APPENDIX G

NOISE ANALYSIS

RECON

Noise Analysis for the Drew Solar Project, Imperial County, California

Prepared for
Drew Solar, LLC
PO Box 317
El Centro, CA 92244

Prepared by
RECON Environmental, Inc.
1927 Fifth Avenue
San Diego, CA 92101
P 619.308.9333

RECON Number 8653
July 24, 2018

Jack T. Emerson, Noise Specialist

William A. Maddux, Senior Noise Specialist

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

FIGURES

TABLES

ATTACHMENTS

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
CAISO	California Independent Service Operator
Caltrans	California Department of Transportation
CNEL	community noise equivalent level
County	County of Imperial
CUP	Conditional Use Permit
dB	decibel
dB(A)	A-weighted decibel
Drew Switchyard	San Diego Gas and Electric Drew Switchyard
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HVAC	heating, ventilation, and air conditioning
L_{eq}	equivalent noise level
$L_{eq(8h)}$	8-hour equivalent noise level
LOS	Level of Service
L_{pw}	sound power
NEMA	National Electrical Manufacturers Association
PPV	peak particle velocity
SDG&E	San Diego Gas and Electric
SoundPlan	SoundPlan Essential
SR-98	State Route 98

Executive Summary

The Drew Solar Project (project) would involve construction of an approximately 100-megawatt (MW) alternating current solar generation facility and energy storage facility on an 844.2 gross-acre (855 gross-acre after the project's Parcel Map is recorded) and 762.8 net farmable-acre project site in the unincorporated Mount Signal area in Imperial County, California. This report discusses potential noise impacts from the construction and operation of the project. The potential for noise impacts to adjacent receptors from construction and operation of future uses on the project site was assessed based on noise level limits from the Imperial County (County) General Plan Noise Element.

Construction Noise

Site preparation and facility installation would include the use of a variety of noise-generating equipment such as scrapers, excavators, loaders, and water trucks, along with others. During construction, average 8-hour equivalent noise levels ($L_{eq[8h]}$) would attenuate to 46 A-weighted decibels (dB(A)) $L_{eq(8h)}$ at the property line of the nearest residence (the single-family residence immediately west of the intersection of Drew Road and State Route 98) within the project site boundaries. When construction activities are focused in smaller areas near the project site boundary, construction noise levels would reach 58 dB(A) $L_{eq(8h)}$ at the property line of the nearest residence (the single-family residence immediately west of the intersection of Drew Road and State Route 98). Project construction noise levels would comply with 75 dB(A) $L_{eq(8h)}$ noise level limit established by the County General Plan Noise Element. Impacts would be less than significant.

Operations Noise

Stationary sources of noise associated with the operation of the project energy generation and storage facilities would include inverters, transformers, solar panel tracker motors, a substation, and transmission gen-tie lines. Noise associated with project operation would attenuate to less than 50 dB(A) L_{eq} within the project site boundary. On-site generated noise would attenuate to 44 dB(A) L_{eq} at the nearest single-family residence immediately (west of the intersection of Drew Road and State Route 98. Noise levels would not exceed applicable daytime or nighttime property line noise level limits from the County General Plan Noise Element. Therefore, noise associated with project operations would be less than significant.

Operational Traffic Noise

During operations, project-generated traffic would increase volumes on local roadways and thereby increase traffic noise levels in the project area. Project trip generation would be extremely limited–up to 20 trips per day. Ambient noise level increases attributable to project-generated traffic are anticipated to be less than 3 dB(A) and thus would be less than barely perceptible. Impacts would be less than significant.

Vibration

Construction Vibration

Project construction would include the use of vibration-generating construction equipment such as large bulldozers, loaded trucks, jackhammers, and mast impact pile drivers. Peak particle velocity at the nearest structure would be anticipated to reach up to 0.073 inch per second at the nearest structure. These vibration levels are not anticipated to result in structural damage and would be less than barely perceptible. Groundborne noise and vibration impacts would be less than significant.

Operation Vibration

Project operation would not include any substantial sources of groundborne vibration. No vibration impacts would result from project operation.

1.0 Introduction

1.1 Project Description

The Drew Solar Project (project) is a proposed solar photovoltaic generation facility and energy storage facility located in Imperial County, California. The project site is located in the unincorporated Mount Signal area, approximately 6.5 miles southwest of the city of El Centro and approximately 1.85 miles north of the U.S.-Mexico border. Figure 1 shows the regional location of the project site.

The project site is approximately 762.8 net farmable acres or 844.2 gross acres (855 gross acres after the project's Parcel Map is recorded) and is comprised of six parcels: Assessor Parcel Numbers (APN) 052-170-031, 052-170-032, 052-170-037, 052-170-039, 052-170-056, and 052-170-067. The project site is bounded by Kubler Road to the north, Westside Main and Wormwood Canals to the west, State Route 98 (SR-98) to the south, and Pulliam Road to the east. Agricultural uses are located on the project site and properties to the north, west, and southwest. Solar generation facilities are located on properties to the east and south of the project site. Nearby noise-sensitive receivers include a single-family residence located immediately west of the intersection of Drew Road and SR-98 (approximately 100 feet from project site) and a single-family residence located northeast of the intersection of Kubler Road and Pulliam Road (approximately 400 feet from project site). Figure 2 shows an aerial photograph of the project site and vicinity.

The purpose of the project is to generate approximately 100 MW of renewable electricity, and the storage of power both generated by the project and from the grid operated by the California Independent Service Operator (CAISO) for the State of California. Five solar power generation and potential energy storage conditional use permits (CUPs) are proposed, and a sixth CUP for energy storage as a component of solar. The project may include an operations and maintenance (O&M) building or buildings, substation(s), photovoltaic modules mounted on horizontal single-axis trackers, energy storage facilities, inverters, internal roadways, and possibly also auxiliary improvements for storm water retention, fire water storage, water filtration and treatment, equipment control buildings, septic systems, and parking. The project would connect to San Diego Gas & Electric's (SDG&E) Drew Switchyard (Drew Switchyard), which is located immediately south of the project, across SR-98, for power transmission to the CAISO grid. Figure 3 shows the anticipated site plan.

The project may also incorporate an energy storage component. The field of energy storage is rapidly advancing; thus a single technology or provider has not been selected for the energy storage component of the project. The storage component may be centralized and located adjacent to the substation, or alternatively, the energy storage component may be distributed throughout the plant adjacent to individual power conversion centers. The storage component would be housed in a warehouse type building or alternatively in modular structures such as cargo shipping containers.

The project site is owned by Imperial Irrigation District and would be leased by the Applicant for at least the duration of the Development Agreement. Project development would be phased, with renewable energy generation and energy storage facilities developed at a flexible rate based on market conditions and changing utility procurement plans. Development phases would occur under up to six separate CUPs. Under the development agreement, the CUPs will be valid for 40 years with up to 10 years to commence construction. After the conclusion of the term of the CUPs, the project entitlements require the Applicant to decommission the site and restore it to farmland uses in accordance with a future reclamation Plan.

Project approvals would include the Development Agreement, Zone Change to add Renewable Energy (RE) Overlay, General Plan Amendment of the Renewable Energy and Transmission Element, 6 CUPs, a Parcel Map, 2 Lot-Tie Agreements, a Variance for power pole height requirements, and certification of the Environmental Impact Report.

1.1.1 Project Construction and Phasing

The construction schedule would be phased based on market conditions and changing utility procurement plans; the specific phasing is not known at this time but may occur over 10 years following approval of the CUPs. If the project construction were to occur in a single phase, construction would take place over approximately 18 months.

No structures are present on the project site and the project site has previously been graded to accommodate agricultural uses. The construction would involve site preparation activities such as clearing, grading, perimeter fencing, development of staging areas and site access roads; and would involve facility installation activities such as installation of support masts (impact pile driving), trenching utility connections, installation of racks and panels on support masts, installation of energy storage facilities including building and/or shipping containers, construction of electrical distribution facilities, construction of the O&M building(s), and construction of substation(s) and gen-tie(s). Daily trip generation during the construction would include up to 436 worker commute trips per day and 10 average daily hauling trips (up to 40 heavy-duty truck trips per day).

1.1.2 Project Operation

Operation of the project would require routine maintenance and security; the operations phase will have approximately 10 full-time personnel. The project would generate up to 20 trips per day.

1.1.3 Project Decommissioning

Consistent with the County of Imperial (County) decommissioning requirements, the project site would be restored to its existing condition upon project conclusion. Although there have been no solar facilities decommissioned in Imperial County, the activities and equipment involved in decommissioning are anticipated to be similar to those involved in construction, thus decommissioning would result in similar noise levels as construction.

1.2 Fundamentals of Noise

Noise is defined as a loud or unpleasant sound that causes disturbance. Sound levels are described in units called the decibel (dB). Decibels are measured on a logarithmic scale that quantifies sound intensity in a manner similar to the Richter scale used for earthquake magnitudes. Thus, a doubling of the energy of a noise source, such as doubling of traffic volume, would increase the noise level by 3 dB; a halving of the energy would result in a 3 dB decrease.

In technical terms, sound levels are described as either a "sound power level" or a "sound pressure level," which while commonly confused are two distinct characteristics of sound. Both share the same unit of measure, the dB. However, sound power, expressed as L_{pw}, is the energy converted into sound by the source. As sound energy travels through the air, it creates a sound wave that exerts pressure on receivers such as an eardrum or microphone, the sound pressure level. Sound measurement instruments only measure sound pressure, and limits used in standards are generally sound pressure levels.

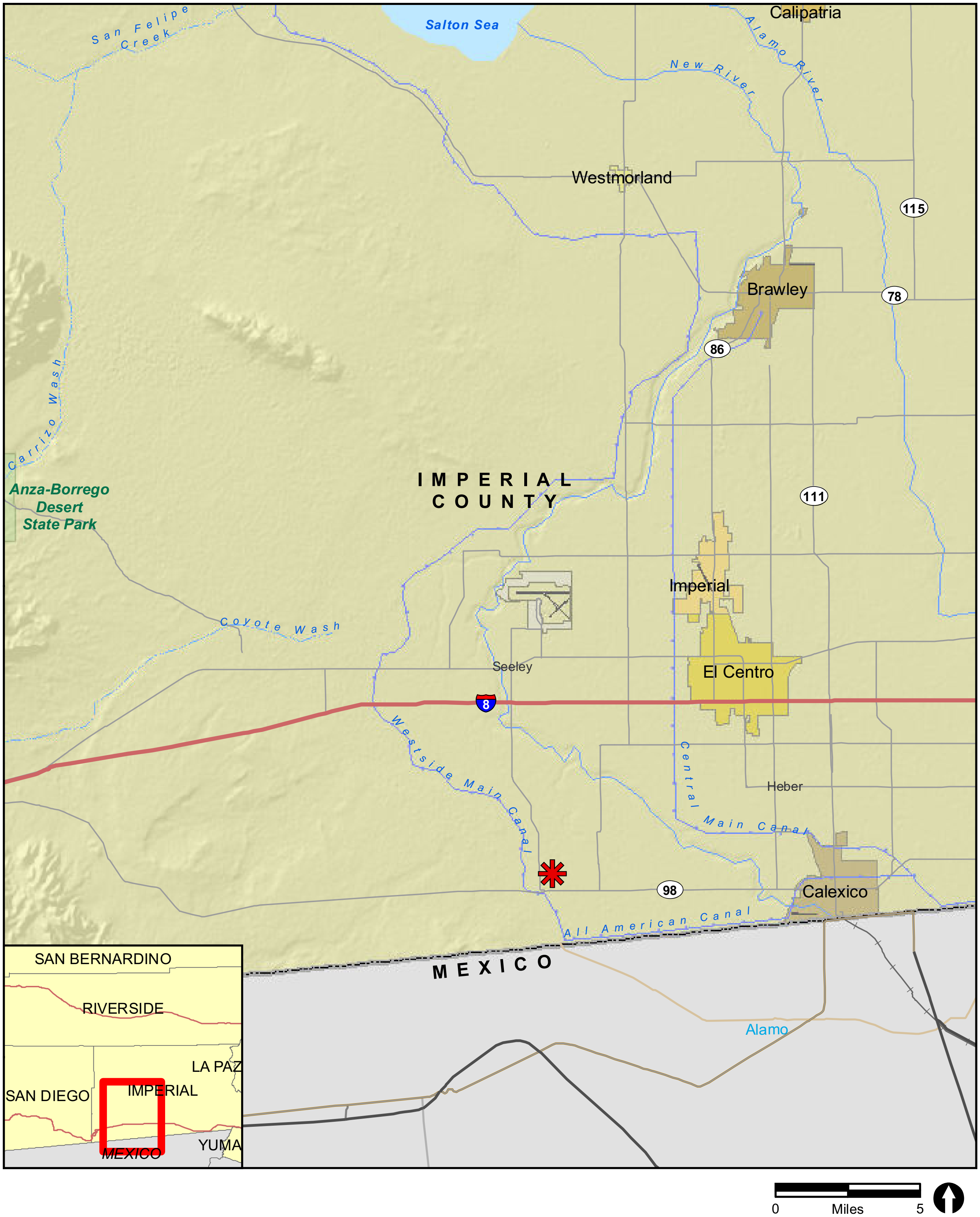
The human ear is not equally sensitive to all frequencies within the sound spectrum. To accommodate this phenomenon, the A-scale, which approximates the frequency response of the average young ear when listening to most ordinary everyday sounds, was devised. When people make relative judgments of the loudness or annoyance of a sound, their judgments correlate well with the A-scale levels of those sounds. Therefore, the "A-weighted" noise scale is used for measurements and standards involving the human perception of noise.

Noise levels using A-weighted measurements are designated with the notation dB(A). Changes in noise levels are generally perceived by the average human ear as follows: 3 dB(A) is barely perceptible, 5 dB(A) is readily perceptible, and 10 dB(A) is perceived as a doubling or halving of noise (California Department of Transportation [Caltrans] 2013a).

1.2.1 Descriptors

The impact of noise is not a function of loudness alone. The time of day when noise occurs and the duration of the noise are also important. In addition, most noise that lasts for more than a few seconds is variable in its intensity. Consequently, a variety of noise descriptors has been developed. Consistent with the County's General Plan Noise Element, the noise descriptors used for this study are the equivalent noise level (L_{eq}) and the community noise equivalent level (CNEL). The L_{eq} is the equivalent steady-state noise level in a stated period of time that is calculated by averaging the sound energy over a time period; when no period is specified, a 1-hour period is assumed. The CNEL is a 24-hour equivalent sound level.

