

Acoustic Assessment for the North Bend Wind Project Hyde and Hughes Counties, South Dakota

June 2021

PRESENTED TO

North Bend Wind Project, LLC

PRESENTED BY

Tetra Tech



EXECUTIVE SUMMARY

Tetra Tech, Inc. (Tetra Tech) has completed an acoustic assessment for the proposed North Bend Wind Project (Project) under development by North Bend Wind Project, LLC (North Bend Wind) in Hyde and Hughes counties, South Dakota. An analysis was completed to evaluate the expected sound levels resulting from the Project wind turbines and substation. The acoustic assessment evaluated 78 potential wind turbine locations represented in the May 4, 2021 Project site layout although 71 wind turbines are ultimately planned for construction. North Bend Wind is considering the General Electric (GE) 2.82-127 wind turbine model with the Low Noise Trailing Edge (LNTE) blade technology option to be installed.

Acoustic analyses for three different modeling scenarios were performed. Scenarios included wind turbine operation at cut-in wind speed, and maximum rotational speed under both moderate downwind and anomalous meteorological conditions for GE 2.82-127 wind turbines with LNTE. The Project substation, which included two 140 megavolt ampere (MVA) transformers, was also included in the acoustic analysis. The overall objective of this study was to determine the feasibility of the Project to operate in compliance with the Hyde County Zoning Ordinance 45 dBA noise limit and the Hughes County Zoning Ordinance 45 dBA noise limit.

Wind turbine sound source data was obtained from GE for the GE 2.82-127 wind turbine. Substation noise impacts were based on a projected 140-MVA transformer. It is expected that the wind turbines and substation equipment installed will have similar sound profiles to what was used in the acoustic modeling analysis; however, it is possible that the final warranty sound power levels may vary slightly.

Sound propagation modeling was conducted using the Computer-Aided Noise Abatement (CadnaA) program (version 2020), a comprehensive three-dimensional acoustic modeling computer simulation software, with calculations made in accordance with the International Organization for Standardization (ISO) standard 9613-2 "Attenuation of Sound during Propagation Outdoors". This acoustic modeling software is widely used by acoustical engineers because of its adaptability to evaluate complex acoustic scenarios. Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by the user, were implemented in the CadnaA model to ensure conservative results.

Acoustic modeling analyses per ISO 9613-2 and inclusive of a number of conservative assumptions were conducted, and sound levels resulting from the Project at all identified noise-sensitive receptors (NSRs) were assessed against the 45 dBA limit for Hyde and Hughes counties to determine whether compliance was achieved. Modeling demonstrated that received sound levels will be greater than 45 dBA at two participating NSRs. No non-participating NSRs would exceed county thresholds. It is expected that received sound levels at NSRs will be consistent with sound generated at similar wind energy projects successfully sited throughout the state of South Dakota employing the same or similar criteria. However, while the acoustic assessment has demonstrated compliance with permitting requirements, the Project may result in periodically audible sound within adjacent areas under certain operational and meteorological conditions.

TABLE OF CONTENTS

1.0 OVERVIEW	5
1.1 Study Area	5
1.2 Existing Acoustic Environment.....	5
1.3 Acoustic Terminology.....	5
2.0 NOISE REGULATIONS AND GUIDELINES	8
3.0 ACOUSTIC MODELING METHODOLOGY AND RESULTS.....	9
3.1 Acoustic Modeling Software and Calculation Methods.....	9
3.2 Acoustic Modeling Input Parameters	11
3.3 Acoustic Modeling Results.....	12
3.4 Substation Acoustic Analysis	14
3.5 Construction Noise.....	15
4.0 CONCLUSIONS	16
5.0 REFERENCES	17

LIST OF TABLES

Table 1.	Sound Pressure Levels (Lp) and Relative Loudness of Typical Noise Sources and Soundscapes.....	6
Table 2.	Acoustic Terms and Definitions.....	7
Table 3.	Wind Turbine Broadband Sound Power Levels Correlated with Wind Speed.....	11
Table 4.	Wind Turbine Broadband Sound Power Level by Octave Band Frequency (10 m/s).....	11
Table 5.	Acoustic Modeling Results Summary	12
Table 6.	140 MVA Transformer Sound Power Level	14
Table 7.	Estimated Maximum Sound Pressure Levels from Construction Equipment	15

ATTACHMENTS

ATTACHMENT A. FIGURES

- Figure A-1. GE 2.82-127: Received Sound Levels – Cut-in Wind Turbine Rotational Speed
- Figure A-2. GE 2.82-127: Received Sound Levels – Maximum Wind Turbine Rotational Speed
- Figure A-3. GE 2.82-127: Received Sound Levels – Maximum Wind Turbine Rotational Speed during Anomalous Meteorological Conditions

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
μPa	micropascal
dB	decibel
dBA	A-weighted decibel
dBL	unweighted (linear) decibel
ft	foot
GE	General Electric Company
Hz	Hertz
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kHz	kilohertz
L_{eq}	equivalent sound level
L_p	sound pressure level
L_w	sound power level
LNTE	Low Noise Trailing Edge
m	meter
m/s	meters per second
North Bend Wind	North Bend Wind Project, LLC
MVA	megavolt ampere
MW	megawatt
NEMA	National Electric Manufacturers Association
NSR	noise-sensitive receptors
pW	picowatt
Project	North Bend Wind Project
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator

1.0 OVERVIEW

North Bend Wind Project, LLC (North Bend) is proposing to construct and operate the North Bend Wind Project (the Project) located in Hyde and Hughes counties, South Dakota. The acoustic assessment analyzed a total of 78 potential wind turbine locations represented in the May 4, 2021 Project site layout although ultimately 71 wind turbines are planned for construction. North Bend Wind is considering the General Electric (GE) 2.82-127 wind turbine model with the Low Noise Trailing Edge (LNTE) blade technology option. The substation transformers are rated at 140 megavolt ampere (MVA) and the substation is located along the west side of 328th Avenue, approximately 1.4 miles north of 212th Street.

This acoustic assessment included modeling analyses to predict future sound levels when the wind turbines are operational. Three different modeling scenarios were performed. Scenarios included wind turbine operation at cut-in wind speed, and maximum rotational speed under both moderate downwind and anomalous meteorological conditions for GE 2.82-127 wind turbines with LNTE. Operational sounds levels resulting from the Project were analyzed at existing noise-sensitive receptors (NSRs; e.g., residential structures), and compliance was assessed relative to the Hyde and Hughes county zoning ordinance requirements for siting large wind energy systems which set numerical decibel limits.

1.1 STUDY AREA

The Project Study Area is split between Hyde and Hughes counties, South Dakota on approximately 46,931 acres of private land. County and township (section line) roads characterize the existing roadway system, and the Study Area is accessible via US Highway 14, State Highway 47, and State Highway 34. The land within the Study Area is primarily agricultural with scattered farmstead residences. The turbines will be located on privately-owned land in southwestern Hyde County and eastern Hughes County. This region of South Dakota has topography that can be described as level to rolling plains. Gentle slopes characterize most of the Study Area and local relief ranges from less than 1,500 to over 2,200 feet. Current land use within the Study Area is primarily agricultural, supporting both crops and livestock grazing. Potential NSR locations within the Study Area and in the vicinity of proposed turbine locations were included in the acoustic analysis. Figures A-1 through A-3 (Attachment A) presents the proposed wind turbine locations as well as the noise sensitive receptor locations.

1.2 EXISTING ACOUSTIC ENVIRONMENT

Hyde and Hughes counties would generally be considered rural agricultural areas. Existing ambient sound levels are expected to be relatively low, although sound levels would be higher near roadways such as US Highway 14, State Highway 47, and State Highway 34. Other human activity such as agricultural operations would seasonally contribute to sound levels in the area associated with crop harvests. Background sound levels are expected to vary both spatially and temporally, depending on natural sounds and proximity to area sound sources such as roadways. Typically, background sound levels are quieter during the night than during the daytime, except during periods when evening and nighttime insect noise may contribute to the soundscape, predominantly in the warmer seasons.

1.3 ACOUSTIC TERMINOLOGY

Airborne sound is described as the rapid fluctuation or oscillation of air pressure above and below atmospheric pressure, creating a sound wave. Sound is characterized by properties of the sound waves, which are frequency, wavelength, period, amplitude, and velocity. Noise is defined as unwanted sound. A sound source is defined by a sound power level (L_w), which is independent of any external factors. The acoustic sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts. Sound energy travels in the form

of a wave, a rapid fluctuation or oscillation of air pressure above and below atmospheric pressure. A sound pressure level (L_p) is a measure of this fluctuation and can be directly determined with a microphone or calculated from information about the source sound power level and the surrounding environment through predictive acoustic modeling. While the sound power of a source is strictly a function of the total amount of acoustic energy being radiated by the source, the sound pressure levels produced by a source are a function of the distance from the source and the effective radiating area or physical size of the source. In general, the magnitude of a source’s sound power level is always considerably higher than the observed sound pressure level near a source since the acoustic energy is being radiated in various directions.

Sound levels are presented on a logarithmic scale to account for the large pressure response range of the human ear and are expressed in units of decibels (dB). A dB is defined as the ratio between a measured value and a reference value usually corresponding to the lower threshold of human hearing defined as 20 micropascals (μPa). Conversely, sound power is commonly referenced to 1 picowatt (pW), which is one trillionth of a watt. Broadband sound includes sound energy summed across the frequency spectrum. In addition to broadband sound pressure levels, analysis of the various frequency components of the sound spectrum is often completed to determine tonal characteristics. The unit of frequency is Hertz (Hz), which corresponds to the rate in cycles per second that sound pressure waves are generated. Typically, a sound frequency analysis examines 11 octave bands (or 33 1/3 octave) ranging from 20 Hz (low) to 20,000 Hz (high). This range encompasses the entire human audible frequency range. 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. Sound exposure in acoustic assessments is commonly measured and calculated as A-weighted dB (dBA). Unweighted sound levels are referred to as linear. Linear dB (dBL) 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 can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level (L_{eq}). The equivalent sound level has been shown to provide both an effective and uniform method for comparing time-varying sound levels and is widely used in acoustic assessments in the state of South Dakota. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness, are presented in Table 1. Table 2 provides additional reference information on acoustic terminology.

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

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (perception of different sound levels)
Jet aircraft takeoff from carrier (50 ft.)	140	Threshold of pain	64 times as loud
50-hp siren (100 ft.)	130		32 times as loud
Loud rock concert near stage or Jet takeoff (200 ft.)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 ft.)	110		8 times as loud
Jet takeoff (2,000 ft.)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 ft.)	90		2 times as loud
Garbage disposal, food blender (2 ft.), or Pneumatic drill (50 ft.)	80	Loud	Reference loudness
Vacuum cleaner (10 ft.)	70	Moderate	1/2 as loud
Passenger car at 65 mph (25 ft.)	65		

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

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (perception of different sound levels)
Large store air-conditioning unit (20 ft.)	60		1/4 as loud
Light auto traffic (100 ft.)	50	Quiet	1/8 as loud
Quiet rural residential area with no activity	45		
Bedroom or quiet living room or Bird calls	40	Faint	1/16 as loud
Typical wilderness area	35		
Quiet library, soft whisper (15 ft.)	30	Very quiet	1/32 as loud
Wilderness with no wind or animal activity	25	Extremely quiet	
High-quality recording studio	20		1/64 as loud
Acoustic test chamber	10	Just audible	
	0	Threshold of hearing	

Note: Adapted from: Beranek 1988; EPA 1971

Table 2. Acoustic Terms and Definitions

Term	Definition
Noise	Typically defined as unwanted sound. This word adds the subjective response of humans to the physical phenomenon of sound. It is commonly used when negative effects on people are known to occur.
Sound Pressure Level (L _P)	Pressure fluctuations in a medium. Sound pressure is measured in decibels referenced to 20 microPascals, the approximate threshold of human perception to sound at 1,000 Hz.
Sound Power Level (L _w)	The total acoustic power of a noise source measured in decibels 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.
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

Table 2. Acoustic Terms and Definitions

Term	Definition
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.
Octave Bands	The audible range of humans spans from 20 to 20,000 Hz and is typically divided into center frequencies ranging from 31 to 8,000 Hz for noise modeling evaluations.
Broadband Sound	Noise which covers a wide range of frequencies within the audible spectrum, i.e., 200 to 2,000 Hz.
Masking	Interference in the perception of one sound by the presence of another sound. At elevated wind speeds, leaf rustle and noise made by the wind itself can mask wind turbine sound levels, which remain relatively constant.
Frequency (Hz)	The rate of oscillation of a sound, measured in units of Hz or kilohertz (kHz). One hundred Hz is a rate of one hundred times (or cycles) per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz.

Note: Compiled by Tetra Tech from multiple technical and engineering resources.

2.0 NOISE REGULATIONS AND GUIDELINES

A review was conducted of noise regulations applicable to the Project at the federal, state, county, and local levels. There are no federal or state environmental noise requirements specific to this Project. At the county level, Hyde and Hughes counties have established regulations applicable to wind energy facilities.

Hyde County proposed regulations for wind energy facilities under Zoning Ordinance Section 9-104-A-18 as follows:

SECTION 9-104 Requirements for Siting Large Wind Energy Systems

A. *Standards. A Large Wind Energy System shall be a Conditional Use in an Ag district subject to the following requirements:*

18. Noise. Noise level produced by the LWES shall not exceed forty-five (45) decibels of sound at the perimeter of occupied residences existing at the time the permit application is filed, unless a signed waiver or easement is obtained from the owner of the residence. The level, however, may be exceeded during short-term events such as utility outages or wind storms.

Hughes County Ordinance 2020-05 amended Zoning Ordinance (No. 1997-03) Article 2 Section 2-117 regulations for wind energy facilities as follows:

SECTION 2-117.F Requirements for Siting Large Wind Energy Conversion Systems

11. Noise. Noise level produced by the LWECs shall not exceed 45 dBA, average A-weighted sound pressure at the perimeter of occupied residences existing at the time the

permit application is filed, unless a signed waiver or easement is obtained from the owner of the residence and recorded with the Register of Deeds.

Sound levels resulting from the Project at all identified receptors located in the vicinity of the Project were assessed against a 45 dBA for Hyde and Hughes counties to determine whether compliance was achieved. The Hyde and Hughes County Zoning Ordinance noise limits are absolute and independent of the existing acoustic environment; therefore, a baseline sound survey is not required to assess conformity.

3.0 ACOUSTIC MODELING METHODOLOGY AND RESULTS

Sound generated by an operating wind turbine is comprised of both aerodynamic and mechanical sound with the dominant sound component from modern utility scale wind turbines being aerodynamic. Aerodynamic noise results from air flowing across and around each blade of the turbine. Secondly, mechanical sound is sound generated by machinery located inside the nacelle of the turbine, such as gearboxes, motors, cooling systems, and pumps. Due to the improved design of wind turbine mechanical components and the use of improved noise damping materials within the nacelle, including elastomeric elements supporting the generator and gearbox, mechanical noise emissions have been minimized.

Wind energy facilities, in comparison to other energy-related facilities, are somewhat unique in that the sound generated by each individual wind turbine increases as the wind speed increases. The sound emitted by a wind turbine is strongly dependent on the speed of the tip of the blade, the design of the blade, and on atmospheric conditions such as the degree of turbulence. Blade noise increases with increasing wind speed until full-rated electrical power is achieved due to the interaction between the incident turbulence eddies and the blade surface. The prevalence of this inflow turbulence noise varies depending on site-specific and variable atmospheric conditions. The second mechanism is the shedding of vortices that form at the tip of each blade. This depends on the strength of the vortex and the design of the blade tip. Finally, noise may be generated by turbulent flow over the trailing edge of the blade. As air flows over the face of the blade, a turbulent boundary layer develops, but remains attached to the trailing edge. Eddies extending past the trailing edge causes sound emission scattering, resulting in the characteristic wind turbine broadband swooshing sound. This turbulent boundary layer noise (trailing edge noise) usually defines the upper limit of wind turbine noise levels and is considered the greatest contributor to aerodynamic noise.

One of the primary blade design features affecting noise emissions is the shape of the trailing edge of the blades. Sound reduction elements have been incorporated into the Project design including the use of LNTE blades for the GE turbines.

It is important to recognize that as wind speeds increase, the background ambient sound level will generally increase as well, resulting in acoustic masking effects; however, this trend is also affected by local contributing sound sources. The net result is that during periods of elevated wind speeds when higher wind turbine sound emissions occur, the sound produced from a wind turbine operating at maximum rotational speed may be largely or fully masked due to wind generated sound in foliage or vegetation. In practical terms, this means a nearby receptor would tend to hear leaves or vegetation rustling rather than wind turbine noise. This relationship is expected to further minimize the potential for any adverse noise effects of the Project. Conversely, these acoustic masking effects may be limited during periods of unusually high wind shear or at receiver locations that are sheltered from the prevailing wind direction.

3.1 ACOUSTIC MODELING SOFTWARE AND CALCULATION METHODS

To assess the noise emissions of a wind energy facility prior to construction, it is necessary to have prediction models with which a noise emission source level measured at a given reference point can be certified. A generally accepted approach for modeling a wind turbine as an idealized point source is described in International

Organization for Standardization (ISO) 9613-2, "Attenuation of Sound during Propagation Outdoors". The standard specifies methods to enable noise levels in the community to be predicted from sources of known sound emission and provides a summary of existing knowledge on outdoor sound propagation as published by ISO, a worldwide federation of national standards bodies. The calculation methodologies described are relied on by professionals in the field of acoustics.

Standard acoustic engineering methods that conform to ISO 9613-2 were used in this noise analysis using DataKustic GmbH's CadnaA, the computer-aided noise abatement program (version 2020). The engineering methods specified in this standard consist of full (1/1) octave band algorithms that incorporate geometric spreading due to wave divergence, reflection from surfaces, atmospheric absorption, screening by topography and obstacles, ground effects, source directivity, heights of both sources and receptors, seasonal foliage effects, and meteorological conditions. For compliance assessment purposes, operational broadband sound pressure levels were calculated assuming that all wind turbines are operating continuously and concurrently at the maximum manufacturer-rated sound level. The sound energy was then summed to determine the equivalent continuous A-weighted downwind sound pressure level at a given point of reception.

The effects of topography were incorporated into the noise prediction model using ground contour data from the official U.S. Geological Survey (USGS) digital elevation dataset to accurately represent terrain in three dimensions. Terrain conditions, vegetation type, ground cover, and the density and height of foliage can also influence the absorption that takes place when sound waves travel over land. The ISO 9613-2 standard accounts for ground absorption rates by assigning a numerical coefficient of $G=0$ for acoustically hard, reflective surfaces and $G=1$ for absorptive surfaces and soft ground. If the ground is hard-packed dirt, typically found in industrial complexes, pavement, bare rock or for sound traveling over water, the absorption coefficient is defined as $G=0$ to account for reduced sound attenuation and higher reflectivity. In contrast, ground covered in vegetation, including suburban lawns, livestock and agricultural fields (both fallow with bare soil and planted with crops), will be acoustically absorptive and aid in sound attenuation (i.e., $G=1.0$). For the purposes of this modeling analysis, a semi-reflective ground absorption factor was applied throughout the Project area. In addition to geometrical divergence, attenuation factors include topographical features, terrain coverage, and/or other natural or anthropogenic obstacles that can affect sound attenuation and result in acoustical screening. To be conservative, sound attenuation through foliage and diffraction around and over existing anthropogenic structures such as buildings was not included in the model. Sound attenuation by the atmosphere is not strongly dependent on temperature and humidity; however, a temperature of 10°C (50°F) and 70 percent relative humidity parameters were selected as reasonably representative of conditions favorable to sound propagation.

Since it is not possible to account for all factors that affect sound propagation and attenuation, acoustic modeling followed the methodologies as described in the ISO 9613-2 standard, which have been accepted as reasonably conservative, to serve as the regulatory worst case. Inherent to the ISO 9613-2 standard is the assumption of downwind sound propagation conditions. That is, the wind turbine sound power levels and modeling methods are representative of when the wind is blowing from the wind turbine to the receptor. In fact, the ISO 9613-2 modeling method unrealistically assumes that downwind conditions exist in all directions, between each wind turbine and each receptor simultaneously, which is physically impossible. Therefore, lower levels are expected in the upwind direction. In addition, the acoustic modeling algorithms essentially assume laminar atmospheric conditions, in which neighboring layers of air do not mix. This conservative assumption does not take into consideration turbulent eddies and micrometeorological variations that may form when winds change speed or direction, which can interfere with the sound wave propagation path and increase attenuation effects.

