APPENDIX J
SOUND SURVEY AND ANALYSIS REPORT

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Administrative Draft
Sound Survey and Analysis Report

Daggett Solar Power Facility
San Bernardino, California

July 2018

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TETRA TECH

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
^{o}F	degrees Fahrenheit
μPa	microPascal
ANSI	American National Standards Institute
CEC	California Energy Commission
CEQA	California Environmental Quality Act
dB	decibel
dBA	A-weighted decibel
dBL	linear decibel
EPRI	Electric Power Research Institute
Facility	Daggett Solar Power Facility
FTA	Federal Transit Authority
HVAC	heating, ventilation, and air conditioning
Hz	hertz
in/sec	inch per second
ISO	International Organization for Standardization
kHz	kilohertz
L_{eq}	equivalent sound level
L_{W}	sound power level
L_{P}	sound pressure level
ML	monitoring location
MW	megawatt
NIST	National Institute of Standards and Technology
PPV	Peak-Particle-Velocity
PV	photovoltaic
rms	root mean square
SCE	Southern California Edison
Tetra Tech	Tetra Tech, Inc.
USEPA	United States Environmental Protection Agency
VdB	vibration decibel

1.0 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech) has prepared this noise impact assessment for the proposed Daggett Solar Power Facility (the Facility) to support a California Environmental Quality Act (CEQA) application. The Facility is proposed on approximately 3,500 acres of land located approximately 0.5 mile east of the town of Daggett within the County of San Bernardino. The Facility will include a utility-scale, solar photovoltaic (PV) electricity generation and energy storage facility that would produce up to 650 megawatts (MW) of power and include up to 450 MW of battery storage capacity.

The balance of this section of the report provides background information, including a discussion of the Facility setting, descriptions of the noise metrics used throughout the report, and applicable noise standards and regulations. Section 2 provides the results of the ambient sound measurement program. Predicted noise levels associated with Facility construction are provided in Section 3, with predicted noise levels from full-load operation of Facility equipment discussed in Section 4. Mitigation measures are identified that demonstrate the Facility can meet the reflected sound levels; however, final design may incorporate different mitigation measures to achieve the same objective. Section 5 provides a summary of the report's findings. References are provided in Section 6.

1.1 FACILITY SETTING

The approximately 3,500-acre Facility Site is located in the Desert Planning Region of San Bernardino County. The Facility Site is generally bounded by the town of Daggett approximately 0.5 mile to the west; the Mojave River, Yermo, and Interstate 15 to the north; Barstow-Daggett Airport, Route 66, and Interstate 40 to the south; and Newberry Springs and Mojave Valley to the east.

There are residences located adjacent to the Facility Site to the north and south as well as residences scattered to north and east of the Facility Site. The town of Daggett is located approximately 0.5 mile to the west and the town of Newberry Springs is located approximately 1 mile southeast of the Facility boundary. Figure 1 provides an overview of the Facility Site as well as the surrounding area.

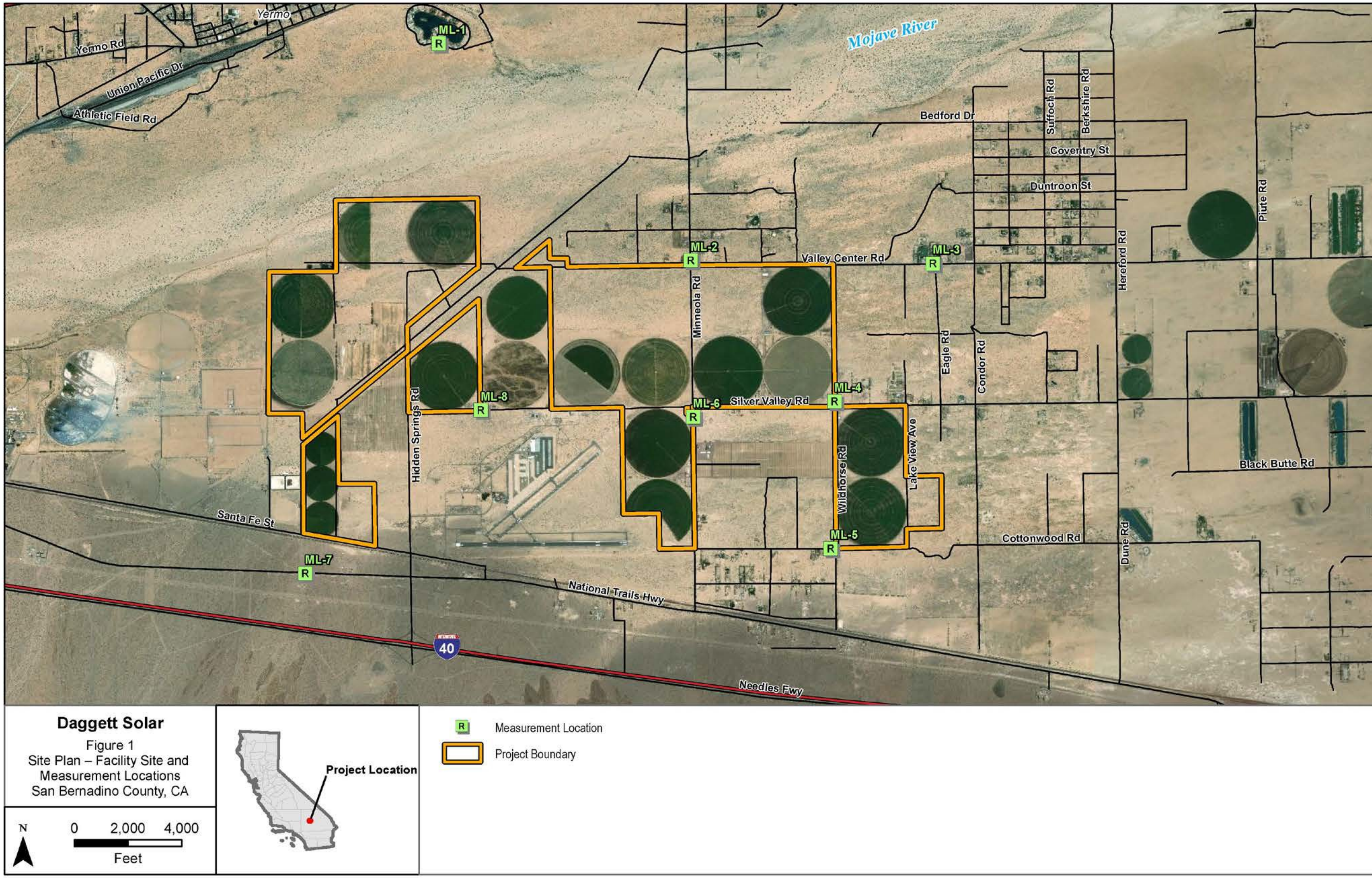

Figure 1. Facility Site and Measurement Locations

1.2 ACOUSTIC METRICS AND TERMINOLOGY

All sounds originate with a source, whether it is a human voice, motor vehicles on a roadway, or a combustion turbine. Energy is required to produce sound and this sound energy is transmitted through the air in the form of sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear. A sound source is defined by a sound power level (abbreviated "L_W"), which is independent of any external factors. By definition, 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 20 μPa for very faint sounds at the threshold of hearing, to nearly 10 million μPa for extremely loud sounds such as a jet during take-off at a distance of 300 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 and is widely used in acoustic assessments in the State of California. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in Table 1. Table 2 presents additional reference information on terminology used in the report.

Table 1. Sound Pressure Levels (L_P) and Relative Loudness of Typical Noise Sources and Acoustic Environments

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Vacuum cleaner (10 feet)	70	Moderate
Passenger car at 65 miles per hour (25 feet)	65	
Large store air-conditioning unit (20 feet)	60	

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

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

Where:

p = the sound pressure in μPa; and

pref = the reference sound pressure of 20 μPa.

