

Appendix D: Noise Study



Noise Study Astoria Station Project

Deuel County, South Dakota

Prepared for:
Otter Tail Power Company

September 1, 2017

Contents

1	Introduction	2
1.1	Noise Concepts	2
1.2	Local Noise Regulations	4
2	Methods	5
2.1	Noise Measurement Methods	5
2.2	Noise Model Methods	7
3	Results	8
3.1	Noise Measurement Results	8
3.2	Noise Model Results	10
4	References	14

Tables

Table 1-1.	Typical Residential Noise Levels	2
Table 1-2.	Typical Source Noise Levels	3
Table 1-3.	ANSI Low-Frequency Noise Limits	5
Table 2-1.	Measurement Locations	5
Table 2-2.	Noise Model Parameters	7
Table 3-1.	Measured and Modeled Noise Levels at ML1	12
Table 3-2.	Measured and Modeled Noise Levels at ML2	13

Figures

Figure 1-1.	Frequency Weightings	4
Figure 2-1.	Noise Monitoring Locations	6
Figure 3-1.	Measurement Results from ML1	9
Figure 3-2.	Measurement Results from ML2	10
Figure 3-3.	Modeled Noise Contours	11

Appendices

Appendix A.	Manufacturer-Provided Equipment Noise Levels	15
-------------	--	----

1 Introduction

Otter Tail Power Company (OTP) is proposing to construct the Astoria Station Project, a new approximate 250 MW simple-cycle combustion turbine electric generation facility (the project). The project is located in Deuel County, South Dakota, in Scandinavia Township.

On behalf of OTP, HDR Engineering, Inc. (HDR) measured existing noise levels in the study area and modeled noise levels from the proposed facility. This report summarizes the methods and results of the ambient noise measurements and the modeling of the facility's noise sources.

1.1 Noise Concepts

Sound is made up of tiny fluctuations in air pressure. Sound is characterized by its amplitude (how loud it is), frequency (or pitch), and duration. Sound, within the range of human hearing, can vary in amplitude by over one million units. Therefore a logarithmic scale, known as the decibel (dB) scale, is used to quantify sound intensity and to compress the scale to a more manageable range. Noise is simply defined as unwanted sound; the terms noise and sound are often used interchangeably.

The human ear does not hear all frequencies equally. In fact, the human hearing organs of the inner ear deemphasize low and very high frequencies. The most common weighting scale used to reflect this selective sensitivity of human hearing is the A-weighted sound level (dBA). The range of human hearing extends from approximately 3 dBA to around 140 dBA (all sound pressure levels in this report are relative to 20 micropascals). Table 1-1 contains typical A-weighted noise levels for residential areas, and Table 1-2 contains additional noise levels for typical residential and rural sources.

Table 1-1. Typical Residential Noise Levels

Residential Land Use Category	Day Sound Pressure Level, dBA (re 20 μ Pa)	Night Sound Pressure Level, dBA (re 20 μ Pa)
Very noisy urban	66	58
Noisy urban	61	54
Urban and noisy suburban	55	49
Quiet urban and normal suburban	50	44
Quiet suburban	45	39
Very quiet suburban and rural	40	34

