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**TO: Langdon Wind, LLC**  
**FROM: Atwell, LLC**  
**DATE: May 24, 2018**  
**RE: Project Summary**  
**Langdon Wind Energy Center Upgrade Project**  
**Certification Relating to N.D.C.C. § 49-22-03(3)(a)**  
**Case Numbers PU-07-26, PU-07-722, and PU-08-159**

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Langdon Wind, LLC (Langdon Wind), a wholly-owned subsidiary of NextEra Energy Resources, LLC (NEER) proposes to upgrade (the “Project”) their portion of the existing Langdon Wind Energy Center (LWEC) in Cavalier County, North Dakota (Figure 1), which began operation in 2008. The LWEC has a nameplate capacity of 199.5 megawatts (MW) and consists of 133 General Electric (GE) 1.5 MW turbines. Langdon Wind owns and operates 106 turbines (159 MW) (see PU-07-026 and PU-07-722) and Otter Tail Power Company (Otter Tail) owns and operates another 27 turbines (40.5 MW) (see PU-08-159).

The Project purpose is to extend the life of Langdon Wind’s older legacy turbines by at least 10 years by modernizing the turbines with new gearboxes and more efficient rotors (i.e. blade assembly). The Project benefits include improved turbine reliability, performance, and operations; reduced maintenance costs; extended power purchase agreements without having to decommission a project and/or build a new project; sustained site suitability; reinvestment in the community and to landowners; and job creation. Langdon Wind considers the Project a maintenance activity, requiring two to three months to complete, with minimal surface and operational impacts, as existing turbine locations, towers, nacelles, roads, electric collection systems, and substations will remain unchanged. Langdon Wind will notify all landowners prior to Project activities. Following the Project, the LWEC will continue to meet the suitability and compatibility criteria as certified by the North Dakota Public Service Commission (Commission).

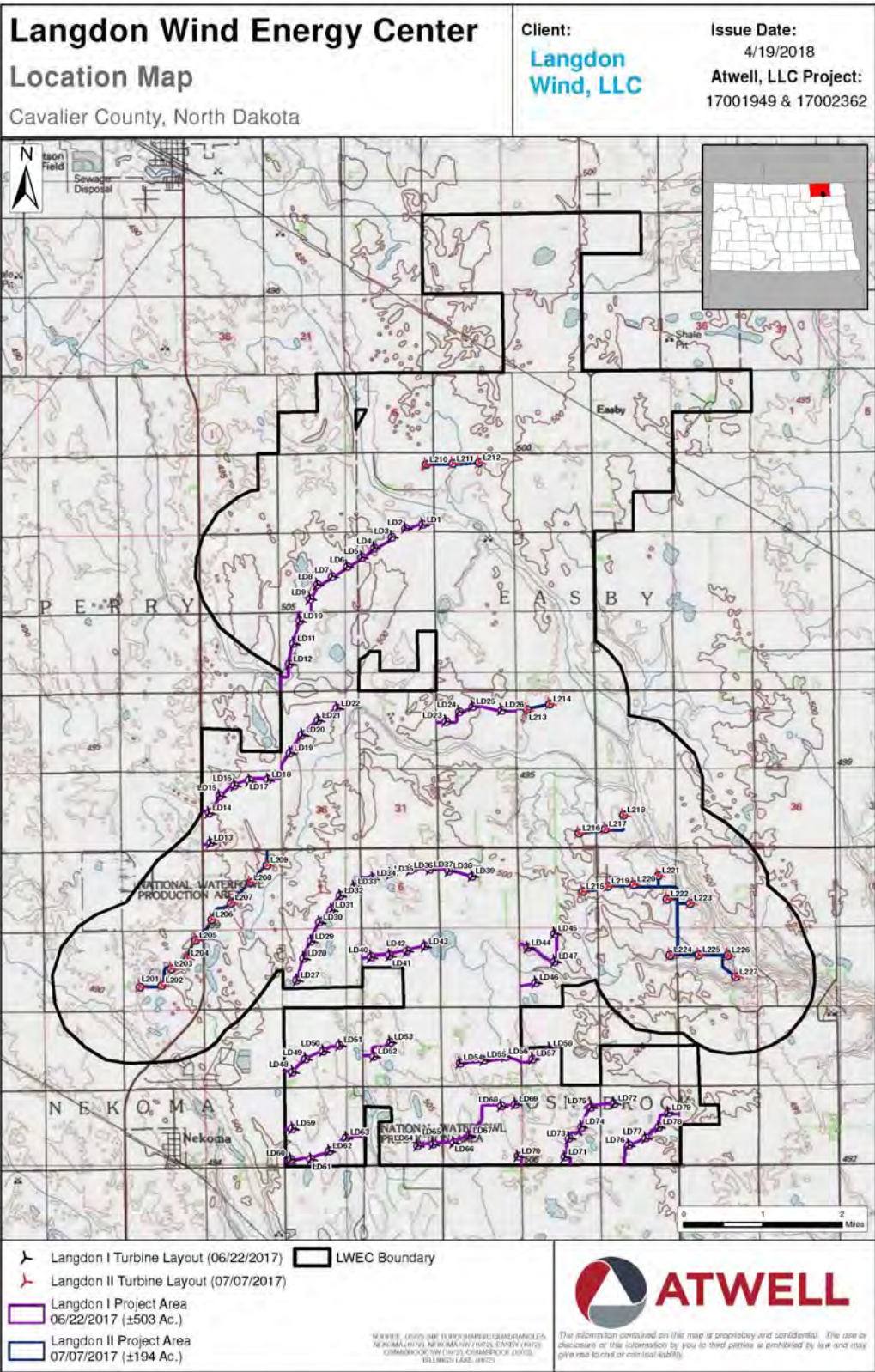


Figure 1. Location Map

***Engineering and Operational Design Analysis***

The Project will consist of upgrades to 106 GE 1.5 MW turbines through installation of new technology, including gearboxes and rotors. The generating capacity of each turbine will increase to 1.62 MW and thus increase the gross (nameplate) generation capability of Langdon Wind owned turbines to 171.72 MW. However, Langdon Wind will cap the output to 159 MW per the requirements of the existing interconnection agreement. The rotor hub height will remain the same as the existing (80 meters), but new blades will increase the rotor diameter from 77 meters up to 91 meters (Figure 2).

The Project will utilize areas previously sited by the Commission for construction and operation of the LWEC (“the Project Area”), including temporary impacts to previously disturbed laydown yards and turning radii. Temporary impacts will be restored to preconstruction conditions, and coordinated with the North Dakota Department of Transportation (NDDOT) and/or Cavalier County, as applicable.

Minnkota Power Cooperative and Otter Tail Power Company will continue to purchase the electricity through amended power purchase agreements currently under negotiation. Operation and maintenance of the LWEC will remain as currently conducted and include scheduled and routine inspections and maintenance. Langdon Wind’s contractual obligation to the landowners for removal and decommissioning of the wind facility will remain the same.