Conversely, there may be meteorological conditions from time to time that may aid in the long-range propagation of sound. These anomalous meteorological conditions may include wind gradients that bend sound downwards, which principally affects long-range sound attenuation. Received sound levels during anomalous meteorological conditions were also estimated using a range-dependent correction factor.

3.2 ACOUSTIC MODELING INPUT PARAMETERS

The operational acoustic assessment was performed using the proposed May 4, 2021 layout with 78 potential wind turbine locations. The following wind turbine model was evaluated in the acoustic analysis:

- **GE 2.82-127 with LNTE** – Wind turbine equipped with LNTE blade technology, a rotor diameter of 417 feet (ft) (127 meters [m]) and a hub height of 292 ft. (89 m).

To assist project developers and acoustical engineers, wind turbine manufacturers report wind turbine sound power data at integer wind speeds referenced to the effective hub height, ranging from cut-in to full rated power. This accepted International Electrotechnical Commission (IEC) standard was developed to ensure consistent and comparable sound emission data of utility-scale wind turbines between manufacturers. The IEC test is an accepted standard providing a uniform methodology for measuring the noise emissions of a wind turbine from cut-in through full rotational wind speeds. The IEC testing standard defines deviation values σ_T , σ_R and σ_P for measured apparent sound power levels as described by IEC/TS 61400-14, where σ_T is the total standard deviation, σ_R is the standard deviation for test reproducibility, and σ_P is the standard deviation for product variation. To account for this inherent deviation associated with the IEC testing methodology, a confidence interval of $k = 2$ dBA was applied. The combination of the modeling parameters used and the inclusion of the 2-dBA term are expected to result in a reasonable and conservative assessment of Project sound levels since it is unlikely that all wind turbines would be operating concurrently 2 dB above the mean.

Table 3 provides a summary of the sound power data correlated by wind speed at reference rotor hub height assuming a roughness length coefficient of 0.05 meter. The roughness length describes the change in wind speed at increased elevation and may vary based on site specific terrain conditions. It is assumed that the wind turbine models for the Project will have similar sound power profiles as those used in the acoustic modeling analysis; however, it is possible that the final manufacturer warranty values may vary slightly. A summary of sound power data for the GE 2.82-127 with LNTE by octave band center frequency during maximum rotational speed is presented in Table 4.

Table 3. Wind Turbine Broadband Sound Power Levels Correlated with Wind Speed

Wind Turbine	Hub Height (m)	Sound Power Level (dBA) at Reference Hub Height Wind Speed (m/s)							
		4	5	6	7	8	9	10	
GE 2.82-127 LNTE	89.0	95.2	95.4	98.9	102.4	105.3	107.7	108.5	

Source: GE 2018

Wind turbines can be somewhat directional, radiating more sound in some directions than others. The IEC test measurement protocol requires that sound measurements are made for the maximum downwind directional location when reporting apparent sound power levels. Thus, it is assumed that wind turbine directivity and sound-generating efficiencies are inherently incorporated in the sound source data and used in acoustic model development. A summary of sound power data by octave band center frequency for both wind turbines operating at maximum rotation are presented in Table 4 (1/1 octave band frequency data provided with stated intended use limited for informational purposes only).

Table 4. Wind Turbine Broadband Sound Power Level by Octave Band Frequency (10 m/s)

Wind Turbine	K-Factor	Octave Band Sound Power Level (dBA) by Frequency (Hz)									Broad band (dBA)
		31.5	63	125	250	500	1000	2000	4000	8000	
GE 2.82-127 LNTE	2.0	82.8	92.6	97.2	98.2	100.4	103.8	102.7	95.0	76.9	108.5

Source: GE 2018

3.3 ACOUSTIC MODELING RESULTS

Acoustic modeling was completed for wind turbine operation for the following conditions thereby describing the full range of expected receive sound levels at receiver locations: (1) initial cut-in wind speeds; (2) maximum rotation; and (3) maximum rotation during anomalous meteorological conditions. Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures A-1 through A-3 in Attachment A. The sound contours are graphical representations of the cumulative noise associated with the Project substation and all project wind turbines operating concurrently at the given operating condition and show how operational noise would be distributed over the surrounding area. The contour lines presented are analogous to elevation contours on a topographic map, i.e., the sound contours are continuous lines of equal noise level. Figure A-1 displays broadband operational sound levels at the wind speeds during initial cut-in, which is when the turbines engage and start producing power. Figure A-2 displays broadband operational sound levels at wind speeds sufficient to sustain wind turbine operation at maximum rotational speeds during moderate downwind propagation. Figure A-3 displays broadband operational sound levels at wind speeds sufficient to sustain wind turbine operation at maximum rotational speeds during anomalous meteorological conditions. The resultant sound contour plots are independent of the existing acoustic environment, i.e., the plots and tabulated results represent Project-generated sound levels only.

Table 5 presents the results of the Project acoustic modeling analysis and includes the NSR ID, Universal Transverse Mercator (UTM) coordinates, NSR status and the received sound levels at each NSR. Received sound levels are rounded to the nearest whole decimal for consistency with the zoning ordinance noise limits.

Acoustic modeling results show that received sound levels will be greater than 45 dBA at 2 participating NSRs (#26 and #51). No non-participating NSRs exceed county thresholds.

Table 5. Acoustic Modeling Results Summary

NSR ID	NSR Status	UTM Coordinates (meters)		Received Sound Levels (dBA)		
				GE 2.82-127 with LNTE		
		Easting	Northing	Cut-in	Maximum Rotational	Anomalous Meteorological
1	Non-Participant	451959	4905460	22	33	35
2	Non-Participant	451961	4905509	22	34	36
3	Non-Participant	451651	4906532	26	38	40
4	Non-Participant	451667	4906508	26	37	39
5	Non-Participant	452007	4912597	32	44	45
6	Non-Participant	456096	4911237	24	36	37
7	Participant	454822	4907004	20	32	34
8	Participant	454834	4907004	20	32	34
9	Non-Participant	456924	4903126	12	23	26
10	Non-Participant	456936	4903193	13	24	27
11	Non-Participant	458027	4909358	13	25	27
12	Participant	456979	4911089	21	33	35
13	Non-Participant	459894	4911262	15	27	29
14	Non-Participant	456174	4911146	23	35	37
15	Non-Participant	446161	4905997	27	40	41

NSR ID	NSR Status	UTM Coordinates (meters)		Received Sound Levels (dBA)		
		Easting	Northing	GE 2.82-127 with LNTE		
				Cut-in	Maximum Rotational	Anomalous Meteorological
16	Non-Participant	441158	4903752	13	25	28
17	Non-Participant	435413	4904474	5	16	19
18	Non-Participant	437507	4925641	13	25	28
19	Non-Participant	440822	4926572	15	27	29
20	Participant	444987	4923741	23	35	37
21	Non-Participant	442558	4922500	23	35	37
22	Non-Participant	442678	4922259	23	35	38
23	Non-Participant	440697	4922015	21	33	35
24	Participant	437557	4918479	21	33	35
25	Participant	440535	4919291	29	42	43
26	Participant	443100	4918873	35	48	48
27	Participant	445446	4917655	28	41	42
28	Participant	445621	4918665	32	45	45
29	Participant	445637	4918675	32	45	45
30	Participant	442663	4914508	20	32	35
31	Participant	442583	4914365	21	33	36
32	Non-Participant	440462	4914037	20	31	34
33	Non-Participant	443049	4911871	21	33	35
34	Non-Participant	442769	4911900	21	33	36
35	Non-Participant	444336	4912677	23	35	38
36	Participant	445432	4912472	26	38	40
37	Participant	445356	4911623	27	39	41
38	Non-Participant	440290	4924270	16	28	30
39	Non-Participant	435597	4906544	8	19	22
40	Non-Participant	440884	4923291	19	31	33
41	Non-Participant	449222	4927447	16	28	31
42	Non-Participant	452104	4916108	23	35	38
43	Participant	439796	4924263	13	25	27
44	Participant	442457	4925507	16	28	31
45	Participant	441883	4923945	19	31	34
46	Participant	446148	4922207	30	43	44
47	Participant	448547	4915128	29	41	42
48	Participant	448560	4915214	28	41	42
49	Participant	450247	4915029	31	44	44

NSR ID	NSR Status	UTM Coordinates (meters)		Received Sound Levels (dBA)		
				GE 2.82-127 with LNTE		
		Easting	Northing	Cut-in	Maximum Rotational	Anomalous Meteorological
50	Participant	445332	4915444	23	35	37
51	Participant	448812	4920035	34	47	47

Note: Predicted sound levels greater than the 45 dBA threshold criteria are identified in **bold**.

3.4 SUBSTATION ACOUSTIC ANALYSIS

Substations have switching, protection, and control equipment, and typically one or more transformers, which generate the sound generally described as a low humming. There are three main sound sources associated with a transformer: core noise, load noise and noise generated by the operation of the cooling equipment. The core vibrational noise is the principal noise source and does not vary significantly with electrical load. Transformers are designed and catalogued by MVA ratings. Just as horsepower ratings designate the power capacity of an electric motor, a transformer’s MVA rating indicates its maximum power output capacity. The National Electrical Manufacturers Association (NEMA) published NEMA Standards TR1-1993 (R2000), which establish the maximum noise level allowed for transformers, voltage regulators, and shunt reactors based on the equipment’s method of cooling its dielectric fluid (air-cooled vs. oil-cooled) and the electric power rating.

Transformer noise is generated and will attenuate with distance at different rates depending on the transformer dimensions, voltage rating, and design. The noise produced by substation transformers 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. The characteristic humming sound consists of tonal components generated at harmonics of 120 Hz. Most of the acoustical energy resides in the fundamental tone (120 Hz) and the first 3 or 4 harmonics (240, 360, 480, 600 Hz). In addition to core vibration noise, transformer cooling fans may generate broadband noise, limited to periods when high heat loads require additional cooling capacity. The resulting audible sound is a combination of core noise and the broadband fan noise. Circuit-breaker operations may also cause audible noise, particularly the operation of air-blast breakers which is characterized as an impulsive sound event of very short duration. This is expected to occur only a few times throughout the year and was therefore not considered in this analysis.

The Project collector substation was also reviewed as part of the acoustic analysis. The proposed substation would be located along 328th Avenue, approximately 13.5 miles (21.8 kilometers) south of US Highway 14, 8 miles (13 kilometers) west of State Highway 47, and 3.5 miles (5.7 kilometers) north of State Highway 34, with the closest residence approximately 1.3 miles (2.1 kilometers) to the south. Sound source levels for the future transformers were calculated for the Project substation, which will consist of two 140-MVA rating transformers. The transformers are expected to have a NEMA sound rating of less than or equal to 80 dBA during maximum load and forced air cooling operation. The transformers were modeled using the latest version of CadnaA implementing ISO 9613-2. Table 6 presents the transformer sound source data by octave band center frequency calculated based on the specified transformer NEMA and MVA ratings using standardized engineering guidelines.

Table 6. 140 MVA Transformer Sound Power Level

Octave Band Sound Power Level (dBA) by Frequency (Hz)									Broadband (dBA)
31.5	63	125	250	500	1000	2000	4000	8000	
57.2	76.4	88.5	91.0	96.4	96.6	89.8	84.6	75.5	100.0

Transformers the size of the one proposed for the Project can present a noise concern if the separation distance is less than a few hundred feet between the transformer and NSRs. The proposed transformer location is approximately 6,830 feet (2,080 meters) from the nearest NSR and poses little concern from a noise perspective. Nevertheless, transformer noise may be periodically audible at nearby NSRs on occasions when background sound levels are very low.

3.5 CONSTRUCTION NOISE

The development of the Project will involve construction to establish access roads, excavate and form wind turbine foundations, prepare the site for crane-lifting, and assemble and commission the wind turbines. Work on large-scale wind projects such as the Project is generally divided into the following four phases:

1. *Site Clearing*: The initial site mobilization phase includes the establishment of temporary site offices, workshops, stores, and other on-site facilities. Installation of erosion and sedimentation control measures will be completed as well as the preparation of initial haulage routes.
2. *Grading*: This phase would begin with the grading and formation of access roads and preparation of laydown areas. Excavation for the concrete turbine foundations would also be completed.
3. *Foundation Work*: Construction of the reinforced concrete turbine foundations would take place in addition to installation of the internal transmission network.
4. *Wind Turbine Generator Installation*: Delivery of the turbine components would occur followed by their installation and commissioning.

Work on these construction activities is expected to overlap. It is likely that the wind turbines will be erected in small groupings. Each grouping may undergo periodic testing and commissioning prior to commencement of full commercial operation. Other construction activities include those for the supporting infrastructure such as the substation, operations and maintenance building, and the overhead transmission line.

The construction of the Project may cause short-term but unavoidable noise impacts. The sound levels resulting from construction activities vary significantly depending on several factors such as the type and age of equipment, the specific equipment manufacturer and model, the operations being performed, and the overall condition of the equipment and exhaust system mufflers. The list of construction equipment that may be used on the Project and estimates of near and far sound source levels are presented in Table 7.

Table 7. Estimated Maximum Sound Pressure Levels from Construction Equipment

Equipment	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2,000 feet (dBA)
Crane	85	53
Forklift	80	48
Backhoe	80	48
Grader	85	53
Man basket	85	53
Dozer	83–88	51–56
Loader	83–88	51–56
Scissor Lift	85	53
Truck	84	52
Welder	73	41
Compressor	80	48

Equipment	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2,000 feet (dBA)
Concrete Pump	77	45
Concrete Batch Plant	83	51

Source: FHWA 2006; Bolt et al. 1977

Sounds generated by construction activities are typically exempt from state and local noise oversight if they occur within weekday, daytime periods as may be specified under local zoning or legal codes. All reasonable efforts will be made to minimize the impact of noise resulting from construction activities. As the design of the Project progresses and construction scheduling is finalized, the construction engineer normally notifies the community, via public notice or alternative method, of the expected Project construction commencement and duration to help minimize the effects of construction noise. In addition, the location of stationary equipment and the siting of construction laydown areas will be carefully selected to be as far removed from existing NSRs as is practical. Candidate construction noise mitigation measures include scheduling louder construction activities during daytime hours and equipping internal combustion engines with appropriately sized muffler systems to minimize noise excessive emissions.

Construction activity will generate traffic having potential noise effects, such as trucks travelling to and from the site on public roads. At the early stage of the construction phase, equipment and materials, such as hydraulic excavators and associated spreading and compacting equipment needed to form access roads and foundation platforms for each turbine, will be delivered to the site. Once the access roads are constructed, equipment for lifting the towers and turbine components will arrive. Traffic noise is categorized into two categories: (1) noise that will occur during the initial temporary traffic movements related to turbine delivery, haulage of components, and remaining construction; and (2) noise from maintenance and ongoing traffic from staff and contractors, which is expected to be minor.

4.0 CONCLUSIONS

Project operational sound has been calculated and compared to the strictest dBA noise requirements of 45 dBA. Acoustic modeling analyses per ISO 9613-2 and inclusive of a number of conservative assumptions demonstrate that received sound levels will be greater than 45 dBA at 2 NSRs (0 non-participating). Both Hyde and Hughes county ordinances allow for levels above 45 dBA if a signed waiver or easement is obtained from the owner of the residence. It is expected that received sound levels at noise-sensitive receptors will be consistent with sound generated at similar wind energy projects successfully sited throughout the state of South Dakota employing the same or similar criteria.

5.0 REFERENCES

Bolt, Beranek and Newman, Inc. 1977. Power Plant Construction Noise Guide, prepared for the Empire State Electric Energy Research Corporation, Report No. 3321.

EPA (U.S. Environmental Protection Agency). 1971. Community Noise. NTID300.3 (N-96-01 IIA-231). Prepared by Wylie Laboratories

FHWA (Federal Highway Administration). 2006. FHWA Roadway Construction Noise Model User's Guide, FHWA-HEP-05-054, January.

General Electric (GE). 2018. Technical Documentation Wind Turbine Generator Systems 2.82-127 with LNTE - 60 Hz. Product Acoustic Specifications Normal Operation according to IEC Including Octave and 1/3rd

ATTACHMENT A. FIGURES

Figure A-1. GE 2.82-127: Received Sound Levels – Cut-in Wind Turbine Rotational Speed



North Bend Wind Project

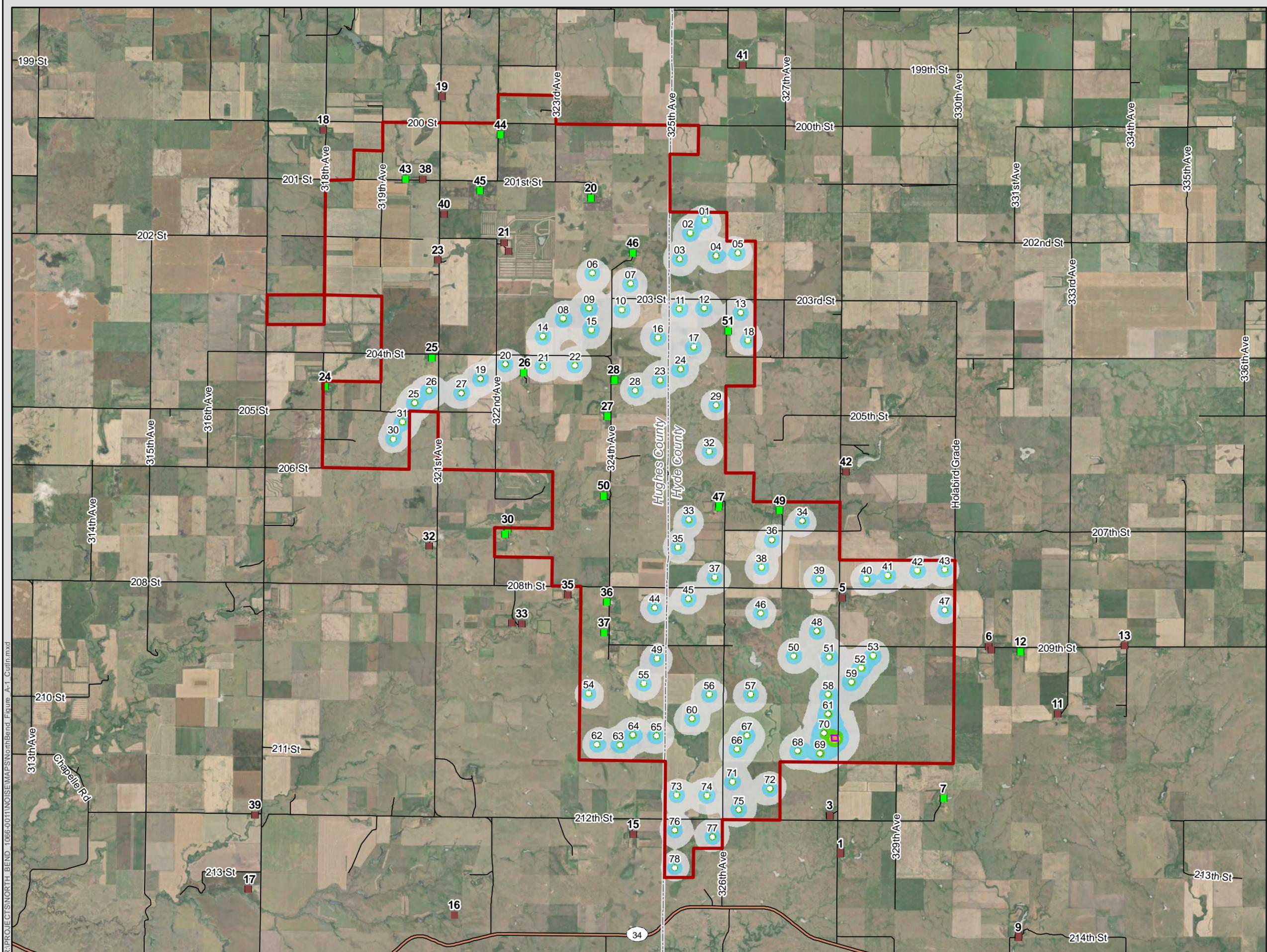
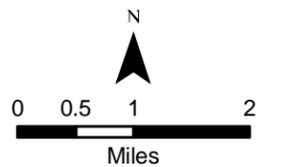
Figure A-1 Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin.mxd



