Attachment H. Acoustic Assessment Report

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Carriger Solar Project
Acoustic Assessment Report

Prepared for:

Carriger Solar, LLC

Prepared by:

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Acronyms and Abbreviations

Applicant	Carriger Solar, LLC
BESS	battery energy storage system
CadnaA	Computer-Aided Noise Abatement
dB	decibel
dBA	A-weighted decibel
dBL	linear decibel
EDNA	Environmental Designation for Noise Abatement
EFSEC	Energy Project Site Evaluation Council
EOZ	Energy Overlay Zone
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
Hz	hertz
ISO	International Organization for Standardization
KCC	Klickitat County Code
kV	kilovolt
L_{dn}	day-night average sound level
L_{eq}	equivalent sound level
L_{max}	maximum sound level
L_P	sound pressure level
L_W	sound power level
MW	megawatt
NSR	noise sensitive receptor
µPa	microPascal
Project	Carriger Solar Project
PV	photovoltaic
Tetra Tech	Tetra Tech, Inc.
WAC	Washington Administrative Code

1.0 Introduction

The Carriger Solar Project (Project) proposed by Carriger Solar, LLC (the Applicant), a wholly owned subsidiary of Cypress Creek Renewables, LLC, is a proposed solar Photovoltaic (PV) electric generating facility that includes 160 megawatts (MW) of solar energy and 63 MW of battery energy storage on private lands in Klickitat County, Washington. The Project components include a solar array comprised of PV modules; pile-driven racking equipment; power inverters and transformers mounted on concrete pads; a collection system of cables; battery energy storage system; Project substation; and interconnection with the regional electric transmission system.

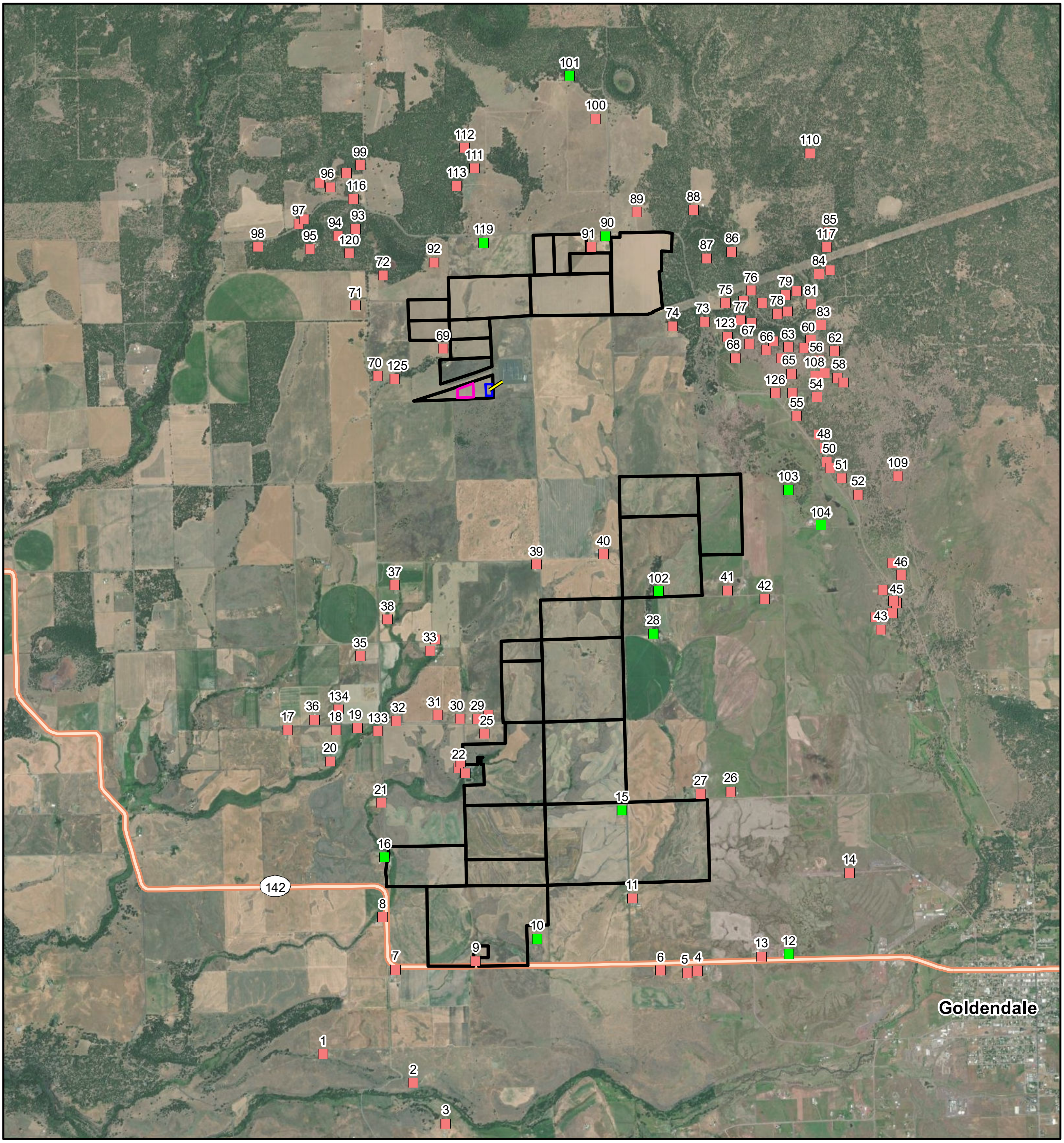
Tetra Tech, Inc. (Tetra Tech) has prepared this acoustic assessment for the Project, evaluating potential sound impacts relative to the applicable noise regulations prescribed in the Washington Administrative Code (WAC). The existing ambient acoustic environment was characterized based on land use, population density, and proximity to major roadways. An acoustic modeling analysis was conducted simulating sound produced during both construction and operation. Operational sound sources consisted primarily of the inverters, step-up transformers, battery storage, and transformer at the on-site substation. The overall objectives of this assessment were to 1) identify Project sound sources and estimate sound propagation characteristics, 2) computer-simulate sound levels using internationally accepted calculation standards, and 3) confirm that the Project will operate in compliance with the applicable noise regulations.