The CNEL calculation applies an additional 5 A-weighted decibels dB(A) penalty to noise occurring during evening hours, between 7:00 p.m. and 10:00 p.m., and a 10 dB(A) penalty is added to noise occurring during the night, between 10:00 p.m. and 7:00 a.m. These increases for certain times are intended to account for the added sensitivity of humans to noise during the evening and night.



Project Location

FIGURE 1
Regional Location

RECON

M:\JOBS5\8653\common_gis\fig1.mxd 11/29/2017 sab

Image Source: USDA FSA NAIP (flown May 2016)

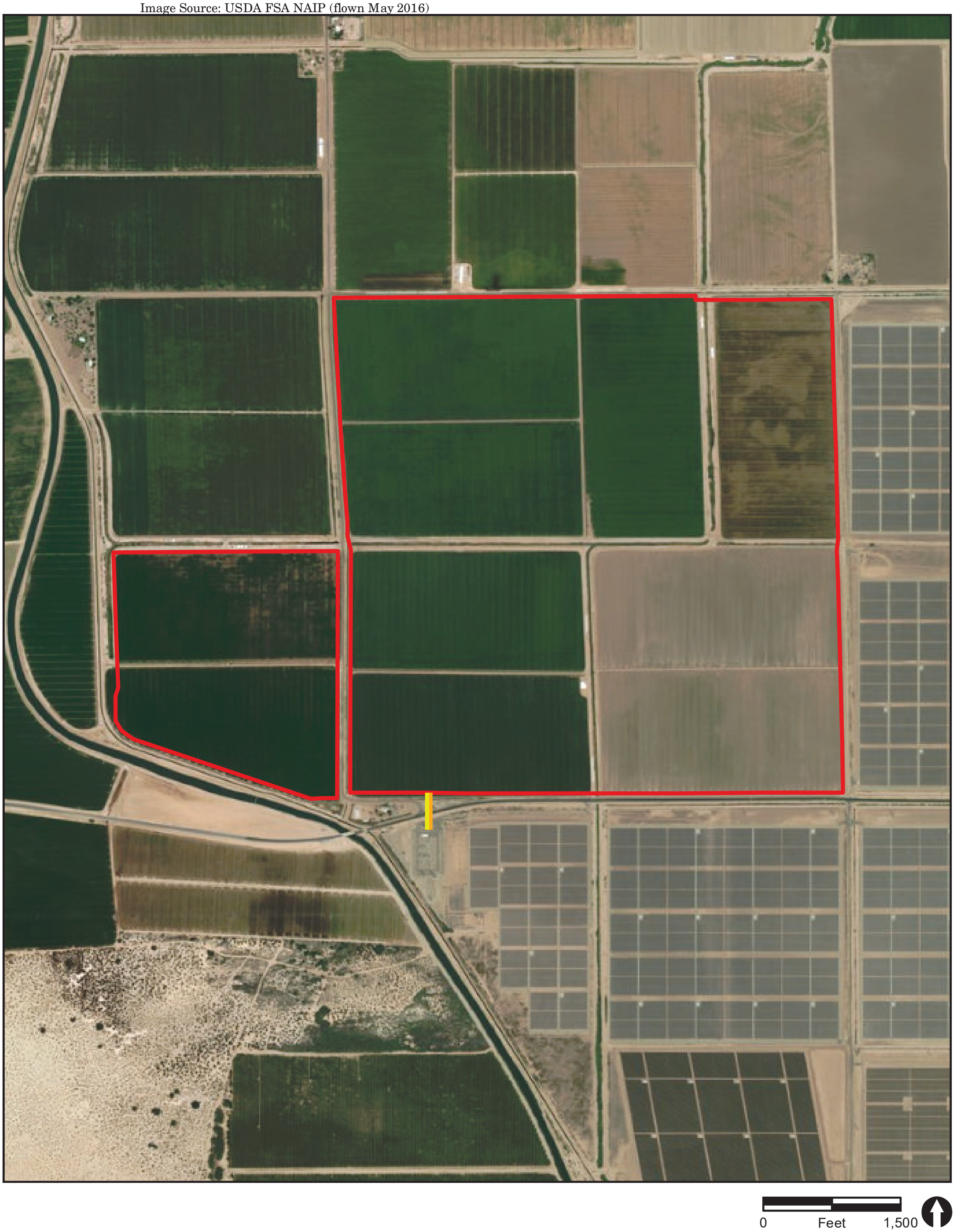


FIGURE 2

Project Location on Aerial Photograph

RECON

M:\JOBS5\8653\common_gis\fig2_nos.mxd 5/17/2018 sab

Image Source: USDA FSA NAIP (flown May 2016)

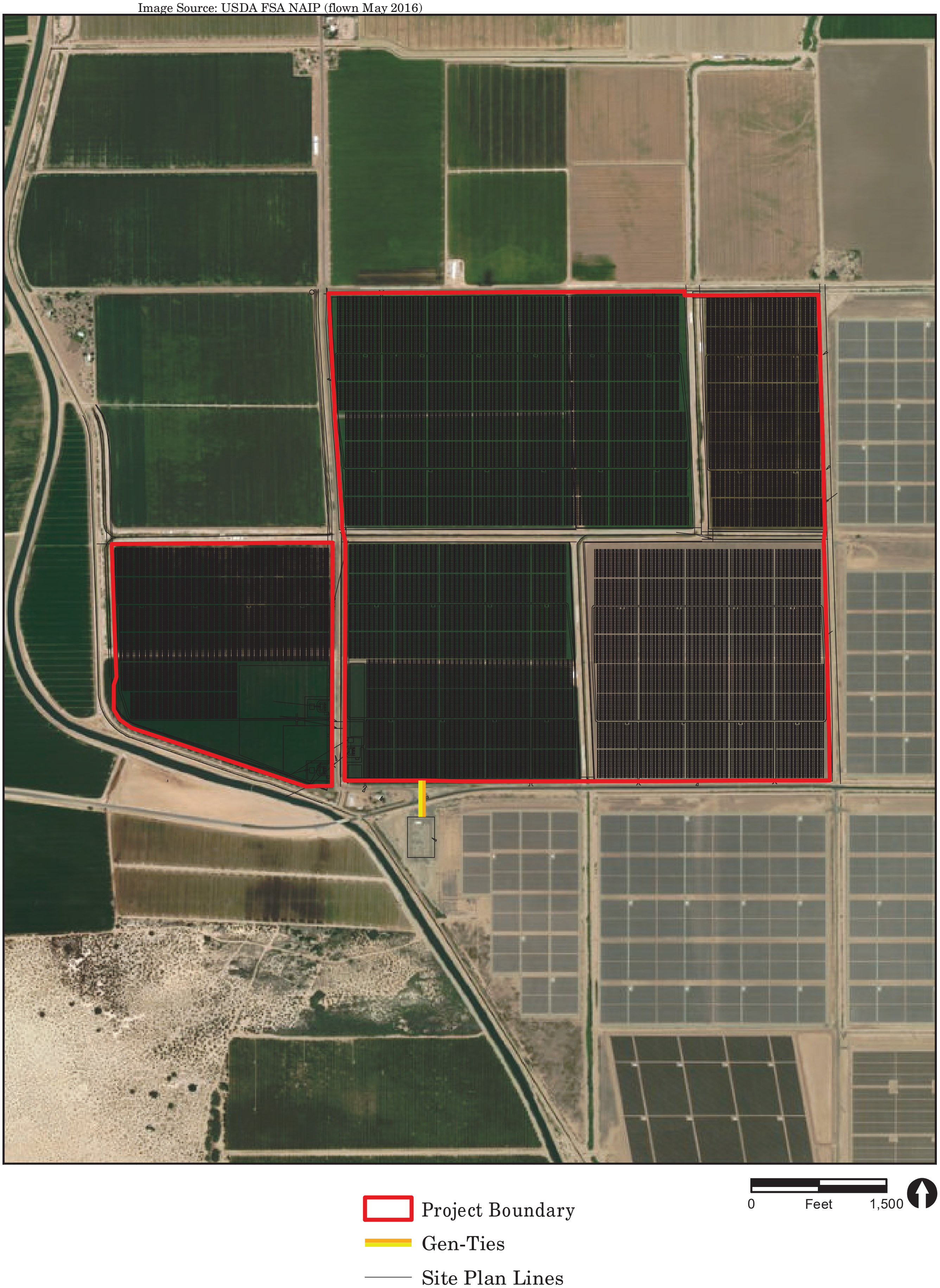


FIGURE 3
Site Plan

RECON

M:\JOBS5\8653\common_gis\fig3_nos.mxd 5/17/2018 sab

1.2.2 Propagation

Sound from a small, localized source (approximating a “point” source) radiates uniformly outward as it travels away from the source in a spherical pattern, known as geometric spreading. The sound level decreases or drops off at a rate (drop-off rate) of 6 dB(A) for each doubling of the distance.

Traffic noise is not a single, stationary point source of sound. The movement of vehicles makes the source of the sound appear to emanate from a line (line source) rather than a point when viewed over some time interval. The drop off rate for a line source is 3 dB(A) for each doubling of distance.

The propagation of noise is also affected by the intervening ground, known as ground absorption. A hard site (such as parking lots or smooth bodies of water) receives no additional ground attenuation, and the changes in noise levels with distance are simply the geometric spreading from the source, which equates to 6 dB(A) per doubling distance. A soft site (such as soft dirt, grass, or scattered bushes and trees) provides an additional ground attenuation value of 1.5 dB(A) per doubling of distance. Thus, a point source over a soft site would drop off at 7.5 dB(A) per doubling of distance.

2.0 Existing Conditions

2.1 Land Use Environment

The project site is located in the unincorporated Mount Signal area. All parcels in the vicinity of the project site are zoned General Agricultural (A2), General Agricultural/Rural Zone (A2R), or Heavy Agricultural (A-3). The General Plan land use designation for all parcels in the immediate vicinity of the project site is Agriculture; west of the Westside Main Canal, the General Plan land use designation is generally Recreation/Open Space.

Agricultural uses are located on the project site and properties to the north, west, and southwest; associated buildings include a single-family residence located immediately west of the intersection of Drew Road and SR-98 (approximately 100 feet from project site), and a single-family residence is located northeast of the intersection of Kubler Road and Pulliam Road (approximately 400 feet from project site). Additionally, three single-family residences are located to the west of the intersection of Kubler Road and Drew Road (approximately 0.5 miles west of the Drew Solar Project site).

Solar generation facilities are located on properties to the east and south of the project site; associated buildings include an O&M building at the SDG&E Drew Switchyard (approximately 400 feet from the Drew Solar Project site), and an O&M building at the Centinela Solar Project (approximately 0.7 miles east of the Drew Solar Project site).

2.2 Transportation Network

Mapping indicates that road elements in the vicinity of the project site include SR-98, Drew Road, Pulliam Road, Kubler Road, and Mandrapa Road.

The segment of SR-98 adjacent to the project site is a two-lane undivided highway with a 24-foot-wide paved width. Access from Drew Road and Pulliam Road is regulated by stop signs. The highway is in good condition. The posted speed limit for SR-98 was observed to be 65 miles per hour (mph), with a reduced speed limit of 55 mph for any vehicle towing.

The segment of Drew Road adjacent to the project site is a 2-lane undivided roadway with an approximate paved width of 24 feet. No posted speed limit was observed for this segment of Drew Road.

The segment of Pulliam Road adjacent to the project site is a two-lane undivided roadway with a paved width of up to 24-feet. No posted speed limit was observed for this segment of Pulliam Road. Pulliam Road does not accommodate substantial traffic volumes; traffic is generally limited to trips generated by adjacent agricultural uses and solar generation facilities.

The segment of Kubler Road adjacent to the project site is a two-lane undivided roadway with a paved width of up to 24 feet. No posted speed limit was observed for this segment of Kubler Road. Kubler Road does not accommodate substantial traffic volumes; traffic is generally limited to trips generated by adjacent agricultural uses and solar generation facilities.

Mandrapa Road is an unpaved, access route for agricultural uses. Grading was observed to be uneven and plants were observed on sections of the access route. Access from SR-98 is afforded by a gap in traffic barriers with no traffic control device. Mandrapa Road does not accommodate substantial traffic volumes.

2.3 Ambient Noise Environment

Three short-term noise measurements were taken on December 5, 2017 and one 24-hour measurement was taken between December 5 and 6, 2017. Measurements were taken using two Larson-Davis Model LxT Type 1 Integrating Sound Level Meter, serial numbers 3827 and 3828. The meters meet American National Standards Institute (ANSI) S1-4 specifications for Type 1 instruments. Meter was calibrated before and after measurements.

The following parameters were used:

Filter:	A-weighted
Response:	Slow
Time History Period:	5 seconds
Height	5 feet above ground

Noise measurements were taken to obtain existing ambient noise levels. Noise measurements are described below and shown in Table 1. Observed traffic volumes were counted during noise measurements; the results are shown in Table 2. The locations of the measurements are shown on Figure 4, and the noise measurement data are contained in Attachment 1.

Table 1
Noise Measurement Data

Site ID	Location	Start Time	Duration	Noise Level (dB[A])			Noise Sources
				L_{eq}	L_{max}	L_{min}	
1	Southwest of the intersection of Pulliam Road and Kubler Road	2:27 pm	20 minutes	38.8	57.8	28.4	Wind; Vehicle traffic on Pulliam Road
2	Southeast of the intersection of Drew Road and Kubler Road	2:58 pm	20 minutes	60.0	80.8	27.4	Vehicle traffic on Drew Road
3	North of SR-98, 50 feet from SR-98 centerline	3:30 pm	20 minutes	63.9	87.6	27.3	Vehicle traffic on SR-98
4	Along Brockman Drain, 1,420 feet north of SR-98	2:30 pm	24 hours	47.8*	49.2*	28.0*	Wind; Distant vehicle traffic on SR-98

dB(A) = A-weighted decibels; L_{eq} = equivalent noise level; L_{max} = maximum hourly L_{eq}; L_{min} = minimum hourly L_{eq}; SR-98 = State Route 98

* Measurement 4 was a 24-hour measurement. The community noise equivalent level is reported in the L_{eq} column, the maximum hourly L_{eq} is reported in the L_{max} column, and the minimum hourly L_{eq} is reported in the L_{min} column.