North Bend Wind Project

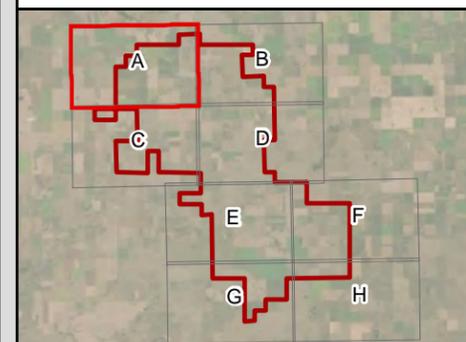
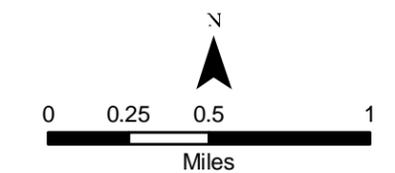
Figure A-1A Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

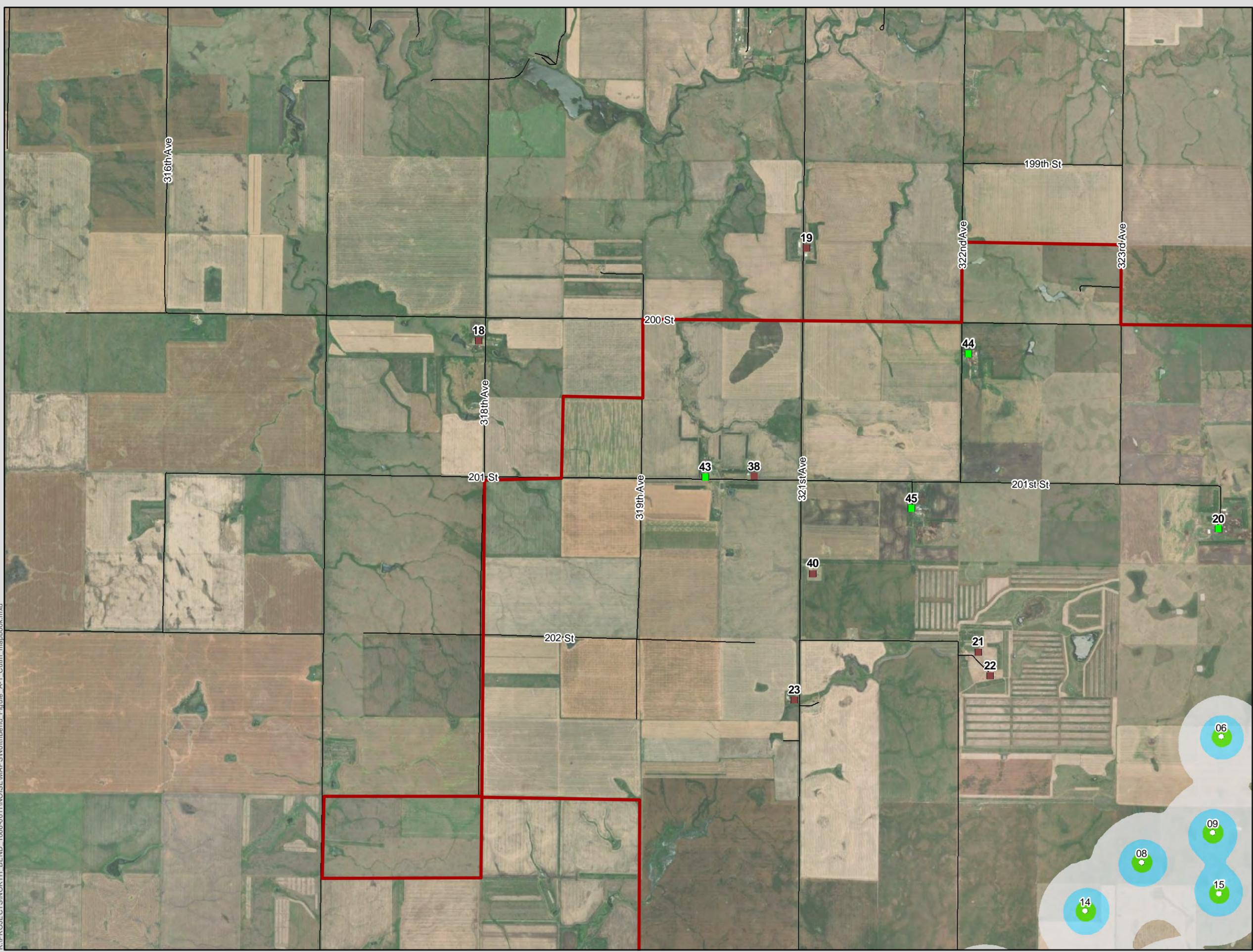
- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_CutIn_mapbook.mxd





North Bend Wind Project

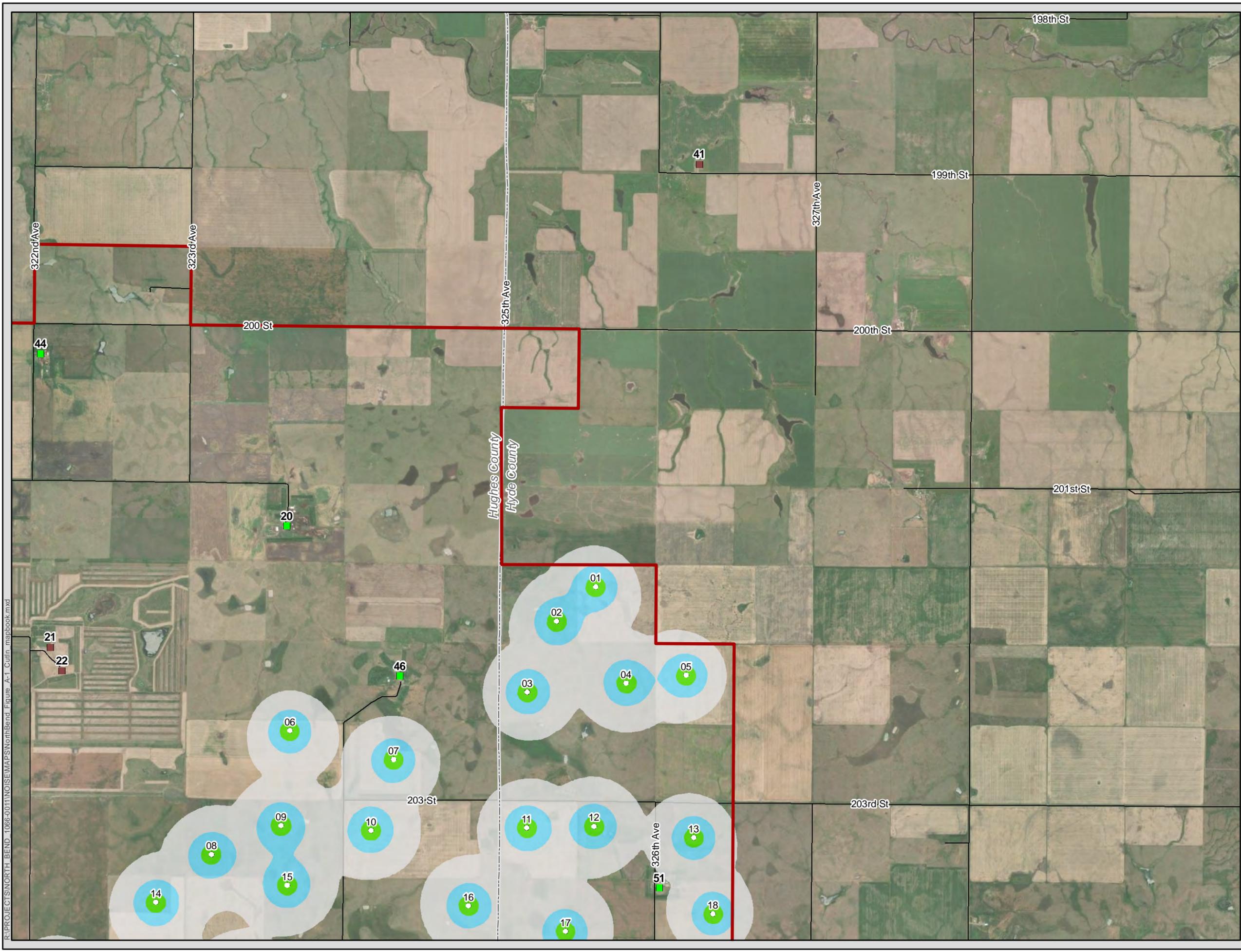
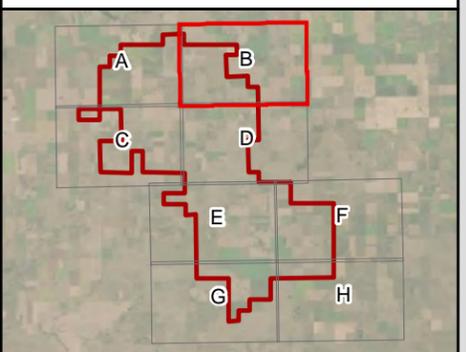
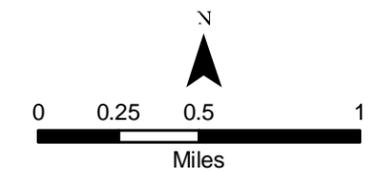
Figure A-1B Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin_mapbook.mxd



North Bend Wind Project

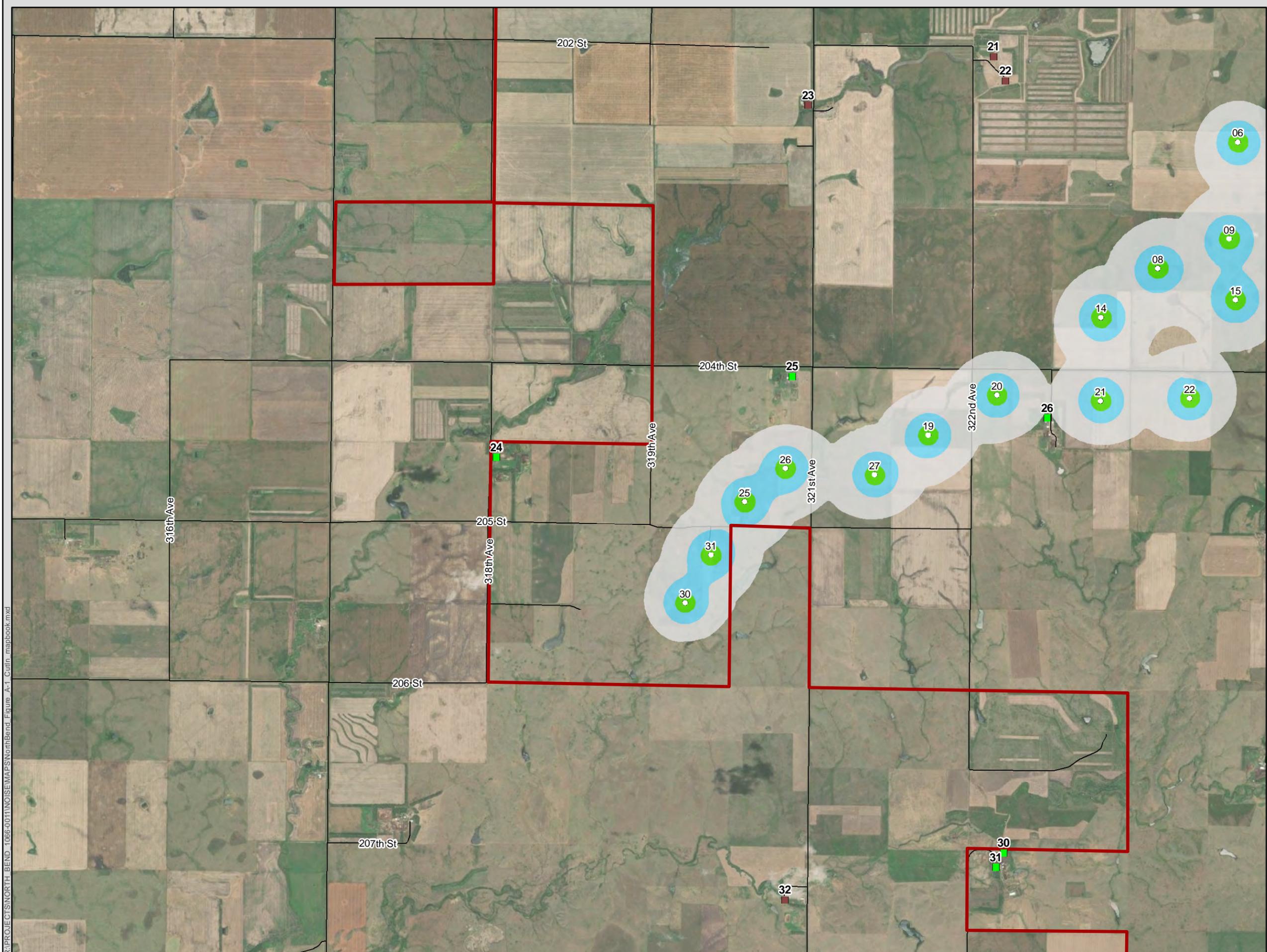
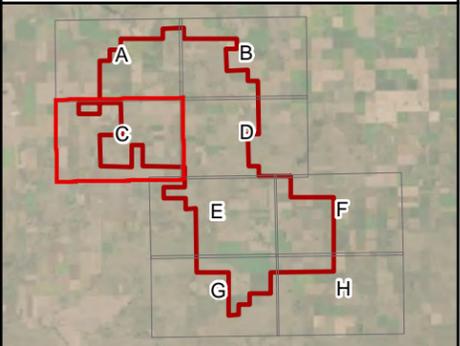
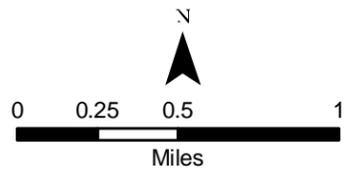
Figure A-1C Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin_mapbook.mxd



North Bend Wind Project

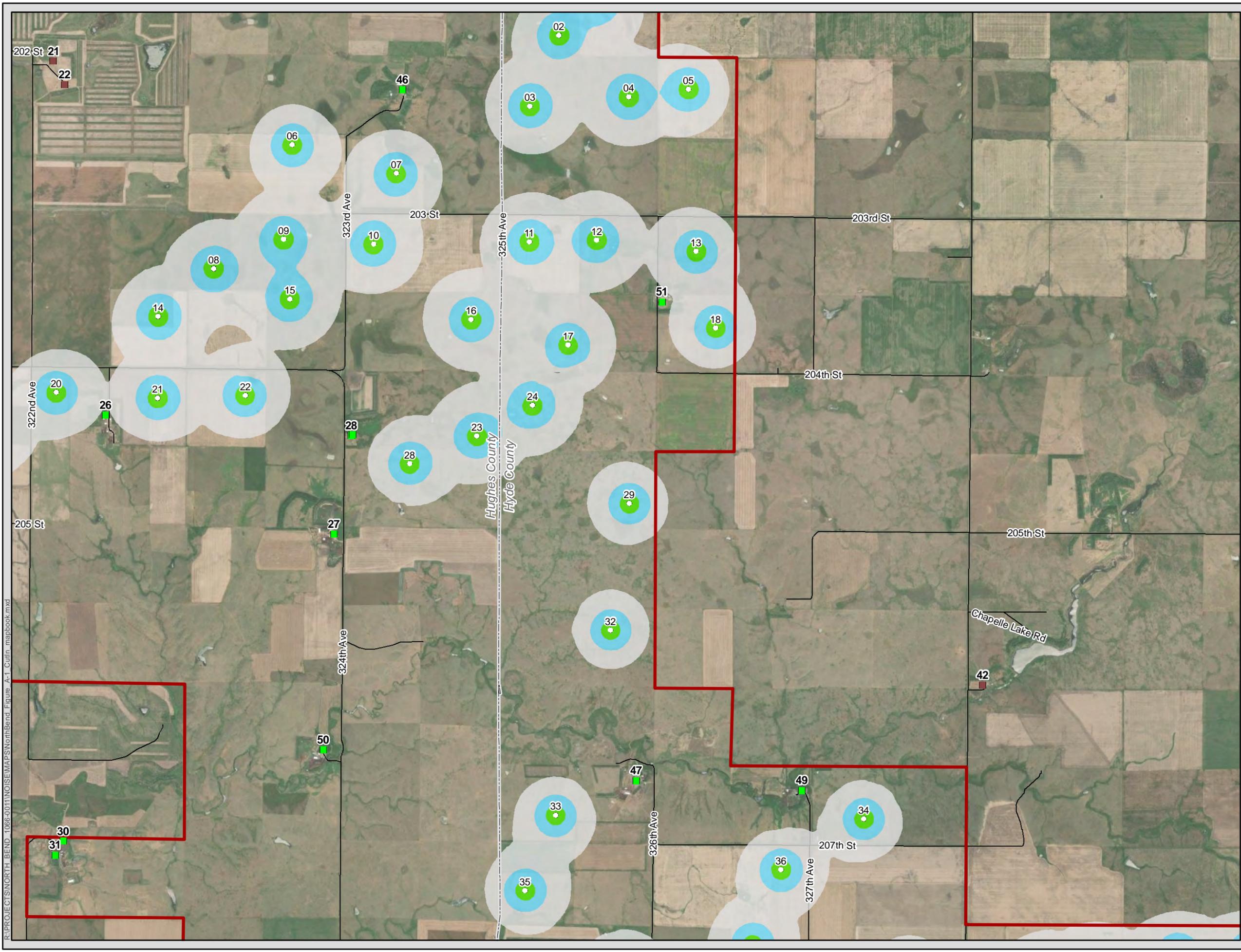
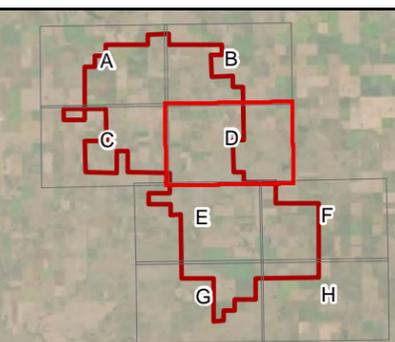
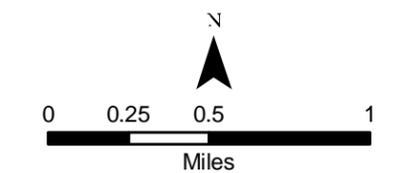
Figure A-1D Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin_mapbook.mxd



North Bend Wind Project

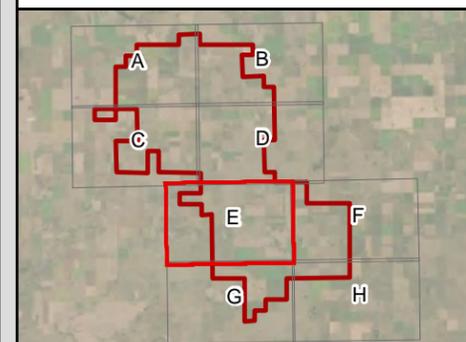
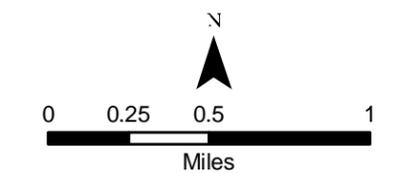
Figure A-1E Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