Source: ANSI/ASA 2013

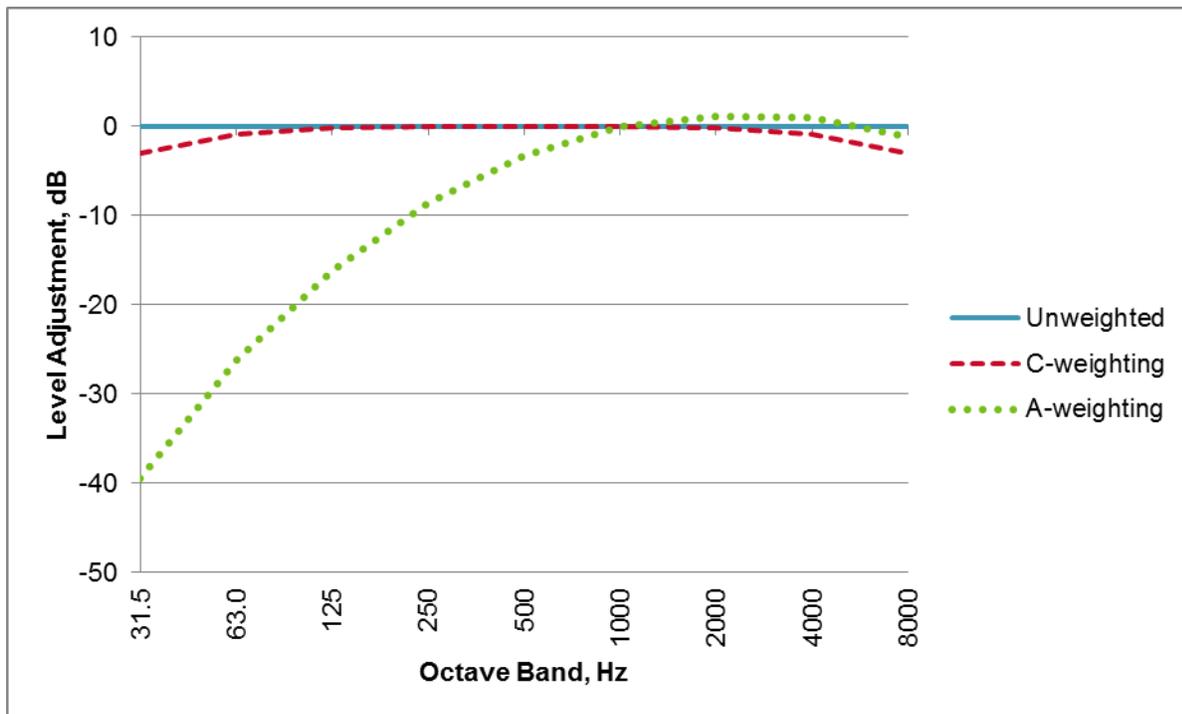
Table 1-2. Typical Source Noise Levels

Sound Pressure Level, dBA	Typical Sources
90	Motorcycle at 25 feet Gas lawn mower at 3 feet
84	Tractor at 50 ft.
80	Garbage disposal
70	City street corner Vacuum Cleaner at 10 ft.
60	Conversational speech
50	Typical office
40	Living room (without television)
30	Quiet bedroom at night
20	Approximate threshold of hearing

dBA = A-weighted decibel scale
Sources: (Rau and Wooten 1980), HDR, FHWA 2015

Another common weighting scale is the C-weighted sound level (dBC), which is often used to evaluate the presence of low-frequency sound. Unweighted sound levels are unaltered and given the unit dB or dBL (L stands for linear, and in this context that means unweighted). Figure 1-1 shows the adjustment levels that are used for A-weighting and C-weighting; C-weighted sound levels retain more low-frequency energy than A-weighted sound levels.

Figure 1-1. Frequency Weightings



Source: ANSI 2001

Because of the logarithmic scale, sound levels cannot be simply added or subtracted. If sound energy is doubled, the sound level only increases by 3 dB. However, a doubling of sound energy is not perceived by humans as a doubling of loudness. A 3-dB change is considered a just noticeable difference, a 5-dB change is considered a noticeable difference, and a 10-dB change is considered a doubling or halving of loudness.

Most sounds are made up of a wide range of frequencies, and are termed broadband sounds. Sounds that are focused in a particular frequency range are tonal sounds. Sound sources can be constant or time-varying. Environmental sound levels are often expressed over periods of time, allowing time-varying signals to be represented by sound levels averaged over intervals (for example, a one-hour period). One metric used to describe environmental sound is the equivalent average sound level (L_{eq}). The L_{eq} represents a constant sound that, over the specified time period, has the same acoustic energy as the time-varying signal. Another descriptor is the L_n , which is the noise level exceeded n percent of the time. For example, the L_{10} is the noise level exceeded 10 percent of the time (90 percent of the time it is quieter than the L_{10}).