Table 2
Observed Traffic Counts

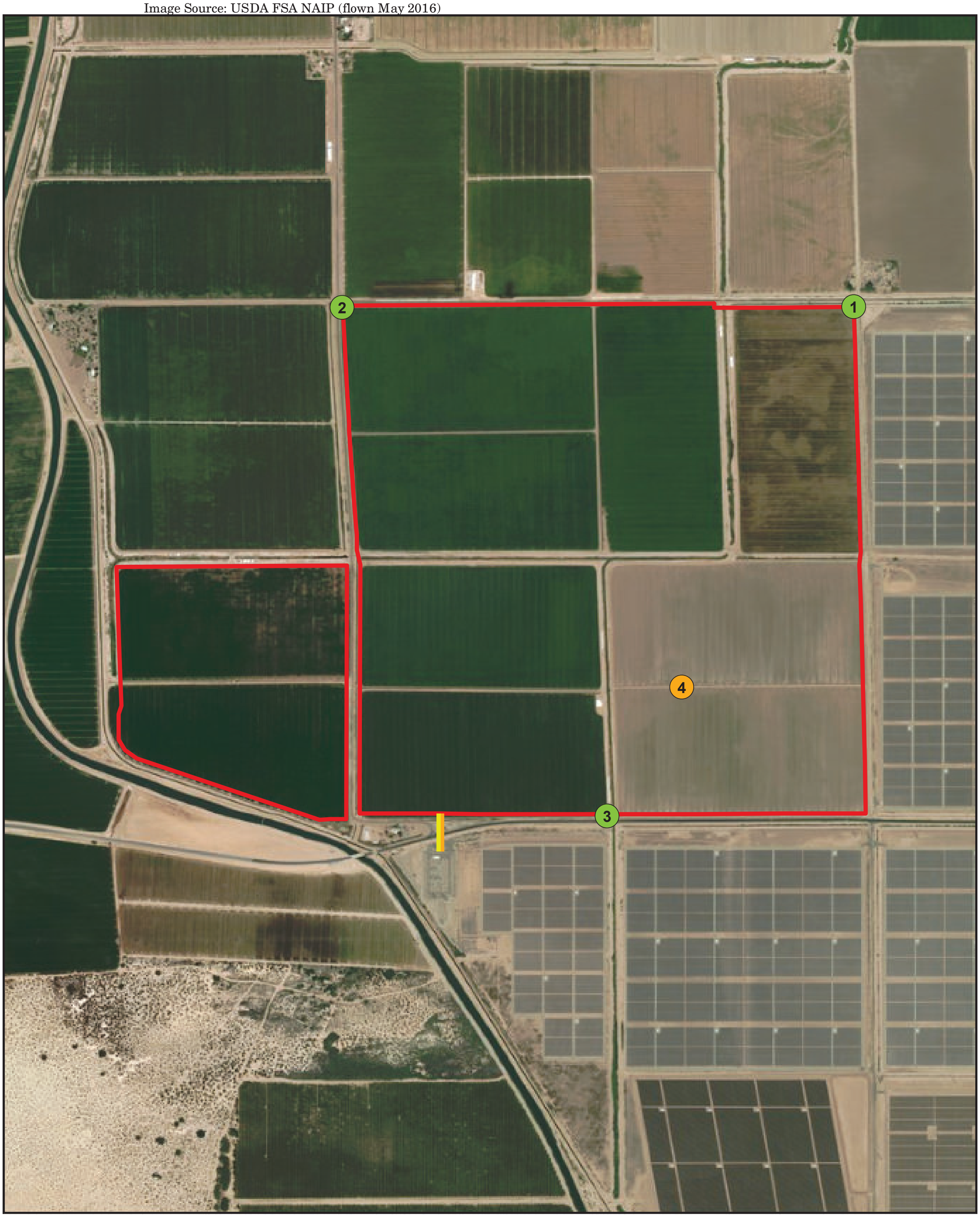
Measurement	Roadway	Direction	Autos	Medium Trucks	Heavy Trucks	Buses	Motor-Cycles
1	Pulliam Road and Kubler Road	Any	1	0	0	0	0
2	Drew Road	Any	7	0	0	0	0
3	State Route 98	Eastbound	30	0	2	0	0
		Westbound	8	0	1	0	0

SOURCE: Field traffic counts.
*Tractor on State Route 98 categorized as a heavy truck.

Measurement 1 was located at the northeast corner of the project site, 75 feet south of the centerline of Kubler Road and 50 feet west of the centerline of Pulliam Road. During the measurement, one pickup truck approached the intersection heading northbound on Pulliam Road and turned east onto Kubler Road. The primary source of noise at this location was wind. The average measured noise level during Measurement 1 was 38.8 dB(A) L_{eq}.

Measurement 2 was located at the northwest corner of the project site, 50 feet south of the centerline of Kubler Road and 50 feet east of the centerline of Drew Road. During the measurement, seven passenger vehicles traveled along Drew Road. No traffic was observed on Kubler Road. The primary source of noise at this location was vehicle traffic on Drew Road.

Image Source: USDA FSA NAIP (flown May 2016)



Project Boundary

Gen-Ties

Noise Measurements

24-Hour

Short-term

RECON

M:\JOBS5\8653\common_gis\fig4_nos.mxd 5/17/2018 sab

FIGURE 4

Noise Measurements

Due to the deteriorated condition of Drew Road, traffic noise levels were notably higher than would be expected. No posted speed limit for Drew Road was observed and vehicle speeds were highly varied. The average measured noise level during Measurement 2 was 60.0 dB(A) L_{eq}.

Measurement 3 was located along the southern boundary of the project site, 50 feet north of the centerline of SR-98 and across from the driveway to the solar farm to the south. During the measurement, 38 passenger vehicles, 2 heavy trucks, and 1 farm-tractor traveled along SR-98. The primary source of noise at this location was vehicle traffic on SR-98. Traffic was free flow and nearly all vehicles were observed to travel near the posted speed limit of 65 mph. The average measured noise level during Measurement 3 was 63.9 dB(A) L_{eq}.

Measurement 4 was located along a drainage ditch in the interior of the project site, approximately 1,420 feet north of the centerline of SR-98 and approximately 2,000 feet west of Pulliam Road. The measured noise level during Measurement 4 was 47.8 CNEL. A minimum hourly noise level of 28.0 dB(A) L_{eq} was measured between 12:30 and 1:30 a.m. and a maximum hourly noise level of 49.2 dB(A) L_{eq} was measured between 1:30 and 2:30 p.m.

3.0 Applicable Standards

3.1 Noise Standards

3.1.1 Imperial County General Plan Noise Element

3.1.1.1 Property Line Noise Level Limits

The County General Plan Noise Element identifies property line noise level limits that apply to noise generation from one property to an adjacent property (excluding construction noise). As stated in the Noise Element, the property line noise level limits imply the existence of a sensitive receptor on the adjacent, or receiving, property. In the absence of a sensitive receptor, an exception or variance to the standards may be appropriate. The property line noise standards are codified in the County Code or Ordinances and thus are enumerated in the subsequent section (see Section 3.1.2).

3.1.1.2 Construction Noise Standards

Imperial County General Plan Noise Element Section IV.C.3 addresses noise generated by construction activities. It states:

- Construction noise, from a single piece of equipment or a combination of equipment, shall not exceed 75 dB L_{eq}, when averaged over an eight (8) hour period, and measured at the nearest sensitive receptor. This standard assumes a construction period, relative to an individual sensitive receptor of days or weeks. In cases of extended length construction times, the standard may be tightened so as not to exceed 75 dB L_{eq} when averaged over a one (1) hour period.

- Construction equipment operation shall be limited to the hours of 7 a.m. to 7 p.m., Monday through Friday, and 9 a.m. to 5 p.m. Saturday. No commercial construction operations are permitted on Sunday or holidays. In cases of a person constructing or modifying a residence for himself/herself, and if the work is not being performed as a business, construction equipment operations may be performed on Sundays and holidays between the hours of 9 a.m. and 5 p.m. Such non-commercial construction activities may be further restricted where disturbing, excessive, or offensive noise causes discomfort or annoyance to reasonable persons of normal sensitivity residing in an area.

3.1.2 Imperial County Noise Abatement and Control

Imperial County Code of Ordinances Title 9, Division 7: Noise Abatement and Control, specifies noise level limits. Noise level limits are summarized in Table 3. Noise level limits do not apply to construction equipment.

Table 3
Imperial County Property Line Noise Limits

Zone	Time	One-Hour Average Sound Level [dB(A) L_{eq}]
Low-Density Residential Zones	7:00 a.m. to 10:00 p.m.	50
	10:00 p.m. to 7:00 a.m.	45
Medium to High-Density-Residential Zones	7:00 a.m. to 10:00 p.m.	55
	10:00 p.m. to 7:00 a.m.	50
Commercial Zones	7:00 a.m. to 10:00 p.m.	60
	10:00 p.m. to 7:00 a.m.	55
Manufacturing/Light Industrial/Industrial Park Zones including agriculture	(anytime)	70
General Industrial Zones	(anytime)	75

dB(A) L_{eq} = weighted decibels equivalent noise level
SOURCE: Imperial County Noise Abatement and Control Ordinance, Tit. 9, Div. 7, § 90702.00(A).

3.2 Vibration Standards

3.2.1 California Department of Transportation Guidance

Caltrans' standards and methodologies used to determine when local land uses may be subject to unacceptable vibrations are based on the *Transportation and Construction Vibration Guidance Manual* (Caltrans 2013b). Maximum recommended vibration limits, set in units of inches per second as measured by the peak particle velocity (PPV), by the

American Association of State Highway and Transportation Officials (AASHTO) are identified in Table 4.

Table 4 American Association of State Highway and Transportation Officials Maximum Vibration Levels for Preventing Damage	
Structure	Peak Particle Velocity (inches/second)
Historic sites or other critical locations	0.1
Residential buildings, plastered walls	0.2–0.3
Residential buildings in good repair with gypsum board walls	0.4–0.5
Engineered structures, without plaster	1.0–1.5
SOURCE: California Department of Transportation 2013b, Table 15, p. 25	

Based on AASHTO recommendations, limiting vibration levels to below 0.2 PPV at residential structures would prevent structural damage regardless of building construction type. These limits are applicable regardless of the persistence of the source. However, as shown in Table 5 and 6, potential human response associated with vibration is typically dependent on the persistence (i.e. whether it is a steady or transient vibration source). These levels are summarized in Tables 5 and 6.

Table 5 Human Response to Steady State Vibration	
Peak Particle Velocity (inches/second)	Human Response
3.6 (at 2 Hertz)–0.4 (at 20 Hertz)	Very disturbing
0.7 (at 2 Hertz)–0.17 (at 20 Hertz)	Disturbing
0.10	Strongly perceptible
0.035	Distinctly perceptible
0.012	Slightly perceptible
SOURCE: California Department of Transportation 2013b, Table 4, p. 21	

Table 6 Human Response to Transient Vibration	
Peak Particle Velocity (inches/second)	Human Response
2.0	Severe
0.9	Strongly perceptible
0.24	Distinctly perceptible
0.035	Barely perceptible
SOURCE: California Department of Transportation 2013b, Table 6, p. 22	

As shown in Table 6, the vibration level threshold at which transient vibration sources (such as construction equipment) are considered to be distinctly perceptible is 0.24 PPV. Although groundborne vibration is sometimes noticeable in outdoor environments, groundborne vibration is almost never annoying to people who are outdoors due to the lack of a reference for the vibration, such as an object on a shelf. Therefore, the vibration level threshold for human perception is assessed at occupied structures (Federal Transit Administration 2006).

4.0 Analysis Methodology

4.1 Construction Analysis Methodology

Project construction noise would be generated by diesel engine-driven construction equipment used for site preparation activities such as clearing, grading, perimeter fencing, development of staging areas and site access roads; and would involve facility installation activities such as installation of support masts (impact pile driving), trenching utility connections, construction of electrical distribution facilities, and construction of the O&M building(s). Diesel engine-driven trucks also would bring materials to the site.

Construction equipment with diesel engines typically generate maximum noise levels from 80 to 90 dB(A) L_{eq} at a distance of 50 feet (Federal Highway Administration [FHWA] 2006). Table 7 summarizes typical construction equipment noise levels. During excavation, grading, and paving operations, equipment moves to different locations and goes through varying load cycles, and there are breaks for the operators and for non-equipment tasks, such as measurement. Thus, average hourly noise levels would be less than maximum noise levels.

Table 7
Typical Construction Equipment Noise Levels

Equipment	Noise Level at 50 Feet [dB(A) L_{eq}]	Typical Duty Cycle
Auger Drill Rig	85	20%
Backhoe	80	40%
Blasting	94	1%
Chain Saw	85	20%
Clam Shovel	93	20%
Compactor (ground)	80	20%
Compressor (air)	80	40%
Concrete Mixer Truck	85	40%
Concrete Pump	82	20%
Concrete Saw	90	20%
Crane (mobile or stationary)	85	20%
Dozer	85	40%
Dump Truck	84	40%
Excavator	85	40%
Front End Loader	80	40%
Generator (25 kilovolt amps or less)	70	50%
Generator (more than 25 kilovolt amps)	82	50%
Grader	85	40%
Hydra Break Ram	90	10%
Impact Pile Driver (diesel or drop)	95	20%
In situ Soil Sampling Rig	84	20%
Jackhammer	85	20%
Mounted Impact Hammer (hoe ram)	90	20%
Paver	85	50%
Pneumatic Tools	85	50%
Pumps	77	50%
Rock Drill	85	20%
Roller	74	40%
Scraper	85	40%

Table 7 Typical Construction Equipment Noise Levels		
Equipment	Noise Level at 50 Feet [dB(A) L_{eq}]	Typical Duty Cycle
Tractor	84	40%
Vacuum Excavator (vac-truck)	85	40%
Vibratory Concrete Mixer	80	20%
Vibratory Pile Driver	95	20%
dB(A) L_{eq} = weighted decibels equivalent noise level SOURCE: Federal Highway Administration 2006		

Earthwork activities generally result in the highest noise levels at adjacent properties. During earthworks operations, equipment moves to different locations and goes through varying load cycles, and there are breaks for the operators and for non-equipment tasks, such as measurement. Although maximum noise levels reach 80 to 90 dB(A) at a distance of 50 feet during most construction activities, hourly equivalent noise level generated by typical earthworks and paving activities is generally 82 dB(A) L_{eq} at 50 feet from the center of construction activity when assessing the loudest pieces of equipment working simultaneously.

