CALVERTON SOLAR ENERGY CENTER PROJECT

ACOUSTIC ASSESSMENT

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ACRONYMS AND ABBREVIATIONS

Applicant	LI Solar Generation, LLC
CadnaA	Computer-Aided Noise Abatement Program
dB	decibel
dBA	A-weighted decibel
dBL	linear decibel
Hz	Hertz
ISO	International Organization for Standardization
L_{eq}	equivalent sound level
L_{max}	maximum instantaneous sound level
L_n	statistical sound level
L_p	sound pressure levels
L_W	sound power level
m	meter
LIPA	Long Island Power Authority
mph	miles per hour
MVA	megavolt ampere
MW	megawatt
NEMA	National Electrical Manufacturers Association
PSEG-LI	Public Service Electric and Gas Long Island
μPa	microPascals
Project	Calverton Solar Energy Center
PV	photovoltaic
Tetra Tech	Tetra Tech, Inc.
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
W	watt

1.0 INTRODUCTION

LI Solar Generation, LLC (Applicant) is proposing to build and operate the Calverton Solar Energy Center (Project) in the hamlet of Calverton in the Town of Riverhead, Suffolk County, New York. The Calverton Solar Energy Center was a selected project for Public Service Electric and Gas Long Island's (PSEG-LI) 2015 Renewable Request for Proposal (2015 Renewable RFP) issued on December 22, 2015 to increase the renewable energy capacity and generation on Long Island. The Project will consist of a 22.9 megawatt (MW) solar energy center.

This report presents the acoustic assessment for the Project, first identifying the applicable noise regulations. In addition, existing land uses that are sensitive to noise were reviewed, consisting of residences located within the Project study area. Potential operational noise impacts were evaluated and compliance was assessed relative to the noise regulations.

1.1 PROJECT DESCRIPTION

The Project will encompass a total of 55 acres on the eastern parcel and 71 acres on the western parcel. The Project will utilize photovoltaic (PV) modules to convert sunlight directly into electrical energy. In addition to the PV modules, the Project will include the following associated facilities:

- Module mounting system.
- Centralized inverter stations – The centralized inverter stations and their corresponding transformer will be delivered to the site on a pre-manufactured skid. These skids will be installed over their secondary transformer oil containment system.
- AC electric collector lines - The centralized inverter stations will be connected to the Project 115kV step up transformer via new underground AC electric lines.
- New Project 115kV Step Up Transformer and Interconnection - The new 115kV step up transformer, controls, collection substation yard, fence, and the new 115kV electric lines connecting to the Long Island Power Authority (LIPA) substation will be constructed in close coordination with LIPA. The objective is to have the interconnection to the LIPA substation ready when the remainder of the Project is complete.

The inverters and transformers represent the only anticipated onsite sound sources and will be included in the acoustic modeling analysis. Details regarding modeling methodology and inputs will be described further, below.

1.2 ACOUSTIC TERMINOLOGY

All sounds originate with a source, whether it is a human voice, motor vehicles on a roadway, or in-home sources such as vacuums, lawn mowers and kitchen appliances. A sound source is defined by a sound power level (abbreviated "L_W"), which is independent of any external factors. Sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts.

A source sound power level cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source outside the acoustic and geometric near-field. A sound pressure level (abbreviated "L_P") is a measure of the sound wave fluctuation at a given receiver location, and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. The sound pressure level in decibels (dB) is the logarithm of the ratio of the sound pressure of the source to the reference sound pressure of 20 microPascals (μPa), multiplied by 20.[1] The range of sound pressures that can be detected by a person with normal hearing is very wide, ranging from about 0 dBA (or 20 μPa) for very faint sounds at the threshold of hearing, to nearly 120 dBA (or 20 million μPa) for extremely loud sounds such as a jet during take-off at a distance of 200 feet.

Broadband sound includes sound energy summed across the entire audible frequency spectrum. In addition to broadband sound pressure levels, analysis of the various frequency components of the sound spectrum can be completed to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves. Typically, the frequency analysis examines 11 octave bands ranging from 16 Hz (low) to 16,000 Hz (high). Since the human ear does not perceive every frequency with equal loudness, spectrally-varying sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system,and is represented in dBA.

