Baldwin Wind Energy Center
Acoustic Assessment
Burleigh County, North Dakota

May 2010

Prepared for

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39 PU-09-668 Filed 06/01/2010 Pages: 59
Late filed Exhibit BW-8
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ACRONYMS AND ABBREVIATIONS

AGL	above ground level
Applicant	NextEra Energy Resources, LLC
BIL	basic impulse level
BLM	Bureau of Land Management
CadnaA	Computer-Aided Noise Abatement Program
dB	decibel
dBA	A-weighted decibel
dBL	unweighted decibel
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
GE	General Electric
Hz	Hertz
HPD	hearing protection devices
IEC	International Electrotechnical Commission
ISO	Organization for International Standardization
kHz	kilohertz
kV	kilovolt
L_{dn}	day-night averaged sound level
L_{eq}	equivalent sound level
LFN	low frequency noise
L_{max}	maximum sound level
L_p	sound pressure level
L_w	sound power level
m/s	meters per second
mph	miles per hour
MVA	megavolt amperes
MW	megawatt
NEMA	National Electrical Manufacturers Association
OSHA	Occupational Safety and Health Administration
PEIS	Programmatic Environmental Impact Statement
Project	Baldwin Wind Energy Center
pW	picowatt
Tetra Tech	Tetra Tech EC, Inc.
µPa	microPascal
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
W	watt
WTG	wind turbine generator

EXECUTIVE SUMMARY

Tetra Tech EC, Inc. (Tetra Tech) has completed the acoustic assessment for the proposed Baldwin Wind Energy Center (Project) located in Burleigh County, North Dakota. An engineering analysis was developed to address sound levels resulting from wind turbine generator (WTG) operations, as well as the consideration of sound from the electrical substation and sound generated during Project construction and maintenance activities. The overall objectives of this study were to: (1) determine Project sound sources and site-specific sound propagation characteristics incorporating terrain effects; (2) computer simulate WTG sound levels over a range of expected future Project operational and meteorological conditions using internationally accepted calculation standards; and (3) determine the feasibility of the Project to operate in compliance with applicable noise standards and guidelines. A cumulative sound impact assessment of the Project in conjunction with the Wilton I and II Wind Energy Centers was also completed.

Wind turbine sound source data was obtained from General Electric (GE), the manufacturer of the GE xle 1.6 megawatt (MW) wind turbine model. Sound propagation modeling was conducted using the Computer-Aided Noise Abatement (CadnaA) software program (version 4.0.136), a comprehensive 3-dimensional acoustic modeling computer simulation software specifically developed for the power generation industry, with calculations made in accordance with the Organization for International Standardization (ISO) 9613-2 “Attenuation of Sound during Propagation Outdoors”. The industry standard CadnaA acoustic modeling software is widely used by sound engineers due to its adaptability to describe complex acoustic scenarios. The results of the acoustic modeling results were compared to U.S. Environmental Protection Agency (EPA) environmental noise guidelines and Occupational Safety and Health Administration (OSHA) regulatory limits for worker exposure and public safety.

The overall conclusions of the acoustic assessment are as follows:

1. Acoustic modeling results show that the Project has been adequately designed, inclusive of a number of conservative model input assumptions, to operate in compliance with EPA noise guidelines at all existing inhabited structures considered to be noise sensitive receptors. The Project will also be constructed and operated in adherence to all applicable OSHA Regulation safety standards.
2. The proposed turbine model will not produce an audible steady state pure tone or apparent tonal conditions at any existing receptors, as defined per International Electrotechnical Commission (IEC) standards for normal WTG operation.
3. Operation of the Project may result in periodically audible sound at noise sensitive receptors under certain operational and meteorological conditions. Specifically, the Project will be audible at the closest receptors relative to the Project, when background sound levels are low, and wind speeds high enough for WTG operation. Residents outside their houses and with a direct line of sight to an operating WTG may hear a gentle swooshing sound characteristic of wind energy projects. During meteorological conditions favorable to sound propagation and very quiet background ambient sound conditions, WTGs may be periodically audible at more distant receptor locations but will be consistent with recommended guideline limits to avoid the potential for adverse noise impacts on public health and safety.

1.0 INTRODUCTION

NextEra Energy Resources, LLC (NextEra; the Applicant) proposes to construct wind energy facility in Burleigh County, North Dakota, referred to as the Baldwin Wind Energy Center (the Project). The Project consists of a total of 64 1.6 megawatt (MW) GE xle wind turbine generators (WTGs) with a rotor diameter of 270 feet (82.5 meters) and an effective hub height of 262.5 feet (80 meters) above grade. An electrical substation, which transforms the power generated from the WTGs to a higher voltage suitable for the local distribution system, will also be constructed. The acoustic assessment analyzed the total potential Project power production output of approximately 102 MW; however, further analysis was conducted to examine 44 possible alternate WTGs and also includes the cumulative assessment of sound resulting from Project in conjunction with the adjacent Wilton I and II Wind Energy Centers, which are both currently operational.

In support of environmental permitting efforts, Tetra Tech EC, Inc. (Tetra Tech) was retained to perform the acoustic assessment of several iterative Project layouts. This document presents the findings of the assessment, including calculated future sound levels resulting from Project operation and provides an evaluation of the feasibility of the Project to operate in compliance with applicable noise regulations and guidelines. Sound associated with Project substation, construction and maintenance activities has also been addressed. While construction is required to erect the Project WTGs and supporting electrical substation, no transmission line construction is anticipated in support of this Project.

1.1 Project Area

The Baldwin Wind Energy Center is located within the Northwestern Great Plains. The landscape includes the western mixed-grass prairie, short-grass prairie, and associated wetlands of the Missouri Slope and River Breaks regions. This semiarid region of North Dakota has topography that can be described as level to rolling plains with isolated sandstone buttes or badlands formations. Native grasslands persist in areas of steep or broken topography, but they have been largely replaced by spring and winter wheat, barley, sunflowers, corn, alfalfa, interspersed with cattle grazing.

The Project is located on privately owned lands in central North Dakota, consists of 21,218 acres, approximately 17 miles north of Bismarck in Burleigh County. The Project area is characteristic of the upland portion of this region, with the majority of the land surface currently covered by agriculture and rangelands with patches of native prairie. The area contains numerous small wetlands that vary from shallow, vegetated depressions to deeper, open water communities. Residences and abandoned farmsteads are widely scattered throughout the Project area. Patches of trees and shrubs exist throughout the Project area and are found primarily between agricultural fields, in drainages, and as shelter belts around homesteads.

A total of 144 receptor locations were identified within the designated acoustic study area using data provided by NextEra in the April 22, 2010 Farmstead Report; however, a further review of these data revealed that of those 144 only 94 are existing occupied residences. Figure 1 presents the Burleigh County acoustic study area, the locations of the proposed WTGs and receptor locations. Though all identified receptors were included in the acoustic modeling analysis, only those considered as noise sensitive receptors where considered for the purposes of the compliance demonstration. Figure 1 presents the land status of the receptor locations incorporated in the Acoustic Assessment.

1.2 Existing Acoustic Environment

Burleigh County would generally be characterized as a rural agricultural land use area. Existing ambient sound levels are expected to be relatively low, although sound levels may be sporadically elevated in localized areas due to roadway noise or periods of human activity. Background sound levels will vary both spatially and temporally depending on proximity to area sound sources, roadways and natural sounds. Principal contributors to the existing acoustic environment likely include motor vehicle traffic, mobile farming equipment, farming activities such as plowing and irrigation, all-terrain vehicles, local roadways, periodic aircraft flyovers, and natural sounds such as birds, insects, and leaf or vegetation rustle during elevated wind conditions in areas with established tree stands or established crops. Diurnal effects result in sound levels that are typically quieter during the night than during the daytime, except during periods when evening and nighttime insect noise may dominate the sound scape, in warmer seasons.

In areas with elevated background sound levels, sound may be obscured through a mechanism referred to as acoustic masking. Seasonal effects such as cricket chirping, certain farming activities, as well as wind-generated ambient noise as ground level airflow interacts with foliage and cropland, contribute to this masking effect. The latter is most prevalent in rural and suburban areas with established tree stands. Wintertime defoliate conditions typically have lower background sound levels due to lower wind masking effects and reduced outdoor activities in colder climates. During colder seasons, people typically exhibit lower sensitivities to outdoor sound levels, particularly in this geographical region of the United States, as windows are closed further enhancing outdoor to indoor transmission losses, and increasingly limited amount of time is spent outdoors.

1.3 Acoustic Terminology

All sounds originate with a source whether it is a human voice, motor vehicles on a roadway, or a wind turbine generator. Sound energy propagates through a medium where it is sensed and then interpreted by a receiver. A sound source is defined by a sound power level (L_w), which is independent of any external factors. By definition, sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts (W). 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 at a given receiver location and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. Sound power, however, cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source.

Sound levels are described on a logarithmic scale to account for the large range of pressure that the human ear can perceive, and is expressed in units of decibels (dB). A decibel 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 referenced to 1 picowatt (pW). Since the human ear does not perceive every frequency with equal loudness, spectrally complex sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system and sound exposure in acoustic assessments is commonly reported in A-weighted decibels (dBA).

An inherent property of the logarithmic decibel scale is that the sound pressure levels of two separate sources are not directly additive. For example, if a sound of 50 dBA is added to another sound of 50 dBA,

the result is a 3-decibel increase (or 53 dBA), not an arithmetic doubling of 100 dBA. The human ear does not sense changes in the sound pressure level as equal changes in perceived loudness. Scientific research demonstrates that the following general relationships hold between sound level and human perception for two broadband sound levels with the same or similar frequency characteristics:

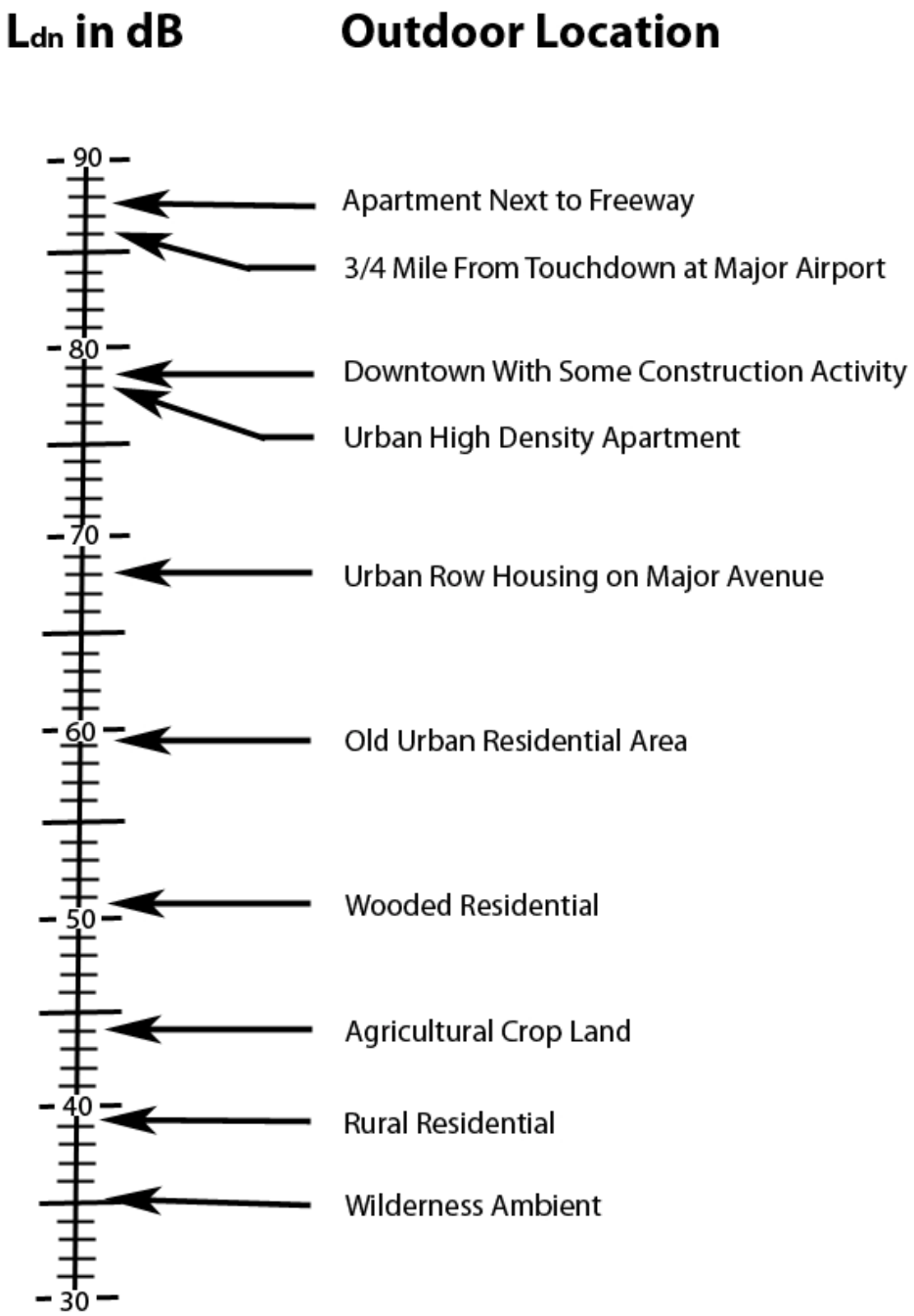
- 1 dBA is the practically achievable limit of the accuracy of sound measurement systems and corresponds to an approximate 10 percent variation in sound pressure. A 1 dBA increase or decrease is a non-perceptible change in sound.
- 3 dBA increase or decrease is a doubling (or halving) of acoustic energy and it corresponds to the threshold of perceptibility of change in a laboratory environment. In practice, the average person is not able to distinguish a 3 dBA difference in environmental sound outdoors.
- 5 dBA increase or decrease is described as a perceptible change in sound level and is a discernable change in an outdoor environment.
- 10 dBA increase or decrease is a tenfold increase or decrease in acoustic energy but is perceived as a doubling or halving in sound (i.e., the average person will judge a 10 dBA change in sound level to be twice or half as loud).

While the concept of sound is defined by the laws of physics, the term 'noise' has further qualities of being excessive or loud. The perception of sound as noise is influenced by technical factors as intensity, sound quality, tonality, duration, and the existing background levels. The effects of noise on people can be classified into three general categories: (1) subjective responses such as annoyance, nuisance, and dissatisfaction; (2) activity interference, e.g., speech, sleep, and learning; and (3) physiological effects such as anxiety or hearing loss. According to the United States Department of the Interior Bureau of Land Management (BLM), "Final Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States," the sound levels associated with environmental noise have been found to generally produce effects only in the first two categories. Responses to comparatively low level sound, generated by modern wind energy projects, are expected to similarly fall principally within the first two categories

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 of wind energy projects. Community sound levels are also often described in terms of the day-night averaged sound level (L_{dn}), which accounts for the increased potential for annoyance that comes with elevated sound levels at night. In addition, the maximum sound level (L_{max}) can be used to quantify the maximum instantaneous sound pressure level generated by a source and is often used in establishing regulatory noise limits. Broadband sound includes sound energy summed across the frequency spectrum. In addition to broadband sound pressure levels, data may also include the analysis of the various frequency components of the sound spectrum to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines 11 octave (or 33 1/3 octave) bands ranging from 16 Hz (low) to 16,000 Hz (high), encompassing the entire human audible frequency range.

The EPA estimates of various outdoor sound pressure levels and acoustic environments are presented in the day-night averaged sound level (L_{dn}) in Table 1. Table 2 presents additional reference information on terminology used in the acoustic assessment.

Table 1. Various Outdoor Sound Pressure (L_P) Levels



Notes:

μPa - Micropascals describe sound pressure levels (force/area).
dBA - A-weighted decibels describe sound pressure on a logarithmic scale referenced to 20 μPa.
Reference: USEPA, Protective Noise Levels. Condensed Version of EPA Levels Document. Publication EPA-550/9-79-100, November 1978.

Table 2. Acoustic Terms and Definitions

Term	Definition
Noise	Unwanted sound dependant on level, character, frequency or pitch, time of day, and sensitivity and perception of the listener. This word adds the subjective response of humans to the physical phenomenon of sound. It s use is limited to 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 1000 Hz.
Sound Power Level (L_W)	Sound power level is not the equivalent to a sound pressure level. While both are reported in decibels, the L_W a noise source measured in decibels referenced to 10^{-12} watts. Sound power is independent of the environment, for this reason wind turbine manufacturer noise specifications are provided in these terms. A sound power level is a function of both the sound pressure level produced by a source with distance and the effective radiating area or physical size of the source. In general, the ostensible magnitude of a sound power level is always considerably higher than the received sound pressure level near a source because of the area term, which for a wind turbine is effectively the entire rotor swept area.
Frequency (Hz)	The rate of oscillation of a sound, measured in units of Hertz (Hz) or kilohertz (kHz). One hundred Hz is a rate of one hundred times 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.
A-Weighted Decibel (dBA)	Environmental sound is typically composed of acoustic energy across all frequencies (Hz). 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.
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 Hertz and is typically divided into octave band center frequencies (Hz) ranging from 31 to 8,000 Hz.
Broadband Sound	Noise which covers a wide range of frequencies within the audible spectrum, i.e. 200 to 2000 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.
Low Frequency Noise (LFN)	The frequency range of 20 to 200 Hz is typically defined as low frequency noise. At sufficiently high levels, low frequency noise can cause vibrations in structures and physiological effects in humans. Low frequency noise is generally associated with older wind turbines that have downwind rotor configurations.
Infrasound	The frequency range of infrasound is normally defined as below 20 Hz. Infrasound from wind turbines are significantly below recognized thresholds for both human perceptibility and standardized health.