The project site and the area surrounding all off-site roadway extensions are relatively flat. This analysis conservatively assumes no attenuation from barriers and topography.

Ground conditions typically change during construction due to fugitive dust control practices such as soil stabilization through site watering and best management practices such as subgrade compaction. This analysis conservatively models ground conditions as acoustically hard. Thus, construction noise would be characterized by hard site attenuation rate of 6 dB(A) per doubling of distance.

4.2 Operations Analysis Methodology

Noise level predictions and contour mapping were developed using noise modeling software, SoundPlan Essential (SoundPlan), version 3.0 (Navcon Engineering 2015). SoundPlan calculates noise propagation based on algorithms and reference levels published by various government agencies, FHWA, and the International Standards Organization (ISO). For traffic the model uses the FHWA traffic noise model algorithms to predict noise levels. For stationary sources, SoundPlan models propagation based on ISO Standard 9613-2, "Attenuation of Sound during Propagation Outdoors, Part 2: General Method of Calculation." The ISO Standard 9613-2 assumes that all receptors would be downwind of stationary sources. This is a worst-case assumption for total noise impacts, since, in reality, only some receptors will be downwind at any one time. The model uses various input parameters, such as distances between sources, barriers, and receivers; and shielding provided by intervening terrain, barriers, and structures. Sources and receivers were input into the model using three-dimensional coordinates. This analysis conservatively assumes no attenuation from barriers and topography. In all cases, receivers were modeled at 5 feet above ground elevation, which represents the average height of the human ear. The model outputs include noise level contours and noise levels at specific receivers.

Stationary sources of noise associated with the operation of the project would include inverters, transformers, solar panel tracker motors, a substation, and transmission gen-tie lines. As the solar generation facility would only generate electricity between sunrise and sunset, noise from solar field inverters and transformers would likely be limited to daylight hours. After daylight hours energy storage facilities may continue to contribute energy to the grid. A single technology or provider has not been selected for the energy storage component of the project. Energy storage technology may be centralized or may be distributed throughout the plant. Depending on the technology selected for the energy storage component, the substation and transmission gen-tie lines as well as the solar field inverters and transformers may be active during both daylight and nighttime hours.

Inverters, transformers, and solar panel tracker motors would be distributed throughout the facility at each solar array block. It is not known at this time which manufacturer, brand, or model of units would be selected for use in the project, or the specific location units would be placed.

Based on review of various manufacturer specifications of inverters sized for nominal 1-to-2-MW solar arrays, a representative sound pressure level of 65 dB(A) at 5 feet from each inverter unit was selected for analysis (Satcon 2008; Attachment 2). This sound level equates to a sound power level of 77 dB(A). The height of the noise source was modeled at 1 meter.

The National Electrical Manufacturers Association (NEMA) specifies audible sound level limits for transformers. Based on these standards and the anticipated size of project transformers (up to 2 kVA), project transformers may generate noise levels up to 61 dB(A) at 5 feet (NEMA 2013; Attachment 3). This equates to a sound power level of 73 dB(A). The height of the noise source was modeled at 1 meter.

Based on available information for similar equipment, solar panel tracker motors typically generate instantaneous sound power levels of up to 79 dB(A), which equates to sound pressure levels of up to 67 dB(A) at 5 feet (ICF International 2010). Solar panel tracker motors are not in operation continuously. Solar panel tracker motors would generally reposition the arrays several times during daylight hours, and would also reposition the arrays once at sunset (resetting array position in preparation for the following day). Each individual repositioning would be brief and the frequency at which arrays are repositioned would be anticipated to be limited to a few times each hour or less. Hourly average noise levels would be less than instantaneous noise levels. During ambient noise measurements, solar panel tracker motors at adjacent solar generation facilities were observed. Repositioning lasted only a few seconds, was infrequent, and did not substantially contribute to the ambient noise environment. As solar panel tracker motors would not substantially contribute to the ambient noise environment they were not included in noise contour modeling.

The project would include the construction of one substation located near the intersection of Drew Road and SR-98 and the gen-tie line. The substation would include equipment such as switches, circuit breakers, and transformers. Switches and circuit breakers do not typically generate substantial noise. The power rating for substation transformers would be several times higher than the power rating for transformers distributed throughout the facility at each solar array block. Based on NEMA standards for oil-immersed transformers, a sound level of 67 dB(A) at 5 feet would be representative of the substation (NEMA 2013). This equates to a sound power level of 97 dB(A). The height of the noise source was modeled at 2 meters.

The gen-tie line would be extended between the project's substation and the SDG&E Drew Switchyard. Corona discharge results from the partial breakdown of the electrical insulating properties of the air surrounding the conductors; energy discharged from the line may form small local pressure changes that result in audible hissing or crackling noises. The intensity of corona noise varies depending on the atmospheric conditions such as atmospheric moisture and pressure (which is related to altitude). The noise generated by similar transmission lines (i.e. approximately 230 kV) has previously been analyzed to be 25 dB(A) at 50 feet. This equates to a sound power level per length of 45 dB(A) per meter. The height of the noise source was modeled at 6 meters.

Table 8 summarizes equipment noise levels and heights.

Table 8
Project Equipment Modeling Parameters

Equipment	Sound Power Level	Noise Source Height
Inverter	87 dB(A)	1 meters
Transformer	86 dB(A)	1 meters
Substation	87 dB(A)	2 meters
Gen-Tie Line	45 dB(A) per meter	6 meters

dB(A) = A=weighted decibels

4.3 Traffic Noise Analysis Methodology

Traffic noise increase would be considered significant where the increase would degrade the existing ambient noise environment at a noise-sensitive use. As discussed in section 1.2, changes in noise levels are generally perceived by the average human ear as follows: 3 dB(A) is barely perceptible, 5 dB(A) is readily perceptible, and 10 dB(A) is perceived as a doubling or halving of noise (Caltrans 2013). Thus for this analysis, a substantial permanent increase in the ambient noise levels is defined as a 3 dB(A) increase.

4.4 Vibration Analysis Methodology

A quantitative assessment of potential vibration impacts from construction activities, such as blasting, pile-driving, vibratory compaction, demolition, drilling, or excavation, may be conducted using the following equations (Caltrans 2013b).

Vibration impacts from normal equipment to structures may be estimated at any distance from the following equation:

$$PPV_{equipment} = PPV_{reference} \times (\frac{25}{Distance})^{1.5}$$

where: $PPV_{equipment}$ is the peak particle velocity in inches per second of the equipment adjusted for distance; and $PPV_{reference}$ is the reference vibration level in inches per second at 25 feet as shown in Table 9.

Table 9
Construction Equipment Vibration Levels

Equipment	Peak Particle Velocity at 25 feet (inches per second)[1]	Approximate Groundborne Noise Level at 25 feet[1]
Large Bulldozer	0.089	87
Trucks	0.076	86
Mounted Impact Hammer	0.089	87
Impact Pile Driver	0.644	104

[1] Where noise level is the level in decibels referenced to 1 micro-inch/second and based on the root mean square velocity amplitude.
SOURCE: Federal Transit Administration 2006; California Department of Transportation 2013b.

5.0 Impact Analysis and Noise Environment

5.1 Construction Noise Analysis

Noise associated with the site preparation and facility installation will potentially result in short-term impacts to surrounding properties. A variety of noise-generating equipment such as scrapers, excavators, loaders, and water trucks, along with others, would be used during each construction phase.

As discussed in Section 4.1, the loudest construction activities typically result in hourly average noise levels of approximately 82 dB(A) L_{eq} at 50 feet from the center of the construction activity. Actual noise levels would vary depending on the nature of the construction phase, including the duration of specific activities, nature of the equipment involved, location of the particular receiver, and nature of intervening barriers. Therefore, the use of 82 dB(A) L_{eq} at 50 feet is considered a conservative value.

As discussed in Section 2.2.2, the County General Plan Noise Element establishes construction time of day restrictions and noise level limits. Construction activities may only occur Monday through Friday between the hours of 7:00 a.m. and 7:00 p.m. or Saturday between the hours of 9:00 a.m. and 5:00 p.m., excluding holidays. Additionally, construction noise may not exceed 75 dB(A) $L_{eq(8h)}$ at the nearest sensitive receptor.

Construction activities can be evaluated as point sources and noise from construction sites typically attenuate at a rate of 6 dB(A) for every doubling of the distance. The nearest sensitive receptor to the project site is the single-family residence immediately west of the intersection of Drew Road and SR-98. If construction were distributed across the entire project site, the distance from the center of construction activity to the nearest residence would be approximately 3,000 feet. Thus, average construction noise levels would attenuate to 46 dB(A) $L_{eq(8h)}$.

Due to the large size of the project site, construction activities are anticipated to be phased. This analysis assumes construction may be temporarily focused in a 10-acre area for at least 8 hours; this focused area is equivalent to approximately one-quarter of a typical 40-acre lot (i.e. land division quarter-quarter section). The assumption that construction would be focused in a small area is conservative because it would reduce the average distance between construction equipment and adjacent receivers. In a worst-case scenario with all construction activity occurring in the 10-acre area nearest to the single-family residence immediately west of the intersection of Drew Road and SR-98, the distance from the center of construction activity to the nearest property line would be approximately 760 feet. Thus, construction noise levels would attenuate to 58 dB(A) $L_{eq(8h)}$ at the nearest sensitive receptor.

Thus, construction noise levels would comply with 75 dB(A) $L_{eq(8h)}$ noise level limit established by County Noise Element. Impacts would be less than significant.

5.2 Operations Noise Analysis

Following the methodology discussed in Section 4.2, Operations Analysis, ground-floor noise level contours were modeled. Noise contours are shown on Figure 5. SoundPLAN data for on-site generated noise modeling are contained in Attachment 4.

As discussed in Section 3.4, the County Code of Ordinances establishes property line noise standards for residential, commercial, light industrial, and general industrial zoning districts. The project site and all surrounding properties are in agricultural zoning districts. The project would include a Conditional Zone Change to Medium Industrial (M-2) for APN 052-170-039 and 052-170-067. The property line noise standard for manufacturing, light industrial, industrial park, and agricultural zoning districts is 70 dB(A) L_{eq}. The nearest non-agricultural zone is the parcel at the southeast corner of the intersection of SR-98 and Brockman Road, which is approximately 5,040 feet from the project site.

As shown in Figure 5, noise associated with project operation would attenuate to less than 50 dB(A) L_{eq} within the project site boundary. On-site generated noise would attenuate to 44 dB(A) L_{eq} at the single-family residence immediately west of the intersection of Drew Road and SR-98 (approximately 100 feet from project site; General Agricultural [A2] zone).

Image Source: USDA FSA NAIP (flown May 2016)

RECON

M:\JOBS5\8653\common_gis\fig5_nos.mxd 5/17/2018 sab

FIGURE 5

Operations Noise

On-site generated noise would attenuate to 20 dB(A) L_{eq} at the single-family residence located northwest of the intersection of Kubler Road and Pulliam Road (approximately 400 feet from project site; Agricultural/Rural Zone [A2R] zone). Property line noise level limits from the County General Plan Noise Element are 70 dB(A) L_{eq} for agricultural zones. Noise levels would not exceed applicable daytime or nighttime property line noise level limits from the County General Plan Noise Element. Impacts would be less than significant.

5.3 Operational Traffic Noise Analysis

As discussed in Sections 1.2 and 4.3, a doubling of the energy of a noise source, such as doubling of traffic volume, would increase the noise level by 3 dB(A) and would generally be perceived by the average human ear as barely perceptible. A permanent increase in the ambient noise levels that is less than 3 dB(A) would be less than significant.

During operations, the project would require approximately two full-time equivalent employees, which would generate up to 20 trips per day. As project trip generation would be extremely limited, the project is not anticipated to result in a doubling of traffic along any well-traveled roadway. For roadways where existing traffic volumes are equal to or less than 10 average daily traffic, project-generated traffic may result in a 3 dB(A) traffic noise increase, however resulting traffic noise levels would remain less than generally ambient noise levels attributable to other sources[1]. Ambient noise level increases attributable to project-generated traffic are anticipated to be less than 3 dB(A). Impacts would be less than significant.

5.4 Vibration

5.4.1 Construction Vibration

As discussed in Section 3.2.2, vibration level threshold at which construction equipment are considered distinctly perceptible is 0.24 PPV and limiting vibration levels to below 0.2 PPV at residential structures would prevent structural damage regardless of building construction type. Groundborne noise and vibration from vibration-generating construction equipment such as large bulldozers, loaded trucks, and jackhammers would attenuate to less than 0.2 PPV at 12, 10, and 5 feet, respectively. Project construction is not anticipated to involve the use of construction equipment within 15 feet of existing structures; therefore these construction activities would not result in substantial groundborne noise and vibration.

Project-generated groundborne noise and vibration levels would be highest during impact pile driving. Project solar array support masts would generally be set back from the

[1] Based on FHWA Traffic Noise Prediction Model, roadways with traffic volumes of 20 average daily traffic and speed limits between 25 and 45 miles per hour would result in noise levels of 36 to 42 dB(A) L_{eq} at 50 feet from the centerline of the roadway. As discussed in 2.3, measured 24-hour ambient noise levels at a location central to the site were 47.8 CNEL.

property line by at least 40 feet to accommodate perimeter access roads. Additionally, the project site is bounded by Kubler Road to the north, Westside Main Canal to the west, SR-98 to the south, and Pulliam Road to the east. Groundborne noise and vibration from impact pile drivers would attenuate to less than the transient vibration level threshold within 72 feet, which would generally be within the public right-of-way.

