SS-CB-2

Memorandum

To: VT Real Estate Holdings 1 LLC - Shaftsbury Solar Project File

Date: May 3, 2023

Project #: 58071.13

From: Chris Bajdek, Director of Noise
Rebecca Shedd, EIT, Noise Analyst

Re: Shaftsbury Solar Project Sound Study

Introduction

At the request of Petitioner VT Real Estate Holdings 1 LLC (to be referred to as "Shaftsbury Solar"), VHB has prepared this technical memorandum concerning the proposed Shaftsbury Solar Project ("SSP" or "Project"), a solar electric generation facility that will occupy approximately 83 acres on several parcels of land totaling approximately 182 acres. The Project site is located off Holy Smoke Road in Shaftsbury, Vermont. VHB conducted a sound study on behalf of Shaftsbury Solar.

When operating, the proposed Project would introduce new sources of sound including eight (8) 3,067 kW power inverters and eight (8) 3,067 kVA transformers to be located throughout the PV array, and one (1) main power transformer rated at 27,000 kVA to be located at the interconnection facility at the site. See **Figure 1 (Attachment B**). This study evaluates whether the proposed Project would result in undue adverse sound conditions as part of the Vermont Public Utility Commission's ("PUC") Section 248 review. The memorandum presents the methodology used to evaluate sound from the proposed Project, sound emission assumptions for the proposed Project, sound prediction results, an assessment of results, and conclusions. VHB relied on Project information provided by the Petitioner and the Project Site Plan attached here as **Attachment D**.

Project Description

The Project involves a 20 MW photovoltaic ("PV") solar array and associated interconnection facilities, which will include a Project substation and a substation to be operated by Green Mountain Power ("GMP"). The interconnection facilities will be colocated at the site, with the Project substation containing a 27,000 kVA transformer and the GMP substation containing a 46 kV three-breaker ring bus. This sound study details the predicted sound levels under simultaneous full operation of all noise emitting equipment during the daytime. Due to the nature of a solar array, the inverters would not operate during the nighttime; as such, the nighttime condition details the predicted sound levels under simultaneous full operation of eight 3,067 kVA transformers and one 27,000 kVA transformer.

Methodology

The methodology used to assess the effects of sound from the operation of the Project includes identifying noise-sensitive receptors in the vicinity of the Project (e.g., residences), predicting future sound emissions from the operation of the Project under full load and fans on condition ("ONAF"), and assessing the potential for undue sound conditions. See **Attachment A** for an explanation of sound level concepts.

The proposed Project at its completion would generate sound from the power inverters and transformers located throughout the array and from the transformer located at the Project substation. Operational sound from the Project has been predicted using Cadna-A sound prediction software, which is an internationally accepted sound prediction program that implements the International Standards Organization ("ISO") 9613-2 "Outdoor Sound Propagation" standard. The Cadna-A model takes into account the sound emissions of equipment, ground cover, terrain, and

Memorandum

intervening objects such as buildings. The ground cover has been assumed to have an absorption coefficient (G) of 0.5 to represent moderately hard ground. No sound attenuation was assumed for trees or foliage. The modeling also excluded the excess attenuation provided by project-related landscape berms, adding a level of conservatism to the computed sound levels. The ISO standard conservatively assumes there are moderate downwind conditions where the wind would blow from the source to each receptor location.

In order to model a transformer as a source of sound, a sound power level must be assigned in Cadna-A. Sound power levels are calculated using the specified sound pressure level, the height of the transformer and the path length of a specified perimeter around transformer[1]. The standard for a large transformer utilizes the following equation:

$$L_W = L_{p,spec} + 10\log_{10} S \quad [Equation\ 1]$$

Where S is an imaginary surface surrounding the transformer with surface area:

$$\mathrm{S} = 1.25 * \mathrm{Dp} * \mathrm{H} \quad [Equation\ 2]$$

D_p is the specified perimeter in meters and H is the height of the transformer in meters.