1.2 Local Noise Regulations

The South Dakota Administrative Rules, Chapter 20:10:22, Energy Facility Siting Rules (the Rules), do not contain noise limits for energy facilities. However, the Rules do require a map showing noise-sensitive land uses in the study area (section 20:10:22:18). In the case of a combined-cycle combustion turbine electric generation facility approximately 13 miles south of the Astoria Station project, the South Dakota Public

Utilities Commission (SD PUC) established noise standards at the nearest occupied residence of: Daytime: $L_{10}=60$ dbA; Nighttime: $L_{10}=55$ dbA.

In addition, The American National Standard Institute (ANSI) and the Acoustical Society of America (ASA) give suggested limits for low-frequency unweighted sound pressure levels to avoid perceptible vibration and rattles at receiving structures in the standard ANSI/ASA S12.2-2008. Table 1-3 presents those limits.

Table 1-3. ANSI Low-Frequency Noise Limits

Sound Pressure Level by Octave Band, dBL (re 20 μ Pa)

Octave Band, Hz	16	31.5	63
Clearly perceptible vibration and rattles likely	75	75	80
Moderately perceptible vibration and rattle likely	65	65	70

Source: ANSI/ASA 2008

Low-frequency noise levels that exceed these limits could produce vibration and rattles in lightweight structures, such as single-family homes.

2 Methods

HDR measured existing noise levels and modeled project-related noise in the vicinity of the proposed energy conversion facility. This section describes the measurement and modeling methods.

2.1 Noise Measurement Methods

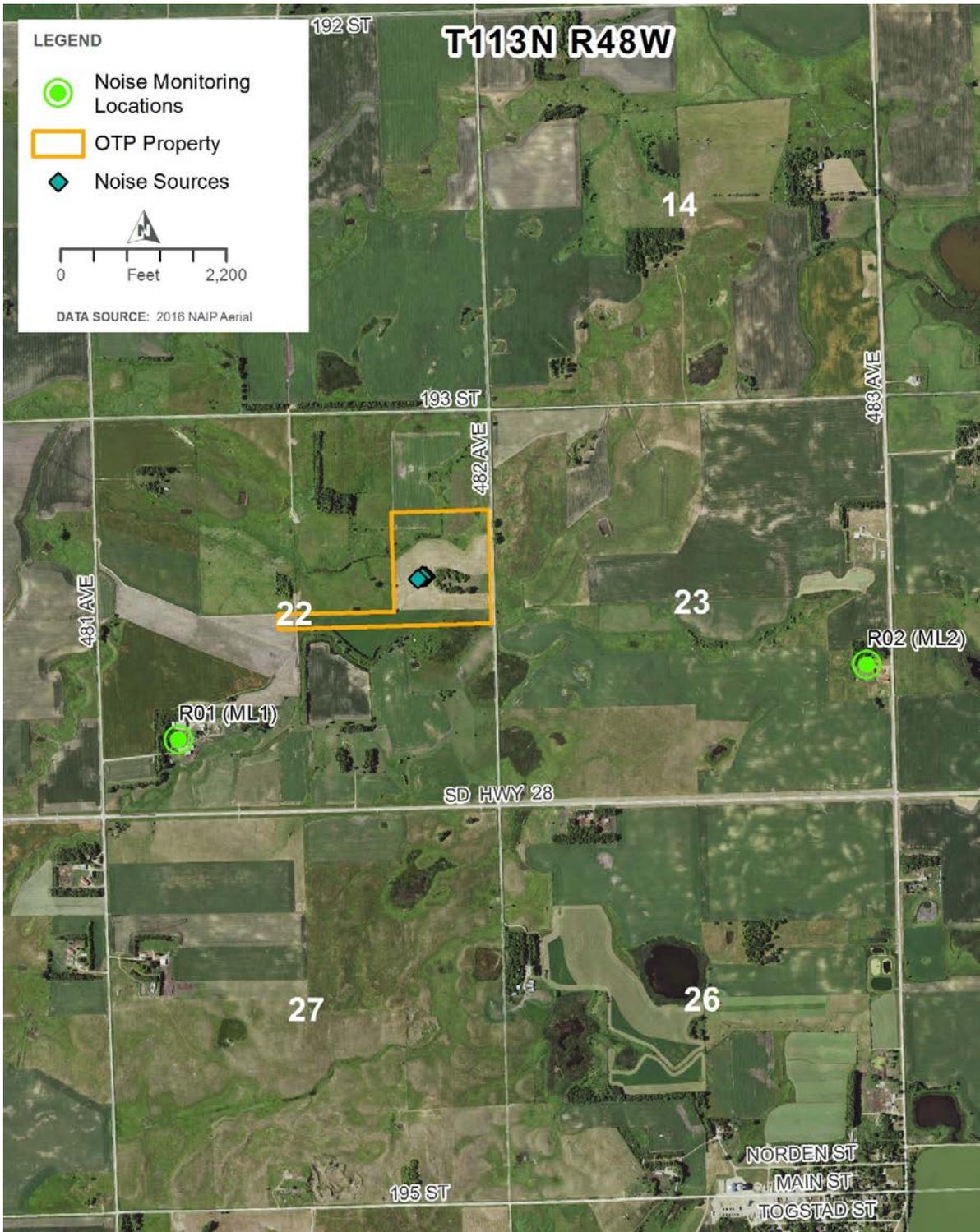
HDR measured existing noise levels in the study area at two measurement locations that were adjacent to and representative of nearby residences (Figure 2-1). The existing noise environment surrounding the proposed site is influenced by natural noise sources, agricultural activities, and traffic on local roads. HDR measured noise levels for approximately 24 hours at each location from July 5th to July 6th, 2017. The measurement systems ran continuously and stored the hourly L_{eq} , spectral noise levels, wind speeds, and audio files. Table 2-1 summarizes the measurement locations.

