Exhibit B

# Acoustic Assessment for the New Frontier Wind Energy Project McHenry County, North Dakota

*Prepared for*

Capital Power

*Prepared by*

TETRA TECH

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# Acronyms and Abbreviations

| | |
|---|---|
| CadnaA | Computer-Aided Noise Abatement Program |
| Capital Power | Capital Power Corporation |
| dB | decibel |
| dBA | A-weighted decibel |
| dBL | unweighted decibel |
| ft. | feet |
| Hz | Hertz |
| IEC | International Electrotechnical Commission |
| ISO | International Organization for Standardization |
| kHz | kilohertz |
| Leq | equivalent sound level |
| Lmax | maximum sound level |
| Lp | sound pressure level |
| Lw | sound power level |
| m | meters |
| Meadowlark | Meadowlark Wind I LLC |
| m/s | meters per second |
| mph | miles per hour |
| MVA | megavolt ampere |
| MW | megawatt |
| NEMA | National Electrical Manufacturers Association |
| NSR | Noise Sensitive Receptor |
| Project | New Frontier Wind Energy Project |
| PSC | North Dakota Public Service Commission |
| PSC Order | Order on Continuing Suitability PU-11-69 |
| pW | picowatt |
| Tetra Tech | Tetra Tech, Inc. |
| µPa | microPascal |
| UTM | Universal Transverse Mercator |

# Executive Summary

Tetra Tech, Inc. (Tetra Tech) has completed an acoustic assessment for the proposed New Frontier Wind Energy Project (Project) under development in McHenry County, North Dakota. A screening-level analysis was completed to evaluate the expected sound levels resulting from the Project wind turbines and substation. Operational turbines were evaluated at the 29 potential locations from the April 11, 2018 Project layout. Acoustic analyses for three different modeling scenarios were performed. Scenarios included wind turbine operation at cut-in wind speed, as well as maximum rotational wind speed under both moderate downwind and anomalous meteorological conditions. The overall objective of this study was to determine the feasibility of the Project to operate in compliance with the North Dakota Public Service Commission (PSC) 50 dBA noise limit applicable within 100 feet of an occupied residence or community building, and to demonstrate continued compliance with the Order of Continuing Suitability PU-11-69 (PSC Order) issued by the PSC May 10, 2017 for the Project.

Wind turbine sound source data was obtained from Vestas for the Vestas V126-3.45 (Vestas 2016). Substation noise impacts were based on a projected 111 megavolt ampere (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 159.4707), a comprehensive 3-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 due to 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.

The results of the acoustic assessment show that the Project will comply with the PSC 50 A-weighted decibel limit at all receptors, except for four participating landowner residences, which may experience sound levels above the applicable noise limit under certain operational and meteorological conditions. Meadowlark Wind I LLC (Meadowlark) has obtained written waivers of the sound level avoidance area criteria from those landowners. 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 North Dakota employing the same or similar criteria. However, while the Project has demonstrated compliance with the requirements, the Project may result in periodically audible sound within adjacent areas under certain operational and meteorological conditions.

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# 1.0 OVERVIEW

On April 26, 2012, the North Dakota Public Service Commission (PSC) issued Certificate of Site Compatibility Number 29 to Meadowlark Wind I LLC (Meadowlark or Applicant) for the New Frontier Wind Energy Project (Project) in McHenry County, North Dakota (Figure 1). In December 2014, Capital Power Investments LLC, a subsidiary of Capital Power Corporation (Capital Power), completed the acquisition of Element Power US, LLC, which included Meadowlark and the Project. In February 2016, Capital Power contracted Tetra Tech to conduct the following acoustic assessment for the Project to support the Certification of Continuing Suitability Application for the Project. On May 10, 2017, the PSC issued Order on Continuing Suitability PU-11-69 (PSC Order) to Meadowlark for the Project. The acoustic analysis was updated in May 2018 to assess the Project's final selected turbine model and array layout per the PSC Order Paragraph No. 7: In the event Project modifications occur that are not covered by its current sound analysis, Meadowlark shall conduct a sound analysis and file a report with the Commission to ensure that the Project complies with the Commission's Avoidance Area Sound Requirement.

Capital Power proposes to construct and operate the Project in McHenry County, North Dakota. The Project is expected to have an up to nominal 100.1 Megawatt (MW) power output capacity using 29 wind turbine locations, which were previously permitted by the PSC. For the Project site layout, Capital Power has selected the Vestas V126-3.45 wind turbine model. The proposed Project infrastructure also includes underground collection lines and a substation. The substation transformer is rated at 111 megavolt ampere (MVA) and located along State Highway 41 north of State Highway 53.

This acoustic assessment included modeling analyses to predict future sound levels when the wind turbines are operational. Three different modeling scenarios were considered, one with wind turbines operating at cut-in wind speed and two others at maximum rotational wind speed, under moderate downwind and anomalous meteorological conditions. 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 PSC noise limit.