Table 1. Sound Pressure Levels (L_P) and Relative Loudness of Typical Noise Sources and Acoustic Environments

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Light auto traffic (100 feet)	50	Quiet
Quiet rural residential area with no activity	45	
Bedroom or quiet living room; 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: Kurze and Beranek (1988) and USEPA (1971)

Table 2. Acoustic Terms and Definitions

Term	Definition
Noise	Typically defined as unwanted sound. This word adds the subjective response of humans to the physical phenomenon of sound. It is commonly used when negative effects on people are known to occur.
Sound Pressure Level (L_P)	Pressure fluctuations in a medium. Sound pressure is measured in dB referenced to 20 microPascals, the approximate threshold of human perception to sound at 1,000 Hz.
Sound Power Level (L_W)	The total acoustic power of a noise source measured in dB referenced to picowatts (one trillionth of a watt). Noise specifications are provided by equipment manufacturers as sound power as it is independent of the environment in which it is located. A sound level meter does not directly measure sound power.
Equivalent Sound Level (L_{eq})	The L_{eq} is the continuous equivalent sound level, defined as the single sound pressure level that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period.
A-Weighted Decibel (dBA)	Environmental sound is typically composed of acoustic energy across all frequencies. To compensate for the auditory frequency response of the human ear, an A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report.
Unweighted Decibels (dBL)	Unweighted sound levels are referred to as linear. Linear decibels are used to determine a sound’s tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Sound levels that are linear are presented as dBL in this report.
Propagation and Attenuation	Propagation is the decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Additional sound attenuation factors include air absorption, terrain effects, sound interaction with the ground, diffraction of sound around objects and topographical features, foliage, and meteorological conditions including wind velocity, temperature, humidity, and atmospheric conditions.

Table 2. Acoustic Terms and Definitions

Term	Definition
Octave Bands	The audible range of humans spans from 20 to 20,000 Hz and is typically divided into center frequencies ranging from 31 to 8,000 Hz.
Broadband Noise	Noise which covers a wide range of frequencies within the audible spectrum, i.e., 200 to 2,000 Hz.
Frequency (Hz)	The rate of oscillation of a sound, measured in units of Hz or kilohertz (kHz). One hundred Hz is a rate of one hundred times (or cycles) per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz.

1.3 VIBRATION METRICS AND TERMINOLOGY

Vibration is an oscillatory motion that is described in terms of displacement, velocity, or acceleration. Velocity is the most common descriptor used when evaluating human perception or structural damage. Velocity represents the instantaneous speed of movement and more accurately describes the response of humans, buildings, and equipment to vibrations.

Peak-Particle-Velocity (PPV) and root mean square (rms) velocity are typical metrics used to describe vibration levels in units of inches per second in the United States. However, to evaluate annoyance to humans, the vibration dB (VdB) notation is commonly used. The decibel notation acts to compress the range of numbers required to describe vibration. In the United States, the accepted velocity reference for converting to dB is $1x10^{-6}$ inches per second. The abbreviation "VdB" is used for vibration dB to reduce the potential for confusion with sound decibels.

In contrast to airborne noise, ground-borne vibration is not an everyday occurrence for humans. The background vibration velocity levels within residential areas are usually 50 VdB or lower, which is well below the human perception threshold of approximately 65 VdB. However, human response to vibration is not usually significant unless the vibration exceeds 70 VdB. Outdoor sources that generate perceptible ground-borne vibrations are typically construction equipment, steel-wheeled trains, and traffic on rough roadways. Table 3 provides common vibration sources as well as human and structural response to ground-borne vibrations.

Table 3. Typical Levels of Ground-Borne Vibration

Human/Structural Response	PPV (in/sec)	Velocity Level (VdB)*	Typical sources (50 feet from source)
Threshold, Minor Cosmetic Damage, Fragile Buildings	0.4	100	Blasting from Construction Projects
	0.17-0.2	92-94	Heavy Tracked Construction Equipment
Difficulty with Tasks, Such as Reading a Computer Screen	0.125	90	
	0.074	85	Commuter Rail, Upper Range
Residential Annoyance, Infrequent Events	0.04	80	Rapid Transit, Upper Range
	0.013	75	Commuter Rail, Typical
	0.023	72	Bus or Truck Bump Over

Table 3. Typical Levels of Ground-Borne Vibration

Human/Structural Response	PPV (in/sec)	Velocity Level (VdB)*	Typical sources (50 feet from source)
Residential Annoyance, Frequent Events	0.013	70	Rapid Transit, Typical
Approximate Threshold of Human Perception	0.007	65	
	0.005	62	Bus or Truck, Typical
	0.0013	50	Typical Background Vibration Levels

*RMS Vibration Velocity in VdB reference to 10^{-6} inches/second
Source: FTA (2006)

The degree of annoyance cannot always be explained by the magnitude of the vibrations alone. Phenomena, such as ground-borne noise and rattling, visual effects (e.g., movement of hanging objects), and time of day, all influence the response of individuals. The American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) has developed criteria for evaluation of human exposure to vibrations. The recommendations of these standards and other studies evaluating human response to vibrations have been incorporated into the Federal Transit Administration's (FTA) Transit Noise and Vibration Impact Assessment Manual (May 2006). The criteria within this manual are used to assess noise and vibration impacts from transit operations.

1.4 NOISE AND VIBRATION LEVEL REQUIREMENTS AND GUIDELINES

Potential noise impacts associated with the Facility were evaluated with respect to the applicable noise requirements prescribed by CEQA, County of San Bernardino Noise Element to the General Plan, and San Bernardino County Development Code Section 83.01.080. Details regarding each set of requirements are provided below.

1.4.1 California Environmental Quality Act

CEQA requires that significant environmental impacts be identified and that such impacts be eliminated or mitigated to the extent feasible. Appendix G of the CEQA Statutes and Guidelines (State Clearing House, Office of Planning and Research and the Natural Resources Agency, 2016) sets forth a series of suggested thresholds for determining a potentially significant impact. Under the thresholds suggested in Appendix G, the proposed project could be considered to have significant noise and vibration impacts if it results in one or more of the following:

a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies.
b) Exposure of persons to or generation of excessive ground-borne vibration or ground-borne noise levels.
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project.
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project.
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, exposure of people residing or working in the project area to excessive noise levels.

f) For a project within the vicinity of a private airstrip, exposure of people residing or working in the project area to excessive noise levels.

The CEQA Statutes and Guidelines Appendix G thresholds for items (c) and (d) do not define the term “substantial”; however, the California Energy Commission (CEC) provides guidelines for operational noise or permanent increases which indicate that an increase of 5 dBA over ambient conditions may be significant and an increase of 10 dBA is significant (CEC 2006).

1.4.2 County of San Bernardino Noise Element to the General Plan

The County of San Bernardino has published a Noise Element to the General Plan for the purpose of limiting the exposure of the community to excessive noise levels. The Noise Element identifies two goals to limit the exposure of the community to excessive noise levels. The first goal (N1) states:

Goal N1. *The County will abate and avoid excessive noise exposures through noise mitigation measures incorporated into the design of new noise-generating and new noise-sensitive land uses, while protecting areas within the County where the present noise environment is within acceptable limits.*

Several policies will be enforced to meet goal N1. The policies are:

N1.1 *Designate areas within San Bernardino County as "noise impacted" if exposed to existing or projected future exterior noise levels from mobile or stationary sources exceeding the standards listed in Chapter 83.01 of the Development Code.*

N1.2 *Ensure that new development of residential or other noise-sensitive land uses is not permitted in noise-impacted areas unless effective mitigation measures are incorporated into the project design to reduce noise levels to the standards of Noise-sensitive land uses include residential uses, schools, hospitals, nursing homes, places of worship and libraries.*

N1.3 *When industrial, commercial, or other land uses, including locally regulated noise sources, are proposed for areas containing noise sensitive land uses, noise levels generated by the proposed use will not exceed the performance standards of Table N-2* (shown in Table 4 in Section 1.4.3 of this report) *within outdoor activity areas. If outdoor activity areas have not yet been determined, noise levels shall not exceed the performance standards listed in Chapter 83.01 of the Development Code at the boundary of areas planned or zoned for residential or other noise-sensitive land uses.*

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outdoor activity areas have not yet been determined, noise levels shall not exceed the performance standards listed in Chapter 83.01 of the Development Code at the boundary of areas planned or zoned for residential or other noise-sensitive land uses.

The second goal (N2) states:

Goal N2. *The County will strive to preserve and maintain the quiet environment of mountain, desert and other rural areas.*

Policies enforced to meet this goal include:

N2.1 *The County will require appropriate and feasible on-site noise attenuating measures that may include noise walls, enclosure of noise generating equipment, site planning to locate noise sources away from sensitive receptors, and other comparable features.*

N2.2 *The County will continue to work aggressively with federal agencies, including the branches of the military, the U.S. Forest Service, BLM, and other agencies to identify and work cooperatively to reduce potential conflicts arising from noise generated on federal lands and facilities affecting nearby land uses in unincorporated County areas.*

There are no specific goals and/or policies identified for the Desert Planning Region where the Facility is proposed to be located.