To determine the sound power level of the transformers [Equation 1 above], their physical size is required. The size of the proposed 3,067 kVA transformer was estimated to be 2.1 meters ("m") wide, 1.9 m deep and 1.9 m high. The estimated size of the 27,000 kVA transformer was estimated to be 3.0 m wide, 2.6 m deep and 2.2 m high. A sound spectrum was developed for the transformers using the Typical Transformer Spectrum for an A-weighted Sound Power Level of 86.1 dBA from the *Handbook of Acoustical Measurements and Noise Control*[2]. This spectrum was adjusted to be representative of the sound power level calculated in Equation 1. It was further assumed that the interconnection facility would meet NEMA TR1 sound performance ratings less 12 dBA as specified by the VA Transformer.[3] **Table 1** summarizes the sound level emissions inputs for the Project.

Table 1 – Equipment Sound Level Emissions Summary

Equipment ID	Total Quantity	Overall dBA	Sound Power Level (dBA) by Octave Band Center Frequency (Hz)							
			63.5	125	250	500	1000	2000	4000	8000
PV Array										
3,067 kW Power Inverter*	8	72.7	42.4	53.6	60.3	65.6	64.0	62.5	68.5	63.6
3,067 kVA Transformer	8	78.7	17.6	28.0	60.9	72.1	77.2	65.8	57.9	45.6
Interconnection Facility										
27,000 kVA Transformer	1	83.9	40.2	46.2	70.4	78.7	83.5	76.6	68.9	61.7
* TMEIC Power Inverter from Juwi Palmer Solar and Williams Creek Substation Noise Impact Study, 2017. The shape of the spectrum is based on a Sunny Central 4600 kVA, 1350 vDC U0N inverter.										

Sound Level Predictions

Sound levels were predicted at the nearest residential buildings. The closest residential building (907 Holy Smoke Road) is located approximately 460 feet (+/-) north of some of the proposed equipment. Sound from the equipment

[1] IEEE C57.12.90-2010

[2] Cyril M. Harris (ed.), Handbook of Acoustical Measurements and Noise Control, Third Edition, McGraw-Hill Inc., Figure 35-1, p. 35.2, 1991.

[3] Virginia Transformer "Liquid Filled Transformers Load Tap Changing Transformers Three-Phase Voltage Regulators"

Memorandum

has been predicted at the nearest receptors (1.5 m above ground) utilizing the Cadna-A sound prediction software. Daytime sounds levels were predicted based on simultaneous full operation of all noise-emitting equipment on the site. Nighttime sound levels were predicted based on simultaneous full operation of the eight 3,067 kVA and one 27,000 kVA transformers on the site.

The daytime maximum predicted sound level from the Project would be 23.8 dBA at R2 (907 Holy Smoke Road). The nighttime maximum predicted sound level would be 23.6 dBA at R2. Based on the predicted sound levels for both the daytime and nighttime, no tonal conditions are anticipated.

Table 2 presents the sound level results associated with the PV solar array and interconnection facility. **Figure 1 (Attachment B)** shows the proposed equipment locations and daytime sound level contours. **Figure 2 (Attachment C)** shows the proposed equipment locations and nighttime sound level contours.

Table 2 – Predicted Sound Levels for PV Solar Array and Petitioner Interconnection Facility

Receptor	Daytime Project Generated Sound Level, dBA	Nighttime Project Generated Sound Level, dBA
R1 - 708 HOLY SMOKE ROAD	19.3	18.9
R2 - 907 HOLY SMOKE ROAD	23.8	23.6
R3 - 1035 HOLY SMOKE ROAD	23.0	20.3
R4 - 2390 EAST ROAD	10.9	10.8
R5 - 2351 EAST ROAD	13.9	13.9
R6 - 2269 EAST ROAD	10.9	10.9
R7 - 2155 EAST ROAD	14.3	14.2
R8 - 2063 EAST ROAD	6.7	6.6
R9 - 2017 EAST ROAD	4.6	4.4
R10 - 1981 EAST ROAD	4.2	3.9
R11 - 1929 EAST ROAD	5.3	4.9
R12 - 1847 EAST ROAD	5.5	5.1
R13 - 1779 EAST ROAD	4.1	3.7
R14 - 1757 EAST ROAD	6.5	6.1
R15 - 280 ROD & GUN CLUB ROAD	9.8	9.4
R16 - 684 ROD & GUN CLUB ROAD	7.6	7.3

Noise-Related Guidelines

The following noise guidelines provide guidance on how the Project's sound levels should be assessed, although we note that they are not regulatory requirements that directly apply to the Project.