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level (L_{eq}). The equivalent sound level has been shown to provide both an effective and uniform method for comparing time-varying sound levels. Sound levels can also be described using statistical levels (L_n). This descriptor identifies the sound level that is exceeded "n" percent of the time over a measurement period (e.g., L_{90} = sound level exceeded 90 percent of the time). The sound level exceeded for a small percent of the time, L_{10}, closely corresponds to short-term, higher-level, intrusive noises (such as vehicle pass-by noise near a roadway). The sound level exceeded for a large percent of the time, L_{90}, closely corresponds to continuous, lower-level background noise (such as continuous noise from a distant industrial facility). L_{50} is the level exceeded 50 percent of the time and is typically referred to the median sound level over a given period.

Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in Table 1.

Table 1. Sound Pressure Levels and Relative Loudness of Typical Noise Sources and Soundscapes

Noise Source or Acoustic Environment	Sound Level (dBA)	Subjective Impression
Garbage disposal, food blender (2 feet), or Pneumatic drill (50 feet)	80	Loud
Vacuum cleaner (10 feet)	70	Moderate
Passenger car at 65 mph (25 feet)	65	
Large store air-conditioning unit (20 feet)	60	
Light auto traffic (100 feet)	50	Quiet
Quiet rural residential area with no activity	45	

[1] The sound pressure level (L_p) in decibels (dB) corresponding to a sound pressure (p) is given by the following equation:

$$Lp = 20 \log10 (p / pref);$$

Where:

p = the sound pressure in μPa; and

pref = the reference sound pressure of 20 μPa.

Table 1. Sound Pressure Levels and Relative Loudness of Typical Noise Sources and Soundscapes

Noise Source or Acoustic Environment	Sound Level (dBA)	Subjective Impression
Bedroom or quiet living room or Bird calls	40	Faint
Typical wilderness area	35	
Quiet library, soft whisper (15 feet)	30	Very quiet
Wilderness with no wind or animal activity	25	Extremely quiet
High-quality recording studio	20	
Acoustic test chamber	10	Just audible
	0	Threshold of hearing

Adapted from: Beranek 1988 and EPA 1974.

2.0 REGULATORY SETTING

Based on Tetra Tech's review the Town of Riverhead has a noise ordinance (Chapter 251 of the Town Code) which prescribes numerical decibel limits applicable to the Project. The noise ordinance limits activities during hours based on noise levels generated. It states that noise disturbances are prohibited: "No person shall make, continue or cause or suffer to be made or continued any unreasonable noise" (§251-5). Construction is not allowed between the hours of 8:00 PM and 7:00 AM during weekdays or at any time on Sundays or legal holidays, "such that the sounds therefrom creates unreasonable noise across a residential real property boundary" (§251-5K).

To define unreasonable noise, the ordinance includes maximum permissible sound levels that limit the sound. As stated in §251-4:

> *"No person shall cause, suffer, allow or permit the operation of any source of sound on a particular category of property or any public land or right-of-way in such a manner as to create a sound level that exceeds the particular level limits set forth in Table I when measured at or within the real property line of the receiving property, except those acts specifically prohibited in this article for which no measurement of sound is required."*

Table 2, below, identifies the maximum permissible sound levels prescribed by the Town of Riverhead. The Project is located on parcels that are zoned "Industrial"; therefore, if the receiving land use under consideration is industrial, then the applicable limit is 75 dBA. If the receiving land use is commercial or residential (during daytime hours) then the applicable limit is 65 dBA. If the receiving land use is residential (during nighttime hours) then the applicable limit is 50 dBA.

Table 2. Town of Riverhead – Maximum Permissible Sound Levels by Receiving Property Category

Sound Source Property Category	Receiving Property Category					
	Another Apartment within Multidwelling Building		Residential		Commercial	Industrial
	7:00 am to 8:00 pm	8:00 pm to 7:00 am	7:00 am to 8:00 pm	8:00 pm to 7:00 am	All Times	All Times
Apartment within Multidwelling Building	50	45	65	50	65	75
Residential	-	-	65	50	65	75
Commercial or public land or rights-of-way	-	-	65	50	65	75
Industrial	-	-	65	50	65	75

Construction noise is also discussed in §251-5(K) which prohibits construction activities between the hours of 8:00 pm and 7:00 am on weekdays, Sundays or legal holidays if the noise is unreasonable across a residential property boundary. At any other time, the sound level across a real property boundary cannot exceed an L_{10} of 80 dBA. Lastly, the peak sound pressure level from an impulsive sound is not permitted to exceed 130 dBA across a real property boundary.