1.4.3 County of San Bernardino Development Code

The San Bernardino County Development Code Section 83.01.080 Noise establishes standards concerning acceptable noise levels for both noise-sensitive land uses and for noise-generating land uses. This section presents standards and requirements for noise measurements, noise impacted areas, noise standards for stationary noise sources, noise standards for adjacent mobile noise sources, increases in allowable noise levels, reductions in allowable noise levels, and exempt noise. Table 83-2 (shown below as Table 4) of the Noise Section describes the noise standard for emanations from a stationary noise source. The table demonstrates that a stationary source may emit up to 55 dBA during the day (7:00 a.m. to 10:00 p.m.) and 45 dBA during the night (10:00 p.m. to 7:00 a.m.) to residential land uses. As shown in Table 4, different sound limits apply to other land use types.

Table 4. San Bernardino County Noise Standards for Stationary Noise Sources

Affected Land Uses (Receiving Noise)	7:00 a.m. – 10:00 p.m. L_{eq} dBA	10:00 p.m. – 7:00 a.m. L_{eq} dBA
Residential	55	45
Professional Services	55	55
Other Commercial	60	60
Industrial	70	70

The San Bernardino County Development Code Section 83.01.090 Vibration establishes standards concerning acceptable vibration levels. The section states that no ground vibration shall be allowed that can be felt without the aid of instruments at or beyond the lot line, nor shall any vibration be allowed which produces a particle velocity greater than or equal to two-tenths (0.2) inches per second measured at or beyond the lot line. Temporary construction, maintenance, repair, or demolition activities between 7:00 a.m. and 7:00 p.m., except Sundays and federal holidays, are exempt from this vibration limit.

2.0 EXISTING SOUND ENVIRONMENT

Tetra Tech conducted a series of ambient sound level measurements to characterize the existing acoustic environment near the Facility during both daytime and nighttime periods. This section summarizes the methodology used by Tetra Tech to conduct the sound survey and describes the measurement locations.

2.1 FIELD METHODOLOGY

To document the existing conditions, baseline sound level measurements were performed on May 29, 30 and 31, 2018. Weather conditions were conducive for the collection of accurate sound data. The measurement locations were selected to be representative of the surroundings of potential receptors nearest to the proposed Facility Site in the principal geographical directions. The ambient sound survey included short-term (ST) measurements in the presence of an acoustics expert for a minimum duration of 30 minutes. The ST measurements were made during both daytime (10:00 a.m. to 4:00 p.m.) and nighttime (10:00 p.m. to 2:00 a.m.) periods at noise-sensitive areas.

All the measurements were conducted using a Larson Davis Model 831 precision integrating sound-level meter that meets the requirements of ANSI Standards for Type 1 precision instrumentation. This sound analyzer has an operating range of 5 dB to 140 dB, and an overall frequency range of 8 to 20,000 Hz. During the measurement program, microphones were fitted with a windscreen, set upon a tripod at a height of approximately 1.5 meters (5 feet) above the ground and located out of the influence of any vertical reflecting surfaces. The sound analyzer was calibrated at the beginning and end of the measurement period using a Larson Davis Model CAL200 acoustic calibrator following procedures that are traceable to the National Institute of Standards and Technology (NIST). Table 5 lists the measurement equipment employed during the survey. The sound level meters were programmed to sample and store A-weighted and octave band sound level data, including L_{eq} and the percentile sound levels.

Table 5. Measurement Equipment

Description	Manufacturer	Type
Signal Analyzer	Larson Davis	831
Preamplifier	Larson Davis	PRM902
Microphone	PCB	377B02
Windscreen	ACO Pacific	7-inch
Calibrator	Larson Davis	CAL200

During the survey, weather conditions were conducive to accurate data collection. Weather conditions were mainly sunny with few clouds and no precipitation occurring during the measurement period. Temperatures ranged from 76 to 97 degrees Fahrenheit (°F) during the day, and 75 to 86°F during the night.

2.2 FIELD METHODOLOGY

Eight short-term, attended sound measurements were performed at public locations near residential properties proximate to the Facility Site. The monitoring locations (ML-1 through ML-8) were selected to represent ambient conditions at land uses in the vicinity of the Facility Site. The short-term monitoring locations are described in Table 6 and mapped on Figure 1. Additional descriptions of the monitoring locations and field observations are provided below.

Table 6. Sound Level Monitoring Locations

Monitoring Location	Coordinates (Universal Transverse Mercator Zone 19N)		Distance and Direction from Facility Site Boundary
	Easting (m)	Northing (m)	
ML-1	518349	3862287	1.1 mile north
ML-2	521180	3859794	190 feet north
ML-3	523930	3859734	0.75 mile east
ML-4	522798	3858181	Adjacent to east boundary
ML-5	522734	3856510	Adjacent to south boundary
ML-6	521190	3858017	Adjacent to south boundary
ML-7	516772	3856284	0.25 mile south
ML-8	518780	3858118	Adjacent to south boundary

2.2.1 Location ML-1

This monitoring location is located along Mountain View Road approximately 1.1 miles north of the Facility Site boundary line. This location was selected to represent the residential community located along Mountain View Road. Mountain View Road is an oval road that encompasses a residential community surrounding a pond.

During the daytime measurements, there was little to no traffic along Mountain View Road. However, there was moderate wind, periodic wind gusts, and rustling trees. Nighttime measurements were consistent with the daytime measurements. The data collected during the wind gusts were removed from the overall data set.

2.2.2 Location ML-2

This monitoring location is located near the intersection of Valley Center Road and Minneola Road, approximately 190 feet north of the Facility Site boundary line. This location represents the closest residence to the north. It is also located 1.5 miles northeast from the Barstow-Daggett Airport.

During the daytime measurement period, noise generated by traffic on Minneola Road and Valley Center Road was dominant. Noise from occasional aircraft at varying distances was also dominant and noise from distant railway operations was audible. Additionally, the sound of birds chirping in trees at the residence was consistent. During the nighttime measurement period, the traffic decreased and there were no birds chirping

2.2.3 Location ML-3

This monitoring location is located along Valley Center Road located approximately 0.75 mile east of the Facility Site boundary line. This location represents the nearest residential community to the east.

During the daytime measurement period, noise generated by traffic on the Valley Center Road was dominant. There was also moderate wind and rustling trees, as well as birds chirping. During the nighttime measurement period, the traffic decreased and there were no birds chirping.

2.2.4 Location ML-4

This monitoring location is located near the intersection of Silver Valley Road and Wildhorse Road located adjacent to the Facility Site boundary line. This location represents the closest residence to the east. It is also located approximately 1.75 miles northeast from the Barstow-Daggett Airport.

During the daytime measurement period, noise generated by traffic on the Silver Valley Road was dominant. Noise from occasional aircraft at varying distances was also dominant and noise from distant railway operations was audible. There was also moderate wind during the daytime period. During the nighttime measurement period, the traffic decreased, but there was increased railway activity.

2.2.5 Location ML-5

This monitoring location is located near the intersection of Chloride Road and Wildhorse Road and is located adjacent to the southeast boundary line of the Facility Site. This location represents the closest residence to the southeast.

During the daytime measurements, there was little to no traffic along Chloride Road and Wildhorse Road. However, nearby railway operations and traffic on Interstate 40 were audible. During the nighttime period, there was still some traffic along Interstate 40; however, railway activity decreased.

2.2.6 Location ML-6

This monitoring location is located near the intersection of Silver Valley Road and Minneola Road and is located adjacent to the southern boundary line of the Facility Site. This location represents the closest residence to the south. It is also located 0.7 mile from Barstow-Daggett Airport.

During the daytime measurement period, noise generated by traffic on the Silver Valley Road and Minneola Road was dominant. Noise from occasional aircraft at varying distances was also dominant and noise from distant railway operations was audible. During the daytime period, there was moderate wind and rustling trees. During the nighttime period, there was light wind, but rustling trees were still audible.

2.2.7 Location ML-7

This monitoring location is located along the National Trails Highway approximately 0.25 mile south of the Facility Site boundary line. This location represents the nearest residence located to southwestern Facility Site boundary line. It is also located 1 mile from Barstow-Daggett Airport.

During the daytime measurements, traffic along National Trails Highway was frequent and the primary source of noise. Noise from nearby railway operations and traffic from Interstate 40 was also audible. There was also moderate wind during the daytime period. During the nighttime period, wind was moderate and the traffic decreased, but there was still some traffic along Interstate 40 as well as railway activity.

2.2.8 Location ML-8

This monitoring location is located along Silver Valley Road, approximately 0.5 mile east of Hidden Springs Road adjacent to the Facility Site boundary line. This location represents the closest residence on the west side of the Facility Site boundary. It is also located approximately 0.5 mile from Barstow-Daggett Airport.