World Health Organization Guidelines

The World Health Organization ("WHO") issued "Night Noise Guidelines for Europe",[4] which are generally considered to be one of the most stringent set of guidelines for nighttime sound levels. Based on research of nighttime noise effects, WHO recommends a target outdoor night noise guideline (NNG) level of 40 dBA

[4] "Night Noise Guidelines for Europe". World Health Organization, Europe. © World Health Organization 2009.

(Leq[8hr]) to protect the public, including the most vulnerable groups such as children, the chronically ill, and the elderly. This noise guideline is applied outside residential buildings.

U.S. EPA Guidance

The U.S. Environmental Protection Agency ("EPA") conducted a study on noise impacts relative to public health and safety[5] which provides guidance on the potential effects of noise that can be considered by federal, state, and local agencies. The EPA study concluded that a day-night average sound level of 55 dBA (Ldn) or less for outdoor residential areas, or 55 dBA (Leq[24]) or less for outdoor areas where people spend limited amounts of time, such as schools and playgrounds, would protect public health and welfare in regard to potential interference with outdoor activity and annoyance.

American National Standards Institute Noise Standard

The American National Standards Institute ("ANSI") Standard S12.9 Parts 4 and 5 (2017), "American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound – Part 4: Noise Assessment and Prediction of Long-term Community Response" and "Part 5: Sound Level Descriptors for Determination of Compatible Land Use" specify methods to assess environmental sounds and predict potential annoyance responses of a residential community to long-term outdoor noise. This is a general noise guideline that is often used to evaluate noise from energy facilities. The ANSI sound standard accounts for the characteristics of the sound, such as tonality, onset rate, impulsivity, time of day, and day of week. A 5-dB penalty is applied to sounds that are tonal, as they have a greater potential to cause annoyance, and a 10-dB penalty is applied for sound that is generated at night. The ANSI standard recommends an exterior nighttime noise limit of 40 dBA (Leq) applied outside residential buildings.

Town of Shaftsbury

The Town of Shaftsbury's Zoning Bylaws and Land Use Regulations (2017) Chapter 3.4 Conditional Use Regulations articulate performance standards related to noise. The Bylaws state that noise generated at a site should not exceed 70 dBA (Leq[1hr]) at the property line in a Rural and Village zones and 75 dBA (Leq[1hr]) at the property line in all other zones. We are informed that by law, local zoning requirements do not apply to section 248 energy projects.

The ANSI standard for exterior nighttime noise of 40 dBA (Leq) for residential buildings was conservatively used to evaluate the potential for sound impacts from the Project under both daytime and nighttime conditions.

Conclusion

The closest residential building (907 Holy Smoke Road) is located 460 feet (+/-) north of the proposed equipment. Future sound levels of the proposed Project under the full build condition of the PV solar array and interconnection facility by the Petitioner and GMP were modeled using Cadna-A sound prediction software. The estimated Project-generated sound levels at the closest sensitive receptor (R2) is 24.0 dBA (daytime) and 23.6 dBA (nighttime). These sound levels would be considered in the low range of audibility, and are comparable to daytime and nighttime sound

[5] "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety." U.S. Environmental Protection Agency. EPA 550/9-74-004. March 1974.

Memorandum

levels in quiet rural areas (See Attachment 1, Figure A1). In addition, the estimated sound levels would be lower than the ANSI Noise Guidelines as well as the other noise guidelines referenced above. As a result, the proposed Project would not cause undue adverse sound conditions.