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

2.0 NOISE REGULATIONS AND GUIDELINES

This section presents information on the criteria used to evaluate the effects of noise from the Project. With the exception of the EPA environmental noise guidelines and the United States Occupational Health and Safety Administration's (OSHA) regulations that describe health and safety limits for noise exposure, there are no overarching state, county, or federal noise requirements specific to this Project or wind energy facilities in the state of North Dakota. Burleigh County does not have an ordinance with numerical decibel limits.

2.1 Environmental Protection Agency Environmental Noise Guidelines

While the EPA has no regulation governing environmental noise, the agency has conducted several extensive studies to identify the effects of sound level on public health and welfare. In 1974, the EPA published a landmark document entitled "Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety." This publication remains the authoritative study based on a large sampling of community reaction to noise. The EPA sound level guidelines do not provide an absolute measure of noise impact, but rather a consensus on potential activity interference, human health and welfare effects, and annoyance. For outdoor residential areas, the recommended EPA guideline is an L_{dn} of 55 dBA (equivalent to an L_{eq} (1-hour) of 48.6 dBA assuming continuous 24-hour operation). The EPA sound level guidelines also suggest an L_{eq} of 70 dBA (24-hour) limit to avoid adverse effects on health and safety at publicly accessible property lines or work areas. Since these protective levels were derived without concern for technical or economic feasibility, and contain a margin of safety to ensure their protective value, they must not be viewed as standards, criteria, regulations, or goals. Rather, they should be viewed as levels below which there is no reason to suspect that the general population will be at risk from any of the identified effects of noise. The EPA criteria limits are summarized in Table 3.

Table 3. Summary of EPA Cause and Effect Noise Levels

Location	Level	Effect
All public accessible areas with prolonged exposure	70 dBA $L_{eq(24)}$	Safety / hearing loss concerns
Outdoor at residential structure and other noise sensitive receptors where a large amount of time is spent	55 dBA L_{dn}	
Outdoor areas where limited amounts of time are spent, e.g., park areas, school yards, golf courses, etc.	55 dBA $L_{eq(24)}$	Protection against annoyance and activity interference
Indoor residential	45 dBA L_{dn}	
Indoor non-residential	55 dBA $L_{eq(24)}$	

The EPA sound level guidelines state that the levels identified are low enough to be protective with an adequate margin of safety. The EPA sound level guidelines do not impose arbitrary federal decisions about the appropriateness of noise environments upon any level of government, nor are they a source of instructions for solving local noise problems, but best viewed as a technical aid for local decision makers who seek to balance scientific information about effects of noise on people, and to reconcile local economic and political realities such as cost and technical feasibility. The relationship between physical acoustic relationships and human response is not linear and depends on factors and cannot be precisely predicted. In any environment, a small portion of the general population may be somewhat annoyed depending on the person's subjective response due to the presence of any level of recurring audible sound, regardless of the actual or perceived loudness.

2.2 Bureau of Land Management Guidance

In June 2005, the United States Department of the Interior Bureau of Land Management (BLM) published the Final Programmatic Environmental Impact Statement (PEIS) to address the potential impacts of wind energy projects on BLM Lands in the Western United States. One of the issues identified was the siting of wind energy projects in areas that do not have applicable noise standards. Section 4.5.4 of that document states, "The EPA guideline recommends an L_{dn} of 55 dBA to protect the public from the effects of broadband environmental noise in typically quiet outdoor and residential areas. The EPA limit is not a regulatory limit but "intentionally conservative to protect the most sensitive portion of the American population" with "an additional margin of safety". The BLM PEIS findings are not directly applicable to the Baldwin Wind Energy Center as it will be entirely sited on private land; however, the BLM restatement of the EPA guideline provides insight on how one governmental agency is addressing the potential for noise impacts produced by wind energy projects in areas with no state or local noise regulation.

2.3 Occupational Safety and Health Administration Noise Safety Standards

The federal government has long recognized the potential hazards caused by noise to work health and safety. Onsite noise levels are regulated by the Occupational Safety and Health of 1970 (29 Code of Federal Regulations [CFR] 1910.95). This regulation establishes standards for permissible noise exposure in the workplace to guard against the risk of hearing loss. The standards shown in Table 4 establish a sliding scale of permissible noise levels by duration of exposure. The exposure level is raised 5 dB for every halving of exposure duration. OSHA permits noise levels up to 90 dBA, over a time-weighted average eight-hour shift ($TWA_{8\text{-}hr}$), measured on the A-scale of a sound level meter set at slow response. If there are workers exposed to a $TWA_{8\text{-}hr}$ above 85 dBA, then the regulations call for a worker hearing protection program that includes baseline and periodic hearing testing, availability of hearing protection devices, and training in hearing damage protection.

Table 4. OSHA Permissible Daily Noise Exposure Limits

Duration of Exposure Per Day (Hours)	Sound Level (dBA)
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

When employees are subjected to noise doses exceeding those shown in Table 4, feasible administrative or engineering controls will be identified and implemented to lower employee noise exposure. If controls fail to reduce sound to these acceptable levels, personal protective equipment must be provided and used to reduce noise exposure. In compliance with OSHA, Project contractors will be required to readily provide construction workers with OSHA-approved hearing protection devices (HPD) and to identify high noise areas and activities where hearing protection Operational sound generated from the Project will not approach OSHA noise exposure limits even in very close proximity to individual WTG locations.

2.4 Summary of Acoustic Criteria

A summary of the pertinent acoustic criteria used to assess sound levels at existing receptors during Project operation is provided below:

- EPA 70 dBA $L_{eq\ (24)}$ at publicly accessible project property lines or extents of work areas where extended public exposure is possible;

- EPA 55 dBA $L_{eq\ (24)}$ in outdoor areas where limited time is spent;
- 55 dBA $L_{dn\ (24)}$ outdoors at all residential receptor locations where extended periods of time are spent outdoors, residential structures and areas in close proximity to the residential structure, e.g., yards. Wind turbines operate intermittently depending on wind conditions at hub height. Assuming the wind turbine is operating as a continuous steady state sound source and is the dominant contributor of environmental sound level at the receiver location, the L_{dn} is approximately 6.4 dB above the measured L_{eq}. Consequently, an L_{dn} of 55 dBA corresponds to a maximum instantaneous L_{eq} of 48.6 dBA; and
- OSHA regulatory limits for the protection of worker exposure and public safety.

The application of the EPA noise guidelines is a common noise assessment compliance approach and used to ensure adequate protection of human health and welfare. While the EPA criteria limits cannot be used to infer audibility thresholds, compliance with EPA guidelines would likely result in the reduced probability of dissatisfaction. Inaudibility under all operating conditions is an unrealistic expectation, and one that is not required under any other industrial, commercial, or agricultural activity in the state of North Dakota. OSHA noise safety standards are mandatory requirements at all times. Guideline limits identified are absolute and independent of the existing acoustic environment; therefore, no baseline sound survey is required to assess conformity.

3.0 ACOUSTIC MODELING METHODOLOGY

With the construction of wind energy projects in North Dakota and throughout the United States, a better understanding of the generation, propagation and attenuation of WTG sound in the natural environment has been gained. While sound generated by an operating WTG is comprised of both aerodynamic and mechanical sound, the dominant sound component from utility scale WTGs is largely aerodynamic. Aerodynamic sound refers to the sound produced from air flow and its interaction with the WTG's tower structure and rotor blades when they're in motion. 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 WTG 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 further minimized. The GE 1.6 MW xle WTG is an upwind variable speed-type wind turbine with an active yaw and pitch regulated with power/torque control capability and an asynchronous generator. Sound reduction elements designed into the GE 1.6 MW xle include impact noise insulation of the gearbox and generator, sound reduced gearbox, noise reduced nacelle, and rotor blades with minimized noise level.

Wind energy projects, in comparison to conventional energy projects, are somewhat unique in that the sound generated by each individual WTG will increase as the wind speed across the site increases, up to a certain maximum sound level under elevated wind conditions (i.e., greater than approximately 9 meters per second [m/s]) per manufacturer's specifications. 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 full rotational speed is achieved. As an offset, as wind speeds increase, the background ambient sound levels likely will continue to increase, resulting in acoustic masking effects.

3.1 Acoustic Modeling Software and Calculation Methods

The operational acoustic assessment was performed using two versions of the Project design layout dated April 26, 2010. The initial version consisted of the 64 planned WTGs and the second includes the original 64 planned and 44 alternate WTGs positions. The acoustic modeling analysis employed the most recent version of DataKustic GmbH's CadnaA, the computer-aided noise abatement program (v 4.0.136). CadnaA is a comprehensive 3-dimensional acoustic software model that conforms to the Organization for International Standardization (ISO) standard ISO 9613-2 "Attenuation of Sound during Propagation Outdoors." The engineering methods specified in this standard consist of 1/1 octave band algorithms that incorporate the following:

- Geometric spreading wave divergence
- Reflection from surfaces
- Atmospheric absorption
- Screening by topography and obstacles
- Terrain complexity and ground effects
- Source directivity factors
- Height of both sources and receptors
- Seasonal foliage effects
- Meteorological conditions including the effects of wind and atmospheric inversions

Topographical information was imported into the acoustic model using the official United States 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 0 for acoustically hard, reflective surfaces and 1 for absorptive surfaces and soft ground. If the ground is hard-packed dirt, typically found in industrial complexes, pavement, or for sound traveling over bodies of water, the absorption coefficient is defined as G=0 to account for reduced sound attenuation. In contrast, ground covered in snow (common in this particular area during the winter season), 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 acoustic modeling analysis, a conservative ground absorption rate was selected for a semi-reflective ground surface. This ground absorption coefficient was further reduced for receiver locations in close proximity to WTGs to account for decreased ground attenuation effects associated with an elevated sound source relative to receiver height. For this model, each WTG was modeled as an elevated point source at the position of the hub of 80 meters, an approach which is valid when the distance from the source to receiver is large compared to the dimensions of the source. For idealized point sources, sound levels will attenuate with increased distance from the source in accordance with the "inverse square law" due to geometric divergence that occurs as the sound energy is spread across a sphere of greater dimensions. The equivalent continuous downwind octave band sound pressure level at a receiver location is calculated for each individual WTG source and its image sources on both a broadband and frequency dependent basis from 31 Hz to 8 kHz. Geometrical divergence accounts for spherical spreading in the free field from a point sound source according to the equation below:

$$L_P = L_W + DI_\theta - 10\log\left(\frac{1}{2}\pi R^2\right) - A \text{ in dBA or dBL}$$

Where:

L_P	=	calculated sound pressure level at receiver location
L_W	=	reference sound power level by octave band center frequency
DI_θ	=	directivity index correction to account for the variation in sound intensity with orientation relative to the noise source
R	=	linear (slant) distance of L_p from source in meters (or feet multiplied by 3.28) to calculate geometrical divergence with distance
A	=	extraneous attenuation factors that may occur during propagation from the point sound source to the receiver

The ISO 9613-2 standard calculates received sound pressure levels for meteorological conditions favorable to propagation, i.e., downwind sound propagation or what might occur typically during a moderate atmospheric ground level inversion, which is assumed to be regulatory worst case. At large distances from a sound source when the influences of wind or temperature gradients are present, atmospheric effects may cause fluctuations in received sound levels over long distances, but will typically attenuate noise to levels below those predicted. Rarely will these effects cause levels to be significantly above those predicted. First, 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 micrometerological inhomogeneities 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, specifically at points of reception located at extended distances from WTGs. The presence of anomalous meteorological conditions can cause sound waves to curve downward towards the ground and then reflect upwards towards the gradient, which is then repeated leading to a trapped sound wave. The wave refraction effects due to wind and temperature gradients during downwind conditions result into the convergence of modified cylindrical wave spreading, which has a reduced rate of sound attenuation. These anomalous meteorological conditions may include well-developed moderate ground-based temperature inversions, such as commonly occurs at nighttime and during early morning hours, and wind gradients which can bend sound downwards, which may occur at anytime depending on predominant weather conditions. Though somewhat infrequent, Project operational sound levels resulting from periodic anomalous meteorological conditions were also considered in the modeling analysis.

In addition to geometrical divergence, attenuation factors (A) include topographical features, terrain coverage, and/or other natural or anthropogenic obstacles that can affect sound attenuation and result in acoustical screening. Atmospheric absorption depends on temperature and humidity and is most important at higher frequencies. Over short distances, the effects of atmospheric absorption are minimal. Though a physical impracticality, the ISO 9613-2 standard simulates omnidirectional downwind propagation and maximum WTG source directivities. For receptors located between discrete WTG locations or WTG groupings, the acoustic model will result in over-predicted received sound level results. Additional sound attenuation through foliage and diffraction around and over existing anthropogenic structures such as buildings were ignored under all acoustic modeling scenarios. The results are therefore representative of defoliate winter time. The acoustic model assumes that all WTGs are operating continuously and concurrently at the maximum manufacturer-rated sound level at the given operational condition and sound energy is summed using the following equation in accordance with ISO 9613-2:

$$L_{PA}(DW) = 10\log\left\{\sum_{i=1}^{n}\left[\sum_{j=1}^{9} 10^{0,1\left[L_{fT}(ij)+f(A-wtd)(j)\right]}\right]\right\}$$

Where:

n	=	the number of contributions i (sources and paths)
j	=	an index indicating the nine standard octave band center frequencies spanning from 31 Hz to 8 kHz

The above equation determines the equivalent continuous A-weighted downwind sound pressure level at a point of reception (i.e., noise sensitive receptors), taking into account the contributing sound pressure levels produced by all Project WTGs. Calculations were completed using an 131-foot (40 meters) by 131-foot grid and also completed at discrete noise sensitive receptor locations.

3.2 Acoustic Modeling Input Parameters

In order to assist project developers and acoustical engineers, wind turbine manufacturers report WTG sound power data at integer wind speeds referenced to the effective hub height, ranging from cut-in to full rated power. This internationally accepted International Electrotechnical Commission (IEC) standard was developed to ensure consistent and comparable sound emission data of utility-scale wind turbines between manufacturers. These data are inclusive of both mechanical and aerodynamic source components. 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, worst-case WTG directivity and sound generating efficiencies are reported in the sound source data and used in the acoustic model calibration.

A summary of sound power data for the selected GE 1.6 MW xle WTG correlated by wind speed at the rotor hub height of 262.4 feet (80 meters) are presented in Table 5. The GE 1.6 MW xle specification reports a confidence interval of K=2 dB to account for the manufacturer's warranty clause, which was incorporated into the acoustic model to ensure a conservative acoustic modeling assessment.

Table 5. Broadband Sound Power Levels (dBA) Correlated with Wind Speed

	WTG L_{max} Sound Power Level (L_W) at Reference Wind Speed						
10-meter AGL Wind Speed	9 mph (4 m/s)	11.2 mph (5 m/s)	13.4 mph (6 m/s)	15.9 mph (7 m/s)	17.9 mph (8 m/s)	20.1 mph (9 m/s)	22.4 mph (10 m/s)
GE 1.6 MW xle	<96	<96	<99	<102	<104	≤106	≤106

A summary of sound power data for the GE 1.6 MW xle by octave band center frequency is presented in Table 6.

Table 6. GE 1.6 MW xle Sound Power Level by Octave Band Center Frequency

Frequency (Hz)	Octave Band Sound Power Level (dBA)								Broadband (dBA)
	63	125	250	500	1000	2000	4000	8000	
GE 1.6 MW xle	84.8	93.6	99.2	100.8	100.1	97.3	89.1	86.2	106.0

4.0 MODELING RESULTS AND COMPLIANCE DETERMINATION

Operational broadband (dBA) sound pressure levels were calculated throughout the Project area. Acoustic modeling results and the overall analysis conclusions are given in the following sections.

4.1 Acoustic Modeling Results

Acoustic modeling for the final Project layout was completed for WTG cut-in and full rotational operating conditions, thereby describing sound pressure levels over the entire range of future Project operational conditions. Two separate tables present the results of the Baldwin Wind Energy Center acoustic modeling analysis. Tables 7a and 7b shows the ID, status, Universal Transverse Mercator (UTM) coordinates, and received sound level for each receptor. Table 7a displays results for operation of only the planned Project WTGs whereas Table 7b displays results for operation of both the planned and alternate Project WTGs.

Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures 2 through 7. Figures 2 and 5 show broadband (dBA) operational sound levels under low-level wind speeds sufficient for WTGs to operate at initial cut-in rotational speeds for the planned WTGs only and planned WTGs in combination with the alternate WTGS, respectively. Figures 3 and 6 show broadband (dBA) operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds for moderate downwind propagation for the planned WTGs only and planned WTGs in combination with the alternate WTGS, respectively. Figures 4 and 7 show broadband (dBA) operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds under anomalous meteorological conditions for the planned WTGs only and planned WTGs in combination with the alternate WTGS, respectively. The acoustic modeling was completed for all WTGs operating concurrently. Results are presented to tenths of decibels for comparison with the EPA criterion, which is given to one decimal place; however, the generally accepted level of accuracy for this calculation procedure is typically to the nearest whole decibel. 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 7a. Summary of WTG Acoustic Model Output at Receptors for Planned WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
2011	Occupied	383232	5219483	<0	<0	<0	<0
2012	Unoccupied	380630	5217738	3.4	13.4	16.1	16.2
2013	Non-Residential	380100	5218948	3.6	13.6	16.3	16.4
2014	Non-Residential	379983	5218952	8.9	18.9	21.6	21.7
2015	Occupied	376198	5217497	18.9	28.9	31.3	31.3
2016	Occupied	372754	5218312	33.2	43.2	43.9	44.1
2018	Occupied	368373	5219341	27.7	37.7	39.6	39.7
2019	Occupied	367510	5219031	28.1	38.1	39.7	39.8
2020	Occupied	365973	5217765	28.0	38.0	39.2	39.4
2020	Occupied	369311	5219083	31.9	41.9	43.1	43.2
2024	Occupied	369232	5219059	31.2	41.2	42.8	43.0
2025a	Unoccupied	370431	5218318	38.4	48.4	48.6	48.7
2027	Unoccupied	369737	5218420	41.3	51.3	52.1	52.4
2028	Occupied	371097	5217187	35.3	45.3	46.1	46.3

Table 7a. Summary of WTG Acoustic Model Output at Receptors for Planned WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
2030	Occupied	374516	5216892	28.0	38.0	39.4	39.4
2036	Occupied	372317	5216000	32.8	42.8	43.8	43.9
2041	Occupied	371025	5215602	31.0	41.0	42.3	42.4
2045	Occupied	370218	5216534	34.4	44.4	45.0	45.2
2047	Occupied	370195	5216578	34.7	44.7	45.1	45.2
2051	Occupied	378621	5221835	13.1	23.1	25.6	25.7
2052	Unoccupied	378705	5221297	10.5	20.5	23.7	23.8
2053	Occupied	379196	5221219	10.5	20.5	22.9	23.0
2053	Occupied	367280	5216355	30.3	40.3	41.5	41.6
2054	Occupied	376457	5222208	14.7	24.7	28.1	28.2
2055	Occupied	376380	5222201	17.8	27.8	30.2	30.3
2056	Occupied	375960	5222198	19.3	29.3	31.8	32.0
2057	Occupied	375513	5220742	17.1	27.1	29.2	29.3
2057a	Occupied	367248	5215913	27.5	37.5	39.2	39.3
2058	Occupied	375404	5220251	19.7	29.7	32.3	32.4
2059	Occupied	374606	5221973	19.4	29.4	33.6	33.7
2060	Occupied	374367	5222200	21.2	31.2	33.6	33.7
2060a	Occupied	368839	5215450	30.6	40.6	41.8	42.0
2061	Non-Residential	373618	5222265	23.2	33.2	35.3	35.4
2062	Occupied	372289	5222275	27.6	37.6	39.0	39.1
2063	Occupied	372584	5220687	26.3	36.3	38.3	38.5
2063	Unoccupied	373499	5211684	19.5	29.5	31.9	32.0
2064	Unoccupied	366589	5221003	20.7	30.7	32.6	32.8
2065	Occupied	366333	5220865	19.8	29.8	32.7	32.8
2066	Occupied	366175	5220821	19.7	29.7	32.1	32.2
2066a	Occupied	365765	5216992	26.9	36.9	38.3	38.5
2067	Occupied	366079	5220821	17.0	27.0	29.3	29.4
2068	Occupied	364110	5219367	17.3	27.3	29.8	29.9
6096	Occupied	366619	5217768	33.9	43.9	44.0	44.2
6099	Occupied	366688	5218078	31.7	41.7	42.1	42.2
6100a	Occupied	372687	5220626	26.0	36.0	38.2	38.4
40001a	Occupied	376933	5223953	18.1	28.1	31.3	31.4
40011a	Non-Residential	375671	5223949	21.5	31.5	33.9	34.0
40018a	Occupied	375524	5224880	23.5	33.5	35.7	35.8
40021a	Occupied	376428	5227682	26.4	36.4	38.1	38.2
40025	Occupied	375732	5229916	24.6	34.6	36.3	36.4
40028a	Non-Residential	375368	5229059	33.0	43.0	43.1	43.3
40031	Occupied	375434	5226226	27.5	37.5	39.3	39.4
40033	Occupied	373882	5225842	32.3	42.3	43.3	43.4
40037a	Occupied	373984	5228148	34.4	44.4	44.8	44.9
40039	Occupied	373837	5227612	37.4	47.4	47.3	47.4
40044	Occupied	375953	5224137	21.2	31.2	33.6	33.7
40049	Non-Residential	373825	5224083	25.6	35.6	37.9	38.0
40051	Occupied	373899	5223691	24.7	34.7	37.0	37.2
40055a	Occupied	372334	5224178	32.6	42.6	43.4	43.5
40060	Unoccupied	372120	5223886	33.7	43.7	44.3	44.4
40063a	Unoccupied	372312	5224843	33.2	43.2	44.0	44.2
40066	Occupied	372315	5225695	36.2	46.2	46.8	47.1
40069	Unoccupied	372228	5226802	37.0	47.0	47.1	47.2
40070a	Unoccupied	372259	5227439	37.1	47.1	47.5	47.7

Table 7a. Summary of WTG Acoustic Model Output at Receptors for Planned WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
40074a	Non-Residential	370668	5225623	36.7	46.7	47.0	47.1
40076a	Non-Residential	370151	5225694	32.2	42.2	43.2	43.4
40077	Occupied	370102	5225602	32.1	42.1	43.2	43.4
40081	Occupied	369701	5225578	30.4	40.4	41.9	42.1
40086	Occupied	368967	5226144	33.9	43.9	44.4	44.5
40089	Occupied	367924	5226018	34.0	44.0	44.8	45.1
40093a	Occupied	367907	5226008	33.8	43.8	44.5	44.8
40097	Occupied	368972	5227351	34.8	44.8	44.5	44.8
40099	Occupied	367401	5228151	24.1	34.1	35.9	36.0
40100	Occupied	367556	5227926	25.7	35.7	37.3	37.4
40105a	Occupied	367270	5227370	26.8	36.8	38.1	38.3
40107a	Occupied	365871	5224958	17.7	27.7	30.1	30.2
40110b	Occupied	366065	5224523	16.1	26.1	29.1	29.3
40112	Occupied	371312	5222602	33.7	43.7	44.5	44.8
40116a	Occupied	372859	5222443	26.0	36.0	38.0	38.1
40120	Occupied	373474	5222500	24.2	34.2	36.4	36.5
40124	Occupied	374934	5222439	20.5	30.5	33.3	33.5
40125a	Non-Residential	372393	5227947	35.4	45.4	45.5	45.7
40128	Non-Residential	372293	5228874	27.8	37.8	39.4	39.5
40130a	Unoccupied	375933	5228266	31.2	41.2	41.8	42.0
40134a	Occupied	371186	5223960	36.5	46.5	46.9	47.2
40135	Occupied	371067	5223960	36.2	46.2	46.5	46.8
40139a	Non-Residential	369726	5224097	31.2	41.2	42.3	42.6
40140a	Unoccupied	368909	5223606	25.1	35.1	37.2	37.4
40142	Non-Residential	367963	5222567	20.8	30.8	33.2	33.4
40149a	Occupied	367475	5223178	20.7	30.7	32.5	32.6
40152a	Unoccupied	365746	5223799	16.2	26.2	28.0	28.1
40155a	Occupied	366297	5223595	17.8	27.8	30.2	30.3
40193	Unoccupied	365836	5222281	16.5	26.5	27.9	28.0
40196	Occupied	365654	5221719	17.4	27.4	29.8	29.9
40198	Occupied	365596	5221731	17.7	27.7	30.2	30.3
40323	Occupied	365791	5225833	19.7	29.7	32.0	32.1
40324	Non-Residential	365832	5226445	20.1	30.1	32.2	32.4
40326	Non-Residential	365834	5226625	18.7	28.7	32.0	32.2
40329	Occupied	364837	5227355	16.2	26.2	28.7	28.8
40333a	Occupied	365619	5228487	17.4	27.4	29.6	29.7
40336a	Unoccupied	373387	5228862	28.5	38.5	40.1	40.2
40342	Non-Residential	370909	5226405	34.3	44.3	44.8	45.0
40343	Unoccupied	370818	5228021	28.7	38.7	39.9	40.0
41013a	Non-Residential	368951	5226825	39.4	49.4	49.4	49.7
41014a	Non-Residential	368950	5226845	39.5	49.5	49.5	49.8
60002a	Unoccupied	375123	5214163	26.0	36.0	37.7	37.8
60005	Non-Residential	372824	5212708	23.1	33.1	35.2	35.3
60010a	Unoccupied	372900	5213255	26.9	36.9	38.7	38.9
60012a	Unoccupied	371877	5212797	22.2	32.2	34.3	34.4
60016	Occupied	372129	5214610	32.7	42.7	43.4	43.6
60018a	Occupied	371895	5212263	20.6	30.6	32.8	32.9
60020a	Occupied	372243	5211194	18.3	28.3	30.9	31.0
60024a	Occupied	372255	5209130	11.8	21.8	24.3	24.4
60027a	Occupied	373800	5209328	12.2	22.2	24.6	24.6

Table 7a. Summary of WTG Acoustic Model Output at Receptors for Planned WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
60028	Occupied	373971	5209320	12.0	22.0	24.8	24.9
60035	Occupied	374268	5209331	11.5	21.5	20.4	20.5
60040	Non-Residential	375079	5209360	9.1	19.1	23.3	23.4
60042	Occupied	375320	5209336	9.7	19.7	21.7	21.8
60044	Occupied	375770	5209460	7.8	17.8	20.9	21.0
60048	Occupied	376397	5210435	12.2	22.2	24.9	24.9
60052	Occupied	376671	5210591	12.4	22.4	25.0	25.1
60054	Occupied	376515	5211062	10.6	20.6	21.6	21.7
60058	Occupied	376209	5210903	13.5	23.5	26.1	26.2
60062	Occupied	375973	5210859	13.6	23.6	22.1	22.1
60066	Occupied	375965	5211018	14.0	24.0	26.5	26.6
60070	Occupied	376164	5212140	16.9	26.9	29.3	29.4
60076	Occupied	376229	5212642	17.8	27.8	30.6	30.6
60080	Occupied	369491	5212432	18.7	28.7	30.5	30.6
60083	Occupied	368754	5212014	14.2	24.2	27.8	27.9
60085	Occupied	368637	5211618	13.4	23.4	27.7	27.8
60090	Occupied	368671	5211608	13.2	23.2	27.0	27.1
60092	Occupied	368562	5211213	13.8	23.8	24.9	25.0
390002	Non-Residential	372431	5226918	35.9	45.9	46.6	46.8
390019	Non-Residential	369513	5212867	16.0	26.0	28.5	28.6
5000000	Non-Residential	378668	5221147	12.0	22.0	25.2	25.3
5000001	Non-Residential	357665	5265179	<0	<0	<0	<0
5000002	Non-Residential	358371	5268393	<0	<0	<0	<0
5000003	Non-Residential	351536	5260919	<0	<0	<0	<0
5000004	Non-Residential	351563	5260995	<0	<0	<0	<0
5000005	Non-Residential	341888	5259710	<0	<0	<0	<0
5000006	Non-Residential	341858	5259899	<0	<0	<0	<0
5000007	Non-Residential	339062	5256981	<0	<0	<0	<0
5000008	Non-Residential	339061	5256780	<0	<0	<0	<0
5000012	Non-Residential	337209	5248969	<0	<0	<0	<0
Number of Potential Exceedances of EPA Noise Guideline at Receptors (48.6 dBA)				**None**	**3**	**3**	**4**

Table 7b. Summary of WTG Acoustic Model Output at Receptors for Planned and Alternate WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
2011	Occupied	383232	5219483	<0	<0	<0	<0
2012	Unoccupied	380630	5217738	5.5	15.5	18.2	18.2
2013	Non-Residential	380100	5218948	3.6	13.6	16.3	16.4
2014	Non-Residential	379983	5218952	8.9	18.9	21.6	21.7
2015	Occupied	376198	5217497	20.4	30.4	32.8	32.9
2016	Occupied	372754	5218312	33.3	43.3	44.1	44.3
2018	Occupied	368373	5219341	28.9	38.9	40.7	40.7
2019	Occupied	367510	5219031	28.9	38.9	40.5	40.6
2020	Occupied	365973	5217765	28.2	38.2	39.6	39.7
2020	Occupied	369311	5219083	33.4	43.4	44.3	44.4
2024	Occupied	369232	5219059	32.8	42.8	43.7	43.8
2025a	Unoccupied	370431	5218318	38.9	48.9	49.2	49.3
2027	Unoccupied	369737	5218420	41.8	51.8	51.9	52.2
2028	Occupied	371097	5217187	35.5	45.5	46.2	46.4
2030	Occupied	374516	5216892	28.7	38.7	40.4	40.5
2036	Occupied	372317	5216000	33.3	43.3	44.4	44.6
2041	Occupied	371025	5215602	32.1	42.1	43.5	43.6
2045	Occupied	370218	5216534	34.7	44.7	45.6	45.7
2047	Occupied	370195	5216578	35.0	45.0	45.8	45.9
2051	Occupied	378621	5221835	13.7	23.7	26.3	26.4
2052	Unoccupied	378705	5221297	11.3	21.3	24.0	24.0
2053	Occupied	379196	5221219	11.2	21.2	23.9	23.9
2053	Occupied	367280	5216355	30.5	40.5	41.6	41.8
2054	Occupied	376457	5222208	15.4	25.4	28.0	28.1
2055	Occupied	376380	5222201	18.5	28.5	31.1	31.2
2056	Occupied	375960	5222198	20.1	30.1	32.6	32.7
2057	Occupied	375513	5220742	17.5	27.5	29.9	30.0
2057a	Occupied	367248	5215913	28.1	38.1	39.8	39.9
2058	Occupied	375404	5220251	19.9	29.9	32.4	32.5
2059	Occupied	374606	5221973	20.4	30.4	32.9	33.0
2060	Occupied	374367	5222200	22.2	32.2	34.6	34.7
2060a	Occupied	368839	5215450	31.2	41.2	42.3	42.5
2061	Non-Residential	373618	5222265	24.0	34.0	36.3	36.4
2062	Occupied	372289	5222275	27.9	37.9	39.5	39.7
2063	Occupied	372584	5220687	26.7	36.7	38.8	38.9
2063	Unoccupied	373499	5211684	36.8	46.8	47.4	47.4
2064	Unoccupied	366589	5221003	21.3	31.3	33.7	33.8
2065	Occupied	366333	5220865	20.4	30.4	32.8	32.9
2066	Occupied	366175	5220821	20.2	30.2	32.7	32.8
2066a	Occupied	365765	5216992	27.2	37.2	38.7	38.8
2067	Occupied	366079	5220821	17.4	27.4	29.8	29.9
2068	Occupied	364110	5219367	17.7	27.7	30.2	30.3
6096	Occupied	366619	5217768	34.0	44.0	44.3	44.5
6099	Occupied	366688	5218078	31.8	41.8	42.5	42.7
6100a	Occupied	372687	5220626	26.3	36.3	38.3	38.4
40001a	Occupied	376933	5223953	19.0	29.0	31.5	31.6
40011a	Non-Residential	375671	5223949	22.6	32.6	35.0	35.0
40018a	Occupied	375524	5224880	24.5	34.5	36.7	36.8
40021a	Occupied	376428	5227682	26.7	36.7	38.4	38.5

Table 7b. Summary of WTG Acoustic Model Output at Receptors for Planned and Alternate WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
40025	Occupied	375732	5229916	24.9	34.9	36.8	36.9
40028a	Non-Residential	375368	5229059	33.1	43.1	43.5	43.8
40031	Occupied	375434	5226226	28.0	38.0	39.8	39.9
40033	Occupied	373882	5225842	33.1	43.1	44.1	44.2
40037a	Occupied	373984	5228148	35.2	45.2	45.7	45.8
40039	Occupied	373837	5227612	38.1	48.1	48.3	48.4
40044	Occupied	375953	5224137	22.2	32.2	34.6	34.6
40049	Non-Residential	373825	5224083	28.6	38.6	40.2	40.3
40051	Occupied	373899	5223691	26.8	36.8	38.8	38.8
40055a	Occupied	372334	5224178	33.7	43.7	44.4	44.5
40060	Unoccupied	372120	5223886	34.2	44.2	44.8	45.0
40063a	Unoccupied	372312	5224843	35.5	45.5	46.2	46.3
40066	Occupied	372315	5225695	36.7	46.7	47.2	47.4
40069	Unoccupied	372228	5226802	37.3	47.3	47.7	47.8
40070a	Unoccupied	372259	5227439	37.8	47.8	48.1	48.3
40074a	Non-Residential	370668	5225623	37.0	47.0	47.4	47.5
40076a	Non-Residential	370151	5225694	33.0	43.0	44.0	44.1
40077	Occupied	370102	5225602	33.0	43.0	43.8	44.0
40081	Occupied	369701	5225578	31.2	41.2	42.4	42.6
40086	Occupied	368967	5226144	34.0	44.0	44.4	44.5
40089	Occupied	367924	5226018	34.0	44.0	44.2	44.5
40093a	Occupied	367907	5226008	33.8	43.8	44.1	44.3
40097	Occupied	368972	5227351	34.8	44.8	45.1	45.4
40099	Occupied	367401	5228151	24.2	34.2	36.1	36.3
40100	Occupied	367556	5227926	25.9	35.9	37.5	37.7
40105a	Occupied	367270	5227370	26.9	36.9	38.4	38.5
40107a	Occupied	365871	5224958	17.9	27.9	30.2	30.4
40110b	Occupied	366065	5224523	16.5	26.5	28.9	29.0
40112	Occupied	371312	5222602	33.8	43.8	44.2	44.4
40116a	Occupied	372859	5222443	26.6	36.6	38.6	38.7
40120	Occupied	373474	5222500	25.1	35.1	37.3	37.4
40124	Occupied	374934	5222439	21.5	31.5	33.9	34.0
40125a	Non-Residential	372393	5227947	36.6	46.6	46.9	47.0
40128	Non-Residential	372293	5228874	29.1	39.1	40.6	40.7
40130a	Unoccupied	375933	5228266	31.3	41.3	42.1	42.2
40134a	Occupied	371186	5223960	36.8	46.8	47.1	47.4
40135	Occupied	371067	5223960	36.6	46.6	46.9	47.2
40139a	Non-Residential	369726	5224097	32.0	42.0	42.8	43.1
40140a	Unoccupied	368909	5223606	25.7	35.7	37.6	37.8
40142	Non-Residential	367963	5222567	21.3	31.3	33.8	33.9
40149a	Occupied	367475	5223178	21.2	31.2	33.7	33.8
40152a	Unoccupied	365746	5223799	16.6	26.6	29.2	29.3
40155a	Occupied	366297	5223595	18.2	28.2	30.7	30.8
40193	Unoccupied	365836	5222281	17.1	27.1	29.6	29.7
40196	Occupied	365654	5221719	17.9	27.9	30.4	30.5
40198	Occupied	365596	5221731	18.1	28.1	30.7	30.8
40323	Occupied	365791	5225833	20.0	30.0	32.3	32.4
40324	Non-Residential	365832	5226445	20.4	30.4	32.6	32.7
40326	Non-Residential	365834	5226625	18.8	28.8	31.0	31.1

