 3 m
Suburban Commercial Area		-	65	Normal Speech at 1 m
	20,000	-	60	
Quiet Urban Area—Daytime		-	55	Quiet Conversation at 1 m
	6,325	-	50	Dishwasher Next Room
Quiet Urban Area—Nighttime		-	45	
	2,000	-	40	Empty Theater or Library
Quiet Suburb—Nighttime		-	35	
	632	-	30	Quiet Bedroom at Night
Quiet Rural Area—Nighttime		-	25	Empty Concert Hall
Rustling Leaves	200	-	20	
		-	15	Broadcast and Recording Studios
	63	-	10	
		-	5	
Reference Pressure Level	20	-	0	Threshold of Hearing

Source: Highway Noise Fundamentals. Federal Highway Administration, September 1980.

* mPA – MicroPascals, which describe pressure. The pressure level is what sound level monitors measure.

** dB(A) – A weighted decibels, which describe sound pressure logarithmically with respect to 20 mPa (the reference pressure level).

A variety of sound level indicators can be used for environmental noise analysis. These indicators describe the variations in intensity and sequential pattern of the sound levels. The indicators used in this analysis are defined as follows:

- Leq is the equivalent continuous A-weighted sound level, which is the value or level of a steady, non-fluctuating sound with the same acoustic energy as the actual time-varying sound levels over a given time period.
- L10 is the A-weighted sound level, which is exceeded for 10 percent of the time over a given time period.
- L90 is the A-weighted sound level, which is exceeded for 90 percent of the time over a given time period. The L90 is generally considered to be the background sound level.

Noise Impact Criteria

The CT DEEP has developed noise impact criteria that establish sound level thresholds deemed to result in adverse impacts. The acoustic analysis for the Project used these criteria to evaluate whether the Project will generate sound levels that result in adverse impacts.

The CT DEEP's noise control regulations identify the limits of sound that can be emitted from specific premises and what activities are exempt. The noise control regulations (Title 22a, §§ 22a-69-1 to 22a 69-7) are contained in the RCSA. The proposed Project is considered a Class C (Industrial) emitter by the CT DEEP. Nearby residential properties to the north, west, and south, are Class A (Residential) Receptors. The recently developed Amazon property to east is a Class C (Industrial) Receptor characterized as generally industrial, where protection against damage to hearing is essential, and the necessity for conversation is limited. The land use in Class A is characterized as generally residential where human beings sleep, or areas where serenity and tranquility are essential to the intended use of the land.

The CT DEEP policy states that a source (emitter) located in the various zones shall not emit noise exceeding the levels stated in **Table 2** at the adjacent noise zones.

Table 2. Noise Zone Standards

	Receptor Noise Zone			
Emitter Zone	**Class A (Daytime)**	**Class A (Nighttime)**	**Class B**	**Class C**
Class A (Residential)	55	45	55	62
Class B (Commercial)	55	45	62	62
Class C (Industrial)	61	51	66	70

Source: Control of Noise (Title 22a, Section 22a-69-1 to 22a-69-7.4), RCSA, Revised 2015-3-6.

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Acoustical Assessment

Methodology

This acoustical study evaluated the sound levels from the Project's proposed mechanical equipment. The Project's noise sources consist of twenty-four electrical inverters used to convert the solar energy to usable electricity, two transformers at the Project (Windsor Solar One) Switchyard, and 110 small actuator motors that move the single-axis panel tracking system to follow the sun. The noise analysis consists of two components: existing ambient sound levels and Project contributions.

The existing condition sound levels were determined by conducting sound level measurements at representative property line locations surrounding the Project Site. Measurements were conducted on the site of the proposed facility, at locations along the north and west property lines that were determined to be representative of the residential land use adjacent to the project site, and at one location along the east property line that would be close to the equipment pad. The measurements were conducted for a 24-hour period to capture typical weekday daytime and nighttime sound levels. Refer to **Figure 1**: Monitoring and Receptor Locations.

The Project-generated sound levels were calculated using manufacturer's sound data and the principles of acoustical propagation of sound over distance and were calculated for each sensitive receptor location. The sources of operational noise associated with the proposed project include:

- Twenty-four (24) CPS three-phase string inverters CPS SCH100/125KTL-DO/US-600;
- Two (2) 1500 kVA transformers; and

- One hundred ten (110) Solar FlexRack (SFR) Slewing Drives (tracking system motors).

The sound power level data for these pieces of equipment are provided in the following table. The sound power level for the CPS inverters was based on the data contained in the noise assessment for the East Windsor Solar Two, LLC project.[1] The reference sound levels for the transformers are based on an empirical approach obtained from the literature that relates the kVA-rating of an air-cooled transformer to its sound power level.[2] Reference sound level data for the tracking system motors were obtained from the manufacturer's testing of the equipment.[3]

Table 3. Modeled Sound Power Levels

	Sound Power Levels (dB) by Octave Band Center Frequency (Hz)								Overall	
Equipment	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8 k**	**dBA**	**dB**
CPS inverter[1]	72	72	67	68	69	64	55	47	72	77
1500 kVA transformer[2]	81	85	79	75	75	69	64	58	79	88
Tracking motor[3]	--	--	--	--	--	--	--	--	56	59

1 WPS, 2023.
2 Barron, 2003.
3 Cone Drive by Timken, 2021.

The A-weighted sound pressure levels due to the operation of the Project were predicted at the receptor locations using the acoustic modeling software CadnaA[4] (Computer Aided Noise Abatement) by Datakustik. CadnaA is an internationally accepted sound prediction program that implements the International Standards Organization (ISO) 9613-2 sound propagation standard. The noise prediction model accounts for the sound emissions of equipment, the ground cover, terrain, and the geometry of the project area. The assessment assumed all equipment operating simultaneously during the daytime period. Sound propagation was assumed to occur over acoustically "mixed" ground (G=0.5). The ground at the equipment pad – the location at which the inverters and transformers would be installed – was assumed to be acoustically "hard" ground (G=0.0). The noise prediction model did not account for excess attenuation provided by trees, or by any on-site or off-site structures, lending some conservatism to the results. The results were compared to the CT DEEP noise impact criteria for determining compliance.