## 1.1 Study Area

The Project Study Area encompasses approximately 10,530 acres (16.5 square miles) within McHenry County. County and township (section line) roads characterize the existing roadway infrastructure in and around the Study Area. The Study Area is accessed via State Highway 41, State Highway 53, and other local two-lane paved and gravel county roads. The land within the Study Area is primarily agricultural with scattered farmstead residences. The turbines will be located on privately-owned land in southwestern McHenry County. This region of North Dakota has topography that can be described as level to rolling plains with isolated sandstone buttes or badlands formations to the west of the Study Area. Gentle slopes characterize most of the Study Area and local relief ranges from less than 1,712 to over 2,196 feet. There are also a number of waterbodies throughout the Study Area. 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. Noise sensitive receptor (NSR) 15 was identified as a military use facility. Figure 1 (Appendix A) presents the proposed wind turbine locations, as well as the noise sensitive receptor locations.

## 1.2 Existing Acoustic Environment

McHenry County would generally be considered a rural agricultural area. Existing ambient sound levels are expected to be relatively low, although sound levels would be higher near roadways such as State Highway 41 and State Highway 53. 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 (Lw), 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 (LP) 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 due to the fact that 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 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 in this report are presented as dBL.

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level (Leq). 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 North 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 ($L_P$) 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) |
|---|---|---|---|
| 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 | |

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 |

| Table 2. Acoustic Terms and Definitions | |
|---|---|
| **Term** | **Definition** |
| | A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report. |
| Unweighted Decibels (dBL) | Unweighted sound levels are referred to as linear. Linear decibels are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Sound levels that are linear are presented as dBL in this report |
| Propagation and Attenuation | Propagation is the decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Additional sound attenuation factors include air absorption, terrain effects, sound interaction with the ground, diffraction of sound around objects and topographical features, foliage, and meteorological conditions including wind velocity, temperature, humidity, and atmospheric conditions. |
| 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, county or local environmental noise requirements specific to this Project. At the state level, the PSC has established regulations applicable to wind energy facilities.

North Dakota adopted noise regulations for wind energy facilities under the PSC Chapter 69-06-08-01(4) as follows:

> *A wind energy conversion facility site must not include a geographic area where, due to operation of the facility, the sound levels within one hundred feet of an inhabited residence or a community building will exceed fifty dBA. The sound level avoidance area*

*criteria may be waived in writing by the owner of the occupied residence or the community building.*

Sound levels resulting from the Project within 100 feet of all identified receptors located in the vicinity of the Project were assessed against the 50 dBA limit to determine whether compliance was achieved. The PSC noise limit is 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 largely aerodynamic. Aerodynamic sound refers to the sound produced from air flow and the interaction with the wind turbine tower structure and moving rotor blades. Mechanical sound is generated at the gearbox, generator, and cooling fan, and is radiated from the surfaces of the nacelle and machinery enclosure and by openings in the nacelle casing. 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. Sound reduction elements designed as a part of the wind turbines include impact noise insulation of the gearbox and generator, sound reduced gearbox, sound reduced nacelle, and rotor blades designed to minimize noise generation.

Wind energy facilities, in comparison to other energy-related facilities, are somewhat unique in that the sound generated by each individual wind turbine will increase as the wind speed across the site increases. Wind turbine sound is negligible when the rotor is at rest, increases as the rotor tip speed increases, and is generally constant once rated power output and maximum rotational speed are achieved. Wind turbine maximum sound power will generally be reached at wind speeds between 7 meters per second [m/s] and 11 m/s, depending on the candidate turbine selected. It is important to recognize 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

The operational acoustic assessment was performed using the proposed April 11,2018 layout with 29 wind turbine locations. The following wind turbine model was evaluated in this analysis:

- **Vestas V126-3.45 –** Wind turbine that has a rotor diameter of 413 ft. (126 m) and a hub height of 285 ft. (87 m).

The acoustic modeling analysis was conducted using the most recent version of DataKustic GmbH's computer-aided noise abatement program or CadnaA (v 159.4707; DataKustic 2016). CadnaA is a comprehensive 3-dimensional acoustic software model that conforms ISO 9613-2 "Attenuation of Sound during Propagation Outdoors." 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. Topographical information was imported into the acoustic model using the official United States Geological Survey 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). A mixed (semi-reflective) ground factor of G=0.5 was used in the Project acoustic modeling analysis. 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, the temperature of 10 degrees Celsius (50 degrees Fahrenheit) and 70 percent relative humidity parameters were selected as reasonably representative of conditions favorable to sound propagation. Atmospheric absorption depends on temperature and humidity and is most important at higher frequencies. Over short distances, the effects of atmospheric absorption are minimal. The ISO 9613-2 standard calculates attenuation for meteorological conditions favorable to propagation, i.e., downwind sound propagation or what might occur typically during a moderate atmospheric ground level inversion. Though a physical impracticality, the ISO 9613-2 standard simulates omnidirectional downwind propagation. For receivers located between discrete wind turbine locations or wind turbine groupings, the acoustic model may result in over-prediction. 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 will aid in the long-range propagation of sound. These anomalous meteorological conditions may include well-developed moderate ground-based temperature inversions and low level jets. While the North Dakota PSC does not specifically require or suggest that these meteorological conditions be explicitly addressed in modeling assessments, ISO 9613-2 includes a methodology to account for effects produced under these conditions and so they were addressed to ensure a conservative assessment.