3.0 ACOUSTIC MODELING ANALYSYS

Sound generated by the Project would consist of: (1) short-term duration during construction and (2) sound during normal facility operations. DataKustic GmbH's CadnaA, a computer-aided noise abatement program (version 2018 MR1), was used to conduct the acoustic modeling analysis for both construction and operation.

CadnaA is a comprehensive 3-dimensional acoustic software model that conforms to the International Organization for Standardization (ISO) standard 9613-2, "Attenuation of Sound during Propagation Outdoors". The engineering methods specified in this standard consist of full (1/1) octave band algorithms that incorporate geometric spreading due to wave divergence, reflection from surfaces, atmospheric absorption, screening by topography and obstacles, ground effects, source directivity, heights of both sources and receptors, seasonal foliage effects, and meteorological conditions.

For each construction phase, the anticipated types of equipment, number of equipment, and their usage factors were determined. Representative sound profiles were input to CadnaA for each type of equipment identified. Individual modeling files were developed for each phase and the appropriate equipment grouping was assumed to be distributed as an area source throughout the two solar array footprints where construction will occur.

During Project operation, concurrent operation of the solar plant site components and the on-site substation was assumed to be limited to daytime hours only. After sunset, when the plant no longer receives solar radiation, the substation transformer will be in a lower power mode, the inverters will not produce noise and the pad-mounted transformers will be energized but likely operating under low noise condition using natural draft cooling (no fans) due to reduced nighttime heat loads. A three-dimensional rendering of the facility was created directly from the preliminary site plan drawing by defining the height and extent of all modeled noise sources. Sound power levels were assigned each source in a manner that best represents their expected acoustic performance and are inclusive of a standardized engineering safety factor. For example, transformer walls are defined as vertical area sources. The complex interaction of the noise walls, enclosures, and plant equipment were modeled as solid structures.

Terrain conditions, vegetation type, ground cover, and the density and height of foliage can influence the absorption that occurs when sound waves travel over land. The ISO 9613-2 standard accounts for ground absorption rates by assigning a numerical coefficient of G=0 for acoustically hard, reflective surfaces and G=1 for absorptive surfaces and soft ground. If the ground is hard-packed dirt (typically found in industrial complexes, pavement, bare rock) or for sound traveling over bodies of water, the absorption coefficient is defined as G=0 to account for the reduced sound attenuation and higher reflectivity. In contrast, ground covered in vegetation, including suburban lawns, livestock, and agricultural fields, will be acoustically absorptive and aid in sound attenuation (i.e., G=1). For the acoustic modeling analysis, a conservative ground absorption rate was selected, accounting for a semi-reflective ground surface. Topographical information was imported into the acoustic model using the official U.S. Geological Survey (USGS) digital elevation dataset to accurately represent terrain in three dimensions.

3.1 Construction

Construction is anticipated to take approximately six months and will occur within the hours of 7:00 am and 8:00 pm, Monday through Saturday in accordance with the Town Code (§ 251-K(1)). The first phase of construction will be demolition and is expected to last approximately two weeks.

The second phase, mass grading, will follow with an expected duration of one month to complete. Trenching and road construction will also last approximately one month with equipment installation expected to last three months. Commissioning is the final phase, which will last approximately one month.

Each construction phase identified will require several types of construction equipment. Table 3 presents the types of construction equipment for each phase, their estimated usage factor over a standard eight-hour work day and their maximum sound level (L_{max}) at 50 feet.

Table 3. Summary of Solar Farm Construction Equipment by Phase

Phase No.	Construction Phase	Construction Equipment	Usage Factor %	Maximum L_{max} Equipment Noise Level at 50 ft (15 m) dBA
1	Demolition	(1) Excavators (168 hp) (1) Tractors/Loaders/Backhoes (108 hp) (1) Rough Terrain Forklifts (93 hp) (1) Dump Truck	57 55 60 40	85 85 85 84
2	Site Preparation and Grading	(2) Graders (174 hp) (1) Rubber Tired Loaders (164 hp) (1) Scrapers (313 hp) (2) Water Trucks (189 hp) (2) Generator Sets	57 59 72 50 74	85 85 89 80 81
3	Trenching and Road Construction	(2) Excavators (168 hp) (2) Graders (174 hp) (2) Water Trucks (189 hp) (1) Trencher (63 hp) (2) Rubber Tired Loaders (164 hp) (2) Generator Sets	57 57 50 75 54 74	85 85 80 83 85 81
4	Equipment Installation	(1) Crane (399 hp) (5) Forklifts (145 hp) (5) Pile drivers (15) Pickup Trucks/ATVs (2) Water Trucks (189 hp) (2) Generator Sets	43 30 20 40 50 74	83 85 84 55 80 81
5	Commissioning	(5) Pickup Trucks/ATVs	40	55