The nearest structure to the project site is the single-family residence immediately west of the intersection of Drew Road and SR-98. Impact pile driving would be anticipated to occur approximately 180 feet from this structure. Transient vibration levels at the single-family residence would be anticipated to reach up to 0.073 PPV. Vibration levels would not exceed the transient vibration level threshold of 0.2 PPV. Groundborne noise and vibration impacts would be less than significant.

5.4.2 Operation Vibration

Project operation would not include any substantial sources of groundborne vibration. No vibration impacts would result from project operation.

6.0 Conclusions

6.1 Construction Noise

Site preparation and facility installation would include use of a variety of noise-generating equipment such as scrapers, excavators, loaders, and water trucks, along with others, would be used during each construction phase. As discussed in Section 5.1.1, due to the large size of the project site, average construction noise levels over the life of project construction (i.e. equal distribution of construction equipment noise across the site) would attenuate to 46 dB(A) $L_{eq(8h)}$ at the property line of the nearest residence. When construction activities are conducted in stages, some stages will be focused near the project site boundary, and higher construction noise levels would be expected. For example, if construction were focused in a 10-acre portion of the project site that is nearest to the single-family residence immediately west of the intersection of Drew Road and SR-98, construction noise levels would reach 58 dB(A) $L_{eq(8h)}$ at the property line of the residence. Project construction noise levels would comply with 75 dB(A) $L_{eq(8h)}$ noise level limit established by County Noise Element. Impacts would be less than significant.

6.2 Operations Noise

Stationary sources of noise associated with the operation of the project would include inverters, transformers, solar panel tracker motors, substation(s), and transmission gen-tie lines. Noise associated with project operation would attenuate to less than 50 dB(A) L_{eq} within the project site boundary. On-site generated noise would attenuate to 44 dB(A) L_{eq} at the nearest single-family residence immediately (west of the intersection of Drew Road and SR-98). Noise levels would not exceed applicable property line noise level limits from the

County General Plan Noise Element. Therefore, noise associated with project operations would be less than significant.

6.3 Operational Traffic Noise

During operations, project-generated traffic would increase volumes on local roadways and thereby increase traffic noise levels in the project area. Project trip generation would be extremely limited–up to 20 trips per day. Ambient noise level increases attributable to project-generated traffic are anticipated to be less than 3 dB(A) along all roadways. Impacts would be less than significant.

6.4 Vibration

6.4.1 Construction Vibration

Project construction would include the use of vibration-generating construction equipment such as large bulldozers, loaded trucks, jackhammers, and mast impact pile drivers. Vibration levels at the nearest structure would be anticipated to reach up to 0.073 PPV the nearest structure. As vibration levels would not exceed the vibration level threshold of 0.2 PPV groundborne noise and vibration impacts would be less than significant.

6.4.2 Operation Vibration

Project operation would not include any substantial sources of groundborne vibration. No vibration impacts would result from project operation.

7.0 References Cited

California Department of Transportation (Caltrans)
2013a Technical Noise Supplement. November.

2013b Transportation and Construction Vibration Guidance Manual. September.

Federal Highway Administration (FHWA)
2006 FHWA Roadway Construction Noise Model User's Guide, Final Report. January.

Federal Transit Administration (FTA)
2006 Transit Noise and Vibration Impact Assessment. Office of Planning and Environment. FTA-VA-90-1003-06. May.

ICF International
2010 Memorandum, Noise Levels for Single Axis Tracking Motors, Rosamond Solar Project, Kern County, California.

Imperial, County of
2015 Imperial County General Plan Noise Element. Approved October 6.

LOS Engineering, Inc.
2018 Drew Solar Farm Traffic Impact Analysis. February.

National Electrical Manufacturers Association (NEMA)
2013 NEMA TR 1-2013 Transformers, Step Voltage Regulators and Reactors.

Navcon Engineering, Inc.
2015 SoundPLAN Essential version 3.0. August.

Satcon
2008 PowerGate Plus Commercial Solar PV Inverters Brochure.

ATTACHMENTS

ATTACHMENT 1

Noise Measurement Data

Summary

Filename	LxT_Data.003
Serial Number	3828
Model	SoundExpert™ LxT
Firmware Version	2.301
User	
Location	
Job Description	
Note	
Measurement Description	
Start	2017/12/05 14:27:08
Stop	2017/12/05 14:47:21
Duration	0:20:12.6
Run Time	0:20:12.6
Pause	0:00:00.0
Pre Calibration	2017/12/05 14:25:57
Post Calibration	None
Calibration Deviation	---

Overall Settings

RMS Weight	A Weighting		
Peak Weight	A Weighting		
Detector	Slow		
Preamp	PRMLxT1L		
Microphone Correction	Off		
Integration Method	Linear		
OBA Range	Normal		
OBA Bandwidth	1/1 and 1/3		
OBA Freq. Weighting	A Weighting		
OBA Max Spectrum	At Lmax		
Overload	121.8 dB		
	A	**C**	**Z**
Under Range Peak	**78.0**	75.0	80.0 dB
Under Range Limit	**26.0**	25.2	32.0 dB
Noise Floor	16.3	16.1	22.0 dB

Results

LAeq	38.8 dB	
LAE	69.6 dB	
EA	1.020 µPa²h	
LApeak (max)	2017/12/05 14:44:10	75.0 dB
LASmax	2017/12/05 14:44:03	57.8 dB
LASmin	2017/12/05 14:36:59	28.4 dB
SEA	-99.9 dB	

LAS > 85.0 dB (Exceedence Counts / Duration)	0	0.0 s
LAS > 115.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 135.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 137.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 140.0 dB (Exceedence Counts / Duration)	0	0.0 s

Community Noise	**Ldn**	**LDay 07:00-22:00**	**LNight 22:00-07:00**	**Lden**	**LDay 07:00-19:00**	**LEvening 19:00-22:00**	**LNight 22:00-07:00**
	38.8	38.8	-99.9	38.8	38.8	-99.9	-99.9

LCeq	58.6 dB
LAeq	38.8 dB
LCeq - LAeq	19.8 dB
LAIeq	41.1 dB
LAeq	38.8 dB
LAIeq - LAeq	2.3 dB
# Overloads	0
Overload Duration	0.0 s
# OBA Overloads	0
OBA Overload Duration	0.0 s

Statistics

LAS5.00	42.2 dB
LAS10.00	40.2 dB
LAS33.30	36.5 dB
LAS50.00	35.1 dB
LAS66.60	33.9 dB
LAS90.00	30.2 dB

Calibration History

Preamp	**Date**	**dB re. 1V/Pa**
Direct	2015/07/16 9:40:54	-26.0
Direct	2015/07/16 9:12:39	-26.0
PRMLxT1L	2017/12/05 14:25:56	-28.1
PRMLxT1L	2017/12/05 14:25:27	-28.1
PRMLxT1L	2017/09/28 18:44:16	-27.9
PRMLxT1L	2017/09/27 14:38:54	-28.0
PRMLxT1L	2017/09/27 14:38:34	-28.0
PRMLxT1L	2017/08/03 11:51:12	-28.1
PRMLxT1L	2017/08/03 11:50:34	-28.0
PRMLxT1L	2017/05/23 11:08:59	-28.0
PRMLxT1L	2017/05/23 10:03:03	-28.0
PRMLxT1L	2017/05/23 10:02:33	-28.0
PRMLxT1L	2017/05/23 10:02:08	-28.0

Summary

Filename	LxT_Data.004		
Serial Number	3828		
Model	SoundExpert™ LxT		
Firmware Version	2.301		
User			
Location			
Job Description			
Note			
Measurement Description			
Start	2017/12/05 14:58:14		
Stop	2017/12/05 15:18:15		
Duration	0:20:01.0		
Run Time	0:20:01.0		
Pause	0:00:00.0		
Pre Calibration	2017/12/05 14:57:48		
Post Calibration	None		
Calibration Deviation	---		

Overall Settings

RMS Weight	A Weighting		
Peak Weight	A Weighting		
Detector	Slow		
Preamp	PRMLxT1L		
Microphone Correction	Off		
Integration Method	Linear		
OBA Range	Normal		
OBA Bandwidth	1/1 and 1/3		
OBA Freq. Weighting	A Weighting		
OBA Max Spectrum	At Lmax		
Overload	121.8 dB		
	A	**C**	**Z**
Under Range Peak	**78.1**	75.1	80.1 dB
Under Range Limit	**26.0**	25.2	32.0 dB
Noise Floor	16.3	16.1	22.0 dB

Results

LAeq	60.0 dB	
LAE	90.8 dB	
EA	132.143 µPa²h	
LApeak (max)	2017/12/05 14:59:56	100.5 dB
LASmax	2017/12/05 15:11:08	80.8 dB
LASmin	2017/12/05 15:15:13	27.4 dB
SEA	-99.9 dB	

LAS > 85.0 dB (Exceedence Counts / Duration)	0	0.0 s
LAS > 115.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 135.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 137.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 140.0 dB (Exceedence Counts / Duration)	0	0.0 s

Community Noise	**Ldn**	**LDay 07:00-22:00**	**LNight 22:00-07:00**	**Lden**	**LDay 07:00-19:00**	**LEvening 19:00-22:00**	**LNight 22:00-07:00**
	60.0	60.0	-99.9	60.0	60.0	-99.9	-99.9

LCeq	69.1 dB
LAeq	60.0 dB
LCeq - LAeq	9.2 dB
LAIeq	63.1 dB
LAeq	60.0 dB
LAIeq - LAeq	3.1 dB
# Overloads	0
Overload Duration	0.0 s
# OBA Overloads	0
OBA Overload Duration	0.0 s

Statistics

LAS5.00	58.6 dB
LAS10.00	49.7 dB
LAS33.30	40.4 dB
LAS50.00	37.9 dB
LAS66.60	36.3 dB
LAS90.00	33.2 dB

Calibration History

Preamp	**Date**	**dB re. 1V/Pa**
Direct	2015/07/16 9:40:54	-26.0
Direct	2015/07/16 9:12:39	-26.0
PRMLxT1L	2017/12/05 14:57:45	-28.1
PRMLxT1L	2017/12/05 14:49:46	-28.1
PRMLxT1L	2017/12/05 14:25:56	-28.1
PRMLxT1L	2017/12/05 14:25:27	-28.1
PRMLxT1L	2017/09/28 18:44:16	-27.9
PRMLxT1L	2017/09/27 14:38:54	-28.0
PRMLxT1L	2017/09/27 14:38:34	-28.0
PRMLxT1L	2017/08/03 11:51:12	-28.1
PRMLxT1L	2017/08/03 11:50:34	-28.0
PRMLxT1L	2017/05/23 11:08:59	-28.0
PRMLxT1L	2017/05/23 10:03:03	-28.0

Summary			
Filename	LxT_Data.005		
Serial Number	3828		
Model	SoundExpert™ LxT		
Firmware Version	2.301		
User			
Location			
Job Description			
Note			
Measurement Description			
Start	2017/12/05 15:30:41		
Stop	2017/12/05 15:50:44		
Duration	0:20:02.7		
Run Time	0:20:02.7		
Pause	0:00:00.0		
Pre Calibration	2017/12/05 15:28:54		
Post Calibration	None		
Calibration Deviation	---		
Overall Settings			
RMS Weight	A Weighting		
Peak Weight	A Weighting		
Detector	Slow		
Preamp	PRMLxT1L		
Microphone Correction	Off		
Integration Method	Linear		
OBA Range	Normal		
OBA Bandwidth	1/1 and 1/3		
OBA Freq. Weighting	A Weighting		
OBA Max Spectrum	At Lmax		
Overload	121.8 dB		
	A	**C**	**Z**
Under Range Peak	**78.1**	75.1	80.1 dB
Under Range Limit	**26.1**	25.2	32.1 dB
Noise Floor	16.3	16.1	22.0 dB

Results		
LAeq	63.9 dB	
LAE	94.7 dB	
EA	325.813 μPa²h	
LApeak (max)	2017/12/05 15:44:44	103.6 dB
LASmax	2017/12/05 15:44:45	87.6 dB
LASmin	2017/12/05 15:38:40	27.3 dB
SEA	-99.9 dB	
LAS > 85.0 dB (Exceedence Counts / Duration)	1	2.4 s
LAS > 115.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 135.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 137.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 140.0 dB (Exceedence Counts / Duration)	0	0.0 s

Community Noise	**Ldn**	**LDay 07:00-22:00**	**LNight 22:00-07:00**	**Lden**	**LDay 07:00-19:00**	**LEvening 19:00-22:00**	**LNight 22:00-07:00**
	63.9	63.9	-99.9	63.9	63.9	-99.9	-99.9

LCeq	70.6 dB
LAeq	63.9 dB
LCeq - LAeq	6.7 dB
LAIeq	66.6 dB
LAeq	63.9 dB
LAIeq - LAeq	2.7 dB
# Overloads	0
Overload Duration	0.0 s
# OBA Overloads	0
OBA Overload Duration	0.0 s

Statistics	
LAS5.00	69.2 dB
LAS10.00	65.8 dB
LAS33.30	49.7 dB
LAS50.00	43.4 dB
LAS66.60	37.5 dB
LAS90.00	31.1 dB

Calibration History

Preamp	**Date**	**dB re. 1V/Pa**
Direct	2015/07/16 9:40:54	-26.0
Direct	2015/07/16 9:12:39	-26.0
PRMLxT1L	2017/12/05 15:28:49	-28.1
PRMLxT1L	2017/12/05 15:20:11	-28.1
PRMLxT1L	2017/12/05 14:57:45	-28.1
PRMLxT1L	2017/12/05 14:49:46	-28.1
PRMLxT1L	2017/12/05 14:25:56	-28.1
PRMLxT1L	2017/12/05 14:25:27	-28.1
PRMLxT1L	2017/09/28 18:44:16	-27.9
PRMLxT1L	2017/09/27 14:38:54	-28.0
PRMLxT1L	2017/09/27 14:38:34	-28.0
PRMLxT1L	2017/08/03 11:51:12	-28.1
PRMLxT1L	2017/08/03 11:50:34	-28.0

Summary

Filename	LxT_Data.014
Serial Number	3827
Model	SoundExpert™ LxT
Firmware Version	2.301
User	
Location	
Job Description	
Note	
Measurement Description	
Start	2017/12/05 14:10:33
Stop	2017/12/06 15:08:06
Duration	1 Day 00:57:32.9
Run Time	1 Day 00:57:32.9
Pause	0:00:00.0
Pre Calibration	2017/12/05 14:07:38
Post Calibration	None
Calibration Deviation	---