During the daytime measurements, there was little to no traffic along Hidden Springs Road; however noise from aircraft at varying distances was audible. Distant railway operations and traffic along Interstate 40 could also be heard. There was also moderate wind during the daytime period. During the nighttime period, there was still noise from aircraft, railway operations, and some traffic along Interstate 40.

2.3 MEASUREMENT RESULTS

Table 7 provides a summary of the measured ambient sound levels observed at each of the monitoring locations for both the daytime and nighttime L_{eq}.

Table 7. Sound Measurement Results – L_{eq} Sound Levels

Monitoring Location	Time Period	L_{10} (dBA)	L_{50} (dBA)	L_{90} (dBA)	L_{eq} (dBA)
ML-1	Day	53	48	45	50
	Night	48	45	44	46
ML-2	Day	46	39	34	43
	Night	43	38	35	40
ML-3	Day	42	36	32	39
	Night	41	37	35	38
ML-4	Day	40	35	32	37
	Night	40	39	37	39
ML-5	Day	50	42	39	46
	Night	44	40	37	41
ML-6	Day	58	56	54	56
	Night	50	47	45	48
ML-7	Day	51	48	46	49
	Night	49	46	44	47
ML-8	Day	48	44	41	46
	Night	48	42	39	45

Ambient sound levels did exhibit typical diurnal patterns. Daytime L_{eq} sound levels at the measurement locations ranged from a low of 37 dBA at ML-4 to a high of 56 dBA at ML-6. Nighttime sound levels ranged from a low of 38 dBA at ML-3 to 48 dBA ML-6. The daytime and nighttime measurements at ML-1 were heavily influenced by rustling trees due to moderate wind. The noise levels at ML-2, ML-3, ML-8, and ML-9 were heavily influenced by vehicle traffic along adjacent roads. Noise levels at ML-6, ML-7, and ML-9 were influenced by vehicle traffic along Interstate 40 as well as train traffic associated with the nearby railway.

3.0 FACILITY CONSTRUCTION

Construction of the Facility is expected to be typical of other power generating facilities in terms of schedule, equipment, and activities. Construction is anticipated to require approximately 27 months. Construction of the Project will require a variety of equipment and vehicles. The equipment and vehicles would comply with noise requirements in Section 83.01.080 of the San Bernardino County Code. Temporary construction, maintenance, repair, or demolition activities between 7:00 a.m. and 7:00 p.m. (except Sundays and federal holidays) are exempt from the noise regulations. The project will comply with this regulation and applicable conditions related to noise.

3.1 NOISE CALCULATION METHODOLOGY

Acoustic emission levels for activities associated with Facility construction were based upon typical ranges of energy equivalent noise levels at construction sites, as documented by the United States Environmental Protection Agency (USEPA 1971) and the USEPA's "Construction Noise Control Technology Initiatives" (USEPA 1980). The USEPA methodology distinguishes between type of construction and construction stage.

Using those energy equivalent noise levels as input to a basic propagation model, construction noise levels were calculated at the nearest Facility Site boundary and the eight MLs.

The basic model assumed spherical wave divergence from a point source located at the acoustic center of the Facility Site. Furthermore, the model conservatively assumed that all pieces of construction equipment associated with an activity would operate simultaneously for the duration of that activity. An additional level of conservatism was built into the construction noise model by excluding potential shielding effects due to intervening structures and buildings along the propagation path from the site to receiver locations.

3.2 PROJECTED NOISE LEVELS DURING CONSTRUCTION

Table 8 summarizes the projected noise levels due to Facility construction, organized into the following five broad work stages:

1. Site preparation, grading, preparation of staging areas, and on-site access routes;
2. Array foundation installation, conductor installation, and construction of control building;
3. Solar panel assembly and constructing electrical components;
4. Inverter pad construction, substation installation, cabling and terminations, and Gen-Tie construction; and
5. Array and interconnection commissioning, revegetation, and construction of waste removal and recycling.

Based on sound propagation calculations, construction sound levels are predicted to range from 44 to 85 dBA at the MLs. Periodically, sound levels may be higher or lower than those presented in Table 8; however, the overall sound levels should generally be lower due to excess attenuation and the trend toward quieter construction equipment in the intervening decades since these data were developed. As shown in Table 8, the highest projected sound level from construction-related activity is expected to occur at ML-5, ML-6, and ML-8, during activities associated with stage 3 and stage 4.

Table 8. Projected Construction Noise Levels by Stage (dBA)

Construction Stage	USEPA Construction Noise Level 50 feet	ML-1	ML-2	ML-3	ML-4	ML-5	ML-6	ML-7	ML-8
Stage 1	87	46	76	50	74	81	74	59	76
Stage 2	86	44	74	48	73	80	73	58	75
Stage 3	91	49	79	53	78	85	78	63	80
Stage 4	89	48	78	52	76	83	76	61	78
Stage 5	82	40	70	44	69	76	69	54	71

The construction of the project may cause short-term, but unavoidable noise impacts that could be loud enough at times to temporarily interfere with speech communication outdoors and indoors with windows open. The noise levels resulting from the construction activities will vary significantly depending on several factors such as the type and age of equipment, specific equipment manufacture and model, the operations being performed, and the overall condition of the equipment and exhaust system mufflers.

Project construction would occur between 7:00 a.m. and 7:00 p.m., Monday through Friday in compliance with the County' Code. All reasonable efforts will be made to minimize the impact of noise resulting from construction activities including implementation of standard noise reduction measures. Due to the infrequent nature of loud construction activities at the site, the limited hours of construction and the implementation of noise mitigation measures, the temporary increase in noise due to construction is considered to be a less than significant impact.

3.3 CONSTRUCTION NOISE MITIGATION

Since construction machines operate intermittently, and the types of machines in use at the Facility Site change with the stage of construction, noise emitted during construction will be mobile and highly variable, making it challenging to control. The construction management protocols will include the following noise mitigation measures to minimize noise impacts:

- Maintain all construction tools and equipment in good operating order according to manufacturers' specifications;
- Limit use of major excavating and earth-moving machinery to daytime hours;
- To the extent practicable, schedule construction activity during normal working hours on weekdays when higher sound levels are typically present, and are found acceptable. Some limited activities, such as concrete pours, will be required to occur continuously until completion;
- Equip any internal combustion engine used for any purpose on the job or related tothe job with a properly operating muffler that is free from rust, holes, and leaks;
- For construction devices that utilize internal combustion engines, ensure the engine's housing doors are kept closed, and install noise-insulating material mounted on the engine housing consistent with manufacturers' guidelines, if possible;
- Limit possible evening shift work to low noise activities such as welding, wire pulling, and other similar activities, together with appropriate material handling equipment;
- Utilize a Complaint Resolution Procedure to address anynoise complaints received from residents; and
- Posting signage showing overall construction schedule.

3.4 VIBRATION CALCULATION METHODOLOGY

Vibration levels for activities associated with Facility construction were based average of source levels in PPV published with the FTA (2006) Noise and Vibration Manual, which documents several types of construction equipment measured under a wide variety of construction activities. Using the documented vibration levels as input into a basic propagation model, construction vibration levels were calculated at the nearest Facility site boundary and then at the MLs.

3.5 PROJECTED VIBRATION LEVELS DURING CONSTRUCTION

As discussed in Section 3.2, Project construction will be completed in five work stages. This vibration level evaluated the worst-case vibration source, which will be pile driving. Based on vibration propagation calculations, construction vibration levels are predicted to range from 0.0002 PPV in/sec (33 VdB) to

0.0805 PPV in/sec (86 VdB) dBA at the MLs. These levels are based on the worst-case vibration producing equipment and it is expected that other vibration generating equipment proposed for the Facility construction will result in lower vibration levels. Table 9 summarizes the predicted vibration levels at each of the MLs based on the highest vibration generating equipment. As shown in Table 9, the Facility construction will comply with Section 83.01.090 of the County Development Code vibration threshold limit of 0.2 PPV in/sec.

Table 9. Projected Construction Vibration Levels

Construction Operation	Vibration Level Metric	FTA Construction Vibration Level (25 feet)	ML-1	ML-2	ML-3	ML-4	ML-5	ML-6	ML-7	ML-8
Pile Driving	PPV in/sec	0.644	0.0002	0.0307	0.0003	0.0247	0.0805	0.0239	0.0017	0.0325
	VdB	104	33	78	39	76	86	75	53	78

4.0 OPERATIONAL NOISE

This section describes the model utilized for the assessment; input assumptions used to calculate noise levels due to the Facility's normal operation; a conceptual noise mitigation strategy, and the results of the noise impact analysis.