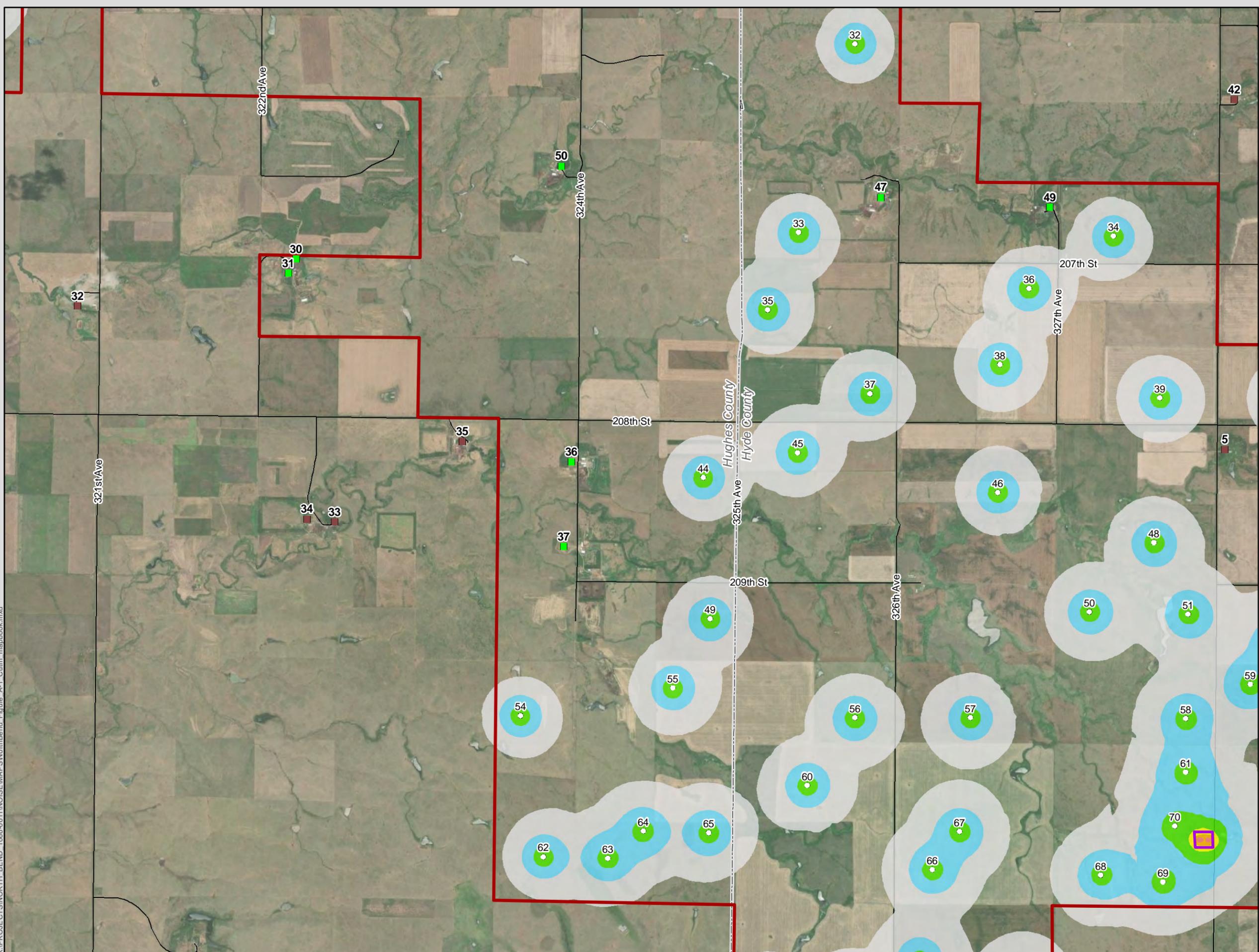
- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin_mapbook.mxd





North Bend Wind Project

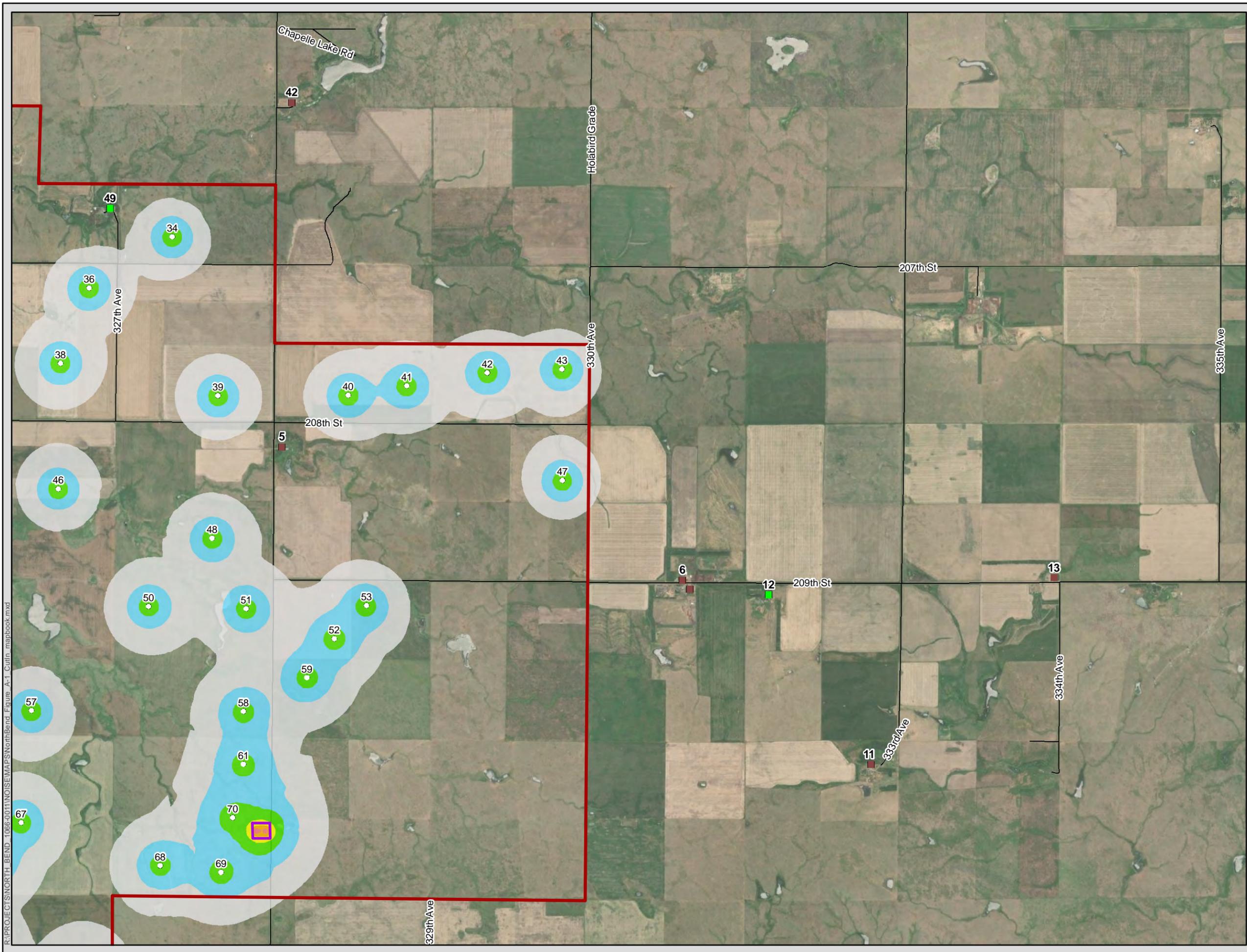
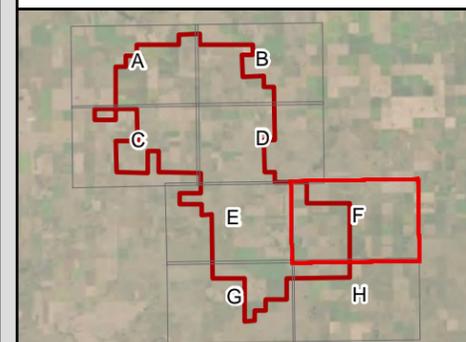
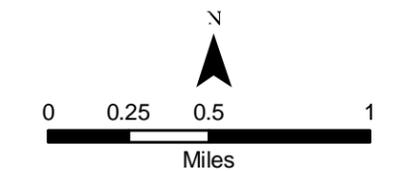
Figure A-1F Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin_mapbook.mxd



North Bend Wind Project

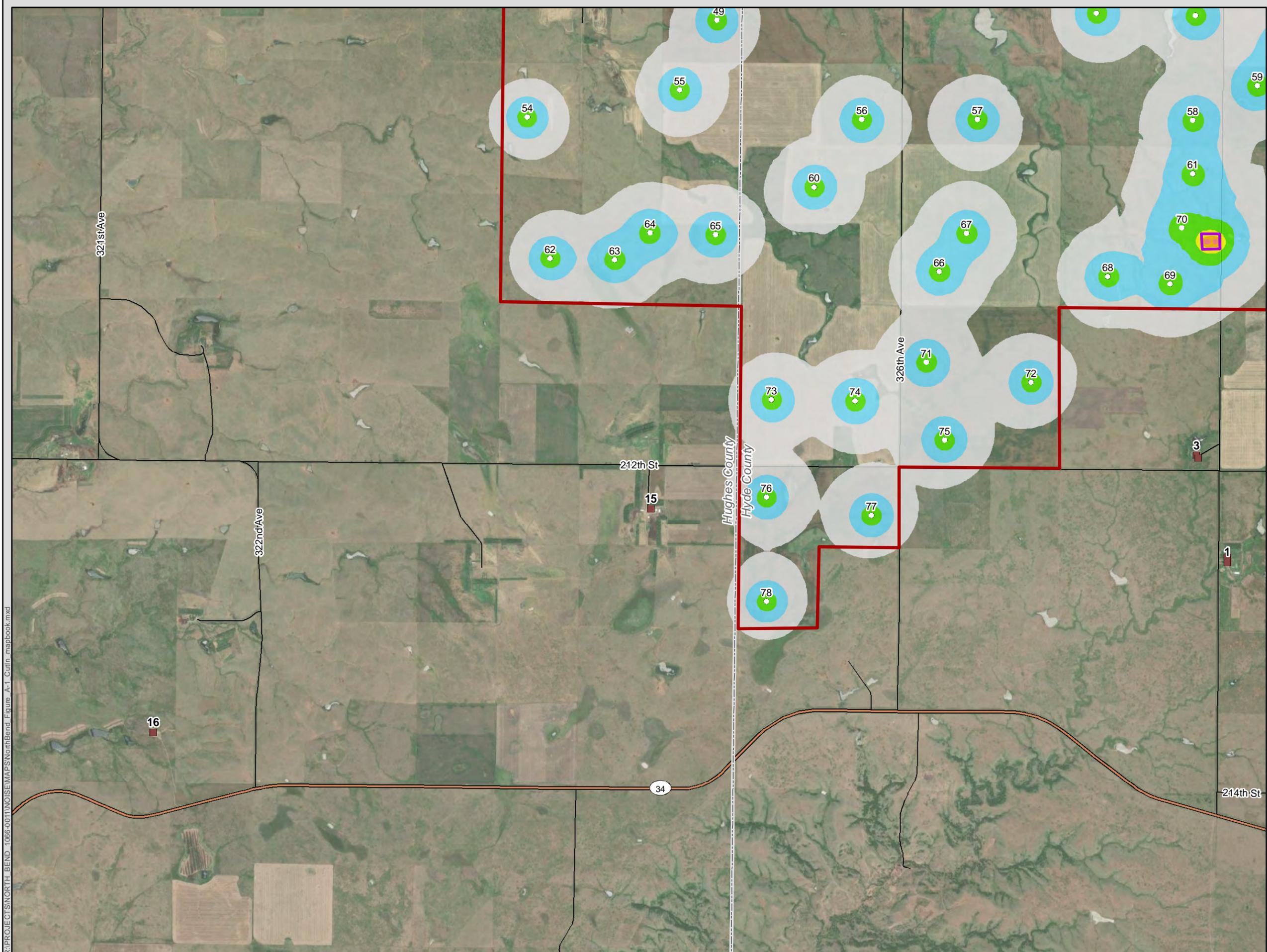
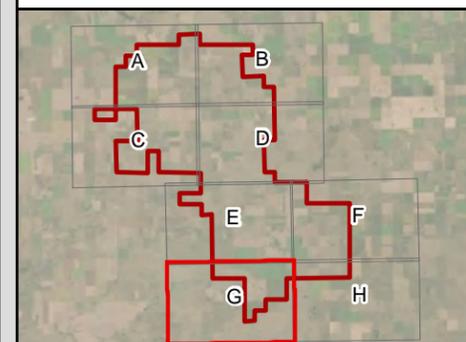
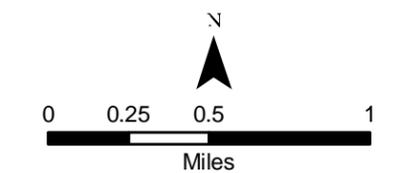
Figure A-1G Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin_mapbook.mxd





North Bend Wind Project

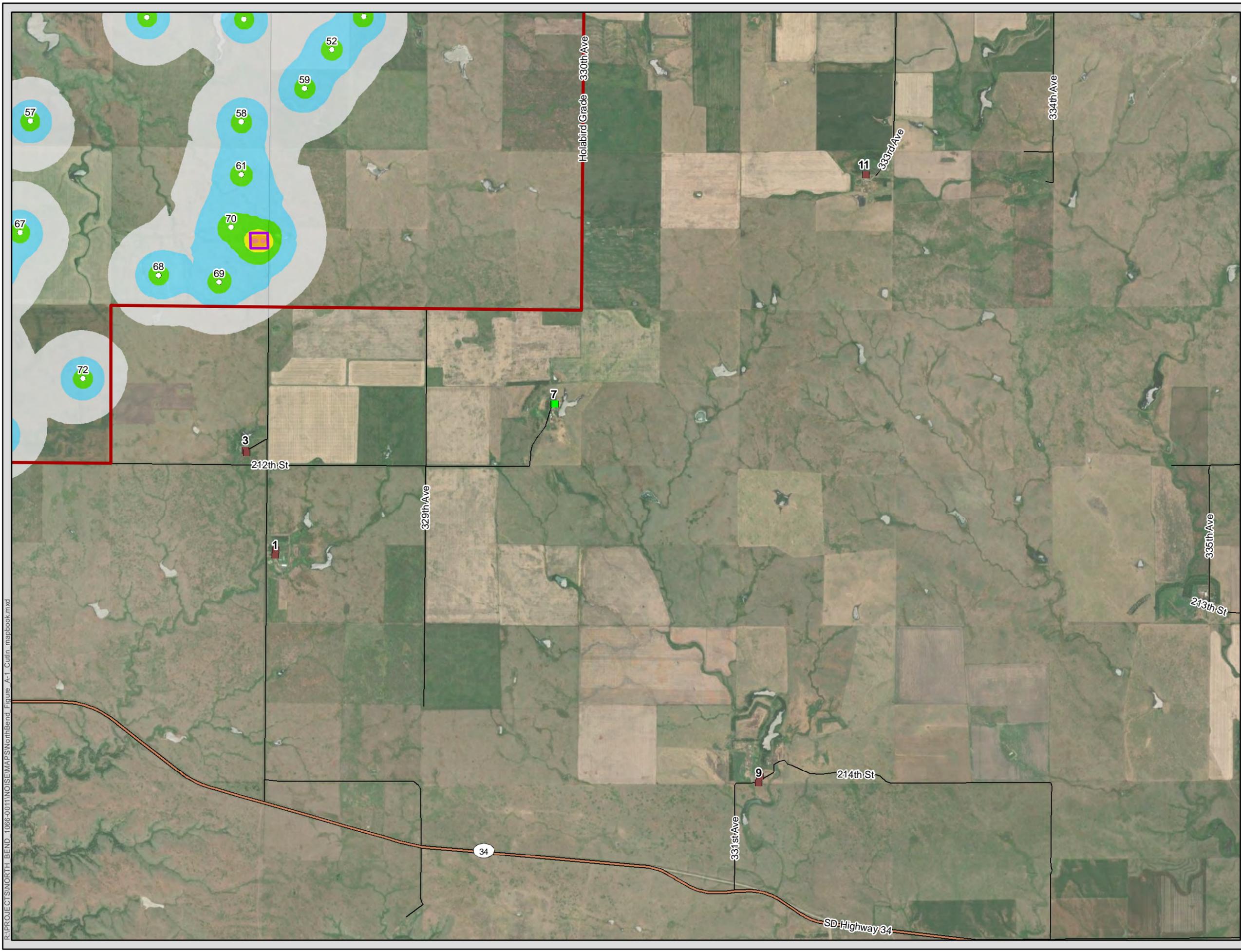
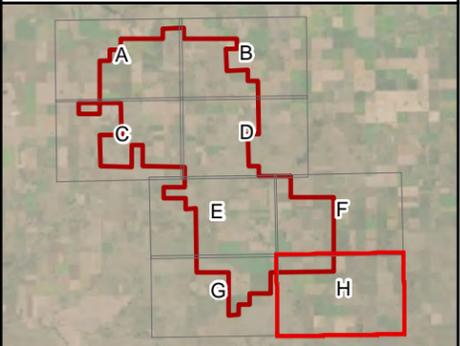
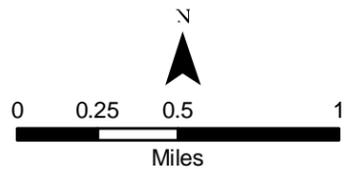
Figure A-1H Received Sound Levels - Cut-in Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-1_Cutin_mapbook.mxd

Figure A-2. GE 2.82-127: Received Sound Levels – Maximum Wind Turbine Rotational Speed



North Bend Wind Project

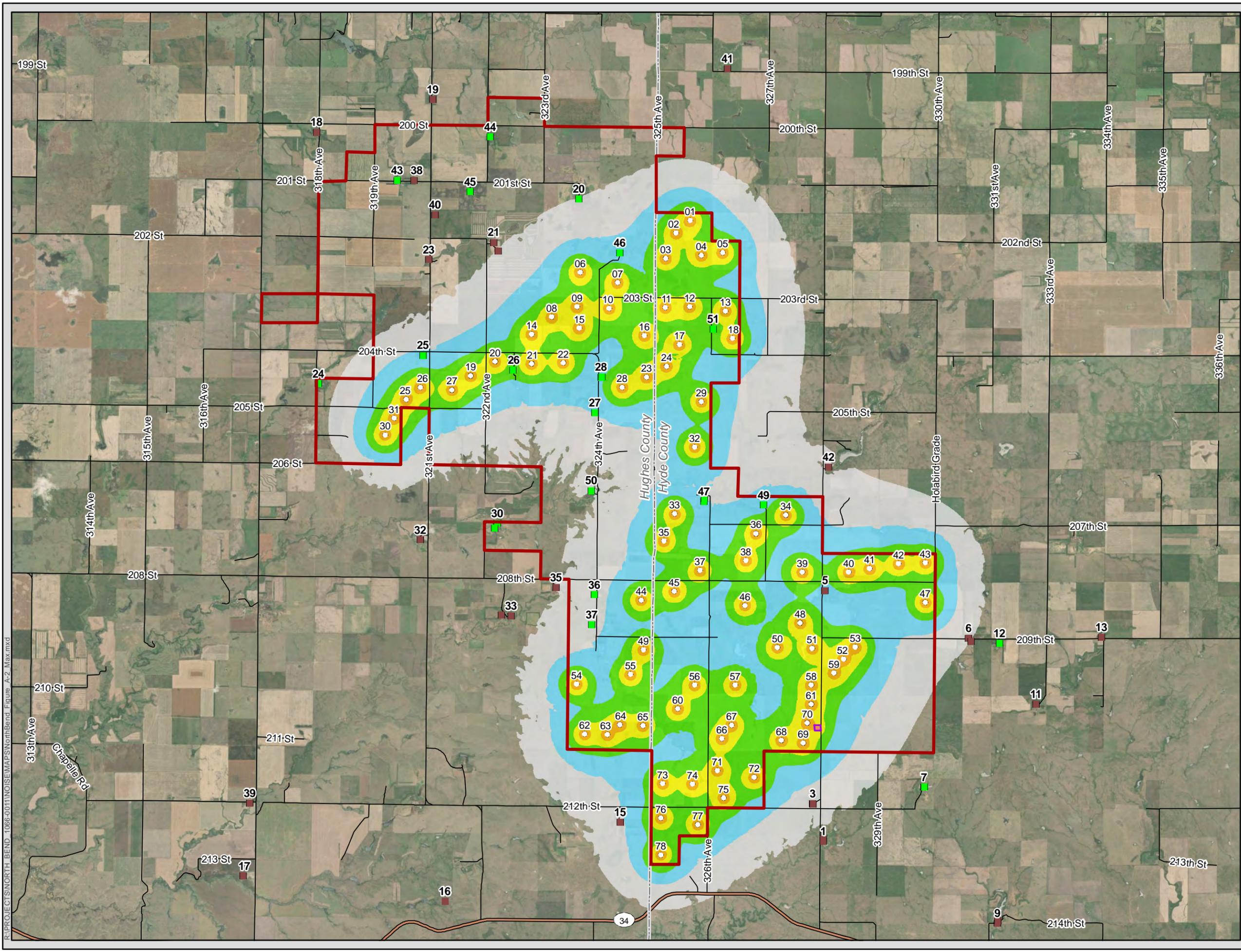
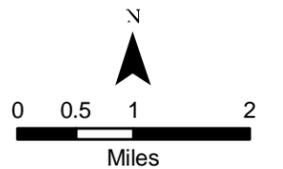
Figure A-2
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max.mxd