## 3.2 Acoustic Modeling Input Parameters

In order 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 per International Electrotechnical Commission (IEC) standard IEC 61400-11:2006 Wind Turbine Generator Systems—Part 11: Acoustic Noise Measurement Techniques. This accepted IEC standard was developed to ensure consistent and comparable sound emission data of utility-scale wind turbines between manufacturers. Tables 3 and 4 present a summary of sound power data for the candidate wind turbine models during normal operations correlated to 10 meter height integer wind speeds 10 meter above ground level.

The specification for the wind turbines includes an expected warranty confidence interval, or k-factor which was added to the nominal sound power level in the acoustic model. As indicated in the manufacturer sound specification, the Vestas 126-3.45 wind turbines have a k-factor of 2 dB applied. This confidence interval incorporates the uncertainty in independent sound power level measurements conducted, the applied probability level and standard deviation for test measurement reproducibility, and product variability.

**Table 3. Vestas V126-3.45 Wind Turbine Broadband Sound Power Levels Correlated with Wind Speed**

| Hub Height (m) | WTG Sound Power Level (dBA) at Reference Wind Speed (m/s) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 87.0 | 92.5 | 92.6 | 94.3 | 97.8 | 101.4 | 104.7 | 107.7 | 109.8 | 110.1 |

Source: Vestas 2016.

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 WTG 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. Vestas V126-3.45 Wind Turbine Broadband Sound Power Level by Octave Band Frequency**

| K-Factor | Octave Band Sound Power Level (dBA) by Frequency (Hz) | | | | | | | | | Broadband (dBA) |
|---|---|---|---|---|---|---|---|---|---|---|
| | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | |
| 2.0 | 79.5 | 90.0 | 96.5 | 100.1 | 102.2 | 105.4 | 104.4 | 98.3 | 84.6 | 110.1 |

Source: Vestas 2016.

## 3.3 Acoustic Modeling Results

Acoustic modeling was completed for wind turbine cut-in and maximum rotational operating conditions, thereby describing resultant sound pressure levels over the entire operational range of the Project. In addition, sound energy contribution from the Project substation was included in the acoustic modeling analysis. When calculating received sound levels, it was assumed that the Project substation and all wind turbines were operating concurrently at the given operating condition. Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures 2 through 4, in Appendix A. Figure 2 shows received sound levels when all wind turbines are operating at cut-in wind speed. Figure 3 shows received sound levels when all wind turbines are operating at maximum rotational wind speed under moderate downwind propagation conditions. Figure 4 shows received sound levels conditions when all wind turbines are operating at maximum rotational wind speed under anomalous meteorological conditions.

Table 5 presents the results of the Project acoustic modeling analysis and includes the 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 State of North Dakota noise limit absolute value of 50 dBA. In addition, a 100-foot buffer was included around the receptors, corresponding to the point of compliance identified in the PSC 50 dBA noise limit.

Acoustic modeling results show that there are four occupied NSRs (NSR IDs 1, 2, 3, and 12) with received sound levels greater than 50 dBA. All of these residences are owned by landowners that are participating in the Project. Received sound levels at all non-participating NSRs were determined to be below the PSC 50 dBA noise limit.

**Table 5. Acoustic Modeling Results Summary**

| NSR ID | NSR Status | UTM Coordinates (meters) | | Vestas V126-3.45 | | |
|---|---|---|---|---|---|---|
| | | Easting | Northing | Cut-in | Maximum Rotational | Anomalous Meteorological |
| 1 | Participant | 355605 | 5301329 | 32 | 50 | 50 |
| 2 | Participant | 355661 | 5302441 | 34 | 52 | 52 |
| 3 | Participant | 355702 | 5304238 | 35 | 53 | 53 |
| 4 | Participant | 354027 | 5303759 | 26 | 44 | 45 |
| 5 | Participant | 354097 | 5304134 | 28 | 45 | 46 |
| 6 | Participant | 355606 | 5307543 | 24 | 42 | 43 |
| 7 | Participant | 355126 | 5306945 | 29 | 47 | 47 |
| 8 | Non-participant | 356588 | 5306315 | 23 | 41 | 41 |
| 9 | Participant | 355290 | 5309265 | 18 | 36 | 38 |
| 10 | Non-participant | 355229 | 5309343 | 18 | 35 | 37 |
| 11 | Non-participant | 354397 | 5309449 | 18 | 36 | 38 |
| 12 | Participant | 354123 | 5306615 | 34 | 52 | 52 |
| 13 | Participant | 354129 | 5306370 | 32 | 49 | 49 |
| 14 | Participant | 352764 | 5304471 | 28 | 46 | 46 |
| 15 | Non-participant | 356024 | 5307978 | 21 | 38 | 40 |
| 16 | Non-participant | 355935 | 5310392 | 13 | 30 | 33 |
| 17 | Non-participant | 357493 | 5309065 | 14 | 31 | 34 |
| 18 | Non-participant | 360751 | 5304944 | 20 | 38 | 40 |
| 19 | Non-participant | 348671 | 5304722 | 5 | 23 | 25 |
| 20 | Non-participant | 348189 | 5304543 | 4 | 21 | 24 |
| 21 | Non-participant | 355635 | 5300982 | 28 | 46 | 46 |
| 22 | Non-participant | 355940 | 5308365 | 20 | 37 | 39 |
| 23 | Non-participant | 357655 | 5306178 | 20 | 37 | 39 |
| 24 | Non-participant | 355731 | 5300486 | 24 | 42 | 43 |
| 25 | Non-participant | 355619 | 5299997 | 20 | 38 | 40 |
| 26 | Non-participant | 355445 | 5300002 | 20 | 38 | 40 |
| 27 | Non-participant | 355401 | 5300005 | 20 | 38 | 40 |
| 28 | Non-participant | 355289 | 5300130 | 21 | 38 | 40 |
| 29 | Non-participant | 355309 | 5300409 | 22 | 40 | 41 |
| 30 | Non-participant | 355799 | 5299704 | 19 | 36 | 38 |