[1] WPS, "Environmental & Community Noise Assessment, East Windsor Solar Two – 31 Thrall Road, East Windsor, CT," August 31, 2023.

[2] Barron, Randall F., "Industrial Noise Control and Acoustics," Marcel Dekker, Inc., Table 5-7, pp. 177-178, 2003.

[3] Cone Drive by Timken, "Solar FlexRack Noise Study, Part Number TD127SF-59956," February 4, 2021.

[4] DataKustik GmbH, 2023. Computer Aided Noise Abatement Model.

Receptor Locations

A total of 14 receptor locations were identified in the vicinity of the Project Site – three along the property line of the proposed facility and 11 at nearby residential properties (see **Figure 2** and **Figure 3**). The receptor locations were selected based on their proximity to the Project Site and their land use. These receptor locations represent the most sensitive locations in the immediate area that may experience changes in sound levels once the Project is in operation.

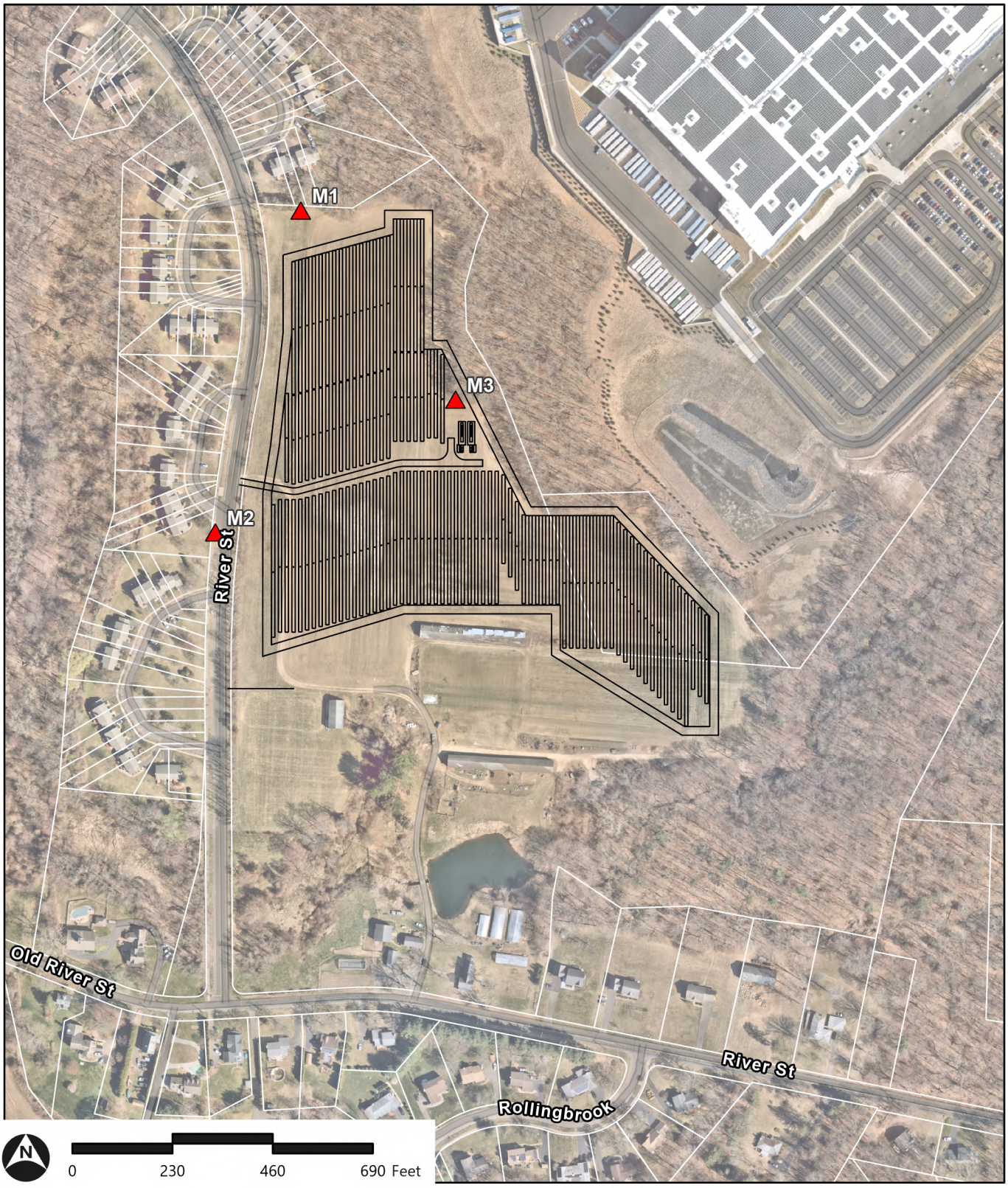

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Figure 1: Noise Monitoring Locations
Windsor Solar 1
Windsor, Connecticut
March 7, 2024

Source: NearMap, and VHB 2024.