1.1 Project Area

The Project Lease Boundary is approximately 2,110 acres that encompasses 25 privately owned assessor parcels for which the Applicant has executed or is pursuing a lease agreement with the underlying property owner. The Project parcels are composed primarily of agricultural and rural residential land uses. Land within the Project Lease Boundary have been heavily disturbed by agricultural crops and livestock grazing. Land in the surrounding area is similarly used and zoned for agricultural and rural residences. State Route 142 is located at the southern boundary of the Project, and the Washington Department of Fish and Wildlife Goldendale Fish Hatchery is located on an adjacent parcel on the western edge of the Project. Other lands to the west of the Project are also proposed for development of an unrelated utility scale solar project.

The Project parcels are located in unincorporated Klickitat County in the Extensive Agricultural District and General Rural Zone. Within the General Rural Zone, uses of a “public utility nature” may be permitted as a conditional use as described in Klickitat County Code (KCC) 19.18.030.H. Within the Extensive Agricultural District, “utility facilities necessary for public service” may be permitted as a conditional use, as described in KCC 19.16.030.E. The southern portion of the Project (south of the line that divides Range 15 East Townships 4 and 5) is located in the Energy Overlay Zone (EOZ) (KCC 19.39). In the EOZ, solar energy facilities are a permitted use (KCC 19.39.4). A portion of the Project is located outside of the EOZ; therefore, the Project requires a Conditional Use Permit pursuant to the underlying zone(s), and the EOZ ordinance (KCC 19.39) does not apply. The preliminary design accounts for Project size, topography, and other constraints; however, the solar modules, supporting components, and precise layout of the solar array have not yet been finalized.

Figure 1 provides an overview of the Project Area and provides the locations of nearby residences, which are considered Noise Sensitive Receptors (NSRs).



Project Lease Boundary Parcels

500 kV Transmission Line

BESS

Substation

Noise Sensitive Receptor

Participant

Non-Participant

0 0.5 1

Miles

N

Figure 1
Project Area

Carriger Solar Project

Klickitat County, WA

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1.2 Acoustic Metrics and Terminology

All sounds originate with a source, whether it is a human voice, motor vehicles on a roadway, or a combustion turbine. Energy is required to produce sound, and this sound energy is transmitted through the air in the form of sound waves – tiny, quick oscillations of pressure just above and just below atmospheric pressure. These oscillations, or sound pressures, impinge on the ear, creating the sound we hear. A sound source is defined by a sound power level (L_W), which is independent of any external factors. By definition, sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts.

A source sound power level cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source outside the acoustic and geometric near-field. A sound pressure level (L_P) is a measure of the sound wave fluctuation at a given receiver location and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. The sound pressure level in decibels (dB) is the logarithm of the ratio of the sound pressure of the source to the reference sound pressure of 20 microPascals (μPa), multiplied by 20.1. The range of sound pressures that can be detected by a person with normal hearing is very wide, ranging from about 20 μPa for very faint sounds at the threshold of hearing, to nearly 10 million μPa for extremely loud sounds such as a jet during take-off at a distance of 300 feet.

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

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level (L_{eq}). The L_{eq} has been shown to provide both an effective and uniform method for comparing time-varying sound levels and is widely used in acoustic assessments in the state of Washington. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in Table 1. Table 2 presents additional reference information on terminology used in the report.

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

Noise Source or Activity	Sound Level (dBA)	Subjective Impression
Vacuum cleaner (10 feet)	70	Moderate
Passenger car at 65 miles per hour (25 feet)	65	
Large store air-conditioning unit (20 feet)	60	
Light auto traffic (100 feet)	50	Quiet
Quiet rural residential area with no activity	45	
Bedroom or quiet living room; Bird calls	40	Faint
Typical wilderness area	35	
Quiet library, soft whisper (15 feet)	30	Very quiet
Wilderness with no wind or animal activity	25	Extremely quiet
High-quality recording studio	20	
Acoustic test chamber	10	Just audible
	0	Threshold of hearing

Adapted from: Beranek (1988) and EPA (1971a)

Table 2. Acoustic Terms and Definitions

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

1.3 Noise Regulations and Guidelines

1.3.1 Federal Regulations

There are no federal noise regulations applicable to the Project.

1.3.2 Washington Administrative Code State Regulations

Environmental noise limits have been established by the Washington Administrative Code (WAC 173-60). WAC 173-60 establishes noise limits based on the Environmental Designation for Noise Abatement (EDNA) of the sound source and the receiving properties.

- Class A EDNA – Lands where people reside and sleep. They typically include residential property; multiple family living accommodations; recreational facilities with overnight accommodations such as camps, parks, camping facilities, and resorts; and community service facilities including orphanages, homes for the aged, hospitals, and health and correctional facilities.
- Class B EDNA – Lands involving uses requiring protection against noise interference with speech. These typically will include commercial living accommodations; commercial dining establishments; motor vehicle services; retail services; banks and office buildings; recreation and entertainment property not used for human habitation such as theaters, stadiums, fairgrounds, and amusement parks; and community service facilities not used for human habitation (e.g., educational, religious, governmental, cultural and recreational facilities).
- Class C EDNA –Lands involving economic activities of a nature that noise levels higher than those experienced in other areas are normally to be anticipated. Typical Class A EDNA uses generally are not permitted in such areas. Typically, Class C EDNA include storage, warehouse, and distribution facilities; industrial property used for the production and fabrication of durable and nondurable man-made goods; and agricultural and silvicultural property used for the production of crops, wood products, or livestock.