Table 2-1. Measurement Locations

Measurement Location	GPS Coordinates
ML1	44.575512, -96.577809
ML2	44.577508, -96.542575

Measurement location 1 (ML1) is approximately 3,800 feet (0.72 miles) southwest of the proposed facility power block. ML2 is approximately 6,000 feet (1.1 miles) east-southeast of the proposed facility power block.

Figure 2-1. Noise Monitoring Locations



HDR used digital sound level meters with 1/3 octave band filters to perform the noise measurements. The sound level meters and a handheld calibrator meet Class 1/Type 1 precision requirements of ANSI and International Electrotechnical Commission standards. All instrumentation used to measure noise levels on this project is calibrated on a regular basis by an independent accredited calibration laboratory using standards traceable to the National Institute of Standards and Technology. The instrumentation was adjusted to a reference level traceable to the National Institute of Standards and Technology prior to transportation to the measurement site. Calibration checks were performed in the field prior to and upon completion of each series of measurements.

No significant precipitation events occurred during the measurements. The measured hourly average microphone-height wind speeds were below 11 miles per hour throughout the measurements; however, gusty wind conditions occurred during portions of the measurement period, which is discussed in more detail below.

2.2 Noise Model Methods

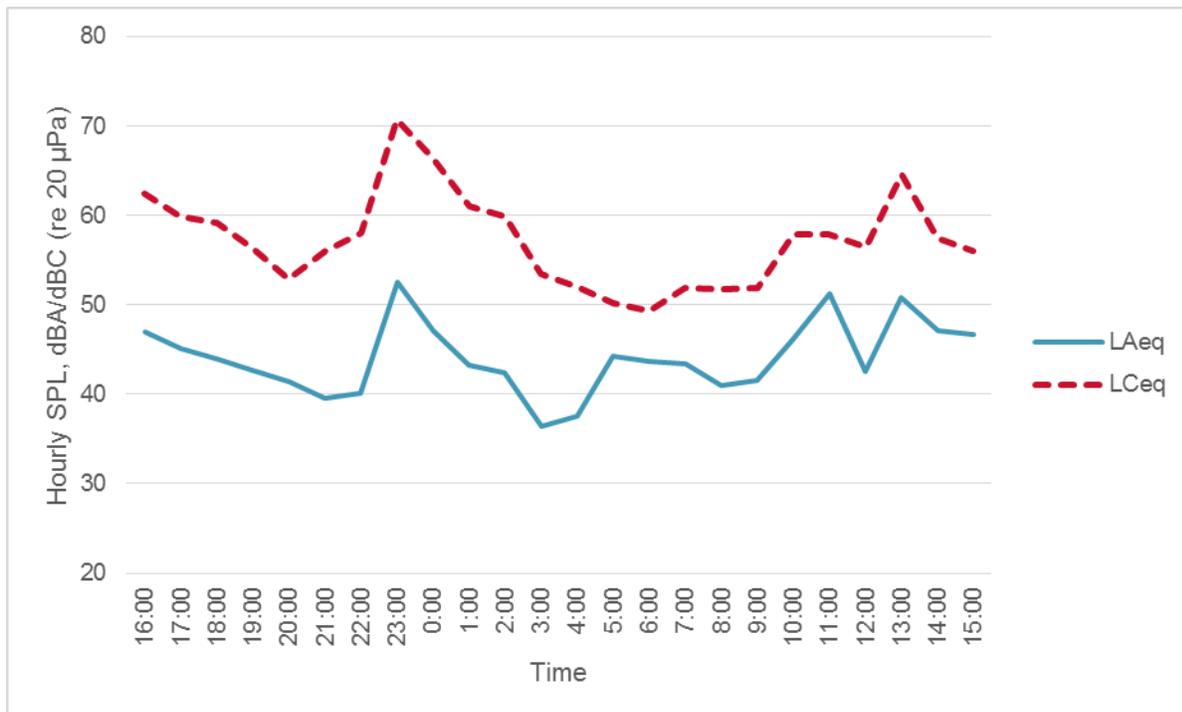
HDR modeled potential future noise levels from the proposed generation facility using the three-dimensional environmental noise analysis program Cadna-A. Cadna-A is based on ISO 9613, “Attenuation of Sound during Propagation Outdoors.” Modeled noise sources included the inlet filter house, generator, combustion turbine, and exhaust stack. Preliminary site plans dated June 30th, 2017, were the basis of the noise model. Table 2-2 summarizes the noise model parameters.

Table 2-2. Noise Model Parameters

Parameter	Model Approach
Noise Emissions	Primary noise sources were modeled using sound power levels provided by a turbine manufacturer.
Terrain	Conservatively modeled with flat terrain.
Buildings	On-site shielding structures such as the storage tanks, control/administration building, and electrical/maintenance building were included in the model.
Ground Factor	All ground was modeled as 50% absorptive. This value is considered conservative because the area is primarily soft ground; however, the modeled value accounts for other ground conditions, such as icy snow cover in the winter months.
Meteorology	A site-specific wind rose was not included, resulting in conservative downwind noise levels in each direction – at each modeled receiver.
Temperature and Relative Humidity	The modeled temperature of 10 degrees Celsius and relative humidity of 70% generally matched annual average values for the area (Climate Zone 2017).

Appendix A lists the modeled noise sources and the modeled sound levels. Figure 2-2 presents a three-dimensional rendering of the modeled noise sources and other structures simulated in the Cadna-A model.