Existing Conditions

Sound level measurements were conducted to document existing conditions in the area surrounding the site of the proposed project. The existing sound levels were measured using Type 1 sound analyzers (Larson Davis SoundExpert LxT and 831) at three locations for a 24-hour period that started at approximately 9:00 AM on February 20, 2024 and ended at approximately 10:00 AM on February 21, 2024. During the daytime period, observed sources of sound in the community included traffic on River Street, occasional aircraft overflights, and a distant train. The measured ambient sound level data are presented in **Table 3** as the hourly L10, the hourly Leq, and the hourly L90. As previously noted, the L90 is generally considered to be the background or ambient sound level.

Table 4. Measured Existing Sound Levels, dB(A)

	CT DEEP Noise Standards		Hourly L10 (dBA)		Hourly Leq (dBA)		Ambient Hourly L90 (dBA)	
Monitoring Location[1]	**Day[2]**	**Night[3]**	**Day[2]**	**Night[3]**	**Day[2]**	**Night[3]**	**Day[2]**	**Night[3]**
M1 – north property line	61[4]	51[4]	48-55	42-53	44-52	41-50	33-46	37-47
M2 – west property line	61[4]	51[4]	49-57	43-55	48-53	43-53	34-47	38-49
M3 – east property line	70[5]	70[5]	39-49	41-50	37-50	40-49	34-46	37-46

1 Refer to Figure 1 for monitoring locations.
2 Day is from 7:00 AM to 10:00 PM.
3 Night is from 10:00 PM to 7:00 AM.
4 Noise Zone Standards for Class C emitter (industrial) and Class A receiver (residential)
5 Noise Zone Standards for Class C emitter (industrial) and Class C receiver (industrial)

The hourly L90 sound levels ranged from 33 dB(A) to 47 dB(A) during the daytime period and from 37 dB(A) to 49 dB(A) during the nighttime period. The result of the monitoring program indicates that the daytime and nighttime ambient sound levels within the study area are currently below the CT DEEP's daytime and nighttime standards for industrial emitters and residential receivers.

Future Conditions

Receptor Locations

Eleven receptor locations were identified in the vicinity of the Project Site (see **Figure 2** and **Figure 3**). The receptor locations were selected based on their proximity to the Project Site and their land use. These receptor locations represent the most sensitive locations in the immediate area that may experience changes in sound levels once the Project is in operation.

VHB evaluated the potential sound level impacts associated with the Project's proposed mechanical equipment at the nearby sensitive receptor locations. This

analysis evaluated the potential sound level impacts from the 24 inverters, two transformers, and 110 tracking system motors operating simultaneously.

The potential sound level associated with the proposed equipment were determined by comparing existing and future sound levels to the CT DEEP's noise standards. The existing sound levels were based upon sound level measurements. The sound levels were adjusted based upon distance, properties of sound propagation over terrain, and applicable blockage and obstructions.

The results of the acoustical analysis demonstrated that the operation of the proposed equipment will comply with CT DEEP's noise standards at the sensitive receptor locations. The sound levels attributed to the proposed equipment ranges from approximately 21 dB(A) at Receptor R03 to 47 dB(A) at the east property line. During the daytime period, the residential locations will experience overall sound levels (ambient plus Project contributions) ranging from approximately 33 dB(A) at Receptor R04 to 47 dB(A) at several receptors close to River Street. These sound levels are below CT DEEP's daytime criteria of 61 dB(A). Due to the nature of the Project, the solar equipment will not be operating during the nighttime period. **Table 5** summarizes the sound levels due to the operation of the inverters and transformers at the receptor locations.

Table 5. Daytime Sound Levels at Receptor Locations, dB(A) – Due to Inverters and Transformers

Receptor Locations	CT DEEP Noise Standard Daytime*	Project Generated Sound Levels	Overall Daytime Sound Levels***	Increase above Daytime L90 (dBA)
PL1 – north property line	61	29.1	34-46	0-1
PL2 – east property line	70**	46.8	47-49	3-13
PL3 – west property line	61	31.3	36-47	0-2
R01 – 166/170/174/178 Eastwood Circle	61	29.9	35-46	0-2
R02 – 265 River Street	61	23.2	34-46	0
R03 – Early Dawn Circle – south end	61	20.9	34-47	0
R04 – Early Dawn Circle – midway	61	21.1	33-46	0
R05 – Early Dawn Circle – north end	61	25.1	35-47	0-1
R06 – Sunrise Circle – south end	61	30.5	36-47	0-2
R07 – Sunrise Circle – midway	61	25.3	34-46	0-1
R08 – Sunrise Circle – north end	61	29.6	35-47	0-1
R09 – Brighton Circle – south end	61	31.2	36-47	0-2
R10 – Brighton Circle – midway	61	24.6	34-46	0-1
R11 – Brighton Circle – north end	61	28.1	35-47	0-1

* Noise standard for Class C emitter and Class A receptor, unless otherwise noted.

** Noise standard for Class C emitter and Class C receptor.

*** Overall daytime sound levels are cumulative, combining the project-generated sound levels with daytime ambient sound levels (hourly L90).

Table 6 summarizes the sound levels due to the operation of the inverters and transformers and the tracking motors at the receptor locations.