Land use that is considered agricultural is defined as Class C receiving properties. Conversely, agricultural properties where their principal use is for residential purposes with no clearly visible farming or ranching activities, are identified as Class A receiving properties. The WAC does maintain flexibility for interpretation in the classification of the appropriate EDNA on both the state and local level. In this assessment, receiving properties consist of Class C lands and Class C Lands containing Class A residential structures. This assessment conservatively assumes all NSRs are Class A receiving properties. Between the hours of 10:00 p.m. and 7:00 a.m., the noise limitations are reduced by 10 dBA for receiving property within Class A EDNAs. WAC 173.60.050 exempts temporary construction noise from the state noise limits.

The noise level limits by EDNA classifications are presented in Table 3. The WAC allows these limits to be exceeded for certain periods of time: 5 dBA for no more than 15 minutes in any hour, 10 dBA for no more than 5 minutes of any hour, and 15 dBA for no more than 1.5 minutes of any hour; these are commonly presented as L_n statistical sound levels as well as maximum sound levels (L_{max}), as shown in Table 4.

Table 3. Washington State Environmental Noise Limits

EDNA of Source Property	EDNA of Receiving Property		
	Class A Land Day/Night	Class B Land	Class C Land
Class A Land	55/45	57	60
Class B Land	57/47	60	65
Class C Land	60/50	65	70

Source: WAC 173-60-040

Table 4. L_n Environmental Noise Limits for Class C Sources

EDNA of Source Property	Statistical Sound Level Limits			
	LN_{25}	$LN_{8.3}$	$LN_{2.5}$	L_{MAX}
Class A Land	60/50	65/55	70/60	75/65
Class B Land	65	70	75	80
Class C Land	70	75	80	85

Source: WAC 173-60-040 (b) and (c)

The Project site is located on Class C land and also abuts Class C Land and Class C Land containing Class A residential structures. Table 3 shows that the applicable daytime and nighttime noise limits will vary based on each abutting land use class. For Class A land, limits of 60 dBA and 50 dBA apply to daytime and nighttime hours, respectively, and for Class C land, a daytime and nighttime limit of 70 dBA is applicable. The WAC regulatory limits are absolute and independent of the existing acoustic environment; therefore, a baseline noise survey is not requisite to determine conformance.

1.3.3 Klickitat County Code

Chapter 9.15.050 in the KCC refers to WAC Chapter 173-60 for noise regulations.

2.0 Existing Sound Environment

The degree of audibility of a new or modified sound source is dependent in a large part on the relative level of the ambient noise. A range of noise settings occurs within the Project Area. Variations in acoustic environment are due in part to existing land uses, population density, and proximity to transportation corridors. Elevated existing ambient sound levels in the region occur near major transportation corridors such as interstate highways and in areas with higher population densities. Nearby rural airstrips and airports, including the Goldendale Municipal Airport and Piper Canyon Airport, also contribute to ambient noise levels in both surrounding urban and rural areas. Principal contributors to the existing acoustic environment likely include motor vehicle traffic, mobile farming equipment, all-terrain vehicles, local roadways, periodic aircraft flyovers, and natural sounds such as birds, insects, and leaf or vegetation rustle during elevated wind conditions. Diurnal effects result in sound levels that are typically quieter during the night than during the daytime, except during periods when evening and nighttime insect noise dominates in warmer seasons.

The analysis area is inclusive of all areas that could be potentially affected by construction or operational noise resulting from the Project. The analysis area for noise around the Project was defined as the area bounded by a perimeter extending approximately 1.2 miles (2 kilometers) from the Solar Siting Area. In the absence of ambient measurement data, the existing sound level environment in the vicinity of Project was estimated with a method published by the Federal Highway Administration (FHWA) in its Transit Noise and Vibration Impact Assessment (FHWA 2006). This document presents the general assessment of existing noise exposure based on the population density per square mile and proximity to area sound sources such as roadways and rail lines.

The proposed Project is approximately 2 miles (3.2 kilometers) northwest of the city of Goldendale, which has a population density of 3,453 per square mile according to the U.S. Census Bureau (2020). Table 5 indicates the estimated baseline sound levels based on population density for daytime, evening, and nighttime L_{eq} as well as the day-night average sound level (L_{dn}). The L_{dn} is the average equivalent sound level over a 24-hour period, with a penalty added for noise during the nighttime hours of 10:00 p.m. – 7:00 a.m. During the nighttime period, 10 dB is added to reflect the impact of the noise.

Table 5. Estimated Baseline Sound Levels in Proximity to the Project

	L_{eq} (Day)	L_{eq} (Evening)	L_{eq} (Night)	L_{dn}
Average Sound Level (dBA)	55	50	45	55

3.0 Project Construction

Construction of the Project is expected to be typical of other solar power generating facilities in terms of schedule, equipment, and activities. Construction is anticipated to occur over approximately 12 to 24 months and would require a variety of equipment and vehicles.

3.1 Noise Calculation Methodology

Acoustic emission levels for activities associated with Project construction were based on typical ranges of energy equivalent noise levels at construction sites, as documented by the U.S. Environmental Protection Agency (EPA; 1971b) and the EPA's "Construction Noise Control Technology Initiatives" (EPA 1980). Using those energy equivalent noise levels as input to a basic propagation model, construction noise levels were calculated at a series of set reference distances. The noise levels were input to a CadnaA (Computer-Aided Noise Abatement) noise model, and resulting construction levels were calculated at nearby receivers.

3.2 Projected Noise Levels During Construction

Construction work will not consist of a phased approach. Table 6 summarizes the expected equipment to be used during Project construction. Table 6 also shows the maximum noise level at 50 feet and the usage factor percentage for the expected equipment phases.

Table 6. Project Construction Noise Levels

Construction Equipment	Maximum (L_{max}) Equipment Noise Level at 50 feet, dBA
Bull Dozer	85
Excavator	85
Pile Driver	101
Fork Lift	85
Total	101

Table 7 shows the projected noise levels from Project construction at nearby NSRs. Periodically, sound levels may be higher or lower than those presented in Table 7; however, the overall sound levels should generally be lower due to excess attenuation and the trend toward quieter construction equipment in the intervening decades since the EPA data were developed.