North Bend Wind Project

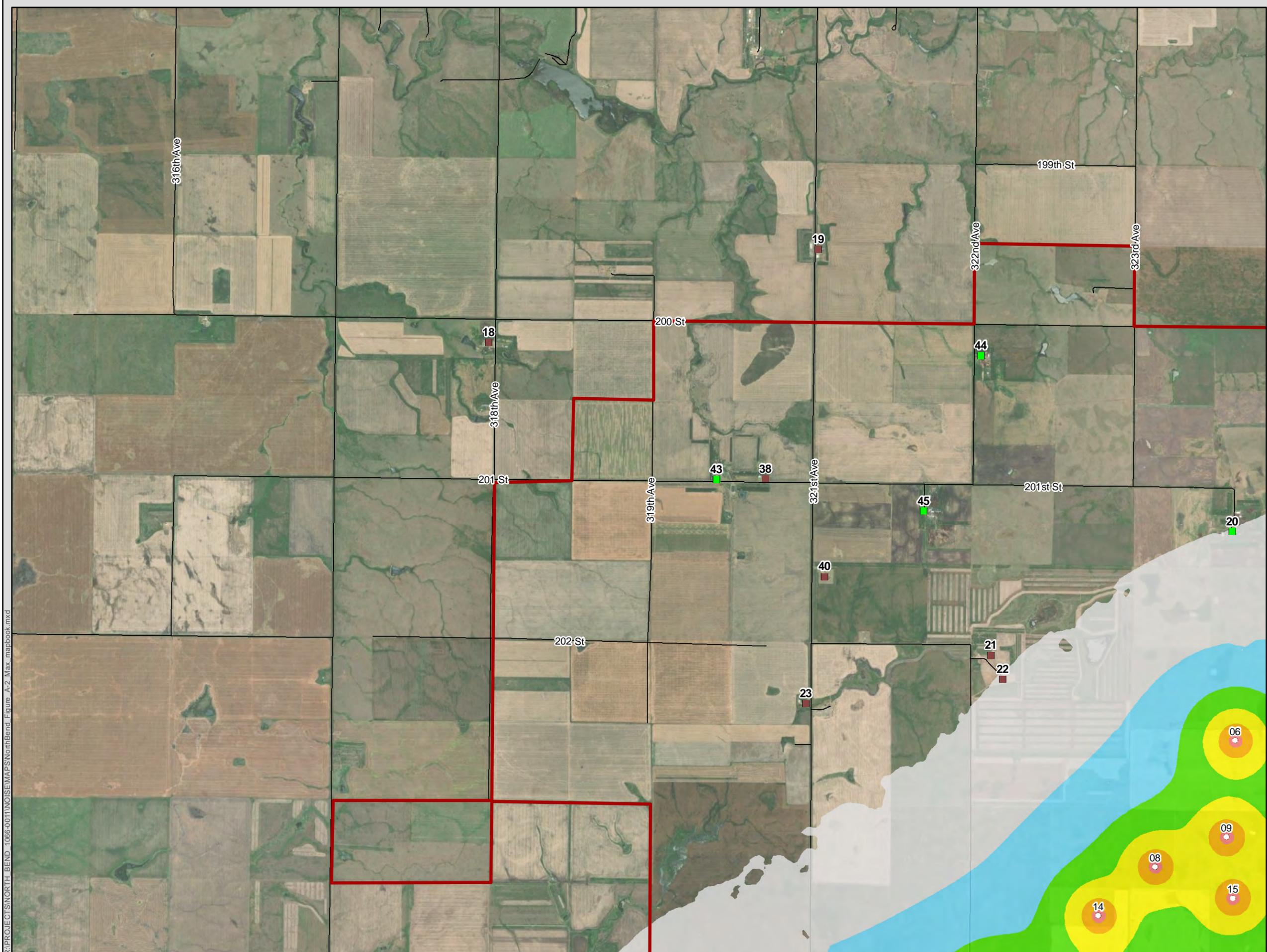
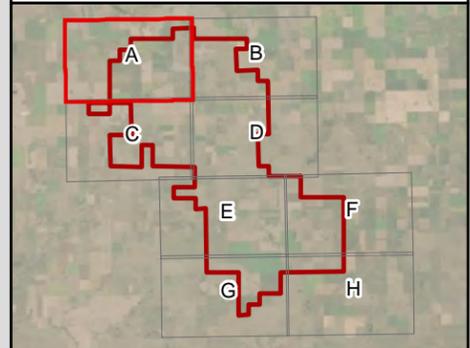
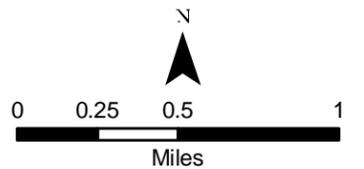
Figure A-2A
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_mapbook.mxd



North Bend Wind Project

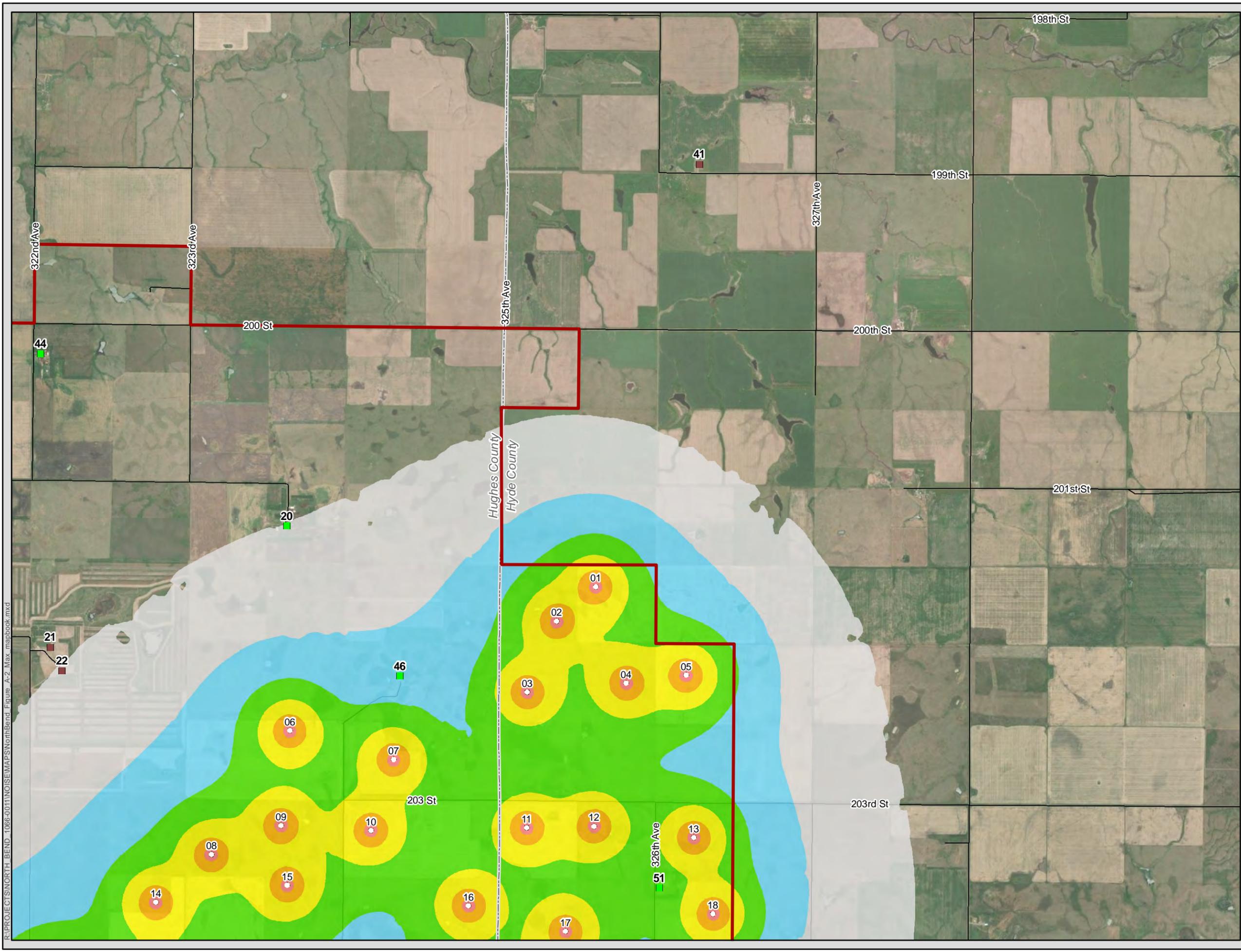
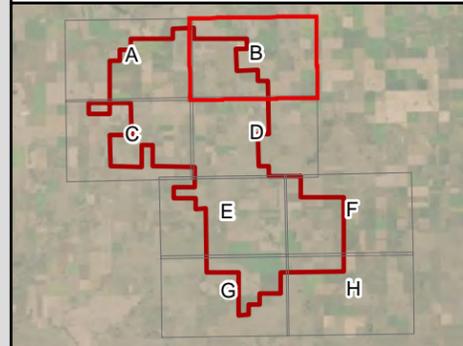
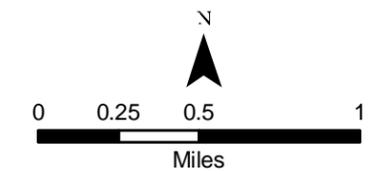
Figure A-2B
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_mapbook.mxd



North Bend Wind Project

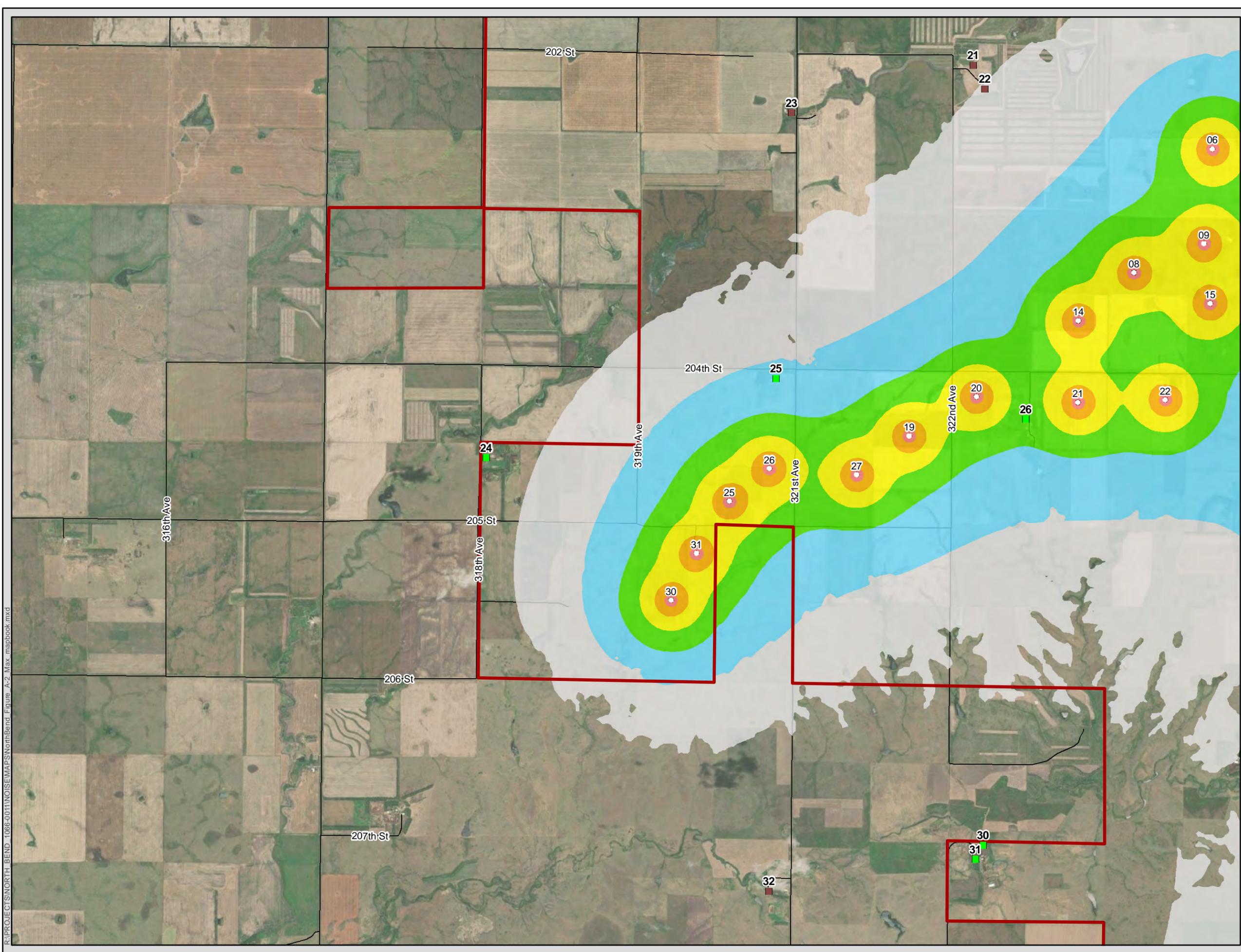
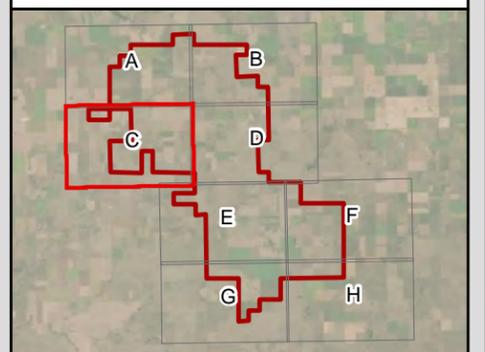
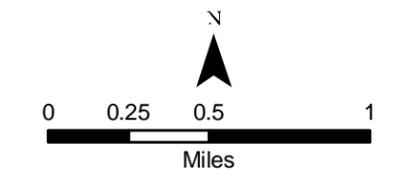
Figure A-2C
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_mapbook.mxd



North Bend Wind Project

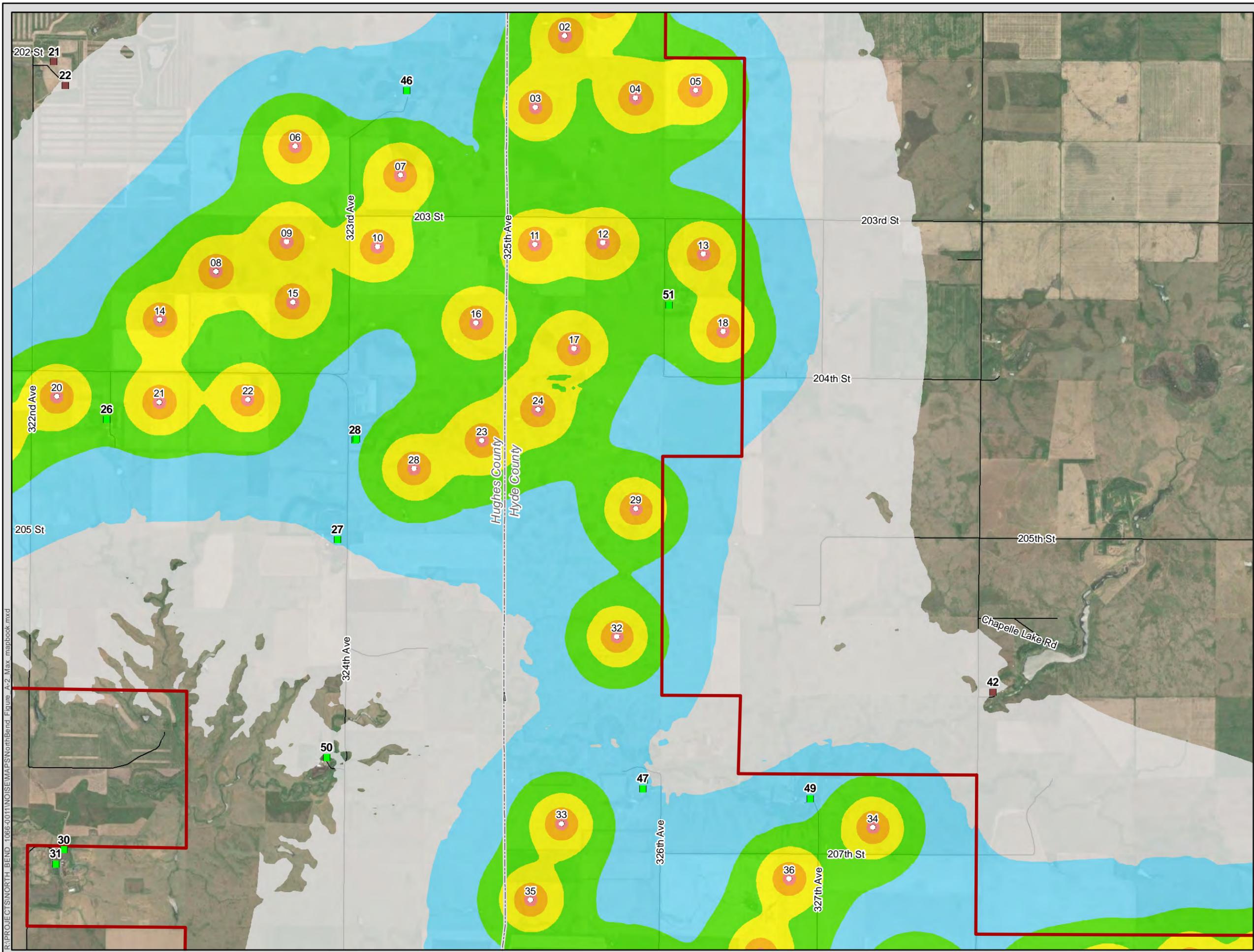
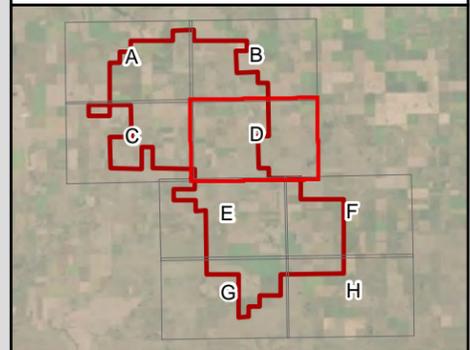
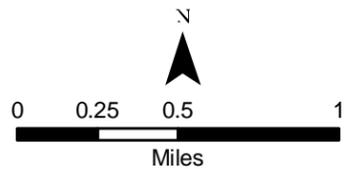
Figure A-2D
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