Table 7b. Summary of WTG Acoustic Model Output at Receptors for Planned and Alternate WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
40329	Occupied	364837	5227355	16.4	26.4	28.8	28.9
40333a	Occupied	365619	5228487	17.7	27.7	30.1	30.2
40336a	Unoccupied	373387	5228862	30.3	40.3	41.7	41.8
40342	Non-Residential	370909	5226405	34.6	44.6	45.3	45.4
40343	Unoccupied	370818	5228021	29.1	39.1	40.6	40.8
41013a	Non-Residential	368951	5226825	39.4	49.4	49.5	49.7
41014a	Non-Residential	368950	5226845	39.5	49.5	49.6	49.9
60002a	Unoccupied	375123	5214163	29.4	39.4	41.2	41.2
60005	Non-Residential	372824	5212708	40.6	50.6	50.8	50.8
60010a	Unoccupied	372900	5213255	37.8	47.8	48.3	48.4
60012a	Unoccupied	371877	5212797	35.1	45.1	46.0	46.0
60016	Occupied	372129	5214610	36.7	46.7	47.2	47.3
60018a	Occupied	371895	5212263	34.4	44.4	45.5	45.5
60020a	Occupied	372243	5211194	33.5	43.5	44.6	44.6
60024a	Occupied	372255	5209130	28.1	38.1	39.6	39.6
60027a	Occupied	373800	5209328	28.4	38.4	40.2	40.2
60028	Occupied	373971	5209320	28.1	38.1	39.9	39.9
60035	Occupied	374268	5209331	28.3	38.3	40.1	40.1
60040	Non-Residential	375079	5209360	29.4	39.4	40.8	40.8
60042	Occupied	375320	5209336	29.6	39.6	40.9	40.9
60044	Occupied	375770	5209460	30.2	40.2	41.2	41.2
60048	Occupied	376397	5210435	32.9	42.9	43.4	43.4
60052	Occupied	376671	5210591	30.2	40.2	41.3	41.3
60054	Occupied	376515	5211062	31.2	41.2	42.3	42.3
60058	Occupied	376209	5210903	34.4	44.4	44.7	44.8
60062	Occupied	375973	5210859	36.9	46.9	47.0	47.1
60066	Occupied	375965	5211018	36.5	46.5	46.8	46.8
60070	Occupied	376164	5212140	31.9	41.9	42.9	42.9
60076	Occupied	376229	5212642	28.1	38.1	39.7	39.7
60080	Occupied	369491	5212432	33.3	43.3	44.2	44.2
60083	Occupied	368754	5212014	29.7	39.7	41.2	41.2
60085	Occupied	368637	5211618	29.0	39.0	40.5	40.5
60090	Occupied	368671	5211608	29.2	39.2	40.6	40.6
60092	Occupied	368562	5211213	28.2	38.2	39.7	39.7
390002	Non-Residential	372431	5226918	36.6	46.6	47.0	47.2
390019	Non-Residential	369513	5212867	36.7	46.7	47.0	47.0
5000000	Non-Residential	378668	5221147	12.5	22.5	25.2	25.3
5000001	Non-Residential	357665	5265179	<0	<0	<0	<0
5000002	Non-Residential	358371	5268393	<0	<0	<0	<0
5000003	Non-Residential	351536	5260919	<0	<0	<0	<0
5000004	Non-Residential	351563	5260995	<0	<0	<0	<0
5000005	Non-Residential	341888	5259710	<0	<0	<0	<0
5000006	Non-Residential	341858	5259899	<0	<0	<0	<0
5000007	Non-Residential	339062	5256981	<0	<0	<0	<0
5000008	Non-Residential	339061	5256780	<0	<0	<0	<0
5000012	Non-Residential	337209	5248969	<0	<0	<0	<0
Number of Potential Exceedances of EPA Noise Guideline at Receptors (48.6 dBA)				**None**	**5**	**5**	**5**

The manufacturers' guaranteed maximum sound power level of 106 dBA for full implementation of the Wind Boost enhanced GE 1.6 xle for the Baldwin Project area. Reported sound pressure levels are representative of receptors located downwind of the WTGs; lower sound levels are expected in other directions dependent on wind velocities, speed, direction, and gustiness. The acoustic modeling results were compared to the broadband (dBA) guideline criteria as described in Section 2.0 of this report, specifically the EPA broadband guideline of 55 dBA L_{dn} (equivalent to a $L_{eq\ (1\text{-hour})}$ of 48.6 dBA assuming continuous 24-hour operation), which was used as a Project design goal.

The EPA guideline limits presented in Section 2.1 are based on the yearly L_{dn}. To calculate the yearly L_{dn}, knowledge of future atmospheric conditions across the entire site over an extended time period are required to determine the long term sound exposure. The conservative approach employed in the Baldwin Wind Energy Center acoustic assessment assumed a sustained wind speed in excess of 8 m/s (17.9 mph) at WTG hub height over a continuous one year period. Actual wind speeds and directions over the course of a year will vary.

The yearly L_{dn} is calculated using the following equation per the EPA guidance document:

$$Yearly\ L_{dn}(exterior) = 10 \cdot \log_{10}\left[\frac{\left(15 \cdot 10^{\left(Leq(1-hour)/10\right)} + 9 \cdot 10^{\left((Leq(1-hour)+10)/10\right)}\right)}{24}\right] dBA$$

To calculate yearly L_{dn}, the $L_{eq\ (1\text{-hour})}$ in the above equation was assigned the value of the Project-generated instantaneous maximum sound level for the WTG operating condition under analysis (cut-in or at full rotational speed). Under real world meteorological conditions wind speed and direction will be variable. Over the course of a year, the actual received sound pressure levels as a result of Project operations will fluctuate from periods of calm or low level wind speeds, to wind speeds ranging from cut-in up to maximum rotational. During periods of calm and low level wind speeds below the rated cut-in wind speeds when WTGs will not operate, the Project will generate negligible sound. For time-varying sources, including wind energy projects, assessing sound levels generated during maximum rotational will ensure compliance during all other WTG operational conditions. Though this worst-case continuous operating scenario is not a realistic scenario, the intention of employing this calculation methodology is to provide a further level of conservatism in the acoustic assessment approach.

4.2 Compliance Determination

Project operational sound has been calculated and compared to relevant environmental noise criteria as established by the EPA and OSHA. Table 8 summarizes sound modeling results for Project cut-in and maximum rotational speeds as may occur during moderate wind velocities and during certain anomalous meteorological conditions. Table 8 also summarizes results for the Project at maximum rotation speeds under anomalous meteorological conditions in conjunction with the Project substation

Table 8. Summary of Modeling Results and Comparison to EPA Guidelines at Existing Occupied Residential Receptors

Operating Scenario	Potential Exceedances of EPA Guideline (48.6 dBA)	
	Planned WTGs	Planned and Alternate WTGs
Cut-in Operation	None	None
Maximum Rotational	ID 2050	ID 2050
Maximum Rotational – Anomalous Meteorological Conditions	ID 2050	ID 2050
Maximum Rotational – Anomalous Meteorological Conditions with Substation	ID 2050	ID 2050

Acoustic modeling analysis results showed potential exceedances of the 55 dBA L_{dn} EPA noise guideline at four receptors when modeling the planned WTGs under maximum rotational wind speeds (during anomalous meteorological conditions and including the substation) and five receptors when modeling the planned and alternate WTGs under maximum rotational wind speeds (during anomalous weather conditions and including the substation). Of these exceedances, none occur at an existing occupied residence, according to the Project Farmstead Report and additional information provided by NextEra. All exceedances occur at receptors that have been categorized as unoccupied or used for non-residential purposes; therefore, these exceedances can be considered insignificant. Results indicate that the Project has been adequately designed to operate in compliance with EPA noise guidelines at all remaining noise sensitive receptors.

The EPA guideline limits identified are not legally enforceable requirements, but serve as useful guidelines to determine the likelihood of adverse community noise impacts. The EPA guidelines do not require inaudibility of a sound source. In fact, even if a Project-generated received sound level is below ambient conditions, the spectral and temporal characteristics of the new sound may result in perceptibility. The results of the acoustic modeling analysis indicate that operation of the Project may result in periodically audible sound within the adjacent areas under certain operational and meteorological conditions. Individual response to low-level WTG sound is largely subjective and therefore not easily predictable and may depend on several technical and non-technical factors, including predetermined perceptions of the Project and wind energy in general, individual and community economic incentives, existing background sound levels, the proximity of the listener to a single or grouping of WTGs, among several others. Due to their support of Project development, Project participants have been found to be less likely to become annoyed by low-level WTG sound than non-participants. Non-participants that consider the development of renewable energy sources, and wind energy projects specifically, as beneficial will also be more likely to deem the low-level environmental noise as generally acceptable. Nonetheless, complaints about noise from wind energy projects may still occur, even when fixed-level noise criteria or standards are met.

In conclusion, the acoustic modeling analysis, inclusive of a number of conservative assumptions has been shown to be adequately designed to operate in compliance with EPA guideline limits. Sound from the Project when audible will likely not be deemed excessive or unusually loud at the setback distance in place and will be consistent with sound generated at similar wind energy projects successfully sited throughout the state of North Dakota employing similar noise criteria limits.

5.0 OTHER SOUND CONSIDERATIONS

5.1 Cumulative Effects

An assessment of cumulative environmental impacts considers the potential impact of a proposed Project in the context of existing developments to ensure that any potential environmental impacts are not considered in isolation. The cumulative effects can result from individually minor, but collectively more significant actions taking place over a given period of time. Cumulative impacts are impacts that result from the incremental consequences of a project when added to other past wind energy developments. A wind energy development would need to be located within approximately 2 to 3 km of the proposed wind farm in order to present a possible cumulative influence on sound. The Project was considered in association the Wilton I and II Wind Energy Centers, adjacent to one another and running east-west through the Baldwin Project area. The Wilton I and II Wind Energy Centers have been constructed and are currently generating electricity, consisting of a total of 66 GE xle 1.5 MW WTGs with a rotor diameter of 270 feet (82.5 meters) and an effective hub height of 262.5 feet (80 meters) above grade. Table 9 provides a summary of sound power data for the GE 1.5 MW xle WTG correlated by wind speed at a height of 10 meters (32.8 ft) above grade. A confidence interval of K=2 dB was incorporated into the acoustic modeling analysis.

Table 9. Broadband Sound Power Levels (dBA) Correlated with Wind Speed

	WTG L_{max} Sound Power Level (L_W) at Reference Wind Speed						
10-meter AGL Wind Speed	9 mph (4 m/s)	11.2 mph (5 m/s)	13.4 mph (6 m/s)	15.9 mph (7 m/s)	17.9 mph (8 m/s)	20.1 mph (9 m/s)	22.4 mph (10 m/s)
GE 1.5 MW xle	<96	<96	98.8	102.3	<104.0	<104.0	<104.0

A summary of sound power data for the GE 1.5 MW xle by octave band center frequency is presented in Table 10.

Table 10. GE 1.5 MW xle Sound Power Level by Octave Band Center Frequency

Frequency (Hz)	Octave Band Sound Power Level (dBA)								Broadband (dBA)
	63	125	250	500	1000	2000	4000	8000	
GE 1.5 MW xle	83.4	92.2	97.8	99.4	97.7	93.4	86.6	84.8	104.0

The existing Wilton I, and Wilton II and proposed Baldwin wind energy projects would invariably operate concurrently; therefore a cumulative impact assessment was completed. Received sound levels resulting from concurrent operation of the as-built Wilton I and II Wind Energy Centers and the Baldwin Wind Energy Center assuming only the planned WTGs and planned plus alternate WTGs are presented at all noise sensitive receptors in Tables 11a and 11b, respectively. In addition, cumulative effects were assessed for all WTGs in conjunction with operation of two on-site electrical substations servicing the Wilton I, Wilton II, and Baldwin Wind Energy Centers.

Table 11a. Cumulative Effects for Wilton I, II and Baldwin Planned WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
2011	Occupied	383232	5219483	34.2	42.2	42.2	42.2
2012	Unoccupied	380630	5217738	25.1	33.2	35.1	35.1
2013	Non-Residential	380100	5218948	36.5	44.5	44.7	44.7
2014	Non-Residential	379983	5218952	37.9	45.9	46.0	46.0
2015	Occupied	376198	5217497	27.8	36.1	38.0	38.1
2016	Occupied	372754	5218312	34.8	44.3	45.3	45.6
2018	Occupied	368373	5219341	36.9	45.2	46.1	46.1
2019	Occupied	367510	5219031	38.1	46.4	46.9	47.0
2020	Occupied	365973	5217765	32.0	40.9	42.2	42.4
2020	Occupied	369311	5219083	37.9	46.5	47.2	47.4
2024	Occupied	369232	5219059	38.1	46.6	47.2	47.3
2025a	Unoccupied	370431	5218318	39.3	49.0	49.5	49.7
2027	Unoccupied	369737	5218420	45.8	54.6	54.8	55.1
2028	Occupied	371097	5217187	35.8	45.6	46.4	46.6
2030	Occupied	374516	5216892	29.9	39.3	41.1	41.2
2036	Occupied	372317	5216000	33.2	43.1	44.2	44.4
2041	Occupied	371025	5215602	31.4	41.2	42.6	42.9
2045	Occupied	370218	5216534	34.9	44.7	45.6	45.8
2047	Occupied	370195	5216578	35.1	45.0	45.7	46.0
2051	Occupied	378621	5221835	24.3	32.5	34.8	34.9
2052	Unoccupied	378705	5221297	25.0	33.1	35.1	35.1
2053	Occupied	379196	5221219	26.0	34.0	36.1	36.1
2053	Occupied	367280	5216355	31.2	40.9	42.1	42.4
2054	Occupied	376457	5222208	24.7	32.9	35.2	35.3
2055	Occupied	376380	5222201	25.6	34.0	36.4	36.4
2056	Occupied	375960	5222198	26.3	34.8	37.2	37.2
2057	Occupied	375513	5220742	30.8	38.9	40.6	40.6
2057a	Occupied	367248	5215913	28.6	38.2	39.9	40.2
2058	Occupied	375404	5220251	33.4	41.5	42.8	42.8
2059	Occupied	374606	5221973	29.4	37.6	39.5	39.5
2060	Occupied	374367	5222200	29.0	37.4	39.4	39.4
2060a	Occupied	368839	5215450	31.1	40.9	42.0	42.3
2061	Non-Residential	373618	5222265	29.8	38.3	40.2	40.3
2062	Occupied	372289	5222275	32.9	41.6	43.1	43.3
2063	Occupied	372584	5220687	37.7	45.8	46.7	46.7
2063	Unoccupied	373499	5211684	19.8	29.7	32.0	32.2
2064	Unoccupied	366589	5221003	29.7	38.0	39.9	40.0
2065	Occupied	366333	5220865	29.0	37.3	39.3	39.3
2066	Occupied	366175	5220821	28.7	37.0	39.0	39.1
2066a	Occupied	365765	5216992	29.3	38.6	40.1	40.4
2067	Occupied	366079	5220821	26.3	34.6	36.6	36.6
2068	Occupied	364110	5219367	28.4	36.6	38.0	38.0
6096	Occupied	366619	5217768	35.5	45.0	45.5	45.7
6099	Occupied	366688	5218078	35.6	44.5	45.2	45.3
6100a	Occupied	372687	5220626	37.0	45.2	46.1	46.1
40001a	Occupied	376933	5223953	21.0	30.1	32.6	32.8
40011a	Non-Residential	375671	5223949	24.5	33.6	36.1	36.2
40018a	Occupied	375524	5224880	25.0	34.5	36.8	37.0
40021a	Occupied	376428	5227682	26.4	36.4	38.1	38.4
40025	Occupied	375732	5229916	24.6	34.6	36.4	36.7