| Table 5. Acoustic Modeling Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| NSR ID | NSR Status | UTM Coordinates (meters) | | Vestas V126-3.45 | | |
| | | Easting | Northing | Cut-in | Maximum Rotational | Anomalous Meteorological |
| 31 | Non-participant | 358962 | 5301030 | 24 | 41 | 42 |
| 32 | Non-participant | 353241 | 5300543 | 18 | 35 | 37 |
| 33 | Non-participant | 355840 | 5311882 | 9 | 26 | 29 |
| 34 | Non-participant | 357661 | 5310795 | 10 | 28 | 30 |
| 35 | Participant | 355462 | 5309266 | 18 | 35 | 37 |
| 36 | Non-participant | 360761 | 5306287 | 15 | 33 | 35 |
| 37 | Non-participant | 358898 | 5299451 | 16 | 34 | 36 |
| 38 | Non-participant | 354692 | 5299450 | 17 | 35 | 37 |
| 39 | Non-participant | 355368 | 5299420 | 18 | 35 | 37 |
| 40 | Non-participant | 355104 | 5300327 | 22 | 40 | 41 |
| 41 | Non-participant | 352663 | 5299129 | 13 | 30 | 33 |
| 42 | Non-participant | 354311 | 5309444 | 18 | 36 | 38 |
| 43 | Non-participant | 355272 | 5309370 | 18 | 35 | 37 |
| 44 | Participant | 355890 | 5305977 | 31 | 48 | 49 |
| 45 | Non-participant | 361733 | 5299729 | 12 | 30 | 32 |
| 46 | Non-participant | 362418 | 5300028 | 11 | 29 | 31 |
| 47 | Non-participant | 357737 | 5299654 | 18 | 35 | 38 |

Tabulated sound levels are rounded values. Please note that sound levels greater than 50 dBA, and exceedances of the PSC noise criteria, are identified in **red**.

### 3.4 Substation Noise

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 proposed substation would be located along State Highway 41 approximately 15,000 feet (4,500 meters) north of State Highway 53, with the closest residence approximately 820 feet (250 meters) to the southwest. The transformer at this substation location was 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 estimated transformer NEMA and MVA ratings using standardized engineering guidelines.

**Table 6. 111 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 | |
| 54.0 | 73.3 | 85.4 | 87.9 | 93.3 | 90.6 | 86.8 | 81.5 | 72.4 | 97.0 |

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 500 feet (150 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 four phases consisting of the following:

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. *WTG 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 $L_{max}$ Sound Pressure Levels from Construction Equipment**

| Equipment | Estimated Sound Pressure Level at 50 feet (dBA) | Estimated Sound Pressure Level at 2000 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 |
| 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 provided that 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 appropriate 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 will be delivered to the site, such as hydraulic excavators and associated spreading and compacting equipment needed to form access roads and foundation platforms for each turbine. Once the access roads are constructed, equipment for lifting the towers and turbine components will arrive. Traffic noise is categorized into two categories: (1) the noise that will occur during the initial temporary traffic movements related to turbine delivery, haulage of components and remaining construction; and (2) 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 50 dBA North Dakota PSC noise limit. Acoustic modeling analysis per ISO 9613-2 and inclusive of a number of conservative assumptions demonstrates the Project will comply with the PSC's sound level avoidance area criteria at all NSRs, except for four participating landowner residences, which may experience sound levels above the applicable noise limit under certain operational and meteorological conditions. Meadowlark has obtained written waivers of the sound level avoidance area criteria from those landowners, and copies are provided in Appendix D of the New Frontier Wind Energy Project Certification of Continuing Suitability Filing dated November 2016. The Project continues to comply with the PSC Order Paragraph 7. 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 North Dakota employing the same or similar criteria.