Table 6. Daytime Sound Levels at Receptor Locations, dB(A) – Due to Inverters and Transformers and Tracking Motors

Receptor Locations	CT DEEP Noise Standard Daytime*	Project Generated Sound Levels	Overall Daytime Sound Levels***	Increase above Daytime L90 (dBA)
PL1 – north property line	61	29.5	35-46	0-2
PL2 – east property line	70**	46.8	47-49	3-13
PL3 – west property line	61	32	36-47	0-2
R01 – 166/170/174/178 Eastwood Circle	61	30.1	35-46	0-2
R02 – 265 River Street	61	23.6	34-46	0
R03 – Early Dawn Circle	61	21.5	34-47	0
R04 – Early Dawn Circle	61	21.7	33-46	0
R05 – Early Dawn Circle	61	25.7	35-47	0-1
R06 – Sunrise Circle	61	30.8	36-47	0-2
R07 – Sunrise Circle	61	26	34-46	0-1
R08 – Sunrise Circle	61	30	35-47	0-1
R09 – Brighton Circle	61	31.5	36-47	0-2
R10 – Brighton Circle	61	25.1	34-46	0-1
R11 – Brighton Circle	61	28.3	35-47	0-1

* Noise standard for Class C emitter and Class A receptor, unless otherwise noted.

** Noise standard for Class C emitter and Class C receptor.

*** Overall daytime sound levels are cumulative, combining the project-generated sound levels with daytime ambient sound levels (hourly L90).

Figure 2 presents sound level contours (i.e., lines of equal sound level that are analogous to topographic contours that are lines of equal ground elevation) for the operation of the inverters and transformers during daytime hours. The sound level contours in **Figure 2** excludes contributions from off-site sources of sound. Likewise, **Figure 3** presents sound level contours for the operation of the inverters and transformers plus the tracking motors during daytime hours. The sound level contours in **Figure 3** excludes contributions from off-site sources of sound.

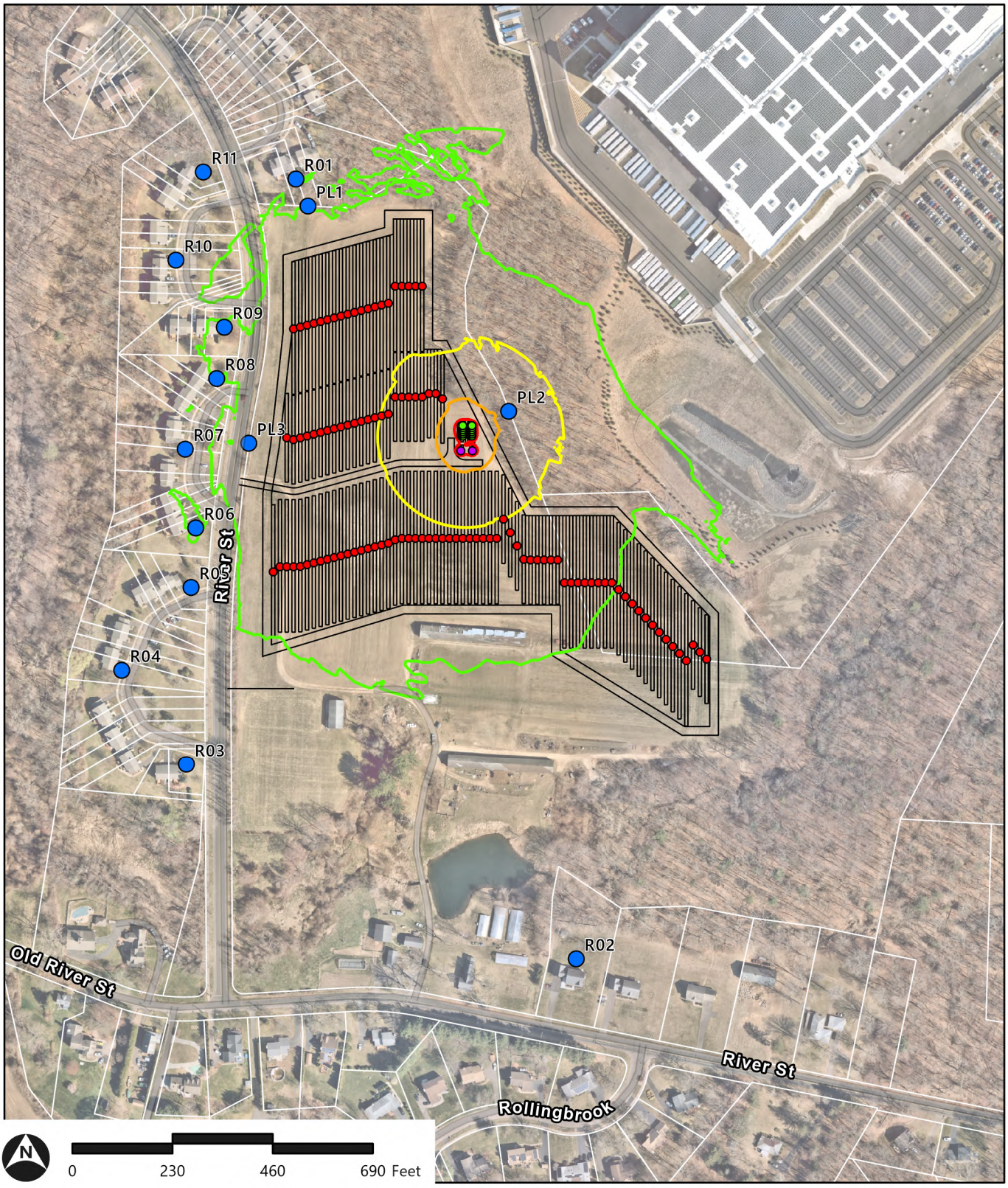

Figure 2: Modeled Daytime Sound Level Contours with Transformers and Inverters
Windsor Solar 1
Windsor, Connecticut
March 7, 2024

Source: NearMap, and VHB 2024.