Overall Settings

RMS Weight	A Weighting
Peak Weight	A Weighting
Detector	Slow
Preamp	PRMLxT1L
Microphone Correction	Off
Integration Method	Linear
OBA Range	Normal
OBA Bandwidth	1/1 and 1/3
OBA Freq. Weighting	A Weighting
OBA Max Spectrum	At Lmax
Overload	121.7 dB

	A	C	Z
Under Range Peak	**78.0**	75.0	80.0 dB
Under Range Limit	**26.0**	25.2	32.0 dB
Noise Floor	16.2	16.1	22.0 dB

Results

LAeq	43.2 dB	
LAE	92.8 dB	
EA	209.781 µPa²h	
LApeak (max)	2017/12/05 14:13:33	112.5 dB
LASmax	2017/12/05 14:13:33	76.1 dB
LASmin	2017/12/06 1:30:35	18.9 dB
SEA	-99.9 dB	

LAS > 85.0 dB (Exceedence Counts / Duration)	0	0.0 s
LAS > 115.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 135.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 137.0 dB (Exceedence Counts / Duration)	0	0.0 s
LApeak > 140.0 dB (Exceedence Counts / Duration)	0	0.0 s

Community Noise	**Ldn**	**LDay 07:00-22:00**	**LNight 22:00-07:00**	**Lden**	**LDay 07:00-19:00**	**LEvening 19:00-22:00**	**LNight 22:00-07:00**
	46.8	44.5	39.1	46.9	45.3	35.4	39.1

LCeq	62.4 dB
LAeq	43.2 dB
LCeq - LAeq	19.2 dB
LAIeq	50.7 dB
LAeq	43.2 dB
LAIeq - LAeq	7.5 dB
# Overloads	0
Overload Duration	0.0 s
# OBA Overloads	0
OBA Overload Duration	0.0 s

Statistics

LAS5.00	47.9 dB
LAS10.00	44.6 dB
LAS33.30	36.8 dB
LAS50.00	33.2 dB
LAS66.60	29.2 dB
LAS90.00	22.3 dB

Calibration History

Preamp	**Date**	**dB re. 1V/Pa**
Direct	2016/12/05 8:48:15	-26.0
Direct	2016/12/05 8:20:31	-26.0
Direct	2016/12/05 7:57:36	-26.0
PRMLxT1	2015/06/01 14:58:37	-50.8
PRMLxT1	2015/06/01 14:58:10	-50.8
PRMLxT1	2015/03/23 12:06:20	-50.8
PRMLxT1	2015/03/03 13:49:49	-50.9
PRMLxT1	2015/03/03 13:28:13	-50.6
PRMLxT1	2015/03/03 13:27:59	-50.6
PRMLxT1	2015/03/03 13:27:25	-50.7
PRMLxT1	2015/03/03 13:27:10	-50.7
PRMLxT1	2015/03/03 13:26:55	-50.7
PRMLxT1	2015/03/03 13:26:42	-50.6
PRMLxT1	2015/03/03 13:26:28	-50.6
PRMLxT1L	2017/12/05 14:07:38	-28.0
PRMLxT1L	2017/09/28 18:26:44	-28.0
PRMLxT1L	2017/09/27 15:43:37	-27.9
PRMLxT1L	2017/09/27 15:43:15	-27.9
PRMLxT1L	2017/09/19 13:38:18	-28.0
PRMLxT1L	2017/09/19 13:17:29	-27.8
PRMLxT1L	2017/09/19 13:00:16	-27.9
PRMLxT1L	2017/09/19 12:39:38	-28.0
PRMLxT1L	2017/09/19 12:25:16	-28.0
PRMLxT1L	2017/09/19 12:04:27	-28.1
PRMLxT1L	2017/08/30 12:21:00	-28.0

ATTACHMENT 2

Sample Inverter Data

Satcon™

PowerGate Plus

Commercial Solar PV Inverters

Clean power.

PowerGate Plus

Making PV Power Profitable

The rate of return on your solar photovoltaic investment is tied directly to performance—the more power your system can harvest and convert efficiently, the shorter your payback period will be.

Satcon® PowerGate® Plus solar PV inverters have a significant impact on the profitability dynamic of commercial- and utility-scale solar PV systems. With their unparalleled system intelligence, next-generation Edge™ MPPT technology, and industrial-grade engineering, PowerGate Plus inverters provide rugged and reliable solutions that maximize system uptime and power production, even in the harshest environments.

Rugged and Reliable

Streamlined Design

With all components encased in a single, space-saving enclosure, PowerGate Plus PV inverters are easy to install, operate, and maintain.

Single Cabinet with Small Footprint

- No clearance required for sides and back
- Convenient access to all components
- Large in-floor cable glands make access to DC and AC cables easy

Rugged Construction

- Engineered for outdoor environments
- Proprietary enclosure made of G-90 galvanized steel for longevity

Output Transformer

- Provides galvanic isolation
- Matches the output voltage of the PV inverter to the grid
- High-speed anti-islanding algorithm
- Transformer built in; standalone transformer available as an option

Quiet Operation

- 65 dB(A) standard
- 55 dB(A) optional

PowerGate Plus Solar PV Inverters

Commercial and Utility Scale

The world's largest solar power installations depend on Satcon PowerGate Plus PV inverters to provide efficient and stable power—even in the harshest climates.

Broad Range of Power Ratings

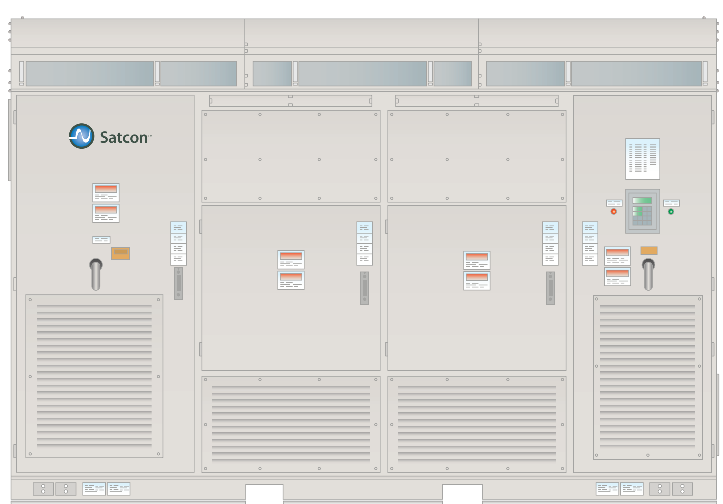
With 11 power ratings—ranging from 30 kW to 1 MW (UL and CE certified)—Satcon offers the widest range of solar PV inverter solutions in the industry.

Advanced, Rugged, and Reliable

Engineered from the ground up to meet the demands of large-scale installations, Satcon PV inverters feature an outdoor-rated enclosure, advanced monitoring and control capabilities, and Edge,™ Satcon's next-generation MPPT solution.

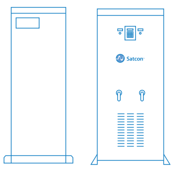
History of Innovation

The proven leader in solar PV inverter solutions for commercial installations, Satcon sets the standards for efficient large-scale power conversion. From the introduction of the first single-cabinet PV inverter, to the first high-efficiency power conditioning system for commercial PV inverters, to the groundbreaking 1 MW PV inverter—Satcon continues to lead the way.

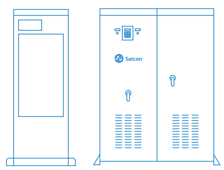


PowerGate Plus 500 kW

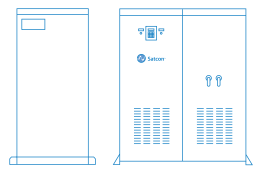
PowerGate Plus Models



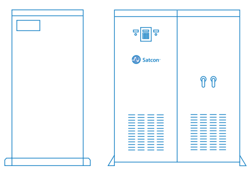
PowerGate Plus 30 kW



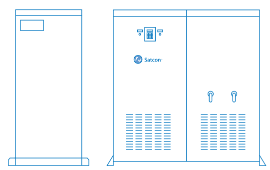
PowerGate Plus 50 kW



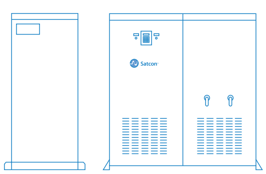
PowerGate Plus 75 kW



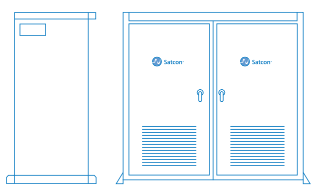
PowerGate Plus 100 kW



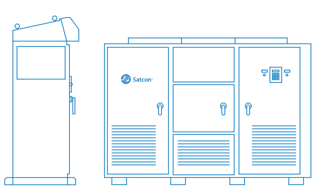
PowerGate 135 kW



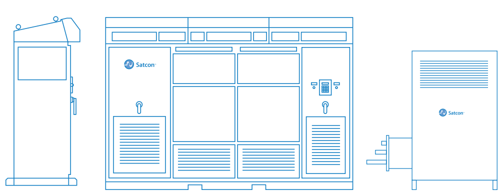
PowerGate Plus 150 kW



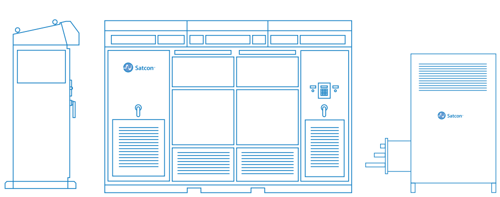
PowerGate 225 kW



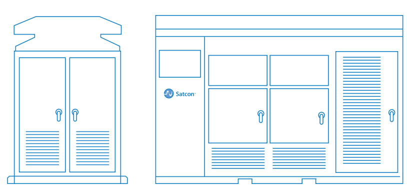
PowerGate Plus 250 kW



PowerGate Plus 375 kW



PowerGate Plus 500 kW



PowerGate Plus 1 MW
(External Transformer Required)

Proven Reliability

Rugged and reliable, PowerGate Plus PV inverters are engineered from the ground up to meet the demands of large-scale installations.

Low Maintenance

- Proven track record of reliable performance
- Modular components make service efficient
- Dual cooling fans

Safety

- Seismic Zone 4 compliant
- Built-in DC and AC disconnect switches
- Integrated DC two-pole disconnect switch isolates the inverter (with the exception of the GFDI circuit) from the photovoltaic power system to allow inspection and maintenance
- Built-in isolation transformer
- Protective cover over exposed power connections

Testing and Certification

- UL1741
- CSA 107.1-01
- IEEE 1547
- IEEE C62.41.2

Warranty

- Five years (standard)
- Extended service agreement (optional)

Performance Optimization

+20%

Unparalleled Performance

With 11 power ratings—ranging from 30 kW to 1 MW—Satcon offers the widest range of solar PV inverter solutions in the industry, enabling you to closely match array capacities and achieve maximum energy throughput.

Edge MPPT

- Features a proprietary maximum power point tracking (MPPT) system
- Provides rapid and accurate control
- Improves performance by up to 20%, even in challenging climate conditions
- Boosts overall PV plant kilowatt yield
- Provides a wide range of operation across all photovoltaic cell technologies, including thin film, monocrystalline, and polycrystalline PV panels

Power and Efficiency Ratings

- Eleven power ratings, ranging from 30 kW to 1 MW (UL and CE certified)
- CEC efficiency rating:
  97% to 98% (without transformer)
  96% to 97% (with transformer)
- CE efficiency rating:
  97% to 98% (without transformer)
- Ambient temperature range: -20º C (-4º F) to 50º C (122º F)
- Full array nameplate power rating maintained throughout the entire MPPT DC voltage range
- Superior dynamic performance in cloudy conditions

DC Inputs at Full Power

- 305–320V DC to more than 600V DC
- 420V DC to 850V DC

Printed Circuit Board Durability

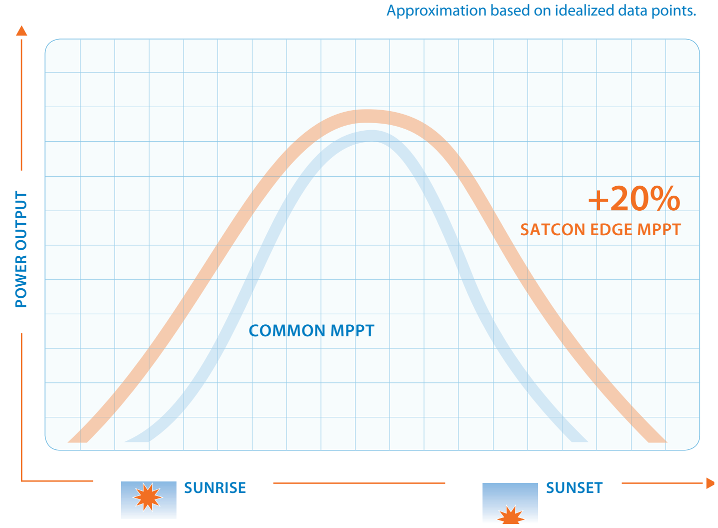
- Wide thermal operating range: -40º C (-40º F) to 85º C (185º F)
- Conformal coated to withstand extreme humidity and air-pollution levels

Satcon Edge MPPT

Boost PV plant yield up to 20 percent.

At the heart of PowerGate Plus is Edge, Satcon's next-generation power optimization solution. With rapid and accurate MPPT control, Edge increases PV plant kilowatt yield up to 20 percent by extending the production window of arrays, enabling them to operate at optimal voltage and current levels for longer periods of time—even in varied sun conditions. To maximize efficiency, Edge improves the performance of all PV technologies, including fixed and tracking solar arrays, enabling you to get the most from your investment.

Approximation based on idealized data points.



Optimize voltage and current, even in harsh climates.

Edge achieves full nameplate power ratings across the entire MPPT DC voltage range. By optimizing output at the lowest end of the DC voltage range without limiting full kilowatt yield, Edge ensures that your PV system delivers maximum throughput, across all photovoltaic cell technologies, including thin film, monocrystalline, and polycrystalline PV panels. Rugged operating temperature ratings—up to 50º C (122º F)—enable PowerGate Plus PV inverters to achieve maximum efficiency, even when DC voltage output is at its lowest.