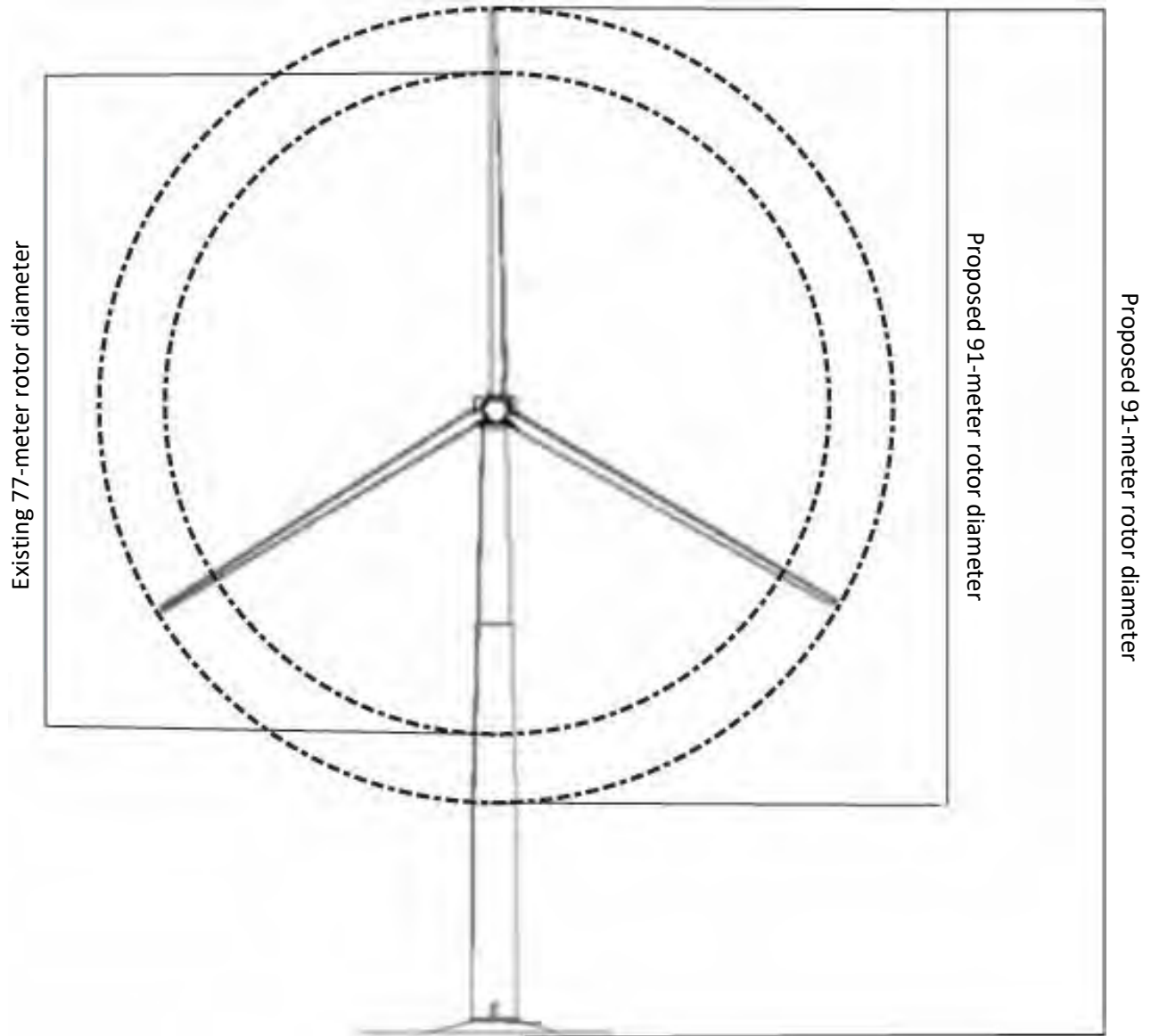


Figure 2. Change in rotor diameter from 77 meters to 91 meters

### ***Environmental Impact Analysis***

Langdon Wind analyzed the environmental resources the Project could potentially impact beyond those addressed under prior certification or amendment. Table 1 provides an environmental impact summary. The following sections and appendices describe this analysis. Appendices include:

1. Sound Level Analysis
2. Shadow Flicker Analysis
3. Aquatic Resource Maps

**Table 1.** Environmental Impact Summary.

<b>Resource</b>	<b>Impact</b>	<b>Mitigation</b>
Demographics	Primarily positive due to long term benefits of lease payments and increased community tax base.	No adverse impacts anticipated.
Land Use	No significant change from existing LWEC.	No adverse impacts anticipated.
Public Services	No significant change from existing LWEC.	No adverse impacts anticipated.
Health and Human Safety	No significant change from existing LWEC.	No adverse impacts anticipated.
Sound and Visual	Sound levels will remain below the Commission's 50 A-weighted decibel limit, and shadow flicker will be less than the Commission's accepted standard of 30 hours per year.	No adverse impacts anticipated.
Cultural and Archaeological	No new National Register of Historic Places eligible cultural resource or archaeological site impacts are anticipated. Visual impacts to one cultural resource previously mitigated.	No new adverse impacts anticipated. Visual impact mitigation completed in 2007.
Recreational Resources	No significant change from existing LWEC.	No adverse impacts anticipated.
Land Based Economies	No significant change from existing LWEC.	No adverse impacts anticipated.
Soil, Geologic, and Ground Water Resources	No significant change from existing LWEC.	No adverse impacts anticipated. Langdon Wind will utilize Best Management Practices to minimize soil erosion and sedimentation.
Aquatic Resources	No significant change from existing LWEC. Aquatic resources, such as surface waters, wetlands, and floodplains will be avoided.	No adverse impacts anticipated.
Vegetation	Construction activities limited to prior disturbance areas. No impacts are anticipated.	No adverse impacts anticipated.
Wildlife	No significant change from existing LWEC.	No adverse impacts anticipated.

### ***Sound and Shadow Flicker***

Langdon Wind modeled the Project's potential sound and shadow flicker effects to inhabited residences or community buildings (collectively, "receptors") (Appendices 1 and 2). These models

are deliberately conservative; thus, actual effects are expected to be less than the modeled effects.

The sound levels modeled within 100 feet of all receptors ranged from 22 to 49 dBA. These sound levels are below the Commission's 50 dBA standard. The predicted worst-case shadow flicker is expected to be below the Commission's accepted threshold of 30 hours per year at all receptor locations. Therefore, the Project meets the Commission's thresholds with respect to sound and shadow flicker.

### *Cultural and Archaeological*

Although Langdon Wind studied cultural and archaeological resources during development of the LWEC, Langdon Wind restudied the Project Area, including the temporary turning radii, to determine if any previously unidentified resources exist. Results of Class I and Class II/III cultural resource inventories did not identify any new cultural or archaeological resources within the Langdon Wind I Project Area. A single newly identified prehistoric isolated find was recorded within the Langdon Wind II Project Area and is not eligible for listing on the National Register of Historic Places (NRHP). The cultural resource inventory reports will be submitted to the State Historic Preservation Office of North Dakota (NDSHPO) for review and concurrence. Langdon Wind will file the NDSHPO's concurrence regarding the Project as soon as it is received.

One resource identified in 2007 during the LWEC's development is the Stanley R. Mickelsen Safeguard Complex Missile Site Radar (MSR) located approximately 0.7 miles west of the closest Project turbine (LD48). The MSR (32CV113) has been previously determined eligible for listing on the NRHP. In 2007, Langdon Wind developed, implemented, and completed a mitigation plan (TetraTech EC, INC 2007) to address indirect (i.e. landscape and viewshed) effects to the MSR. As the turbine locations will remain unchanged, so too will the effects to the MSR landscape and viewshed. Thus, the prior mitigation will continue to adequately minimize adverse indirect effects to the MSR.

### *Aquatic Resources*

Although Langdon Wind studied (TetraTech EC, INC 2007) aquatic resources (e.g. wetlands, potholes, streams, surface waters, floodplains) during development of the LWEC, Langdon Wind restudied the Project Area, including the temporary turning radii, to determine if any previously unidentified resources exist. Federal Emergency Management Agency floodplains are unmapped in Cavalier County. Aquatic resources, like wetlands and streams, were identified and delineated utilizing methods prescribed by the U.S. Army Corps of Engineers. Langdon Wind will avoid all aquatic resources.