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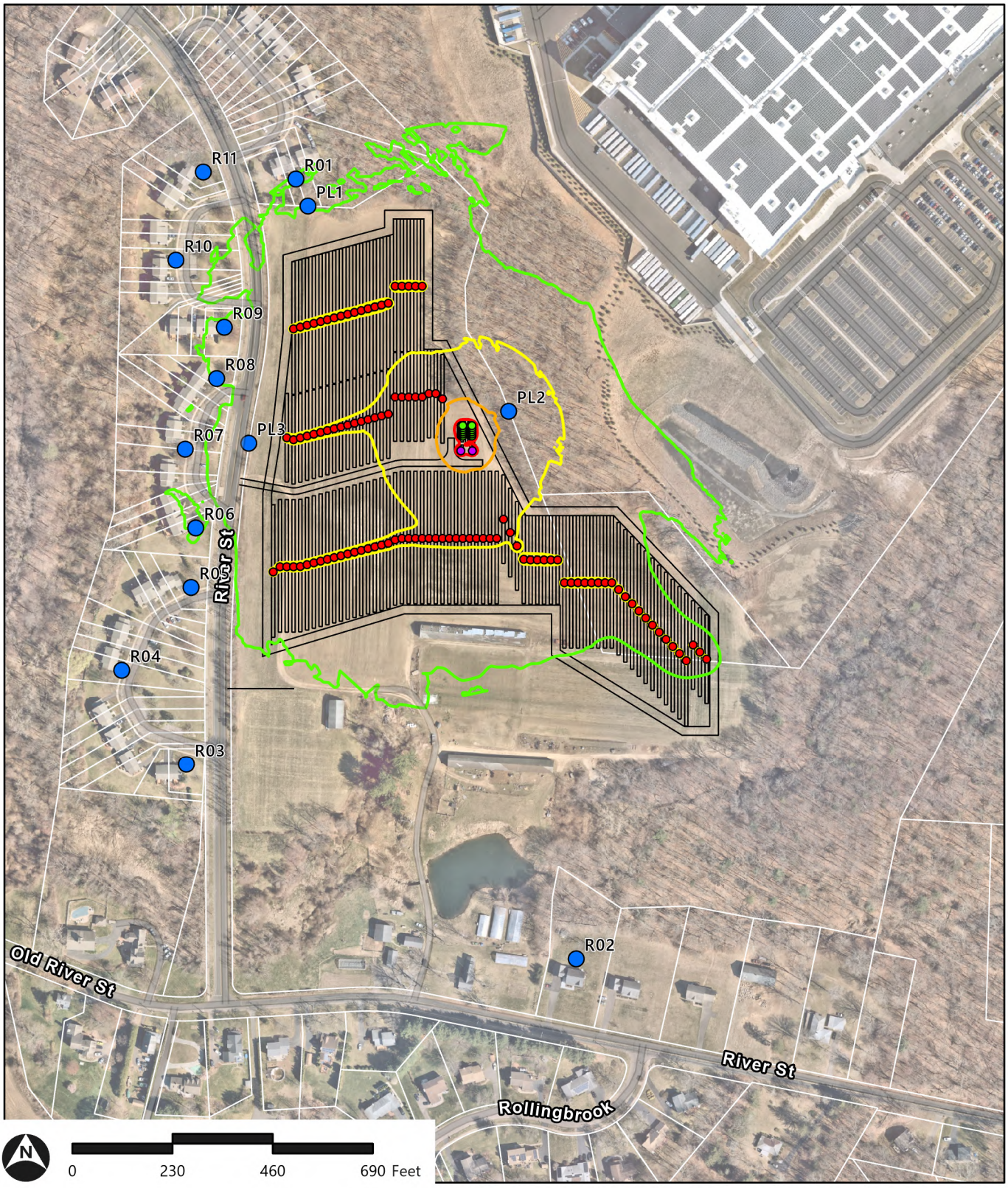

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Figure 3: Modeled Daytime Sound Level Contours with Transformers, Inverters, and Tracking Motors
Windsor Solar 1
Windsor, Connecticut
March 7, 2024

Source: NearMap, and VHB 2024.

3

Findings

Conclusion of Acoustical Assessment

In this acoustical analysis, VHB evaluated the sound levels associated with the Project's mechanical equipment which includes 24 inverters, two transformers, and 110 tracking system motors. This analysis determined that the properties abutting the Project Site currently experience sound levels below CT DEEP's daytime noise standards.

Due to the low noise equipment and siting of the proposed equipment central to the Project Site, the sound levels associated with the Project's mechanical equipment are expected to comply with CT DEEP's noise standards and have no adverse noise impacts at nearby sensitive receptor locations.

Construction Activities

Construction activities, including the intermittent use of heavy machinery, may result in temporary increases in nearby sound levels at the proposed Project. The Project is expected to generate typical sound levels from construction activities, including truck movements, heavy equipment operations, and general construction activities. Heavy machinery, such as front-end loaders, graders, bull dozers, and backhoes, would be used intermittently throughout the proposed Project's construction.

Section 22a-69-1.8(g) of the CT DEEP's noise control regulation states that noise associated with construction activities are exempt from the regulation. However, even though construction noise is exempt from the regulation, construction activities such as site excavation/grading and installation of the solar panel systems would typically be limited to normal daytime working hours. Construction activities beyond normal daytime work hours would be minimized to the extent practicable.