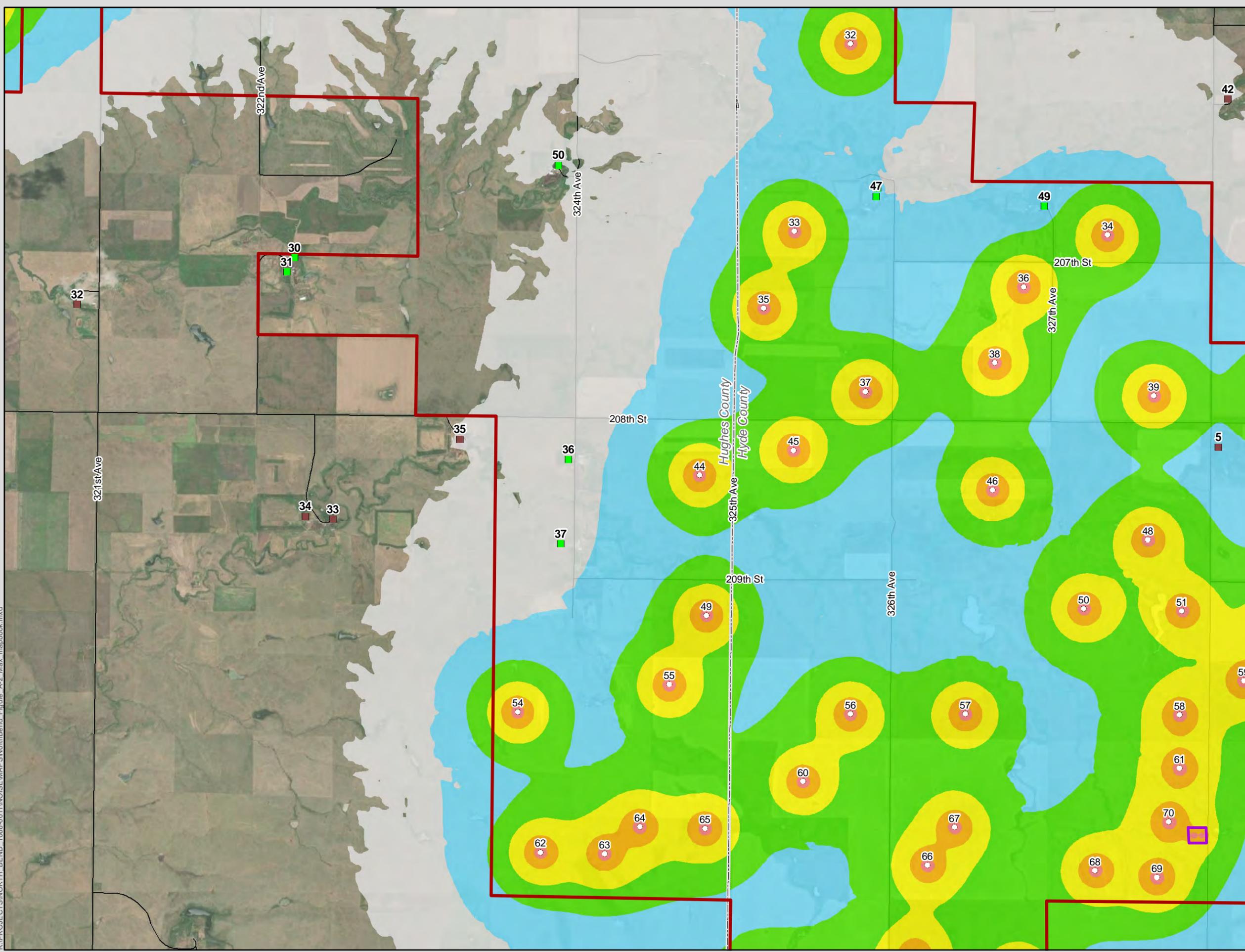
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_mapbook.mxd

North Bend Wind Project

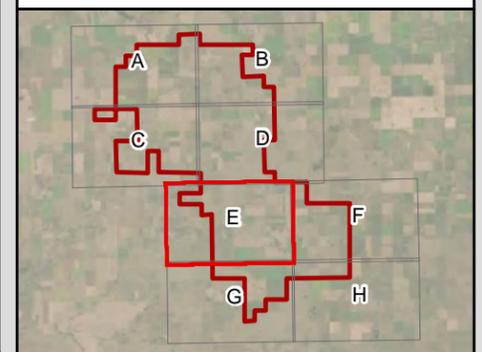
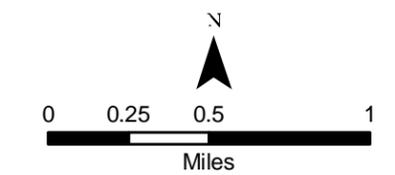
Figure A-2E
 Received Sound Levels - Maximum
 Wind Turbine Rotational Speed
 Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
- Participating
- Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_mapbook.mxd



North Bend Wind Project

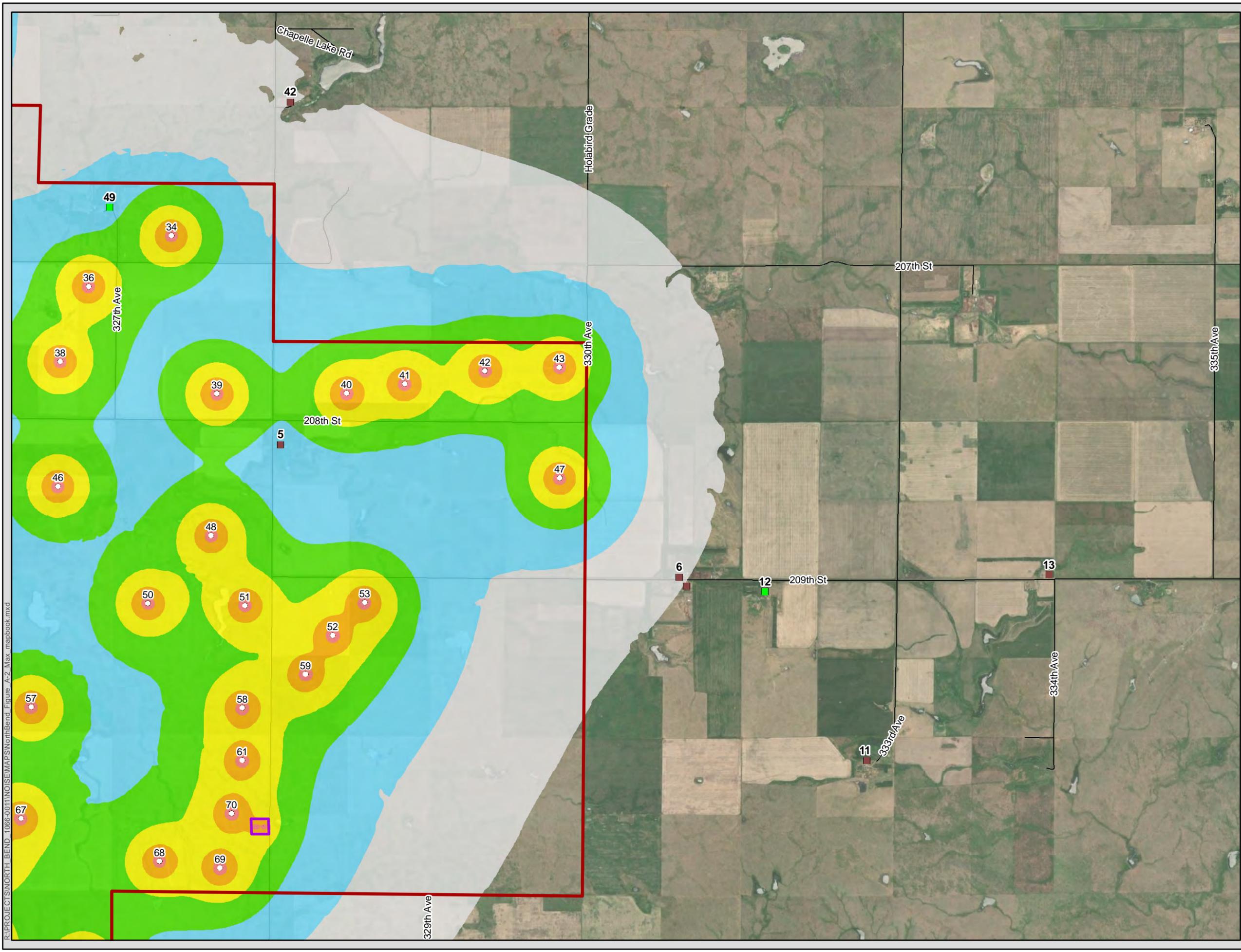
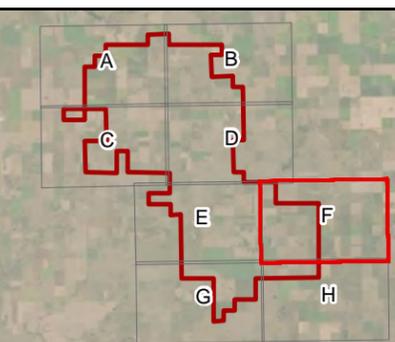
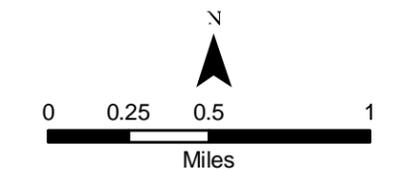
Figure A-2F
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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

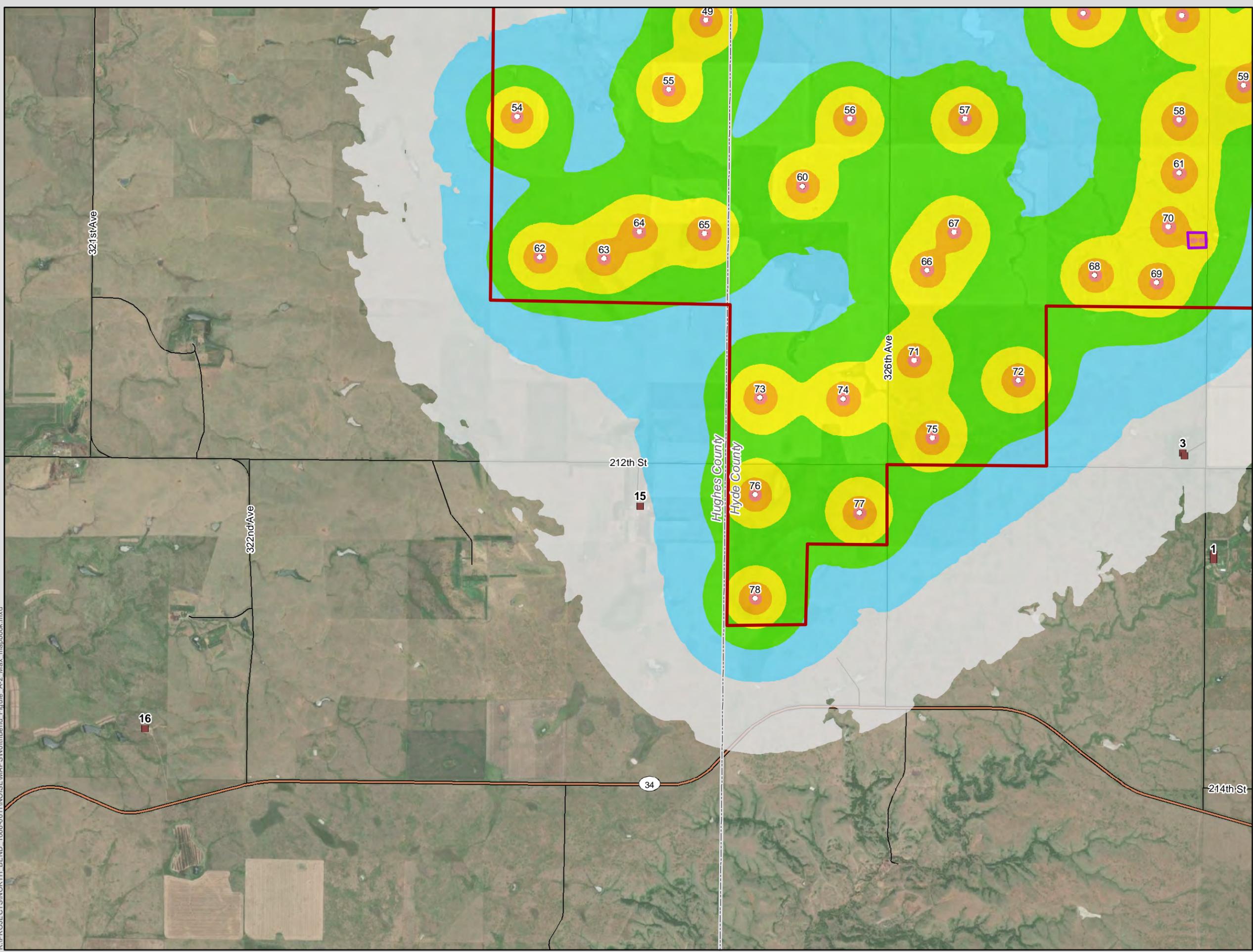


R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_mapbook.mxd

North Bend Wind Project

Figure A-2G
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

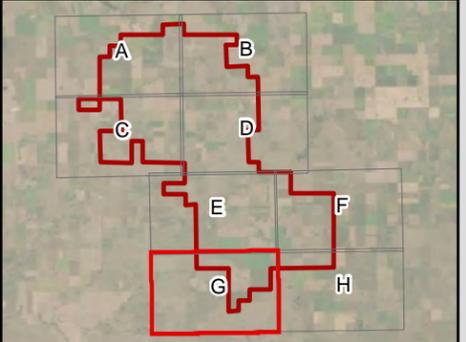
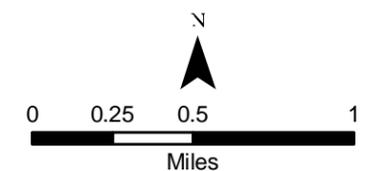
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_noisebook.mxd



North Bend Wind Project

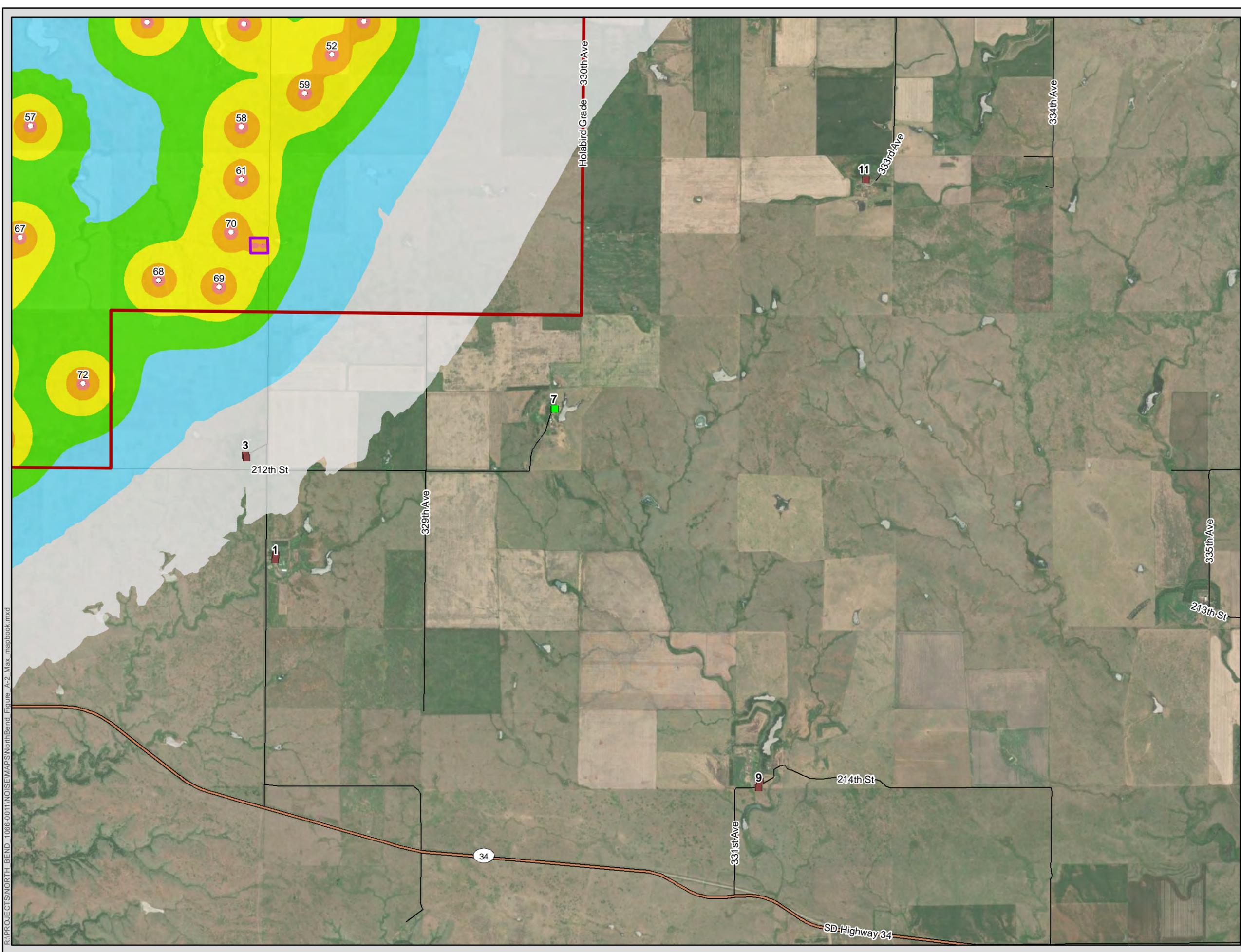
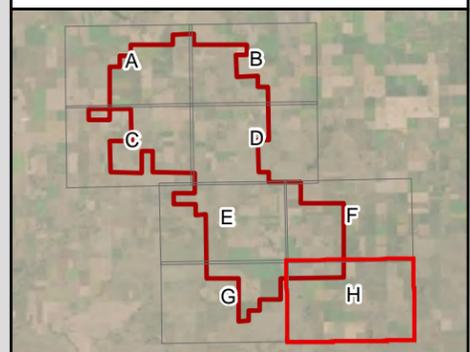
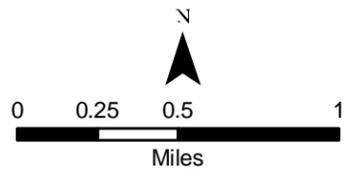
Figure A-2H
Received Sound Levels - Maximum
Wind Turbine Rotational Speed

Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



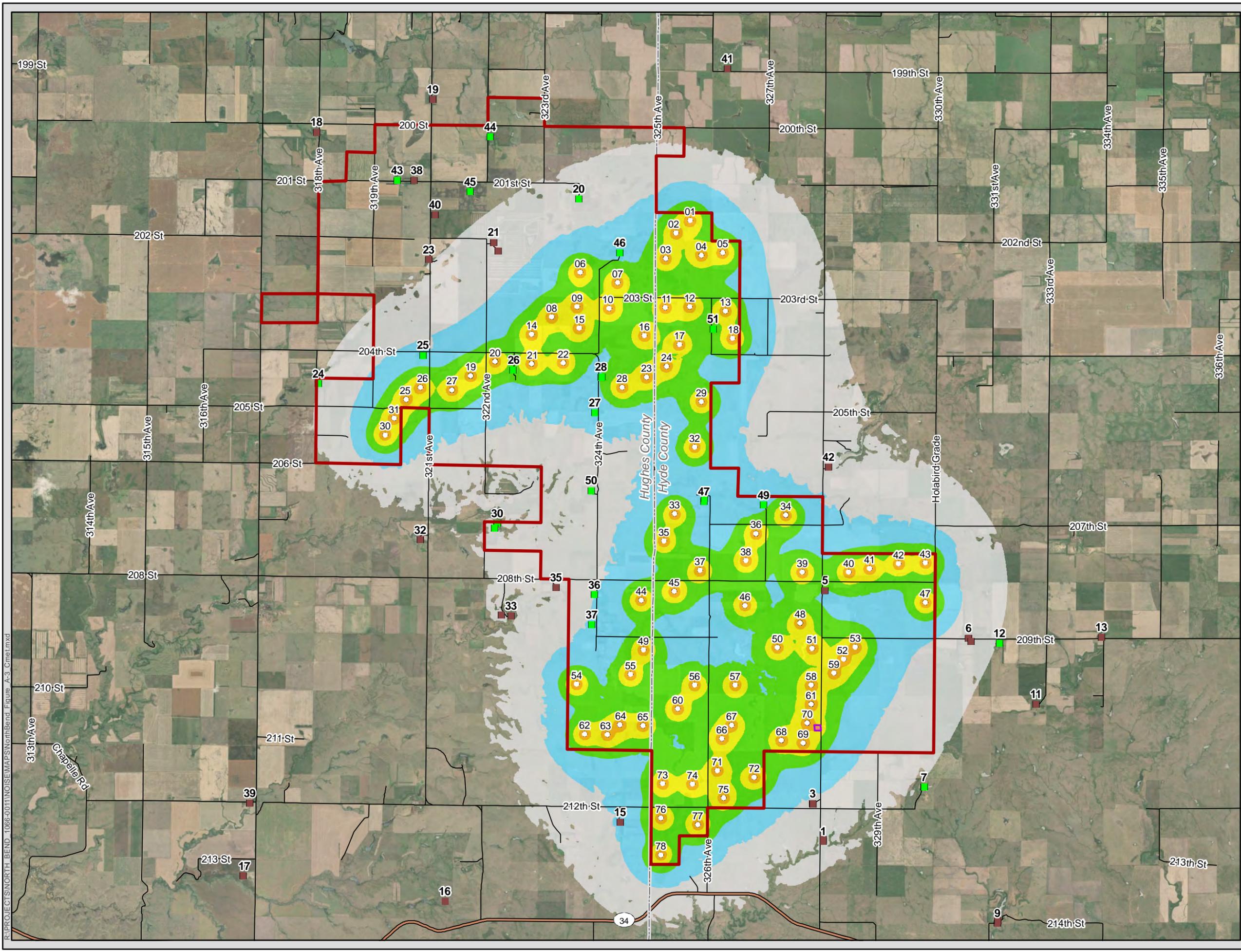
R:\PROJECTS\NORTH BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-2_Max_mapbook.mxd

Figure A-3. GE 2.82-127: Received Sound Levels – Maximum Wind Turbine Rotational Speed during Anomalous Meteorological Conditions



North Bend Wind Project

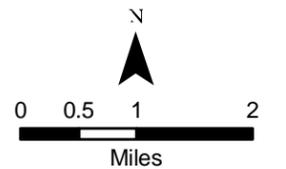
Figure A-3
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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

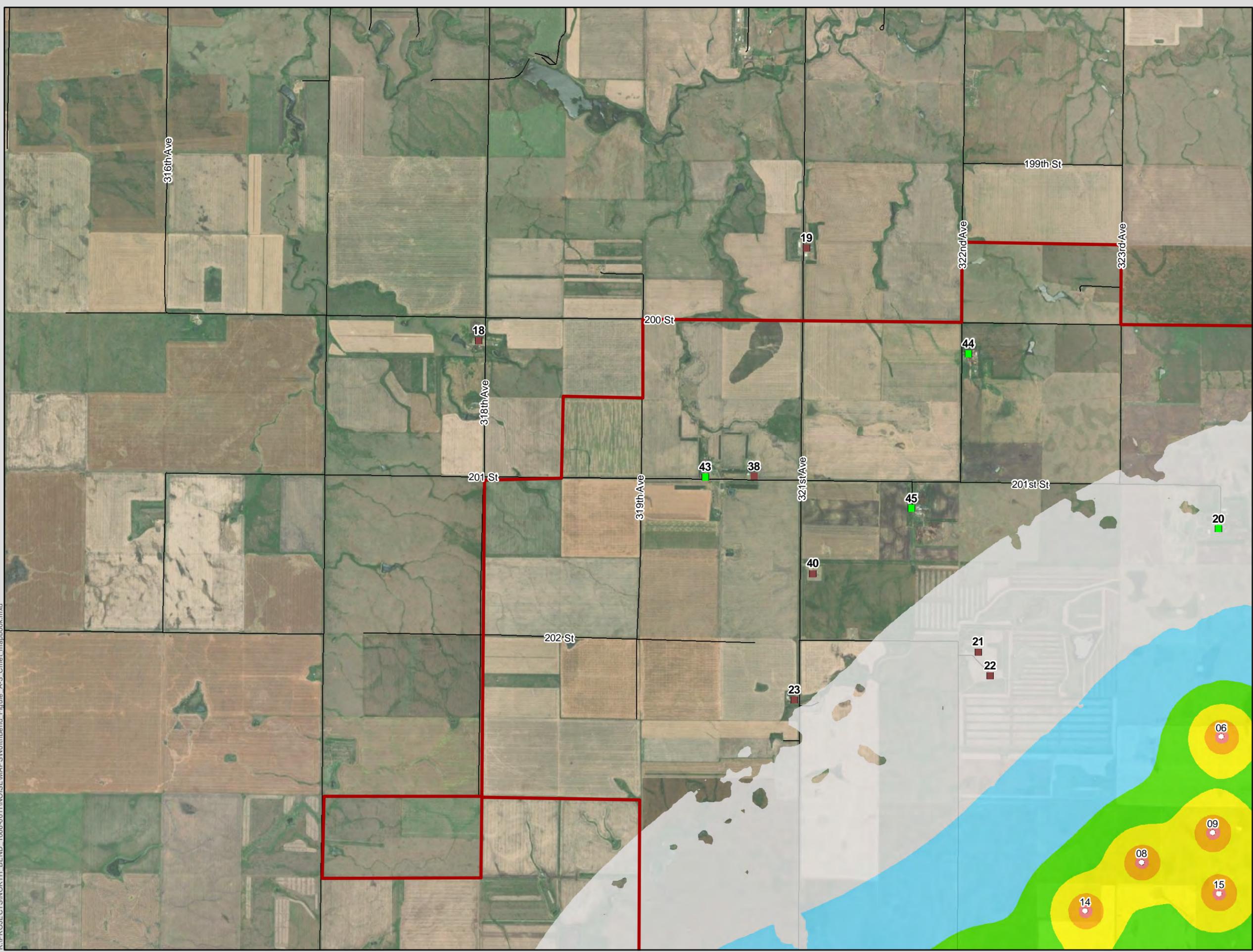


R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet.mxd



North Bend Wind Project

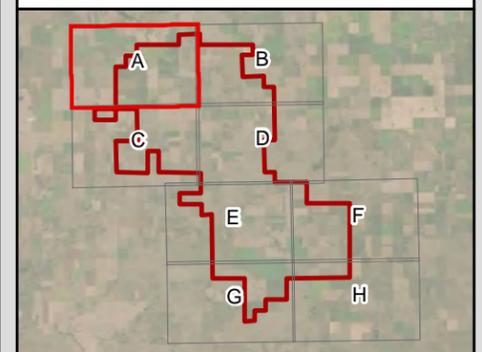
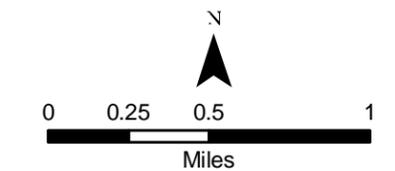
Figure A-3A
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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

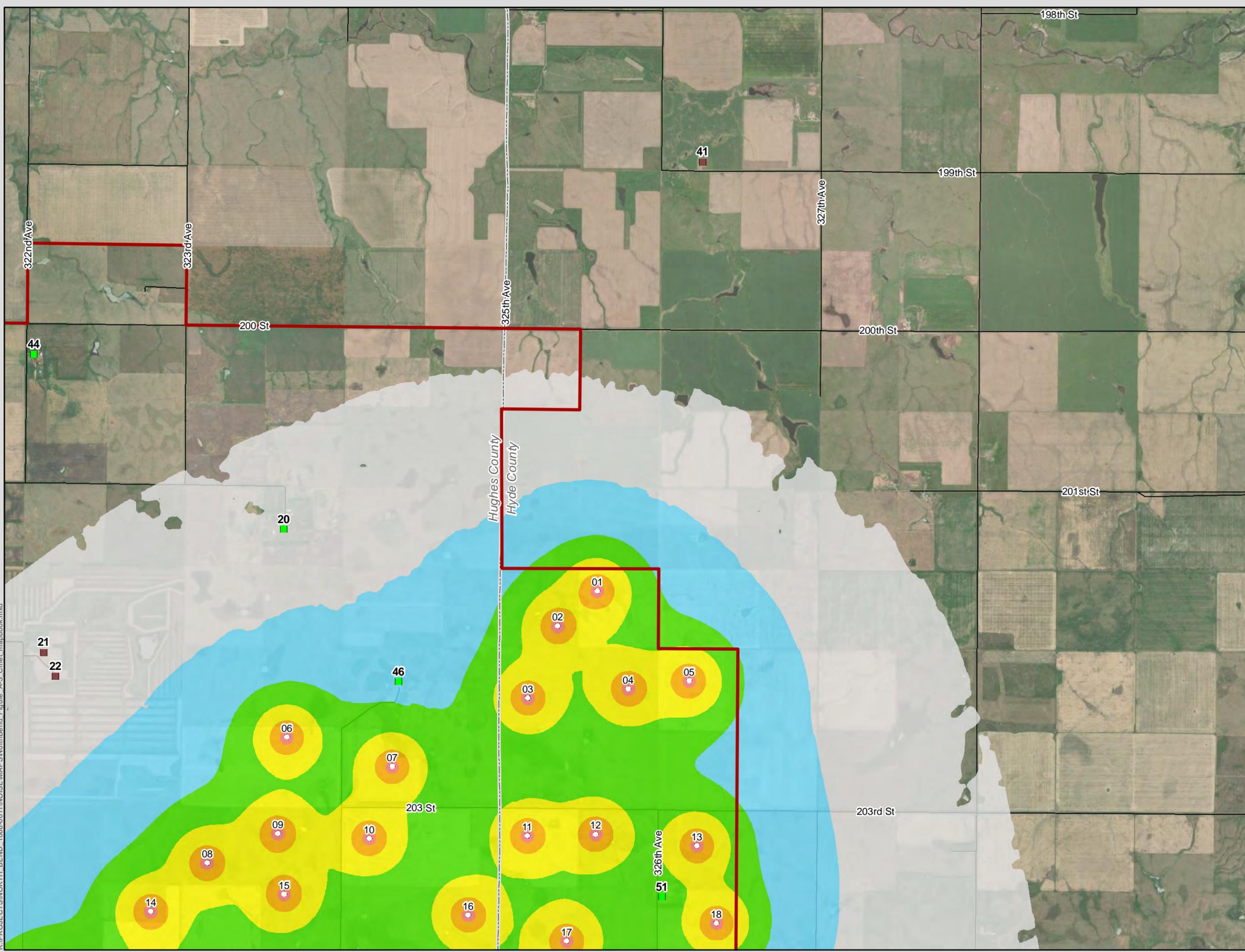


R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd



North Bend Wind Project

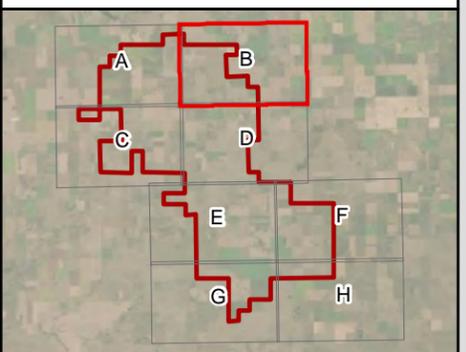
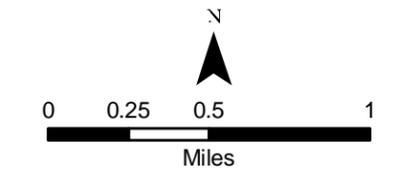
Figure A-3B
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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

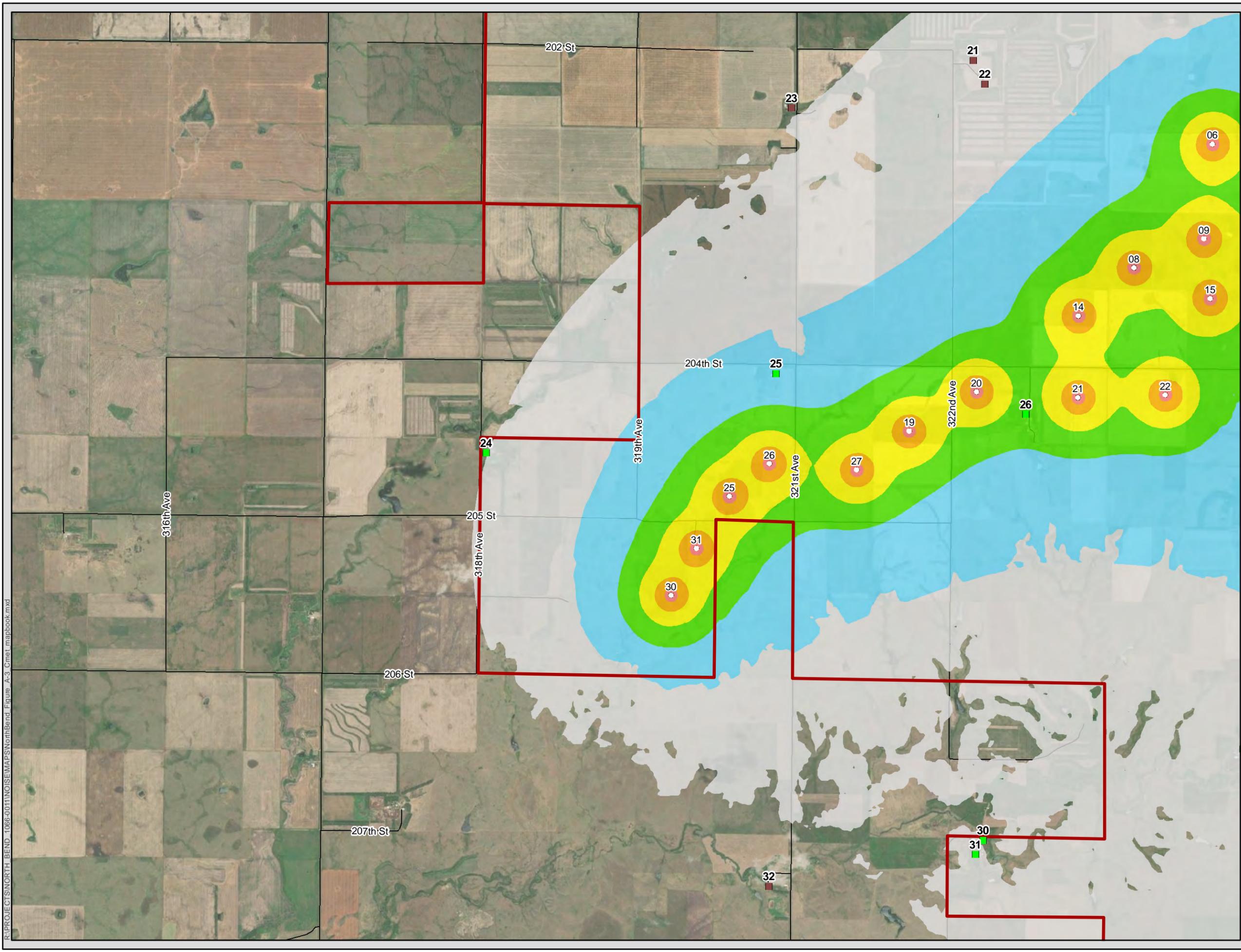


R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd



North Bend Wind Project

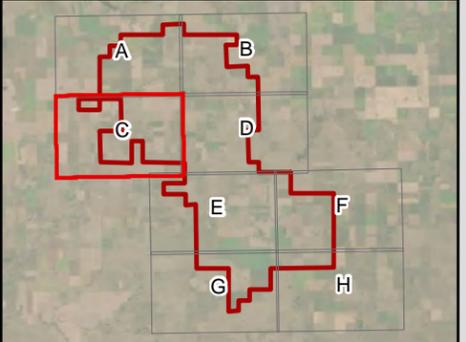
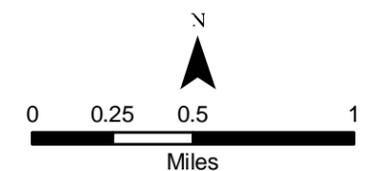
Figure A-3C
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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

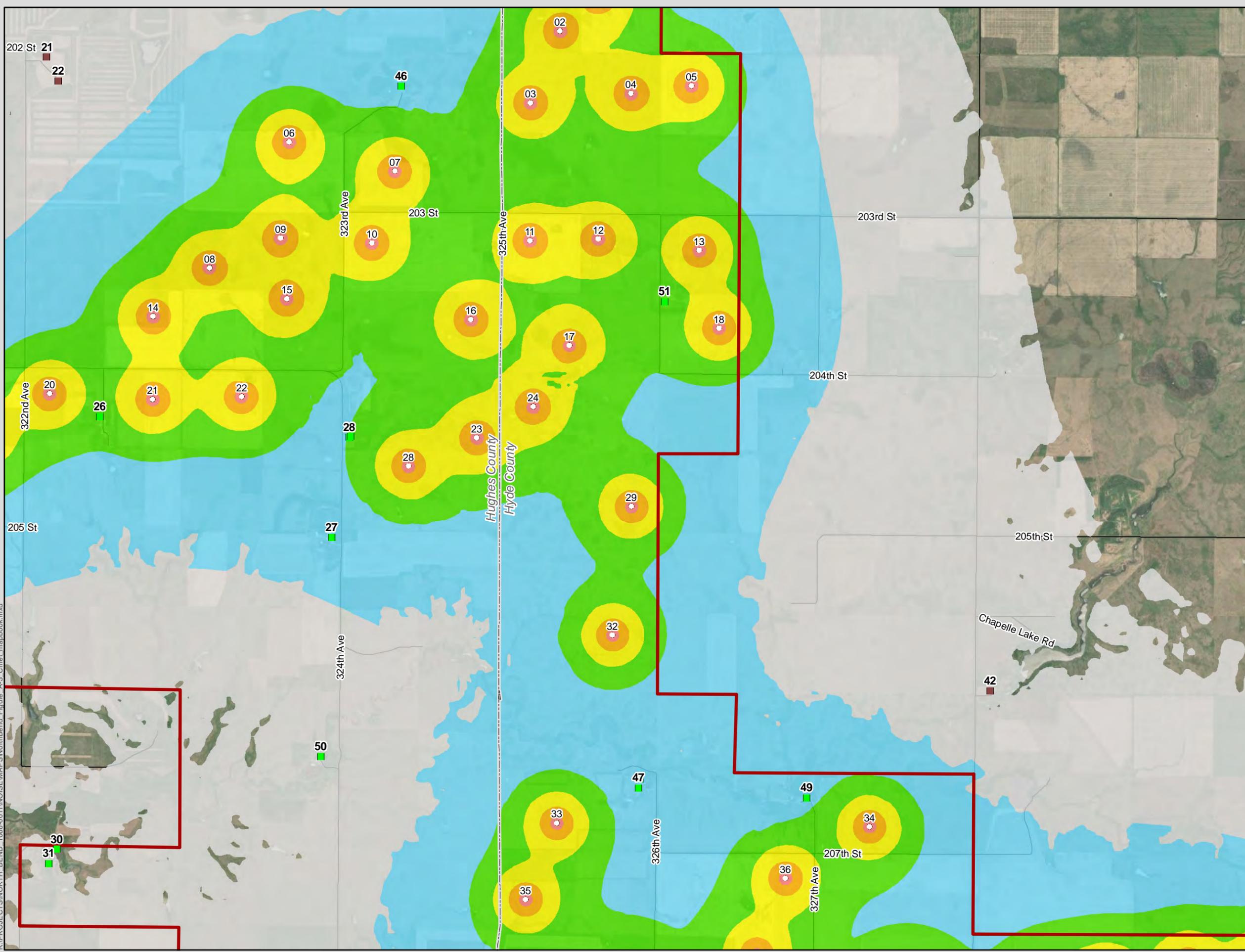


R:\PROJECTS\NORTH BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd



North Bend Wind Project

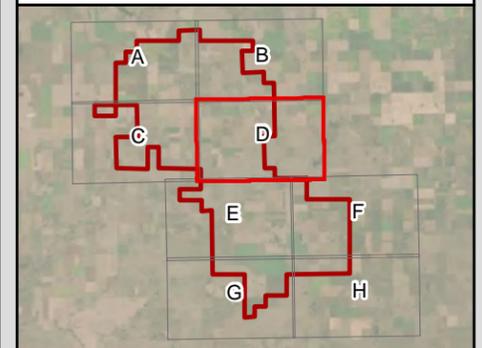
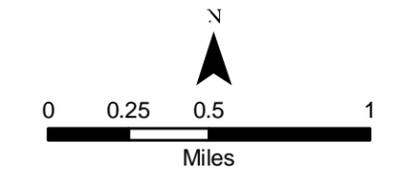
Figure A-3D
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