Using the assumptions presented in Table 3, construction noise levels were analyzed with CadnaA and received sound levels at each receptor were evaluated. Table 4 provides the results of the construction acoustic modeling analysis. Received sound levels are given in terms of the sound level exceeded 10 percent of the time (L_{10}), which as a rule is 3 dBA greater than the L_{eq} sound level. The L_{10} sound level is also the relevant sound metric prescribed by the Town of Riverhead when evaluating potential noise impacts associated with construction activities.

Table 4. Summary of Acoustic Modeling Results - Construction

Receptor ID	Status	UTM Coordinates (meters) NAD83 UTM Zone 18		Received Sound Level, L_{10} (dBA)				
				Construction Phase				
		Easting	Northing	Demolition	Site Preparation and Grading	Trenching and Road Construction	Equipment Installation	Commissioning
1	Residence	689823	4531379	68	70	71	69	69
2	Residence	689816	4531419	66	68	69	67	67
3	Residence	689813	4531452	65	67	68	66	66
4	Residence	689813	4531473	65	66	68	66	65
5	Residence	689766	4531834	63	64	66	63	63
6	Residence	689154	4530794	66	68	70	68	53
7	Residence	689226	4530573	63	64	66	64	51
8	Residence	689221	4530513	60	62	63	61	46
9	Abandoned	689319	4530593	65	66	68	66	52
10	Residence	689567	4530664	63	64	66	64	53
11	Residence	689593	4530687	62	64	65	63	53
12	Residence	689588	4530768	63	65	67	65	56
13	Residence	689605	4530811	61	62	64	61	57
14	Not a Residence	689751	4530841	61	63	64	62	58
15	Residence	689810	4530852	61	62	64	61	58
16	Residence	689989	4531001	61	63	65	62	61

Modeling results show that received sound levels at residences are below the applicable 80 dBA L_{10} construction sound level limit. Compliance with that limit is also demonstrated at the Project property boundary and can be inferred by compliance at receptor ID 1, which is predicted to be the most impacted receptor during construction and is located within approximately 80 feet of the Project property boundary.

Construction sound will be attenuated with increased distance from the source. Other factors, such as vegetation, terrain and obstacles such as buildings will act to further limit the impact of construction noise levels, but were not considered in the analysis. Actual received sound levels would fluctuate depending on the construction activity, equipment type, and separation distances between source and receiver. The variation in power and usage imposes additional complexity in characterizing construction noise levels and, therefore, the analysis conservatively assumes all phased construction equipment operating simultaneously; however, equipment is generally not operated continuously.

3.2 Operation

The Project would generate power using PV modules mounted in rows of parallel racks. The solar energy generating facility will be unmanned during normal operation. Systems monitoring will be completed remotely and onsite staff will be limited to repair or cleaning of the PV modules. Maintenance staff will visit periodically to clean the PV modules, clearing vegetation, and other general maintenance activities.

Sound sources considered in the Project operational acoustic analysis include the centralized inverters and transformers associated with the PV modules, and the proposed onsite substation. The principal sources of noise are the cooling-ventilation fans, the electrical components of the inverters and the step-up transformer at the on-site substation. Each centralized inverter location would include an inverter inside a pre-fabricated enclosure and one transformer mounted on a concrete pad. The transformers and inverters are mounted on pads at grade level and would be centrally located within each 2 MW array of solar panels. PV station transformers and power inverters are generally considered a low-level source of noise.