If noise concerns arise during construction, Windsor Solar One will evaluate and implement appropriate noise abatement measures to reduce or minimize noise from the construction activities. Windsor Solar One plans to coordinate closely with the Town during construction. Construction vehicles and equipment would be required to maintain their original engine noise control equipment. Specific mitigation measures may include, but not limited to, the following:

- Implement appropriate traffic management techniques during the construction period to minimize roadway traffic noise impact;
- Implement procedures for proper operation and maintenance, and prohibition of excessive idling of construction equipment engines;
- Adjust construction activity timing to reduce impact of noise at certain times of day.

ATTACHMENT A
Additional Details from the Ambient Sound Level Measurements

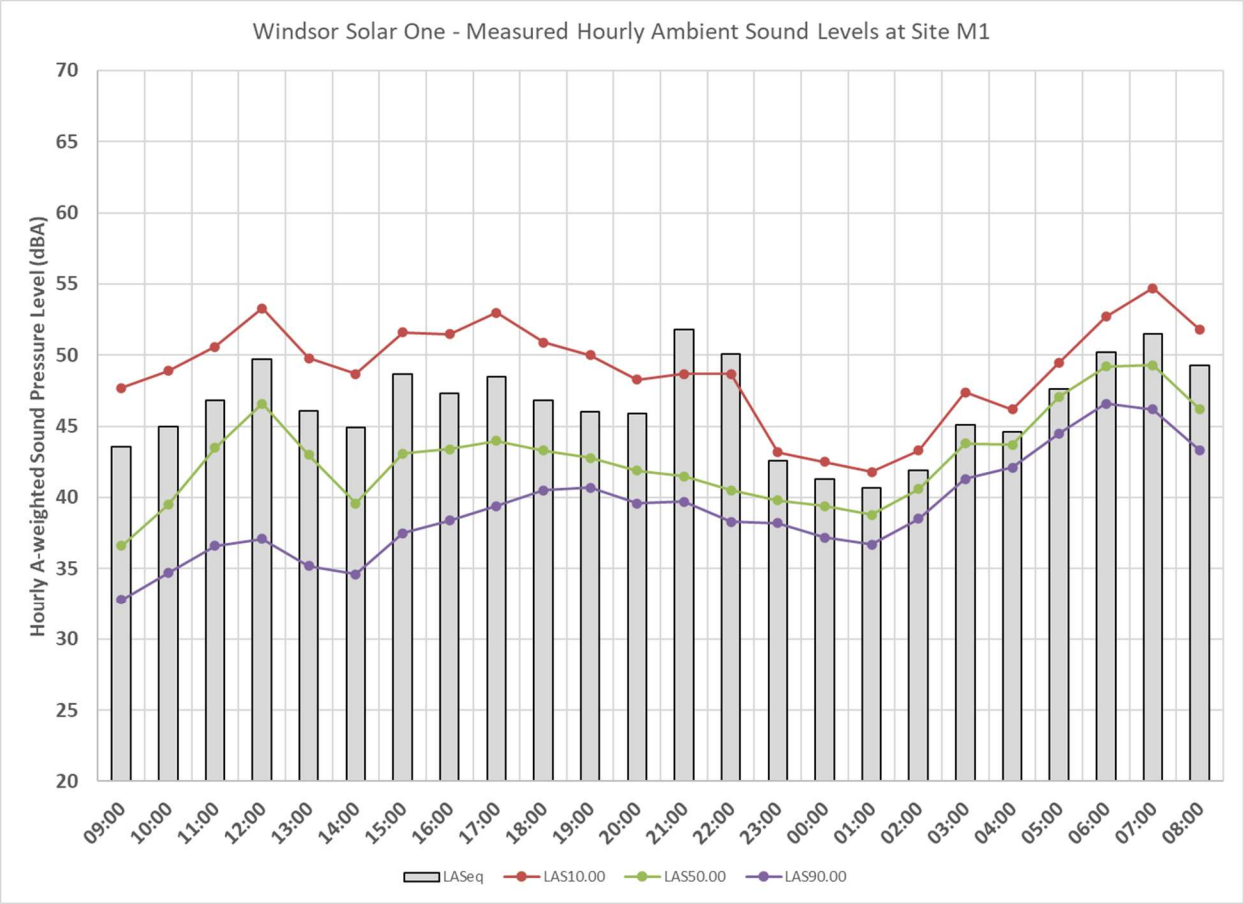


Figure A-1 Measured hourly ambient sound levels at Site M1 along the north property line