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

Project construction would generally occur during the day, Monday through Friday. Furthermore, all reasonable efforts would be made to minimize the impact of noise resulting from construction activities including implementation of standard noise reduction measures. Due to the infrequent nature of loud construction activities at the site, the limited hours of construction, and the implementation of noise mitigation measures, the temporary increase in noise due to construction is considered to be a less than significant impact.

Table 7. Received Project Construction Noise Levels, dBA L_{eq}

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, dBA
		Easting	Northing	
1	Non-Participant	662039	5075841	58
2	Non-Participant	662935	5075557	59
3	Non-Participant	663257	5075150	57
4	Non-Participant	665766	5076669	69
5	Non-Participant	665663	5076650	70
6	Non-Participant	665398	5076674	72
7	Non-Participant	662763	5076684	73
8	Non-Participant	662628	5077207	73
9	Non-Participant	663557	5076769	86
10	Participant	664169	5076989	83
11	Non-Participant	665118	5077393	83
12	Participant	666676	5076837	64
13	Non-Participant	666405	5076814	65
14	Non-Participant	667283	5077646	64
15	Participant	665016	5078267	86
16	Participant	662650	5077803	74
17	Non-Participant	661686	5079068	66
18	Non-Participant	662165	5079069	69
19	Non-Participant	662384	5079088	70
20	Non-Participant	662107	5078756	68
21	Non-Participant	662615	5078344	69

Table 7. Received Project Construction Noise Levels, dBA L_{eq}

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, dBA
		Easting	Northing	
22	Non-Participant	663389	5078691	75
23	Non-Participant	663410	5078749	75
24	Non-Participant	663457	5078635	76
25	Non-Participant	663643	5079033	78
26	Non-Participant	666100	5078457	74
27	Non-Participant	665801	5078430	75
28	Participant	665324	5080031	86
29	Non-Participant	663575	5079179	78
30	Non-Participant	663402	5079182	75
31	Non-Participant	663181	5079214	74
32	Non-Participant	662766	5079161	72
33	Non-Participant	663104	5079860	74
34	Non-Participant	663155	5079973	74
35	Non-Participant	662411	5079805	70
36	Non-Participant	661956	5079172	68
37	Non-Participant	662755	5080515	72
38	Non-Participant	662684	5080169	71
39	Non-Participant	664164	5080716	82
40	Non-Participant	664834	5080818	90
41	Non-Participant	666068	5080458	86
42	Non-Participant	666440	5080374	80
43	Non-Participant	667595	5080069	68
44	Non-Participant	667544	5080191	69
45	Non-Participant	667750	5080336	67
46	Non-Participant	667797	5080611	68
47	Non-Participant	667708	5080733	71
48	Non-Participant	667031	5081881	73

Table 7. Received Project Construction Noise Levels, dBA L_{eq}

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, dBA
		Easting	Northing	
49	Non-Participant	666973	5082010	74
50	Non-Participant	667051	5081738	74
51	Non-Participant	667204	5081577	73
52	Non-Participant	667369	5081415	72
54	Non-Participant	666952	5082386	76
55	Non-Participant	666758	5082197	75
56	Non-Participant	666971	5082750	74
57	Non-Participant	667031	5082618	74
58	Non-Participant	667160	5082576	73
59	Non-Participant	667226	5082533	73
60	Non-Participant	666891	5082950	70
61	Non-Participant	666829	5082875	72
62	Non-Participant	667131	5082840	72
63	Non-Participant	666669	5082879	72
64	Non-Participant	666600	5082768	73
65	Non-Participant	666704	5082615	76
66	Non-Participant	666448	5082853	75
67	Non-Participant	666282	5082915	76
68	Non-Participant	666146	5082772	79
69	Non-Participant	663236	5082867	95
70	Non-Participant	662585	5082594	82
71	Non-Participant	662360	5083295	78
72	Non-Participant	662636	5083597	82
73	Non-Participant	665840	5083134	78
74	Non-Participant	665524	5083091	84
75	Non-Participant	666046	5083321	78
76	Non-Participant	666303	5083444	72

Table 7. Received Project Construction Noise Levels, dBA L_{eq}

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, dBA
		Easting	Northing	
77	Non-Participant	666197	5083150	75
78	Non-Participant	666564	5083214	74
79	Non-Participant	666644	5083403	70
80	Non-Participant	666753	5083442	67
81	Non-Participant	666901	5083311	68
82	Non-Participant	666666	5083236	70
83	Non-Participant	666997	5083101	70
84	Non-Participant	666974	5083610	68
85	Non-Participant	667065	5084022	67
86	Non-Participant	666105	5083833	65
87	Non-Participant	665859	5083765	83
88	Non-Participant	665731	5084246	82
89	Non-Participant	665162	5084224	85
90	Participant	664851	5083988	89
91	Non-Participant	664706	5083877	91
92	Non-Participant	663141	5083726	87
93	Non-Participant	662360	5084060	74
94	Non-Participant	662185	5083992	73
95	Non-Participant	661906	5083857	75
96	Non-Participant	662109	5084475	70
97	Non-Participant	661797	5084111	69
98	Non-Participant	661388	5083880	68
99	Non-Participant	662409	5084694	71
100	Non-Participant	664758	5085158	76
101	Participant	664496	5085582	72
102	Participant	665375	5080450	99
103	Participant	666671	5081459	84