Attachments:

A. Sound Level Concepts and Figure A1

B. Figure 1: Daytime Sound Level Contours

C. Figure 2: Nighttime Sound Level Contours

D. Project Site Plan

Memorandum

Attachment A: Sound Level Concepts

Sound is the rapid fluctuations of air pressure above and below ambient pressure levels. Noise is defined as unwanted or excessive sound. Sound becomes unwanted when it interferes with normal activities such as sleep, work, communication or recreation. How people perceive sound depends on several measurable physical characteristics including:

Sound Level - Sound level is based on the amplitude change in pressure and is related to the loudness or intensity. Human hearing covers a wide range of changes in sound pressure amplitude. Therefore, sound levels are most often measured on a logarithmic scale of decibels (dB) relative to 20 micro-pascals. The decibel scale compresses the audible range of acoustic pressure levels, which can vary from the threshold of hearing (0 dB) to the threshold of pain (120 dB). Because sound levels are measured in dB, the addition of two sound levels is not linear. For example, adding two equal sound levels results in a 3 dB increase in the overall level. Research indicates the general relationships between sound level and human perception are as follows:

- A 3-dB increase is a doubling of acoustic energy and is approximately the smallest difference in sound level that can be perceived in most environments.
- A 10-dB increase is a tenfold increase in acoustic energy and is generally perceived as a doubling in loudness to the average person.

Frequency - Sounds are comprised of acoustic energy distributed over a range of frequencies. Acoustic frequencies, commonly referred to as tone or pitch, are typically measured in Hertz. Human hearing generally ranges from 20 to 20,000 Hz; however, 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-weighting is commonly used to evaluate environmental noise levels and sound levels are denoted as "dBA".

- Sound levels reported in octave or one-third-octave frequency bands are often used to describe the frequency content of different sounds. Some sources of sound can generate "pure tones" which is when there is a concentration of sound within a narrow frequency range such as a whistle. Humans can hear pure tones very well and such conditions can be a cause of increased annoyance.

A variety of sound level descriptors can be used for environmental noise analyses. These descriptors relate to the way sound varies in level over time. The following is a list of common sound level descriptors:

- **Statistical Sound Levels** – Sound level metrics, such as L_{10}, L_{50} or L_{90}, represent the levels that are exceeded for a particular percentage of time over a given period. For example, L_{10} is the level that is exceeded for 10 percent of the time. Therefore, it represents the higher end of the range of sound levels. The L_{90}, on the other hand, is the level that is exceeded 90 percent of the time, and therefore, is representative of the background sound level and of constant sources of sound that are present.
- **Equivalent Sound Level (Leq)** - Leq is a single value, which represents the same acoustic energy as the fluctuating levels that exists over a given period of time. The Leq takes into account how loud noise events are during the period, how long they last, and how many times they occur. Leq is commonly used to describe environmental noise and relates well to human annoyance.
- **Day-night Average Sound Level (Ldn)** - Ldn is similar to the Leq in that it is a single value, which represents the same acoustic energy as the fluctuating levels, that exists over a 24-hour period. The Ldn takes into account how loud sound events are, how long they last, how many times they occur over a 24-hour period, and whether they occur during the day (7:00 AM to 10:00 PM) or night (10:00 PM to 7:00 AM). Sound that occurs during the night is given a 10-dB penalty to account for the increased human sensitivity to noise at night. If sound levels are constant over a 24-hour period, the Ldn level is 6.4 dB greater than the Leq level due to the 10-dB nighttime penalty.
- **Maximum Sound Level (Lmax)** – Many sources of sound, including mobile sources and stationary sources, change over time. It is common to describe sound in terms of the maximum (Lmax) sound level emissions. The following figure presents a list of the maximum sound levels of common outdoor and indoor sources.