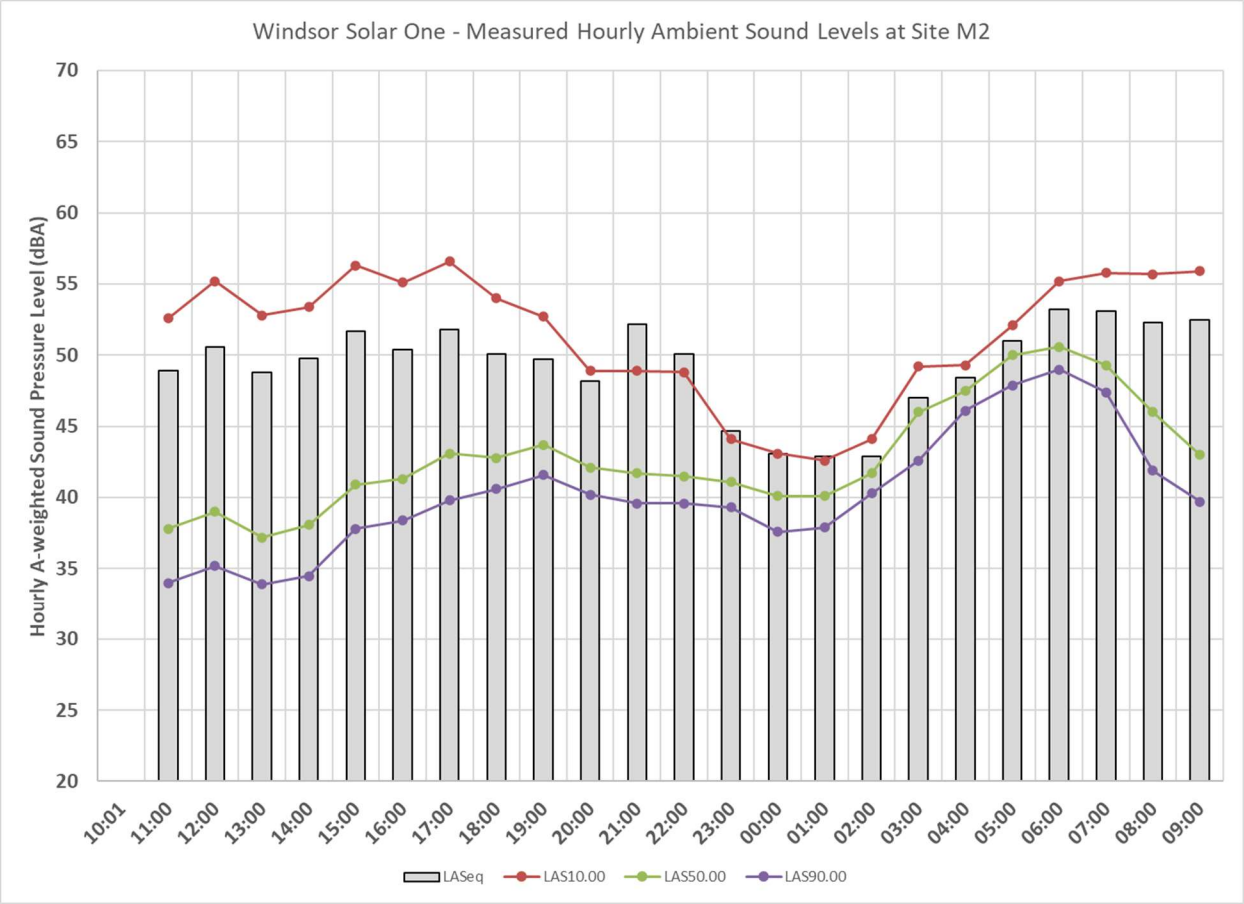


Figure A-2. Measured hourly ambient sound levels at Site M2 along the west property line