Table 7. Received Project Construction Noise Levels, dBA L_{eq}

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, dBA
		Easting	Northing	
104	Participant	666998	5081105	73
105	Non-Participant	663685	5079222	80
106	Non-Participant	661850	5084155	69
107	Non-Participant	666220	5083342	72
108	Non-Participant	666939	5082598	75
109	Non-Participant	667765	5081596	68
110	Non-Participant	666888	5084812	68
111	Non-Participant	663547	5084665	75
112	Non-Participant	663447	5084867	74
113	Non-Participant	663371	5084486	78
114	Non-Participant	662272	5084616	70
115	Non-Participant	662004	5084521	69
116	Non-Participant	662345	5084359	72
117	Non-Participant	667053	5083878	67
118	Non-Participant	667087	5083645	67
119	Participant	663638	5083922	87
120	Non-Participant	662298	5083814	79
121	Non-Participant	666409	5083321	73
122	Non-Participant	666522	5082941	74
123	Non-Participant	666065	5082988	79
124	Non-Participant	666305	5083122	75
125	Non-Participant	662756	5082565	84
126	Non-Participant	666543	5082424	77
127	Non-Participant	666587	5082556	77
128	Non-Participant	666710	5082425	75
129	Non-Participant	667087	5081682	73
130	Non-Participant	667613	5080465	67

Table 7. Received Project Construction Noise Levels, dBA L_{eq}

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, dBA
		Easting	Northing	
131	Non-Participant	667718	5080351	67
132	Non-Participant	667712	5080230	67
133	Non-Participant	662581	5079059	70
134	Non-Participant	662195	5079272	69
135	Non-Participant	662784	5083303	89
136	Non-Participant	662719	5083095	84

3.3 Construction Noise Mitigation

Since construction equipment operates intermittently, noise emitted during construction would be mobile and highly variable, making it challenging to control. The construction management protocols would include the following noise mitigation measures to minimize noise impacts:

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

4.0 Operational Noise

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

4.1 Noise Prediction Model

The CadnaA (Computer-Aided Noise Abatement) computer noise model was used to calculate sound pressure levels from the operation of the Project equipment in the vicinity of the Project site. An industry standard, CadnaA was developed by DataKustik GmbH (2020) to provide an estimate of sound levels at distances from sources of known emission. It is used by acousticians and acoustic engineers due to the capability to accurately describe noise emission and propagation from complex facilities consisting of various equipment types like the Project, and in most cases, yields conservative results of operational noise levels in the surrounding community.

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

- Geometric spreading wave divergence;
- Reflection from surfaces;
- Atmospheric absorption at 10 degrees Celsius and 70 percent relative humidity;
- Screening by topography and obstacles;
- The effects of terrain features including relative elevations of noise sources;
- Sound power levels from stationary and mobile sources;
- The locations of noise-sensitive land use types such as residential land uses;
- Intervening objects including buildings and barrier walls, to the extent included in the design;
- Ground effects due to areas of pavement and unpaved ground;
- Sound power at multiple frequencies;
- Source directivity factors;
- Multiple noise sources and source type (point, area, and/or line); and
- Averaging predicted sound levels over a given time.

CadnaA allows for three basic types of sound sources to be introduced into the model: point, line, and area sources. Each noise-radiating element was modeled based on its noise emission pattern. Larger dimensional sources such as the transformers and inverters were modeled as area sources.

Off-site topography was obtained using the publicly available U.S. Geological Survey digital elevation data. A default ground attenuation factor of 0.5 was assumed for off-site sound propagation over acoustically “mixed” ground.

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

4.2 Input to the Noise Prediction Model

The Project’s general arrangement was reviewed and directly imported into the acoustic model so that on-site equipment could be easily identified, buildings and structures could be added, and sound emission data could be assigned to sources as appropriate. The primary noise sources during operations are the inverters, their integrated step-up transformers, battery energy storage system (BESS) units, and the substation transformer. The Project layout includes 44 step-up transformers and 44 inverters distributed throughout the solar array areas. BESS units will be positioned adjacent to the substation, and their associated sound emissions were considered in the acoustic analysis.

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

Reference sound power levels input to CadnaA were provided by equipment manufacturers, based on information contained in reference documents or developed using empirical methods. The source levels used in the predictive modeling are based on estimated sound power levels that are generally deemed to be conservative. The projected operational noise levels are based on Applicant-supplied sound power level data for the major sources of equipment. Table 8 summarizes the equipment sound power level data used as inputs to the acoustic modeling analysis. For the purpose of the analysis, it was assumed that all equipment would operate consistently during both daytime and nighttime periods.

Table 8. Modeled Octave Band Sound Power Level for Major Pieces of Project Equipment

Sound Source	Sound Power Level (L_W) by Octave Band Frequency dBL									Broadband Level
	31.5	63	125	250	500	1k	2k	4k	8k	dBA
Step-up Transformer	98	102	98	98	98	92	87	81	74	98
Inverter	78	86	93	94	93	90	85	78	71	99
BESS	85	93	100	101	100	97	92	85	78	106
Substation Transformer	98	102	98	98	98	92	87	81	74	98

In addition to the above, the modeling analysis accounts for the 500-foot-long 500-kilovolt (kV) transmission line located between the Project substation and the existing Knight substation. Transmission lines generate sound referred to as corona. The level of corona noise generated by a transmission line is highly dependent on weather conditions (i.e., foul weather), electrical gradient, altitude, and condition of the conductor wires. The corona effect is initiated where the conductor's electric field is concentrated by imperfections in the conductor surface such as nicks or scratches, or by substances on the lines such as water droplets, dirt or dust, and bird droppings. Corona activity increases with increasing altitude, and with increasing voltage in the line, but is generally not affected by system loading. Details pertaining the transmission line have not been finalized, but the audible sound level associated with transmission line operation under foul weather conditions was conservatively estimated at 69 dBA at a distance of 50 feet from the transmission line.

4.3 Noise Prediction Model Results

Broadband (dBA) sound pressure levels were calculated for expected normal Project operation assuming that all components identified previously are operating continuously and concurrently at the representative manufacturer-rated sound power level. It is expected that all sound-producing equipment would operate during both daytime and nighttime periods. After calculation, the sound energy was then summed to determine the equivalent continuous A-weighted downwind sound pressure level at a point of reception. Sound contour plots displaying broadband (dBA) sound levels presented as color-coded isopleths are provided in Figures 2 and 3 for operations with the under clear and rainy conditions. The sound contours are graphical representations of the cumulative noise associated with full operation of the equipment and show how operational noise would be distributed over the surrounding area of the Project site. The contour lines shown are analogous to elevation contours on a topographic map (i.e., the sound contours are continuous lines of equal noise level around some source, or sources, of sound).