4.1 NOISE PREDICTION MODEL

The Cadna-A® computer noise model was used to calculate sound pressure levels from the operation of the Facility equipment in the vicinity of the Facility Site. An industry standard, Cadna-A® was developed by DataKustik GmbH to provide an estimate of sound levels at distances from sources of known emission. It is used by acousticians and acoustic engineers due to the capability to accurately describe noise emission and propagation from complex facilities consisting of various equipment types like the Facility and in most cases, yields conservative results of operational noise levels in the surrounding community.

The current ISO standard for outdoor sound propagation, ISO 9613 Part 2 – "Attenuation of Sound during Propagation Outdoors," was used within Cadna-A (ISO 1996). The method described in this standard calculates sound attenuation under weather conditions that are favorable for sound propagation, such as for downwind propagation or atmospheric inversion, conditions which are typically considered worst-case. The calculation of sound propagation from source to receiver locations consists of full octave band sound frequency algorithms, which incorporate the following physical effects:

- Geometric spreading wave divergence;
- Reflection from surfaces;
- Atmospheric absorption at 10 degrees Celsius and 70 percent relative humidity;
- Screening by topography and obstacles;
- The effects of terrain features including relative elevations of noise sources;
- Sound power levels from stationary and mobile sources;
- The locations of noise-sensitive land use types;
- Intervening objects including buildings and barrier walls, to the extent included in the design;
- Ground effects due to areas of pavement and unpaved ground;
- Sound power at multiple frequencies;
- Source directivity factors;

- Multiple noise sources and source type (point, area, and/or line); and
- Averaging predicted sound levels over a given time.

Cadna-A allows for three basic types of sound sources to be introduced into the model: point, line, and area sources. Each noise-radiating element was modeled based on its noise emission pattern. Point sources were programmed for concentrated small dimension sources such as heating, ventilation, and air conditioning (HVAC) units that radiate sound hemispherically. Larger dimensional sources such as the transformers and inverters were modeled as area sources.

Off-site topography was obtained using the publicly available United States Geological Survey digital elevation data. A default ground attenuation factor of 0.5 was assumed for off-site sound propagation over acoustically “mixed” ground. A ground attenuation factor of 0.0 for a reflective surface was assumed for paved onsite areas.

The output from Cadna-A includes tabular sound level results at selected receiver locations and colored noise contour maps (isopleths) that show areas of equal and similar sound levels.

4.2 INPUT TO THE NOISE PREDICTION MODEL

The Facility’s general arrangement was reviewed and directly imported into the acoustic model so that on-site equipment could be easily identified; buildings and structures could be added; and sound emission data could be assigned to sources as appropriate. Figure 2 shows the Facility equipment layout based on REVAMP Engineering Drawing No. E200 dated February 2, 2018, which NRG provided to Tetra Tech on June 21, 2018.

The primary noise sources during operations are the inverters, transformers, and battery storage HVAC units. It is expected that this equipment will operate during the daytime period only. Reference sound power levels input to Cadna-A were provided by equipment manufacturers, based on information contained in reference documents or developed using empirical methods. The source levels used in the predictive modeling are based on estimated sound power levels that are generally deemed to be conservative. The projected operational noise levels are based on client-supplied sound power level data for the major sources of equipment. Table 10 summarizes the equipment sound power level data used as inputs to the initial modeling analysis.

Table 10. Modeled Octave Band Sound Power Level (L_P) for Major Pieces of Facility Equipment

Sound Source	Sound Power Level (L_P) by Octave Band Frequency dBL									Broadband Level
	31.5	63	125	250	500	1k	2k	4k	8k	dBA
Inverter	72	80	87	88	87	84	79	72	65	93
Inverter Distribution Transformer	69	75	77	72	72	66	61	56	49	81
Substation Transformer	82	88	90	85	85	79	74	69	62	94
Battery Storage HVAC Unit	--	107	96	96	98	99	95	89	83	102

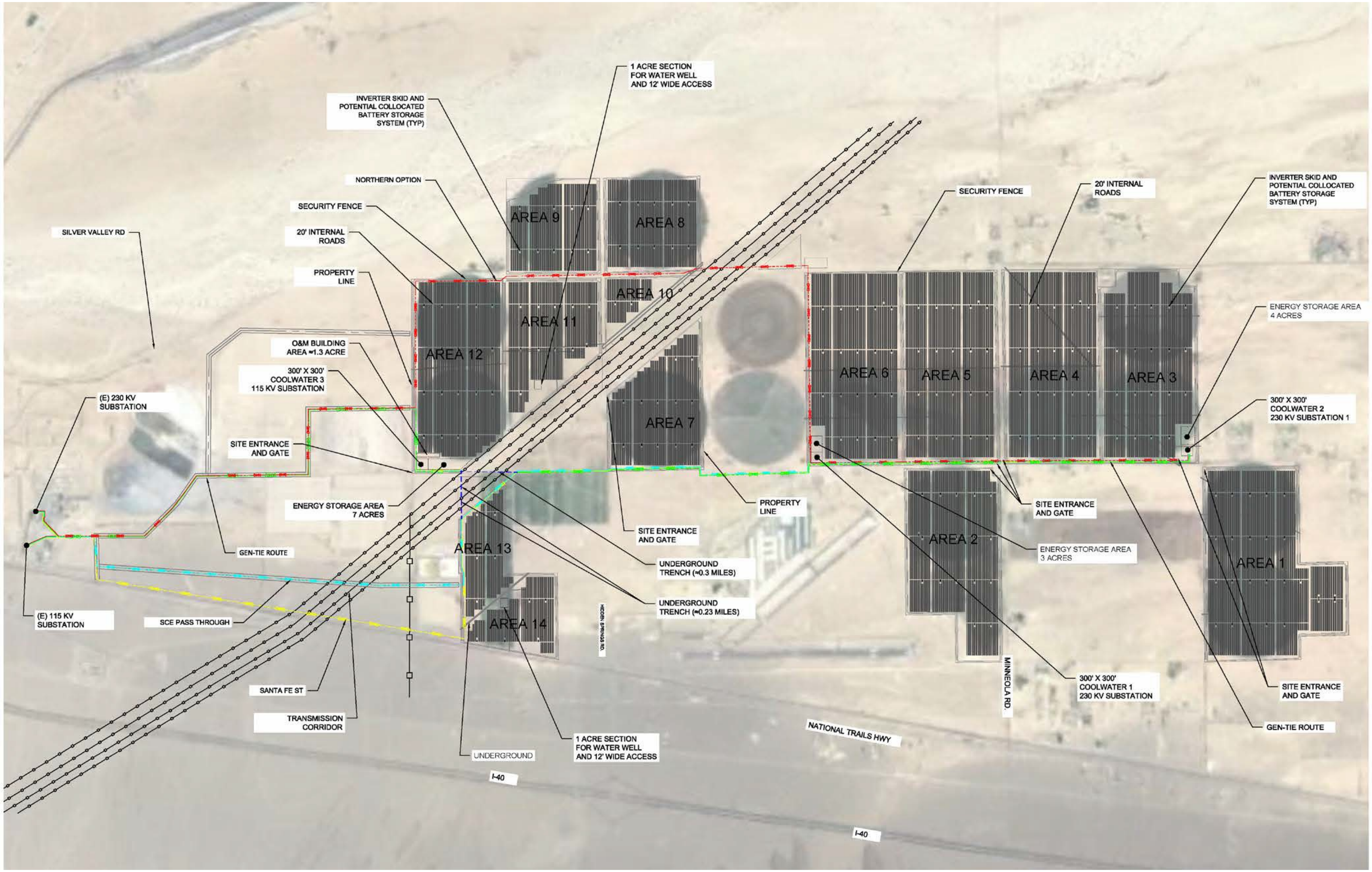

Figure 2. Facility Equipment Layout

4.3 NOISE PREDICTION MODEL RESULTS

Broadband (dBA) sound pressure levels were calculated for expected normal Facility operation assuming that all components identified previously are operating continuously and concurrently at the representative manufacturer-rated sound. The Facility equipment is expected to operate during the daytime period only. The sound energy was then summed to determine the equivalent continuous A-weighted downwind sound pressure level at a point of reception. Sound contour plots displaying broadband (dBA) sound levels presented as color-coded isopleths are provided in Figure 3. The noise contours are graphical representations of the cumulative noise associated with full operation of the equipment and show how operational noise would be distributed over the surrounding area within a 1-mile radius of the Facility Site. 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. Figure 3 also shows the ambient sound monitoring locations, representative of proximate noise sensitive land uses, that were used to assess potential noise impacts on a cumulative basis.