Table 11a. Cumulative Effects for Wilton I, II and Baldwin Planned WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
40028a	Non-Residential	375368	5229059	33.0	43.0	43.4	43.9
40031	Occupied	375434	5226226	27.8	37.7	39.5	39.7
40033	Occupied	373882	5225842	32.5	42.4	43.4	43.6
40037a	Occupied	373984	5228148	34.4	44.4	44.9	45.1
40039	Occupied	373837	5227612	37.4	47.4	47.6	47.8
40044	Occupied	375953	5224137	24.0	33.2	35.6	35.7
40049	Non-Residential	373825	5224083	27.1	36.6	38.8	39.0
40051	Occupied	373899	5223691	27.4	36.6	38.9	39.0
40055a	Occupied	372334	5224178	33.1	42.9	43.8	44.1
40060	Unoccupied	372120	5223886	34.3	44.1	44.8	45.1
40063a	Unoccupied	372312	5224843	33.5	43.4	44.4	44.7
40066	Occupied	372315	5225695	36.3	46.3	46.8	47.2
40069	Unoccupied	372228	5226802	37.0	47.0	47.4	47.6
40070a	Unoccupied	372259	5227439	37.2	47.1	47.5	47.9
40074a	Non-Residential	370668	5225623	36.8	46.7	47.1	47.4
40076a	Non-Residential	370151	5225694	32.5	42.4	43.5	43.8
40077	Occupied	370102	5225602	32.4	42.3	43.3	43.7
40081	Occupied	369701	5225578	30.8	40.7	42.1	42.4
40086	Occupied	368967	5226144	34.0	44.0	44.4	44.7
40089	Occupied	367924	5226018	34.1	44.0	44.3	44.8
40093a	Occupied	367907	5226008	33.9	43.8	44.1	44.6
40097	Occupied	368972	5227351	34.8	44.8	45.1	45.6
40099	Occupied	367401	5228151	24.3	34.2	36.1	36.4
40100	Occupied	367556	5227926	25.9	35.9	37.5	37.8
40105a	Occupied	367270	5227370	27.0	36.9	38.4	38.7
40107a	Occupied	365871	5224958	19.2	28.7	31.1	31.3
40110b	Occupied	366065	5224523	19.3	28.4	30.8	31.0
40112	Occupied	371312	5222602	35.8	45.1	45.8	46.2
40116a	Occupied	372859	5222443	31.0	39.8	41.7	41.8
40120	Occupied	373474	5222500	29.9	38.5	40.6	40.7
40124	Occupied	374934	5222439	27.5	36.0	38.2	38.3
40125a	Non-Residential	372393	5227947	35.4	45.4	45.8	46.1
40128	Non-Residential	372293	5228874	27.8	37.8	39.4	39.6
40130a	Unoccupied	375933	5228266	31.2	41.2	41.9	42.3
40134a	Occupied	371186	5223960	36.8	46.7	47.1	47.6
40135	Occupied	371067	5223960	36.6	46.5	46.9	47.5
40139a	Non-Residential	369726	5224097	31.9	41.6	42.6	43.1
40140a	Unoccupied	368909	5223606	26.7	36.2	38.2	38.5
40142	Non-Residential	367963	5222567	28.1	36.5	38.7	38.8
40149a	Occupied	367475	5223178	25.7	34.4	36.8	36.9
40152a	Unoccupied	365746	5223799	21.2	30.0	32.5	32.6
40155a	Occupied	366297	5223595	22.8	31.5	34.0	34.1
40193	Unoccupied	365836	5222281	24.1	32.6	34.9	35.0
40196	Occupied	365654	5221719	25.2	33.6	36.0	36.0
40198	Occupied	365596	5221731	25.2	33.6	35.9	36.0
40323	Occupied	365791	5225833	21.2	30.7	33.1	33.3
40324	Non-Residential	365832	5226445	21.0	30.7	32.9	33.2
40326	Non-Residential	365834	5226625	19.1	29.0	31.2	31.4
40329	Occupied	364837	5227355	16.4	26.3	28.8	29.0
40333a	Occupied	365619	5228487	17.4	27.4	29.8	30.1

Table 11a. Cumulative Effects for Wilton I, II and Baldwin Planned WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
40336a	Unoccupied	373387	5228862	28.6	38.5	40.3	40.5
40342	Non-Residential	370909	5226405	34.4	44.4	45.1	45.3
40343	Unoccupied	370818	5228021	28.8	38.7	40.2	40.5
41013a	Non-Residential	368951	5226825	39.4	49.4	49.5	50.0
41014a	Non-Residential	368950	5226845	39.5	49.5	49.6	50.2
60002a	Unoccupied	375123	5214163	26.6	36.4	38.1	38.2
60005	Non-Residential	372824	5212708	23.3	33.2	35.1	35.4
60010a	Unoccupied	372900	5213255	27.2	37.1	38.7	38.9
60012a	Unoccupied	371877	5212797	22.5	32.4	34.5	34.7
60016	Occupied	372129	5214610	33.0	42.9	43.6	44.0
60018a	Occupied	371895	5212263	20.8	30.7	33.0	33.2
60020a	Occupied	372243	5211194	18.5	28.4	30.9	31.1
60024a	Occupied	372255	5209130	11.8	21.8	24.4	24.6
60027a	Occupied	373800	5209328	12.2	22.2	24.8	25.0
60028	Occupied	373971	5209320	12.0	22.0	24.6	24.7
60035	Occupied	374268	5209331	11.5	21.5	24.0	24.2
60040	Non-Residential	375079	5209360	9.1	19.1	21.7	21.9
60042	Occupied	375320	5209336	9.7	19.7	22.3	22.5
60044	Occupied	375770	5209460	7.8	17.8	20.4	20.5
60048	Occupied	376397	5210435	12.2	22.2	24.8	25.0
60052	Occupied	376671	5210591	12.4	22.4	25.0	25.2
60054	Occupied	376515	5211062	10.6	20.6	23.2	23.4
60058	Occupied	376209	5210903	13.5	23.5	26.1	26.2
60062	Occupied	375973	5210859	13.6	23.6	26.1	26.3
60066	Occupied	375965	5211018	14.0	24.0	26.5	26.6
60070	Occupied	376164	5212140	18.1	27.7	30.1	30.3
60076	Occupied	376229	5212642	19.3	28.8	31.2	31.4
60080	Occupied	369491	5212432	19.7	29.3	31.8	32.0
60083	Occupied	368754	5212014	14.9	24.7	27.2	27.4
60085	Occupied	368637	5211618	13.9	23.7	26.3	26.5
60090	Occupied	368671	5211608	13.7	23.5	26.1	26.3
60092	Occupied	368562	5211213	14.1	24.0	26.6	26.8
390002	Non-Residential	372431	5226918	36.0	46.0	46.5	46.8
390019	Non-Residential	369513	5212867	17.1	26.7	29.2	29.4
5000000	Non-Residential	378668	5221147	26.6	34.7	36.7	36.7
5000001	Non-Residential	357665	5265179	<0	<0	<0	<0
5000002	Non-Residential	358371	5268393	<0	<0	<0	<0
5000003	Non-Residential	351536	5260919	<0	<0	<0	<0
5000004	Non-Residential	351563	5260995	<0	<0	<0	<0
5000005	Non-Residential	341888	5259710	<0	<0	<0	<0
5000006	Non-Residential	341858	5259899	<0	<0	<0	<0
5000007	Non-Residential	339062	5256981	<0	<0	<0	<0
5000008	Non-Residential	339061	5256780	<0	<0	<0	<0
5000012	Non-Residential	337209	5248969	<0	<0	<0	<0
Number of Potential Exceedances of EPA Noise Guideline at Receptors (48.6 dBA)				**None**	**4**	**4**	**4**

Table 11b. Cumulative Effects for Wilton I, II and Baldwin Planned and Alternate WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
2011	Occupied	383232	5219483	34.2	42.2	42.2	42.2
2012	Unoccupied	380630	5217738	25.2	33.2	35.1	35.1
2013	Non-Residential	380100	5218948	36.5	44.5	44.7	44.7
2014	Non-Residential	379983	5218952	37.9	45.9	46.0	46.0
2015	Occupied	376198	5217497	28.2	36.4	38.4	38.5
2016	Occupied	372754	5218312	35.0	44.4	45.4	45.7
2018	Occupied	368373	5219341	37.2	45.5	46.4	46.4
2019	Occupied	367510	5219031	38.3	46.5	47.1	47.1
2020	Occupied	365973	5217765	32.2	41.0	42.4	42.5
2020	Occupied	369311	5219083	32.2	47.1	47.8	47.9
2024	Occupied	369232	5219059	38.6	47.1	47.7	47.8
2025a	Unoccupied	370431	5218318	40.0	49.5	49.9	50.1
2027	Unoccupied	369737	5218420	46.1	54.9	55.0	55.3
2028	Occupied	371097	5217187	36.1	45.8	46.6	46.9
2030	Occupied	374516	5216892	30.5	39.8	41.6	41.7
2036	Occupied	372317	5216000	33.9	43.5	44.8	45.0
2041	Occupied	371025	5215602	32.9	42.3	43.8	44.0
2045	Occupied	370218	5216534	35.3	45.0	46.0	46.2
2047	Occupied	370195	5216578	35.5	45.2	46.1	46.3
2051	Occupied	378621	5221835	24.4	32.6	34.9	34.9
2052	Unoccupied	378705	5221297	25.1	33.1	35.2	35.2
2053	Occupied	379196	5221219	26.0	34.1	36.1	36.1
2053	Occupied	367280	5216355	26.0	41.1	42.4	42.6
2054	Occupied	376457	5222208	24.8	33.0	35.4	35.4
2055	Occupied	376380	5222201	25.8	34.2	36.6	36.6
2056	Occupied	375960	5222198	26.6	35.0	37.4	37.5
2057	Occupied	375513	5220742	30.8	38.9	40.6	40.6
2057a	Occupied	367248	5215913	30.8	38.7	40.5	40.7
2058	Occupied	375404	5220251	33.4	41.6	42.8	42.8
2059	Occupied	374606	5221973	29.5	37.8	39.6	39.7
2060	Occupied	374367	5222200	29.3	37.7	39.6	39.7
2060a	Occupied	368839	5215450	28.7	41.5	42.7	43.0
2061	Non-Residential	373618	5222265	30.1	38.6	40.5	40.6
2062	Occupied	372289	5222275	33.1	41.7	43.3	43.4
2063	Occupied	372584	5220687	37.7	45.9	46.7	46.8
2063	Unoccupied	373499	5211684	37.5	46.8	47.4	47.4
2064	Unoccupied	366589	5221003	29.8	38.1	40.1	40.1
2065	Occupied	366333	5220865	29.1	37.4	39.4	39.4
2066	Occupied	366175	5220821	28.8	37.1	39.2	39.2
2066a	Occupied	365765	5216992	29.0	38.8	40.4	40.6
2067	Occupied	366079	5220821	26.4	34.7	36.7	36.7
2068	Occupied	364110	5219367	28.4	36.6	38.1	38.1
6096	Occupied	366619	5217768	35.6	45.0	45.6	45.8
6099	Occupied	366688	5218078	35.7	44.6	45.3	45.4
6100a	Occupied	372687	5220626	37.0	45.2	46.1	46.2
40001a	Occupied	376933	5223953	21.8	30.7	33.3	33.4
40011a	Non-Residential	375671	5223949	25.4	34.3	36.7	36.8
40018a	Occupied	375524	5224880	26.1	35.3	37.6	37.7
40021a	Occupied	376428	5227682	26.8	36.7	38.4	38.7
40025	Occupied	375732	5229916	25.1	34.9	36.8	37.0

Table 11b. Cumulative Effects for Wilton I, II and Baldwin Planned and Alternate WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
40028a	Non-Residential	375368	5229059	33.2	43.1	43.5	44.0
40031	Occupied	375434	5226226	28.5	38.2	40.0	40.2
40033	Occupied	373882	5225842	33.7	43.2	44.2	44.4
40037a	Occupied	373984	5228148	35.6	45.2	45.7	45.9
40039	Occupied	373837	5227612	38.5	48.1	48.3	48.5
40044	Occupied	375953	5224137	24.9	33.8	36.3	36.4
40049	Non-Residential	373825	5224083	30.4	39.1	40.8	40.9
40051	Occupied	373899	5223691	29.3	38.1	40.1	40.2
40055a	Occupied	372334	5224178	34.7	44.0	44.8	45.0
40060	Unoccupied	372120	5223886	34.9	44.5	45.3	45.6
40063a	Unoccupied	372312	5224843	36.6	45.6	46.3	46.5
40066	Occupied	372315	5225695	37.1	46.8	47.3	47.7
40069	Unoccupied	372228	5226802	37.5	47.3	47.8	48.0
40070a	Unoccupied	372259	5227439	38.1	47.8	48.1	48.5
40074a	Non-Residential	370668	5225623	37.3	47.1	47.5	47.7
40076a	Non-Residential	370151	5225694	33.6	43.1	44.2	44.5
40077	Occupied	370102	5225602	33.7	43.2	44.0	44.4
40081	Occupied	369701	5225578	31.9	41.4	42.7	43.0
40086	Occupied	368967	5226144	34.2	44.1	44.5	44.8
40089	Occupied	367924	5226018	34.1	44.1	44.3	44.8
40093a	Occupied	367907	5226008	33.9	43.9	44.2	44.7
40097	Occupied	368972	5227351	34.9	44.9	45.2	45.7
40099	Occupied	367401	5228151	24.5	34.4	36.3	36.5
40100	Occupied	367556	5227926	26.1	36.0	37.7	37.9
40105a	Occupied	367270	5227370	27.1	37.0	38.5	38.8
40107a	Occupied	365871	5224958	19.4	28.9	31.2	31.4
40110b	Occupied	366065	5224523	19.6	28.6	31.1	31.2
40112	Occupied	371312	5222602	35.9	45.2	45.9	46.3
40116a	Occupied	372859	5222443	31.3	40.0	41.9	42.0
40120	Occupied	373474	5222500	30.2	38.8	40.9	41.0
40124	Occupied	374934	5222439	27.8	36.3	38.5	38.6
40125a	Non-Residential	372393	5227947	37.2	46.6	46.9	47.1
40128	Non-Residential	372293	5228874	29.7	39.1	40.6	40.8
40130a	Unoccupied	375933	5228266	31.4	41.3	42.1	42.4
40134a	Occupied	371186	5223960	37.2	47.0	47.4	47.9
40135	Occupied	371067	5223960	37.0	46.8	47.2	47.7
40139a	Non-Residential	369726	5224097	32.9	42.3	43.3	43.7
40140a	Unoccupied	368909	5223606	27.3	36.6	38.7	38.9
40142	Non-Residential	367963	5222567	28.2	36.7	38.9	39.0
40149a	Occupied	367475	5223178	26.0	34.7	37.0	37.1
40152a	Unoccupied	365746	5223799	21.4	30.1	32.6	32.7
40155a	Occupied	366297	5223595	23.0	31.7	34.2	34.3
40193	Unoccupied	365836	5222281	24.3	32.7	35.1	35.2
40196	Occupied	365654	5221719	25.4	33.8	36.1	36.2
40198	Occupied	365596	5221731	25.3	33.7	36.1	36.1
40323	Occupied	365791	5225833	21.5	30.9	33.3	33.5
40324	Non-Residential	365832	5226445	21.3	30.9	33.2	33.4
40326	Non-Residential	365834	5226625	19.4	29.1	31.3	31.6
40329	Occupied	364837	5227355	16.6	26.5	28.9	29.2
40333a	Occupied	365619	5228487	17.8	27.7	30.1	30.3

Table 11b. Cumulative Effects for Wilton I, II and Baldwin Planned and Alternate WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
40336a	Unoccupied	373387	5228862	31.1	40.3	41.8	41.9
40342	Non-Residential	370909	5226405	34.8	44.6	45.3	45.6
40343	Unoccupied	370818	5228021	29.3	39.1	40.7	40.9
41013a	Non-Residential	368951	5226825	39.4	49.4	49.5	50.0
41014a	Non-Residential	368950	5226845	39.6	49.5	49.7	50.2
60002a	Unoccupied	375123	5214163	30.8	39.5	41.4	41.5
60005	Non-Residential	372824	5212708	42.5	50.6	50.8	50.8
60010a	Unoccupied	372900	5213255	39.7	47.9	48.4	48.4
60012a	Unoccupied	371877	5212797	37.0	45.1	46.0	46.0
60016	Occupied	372129	5214610	38.1	46.8	47.3	47.5
60018a	Occupied	371895	5212263	36.3	44.4	45.5	45.5
60020a	Occupied	372243	5211194	35.5	43.5	44.6	44.6
60024a	Occupied	372255	5209130	30.1	38.1	39.6	39.6
60027a	Occupied	373800	5209328	30.4	38.4	40.2	40.2
60028	Occupied	373971	5209320	30.1	38.1	39.9	39.9
60035	Occupied	374268	5209331	30.2	38.3	40.1	40.1
60040	Non-Residential	375079	5209360	31.4	39.4	40.8	40.8
60042	Occupied	375320	5209336	31.6	39.6	40.9	40.9
60044	Occupied	375770	5209460	32.2	40.2	41.2	41.2
60048	Occupied	376397	5210435	34.9	42.9	43.4	43.4
60052	Occupied	376671	5210591	32.2	40.2	41.3	41.3
60054	Occupied	376515	5211062	33.2	41.2	42.3	42.3
60058	Occupied	376209	5210903	36.3	44.4	44.7	44.8
60062	Occupied	375973	5210859	38.9	46.9	47.0	47.1
60066	Occupied	375965	5211018	38.5	46.5	46.8	46.8
60070	Occupied	376164	5212140	33.9	41.9	42.9	43.0
60076	Occupied	376229	5212642	30.1	38.2	39.8	39.8
60080	Occupied	369491	5212432	35.3	43.3	44.3	44.3
60083	Occupied	368754	5212014	31.7	39.7	41.2	41.2
60085	Occupied	368637	5211618	31.0	39.0	40.5	40.5
60090	Occupied	368671	5211608	31.2	39.2	40.7	40.7
60092	Occupied	368562	5211213	30.1	38.2	39.7	39.7
390002	Non-Residential	372431	5226918	36.9	46.6	47.1	47.4
390019	Non-Residential	369513	5212867	38.7	46.7	47.0	47.0
5000000	Non-Residential	378668	5221147	26.7	34.7	36.8	36.8
5000001	Non-Residential	357665	5265179	<0	<0	<0	<0
5000002	Non-Residential	358371	5268393	<0	<0	<0	<0
5000003	Non-Residential	351536	5260919	<0	<0	<0	<0
5000004	Non-Residential	351563	5260995	<0	<0	<0	<0
5000005	Non-Residential	341888	5259710	<0	<0	<0	<0
5000006	Non-Residential	341858	5259899	<0	<0	<0	<0
5000007	Non-Residential	339062	5256981	<0	<0	<0	<0
5000008	Non-Residential	339061	5256780	<0	<0	<0	<0
5000012	Non-Residential	337209	5248969	<0	<0	<0	<0
Number of Potential Exceedances of EPA Noise Guideline at Receptors (48.6 dBA)				**None**	**5**	**5**	**5**

Modeling results for the cumulative effects assessment are also presented in the form of sound contour level maps. Figures 8, 9, and 10 show the Wilton I, II WTGs with the Baldwin planned WTGs at cut-in

wind speeds, and maximum rotational wind speeds for moderate downwind meteorological conditions and during anomalous meteorological conditions. Figures 11, 12, and 13 show the Wilton I, II WTGs with the Baldwin planned and alternate WTGs for the same operating scenarios. In addition, Table 12 summarizes the findings of the cumulative effects assessment. There are no exceedances at an occupied residence.