Table 9 shows the projected exterior sound levels resulting from full, normal operation of the Project during both daytime and nighttime hours, at all nearby NSRs. The Project is located on Class C land while the adjacent properties consist of a mix of both Class C land with Class A residential structures, which has a daytime limit of 60 dBA and nighttime limit of 50 dBA, and Class C land, which has a daytime and nighttime limit of 70 dBA. The Project will be in compliance with the applicable noise regulations at all non-participating and participating receptors .

Table 9. Acoustic Modeling Results Summary

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, Clear Conditions (dBA)	Received Noise Level, Rainy Conditions (dBA)
		Easting	Northing		
1	Non-Participant	662039	5075841	31	31
2	Non-Participant	662935	5075557	32	32
3	Non-Participant	663257	5075150	28	28
4	Non-Participant	665766	5076669	37	37
5	Non-Participant	665663	5076650	38	38
6	Non-Participant	665398	5076674	38	38
7	Non-Participant	662763	5076684	41	41
8	Non-Participant	662628	5077207	43	43
9	Non-Participant	663557	5076769	44	44
10	Participant	664169	5076989	46	46
11	Non-Participant	665118	5077393	45	45
12	Participant	666676	5076837	33	33
13	Non-Participant	666405	5076814	35	35
14	Non-Participant	667283	5077646	33	33
15	Participant	665016	5078267	53	53
16	Participant	662650	5077803	42	42
17	Non-Participant	661686	5079068	33	33
18	Non-Participant	662165	5079069	36	36
19	Non-Participant	662384	5079088	36	36
20	Non-Participant	662107	5078756	35	35
21	Non-Participant	662615	5078344	37	37
22	Non-Participant	663389	5078691	43	43
23	Non-Participant	663410	5078749	43	43
24	Non-Participant	663457	5078635	43	43
25	Non-Participant	663643	5079033	42	42
26	Non-Participant	666100	5078457	42	42
27	Non-Participant	665801	5078430	45	45
28	Participant	665324	5080031	43	43
29	Non-Participant	663575	5079179	41	41
30	Non-Participant	663402	5079182	40	40

Table 9. Acoustic Modeling Results Summary

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, Clear Conditions (dBA)	Received Noise Level, Rainy Conditions (dBA)
		Easting	Northing		
31	Non-Participant	663181	5079214	39	39
32	Non-Participant	662766	5079161	38	38
33	Non-Participant	663104	5079860	36	36
34	Non-Participant	663155	5079973	36	36
35	Non-Participant	662411	5079805	34	34
36	Non-Participant	661956	5079172	34	34
37	Non-Participant	662755	5080515	35	35
38	Non-Participant	662684	5080169	34	35
39	Non-Participant	664164	5080716	41	41
40	Non-Participant	664834	5080818	44	44
41	Non-Participant	666068	5080458	45	45
42	Non-Participant	666440	5080374	41	41
43	Non-Participant	667595	5080069	31	31
44	Non-Participant	667544	5080191	31	31
45	Non-Participant	667750	5080336	30	30
46	Non-Participant	667797	5080611	33	33
47	Non-Participant	667708	5080733	34	34
48	Non-Participant	667031	5081881	33	33
49	Non-Participant	666973	5082010	33	33
50	Non-Participant	667051	5081738	33	33
51	Non-Participant	667204	5081577	34	34
52	Non-Participant	667369	5081415	34	34
54	Non-Participant	666952	5082386	34	34
55	Non-Participant	666758	5082197	34	35
56	Non-Participant	666971	5082750	34	34
57	Non-Participant	667031	5082618	34	34
58	Non-Participant	667160	5082576	34	34
59	Non-Participant	667226	5082533	34	34
60	Non-Participant	666891	5082950	33	33
61	Non-Participant	666829	5082875	33	33

Table 9. Acoustic Modeling Results Summary

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, Clear Conditions (dBA)	Received Noise Level, Rainy Conditions (dBA)
		Easting	Northing		
62	Non-Participant	667131	5082840	33	33
63	Non-Participant	666669	5082879	33	33
64	Non-Participant	666600	5082768	34	34
65	Non-Participant	666704	5082615	35	35
66	Non-Participant	666448	5082853	36	36
67	Non-Participant	666282	5082915	37	37
68	Non-Participant	666146	5082772	39	39
69	Non-Participant	663236	5082867	48	48
70	Non-Participant	662585	5082594	37	38
71	Non-Participant	662360	5083295	35	35
72	Non-Participant	662636	5083597	38	38
73	Non-Participant	665840	5083134	39	39
74	Non-Participant	665524	5083091	43	43
75	Non-Participant	666046	5083321	39	39
76	Non-Participant	666303	5083444	35	35
77	Non-Participant	666197	5083150	37	37
78	Non-Participant	666564	5083214	35	35
79	Non-Participant	666644	5083403	32	32
80	Non-Participant	666753	5083442	30	30
81	Non-Participant	666901	5083311	31	31
82	Non-Participant	666666	5083236	32	32
83	Non-Participant	666997	5083101	32	32
84	Non-Participant	666974	5083610	31	31
85	Non-Participant	667065	5084022	30	30
86	Non-Participant	666105	5083833	28	28
87	Non-Participant	665859	5083765	43	43
88	Non-Participant	665731	5084246	41	41
89	Non-Participant	665162	5084224	40	40
90	Participant	664851	5083988	44	44
91	Non-Participant	664706	5083877	46	46