# 5.0 REFERENCES

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# Figures

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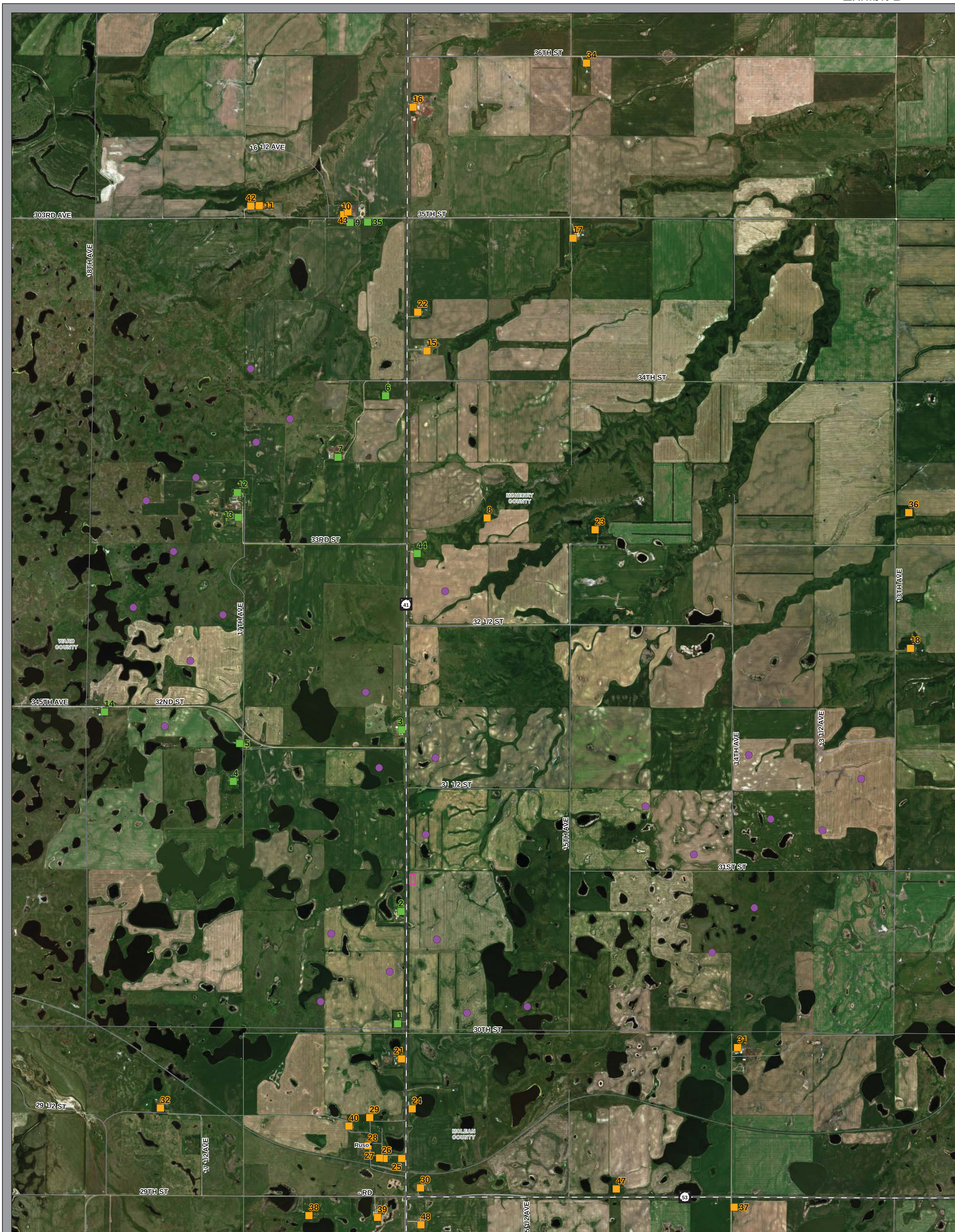
Exhibit B




# NEW FRONTIER WIND ENERGY PROJECT

## Figure 1: Project Layout

- Wind Turbine
- Participant Receptor
- Non-Participant Receptor
- Substation

0 0.25 0.5 Miles

Scale is 1:18,000 when printed at 22x34"