Seven wetlands (Wetlands 1-7), four watercourses (Watercourse 1-4), and one open water (Open Water 1) were identified within the Project Area (Table 2 and Appendix 3). All wetlands are classified as palustrine emergent. Many of the wetlands occurred within linear ditch features that border agricultural fields and/or roadways. Dominant wetland vegetation consisted of narrow-leaved cattail (*Typha angustifolia*), foxtail barley (*Hordeum jubatum*), curly dock (*Rumex crispus*),

and rush (*Juncus* spp.). Water sources appeared to be runoff from nearby agricultural fields and adjacent roads, field drain tile discharge, precipitation, and groundwater. Hydrologic regimes appeared to range from seasonally or semi-permanently saturated to seasonally inundated.

The watercourses varied in width and depth; however, they all possessed a defined bed, bank, and ordinary high water mark (OHWM). All watercourses were ephemeral to intermittent in nature and have generally been altered to expedite drainage for agriculture. Some of the watercourses contain, or are buffered by, emergent vegetation that is commonly mowed or burned so as not to impede drainage.

Open Water 1 has permanent standing water with an emergent wetland fringe dominated by narrow-leaved cattail. The water source appears to be groundwater, rainfall, and surface runoff from adjacent agricultural fields. The hydrologic regimes for this feature appear to be permanently inundated.

**Table 2.** Aquatic Resource Summary (Langdon Wind will avoid all resources).

Resource Identification	General Location	Mapped Acres	Mapped Linear Feet
Wetland 1	Access road between Turbine 77 and 78	0.01	-
Wetland 2	Turbine 71	0.24	-
Wetland 3	Turning radius to Turbine 70	0.04	-
Wetland 4	Turning radius south of Turbine 48 at intersection of 81 <sup>st</sup> St NE and 107 <sup>th</sup> Ave NE	0.10	-
Wetland 5	Turning radius to Turbine 13	0.1	-
Wetland 6	Turning radius to Turbine 206	0.03	-
Wetland 7	Turbine 206 and Access road between Turbine 206 and 207	0.25	-
Watercourse 1	Access road between Turbine 77 and 78	-	57.9
Watercourse 2	Access road between Turbine 60 and 61	-	127.9
Watercourse 3	Turbine 59	-	363.6
Watercourse 4	Turbine 211	-	363.8
Open Water 1	Turning radius south of Turbine 52 at intersection of 81 <sup>st</sup> St NE and 108 <sup>th</sup> Ave NE	0.40	-

*Wildlife*

In April 2015, following the Commission’s certification of the LWEC, the United States Fish and Wildlife Service (“USFWS”) listed the northern long-eared bat (“NLEB,” *Myotis septentrionalis*) as threatened under the Endangered Species Act. The LWEC is within the geographic range of the NLEB but does not contain NLEB critical habitat. Langdon Wind assessed the potential for NLEB to occur in the LWEC since it was not addressed in prior wildlife assessments. Suitable NLWB habitat consists of forested areas for summer roosting and spring through fall hibernacula. Based

on a desktop review and site visits, the expected use and occurrence of NLEB is low due to lack of suitable habitat within and in the vicinity of the LWEC. Furthermore, since operations began, no NLEB have been reported through the Wildlife Resource Reporting System (WRRS). Langdon Wind will continue to implement the WRRS as described in the Commission Orders previously issued for the LWEC.

***Other Permits/Approvals***

Langdon Wind has communicated with Cavalier County and no new county permits are required and existing road use agreements are applicable. Langdon Wind will also obtain, as applicable, all other necessary permits or approvals prior to engaging in construction activities, including those from the North Dakota Water Commission, North Dakota High Patrol, and NDDOT.

***Factors Considered***

The preceding sections and attached appendices discuss the potential Project effects on public health and welfare, natural resources, and the environment. As discussed, the proposed Project will not have additional adverse effects on cultural or natural resources above those currently in existence for the LWEC. Langdon Wind is committed to utilizing the most recent technologies to minimize impacts to the environment. The Project is one more example of Langdon Wind’s commitment to optimize wind and land resources. It will extend the viability of the LWEC into the future, ensuring that current economic benefits for county residents and state and local taxes remain in place.

***Qualifications of Contributors to Project Summary***

<b>Name Project Role</b>	<b>Education and Professional Experience</b>
<b>Dustin Jones</b> NEER Environmental Services Project Manager	Mr. Jones has 15 years of environmental permitting experience as both a consultant and environmental manager in the renewable industry. His primary responsibility is permitting and licensing projects on private and public land in compliance with federal and state environmental laws. He is a certified wetland delineator.  B.S. Wildlife and Fisheries Sciences, Texas A&M University 1999
<b>David Kuhn</b> NEER Project Manager, Renewable Development	Mr. Kuhn has over 2 years of power marketing experience and brings a strong understanding of wholesale power markets, particularly from a load-serving entity’s perspective. A former Army officer, Mr. Kuhn has over 4 years of leadership experience, both in the US and overseas in Afghanistan, and is now responsible for managing projects that require input from a diverse network of sophisticated professionals.  M.S. Finance, Florida State University 2015 B.S. Finance, Florida State University 2014 B.S. Multinational Business Operations 2008

Name Project Role	Education and Professional Experience
<b>David Todorovich</b> NEER Engineering and Construction	<p>Mr. Todorovich has over 16 years of experience in engineering and construction, 13 years of which with regulated utilities, and more than two years in the development of wind energy projects. He is responsible for the management and oversight of early stage phases of project planning, engineering, and construction of wind projects. Duties also include budget development, contract execution, procurement, logistical planning, and ultimately transition to the construction execution team.</p> <p>B.S. Electrical Engineering , Purdue University 2002</p>
<b>Bourke Thomas</b> Atwell, LLC Team Leader	<p>Mr. Thomas has over 12 years of experience in project management of natural resources consulting and environmental construction management. As Team Leader of Environmental, he is responsible for managing staff and environmental based projects. Mr. Thomas also performs environmental compliance/coordination as a construction manager on renewable energy projects.</p> <p>MBA DeVos Graduate School of Business, Northwood University 2012 B.S. Environmental Studies, Michigan State University 2004</p>
<b>Ethan Jahnke</b> Atwell, LLC Project Manager	<p>Mr. Jahnke has over 22 years of experience in energy project management, federal, state and local regulatory permitting and compliance, NEPA, evaluation and permitting of energy projects, water management and hydrologic modeling.</p> <p>M.S. Water Resources Science, University of Minnesota 2000 B.S. Natural Resources Management, Colorado State University 1995</p>
<b>Benjamin Banks</b> Atwell, LLC Environmental Consultant/Cultural Resources Specialist	<p>Mr. Banks has over nine years of experience in cultural resources and environmental compliance projects. He has prepared numerous cultural resources reports and environmental assessments for wind energy and development projects across the contiguous United States. Mr. Banks has experience conducting cultural resources fieldwork and analysis, Phase I environmental site assessments, and cultural resources construction monitoring.</p> <p>Register of Professional Archaeologists M.A. Anthropology, University of Arkansas – Fayetteville 2011 B.S. Sociology, Oklahoma State University 2009</p>
<b>Jeffrey Bunch</b> Atwell, LLC Environmental Consultant/Ecologist	<p>Mr. Bunch has over 20 years of professional experience in the biological, ecological, and environmental consulting fields and is a trained U.S. Army Corps of Engineers Wetland Delineator. He has conducted over 500 wetland determinations and delineations and has provided scientific and technical expertise to a wide variety of private, municipal, State, and Federal clients.</p> <p>B.S. Natural Resources and Environmental Science, Kansas State University 1998</p>
<b>Joshua Allen</b> Atwell, LLC Environmental Technician	<p>Mr. Allen has over two years of experience in natural resources and environmental science. He has experience in wetland and watercourse delineations, small mammal data collection and analysis, environmental construction monitoring, and Phase I environmental site assessments.</p> <p>B.S. Natural Resources and Environmental Science, Kansas State University 2015</p>

**References**

- Atwell. 2018a. "Class I Cultural Resources Inventory for the Langdon Wind Energy Center Repower Project Cavalier County, North Dakota." Atwell Project Number: 17001949 and 17002362. Southfield, Michigan: Atwell, LLC.
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- USFWS. 2017. "IPaC - Information for Planning and Consultation." Environmental Conservation Online System. 2017. <http://ecos.fws.gov/ipac/>.