Table 12. Summary of Cumulative Modeling Results and Comparison to EPA Guidelines at Existing Occupied Residential Receptors

Operating Scenario	Potential Exceedances of EPA Guideline (48.6 dBA)	
	Wilton I and II and Baldwin Planned WTGs	Wilton I and II and Baldwin Planned and Alternate WTGs
Cut-in Operation	None	None
Maximum Rotational – Moderate Downwind Meteorological Conditions	None	None
Maximum Rotational – Anomalous Downwind Meteorological Conditions	None	None
Maximum Rotational – Anomalous Downwind Meteorological Conditions with Substation	None	None

5.2 Electrical Substation

The substation is an integral part of the Project as it collects and increases the voltage produced by the WTGs to the higher voltage needed for transmission by the local grid system. Sound from the Project electrical substations was examined as part of the Acoustic Assessment. Substations have switching, protection and control equipment and 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 is the principal noise source, dominating in the intermediate frequency range between 100 and 600 Hz. The relative magnitudes of the noise at these different frequency components is dependent on the design of the transformer (i.e., core material, core geometry) and does not vary significantly with the load on the transformer, meaning that the noise generated is largely independent of the transformer load. The load noise is primarily caused by the load current in the transformer's conducting coils (or windings) and consequently the main frequency of this sound is twice the supply frequency; 100 Hz for 50 Hz transformers and 120 Hz for 60 Hz transformers. The cooling equipment (fans and pumps) noise typically dominates the very low and very high frequency ends of the sound spectrum; however, cooling equipment sound is comparatively lower and considered secondary to the sound produced by the core and load.

Transformers are designed and catalogued by kilovolt ampere (kVA) ratings. Just as horsepower ratings designate the power capacity of an electric motor, a transformer's kVA rating indicates its maximum power output capacity. The transformer industry uses the National Electrical Manufacturers Association (NEMA) sound level rating to designate the sound emitted from a transformer. This rating system requires the determination of the average A-weighted sound level at a distance of 0.3 meters (1 foot) from the wall surfaces of the transformer and is specified by the equipment manufacturer. The sound power radiated is a function of the NEMA rating and the total surface area of the four side walls.

The proposed Baldwin electrical substation and as-built substation servicing Wilton I and II Wind Energy Centers were modeled using CadnaA. These substations are centrally located within the Project area. The existing Wilton I and II substations are located at the northwest corner of 279th Avenue NE and 52nd Street NE. The proposed Baldwin substation will be located in close proximity to the Wilton substations, immediately south of 279th Avenue NE. The closest occupied receptor (ID 2020) is approximately 910 meters (2,985 feet) west of the electrical substations. To assess potential impacts of substation operation on nearby residential receptors, a screening level acoustic analysis was conducted using the CadnaA model incorporating site-specific topographic and terrain data and modeled cumulatively with WTG operational scenarios. Transformer sound source levels were estimated for a NEMA sound rating of 82 dBA and are presented in Table 13. The octave band center frequencies were calculated linearly based on the estimate transformer NEMA rating using standard engineering technical guidelines.

Table 13. Transformer Sound Power Level (NEMA 82 dBA)

	Unweighted Octave Band Sound Power Data (dBL)								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
NEMA Rating 82 dBA	100	106	108	103	103	97	92	87	80

Sound contour plots displaying operational broadband (dBA) sound levels in color-coded isopleths corresponding to maximum electrical output are provided in Figures 14 and 15 for the Baldwin and Wilton substations, respectively. Tables 7a and 7b show received sound levels resulting from the Baldwin substation in combination with the planned and planned plus alternate WTGs at maximum rotational wind speed, respectively. Tables 11a and 11b show received sound levels resulting from both the Baldwin and Wilton substations in combination with the Wilton I and II WTGs and Baldwin planned and planned plus alternate WTGs, respectively.

Few complaints from nearby residents are expected regarding substations with transformers less than 10 MVA capacities, except in urban areas with little or no buffer distance attenuation between source and receiver locations. Complaints are more likely at substations with transformer sizes of 10 to 150 MVA with separation distances of 500 to 600 feet or less. In very quiet rural areas where the nighttime ambient acoustic environment can reach levels of 20 to 25 dBA under calm wind conditions, the sound generated from transformers of this size may be periodically audible at distances of half a mile or greater.

5.3 Construction Noise

The development of the Baldwin Wind Energy Center will involve construction to establish access roads, excavate and form WTG foundations, works associated with preparing the site for crane-lifting and actual WTG assembly and commissioning. Work on large-scale wind projects such as the Baldwin Wind Energy Center 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. *Excavation*: This phase would begin with the excavation 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 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 testing and commissioning prior to commencement of full commercial operation. Other construction activities include those for the supporting infrastructure such as the substation, maintenance building, and the overhead transmission lines (although no transmission lines are required for the Project, approximately 250 feet of an existing line is being re-routed).

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 14.

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 should notify the community via public notice or alternative method of 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 should be carefully selected to be as far removed from existing noise sensitive receptors as is practical. Candidate construction noise mitigation measures include scheduling louder construction activities during daytime hours and treating internal combustion engines with appropriate sized muffler systems to minimize noise excessive emissions. If blasting for foundation or other noisy activities are required during the construction period, nearby residents shall be notified in advance.

Table 14. 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

Equipment*	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2000 feet (dBA)
Data compiled in part from the following sources:		
Federal Highway Administration, "Roadway Construction Noise Model User's Guide," Report FHWA-HEP-05-054 / DOT-VNTSC-FHWA-05-01, January 2006.		
Power Plant Construction Noise Guide, Bolt Beranek and Newman, Inc. 1977.		
Federal Highway Administration, "Procedures for Abatement of Highway Traffic Noise and Construction Noise." Code of Federal Regulations, Title 23, Part 772, 1992.		

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.

Federal laws prohibit state and local governments from regulating off-site sound levels generated by trucks and automobiles operating on a private site or public roadways. This federal regulatory preemption is specified in the Federal Noise Control Act of 1972 and in the Surface Transportation Assistance Act of 1982, both of which prohibit states and local authorities from regulating the noise emitted by trucks engaged in interstate commerce, i.e., truck deliveries. A federal OSHA preemption also prohibits local and state governments from regulating safety signals on trucks and construction equipment.

6.0 TECHNICAL REFERENCES

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FIGURES

BALDWIN WIND, LLC

BALDWIN WIND ENERGY CENTER

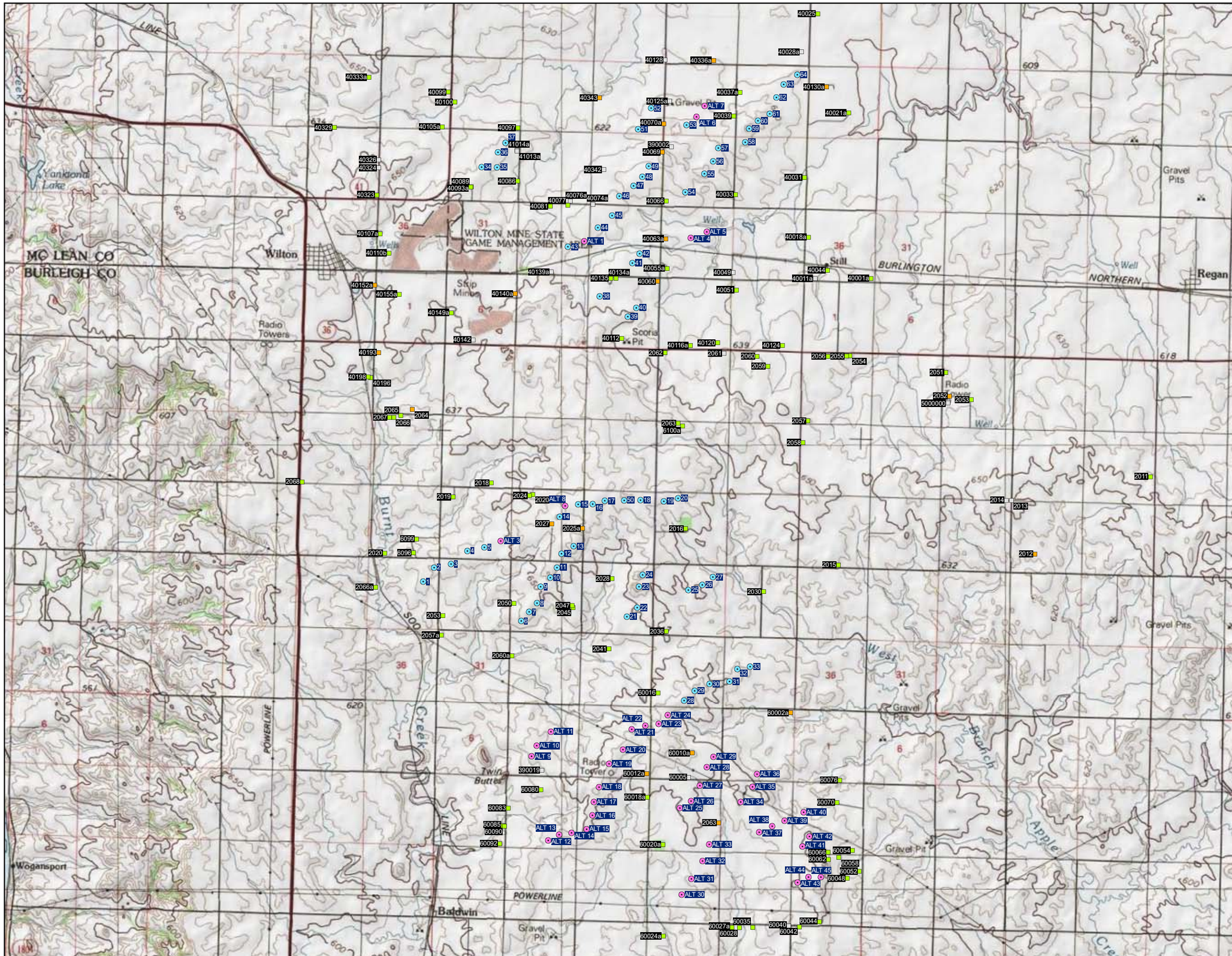
BURLEIGH COUNTY, NORTH DAKOTA

FIGURE 1

PROJECT LAYOUT

MAY 2010

TETRA TECH EC, INC.



Legend

Turbine Location (4-30-2010 layout)

- Planned
- Alternate

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig1....mxd

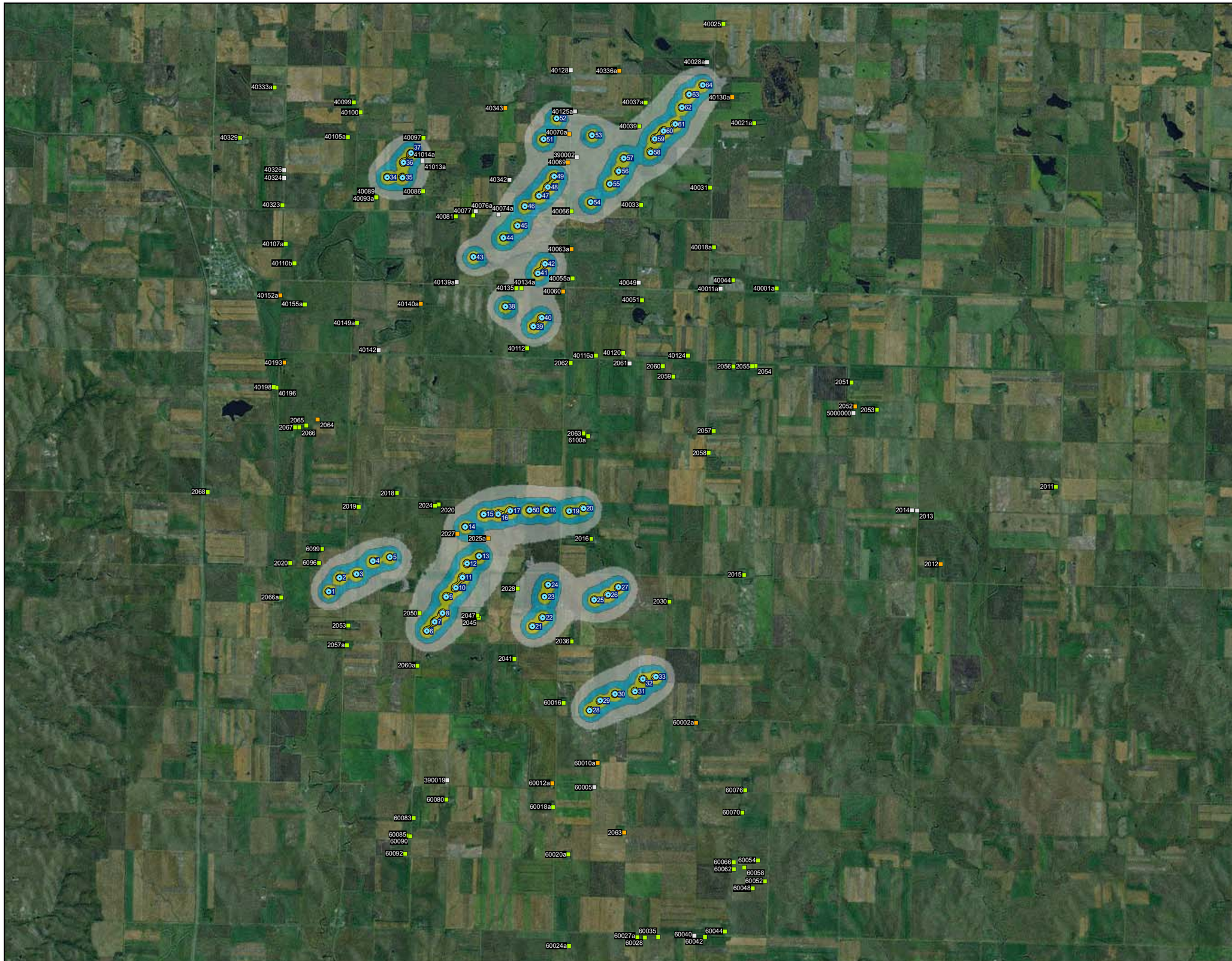


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FIGURE 2
PLANNED WIND TURBINES RECEIVED SOUND LEVELS: WIND TURBINES AT CUT-IN

MAY 2010

TETRA TECH EC, INC.

Legend

Wind Turbine Location (4-30-2010 layout)

- Planned

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig2....mxd

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FIGURE 3
PLANNED WIND TURBINES RECEIVED SOUND LEVELS: MAXIMUM ROTATION

MAY 2010

TETRA TECH EC, INC.

Legend

Wind Turbine Location (4-30-2010 layout)

- Planned

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N
W E
S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig3....mxd

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FIGURE 4
PLANNED WIND TURBINES RECEIVED SOUND LEVELS: MAXIMUM ROTATION

ANOMALOUS METEOROLOGICAL CONDITIONS

MAY 2010

TETRA TECH EC, INC.

Legend

Wind Turbine Location (4-30-2010 layout)

- Planned

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig4....mxd

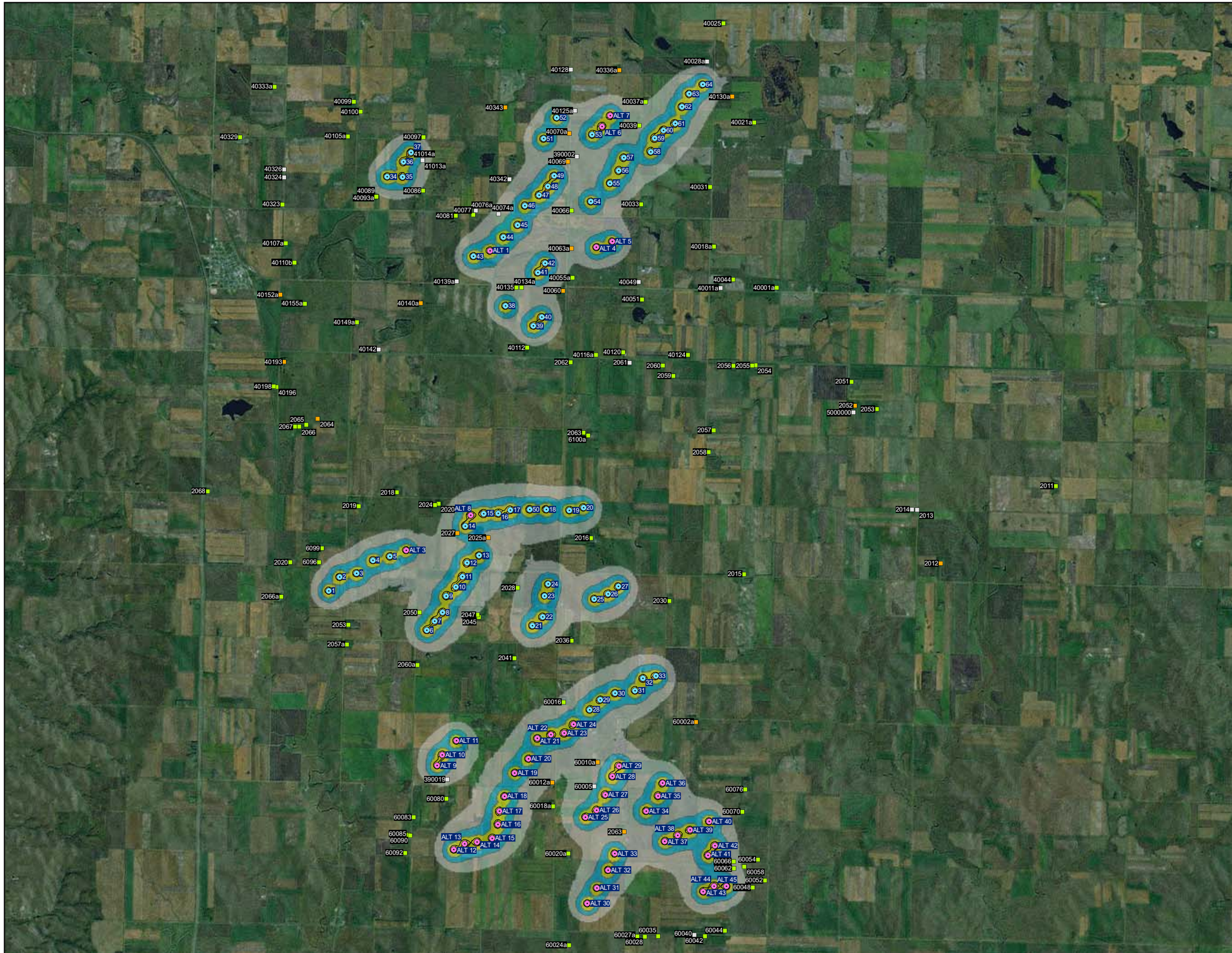

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FIGURE 5
PLANNED & ALTERNATE WIND TURBINES
RECEIVED SOUND LEVELS:
WIND TURBINES AT CUT-IN

MAY 2010

TETRA TECH EC, INC.