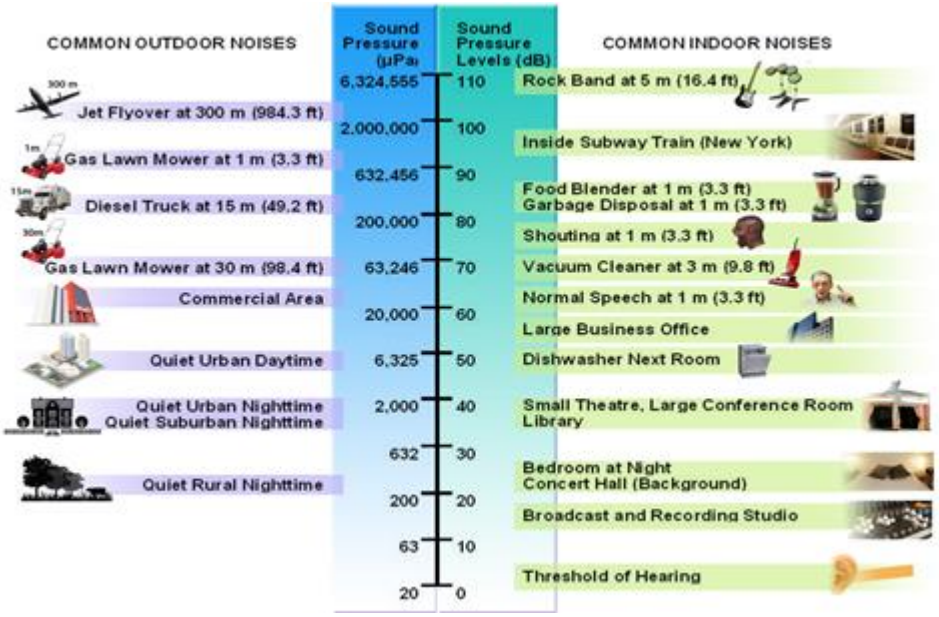


Figure A1: Common Outdoor and Indoor Noises

Source: FHWA, 2018.

Attachment B: Daytime Sound Level Contours

Engineers | Scientists | Planners | Designers
101 Walnut Street, PO Box 9151, Watertown, Massachusetts 02471
P 617.924.1770 **F** 617.924.2286 www.vhb.com