**Appendix 1. Sound Level Analysis**

## SOUND LEVEL ASSESSMENT REPORT

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# Langdon Wind Energy Center Repower Project Cavalier County, North Dakota

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May 17, 2018

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## **1.0 EXECUTIVE SUMMARY**

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The Langdon Wind Energy Center Repower Project (the Project) is a proposed re-powering of a wind power electric generation facility consisting of 106 wind turbines in Cavalier County, North Dakota. The Project is being developed by Langdon Wind, LLC, a subsidiary of NextEra Energy Resources, LLC (NEER). Epsilon Associates, Inc. (Epsilon) has been retained by Atwell, LLC (Atwell) to conduct a sound level assessment for this Project. The project plans to upgrade and replace the rotors on the existing turbines, which will increase the rotor diameter on each unit from 77m to 91m.

A sound level modeling analysis was conducted for the 106 Langdon wind turbines. GE 1.6-91 wind turbines are proposed for this Project. The purpose of this assessment is to predict worst-case community sound levels in Cavalier County when the wind turbines are operational and to compare the modeling results to applicable limits. Sound levels are limited to 50 dBA at a noise sensitive receptor. Atwell and NEER provided information via shapefiles and AutoCAD drawings which included turbine locations, participation status, and occupancy status for the receptors in the project area.

Using the Project specific data provided by Atwell and NEER, the sound levels modeled at receptors in Cavalier County ranged from 22 to 49 dBA. Receptors in this analysis were evaluated against the 50 dBA limit contained in the North Dakota Administrative Code section 69-06-08-01(4). Therefore, the Project meets the North Dakota regulations with respect to sound.

## 2.0 INTRODUCTION

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A detailed discussion of sound from wind turbines is presented in a white paper prepared by the Renewable Energy Research Laboratory.<sup>1</sup> A few points are repeated herein. Wind turbine noise can originate from two different sources; mechanical sound from the interaction of turbine components, and aerodynamic sound produced by the flow of air over the rotor blades. Prior to the 1990's, both were significant contributors to wind turbine noise. However, recent advances in wind turbine design have greatly reduced the contribution of mechanical noise. Aerodynamic noise has also been reduced from modern wind turbines due to slower rotational speeds and changes in materials of construction. Aerodynamic noise, in general, is broadband (has contributions from a wide range of frequencies). It originates from encounters of the wind turbine blades with localized airflow inhomogeneities and wakes from other turbine blades and from airflow across the surface of the blades, particularly the front and trailing edges. Aerodynamic sound generally increases with increasing wind speed up to a certain point, then remains constant, even with higher wind speeds. However, sound levels in general also increase with increasing wind speed with or without the presence of wind turbines.

This report presents the findings of a sound level modeling analysis for the Project. The wind turbines were modeled with the Cadna/A software package using sound data from GE technical documents. The results of this analysis are found within this report.

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<sup>1</sup> Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, Wind Turbine Acoustic Noise, June 2002, amended January 2006.

### 3.0 SOUND TERMINOLOGY

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There are several ways in which sound (noise) levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The following information defines the sound level measurement terminology used in this analysis.

The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy but not equal to a doubling in decibel quantity (100 dB). Thus, every 3-dB change in sound level represents a doubling or halving of sound energy. Relative to this characteristic, a change in sound levels of less than 3 dB is imperceptible to the human ear.

Another mathematical property of decibels is that if one source of noise is 10 dB (or more) louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter (SLM) that is used to measure sound is a standardized instrument.<sup>2</sup> It contains “weighting networks” (e.g., A-, C-, Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz (Hz), are detailed characterizations of sounds, often addressed in musical terms as “pitch” or “tone”. The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies. The A-weighting network is the accepted scale used for community sound level measurements; therefore, sounds are frequently reported as detected with a sound level meter using this weighting. A-weighted sound levels emphasize middle frequency sounds (i.e., middle pitched – around 1,000 Hz), and de-emphasize low and high frequency sounds. These sound levels are reported in decibels designated as “dBA”.

Because the sounds in the environment vary with time, many different sound metrics may be used to quantify them. There are two typical methods used for describing variable sounds. These are exceedance levels and equivalent levels, both of which are derived from a large number of moment-to-moment A-weighted sound pressure level measurements. Exceedance levels are values from the cumulative amplitude distribution of all of the sound levels observed during a measurement period. Exceedance levels are designated  $L_n$ , where

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<sup>2</sup> *American National Standard Specification for Sound Level Meters*, ANSI S1.4-1983 (R2006), published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

“n” is a value (typically an integer between 1 and 99) in terms of percentage. Equivalent levels are designated  $L_{eq}$  and quantify a hypothetical steady sound that would have the same energy as the actual fluctuating sound observed. The sound level metric that is commonly reported in community noise monitoring and is utilized in this report is described below.

- ◆  $L_{eq}$ , the equivalent level, is the level of a hypothetical steady sound that would have the same energy (*i.e.*, the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated  $L_{eq}$  and is commonly A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with time-averaged mean square sound pressure values, the  $L_{eq}$  is mostly determined by occasional loud noises.

## 4.0 NOISE REGULATIONS

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The proposed Langdon Wind Energy Center Repower Project in Cavalier County, North Dakota is subject to the following sound level requirements in Title 69, Article 6, Chapter 8 of the North Dakota Administrative Code:

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

Therefore, sensitive receptors were evaluated in this analysis against the 50 dBA limit.

## 5.0 FUTURE CONDITIONS

### 5.1 Equipment and Operating Conditions

The sound level analysis includes 106 wind turbines. All wind turbines are GE 1.6-91 units with a hub height of 80 meters and a rotor diameter of 91 meters. Technical documentation from GE<sup>3</sup> was provided by Atwell which documented the expected sound power levels associated with the GE 1.6-91 wind turbines. According to this technical document, which included broadband, octave band, and one-third octave band A-weighted sound power levels for various wind speeds, the maximum sound power level for the GE 1.6-91 of 106.5 dBA occurs at wind speeds of 9 m/s (and above) at an 80-meter hub-height. These sound power levels are defined as “normal operation apparent” by the turbine manufacturer and therefore do not include any additional uncertainty factor. Table 5-1 presents the modeled broadband and octave band sound power levels for each wind turbine.