Maximize system throughput from end to end.

Edge accommodates a wide range of solar array input voltages—from 305–320V DC to more than 600V DC and from 420V DC to 850V DC—and converts DC power to grid-compatible AC power with unparalleled efficiency. With PowerGate Plus, you'll achieve maximum throughput and optimized performance—from the array to the grid.

Satcon PV View Plus

Monitor and control system performance and increase ROI.

Uptime, output, and overall profitability are dramatically reduced when system performance issues go unnoticed. To maximize efficiency, you need a comprehensive view of the array's performance—critical information that will help your team identify issues, improve throughput, and increase system uptime.

With Satcon PV View® Plus, an advanced layer of intelligence is added to PowerGate Plus, giving you complete visibility into and control over the variables that affect energy conversion. Real-time data acquisition and performance monitoring make it easy to assess array output, evaluate site conditions, pinpoint problems, and identify maintenance needs rapidly—before performance is compromised.

Manage your entire system through a single dashboard.

Using real-time sensing, PV View Plus monitors, analyzes, and delivers critical performance information through a centralized dashboard. By aggregating data, PV View Plus establishes benchmarks for normal performance, predicts anomalies, and provides system health information, making it easy to keep your PV plant operating at peak performance.

Intelligent Insight

With Satcon PV View Plus, you have unparalleled access to the critical information you need to keep your PV plant running at its peak efficiency.

Variables Monitored

- Solar array power production (digital display that shows AC voltage, current, kVA, kVAR, and kW)
- Power and energy output
- Greenhouse gasses (emissions avoidance)
- Inverter status
- Inverter faults history
- AC grid conditions
- Weather station data
- Photovoltaic system performance

Real-Time Sensing

- Air temperature
- PV array cell temperature
- Irradiance
- Wind speed and direction

Third-Party Compatibility

PowerGate Plus PV inverters are also compatible with leading third-party monitoring systems

Satcon. The standard for clean power.

www.satcon.com/go/powergateplus

PowerGate Plus Solar PV Inverters

Specifications			30 kW	50 kW	75 kW	100 kW	135 kW	150 kW	225 kW	250 kW	375 kW	500 kW	1 MW
Full-Power MPPT DC Input Range (V DC)	US	305–600	o	o									
		315–600			o	o							
		320–600					o		o	o	o	o	
	EU	430–850				o		o		o		o	o
Low Voltage Tap Line[1]		20%	o (Optional)	o (Optional)	o (Optional)	o (Optional)	o (Optional)	o (Optional)	o (Optional)	o (Optional)	o (Optional)	o (Optional)	
Maximum Voc (V DC)	UL	600	o	o	o	o	o		o	o	o	o	
	CE	900				o		o		o		o	o
Nominal Frequency Range (Hz)	US	59.5–60.5	o	o	o	o	o		o	o	o	o	o
	EU	49.5–50.5				o		o		o		o	o
AC Voltage Range Set Points		+/- 10%	o	o	o	o	o	o	o	o	o	o	o
Power Factor = Unity		>0.99	o	o	o	o	o	o	o	o	o	o	o
Harmonic Distortion		<3% THD	o	o	o	o	o	o	o	o	o	o	o
Efficiency w/ Transformer (CEC)		95%	o										
		95.5%		o					o				
		96%–97%			o	o	o	o		o	o	o	
Efficiency w/o Transformer		97%–98%						o		o		o	o
Forced Air Cooling			o	o	o	o	o	o	o	o	o	o	o
Noise Level		<65 dB(A)	o	o	o	o	o	o	o	o	o	o	o
Ambient Temperature Range (° C)		-20 to +50	o	o	o	o	o	o	o	o	o	o	o
Enclosure Rating		NEMA 3R	o	o	o	o	o	o	o	o	o	o	o
Cabinet Finish (16-Gauge, Powder-Coated Steel)			o	o	o	o		o		o	o	o	o
Base and Door Finish (14-Gauge Powder-Coated Steel)			o	o	o	o		o		o	o	o	o
Cabinet, Base, and Door Finish (11-Gauge, Powder-Coated Steel)							o		o				
Seismic Rating		Zone 4	o	o	o	o	o	o	o	o	o	o	o

[1] Accommodates low solar array voltages by reducing minimum input voltage requirements by 20%.

o Standard o Optional Specifications are subject to change without notice.

Satcon™
Clean power.

Satcon Corporate
27 Drydock Avenue
Boston, MA 02210
P 617.897.2400
F 617.897.2401
E sales@satcon.com

Satcon West
2925 Bayview Drive
Fremont, CA 94539
P 510.226.3800
F 510.226.3801
E sales@satcon.com

Satcon Canada
835 Harrington Court
Burlington, ON L7N 3P3
Canada
P 905.639.4692
F 905.639.0961
E sales@satcon.com

Satcon Spain
Príncipe de Vergara 93 - 1º
28006 Madrid, Spain
P 34 917610275
F 34 915612987
E sales@satcon.com

ATTACHMENT 3

NEMA Standards

NEMA TR 1-2013

Transformers, Step Voltage Regulators and Reactors

Published by:

National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, VA 22209

NOTICE AND DISCLAIMER

The information in this publication was considered technically sound by a consensus among persons engaged in its development at the time it was approved. Consensus does not necessarily mean there was unanimous agreement among every person participating in the development process.

The National Electrical Manufacturers Association (NEMA) standards and guideline publications, of which the document herein is one, are developed through a voluntary standards development process. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. Although NEMA administers the process and establishes rules to promote fairness in the development of consensus, it does not write the documents, nor does it independently test, evaluate, or verify the accuracy or completeness of any information or the soundness of any judgments contained in its standards and guideline publications.

NEMA disclaims liability for any personal injury, property, or other damages of any nature, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, application, or reliance on this document. NEMA disclaims and makes no guaranty or warranty, express or implied, as to the accuracy or completeness of any information published herein, and disclaims and makes no warranty that the information in this document will fulfill any particular purpose(s) or need(s). NEMA does not undertake to guarantee the performance of any individual manufacturers or seller's products or services by virtue of this standard or guide.

In publishing and making this document available, NEMA is not undertaking to render professional or other services for or on behalf of any person or entity, nor is NEMA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstance. Information and other standards on the topic covered by this publication may be available from other sources, which the user may wish to consult for additional views or information not covered by this publication.

NEMA has no power, nor does it undertake to police or enforce compliance with the contents of this document. NEMA does not certify, test, or inspect products, designs, or installations for safety or health purposes. Any certification or other statement of compliance with any health- or safety-related information in this document shall not be attributable to NEMA and is solely the responsibility of the certifier or maker of the statement.

FOREWORD

This foreword is not part of NEMA TR1-2013 Transformers, Step Voltage Regulators, and Reactors.

The standards appearing in this publication have been developed by the Transformer Section and have been approved for publication by the National Electrical Manufacturers Association. They are used by the electrical industry to promote production economies and to assist users in the proper selection of transformers.

The Transformer Section is working actively with the IEEE Committee, C57 on Transformers, Regulators, and Reactors, in the development, correlation, and maintenance of national standards for transformers. This Committee operates under the procedures both the American National Standards Institute (ANSI) and the Institute of Electrical and Electronics Engineers (IEEE).

It is the policy of the NEMA Transformer Section to remove material from the NEMA standards publication as it is adopted and published in the IEEE C57 series standards. The NEMA standards publication for Transformers, Regulators, and Reactors references these and other American National Standards applying to transformers, and is intended to supplement without duplication both the American National and IEEE standards.

The NEMA standards publication for Transformers, Regulators and Reactors contains provision for the following:

a. IEEE and American National Standards adopted by reference and applicable exceptions approved by NEMA if any.
b. NEMA Official Standards Proposals—These are official drafts of proposed standards developed within NEMA or in cooperation with other interested organizations, for consideration by ANSI and IEEE. They have a maximum life of ten years, during which time they must be revised as American National Standards, IEEE standards, or adopted as NEMA standards, or rescinded.
c. Manufacturing Standards—These are NEMA standards which are primarily of interest to the manufacturers of transformers and which are not yet included in an American National or IEEE standards.
d. Standards Which Are Controversial—These are NEMA standards, on which there is a difference of opinion within Committee C57. The NEMA version will be included in the NEMA standards publication until such time as the differences between ANSI, IEEE, and NEMA are resolved.

NEMA standards publications are subject to periodic review and take into consideration user input. They are being revised constantly to meet changing economic conditions and technical progress. Users should secure latest editions. Proposed or recommended revisions should be submitted to:

Senior Technical Director, Operations
National Electrical Manufacturers Association
1700 13th Street, Suite 900
Rosslyn, VA 22209

This standards publication was developed by the Transformer Products Section of the National Electrical Manufacturers Association. Section Approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Section was composed of the following members:

ABB, Inc.	Raleigh, NC
CG Power Systems USA Inc.	Washington, MO
Cooper Power Systems by Eaton	Cleveland, OH
Federal Pacific	Bristol, VA
General Electric	Fairfield, CT
Hammond Power Solutions, Inc.	Guelph, Ontario
L-3 Communications Power Paragon	Anaheim, CA
MGM Transformer Company	Commerce, CA
Mirus International Inc	Brampton, Ontario
Niagara Transformer Corporation	Buffalo, NY
ONYX Power Inc.	Santa Ana, CA
Power Quality International Corp.	Odessa, FL
Powersmiths International Corp.	Brampton, Ontario
Schneider Electric	Palatine, IL
Siemens Industry	Norcross, GA
SolaHD	Rosemont, IL
SPX Transformers	Waukesha, WI
VanTran Industries	Waco, TX
WEG Electric Corp.	Duluth, GA

SCOPE

This standards publication applies to single phase and poly phase power and distribution transformers (including step-voltage regulators and reactors). This standard excludes dry type transformers covered by NEMA ST20. This publication provides a reference list of applicable ANSI and IEEE C57 standards.

In addition, this publication includes certain NEMA standard test methods, test codes, properties, etc. of liquid-immersed transformers, step-voltage regulators, and reactors that are not IEEE standards.

TABLE OF CONTENTS

TABLES

PART 0
GENERAL

The following IEEE and 10 CFR standards are applicable references and should be inserted in this Part 0:

IEEE Std. C57.12.00-2010	*IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*
IEEE Std. C57.12.01-2005	*IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers including those with Solid-Cast and/or Resin-Encapsulated windings*
IEEE Std. C57.12.10-2010	*IEEE Standard Requirement for Liquid-Immersed Power Transformers*
IEEE Std. C57.12.70-2011	*IEEE Standard for Standard Terminal Markings and Connections for Distribution and Power Transformers*
IEEE Std. C57.12.90-2010	*IEEE Standard Test Code for Liquid-immersed Distribution, Power & Regulating Transformers*
IEEE Std. C57.12.90-2011	*IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*
IEEE Std. C57.19.00-2004	*IEEE Standard General Requirements and Test Procedure for Power Apparatus Bushings*
IEEE Std. C57.19.01-2000	*IEEE Standard Performance Characteristics & Dimensions for Outdoor Apparatus Bushings*
IEEE Std. C57.91-2011	*IEEE Guide for Loading Mineral-oil-immersed Transformers and Step-Voltage Regulators*
10 CFR 429	*Part 429-Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment*
10 CFR 431	*Part 431- Energy Efficiency Program for Certain Commercial and Industrial Equipment*

The NEMA standards TR 1-0.01 through TR 1-0.03 on the following pages (see Part 0, Pages 2-3) also generally apply to transformers.

0.01 PREFERRED VOLTAGE RATINGS

Preferred system voltages and corresponding transformer voltage ratings are given in the American National Standard for Electric Power Systems and Equipment-Voltage Ratings (60 Hz); C84.1-2011. It is recommended that these ratings be used as a guide in the purchase and operation of transformers.

0.02 PREFERRED FORCED-AIR AND FORCED-LIQUID RATINGS

Preferred forced-air and forced-liquid ratings are given in section 4 Table 1 of IEEE Std. C57.12.00-2010. It is recommended that these ratings be used as a guide in the purchase and operation of transformers.

0.03 AUDIBLE SOUND LEVELS

Transformers shall be so designed that the average sound level will not exceed the values given in Tables 0-1 through 0-2 when measured at the factory in accordance with the conditions outlined in IEEE Std. C57.12.90-2010.

The guaranteed sound levels should continue to be per Tables 1 through 2 until such time as enough data on measured noise power levels becomes available.

Sound pressure levels are established and published in this document. Sound power may be calculated from sound pressure using the method described in C57.12.90-2010.

Rectifier, railway, furnace, grounding, mobile and mobile unit substation transformers are not covered by the tables. The tables do not apply during operation “of” on load tap changers in power transformers and step-voltage regulators.

For audible sound levels of dry-type transformers 15000-Volt nominal system voltage and below the tables listed in the IEEE C57.12.01 standard are applicable references.