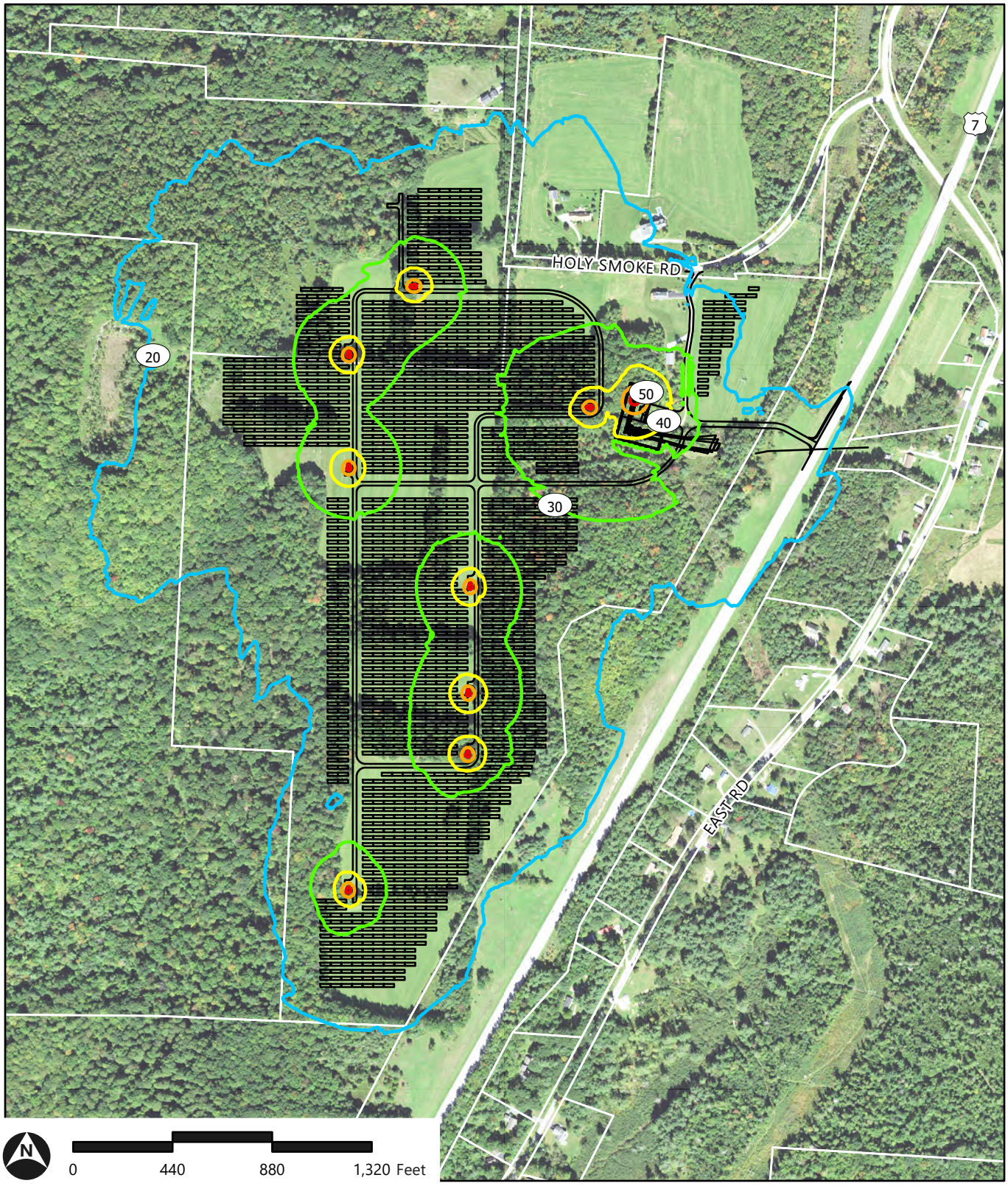


Figure 1: Modelled Daytime Sound Level Contours
Shaftsbury Solar Project
Shaftsbury, Vermont
May 3, 2023

Source: Vermont Geodata Portal, NearMap, and VHB 2023.

Attachment C: Nighttime Sound Level Contours

Engineers | Scientists | Planners | Designers
101 Walnut Street, PO Box 9151, Watertown, Massachusetts 02471
P 617.924.1770 **F** 617.924.2286 www.vhb.com