Table 9. Acoustic Modeling Results Summary

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, Clear Conditions (dBA)	Received Noise Level, Rainy Conditions (dBA)
		Easting	Northing		
92	Non-Participant	663141	5083726	43	43
93	Non-Participant	662360	5084060	34	34
94	Non-Participant	662185	5083992	33	33
95	Non-Participant	661906	5083857	33	33
96	Non-Participant	662109	5084475	31	31
97	Non-Participant	661797	5084111	30	30
98	Non-Participant	661388	5083880	30	31
99	Non-Participant	662409	5084694	32	32
100	Non-Participant	664758	5085158	37	37
101	Participant	664496	5085582	35	35
102	Participant	665375	5080450	47	47
103	Participant	666671	5081459	40	40
104	Participant	666998	5081105	34	34
105	Non-Participant	663685	5079222	42	42
106	Non-Participant	661850	5084155	30	30
107	Non-Participant	666220	5083342	35	35
108	Non-Participant	666939	5082598	34	34
109	Non-Participant	667765	5081596	30	30
110	Non-Participant	666888	5084812	31	31
111	Non-Participant	663547	5084665	36	36
112	Non-Participant	663447	5084867	36	36
113	Non-Participant	663371	5084486	38	38
114	Non-Participant	662272	5084616	32	32
115	Non-Participant	662004	5084521	30	30
116	Non-Participant	662345	5084359	32	32
117	Non-Participant	667053	5083878	31	31
118	Non-Participant	667087	5083645	31	31
119	Participant	663638	5083922	45	45
120	Non-Participant	662298	5083814	35	36
121	Non-Participant	666409	5083321	34	34

Table 9. Acoustic Modeling Results Summary

NSR ID	Participation Status	UTM Coordinates (meters) NAD83 UTM Zoning 10		Received Noise Level, Clear Conditions (dBA)	Received Noise Level, Rainy Conditions (dBA)
		Easting	Northing		
122	Non-Participant	666522	5082941	36	36
123	Non-Participant	666065	5082988	39	39
124	Non-Participant	666305	5083122	37	37
125	Non-Participant	662756	5082565	39	39
126	Non-Participant	666543	5082424	36	36
127	Non-Participant	666587	5082556	36	36
128	Non-Participant	666710	5082425	35	35
129	Non-Participant	667087	5081682	33	33
130	Non-Participant	667613	5080465	31	31
131	Non-Participant	667718	5080351	30	30
132	Non-Participant	667712	5080230	31	31
133	Non-Participant	662581	5079059	36	36
134	Non-Participant	662195	5079272	34	34
135	Non-Participant	662784	5083303	43	43
136	Non-Participant	662719	5083095	40	40