Vicinity Map

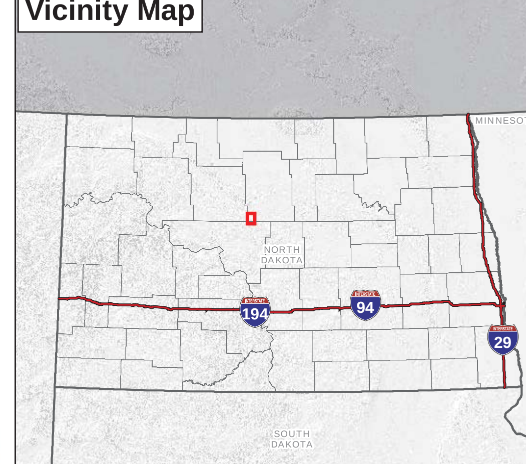



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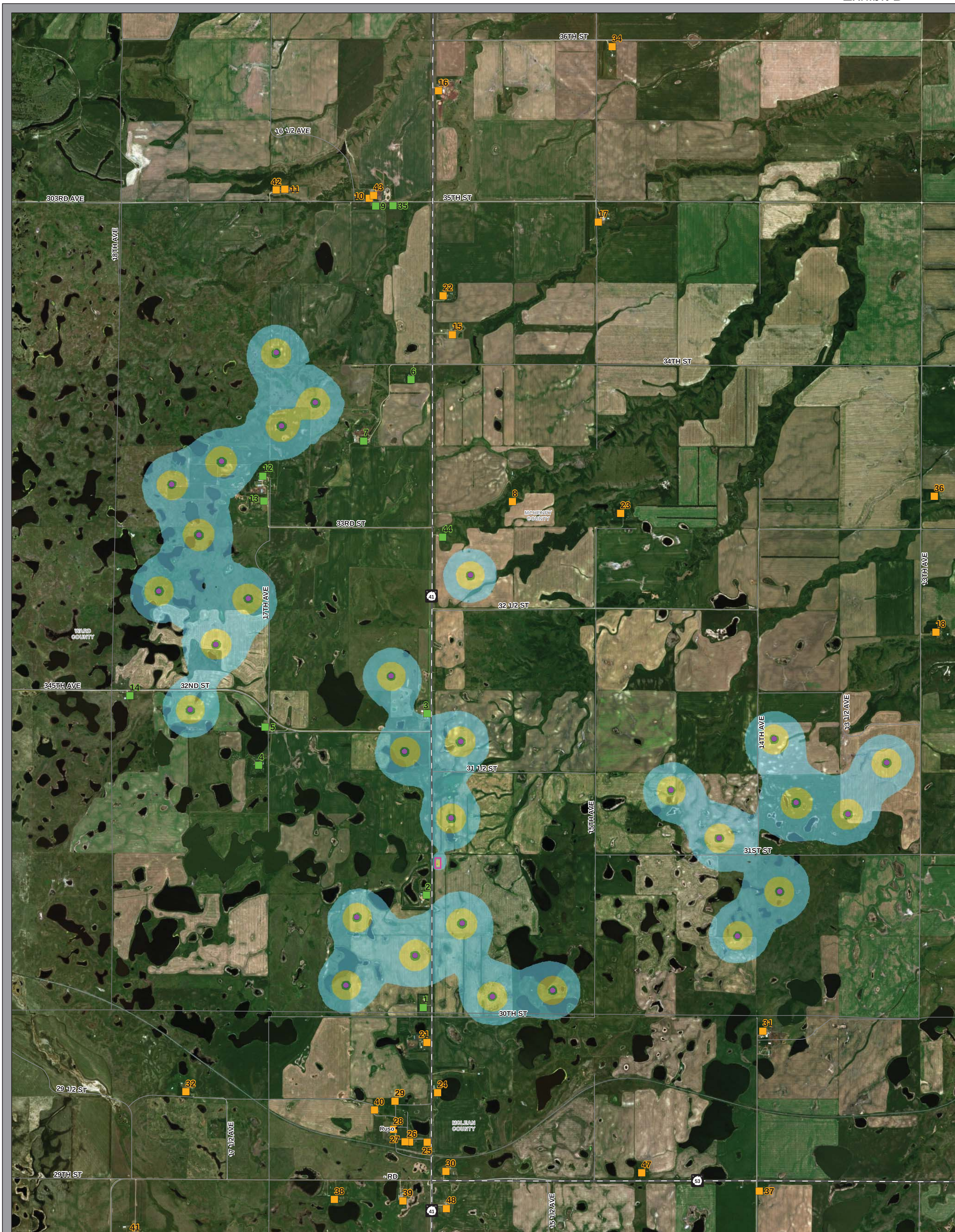
Exhibit B




# NEW FRONTIER WIND ENERGY PROJECT

## Figure 2 – Vestas V126-3.45: Received Sound Levels

## Wind Turbines at Cut-In Wind Speed

- Vestas V126-3.45 Wind Turbine
- Participant Receptor
- Non-Participant Receptor
- Substation

**Sound Level Contour Ranges (dBA)**

- 35 - 40 dBA
- 40 - 45 dBA
- 45 - 50 dBA

0 0.25 0.5 Miles

Scale is 1:18,000 when printed at 22x34"

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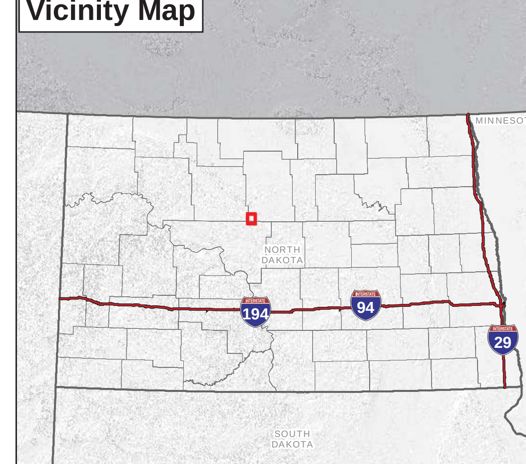
**Vicinity Map**