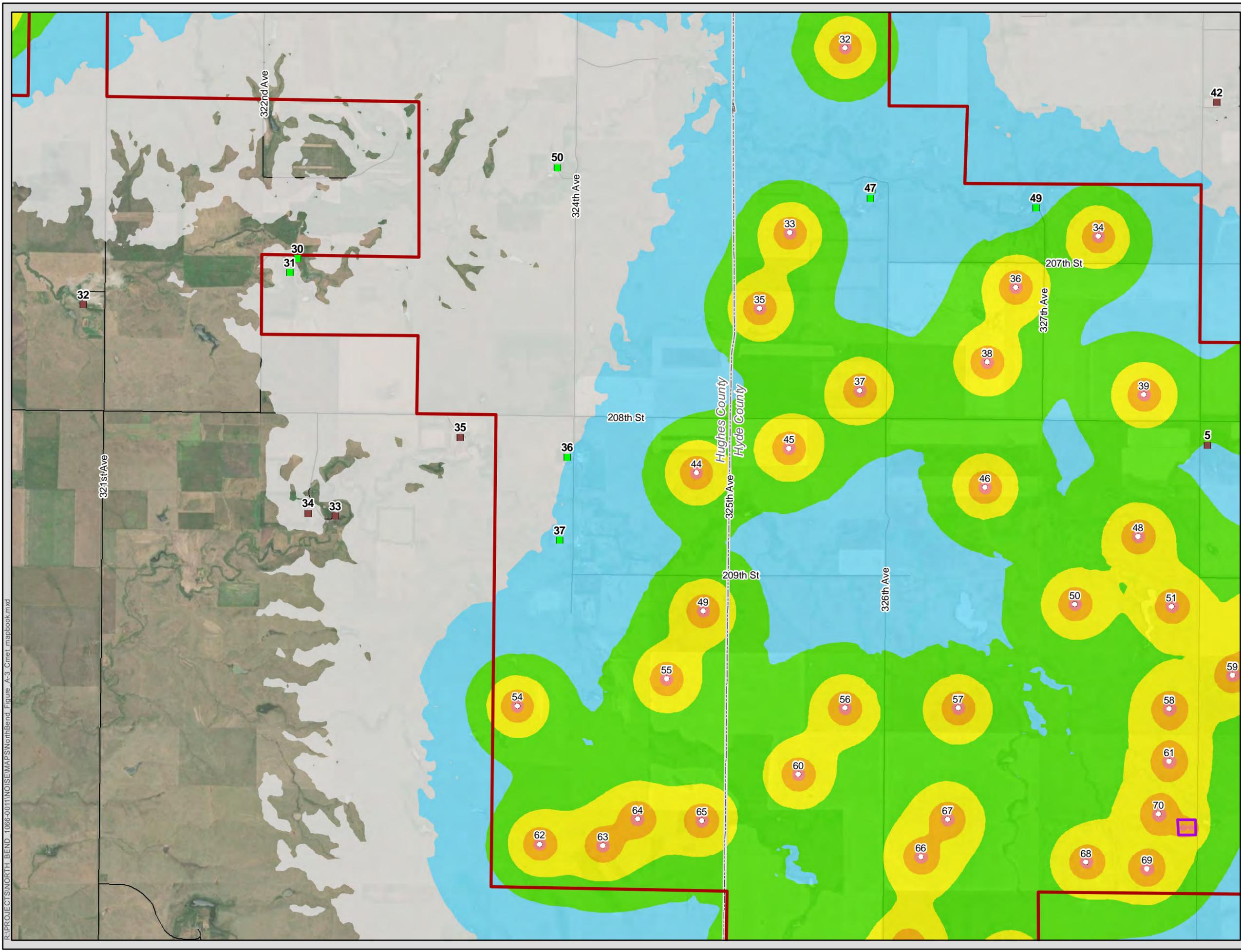
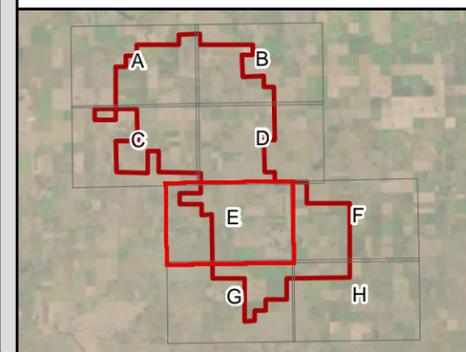
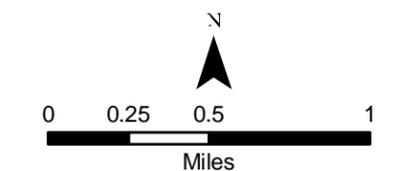
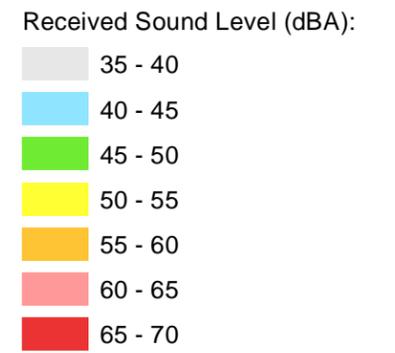
R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd



North Bend Wind Project

Figure A-3E
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD

- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

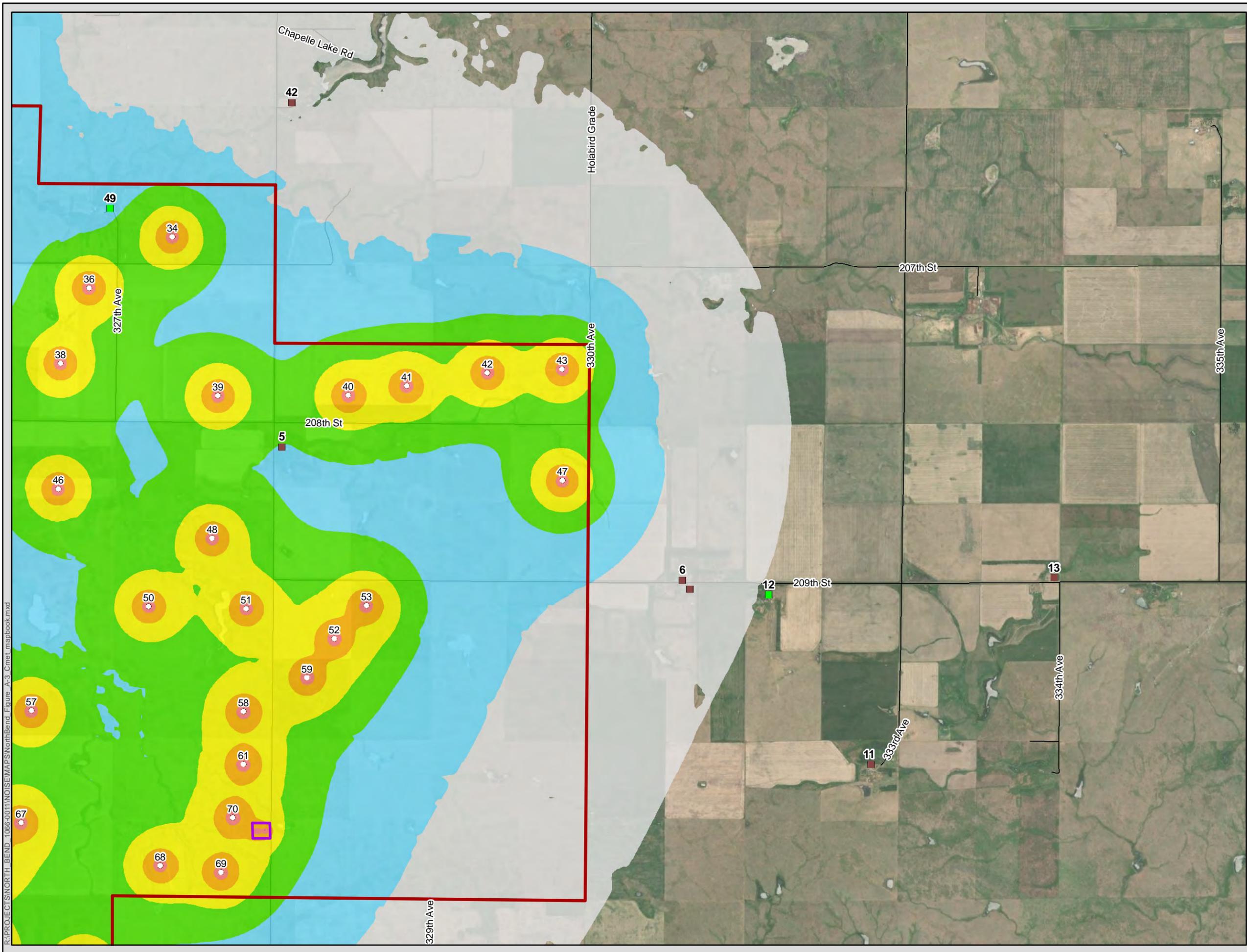


R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd



North Bend Wind Project

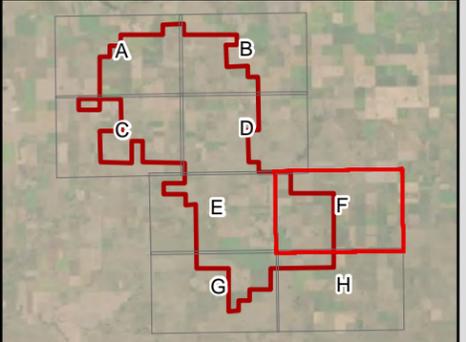
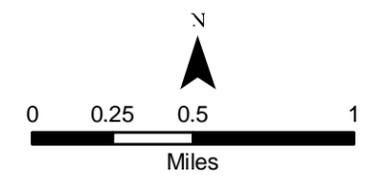
Figure A-3F
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



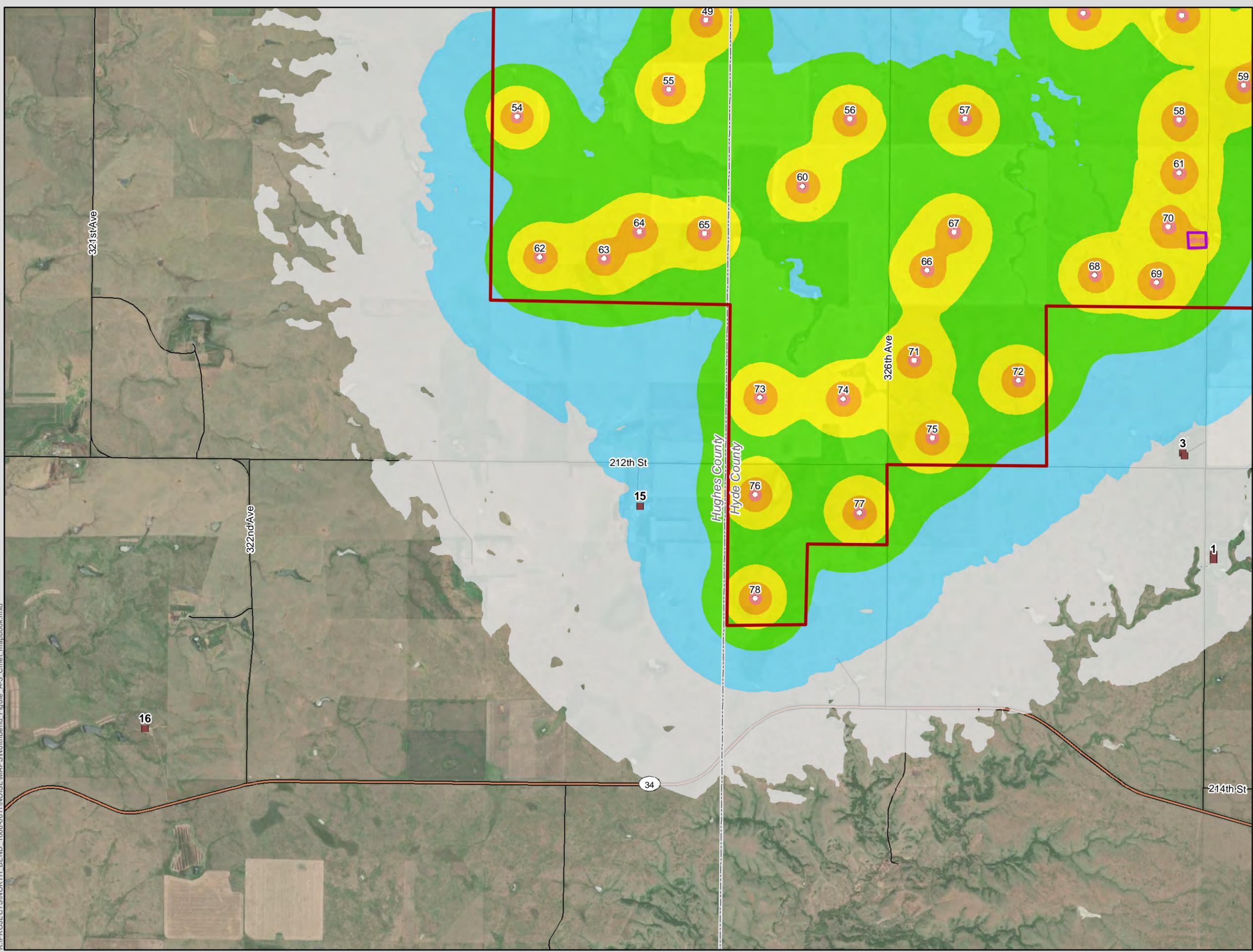
R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd





North Bend Wind Project

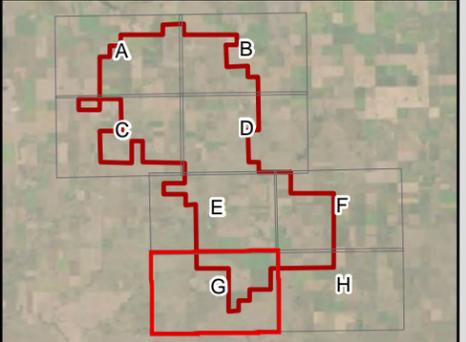
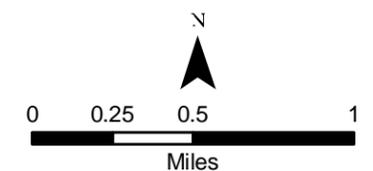
Figure A-3G
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor**
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



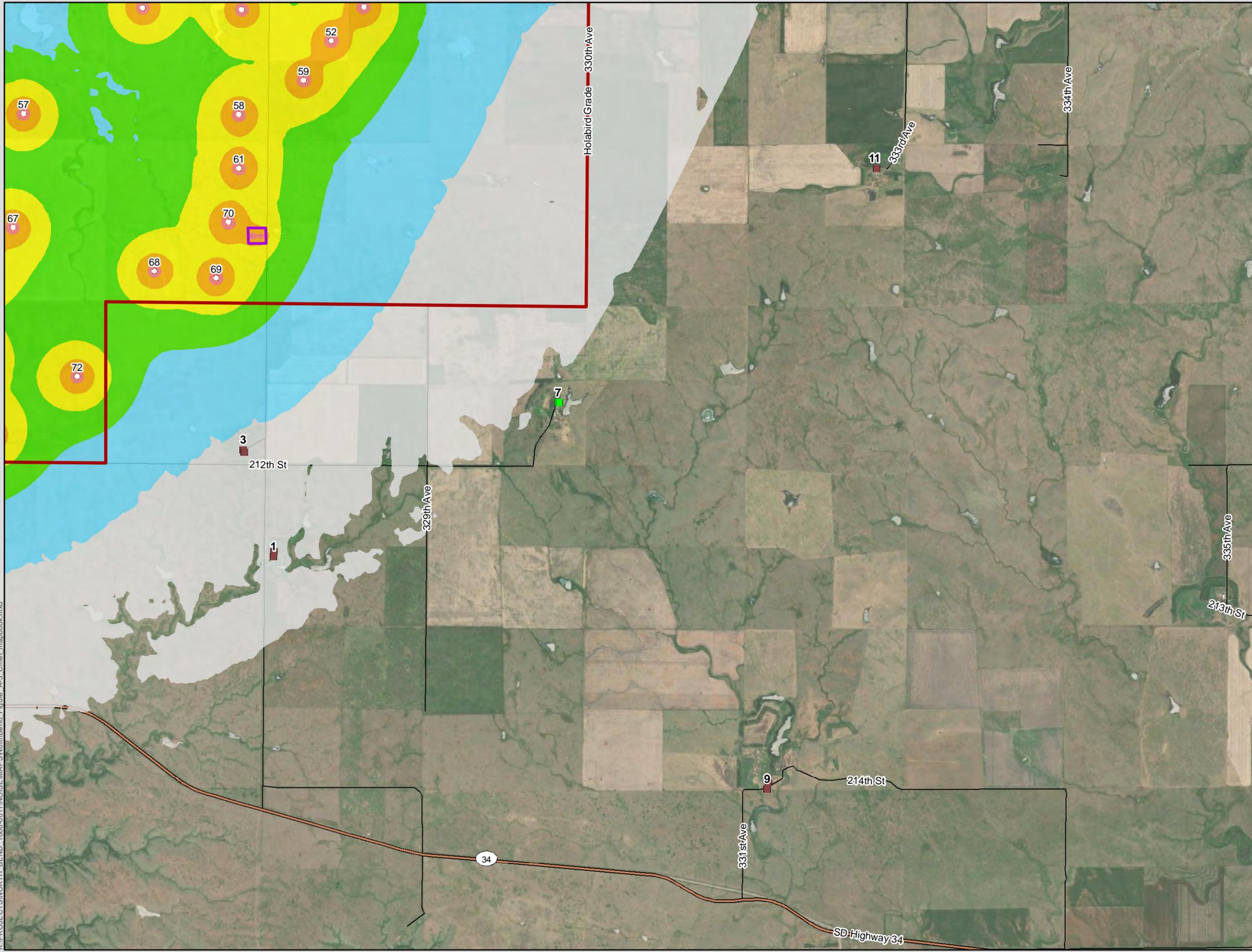
R:\PROJECTS\NORTH_BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd





North Bend Wind Project

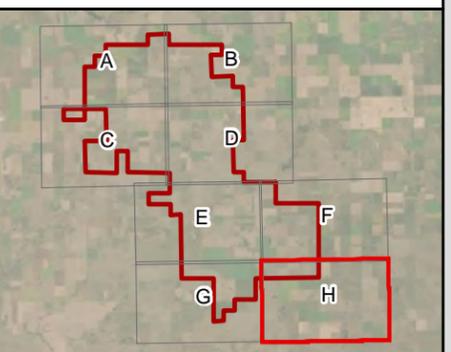
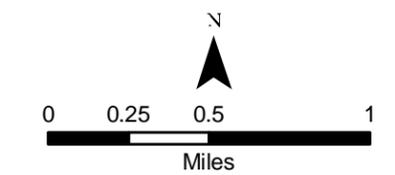
Figure A-3H
Received Sound Levels - Maximum
Wind Turbine Rotational Speed during
Anomalous Meteorological Conditions
Hughes and Hyde Counties, SD



- Project Area
- Proposed Turbine
- Proposed Substation
- Sensitive Receptor
 - Participating
 - Non-Participating
- County Boundary
- Highway/Major Road
- Local Road

Received Sound Level (dBA):

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



R:\PROJECTS\NORTH BEND_1066-001\NOISEMAPS\NorthBend_Figure_A-3_Cmet_mapbook.mxd