Table 11 shows the projected exterior sound levels resulting from full, normal operation of the Facility at the MLs. The table also provides the total predicted net increase in sound energy at each of the eight MLs, which are representative of proximate noise sensitive areas in each of the principal geographical directions relative to the Facility Site.

Table 11. Acoustic Modeling Results Summary

Monitoring Location	Daytime Ambient L_{eq}, dBA	Facility Sound Level, dBA	Total Sound Level (Ambient + Project), dBA	Net Increase in Sound Level, dBA
ML-1	50	28	50	0
ML-2	43	46	48	5
ML-3	39	33	40	1
ML-4	37	55	55	18
ML-5	46	41	47	1
ML-6	56	46	56	0
ML-7	49	40	50	1
ML-8	46	44	48	2

Normal Facility operations will only occur during the daytime operations, and the major noise-producing equipment will not operate during the nighttime period. Therefore, the Facility operations will comply with the County of San Bernardino's nighttime threshold limits of 45 dBA. The calculated noise level at ML-4 is shown to be right at the County's daytime threshold of 55 dBA. To reduce the noise levels at the sensitive receptors near ML-4 the battery storage containers located at the eastern portion of the Facility may be rotated so that the HVAC units are blocked by the storage units and are pointed away from any receptor. By rotating these battery storage containers, the noise levels at ML-4 will be reduced to 48 dBA and result in a noise level increase of 11 dB. With the rotated battery storage containers, the project will be well below theCounty's daytime threshold.

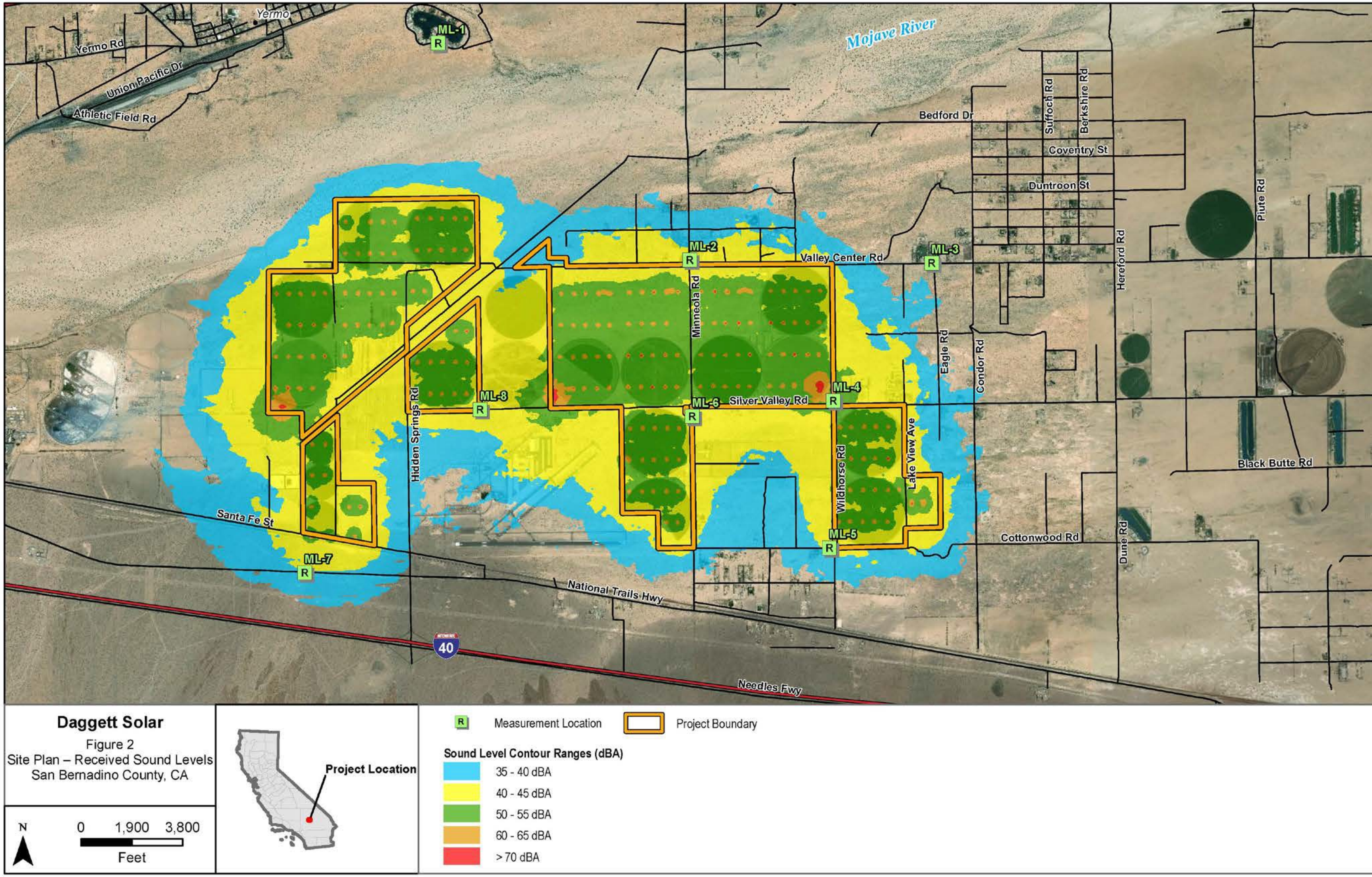

Figure 3. Received Sound Levels

4.4 GEN-TIE LINE NOISE ANALYSIS

Each of the Facility substations will incorporate a gen-tie line that would be constructed to connect the Facility's output to the electrical grid at the existing Southern California Edison (SCE)-owned 115-kV and 230-kV substations. Two primary alternative routes are being considered for the project gen-tie lines. These routes traverse the Facility site from east to west and would be primarily along Silver Valley Road. The alternative routes deviate on Powerline Road, with one alternative turning east at approximately the location of Santa Fe Road and the second alternative turning east using an existing roadway alignment to SCE's Coolwater substations. For both routes, the nearest sensitive residential receptor would be approximately 450 feet away from the gen-tie lines.

When a subtransmission line is in operation, an electric field is generated in the air surrounding the conductors, forming a corona. The corona results from the partial breakdown of the electrical insulating properties of the air surrounding the conductors. When the intensity of the electric field at the surface of the conductor exceeds the insulating strength of the surrounding air, a corona discharge occurs at the conductor surface, representing a small dissipation of heat and energy. Some of the energy may dissipate in the form of small local pressure changes that result in audible noise or in radio or television interference. Audible noise generated by corona discharge is characterized as a hissing or crackling sound that may be accompanied by a 120 Hz hum. Slight irregularities or water droplets on the conductor and/or insulator surface accentuate the electric field strength near the conductor surface, thereby making corona discharge and the associated audible noise more likely. Therefore, audible noise from subtransmission lines is generally a foul-weather phenomenon that results from wetting of the conductor. However, during fair weather, insects and dust on the conductors can also serve as sources of corona discharge.

The Electric Power Research Institute (EPRI) has conducted several studies of corona effects (EPRI 1978 and 1987). The typical noise levels for transmission lines with wet conductors are shown in Table 12.

Table 12. Transmission and Subtransmission Line Voltage and Audible Noise Levels

Line Voltage (kV)	Audible Noise Level Directly Below the Conductor (dBA)
138	34
240	40
360	51

As shown in Table 12, the audible noise associated with transmission and subtransmission lines decreases as the line voltage decreases; the audible noise associated with the 240-kV line is lower than 40 dBA and the audible noise associated with the 115-kV line is lower than 34 dBA. The noise levels from the Facility's gen-tie lines at the nearest sensitive residential receptor located 450 feet away will be less than 30 dBA. This noise level will comply with the County's nighttime threshold of 45 dBA and will result in a less than 1 dB increase to the existing ambient noise level.

5.0 CONCLUSIONS

The construction of the Facility has been organized into five broad work stages. Based on sound propagation calculations, construction sound levels are predicted to range from 45 to 53 dBA at the MLs. Periodically, sound levels may be higher or lower; however, the overall sound levels should generally be lower due to excess attenuation and the trend toward quieter construction equipment in the intervening decades since these data were developed. The highest projected sound level from construction-related activity is expected to occur at ML-5, ML-6, and ML-8, during activities associated with stage 3 and stage 4. Reasonable efforts will be made to minimize the impact of noise resulting from construction activities at proximate noise sensitive areas through the use of noise mitigation. Because of the temporary nature of the construction noise, no adverse or long-term effects are expected.