Legend

Turbine Location (4-30-2010 layout)

- Planned
- Alternate

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N
W E
S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig5....mxd

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FIGURE 6

PLANNED & ALTERNATE WIND TURBINES

RECEIVED SOUND LEVELS:

MAXIMUM ROTATION

MAY 2010

TETRA TECH EC, INC.

Legend

Turbine Location (4-30-2010 layout)

- Planned
- Alternate

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig6....mxd

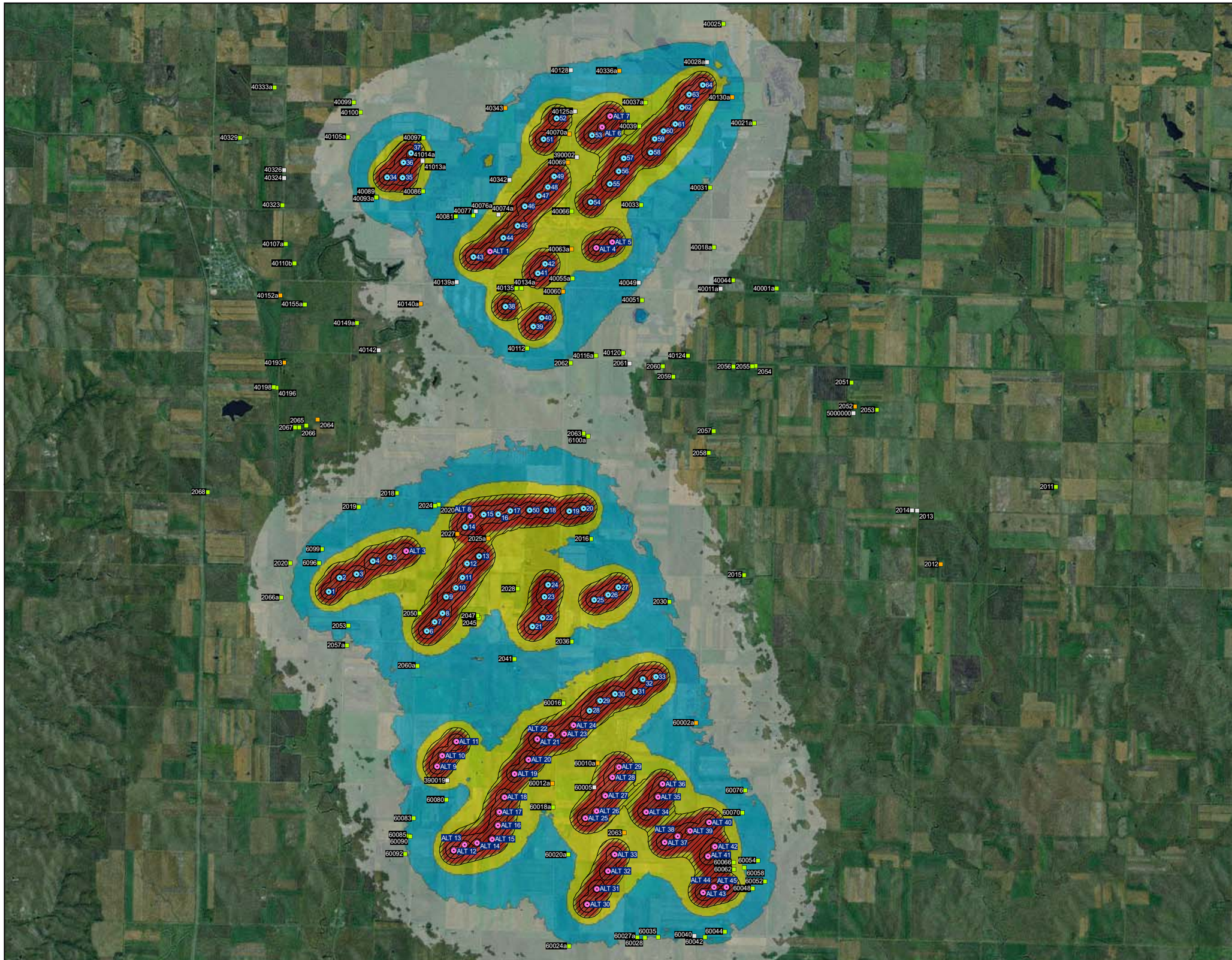

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FIGURE 7
PLANNED & ALTERNATE WIND TURBINES
RECEIVED SOUND LEVELS:
MAXIMUM ROTATION
ANOMALOUS METEOROLOGICAL CONDITIONS

MAY 2010

TETRA TECH EC, INC.

Legend

Turbine Location (4-30-2010 layout)
- Planned
- Alternate

Receptor (based on 4-22-2010 Farmstead Report)
- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N
W E
S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig7....mxd

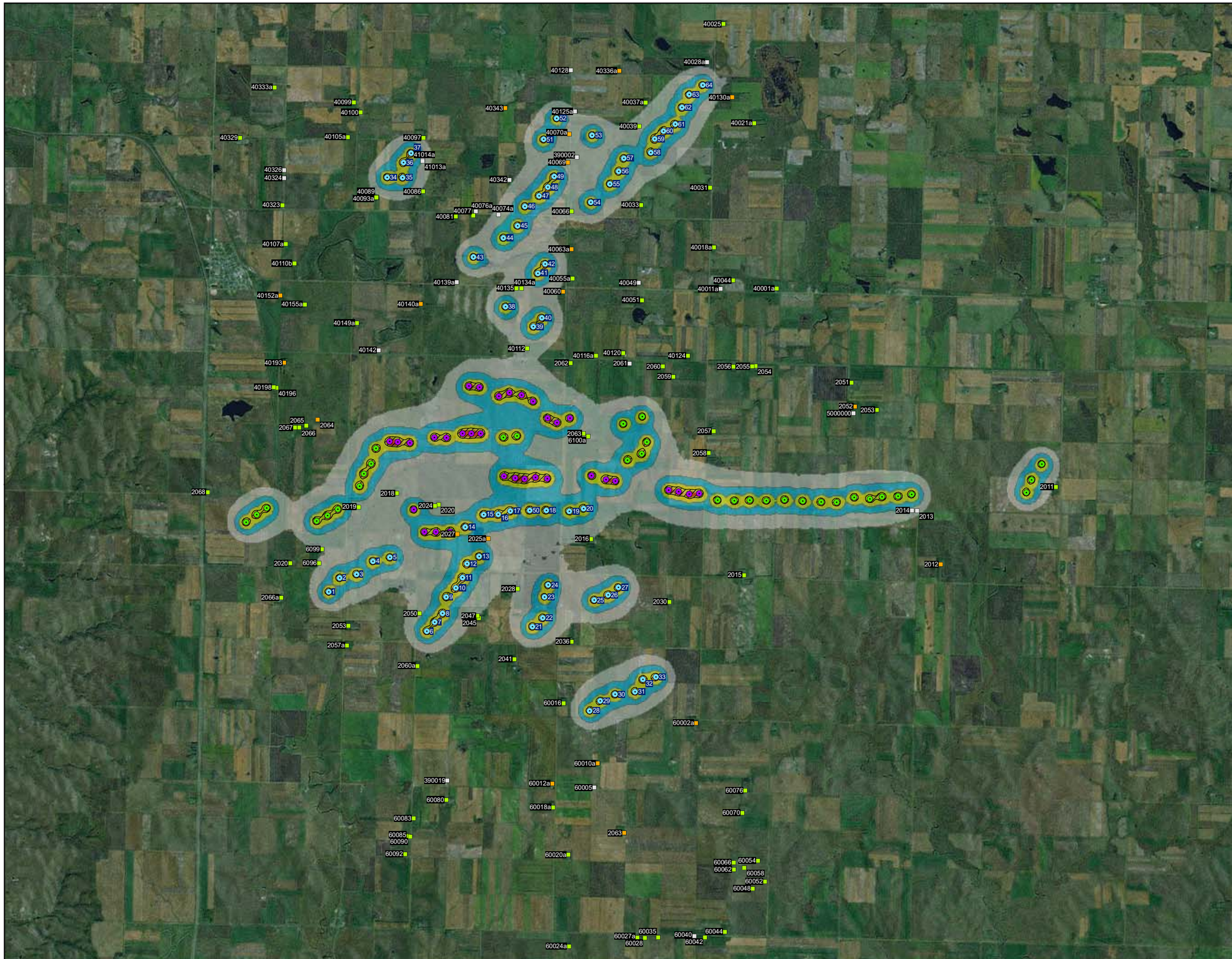

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FIGURE 8

WILTON AND BALDWIN

PLANNED WIND TURBINES

RECEIVED SOUND LEVELS:

WIND TURBINES AT CUT-IN

MAY 2010

TETRA TECH EC, INC.

Legend

- Wilton I Turbine Location
- Wilton II Turbine Location

Wind Turbine Location (4-30-2010 layout)

- Planned

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig8....mxd

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FIGURE 9

WILTON AND BALDWIN

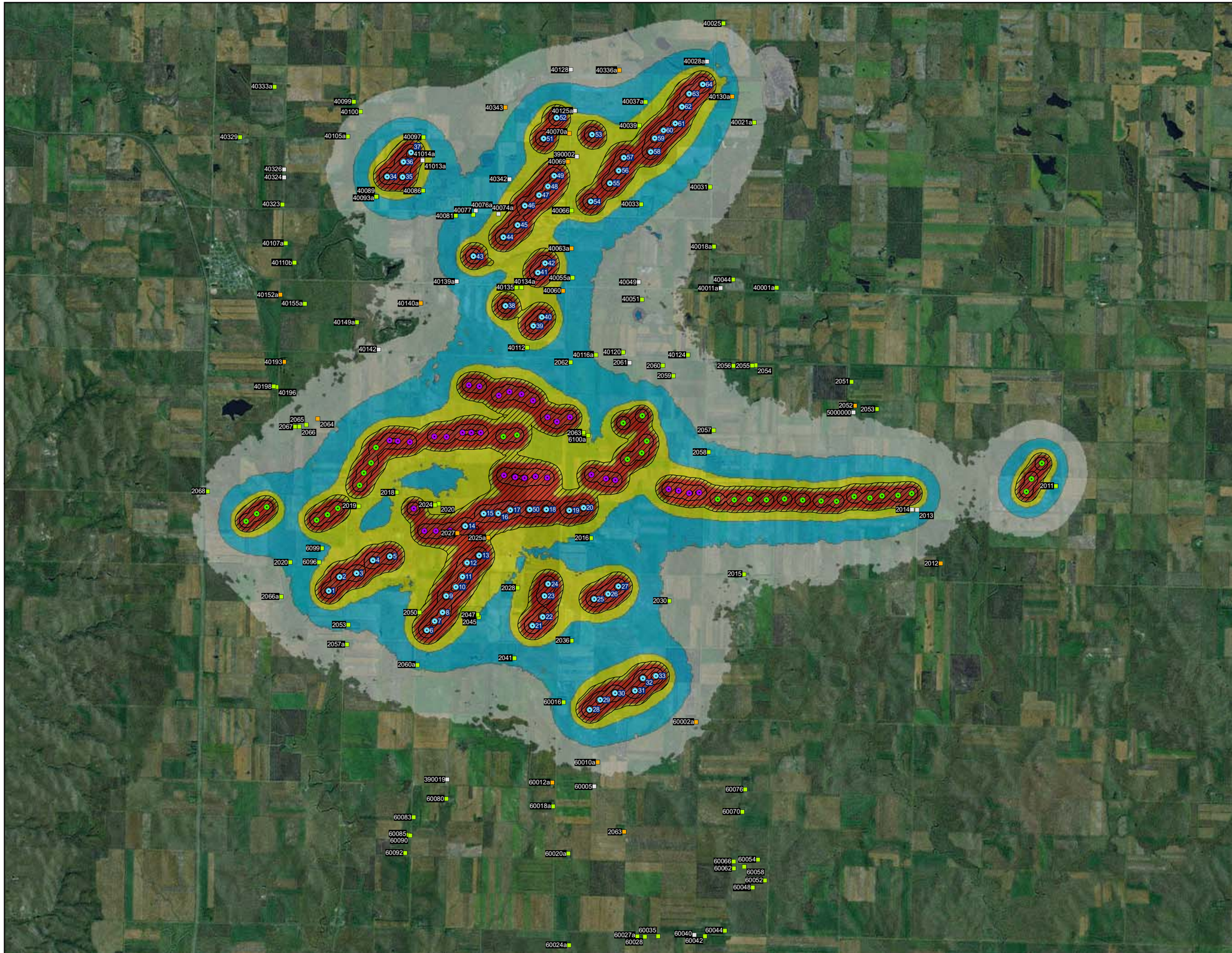
PLANNED WIND TURBINES

RECEIVED SOUND LEVELS:

MAXIMUM ROTATION

MAY 2010

TETRA TECH EC, INC.



Legend

- Wilton I Turbine Location
- Wilton II Turbine Location

Wind Turbine Location (4-30-2010 layout)

- Planned

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig9....mxd

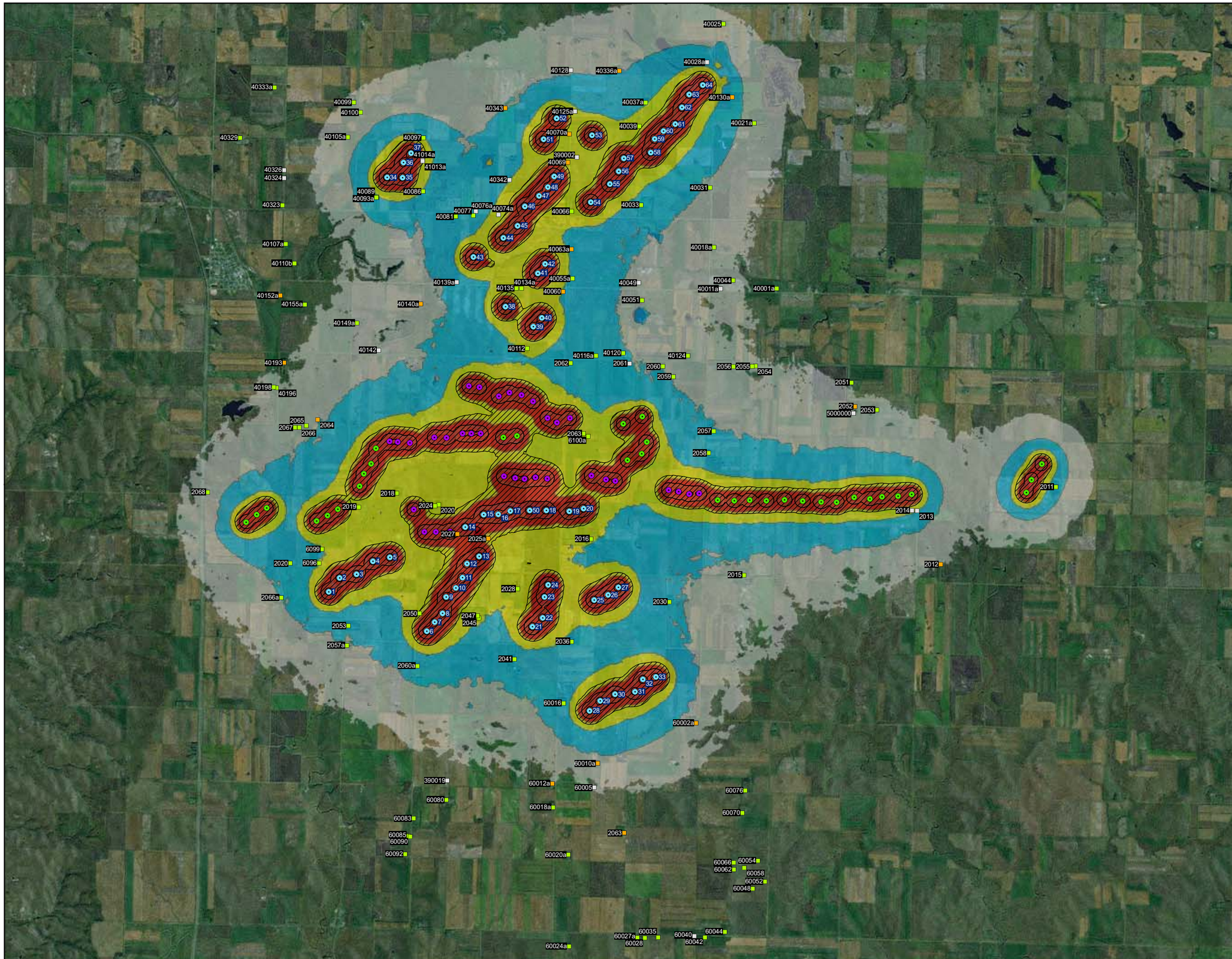


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FIGURE 10

WILTON AND BALDWIN

PLANNED WIND TURBINES

RECEIVED SOUND LEVELS:

MAXIMUM ROTATION

ANOMALOUS METEOROLOGICAL CONDITIONS

TETRA TECH EC, INC.