Substations have switching, protection and control equipment and a transformer, which generate the sound generally described as a low humming. There are three main sound sources associated with a transformer: core noise, load noise and noise generated by the operation of the cooling equipment. The core is the principal noise source and does not vary significantly with electrical load. The load noise is primarily caused by the load current in the transformer’s conducting coils (or windings) and consequently the main frequency of this sound is twice the supply frequency: 120 Hz for 60 Hz transformers. The cooling equipment (fans and pumps) may also be a noise component, depending on fan design. During air forced cooling method, cooling fan noise is produced in addition to the core noise. The resulting audible sound is a combination of hum and the broadband fan noise. Breaker noise is a sound event of very short duration, expected to occur only a few times throughout the year. Just as horsepower ratings designate the power capacity of an electric motor, a transformer’s MVA rating indicates its maximum power output capacity. The transformers included in the PV modules are rated at 2-MVA whereas the transformer at the Project substation is rated at 25-MVA. Table 5 summarizes the equipment sound power level data used as inputs to the modeling analysis.

Table 5. Modeled Octave Band Sound Power Levels for Project Equipment

	Unweighted Octave Band Sound Power Data re to 1 picoWatt, or 10^{-12} W (dBL)									
	31.5	63	125	250	500	1000	2000	4000	8000	dBA
Substation Transformer (25 MVA)	88	94	96	92	92	85	80	75	68	91
Pad-Mounted Transformer (2 MVA)	66	72	74	69	69	63	58	53	46	69
Inverter (2,500 kW)	71	79	86	87	86	83	78	71	64	88

4.0 RESULTS AND CONCLUSIONS

As indicated above, the acoustic modeling analysis was conducted assuming Project operation during daytime hours, when all equipment could potentially be operating continuously and concurrently at the sound levels presented in Table 4. Broadband (dBA) sound pressure levels were calculated at an elevation of 1.5 meters (5 feet) above the ground, the height of the ears of a standing person. The sound energy was then summed to determine the equivalent A-weighted sound pressure level at a point of reception during normal operation. A sound contour plot displaying broadband (dBA) sound levels presented as color-coded noise isopleths in 5-dBA intervals is provided in Figure 1. The noise contours are graphical representations of the cumulative noise associated during normal operation of the individual equipment components and show how operational noise would be distributed over the surrounding area. The contour lines shown are analogous to elevation contours on a topographic map, i.e., the noise contours are continuous lines of equal noise level around some source, or sources, of noise.

Modeling results show that the Project meets the Town's Noise Code when measured both at and within the real property line of the receiving property. Land use adjacent to the Project is zoned as industrial and received sound levels within those adjacent parcels are well below the applicable daytime sound limit of 75 dBA for industrial property. In addition, Table 6 shows the projected exterior sound levels resulting at the closest residences, which range from 25 to 33 dBA and are well below the applicable residential sound limits of 65 dBA from 7am to 8pm and 50 dBA from 8pm to 7am (although the facility will only generate noise during the daylight periods) and the commercial sound limit of 65 dBA (all times). There are no multi-dwelling buildings adjacent to the Project but these results are below the applicable standards for this classification as well.