**Table 5-1 Modeled Wind Turbine Sound Power Levels**

Turbine Model	Broadband dBA	Sound Power Levels per Octave-Band Center Frequency [Hz]								
		31.5 dBA	63 dBA	125 dBA	250 dBA	500 dBA	1k dBA	2k dBA	4k dBA	8k dBA
GE 1.6-91	106.5	73	86	95	99	102	101	97	91	80

Note: these levels do not include the 2dB uncertainty factor.

In addition to the wind turbines, there is a collector substation associated with the Project. The substation is located north of wind turbine #LD34, and as shown in Figure 5-1. One 179 megavolt-ampere (MVA) transformer, and one 45 MVA transformer are located at the substation. No changes to the transformers are proposed as part of the Project. NEER provided transformer test reports indicating the MVA ratings. From these ratings, Epsilon estimated octave band sound power levels using the calculated broadband sound pressure level and techniques in the Electric Power Plant Environmental Noise Guide (Edison Electric Institute), Table 4.5 Sound Power Levels of Transformers. Table 5-2 summarizes the sound power level data used in the modeling.

**Table 5-2 Modeled Substation Transformer Sound Power Levels**

Maximum Rating	Broadband dBA	Sound Power Levels per Octave-Band Center Frequency [Hz]								
		31.5 dB	63 dB	125 dB	250 dB	500 dB	1k dB	2k dB	4k dB	8k dB
179 MVA	102	99	105	107	102	102	96	91	86	79
45 MVA	93	90	96	98	93	93	87	82	77	70

<sup>3</sup> General Electric Company, Technical Documentation Wind Turbine Generator Systems 1.6-91 60 Hz Product Acoustic Specifications, 2017.

## 5.2 Modeling Scenarios

The noise impacts associated with the proposed wind turbines were predicted using the Cadna/A noise calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation (Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation). The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections, drop-off with distance, and atmospheric absorption. The Cadna/A software allows for octave band calculation of sound from multiple sources as well as computation of diffraction.

Inputs and significant parameters employed in the model are described below:

- ◆ *Project Layout:* The project is an existing wind energy facility, and the turbine locations were provided as two groups of as-built coordinates. A project layout named 170622 was provided by Atwell for Langdon I turbines, and a project layout named 170707 was provided for the Langdon II turbines. The 106 wind turbines were input into the model. The existing substation location was provided by NextEra via email on October 31, 2017. For the modeling analysis, it was assumed that the substation transformers would be located at the center of each transformer, as they appeared on existing aerial imagery. The proposed wind turbines and substations are shown in Figure 5-1.
- ◆ *Modeling Locations:* A modeling receptor dataset dated October 2, 2017 was provided by Atwell. The dataset included 120 receptors which were input into the Cadna/A model. These sensitive receptors were modeled as discrete points at a height of 1.5 meters above ground level (AGL) to mimic the ears of a typical standing person. These locations are shown in Figure 5-1. In addition, a dataset containing parcel participation status was provided by Atwell which allowed for participation status to be assigned to each modeling receptor.
- ◆ *Terrain Elevation:* Elevation contours for the modeling domain were directly imported into Cadna/A which allowed for consideration of terrain shielding where appropriate. The terrain height contour elevations for the modeling domain were generated from elevation information derived from 2-meter 3X3 Digital Elevation Models (DEMs) provided by the North Dakota Department of Natural Resources.
- ◆ *Source Sound Levels & Controls:* Octave band sound power levels for the GE 1.6-91 wind turbines provided in technical reports (presented above in Table 5-1) were input to the model. The substation transformer sound power levels as presented in Table 5-2 were input to the model.

- ◆ *Uncertainty factor:* The wind turbine manufacturer provided an uncertainty factor of 2.0 dBA which was added to the sound power level for each modeled wind turbine.
- ◆ *Ground Attenuation:* Spectral ground absorption was calculated using a G-factor of 0.5 which corresponds to “mixed ground” consisting of both hard and porous ground cover.

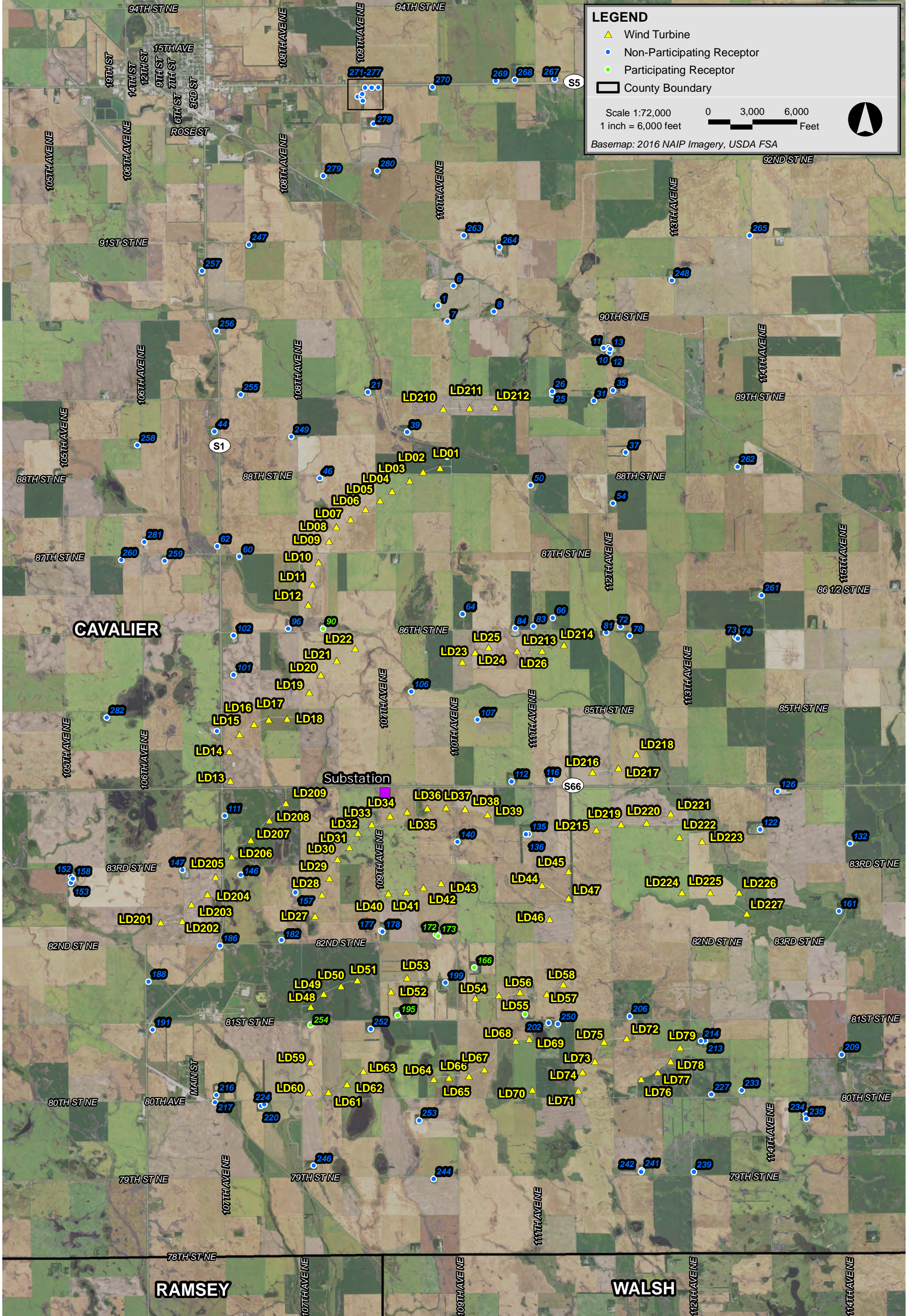
The highest wind turbine sound power level including uncertainty (108.5 dBA) was input into the Cadna/A model. From this sound power level, wind turbine generated sound pressure levels during conditions favorable to sound propagation were calculated.  $L_{eq}$  sound pressure levels due to operation of all 106 wind turbines and the substation transformer were predicted at 120 sensitive receptors in Cavalier County. In addition to modeling at discrete points, sound levels were also modeled throughout a large grid of receptor points, each spaced 20 meters apart to allow for the generation of sound level isolines.

Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by Epsilon, were implemented in the Cadna/A model to ensure conservative results (i.e., higher sound levels), and are described below:

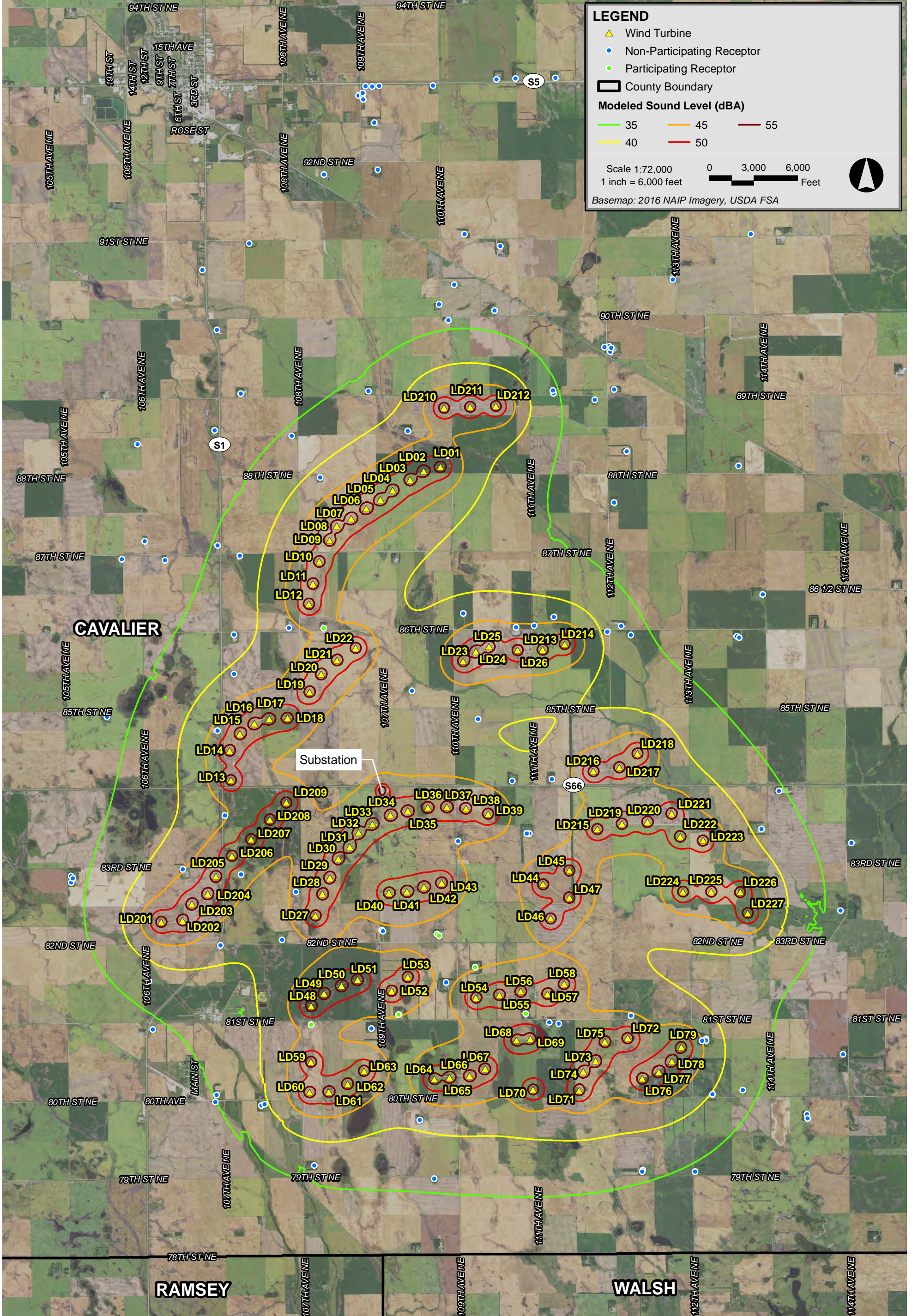
- ◆ All modeled sources were assumed to be operating simultaneously and at the design wind speed corresponding to the greatest sound level impacts.
- ◆ As per ISO 9613-2, the model assumed favorable conditions for sound propagation, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night or equivalently downwind propagation.
- ◆ Meteorological conditions assumed in the model (temperature=10°C & relative humidity=70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive.
- ◆ No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

### 5.3 Sound Level Results

Table A-1 in Appendix A shows the predicted “Project-Only” broadband (dBA)  $L_{eq}$  sound levels under conditions specified in the previous section. The table presents sound levels at the 120 receptors in Cavalier County included in the analysis. These sound levels range from 22 to 49 dBA. In addition to these discrete modeling points, sound level isolines generated from the modeling grid are presented in Figure 5-2.



Langdon I and II Cavalier County, North Dakota



Langdon I and II Cavalier County, North Dakota

## 6.0 EVALUATION OF SOUND LEVELS

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The Project is subject to the requirements contained in the North Dakota Administrative Code. The sound level limit in this regulation is 50 dBA within 100 feet of a noise sensitive receptor. The predicted worst-case sound levels from the Langdon Wind Energy Center Repower Project are below the 50 dBA limit at all modeled noise sensitive receptors. Locations that are up to 100 feet closer to a turbine than at the discrete points where sound levels were calculated would be up to 1 dBA higher. A review of the table in Appendix A shows the highest sound level at a non-participating structure to be 47 dBA at Location 146. The highest modeled sound level at a participating structure is 49 dBA (Location 38). Therefore, the Project meets the requirements with respect to sound in the regulation.

## 7.0 CONCLUSIONS

---

A comprehensive sound level analysis was conducted for the proposed Langdon Wind Energy Center Repower Project within Cavalier County. A total of 106 wind turbines are included for this Project. Sound levels resulting from the operation of these 106 wind turbines and a collector substation were calculated at 120 discrete modeling points, and isolines were generated from a grid encompassing the area surrounding the wind turbines using the provided as-built layout. The sound levels modeled at receptors in Cavalier County ranged from 22 to 49 dBA. These sound levels are all below the state limit of 50 dBA, even if evaluated at locations 100 feet closer to a turbine. Therefore, the Project meets the requirements with respect to sound in the regulation.