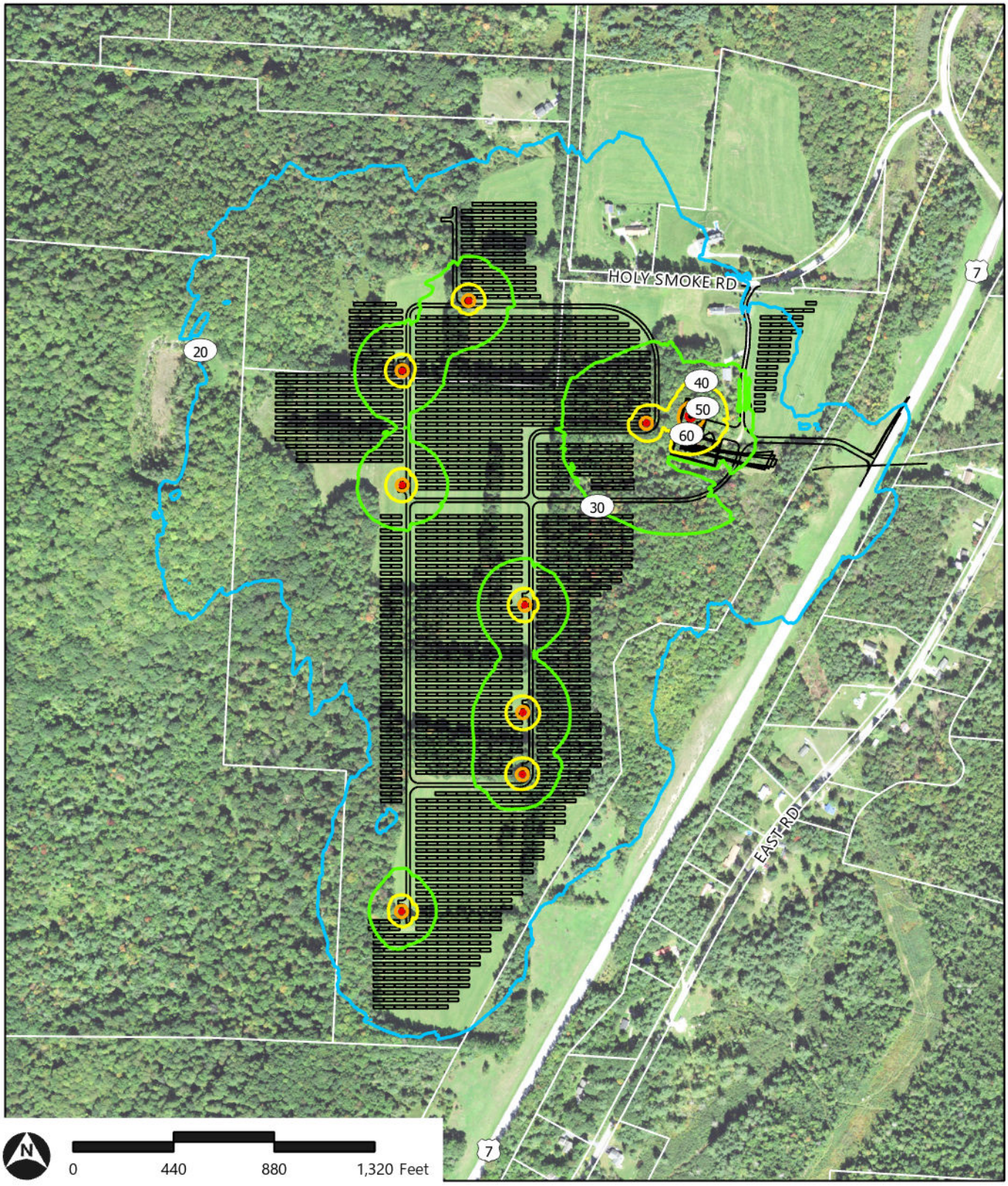


Figure 2: Modelled Nighttime Sound Level Contours
Shaftsbury Solar Project
Shaftsbury, Vermont
May 1, 2023

Source: Vermont Geodata Portal, NearMap, and VHB 2023.

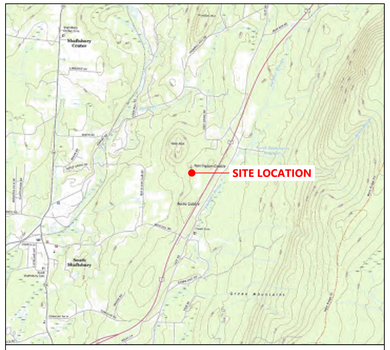
Attachment D: Project Site Plan

Engineers | Scientists | Planners | Designers
101 Walnut Street, PO Box 9151, Watertown, Massachusetts 02471
P 617.924.1770 **F** 617.924.2286 www.vhb.com