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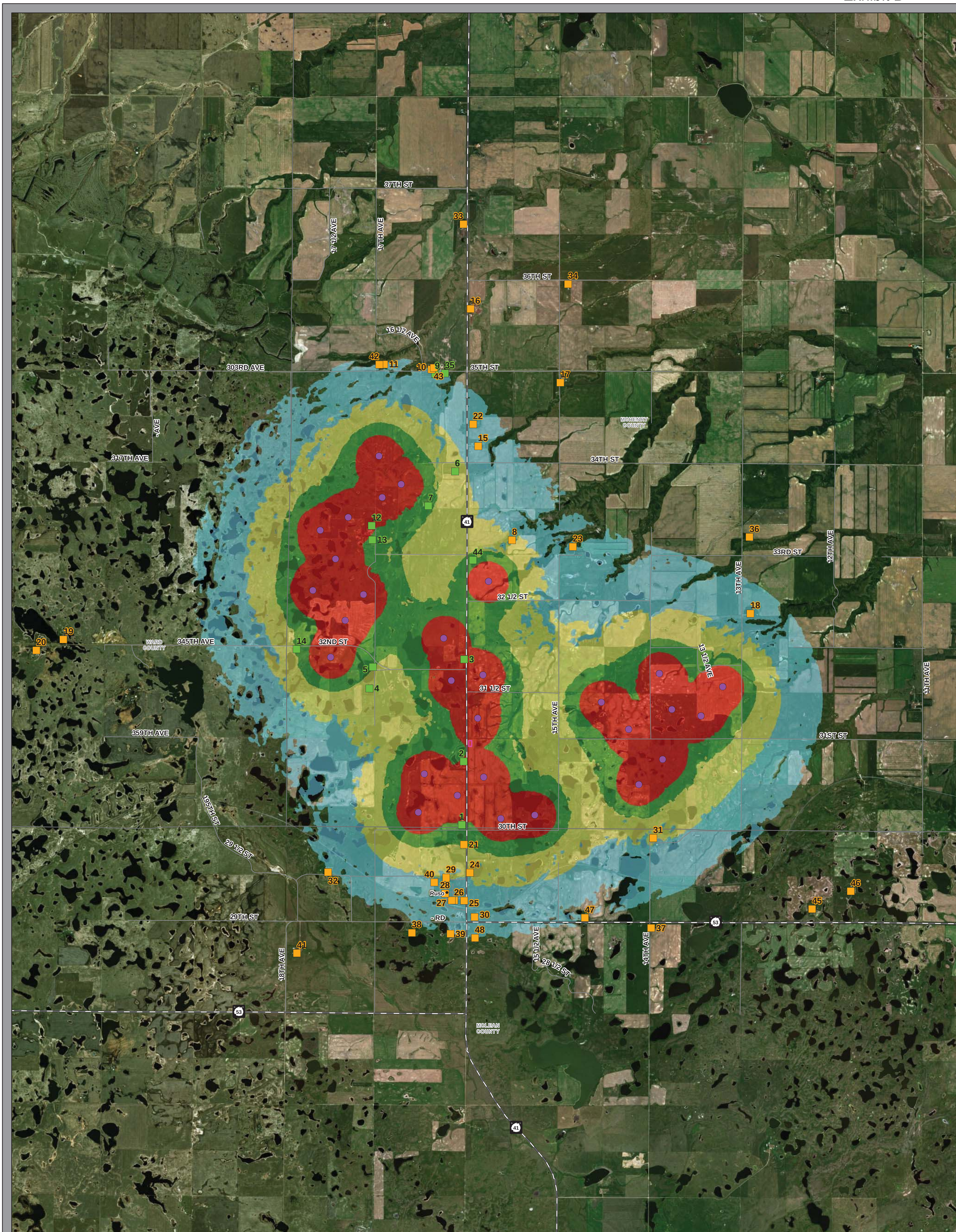



# NEW FRONTIER WIND ENERGY PROJECT

## Figure 3 – Vestas V126-3.45: Received Sound Levels Wind Turbines at Maximum Rotational Wind Speed

- Vestas V126-3.45 Wind Turbine
- Participant Receptor
- Non-Participant Receptor
- Substation

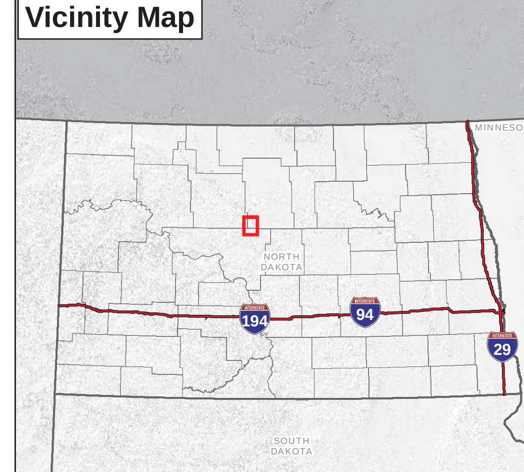
**Sound Level Contour Ranges (dBA)**

- 35 - 40 dBA
- 40 - 45 dBA
- 45 - 50 dBA
- > 50 dBA

0 0.5 1 Miles

Scale is 1:32,000 when printed at 22x34"