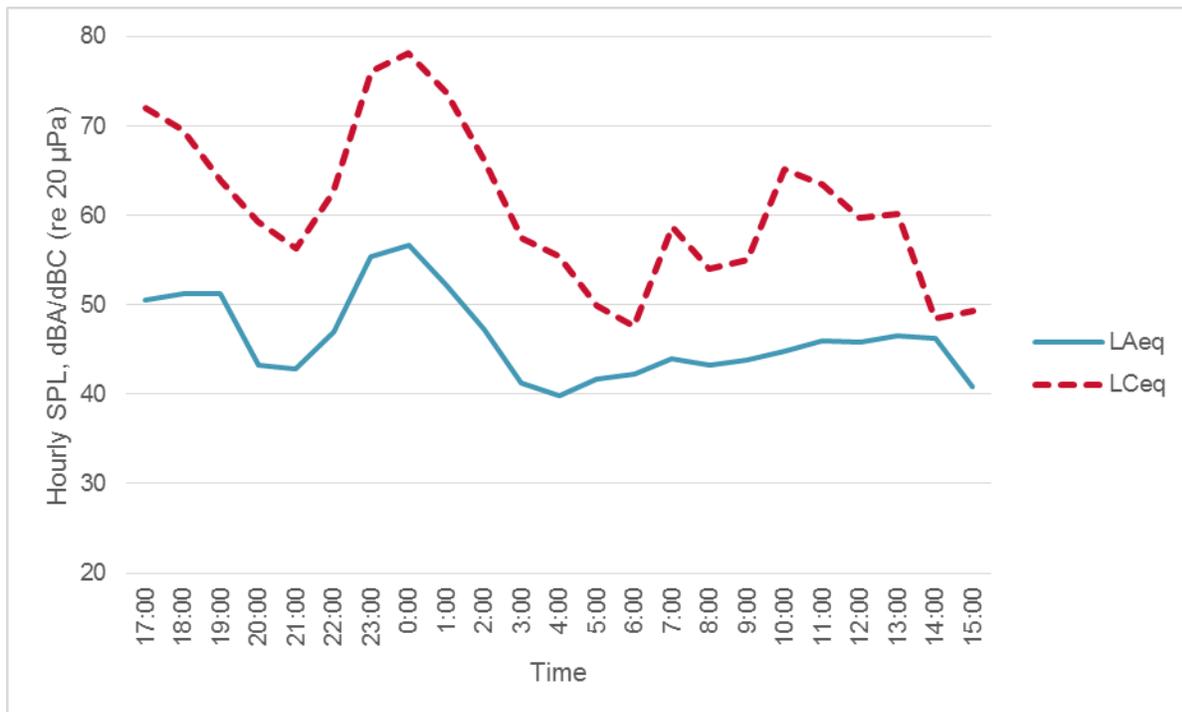
Figure 3-1. Measurement Results from ML1



The average hourly microphone-height wind speeds at ML1 were below 11 miles per hour throughout the measurement; however, gusty wind conditions occurred, particularly between 11:00 PM and 1:00 AM. The wind may have influenced the microphone periodically, but the gusty wind conditions at the very least resulted in increased noise from rustling trees. The gusty winds died down by the 3:00 and 4:00 AM hours, so the measured noise levels from the quietest hours are considered representative of typical conditions without gusty winds. The measured C-weighted L_{eq} was well above the measured A-weighted L_{eq} , which indicates the existing noise environment is influenced by low-frequency sound from wind and other sources.

Figure 3-2 presents a summary of the measurement results from ML2.