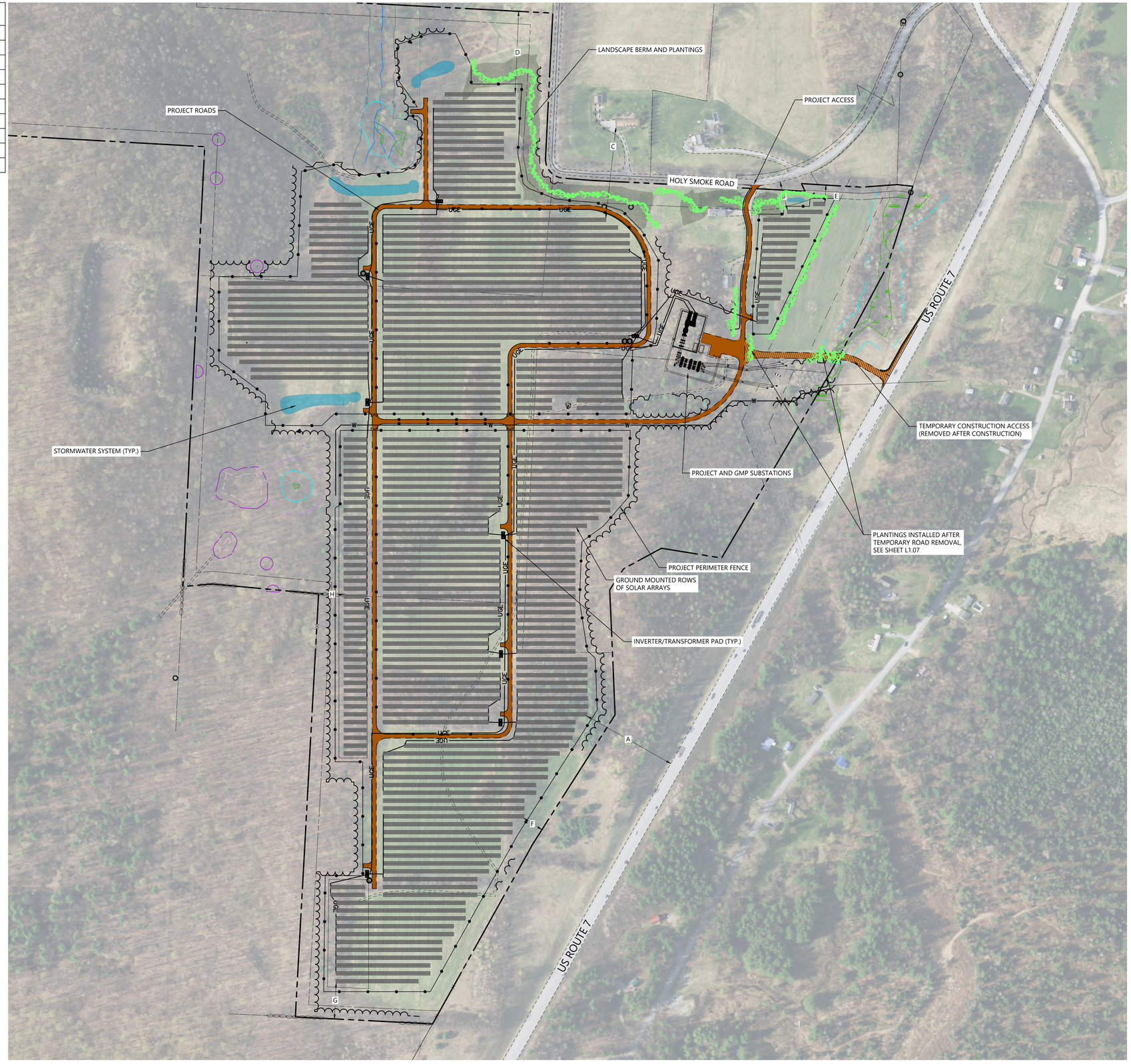
Distance Table

A	Approximate distance to roadway (Route 7)	±382'
B	Approximate distance to roadway (Holy Smoke Rd.)	±115'
C	Approximate distance to residence	±360'
D	Approximate distance to property line (North 1)	±323'
E	Approximate distance to property line (North 2)	±68'
F	Approximate distance to property line (East)	±86'
G	Approximate distance to property line (South)	±142'
H	Approximate distance to property line (West)	±100'

Note: All distances measured to the closest portion of the solar array.



0 2500 5000 10000 Feet



0 100 200 400Feet

Legend

- EXISTING MINOR CONTOUR
- EXISTING MAJOR CONTOUR
- EXISTING DELINEATED WETLAND
- EXISTING DELINEATED STREAM
- EXISTING 50' WETLAND BUFFER
- EXISTING 50' RIPARIAN BUFFER
- EXISTING RTE SPECIES AREA
- EXISTING 50' RTE SPECIES BUFFER
- EXISTING VERNAL POOL BUFFER
- EXISTING TREELINE
- EXISTING PROPERTY LINE
- EXISTING PROPERTY LINE SETBACK LINE
- EXISTING ABUTTING PROPERTY LINE
- EXISTING OVERHEAD WIRE EASEMENT
- EXISTING GRAVEL ROAD
- EXISTING EDGE OF PAVEMENT
- EXISTING STONE WALL
- EXISTING PATH
- PROPOSED GRAVEL ROAD
- PROPOSED EDGE OF PAVEMENT
- PROPOSED PATH
- PERIMETER FENCE
- PROPOSED WATER LINE EASEMENT
- PROPOSED TEMPORARY CONSTRUCTION EASEMENT
- PROPOSED DETENTION BASIN
- PROPOSED TREELINE

vhb.com

vhb

40 IDX Dr
Building 100 Suite 200
South Burlington, VT 05403
802.497.6100

Shaftsbury Solar
VT Real Estate Holdings 1 LLC

1004 Holy Smoke Road
Shaftsbury, VT 05262

No.	Revision	Date	Appvd.

Designed by ZJD | Checked by SMW

Issued for: **Permitting** | Date: May 1, 2023

Not Approved for Construction

Drawing Title
Contextual Site Plan

Drawing Number
C1

Sheet 1 of 1

Project Number
58071.01