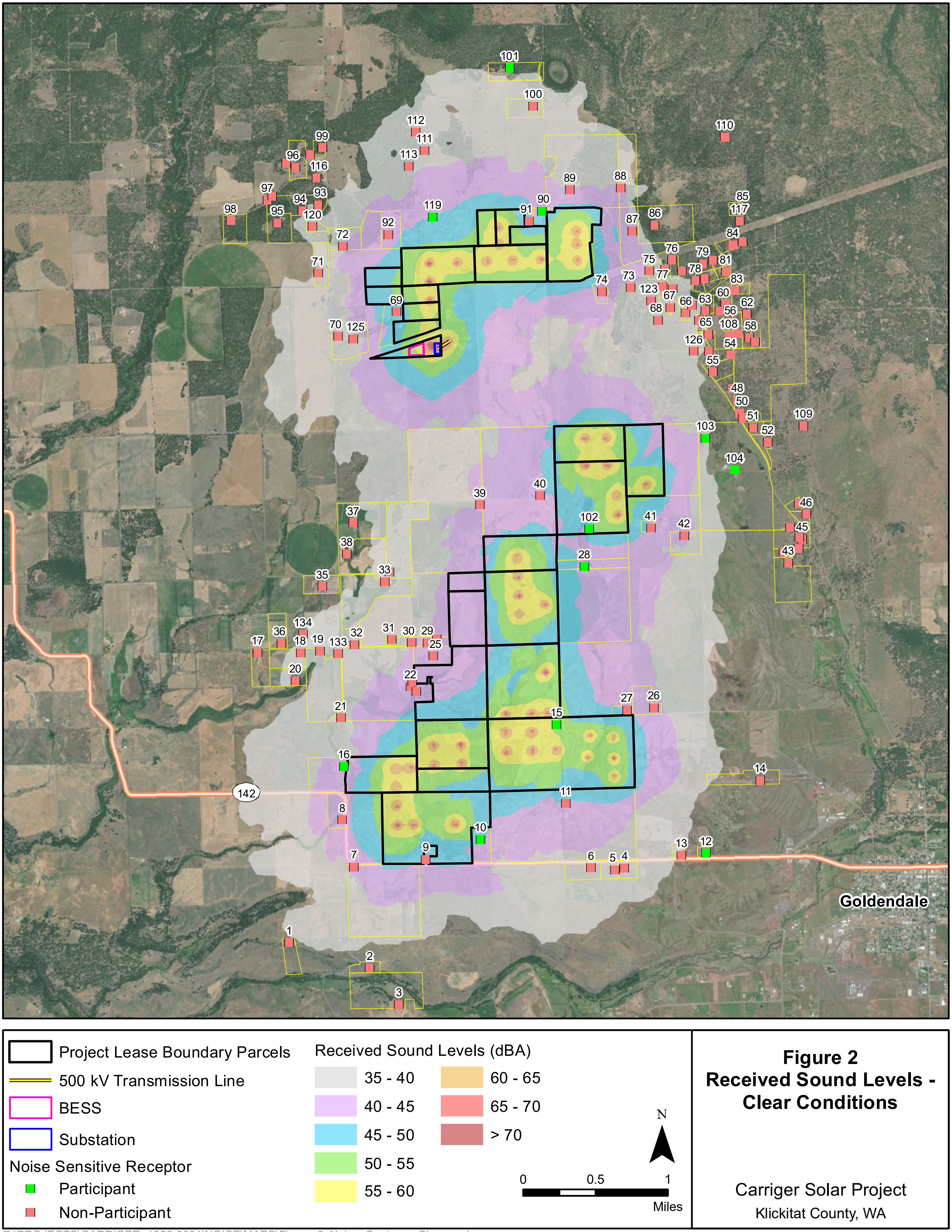

Figure 2
Received Sound Levels - Clear Conditions

Carriger Solar Project
Klickitat County, WA

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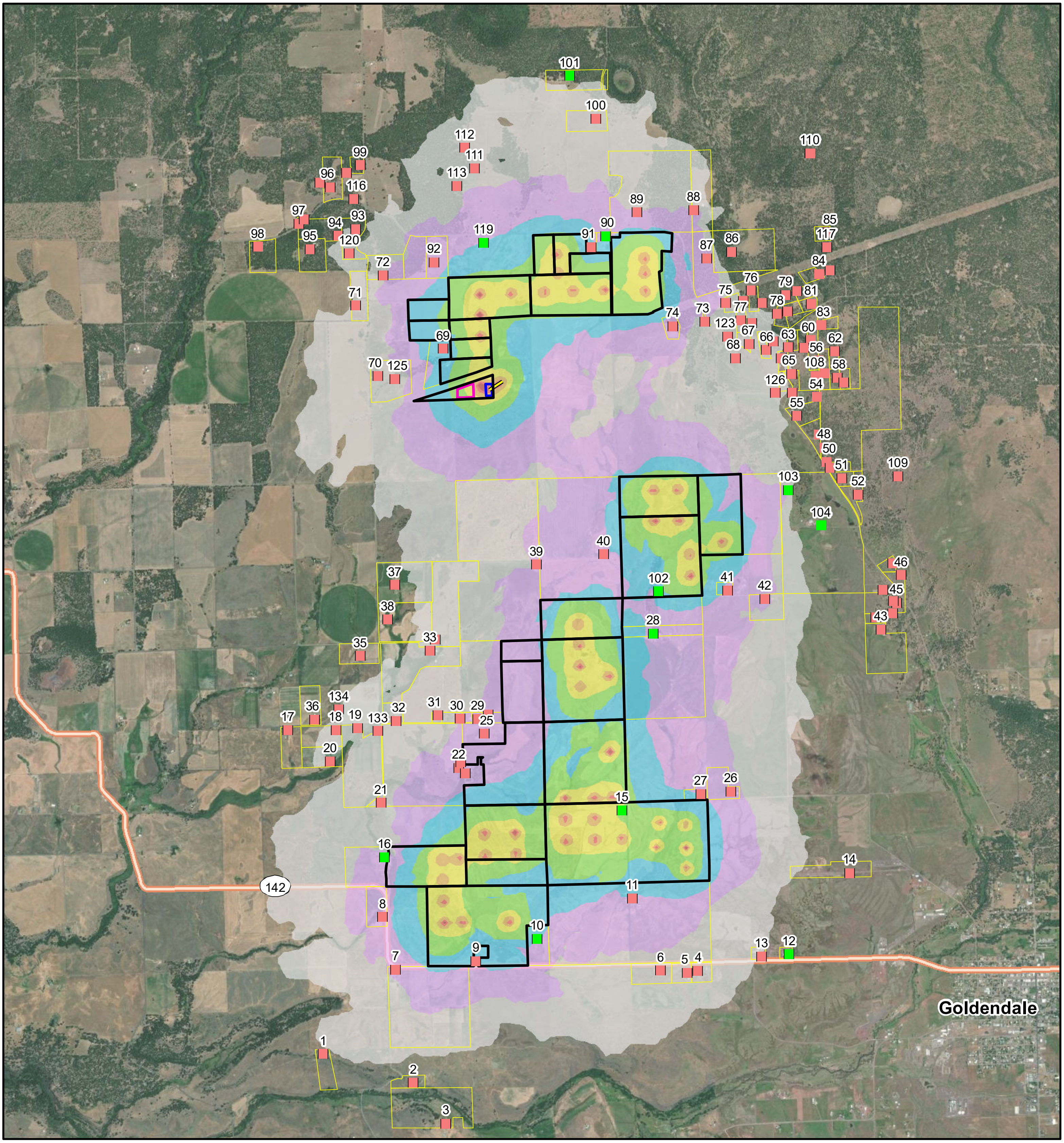

Project Lease Boundary Parcels
500 kV Transmission Line
BESS
Substation
Noise Sensitive Receptor
Participant
Non-Participant

Received Sound Levels (dBA)

35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
65 - 70
> 70

N

0 0.5 1
Miles

Figure 3
Received Sound Levels - Rainy Conditions

Carriger Solar Project
Klickitat County, WA

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5.0 Conclusion

Tetra Tech completed a detailed acoustic assessment of the Carriger Solar Energy Project, proposed in Klickitat County, Washington. The assessment included an evaluation of potential Project sound level impacts during construction and operation phases.

The construction noise assessment indicated that construction noise would be periodically audible at off-site locations; however, that noise would be temporary and minimized to the extent practicable through implementation of best management practices and noise mitigation measures as identified in Section 3.3. Traffic noise generated during construction onsite and offsite would also add to overall sound levels but would be intermittent and short-term.

Operational sound levels were modeled and evaluated at nearby NSRs. Anticipated Project sound sources consist of the collector substation main power transformer, inverters, step-up transformers, BESS units, and the 500-kV transmission line. Incorporating a number of conservative assumptions, acoustic modeling results indicate that received sound levels resulting from Project operations would comply with the applicable WAC 173-60 50-dBA daytime and nighttime limits at all NSRs, as well as the Class C 70-dBA limit at the Project boundary. In addition, sound generated from existing sound sources in the Project Area, such as the operation of agricultural equipment, would be expected to be relatively higher than Project operations. Overall, sound emissions associated with the Project are expected to remain at a low level, consistent with other solar energy facilities of similar size and design.

6.0 References

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