Table 1
AUDIBLE SOUND LEVELS FOR OIL-IMMERSED POWER TRANSFORMERS

Average Sound Level tt. Decibels	Equivalent Two-Winding Rating*																	
	350 kV BIL and Below			450, 550, 650 kV BIL			750 and 825 kV BIL			900 and 1050 kV BIL			1175 kV BIL			1300 kV BIL. and Above		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
57	700																	
58	1000																	
59				700														
60	1500			1000														
61	2000																	
62	2500			1500														
63	3000			2000														
64	4000			2500														
65	5000			3000														
66	6000			4000			3000											
67	7500	6250▲▲		5000	3750▲▲		4000	3125▲▲										
68	10000	7500		6000	5000		5000	3750										
60	12500	9375		7500	6250		6000	5000										
70	15000	12500		10000	7500		7500	6250										
71	20000	16667		12500	9375		10000	7500										
72	25000	20000	20800	15000	12500		12500	9375										
73	30000	26667	25000	20000	16667		15000	12500		12500								
74	40000	33333	33333	25000	20000	20800	20000	16667		15000			12500					
75	50000	40000	41687	30000	26667	25000	25000	20000	20800	20000	16667		15000			12500		
76	60000	53333	50000	40000	33333	33333	30000	26667	25000	25000	20000	20800	20000	16667		15000		
77	80000	66687	66667	50000	40000	41667	40000	33333	33333	30000	26667	25000	25000	20000	20800	20000	16667	
78	100000	80000	83333	60000	53333	50000	50000	40000	41667	40000	33333	33333	30000	26667	25000	25000	20000	20800
79		106667	100000	80000	66667	66667	60000	53333	50000	50000	40000	41667	40000	33333	33333	30000	26667	25000
80		133333	133333	100000	60000	83333	80000	66667	66667	60000	53333	50000	50000	40000	41667	40000	33333	33333
81			166667		106667	100000	100000	80000	83333	80000	66667	66667	60000	53333	50000	50000	40000	41667
82			200000		133333	133333		106867	100000	100000	80000	83333	80000	66667	66667	60000	53333	50000
83			250000			166667		133333	133333		10686	100000	100000	80000	83333	80000	66667	68667
84			300000			200000			166667		13333	133333		106667	100000	100000	80000	83333
85			400000			250000			200000			166667		133333	133333		106667	100000
86						300000			250000			200000			166667		133333	133333
87						400000			300000			250000			200000			168667
88									400000			300000			250000			200000
89												400000			300000			250000
90															400000			300000
91																		400000

Column 1 • Class*ONAN. ONWN and OFWF Rating*
Column 2 • Class* ONAF and ODAF First stage Auxiliary Cooling"t
Column 3 • Straight OFAF Ratings, ONAF * and ODAF * Second stage Auxiliary Cooling"t'
Classes of cooling, see section 5.1 IEEE Std.. C57.12-2010

"First- and second stage auxiliary cooling, see section 4 Table 1 of IEEE Std.. C57-12-2010
f For column 2 and 3 ratings, the sound levels are with the auxiliary cooling equipment in operation.
tf For intermediate kVA ratings, use the average sound level of the next larger kVA rating.
▲The equivalent two-winding 55ºC or 65ºC rating is defined as one-half the sum of the kVA rating of all windings
▲▲ Sixtv-seven decibels for all kVA ratings equal to this or smaller.

Table 2
AUDIBLE SOUND LEVELS FOR LIQUID-IMMERSED NETWORK TRANSFORMERS AND STEP-VOLTAGE REGULATORS

Equivalent Two-Winding kVA	Average Sound Level Decibels
0-50	48
51-100	51
101-300	55
301-500	56
501-750	57
751-1000	58
1001-1500	60
1501-2000	61
2001-2500	62
2501-3000	63

PART 1
POWER TRANSFORMERS

The IEEE Std. C57.12.10-2010 is an applicable reference standard for power transformers and should be inserted in this Part 1.

The IEEE Std. C57.91-2011 is an applicable reference standard and should be inserted in this Part 1.

The following other parts of this edition of NEMA TR 1 shall also apply for power transformers.

a. Part 0 General
b. Part 9 Terminology
c. Part 10 Test Code

PART 2
SUBSTATION AND DISTRIBUTION STEP-VOLTAGE REGULATORS

The following IEEE standards are applicable references for substation and distribution step-voltage regulators and should be inserted in this Part 2:

IEEE Std. C57.15-2009	*IEEE Standard Requirements, Terminology, and Test Code for Step-Voltage Regulators*
IEEE Std. C37.90-1-2012	*IEEE Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus*
IEEE Std. C37.90.2-2004 (R2010)	*IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers*
IEEE Std. C37.90.3-2001	*IEEE Standard Electrostatic Discharge Tests for Protective Relays*
IEEE Std. C57.12.31-2010	*IEEE Standard for Pole-Mounted Equipment--Enclosure Integrity*
IEEE Std C57.91-2011	*IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators*
IEEE Std. C57.98-2011	*IEEE Guide for Transformer Impulse Tests*
IEEE Std. C57.131-2012	*IEEE Standard Requirements for Tap Changers*

PART 3
DISTRIBUTION TRANSFORMERS

The following IEEE Standards are applicable references for distribution transformers and should be inserted in this Part 3:

IEEE Std. C57.12.20-2011	*IEEE Standard for Overhead-Type Distribution Transformers, 500 kVA and Smaller: High Voltage, 34500 Volts and Below; Low Voltage, 7970/13800Y Volts and Below*
IEEE Std. C57.12.23-2009	*IEEE Standard for Submersible Single-Phase Transformers: 167 kVA and Smaller, High-Voltage 25000 V and Below; Low-Voltage 600 V and Below*
IEEE Std. C57.12.24-2009	*IEEE Standard for Submersible, Three-Phase Transformers, 3750 kVA and Smaller: High Voltage, 34500 GrdY/19920 Volts and Below; Low Voltage, 600 Volts and Below*
IEEE Std. C57.12.29™-2005	*IEEE Standard for Pad-Mounted Equipment-Enclosure Integrity for Coastal Environments*
IEEE Std. C57.12.30™-2010	*IEEE Standard for Pole-Mounted Equipment-Enclosure Integrity for Coastal Environments*
IEEE Std. C57.12.31™-2002	*IEEE Standard for Pole-Mounted Equipment-Enclosure Integrity*
IEEE Std. C57.12.32™-2002 (R2008)	*IEEE Standard for Submersible Equipment- Enclosure Integrity*
IEEE Std. C57.12.34™-2009	*IEEE Standard for Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below.*
IEEE Std. C57.12.35™-2007	*IEEE Standard for Bar Coding for Distribution Transformers and Step-Voltage Regulators*
IEEE Std. C57.12.36™-2007	*IEEE Standard Requirements for Liquid-Immersed Distribution Substation Transformers*
IEEE Std. C57.12.38™-2009	*IEEE Standard for Pad-Mounted-Type, Self-Cooled, Single-Phase Distribution Transformers; High Voltage, 34 500 GrdY/19 920 V and below, Low Voltage, 240/120 V; 167 kVA and smaller*
IEEE Std. C57.105™-1978 (R2008)	*IEEE Guide for Application of Transformer Connections in Three-Phase Distribution Systems*

The following other parts of this edition of NEMA TR 1 shall apply for distribution transformers:

a. Part 0 General
b. Part 9 Terminology
c. Part 10 Test Code

3.01 DESIGN TEST FOR ENCLOSURE SECURITY OF PADMOUNTED COMPARTMENTAL TRANSFORMERS

The following IEEE standards provide a means for evaluating the security of enclosures for transformers.

IEEE Std. C57.12.28™-2009	*IEEE Standard for Pad-Mounted Equipment - Enclosure Integrity*
IEEE Std. C57.12.34™-2009	*IEEE Standard for Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage and Below.*
IEEE Std. C57.12.38™-2009	*IEEE Standard for Pad-Mounted-Type, Self-Cooled, Single-Phase Distribution Transformers; High Voltage, 34 500 GrdY/19 920 V and Below, Low Voltage, 240/120 V; 167 kVA and Smaller*

Part 4
SECONDARY NETWORK TRANSFORMERS

The American National Standard Requirements for C57.12.40-2011 *Secondary Network Transformers, Subway and Vault Types (Liquid Immersed)*, (with the exception of paragraphs 5.5.4 and 11.5.2 on finishes) is an applicable reference for secondary network transformers and should be inserted in this Part 3.

The following other parts of this edition of NEMA TR 1 shall also apply for secondary network transformers.

a. Part 0 General
b. Part 9 Terminology
c. Part 10 Test Code

Part 5
DRY-TYPE TRANSFORMERS

The following IEEE/NEMA standards are applicable references for dry-type transformers and should be inserted in this Part 4:

IEEE Std. C57.12.01 -2005	*IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin-Encapsulated Windings*
IEEE Std. C57.12.91-2011	*IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*
IEEE Std. C57.12.50-1998	*Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase; With High-Voltage 601-34500 Volts, Low-Voltage 120-600 Volts*
IEEE Std. C57.12.51-2008	*IEEE Standard for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, With High-Voltage 601-34500 Volts, Low-Voltage 208Y/120V to 4160V-General Requirements*
IEEE Std. C57.12.52-2012	*IEEE Standard for Sealed Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase, With High-Voltage 601-34500 Volts, Low-Voltage 208Y/120V to 4160V-General Requirements*
IEEE Std. C57.94-1982 (R2006)	*IEEE Recommended Practices for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers*
IEEE Std. C57.96-1989 (R2004)	*Guide for Loading Dry-Type Distribution and Power Transformers*
NEMA ST 20	*Dry Type Transformers for General Applications*

Part 6
SUBSTATION TRANSFORMERS

The following other parts of this edition of NEMA TR 1 shall also apply for substation transformers.

a. Part 0 General
b. Part 9 Terminology
c. Part 10 Test Code

PART 7
ARC FURNACE TRANSFORMERS

The following other parts of this edition of NEMA TR 1 shall also apply for arc furnace transformers.

a. Part 0 General
b. Part 9 Terminology
c. Part 10 Test Code

PART 8
SHUNT REACTORS

The IEEE Std. C57.21-2008 is an applicable reference and should be inserted in this Part 8.

To facilitate safe and effective operation and consistency of reporting for all shunt reactor transformers, it is recommended that the information listed this IEEE standard be included in the test report for every shunt reactor transformer.

PART 9
TERMINOLOGY

The ANSI/IEEE Std. C57.12.80-2010 is an applicable reference for terminology and should be inserted in this Part 9.

PART 10
TEST CODE

The following IEEE standards are applicable references for transformer test codes and should be inserted in this Part 10:

IEEE Std. C57.12.90™-2010	*IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers*
IEEE Std. C57.12.91-2011	*IEEE Standard Test Code for Dry-Type Distribution and Power Transformers*
IEEE Std. C57.13™-2008	*IEEE Standard Requirements for Instrument Transformers*
IEEE Std. C57.98™-2011	*IEEE Guide for Transformer Impulse Tests*

To facilitate safe and effective operation and consistency of reporting for all power and distribution transformers, it is recommended that the information listed in the IEEE Std. C57.12.00-2010, section 8.7 be included in the test report for every transformer.

ATTACHMENT 4

Noise Modeling Parameters

Source name	Reference	Level Day dB(A)	Night dB(A)	Corrections Kwall dB(A)	CI dB(A)	CT dB(A)
Substation	Unit	97.0	-	-	-	-
Inverter1	Unit	77.0	-	-	-	-
Inverter2	Unit	77.0	-	-	-	-
Inverter3	Unit	77.0	-	-	-	-
Inverter4	Unit	77.0	-	-	-	-
Inverter5	Unit	77.0	-	-	-	-
Inverter6	Unit	77.0	-	-	-	-
Inverter7	Unit	77.0	-	-	-	-
Inverter8	Unit	77.0	-	-	-	-
Inverter9	Unit	77.0	-	-	-	-
Inverter10	Unit	77.0	-	-	-	-
Inverter11	Unit	77.0	-	-	-	-
Inverter12	Unit	77.0	-	-	-	-
Inverter13	Unit	77.0	-	-	-	-
Inverter14	Unit	77.0	-	-	-	-
Inverter15	Unit	77.0	-	-	-	-
Inverter16	Unit	77.0	-	-	-	-
Inverter17	Unit	77.0	-	-	-	-
Inverter18	Unit	77.0	-	-	-	-
Inverter19	Unit	77.0	-	-	-	-
Inverter20	Unit	77.0	-	-	-	-
Inverter21	Unit	77.0	-	-	-	-
Inverter22	Unit	77.0	-	-	-	-
Inverter23	Unit	77.0	-	-	-	-
Inverter24	Unit	77.0	-	-	-	-
Inverter25	Unit	77.0	-	-	-	-
Inverter26	Unit	77.0	-	-	-	-
Inverter27	Unit	77.0	-	-	-	-
Inverter28	Unit	77.0	-	-	-	-
Inverter29	Unit	77.0	-	-	-	-
Inverter30	Unit	77.0	-	-	-	-
Inverter31	Unit	77.0	-	-	-	-
Inverter32	Unit	77.0	-	-	-	-
Inverter33	Unit	77.0	-	-	-	-
Inverter34	Unit	77.0	-	-	-	-
Substation35	Unit	77.0	-	-	-	-
Inverter36	Unit	77.0	-	-	-	-
Transformer1	Unit	73.0	-	-	-	-
Transformer2	Unit	73.0	-	-	-	-
Transformer3	Unit	73.0	-	-	-	-
Transformer4	Unit	73.0	-	-	-	-
Transformer5	Unit	73.0	-	-	-	-
Transformer6	Unit	73.0	-	-	-	-

Source name	Reference	Level		Corrections		
		Day	Night	Kwall	CI	CT
		dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
Transformer7	Unit	73.0	-	-	-	-
Transformer8	Unit	73.0	-	-	-	-
Transformer9	Unit	73.0	-	-	-	-
Transformer10	Unit	73.0	-	-	-	-
Transformer11	Unit	73.0	-	-	-	-
Transformer12	Unit	73.0	-	-	-	-
Transformer13	Unit	73.0	-	-	-	-
Transformer14	Unit	73.0	-	-	-	-
Transformer15	Unit	73.0	-	-	-	-
Transformer16	Unit	73.0	-	-	-	-
Transformer17	Unit	73.0	-	-	-	-
Transformer18	Unit	73.0	-	-	-	-
Transformer19	Unit	73.0	-	-	-	-
Transformer20	Unit	73.0	-	-	-	-
Transformer21	Unit	73.0	-	-	-	-
Transformer22	Unit	73.0	-	-	-	-
Transformer23	Unit	73.0	-	-	-	-
Transformer24	Unit	73.0	-	-	-	-
Transformer25	Unit	73.0	-	-	-	-
Transformer26	Unit	73.0	-	-	-	-
Transformer27	Unit	73.0	-	-	-	-
Transformer28	Unit	73.0	-	-	-	-
Transformer29	Unit	73.0	-	-	-	-
Transformer30	Unit	73.0	-	-	-	-
Transformer31	Unit	73.0	-	-	-	-
Transformer32	Unit	73.0	-	-	-	-
Transformer33	Unit	73.0	-	-	-	-
Transformer34	Unit	73.0	-	-	-	-
Transformer35	Unit	73.0	-	-	-	-
Transformer36	Unit	73.0	-	-	-	-
Gen-Tie Line	Meter	42.0	-	-	-	-

No.	Receiver name	Floor	Level Day dB(A)
1	1	GF	43.9
2	2	GF	20.3