**Appendix A**

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**Predicted Wind Energy Facility Sound Levels at Discrete Modeling Points**

**Table A-1: Sound Level Modeling Results at Discrete Points in Calvalier County - Sorted by Modeling ID**

Modeling ID	Coordinates UTM NAD83 Zone 14N		Source Only Broadband Sound Level (dBA)	Participation Status
	X (m)	Y (m)		
1	551,489	5,396,568	33	Non-Participating
6	551,800	5,396,972	31	Non-Participating
7	551,680	5,396,241	34	Non-Participating
8	552,632	5,396,443	33	Non-Participating
10	555,004	5,395,704	30	Non-Participating
11	554,902	5,395,684	30	Non-Participating
12	555,025	5,395,593	30	Non-Participating
13	555,038	5,395,668	30	Non-Participating
21	550,035	5,394,778	37	Non-Participating
25	553,848	5,394,734	36	Non-Participating
26	553,840	5,394,795	36	Non-Participating
31	554,701	5,394,598	32	Non-Participating
35	555,099	5,394,812	31	Non-Participating
37	555,363	5,393,534	31	Non-Participating
38	551,672	5,393,446	49	Participating
39	550,842	5,393,952	43	Non-Participating
44	546,861	5,393,967	32	Non-Participating
46	549,037	5,392,994	41	Non-Participating
50	553,400	5,392,854	36	Non-Participating
54	555,099	5,392,476	32	Non-Participating
60	547,382	5,391,381	37	Non-Participating
62	546,923	5,391,594	35	Non-Participating
64	551,989	5,390,192	42	Non-Participating
66	553,857	5,390,116	44	Non-Participating
72	555,248	5,389,929	37	Non-Participating
73	557,627	5,389,717	32	Non-Participating
74	557,679	5,389,689	32	Non-Participating
78	555,446	5,389,741	36	Non-Participating
81	554,959	5,389,809	39	Non-Participating
83	553,455	5,389,940	46	Non-Participating
84	553,079	5,389,902	46	Non-Participating
90	549,109	5,389,885	46	Participating
96	548,389	5,389,890	43	Non-Participating
101	547,260	5,388,937	41	Non-Participating
102	547,260	5,389,748	38	Non-Participating
106	550,929	5,388,592	40	Non-Participating
107	552,297	5,388,011	41	Non-Participating
109	546,919	5,387,772	47	Non-Participating
111	547,073	5,386,020	45	Non-Participating
112	553,001	5,386,731	42	Non-Participating
116	553,817	5,386,769	42	Non-Participating
122	558,140	5,385,743	39	Non-Participating
126	558,501	5,386,526	35	Non-Participating
132	559,994	5,385,451	32	Non-Participating
135	553,352	5,385,648	43	Non-Participating
136	553,302	5,385,647	43	Non-Participating

**Table A-1: Sound Level Modeling Results at Discrete Points in Calvalier County - Sorted by Modeling ID**

Modeling ID	Coordinates UTM NAD83 Zone 14N		Source Only Broadband Sound Level (dBA)	Participation Status
	X (m)	Y (m)		
140	551,885	5,385,488	46	Non-Participating
146	547,407	5,384,802	47	Non-Participating
147	546,203	5,384,909	45	Non-Participating
152	543,900	5,384,769	34	Non-Participating
153	543,901	5,384,638	34	Non-Participating
157	548,538	5,384,445	46	Non-Participating
158	543,938	5,384,722	34	Non-Participating
161	559,768	5,384,056	34	Non-Participating
166	552,232	5,382,887	45	Participating
172	551,440	5,383,574	43	Participating
173	551,488	5,383,536	43	Participating
177	550,306	5,383,654	45	Non-Participating
178	550,335	5,383,633	45	Non-Participating
182	548,254	5,383,454	43	Non-Participating
186	546,979	5,383,342	42	Non-Participating
188	545,502	5,382,599	38	Non-Participating
191	545,586	5,381,605	34	Non-Participating
195	550,650	5,381,911	45	Participating
199	551,638	5,382,577	44	Non-Participating
202	553,767	5,381,750	47	Non-Participating
206	555,445	5,381,887	46	Non-Participating
209	559,820	5,381,094	31	Non-Participating
212	556,995	5,381,408	44	Non-Participating
213	557,000	5,381,381	44	Non-Participating
214	556,916	5,381,374	45	Non-Participating
216	546,903	5,380,257	35	Non-Participating
217	546,872	5,380,106	35	Non-Participating
220	547,825	5,380,033	39	Non-Participating
224	547,894	5,380,060	40	Non-Participating
227	557,131	5,380,269	40	Non-Participating
233	557,754	5,380,353	37	Non-Participating
234	559,076	5,379,857	31	Non-Participating
235	559,089	5,379,766	31	Non-Participating
239	556,767	5,378,671	34	Non-Participating
241	555,690	5,378,701	36	Non-Participating
242	555,679	5,378,674	36	Non-Participating
244	551,391	5,378,526	36	Non-Participating
246	548,917	5,378,800	37	Non-Participating
247	547,575	5,397,822	26	Non-Participating
248	556,310	5,397,082	26	Non-Participating
249	548,454	5,393,855	36	Non-Participating
250	553,961	5,381,723	46	Non-Participating
251	553,281	5,381,927	49	Participating
252	550,093	5,381,623	44	Non-Participating
253	551,091	5,379,735	41	Non-Participating
254	548,852	5,381,704	47	Participating

**Table A-1: Sound Level Modeling Results at Discrete Points in Calvalier County - Sorted by Modeling ID**

Modeling ID	Coordinates UTM NAD83 Zone 14N		Source Only Broadband Sound Level (dBA)	Participation Status
	X (m)	Y (m)		
255	547,403	5,394,726	31	Non-Participating
256	546,908	5,396,042	28	Non-Participating
257	546,609	5,397,280	26	Non-Participating
258	545,274	5,393,681	29	Non-Participating
259	545,840	5,391,288	33	Non-Participating
260	544,945	5,391,310	31	Non-Participating
261	558,169	5,390,579	30	Non-Participating
262	557,670	5,393,237	28	Non-Participating
263	552,015	5,398,016	28	Non-Participating
264	552,751	5,397,768	29	Non-Participating
265	557,920	5,398,016	23	Non-Participating
266	554,785	5,401,284	22	Non-Participating
267	553,894	5,401,246	22	Non-Participating
268	553,067	5,401,229	22	Non-Participating
269	552,677	5,401,207	22	Non-Participating
270	551,365	5,401,081	23	Non-Participating
271	550,251	5,401,077	23	Non-Participating
272	550,115	5,401,066	23	Non-Participating
273	549,974	5,401,069	23	Non-Participating
274	549,826	5,400,879	23	Non-Participating
275	549,905	5,400,880	23	Non-Participating
276	549,930	5,400,795	23	Non-Participating
277	549,917	5,400,932	23	Non-Participating
278	550,156	5,400,317	24	Non-Participating
279	549,113	5,399,246	25	Non-Participating
280	550,225	5,399,350	25	Non-Participating
281	545,416	5,391,682	32	Non-Participating
282	544,638	5,388,052	34	Non-Participating

## **Appendix 2. Shadow Flicker Analysis**

## SHADOW FLICKER REPORT

---

# Langdon Wind Energy Center Repower Project Cavalier County, North Dakota

*Prepared for:*

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*Prepared by:*



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May 17, 2018

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## 1.0 EXECUTIVE SUMMARY

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The Langdon Wind Energy Center Repower Project (the Project) is a proposed re-powering of a wind power electric generation facility consisting of 106 wind turbines in Cavalier County, North Dakota. The Project is being developed by Langdon Wind, LLC, a subsidiary of NextEra Energy Resources, LLC (NEER). Epsilon Associates, Inc. (Epsilon) has been retained by Atwell, LLC (Atwell) to conduct a shadow flicker analysis for this Project. The project plans to upgrade and replace the rotors on the existing turbines, which will increase the rotor diameter on each unit from 77m to 91m.

Shadow flicker modeling was conducted to determine the location and duration of shadow flicker in the vicinity of the Project. The duration of shadow flicker was calculated at 120 discrete modeling points, and isolines were generated from a grid encompassing the area surrounding the wind turbines.