During the Facility construction, the worst-case vibration source will be pile driving. Based on vibration propagation calculations, construction vibration levels are predicted to range from 0.0002 PPV inches per second (in/sec) (32 VdB) to 0.0805 PPV in/sec (86 VdB) dBA at the MLs. These levels are based on the worst-case vibration-producing equipment and it is expected that other vibration-generating equipment proposed for the Facility construction will result in lower vibration levels. The Facility construction will comply with Section 83.01.090 of the County Development Code vibration threshold limit of 0.2 PPV in/sec.

Normal Facility operations will only occur during the daytime operations and the major noise-producing equipment will not operate during the nighttime period. Therefore, the Facility operations will comply with the County of San Bernardino's nighttime threshold limits of 45 dBA. The calculated noise level at ML-4 is shown to be right at the County's daytime threshold of 55 dBA. To reduce the noise levels at the sensitive receptors near ML-4 the battery storage containers located at the eastern portion of the Facility may be rotated so that the HVAC units are blocked by the storage units and are pointed away from any receptor. By rotating these battery storage containers, the noise levels at ML-4 will be reduced to 48 dBA and result in a noise level increase of 11 dB. With the rotated battery storage containers, the project will be well below the County's daytime threshold.

Each of the Facility substations will incorporate a gen-tie line that would be constructed to connect the Facility's output to the electrical grid at the existing SCE-owned 115-kV and 230-kV substations. The audible noise associated with the 240-kV line is lower than 40 dBA and the audible noise associated with the 115-kV line is lower than 34 dBA. The noise levels from the Facility's gen-tie lines at the nearest sensitive residential receptor located 450 feet away will be less than 30 dBA. This noise level will comply with the County's nighttime threshold of 45 dBA and will result in a less than 1 dB increase to the existing ambient noise level.

6.0 REFERENCES

County of San Bernardino. 2007. General Plan

County of San Bernardino. 2014. Development Code.

FTA (Federal Transit Authority). 2006. Transit Noise and Vibration Impact Assessment Manual.

ISO (International Organization for Standards). 1996. Acoustics – Attenuation of Sound during Propagation Outdoors. Part 2: General Method of Calculation. ISO Standard 9613-2. Geneva, Switzerland.

Kurze, U., and L. Beranek. 1988. Noise and Vibration Control. Institute of Noise Control Engineering, Washington, DC.

USEPA (United States Environmental Protection Agency). 1971. Technical Document NTID300.1, Noise from Construction Equipment and Operations, US Building Equipment, and Home Appliances. Prepared by Bolt Beranek and Newman for USEPA Office of Noise Abatement and Control, Washington, DC. December 1971.

APPENDIX A: EQUIPMENT CALIBRATION CERTIFICATES

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; **ANSI** S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class O; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class O; 61252-2002.

Manufacturer:	Larson Davis	Temperature:	71.1	OF
Model Number:	831		21.72	OC
Serial Number:	4278	Rel. Humidity:	40.7	%
Customer:	TMS Rental	Pressure:	998.9	mbars
Description:	Sound Level Meter		998.9	hPa

Note: As Found/As Left: In Tolerance

Upon receipt for testing, this instrument was found to be:

Wlthin the stated tolerance of the manufacturer's specification.

Calibration Date: 2/16/2018 Calibration Due:

Calibration Standards Used:

Manufacturer	Model	Serial Number	Cal Due
Stanford Research Systems	OS360	123270	4/25/2018

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy/ uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

The results documented In this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except In full, without the written approval of The Modal Shop.

Technician: Adam Magee Signature:

THE MODAL SHOP
A PCB GROUP CO.

3149 East Kemper Road
Cincinnati, OH. 45241
Phone: (513) 351-9919
(800) 860-4867
www.modalshop.com

r.J Certificate of Calibration and Compliance r.J

Microphone Model: 377B02 Serial Number: 304093 Manufacturer: PCB

Calibration Environmental Conditions

Environmental *test* conditions as printed on microphone calibration chart.

Reference Equipment

Manufaclurer	**Model#**	Serial#	PCB Control #	Cal **Date**	**Due Dale**
National Instruments	PClc-6351	1896F08	CA19l8	10/20117	10/19/18
I.anon Davis	PRM915	146	*CA211S*	2/15/17	2/IS/18
I.anon Davis	PRM902	4943	CA1162	11/13/17	11/13/18
Larson Davis	PRM916	104	LDOI5	2/15/17	2/lS/18
Larson Davis	CAUSO	**SI09**	CA1496	10/19/17	10/19/18
Larson Davis	2201	140	CA890	5/3/17	S/3/18
Brucl & Kjacr	4192	2954556	CA2323	9/15/17	9/14/18
Larson Davis	OPRM902	3999	CAI090	9/20/17	9!20/18
Newport	ITHX-SD/N	1080002	CA!Sll	2/14/17	2/14/18
Larson Davis	PRA9S1-4	241	CA1449	10!26/17	10/26/18
Larson Davis	PRM91S	147	CA2179	6/6/17	6/6/18
PCB	68S10-02	*NIA*	CA2672	12!27/17	12127/18
0	0	0	0	not rcqum:d	not **required**
0	0	0	0	not required	not required
0	0	0	0	not required	not n:quifcd

Frequency sweep perfonned with B&K UA0033 electrostatic actuator.

Condition of Unit

A!!. Found: n/a

A!!. Left: New Unit, In Tolerance

Notes

I. Calibration of reference equipment Is traceable to one or more of the followlng National Labs; NIST, PTB or DFM.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piczolronlcs, Inc.
3. Calibration ls performed in compliance with ISO 10012-1, ANSI/NCSL Z540.3 and ISO 17025.
4. Sec Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Open Circuit Sensitivity is measured using the insertion voltage method following procedure AT603-5.
6. Measurement uncertainty (95% confidence level with coverage factor of 2) for sensitivity is +/-0.20 dB.
7. Unit calibrated per ACS-20.

Technician: Leonard Lukasik ll, Date: January 30, 2018

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3425 Walden Avenue, Depew, New York, 14043
TEL: 888-684-0013 FAX: 716-685-3886 \VWIY.pcb,com

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CD:CA.tf2-aaotlM11

l'lplo/2

,..,, *Calibration Report* ,..,,

Microphone Model: 377B02 | Serial Number: 304093 | Description: 1/2" Free-Field Microphone

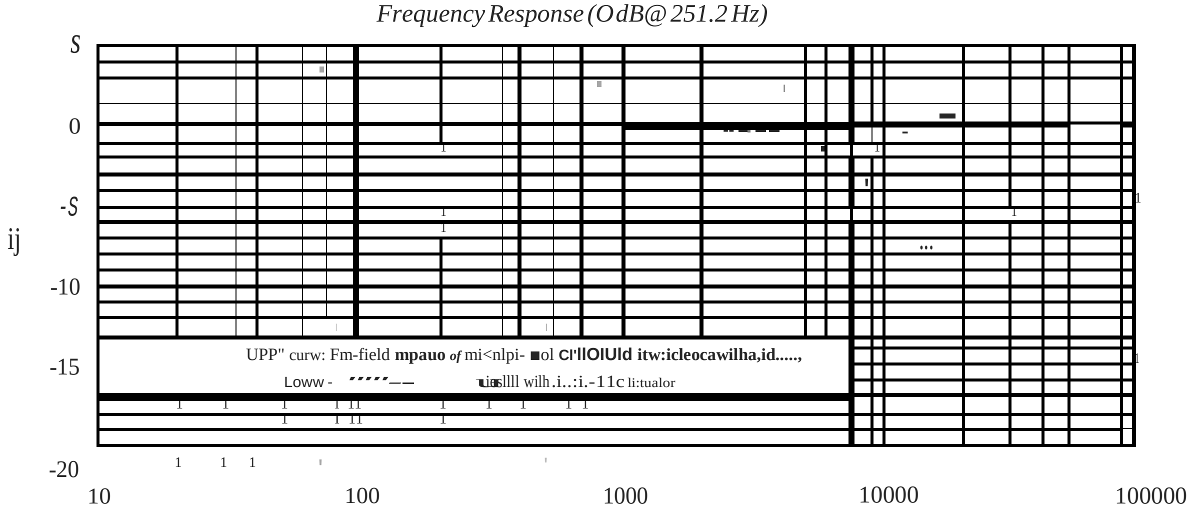
Calibration Data

Open Circuit Sensitivity @ 251.2 Hz: 5I.90 mV/Pa | Polarization Voltage, External: 0 V