MAY 2010

Legend

- Wilton I Turbine Location
- Wilton II Turbine Location

Wind Turbine Location (4-30-2010 layout)

- Planned

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

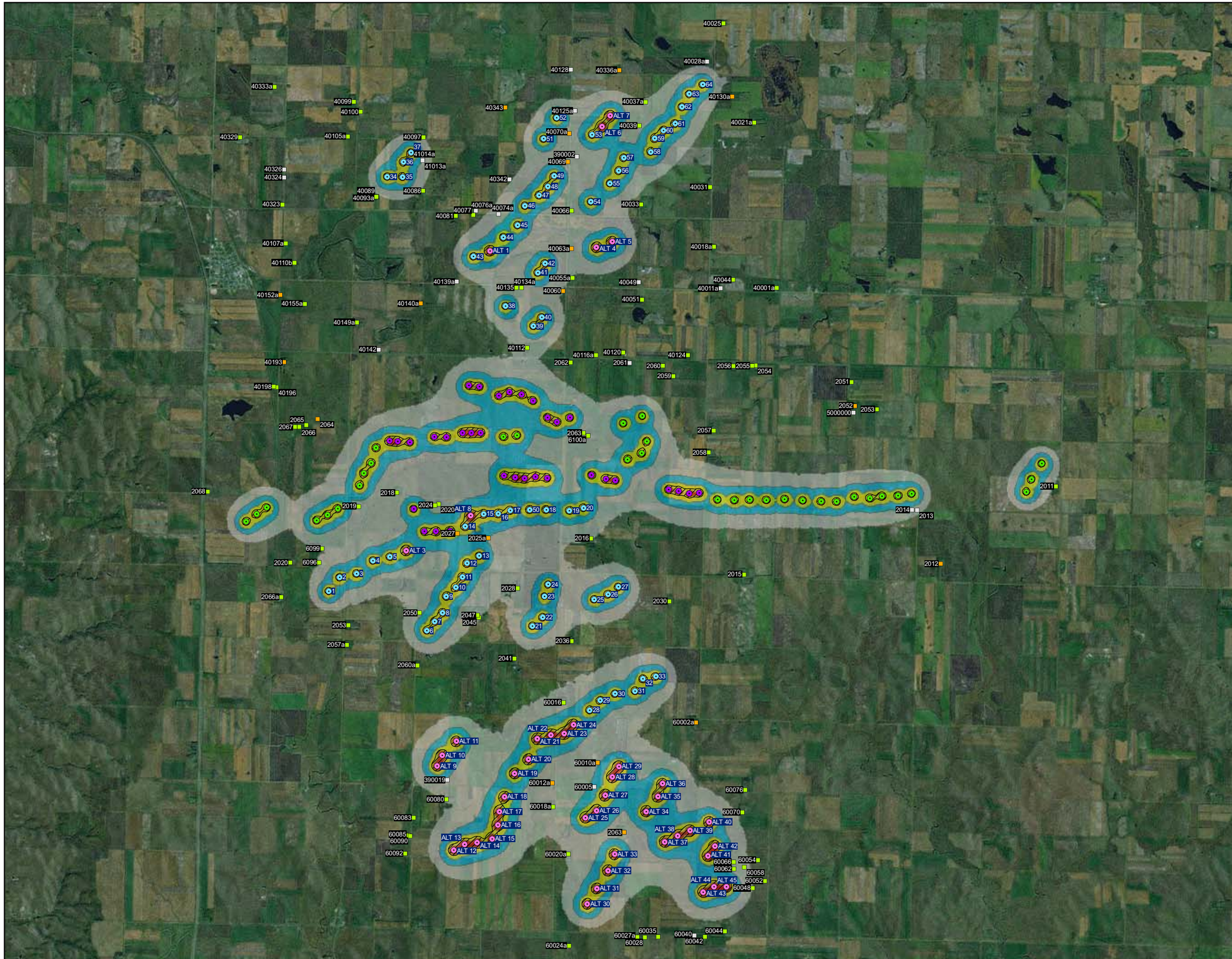
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig10....mxd



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BURLEIGH COUNTY, NORTH DAKOTA

FIGURE 11

WILTON AND BALDWIN

PLANNED & ALTERNATE WIND TURBINES

RECEIVED SOUND LEVELS:

WIND TURBINES AT CUT-IN

MAY 2010

TETRA TECH EC, INC.

Legend

- Wilton I Turbine Location
- Wilton II Turbine Location

Turbine Location (4-30-2010 layout)

- Planned
- Alternate

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig11....mxd

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FIGURE 12

WILTON AND BALDWIN

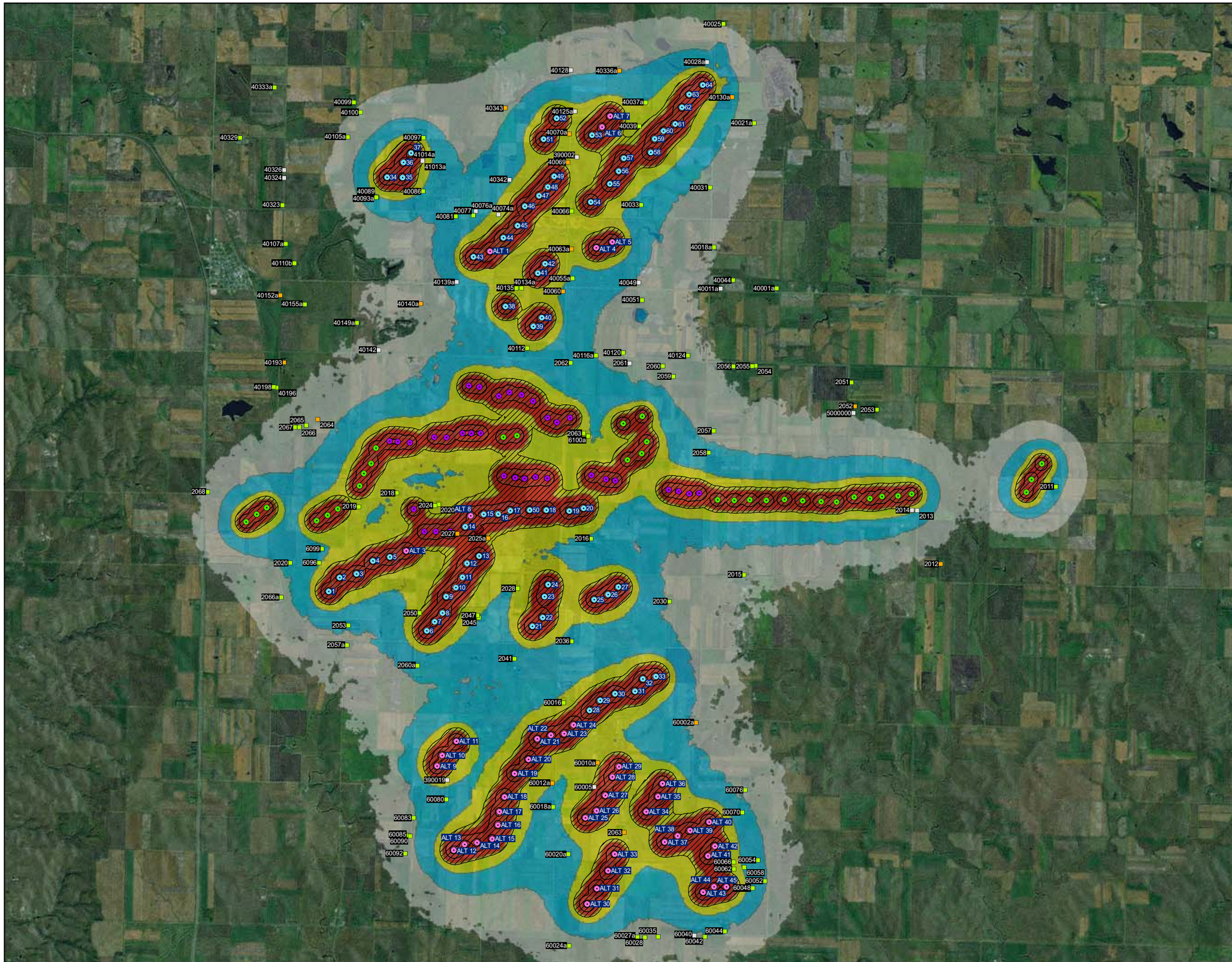
PLANNED & ALTERNATE WIND TURBINES

RECEIVED SOUND LEVELS:

MAXIMUM ROTATION

MAY 2010

TETRA TECH EC, INC.



Legend

- Wilton I Turbine Location
- Wilton II Turbine Location

Turbine Location (4-30-2010 layout)

- Planned
- Alternate

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

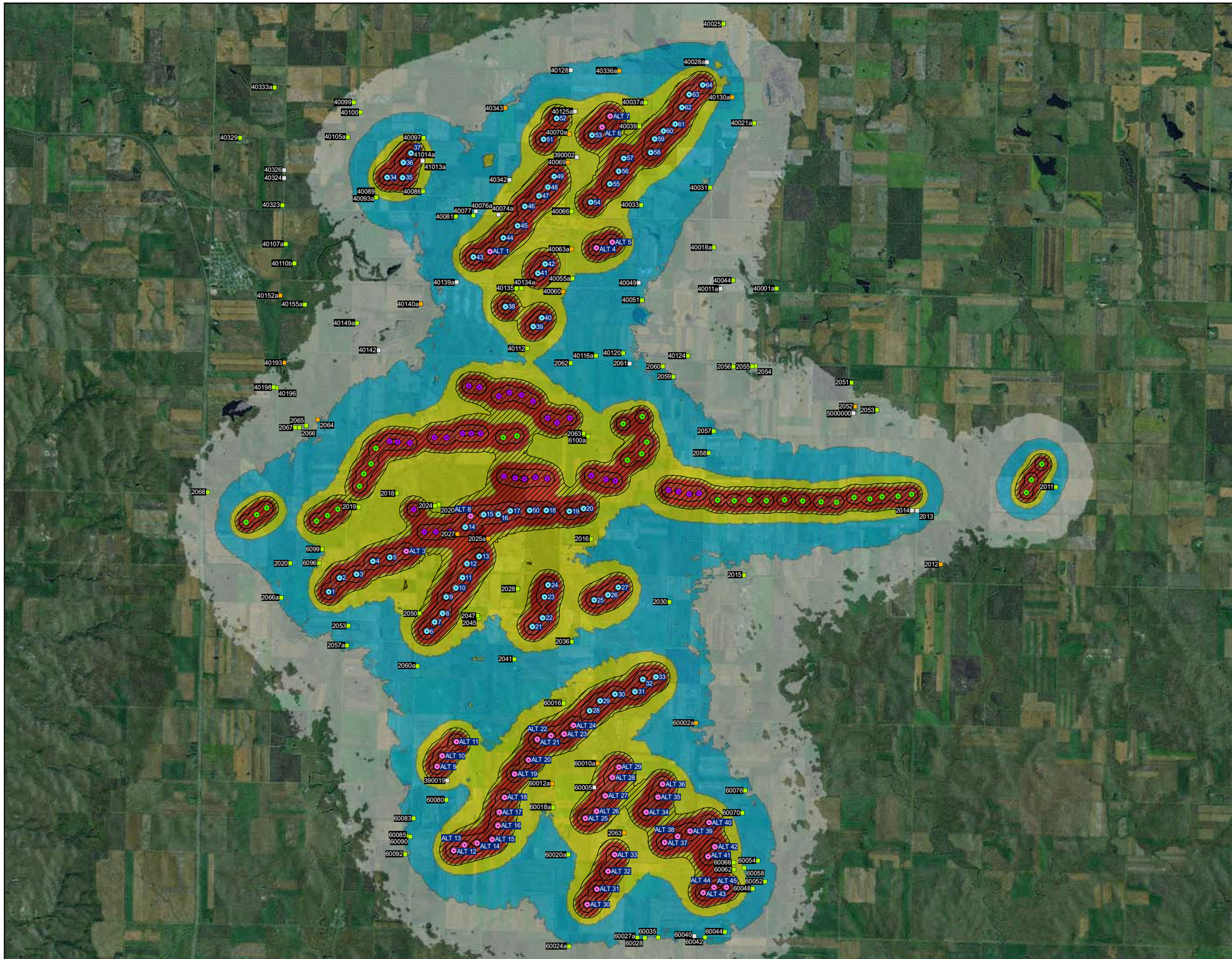
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig12....mxd



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BURLEIGH COUNTY, NORTH DAKOTA

FIGURE 13
WILTON AND BALDWIN
PLANNED & ALTERNATE WIND TURBINES
RECEIVED SOUND LEVELS:
MAXIMUM ROTATION
ANOMALOUS METEOROLOGICAL CONDITIONS

TETRA TECH EC, INC.

MAY 2010

Legend

- Wilton I Turbine Location
- Wilton II Turbine Location

Turbine Location (4-30-2010 layout)

- Planned
- Alternate

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N W E S

0 0.5 1 2 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig13....mxd

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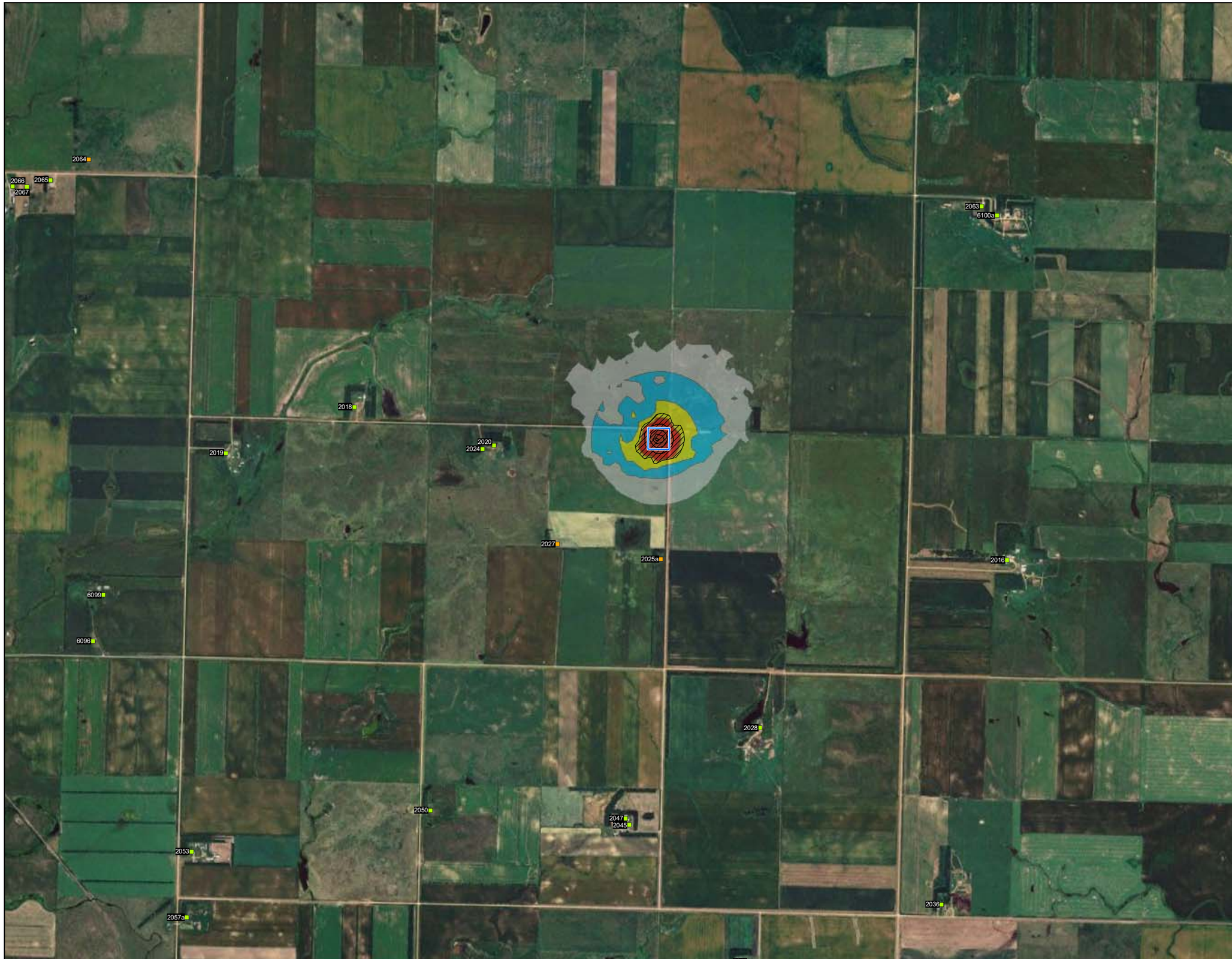
BURLEIGH COUNTY, NORTH DAKOTA

FIGURE 14
RECEIVED SOUND LEVELS:
BALDWIN SUBSTATION

MAY 2010

TETRA TECH EC, INC.



Legend

Proposed Substation Location

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N
W E
S

0 0.25 0.5 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig14....mxd

BALDWIN WIND, LLC
BALDWIN WIND ENERGY CENTER
BURLEIGH COUNTY, NORTH DAKOTA

FIGURE 15
RECEIVED SOUND LEVELS:
WILTON SUBSTATION

MAY 2010

TETRA TECH EC, INC.

Legend

Wilton Substation Location

Receptor (based on 4-22-2010 Farmstead Report)

- Occupied
- Unoccupied
- Non-Residential

Isopleth Ranges (dBA)

- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)

N
W E
S

0 0.25 0.5 Miles

REFERENCE MAP

TODD.GYS(ECIBOSDGYST) P:\FPL Energy\Dakotas\Contract 3935 Baldwin - Burleigh County ND\GIS and Figures\GIS\Spatial\MXD\Noise\Fig15....mxd