Figure 3-2. Measurement Results from ML2

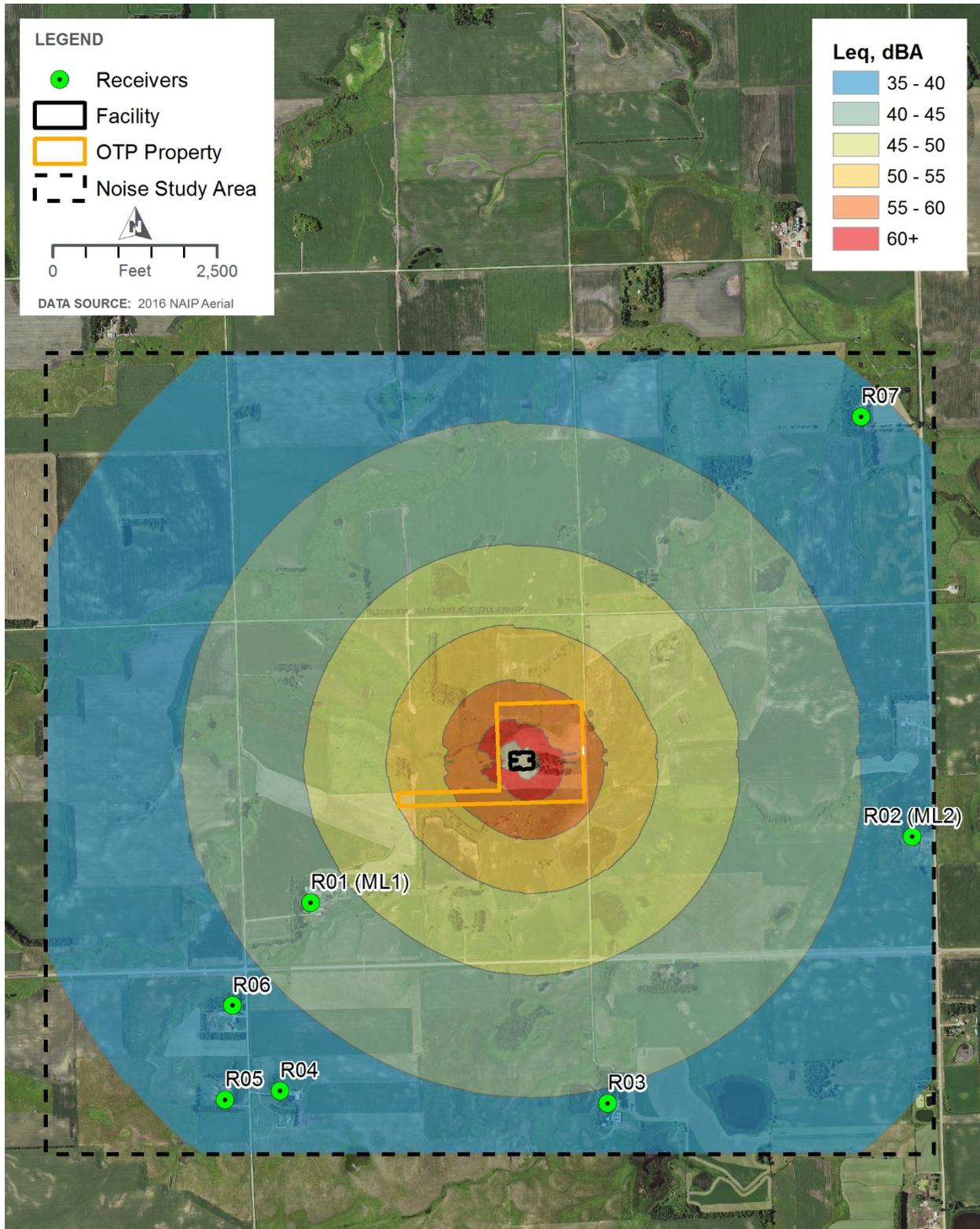


The measured wind speeds at ML2 were similar to ML1. The average hourly microphone-height wind speeds at ML2 were below 11 miles per hour throughout the measurement; however, gusty wind conditions occurred, particularly between 11:00 PM and 1:00 AM. The measured C-weighted L_{eq} was well above the measured A-weighted L_{eq} , just like ML1.

3.2 Noise Model Results

HDR modeled project-related noise levels (meaning only future project noise sources were modeled and no existing noise sources) throughout a Cartesian coordinate grid and at specific receiver points for the nearest residences. Figure 3-3 presents modeled noise contours.

Figure 3-3. Modeled Noise Contours



The noise study area is the area within approximately 1 mile of the project area. The receiver points are representative of noise-sensitive receptors that HDR identified using publically available aerial photographs. The noise contours represent project noise levels over areas of equal loudness; areas with the same color contour are predicted to experience similar noise levels. The noise contours illustrate the broadband A-weighted L_{eq} . As indicated by the noise contours, the modeled project-only noise levels at noise-sensitive receptors are below 45 dBA.

HDR configured the Cadna-A model to calculate project-related noise at ML1 and ML2 to evaluate any changes in the noise environment due to the proposed project. HDR summed the measured existing noise levels with the modeled project noise levels, including the A-weighted L_{eq} , C-weighted L_{eq} , and low-frequency octave band L_{eq} at 31.5 Hz and 63 Hz. HDR assumed the proposed facility could operate at any time of the day. Table 3-1 presents the results of summing measured existing and modeled project noise levels at ML1.