Table 6. Summary of Acoustic Modeling Results - Operation

Receptor ID	Status	UTM Coordinates (meters) NAD83 UTM Zone 18		Received Sound Level (dBA)
		Easting	Northing	
1	Residence	689823	4531379	33
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6	Residence	689154	4530794	30
7	Residence	689226	4530573	28
8	Residence	689221	4530513	25
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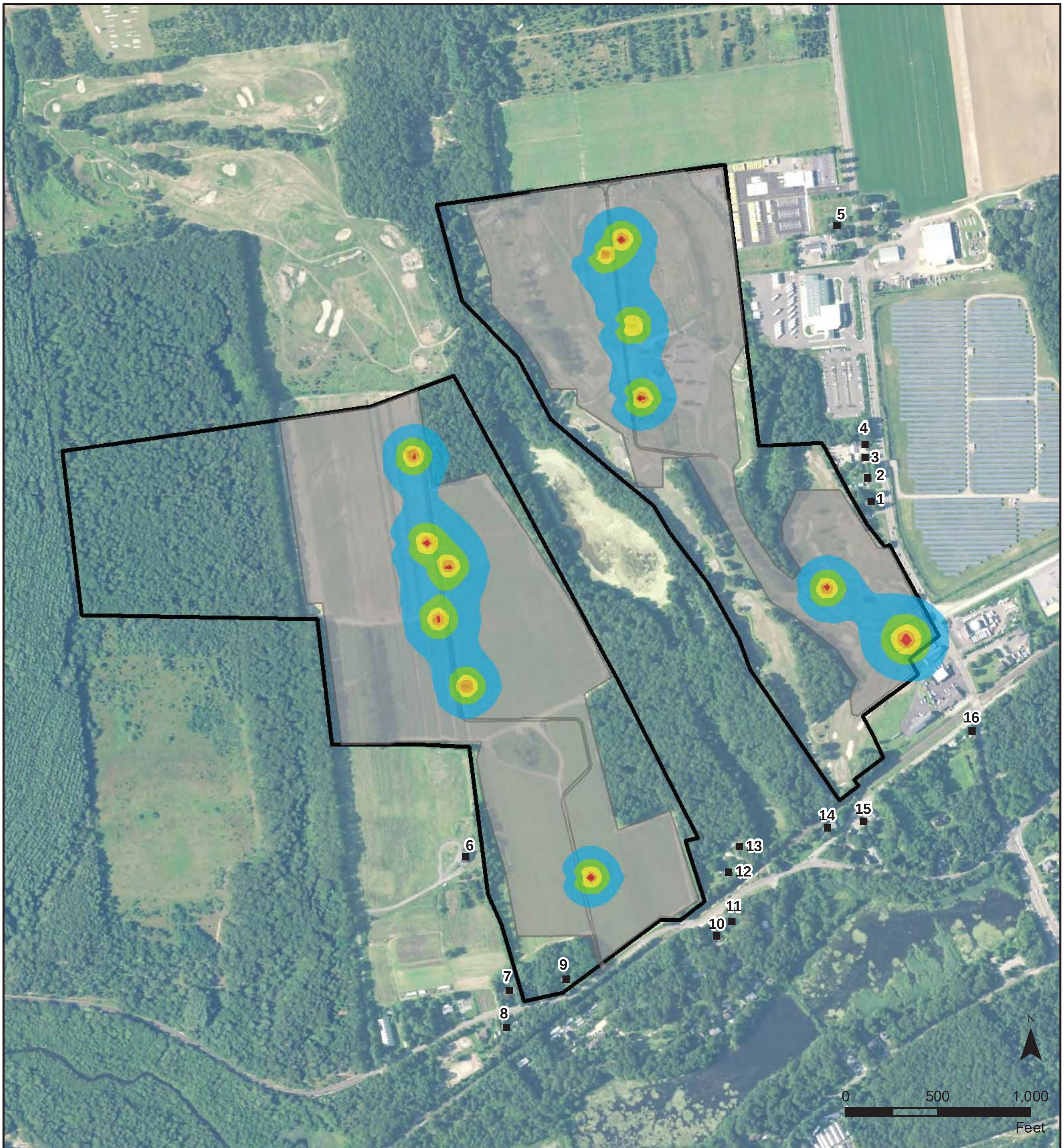
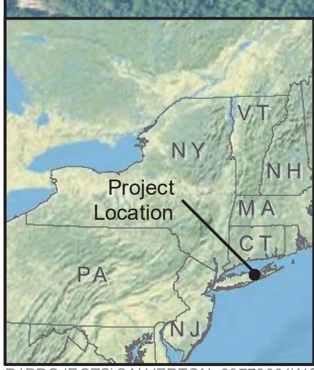
14	Not a Residence	689751	4530841	28
15	Residence	689810	4530852	28
16	Residence	689989	4531001	32





Legend

- Project Property Boundary
- Proposed Array Footprint
- Noise Sensitive Receptor

Sound Level Contour Range (dBA):

- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- > 60

Figure 1
Received Sound Levels – Normal Operation

Calverton Solar Project
Suffolk County, New York

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5.0 REFERENCES

Bies D. and Hansen C. 2003. "Engineering Noise Control: Theory and Practice", Published by Taylor & Francis, 2003.

National Electrical Manufacturers Association, NEMA Standards Publication No. TR 1-1993 (R2000) Transformers, Regulators and Reactors.

IEEE Standard 1127-1998. 1998. IEEE Guide for the Design, Construction and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility. IEEE: USA.

FHWA (U.S. Department of Transportation, Federal Highway Administration). 2006. Construction Noise Handbook. FHWA-HEP-06-015. August. Available online at: http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/index.cfm

Federal Highway Administration, "Procedures for Abatement of Highway Traffic Noise and Construction Noise". Code of Federal Regulations, Title 23, Part 772, 1992.