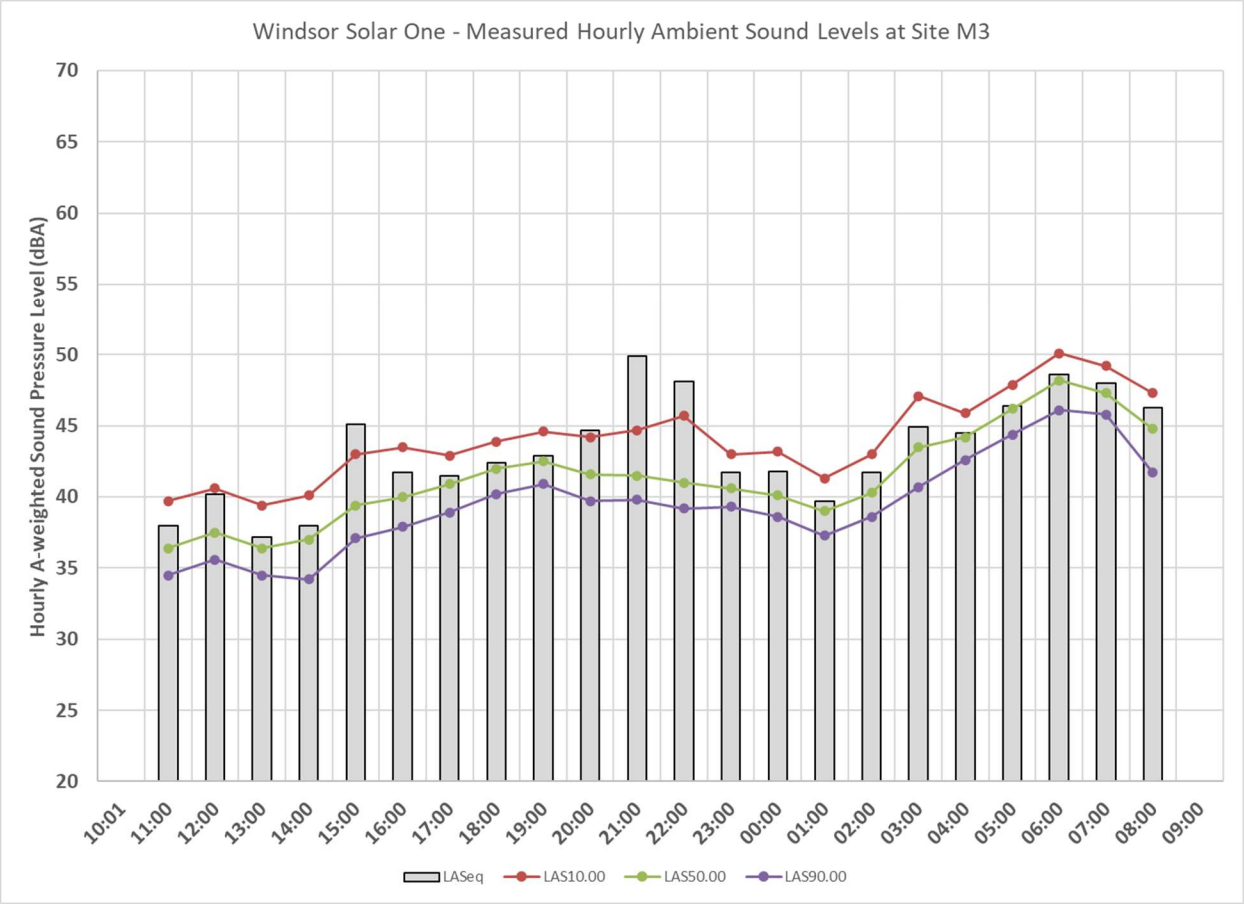


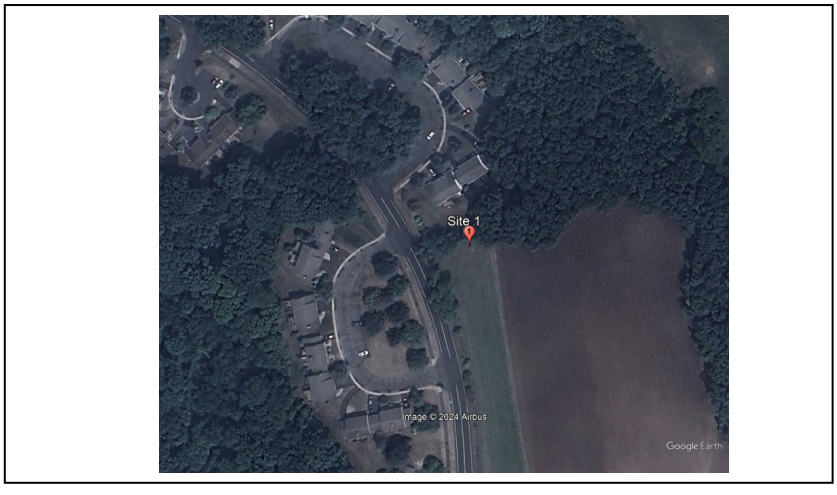
Figure A-3. Measured hourly ambient sound levels at Site M3 along the east property line.

Long-term Study Noise Measurement

Project Number: 43322.00	Date: February 21, 2024 10:23 AM
Project Name: Verogy Windsor 3MW Solar Farm	Personnel: Chris Bajdek
Lat/Long: 41.9024346 | -72.66470731	Noise Meter ID: LXTA S/N: 3707
Site: Site M1 north property line	Data File: 002

Plan View:

Aerial View:



Long-term Study Noise Measurement

Pre-Cal (Variance, dB): -0.11	Temperature (F): 29.37
Post-Cal (Variance, dB): 0.08	Wind Speed (mph): 4.61
Overall Leq: 47.8	Wind Direction: 4.61
Measurement Start Time:	Precipitation: No

Notes:
Verogy Solar site 1 retrieval
Aircraft departure from the north with a southwest heading
Distant freight train to the south with a horn

Long-term Study Noise Measurement

Photo 1-1: Measurement 1 Facing North

Photo 1-2: Measurement 1 Facing East

Photo 1-3: Measurement 1 Facing West

Photo 1-4: Measurement 1 Facing South

Long-term Study Noise Measurement

Project Number: 43322.00	Date: February 20, 2024 11:17 AM
Project Name: Verogy Windsor 3MW Solar Farm	Personnel: Chris Bajdek
Lat/Long: 41.9007491 | -72.66483383	Noise Meter ID: LXTC S/N: 5472
Site: Site M2	Data File: 022

Plan View:

Street View:

Long-term Study Noise Measurement

Pre-Cal (Variance, dB): -0.02	Temperature (F): 28.56
Post-Cal (Variance, dB):	Wind Speed (mph): 3.44
Overall Leq:	Wind Direction: 3.44
Measurement Start Time: 10:20	Precipitation: No

Notes:
Verogy Solar Site 2 near west property line.

Photo 2-1: Measurement 2 Facing East

Photo 2-2: Measurement 2 Facing West

Photo 2-3: Measurement 2 Secured Monitor

Photo 2-4: Measurement 2 Facing South

Photo 2-5: Measurement 2 Facing North

Long-term Study Noise Measurement

Project Number: 43322.00	Date: February 20, 2024 11:29 AM
Project Name: Verogy Windsor 3MW Solar Farm	Personnel: Chris Bajdek
Lat/Long: 41.90119775 | -72.66329344	Noise Meter ID: LXTD S/N: 5473
Site: Windsor	Data File: 004

Plan View:

Street View:

Long-term Study Noise Measurement

Pre-Cal (Variance, dB): 0.16	Temperature (F): 28.96
Post-Cal (Variance, dB):	Wind Speed (mph): 3.44
Overall Leq:	Wind Direction: 3.44
Measurement Start Time: 10:00	Precipitation: No

Notes:
Verogy Solar Windsor CT Site 3

Photo 3-1: Measurement 3 Facing Southwest

Photo 3-2: Measurement 3 Facing West

Photo 3-3: Measurement 3 Facing Southeast

Photo 3-4: Measurement 3 Facing Northeast, Amazon Behind Trees

Photo 3-5: Measurement 3 Secured Monitor