Table 3-1. Measured and Modeled Noise Levels at ML1

Sound Pressure Level, dBA/dBC/dBL (re 20 μ Pa)

	Measured Existing	Modeled Project	Calculated Future Condition (Existing + Project)	Change over Existing
<i>Quietest Existing Nighttime Hour (3:00 AM)</i>				
Broadband L_{eq} , dBA	36	43	44	+8
Broadband L_{eq} , dBC	53	55	57	+4
L_{eq} at 31.5 Hz, dBL	51	53	55	+4
L_{eq} at 63 Hz, dBL	48	49	51	+3
<i>Loudest Existing Daytime Hour (11:00 AM)</i>				
Broadband L_{eq} , dBA	51	43	52	+1
Broadband L_{eq} , dBC	58	55	60	+2
L_{eq} at 31.5 Hz, dBL	55	53	57	+2
L_{eq} at 63 Hz, dBL	50	49	53	+3

During the quietest measured nighttime hour, the proposed project was modeled to produce a future (existing + project) L_{eq} nighttime condition of 44 dBA. Thus, the project could increase A-weighted nighttime noise levels by 8 dBA. This increase would be expected to be a noticeable change, but would be perceived as being less than twice as loud (a 10 dBA increase is generally perceived to be as twice as loud to a person with average hearing abilities). The primary noise source is the exhaust stack. During the loudest measured daytime conditions, the estimated increase over existing is 1 dBA. This increase would not be noticeable to a person with average hearing abilities. The modeled low-frequency octave band noise levels are below the ANSI noise limits presented in Table 1-3. This suggests that there is low potential for annoyance due to

low-frequency noise-induced vibrations and rattling. Noise levels are not presented at 16 Hz, because equipment noise emissions are not available at 16 Hz. Both nighttime and daytime modeled results are below the previous standard set by the SD PUC for a nearby combined-cycle electric generation facility project.

Table 3-2 presents the results of summing measured existing and modeled project noise levels at ML2.

Table 3-2. Measured and Modeled Noise Levels at ML2

Sound Pressure Level, dBA/dBC/dBL (re 20 μ Pa)

	Measured Existing	Modeled Project-Only	Calculated Future Condition (Existing + Project)	Change over Existing
Quietest Existing Nighttime Hour (4:00 AM)				
Broadband L_{eq} , dBA	40	38	42	+2
Broadband L_{eq} , dBC	55	51	57	+2
L_{eq} at 31.5 Hz, dBL	52	49	54	+2
L_{eq} at 63 Hz, dBL	46	46	49	+3
Loudest Existing Daytime Hour (7:00 PM)				
Broadband L_{eq} , dBA	51	38	52	+1
Broadband L_{eq} , dBC	64	51	64	0
L_{eq} at 31.5 Hz, dBL	61	49	61	0
L_{eq} at 63 Hz, dBL	51	46	52	+1

The modeled project noise levels at ML2 are below the measured existing noise levels, so the estimated change over existing is an increase of 2 dBA based on the quietest measured nighttime hour and an increase of 1 dBA based on the loudest measured daytime hour. A change in noise levels of less than 3 dBA would not be noticeable to the average person. The modeled low-frequency octave band noise levels are below the ANSI noise limits presented in Table 1-3. Both nighttime and daytime modeled results are below the previous standard set by the SD PUC for a nearby combined-cycle electric generation facility project.

4 References

American National Standards Institute (ANSI) and Acoustical Society of America (ASA)

- 2013 *Quantities and Procedures for Description and Measurement of Environmental Sound – Part 3: Short-term Measurements with an Observer Present*. ANSI/ASA S12.9-2013/Part 3.

American National Standards Institute (ANSI) and Acoustical Society of America (ASA)

- 2008 *Criteria for Evaluating Room Noise*. ANSI/ASA S12.2-2008.

American National Standards Institute (ANSI)

- 2001 *Design Response of Weighting Networks*. ANSI S1.42-2001 (Reaffirmed by ANSI April 22, 2011).

South Dakota Public Utilities Commission

- 2009 *Docket EL09-015*. <http://puc.sd.gov/commission/dockets/electric/2009/el09-015/stipulation.pdf>