-25.7 dB re 1V/Pa | Capacitance: 12.8 pF

Temperature: 67 °F (l9°C) | Ambient Pressure: 996 mbar | Relative Humidity: 24 %

Frequency Response (OdB@ 251.2 Hz)



Freq (Hz)	Lower (dB)	Upper (dB)	Freq (Hz)	Lower (dB)	Upper (dB)	rreq (Hz)	Lower (dB)	Upper {dB)	Freq (Hz)	Lower (dB)	Upper (dB)
20.0	0.09	0.09	1679	-0.14	0.09	7499	-2.69	0.38			
25.1	0.05	0.05	1778	-0.14	0.11	7943	-3 Ol	0.38			
31.6	005	0.0S	1884	-0.16	0.12	8414	-3.46	0.27			
39.8	007	0.07	1995	-0,18	0,13	8913	-3,87	0,24			
50.1	OOS	0,05	2114	-020	0.14	9441	•4,40	0.12			
63.1	0.06	0.06	2239	-0.22	0,15	10000	-5.08	-0.13			
79.4	0.03	0.03	2371	-0.24	0.17	10593	-5.60	-0.20			
1000	O.oJ	0 0	2512	-0.26	0.20	11220	-6.20	-0.34			
125.9	0.o2	0 0	2661	-0.30	0.21	1188S	-6.76	-0.44			
158.5	0.02	0.02	2818	-0.34	0.22	**12589**	-7.10	-0.33			
199,S	0.01	0,01	298S	-0.37	0.25	13335	-7.3S	-0.16			
251.2	0.00	0.00	3162	-0.43	0.2S	14125	-7.63	-0.04			
316.2	0.00	001	3350	-0.49	0.25	14962	-7.8S	0.12			
398.1	-0.01	-0.01	3548	-0.56	026	15849	-8.09	0.26			
501.2	-0.01	0.03	3758	-0.63	028	16788	-8.31	0.41			
631.0	-0.02	0.02	3981	-0.70	0.30	17783	-8 60	0.51			
794.3	-0.04	0.05	4217	-0.80	0.31	18837	-9.00	0.51			
1000.0	-0.05	0.07	4467	-0.93	0.30	19 953	-9.71	0.22			
10S9.3	-0.06	0.07	4732	-1.04	0.34						
1122.0	-0.07	0.07	5012	*-I.IS*	0.38						
1188.5	-0.07	0.08	*5309*	-1.31	0.39						
1258.9	-0.08	0.08	5623	-1.48	0.41						
1333.5	-0.09	0.09	S957	-1.6S	0.42						
1412.S	-0.10	0.09	6310	·I.BS	**0.44**						
1496.2	-0.11	0.09	**6683**	-2.13	0.39						
IS84.9	-0.12	0.09	7080	-2.41	0.37						

Technician: Leonard Lukasik *lu* | Date: January 30, 2018

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FAX; 716-685-3886

www.pcb.com

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Calibration Certificate

Certificate Number 2017011339

Customer.
The **Modal** Shop
3149 East Ki:mper Road
Clnclnnat OH 45241, United State,

Model Number	CAL200	*Procedure Number*	00001.8386		
Ser/al Number	12960	*Technician*	Scott Montgomery		
Test Results	Pass	*Celtbratlon Date*	27 Oct 2017		
Initial Condition	Inoperable	*Calibration Due*	27 Oct **2018**		
		Temperature	23	·c	±o.J·c
Description	Larson Davis CAL200 Acoustic Calibrator	*Humidity*	33	%RH	±3%RH
		Static Pressure	101.5	kPa	± 1 kPa

Evaluation Method The data is aqulred by the Insert voltage calibration method using the reference microphone's open circuit sensitivity. Data reported in dB re 20 µPa.

Compliance Standards Compliant to Manufacturer Specifications per D0001.8190 and the following standards:
IEC 60942:2003 ANSI 51.40-2006

Issuing lab certifies that the lnslrument described above meets *or* exceeds all speclllcatlons as stated ln1he referenced procedure (unless otheMise noted). Il has been calibrated using measurement standards traceable to the SIlhrough the National lnsUtute of Standards end Technology (NIST), or other national measurement institutes, end meeta the requirements or ISO/lEC 17025:2005. Test points marked with a ; In the uncartalntlas column do not fall within thla laboratory's **acopa** of accreditation.

The qua51y system Is registered lo ISO 9001:2008.

This calibration Is a dlrecl comparison of the unit under test to the llsled reference standards and did not Involve any sampling plans to complete. No allowance has been made for the lnslabillty of 1he test devlca due to use, Ume, etc. Such allowances would be made by the customer as needed.

The uncertalnUes were computed in accordance with the ISO Gulde to the Expression of Uncertainty In Measurement (GUM). A coverage factor or approximately 2 sigma (k=2) has been applied to the standard uncestalnty to express the expanded uncertafnly et approximately 95% conlldence level.

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Slanili rcts J'sed

Description	Cal Date	Cal Due	Cal Slamlard
Aailcnt 34401A DMM	09/06/20)7	09/06/2018	001021
Larson Davis Model 2900 Real Time Analyzer	04/10/20)7	04/10/2018	OOI0SJ
Microphone Calibration System	08/08/2017	08/08/2018	005446
1/2" Preamplifier	I0/0S/2017	IO/OS/2018	006506
Larson Davis 1/2" Preamplifier 7-pin LEMO	08/08/2017	08/08/2018	006507
J/2 inch Microphone• RI• 200V	04/24/2017	04/24/2018	0065)0
Pressure Transducer	06/01/2017	06/0J/2018	007310

Output Level

Nominal Level [dB]	Pressure [kPa]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
114	101.2	114.00	113.80	114.20	0.13	Pass
94	101.5	93.99	93.80	94.20	0.14	Pass

- End of measurement results-

Frequency

Nominal Level [dB]	Pressure [kPa]	Test Result [Hz]	Lower limit [Hz]	Upper limit [Hz]	Expanded Uncertainty [Hz]	Result
94	101.5	1,000.19	990.00	1,010.00	0.20	Pass
114	1012	1,000.18	980.00	1,010.00	0.20	Pass

- End or **measurement** resulls-

Total Harmonic Distortion+ Norse (THD+N)

Nominal Level [dB]	Pressure [kPa]	Test Result [%]	Lower limit [%]	Upper limit [%]	Expanded Uncertainty [%]	Result
94	101.5	0.53	0.00	2.00	0.25	Pass
114	101.2	0.41	0.00	2.00	0.25	Pass

- End or measurement resulls-

Level Change Over Pressure

Tested at; 114 dB, 24 •C, 30 %RH

Nominal Pressure [kPa]	Pressure [kPa]	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
101.3	101.3	0.00	-0.30	0.30	0.04 :j:	Pass
74.0	74.1	0.00	-0.30	0.30	0.04:f:	Pass
108.0	108.0	-0.05	-0.30	0.30	0.04:f:	Pass
92.0	91.9	0.04	-0.30	0.30	0.04 :f:	Pass
83.0	82.9	0.05	-0.30	0.30	0.04 :f:	Pass
65.0	65.2	-0.14	-0.30	0.30	0.04 :t:	Pass

- End **or measurement** resulls-

Frequency Change Over Pressure

Tested al: 114 dB, 24 •C, 30 %RH

Nominal Pressure [kPa]	[illegible]	[illegible]	[illegible]	[illegible]	Expanded Uncertainty [Hz]	Result
108.0	--- -	- --	.- --	10.00	0.20 :j:	Pass
101.3	101.3	0.00	-10.00	10.00	0.20:t:	Pass
92.0	91.9	0.01	-10.00	10.00	0.20:t:	Pass
83.0	82.9	0.00	-10.00	10.00	0.20 :t:	Pass
74.0	74,1	0.00	-10.00	10.00	0.20:t:	Pass
65.0	65.2	0,00	-10.00	10.00	0.20:t:	Pass

- End of measurement results-t

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Total Harmonic Distortion + Noise (THD+N) Over Pressure

Tested el: 114 dB, 24 •C, 30 %RH

Nominal Pressure [kPa]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Result
65.0	[illegible]	[illegible]	[illegible]	[illegible]	0.25:I:	Pass
108.0	108.0	0.41	0.00	2.00	0.25:I:	Pass
101.3	101.3	0.41	0.00	2.00	0.25:1:	Pass
92.0	91.9	0.43	0.00	2.00	0.25:1:	Pass
83.0	82.9	0.45	0.00	2.00	0.25:1:	Pass
74.0	74.1	0.47	0,00	2.00	0.25:1:	Pass

•· End of measurement results-

Signatory: $'42:it:*Mcnf9(l'lllll.f.r!J*