Vicinity Map

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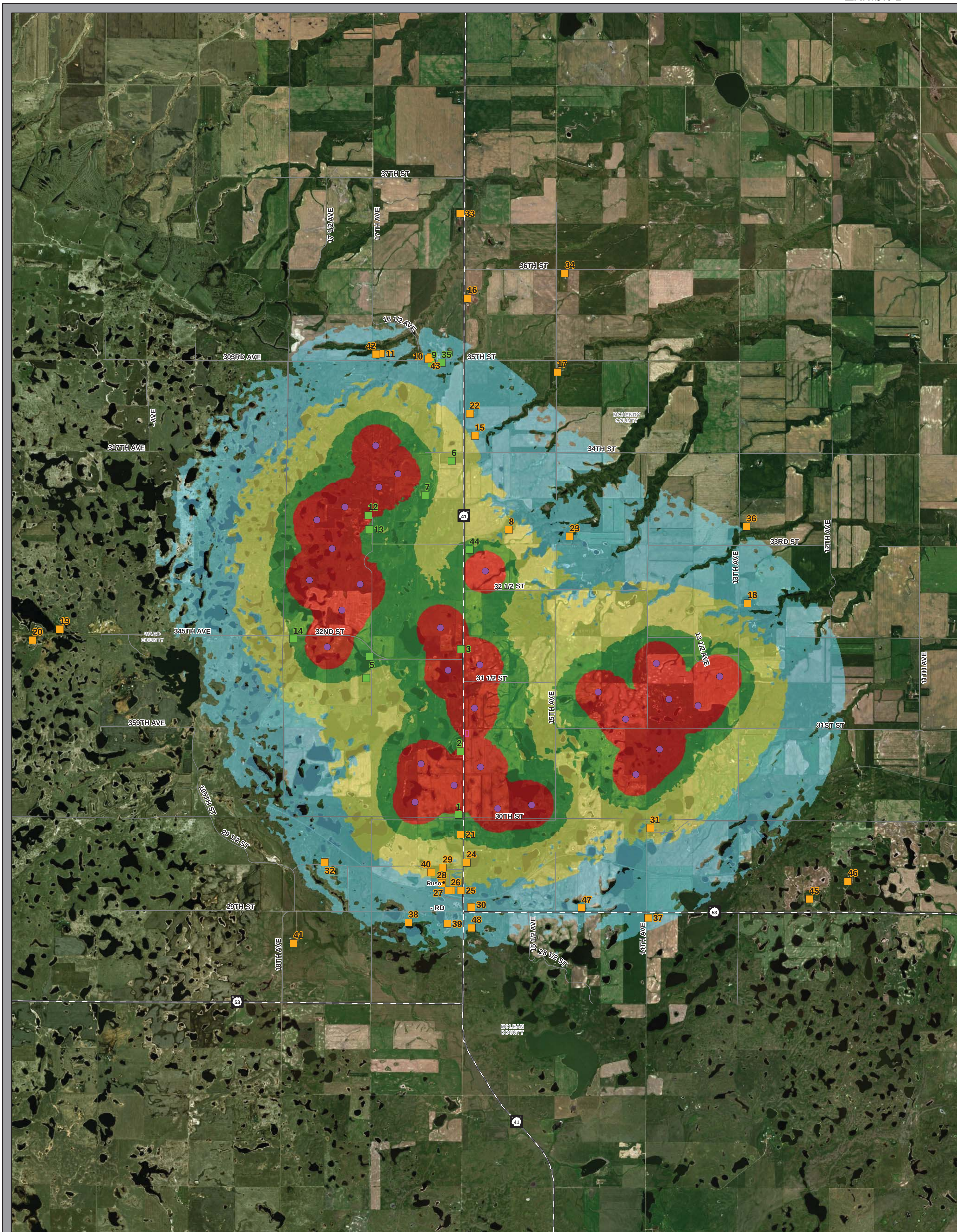
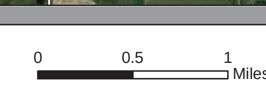



# NEW FRONTIER WIND ENERGY PROJECT

## Figure 4 – Vestas V126-3.45: Received Sound Levels Wind Turbines at Maximum Rotational Wind Speed Anomalous Meteorological Conditions

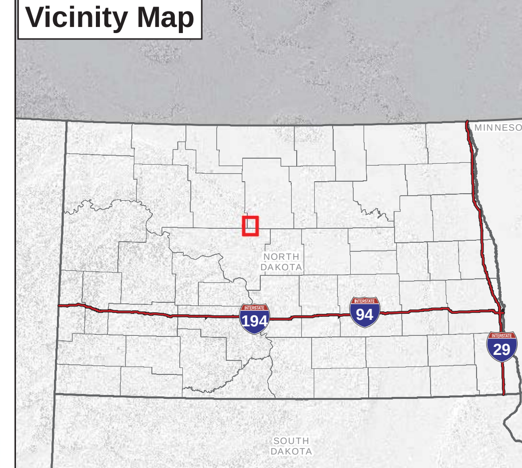
- Vestas V126-3.45 Wind Turbine
- Participant Receptor
- Non-Participant Receptor
- Substation

**Sound Level Contour Ranges (dBA)**

- 35 - 40 dBA
- 40 - 45 dBA
- 45 - 50 dBA
- > 50 dBA

TETRA TECH

Vicinity Map

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