The existing layout repowered with new rotors results in a maximum expected annual duration of shadow flicker at a receptor of 48 hours, 6 minutes (ID# 38). This receptor is a vacant structure on a participating parcel. The maximum expected annual shadow flicker duration at a non-participating receptor is 28 hours, 8 minutes (ID# 157). This receptor is a vacant structure. The maximum expected annual shadow flicker duration at an occupied structure located on non-participating parcel is 26 hours, 37 minutes (ID# 202). The modeling results are conservative in that modeling receptors were treated as “greenhouses” and the surrounding area was assumed to be without vegetation or structures (“bare earth”).

## 2.0 INTRODUCTION

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With respect to wind turbines, shadow flicker can be defined as an intermittent change in the intensity of light in a given area resulting from the operation of a wind turbine due to its interaction with the sun. While indoors, an observer experiences repeated changes in the brightness of the room as shadows cast from the wind turbine blades briefly pass by windows as the blades rotate. In order for this to occur, the wind turbine must be operating, the sun must be shining, and the window must be within the shadow region of the wind turbine, otherwise there is no shadow flicker. A stationary wind turbine only generates a stationary shadow similar to any other structure.

This report presents the findings of a shadow flicker modeling analysis for the Project. The wind turbines were modeled with the WindPRO software package using information provided by Atwell and NEER. The expected annual duration of shadow flicker was calculated at discrete modeling locations within Cavalier County and shadow flicker isolines for the area surrounding the Project were generated. The results of this analysis are found within this report.

## 3.0 SHADOW FLICKER ANALYSIS

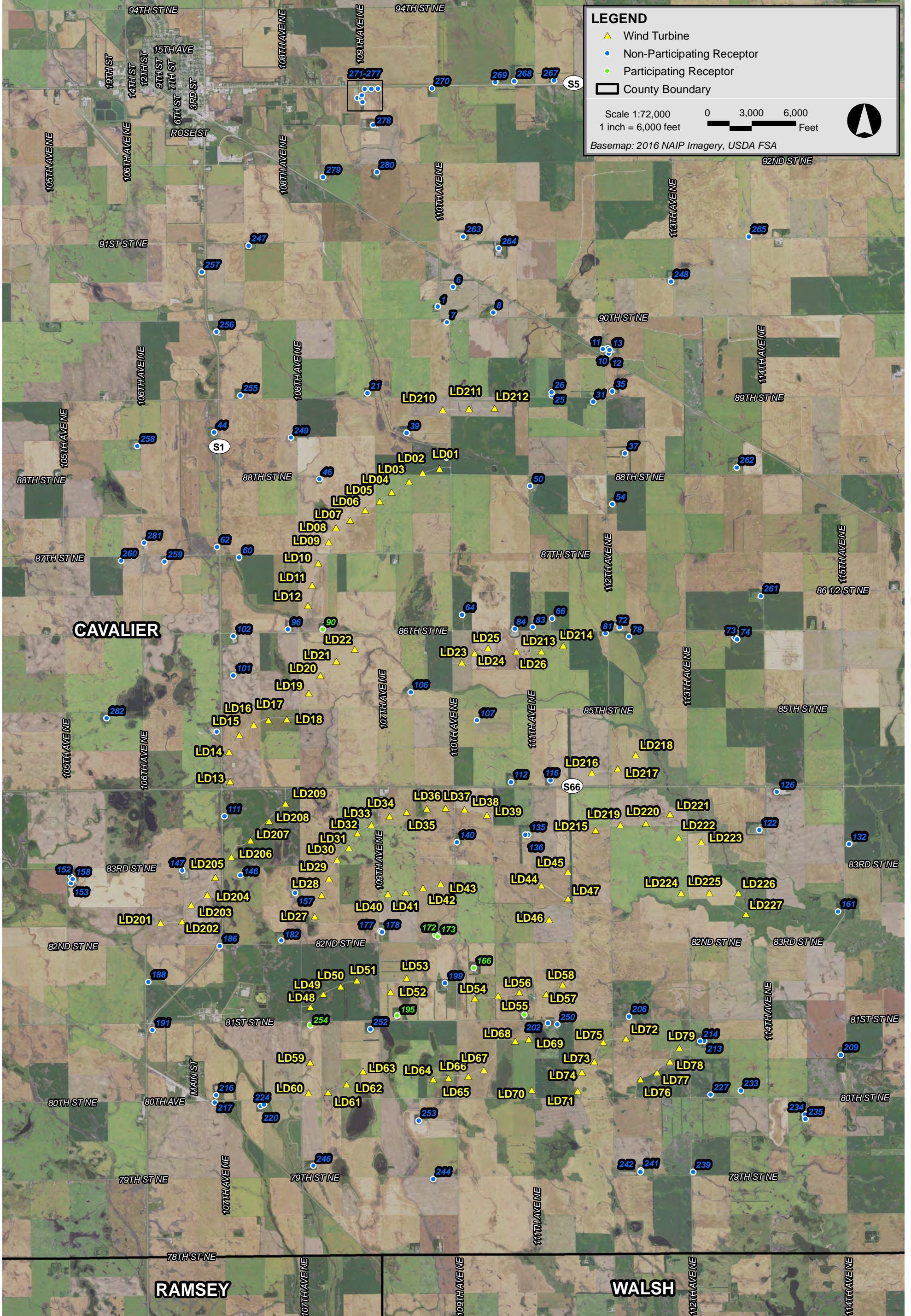
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### 3.1 Modeling Methodology

Shadow flicker was modeled using a software package, WindPRO version 3.1.617. WindPRO is a software suite developed by EMD International A/S and is used for assessing potential environmental impacts from wind turbines. Using the Shadow module within WindPRO, worst-case shadow flicker in the area surrounding the wind turbines was calculated based on data inputs including: location of the wind turbines, location of discrete modeling points, wind turbine dimensions, flicker calculation limits, and terrain data. Based on these data, the model was able to incorporate the appropriate sun angle and maximum daily sunlight for this latitude into the calculations. The resulting worst-case calculations assume that the sun is always shining during daylight hours and that the wind turbine is always operating. The WindPRO Shadow module can be further refined by incorporating sunshine probabilities and wind turbine operational estimates by wind direction over the course of a year. The values for this further refinement, also known as the “expected” shadow flicker, are presented in this section.

The existing as-built wind turbine layout was presented as two groups of turbines. The Langdon I (Layout 170622) and Langdon II (Layout 170707) for the Project were provided in AutoCAD format by Atwell. The layouts included a total of 106 existing wind turbines. Locations of the wind turbines are shown in Figure 3-1. All of the 106 wind turbines are GE 1.6-91 units. These wind turbines entered into the model using the WindPRO WTG Catalog which provided operational specifics relative to flicker modeling. The GE 1.6-91 wind turbines have a hub height of 80 meters and a rotor diameter of 91 meters.

A modeling receptor dataset named 171002 dated October 2, 2017 was provided by Atwell which included participation status, and occupancy status for the receptors in the project area. The dataset included receptors at a significant distance from wind turbines (greater than 2 miles from the wind turbines) and these receptors were excluded from the analysis. The remaining 120 receptors from this dataset were included in the analysis. These sensitive receptors were modeled as discrete points and are shown on Figure 3-1. Each modeling point was assumed to have a window facing all directions (“greenhouse” mode) which yields conservative results. In addition, a dataset containing parcel participation status was provided by Atwell which allowed for participation status to be assigned to each modeling receptor.



Langdon I and II Cavalier County, North Dakota

The model was set to limit calculations to 2,012 meters from a wind turbine, the equivalent of 1.25 miles. Consequently, shadow flicker at any of the 120 modeling receptors greater than the corresponding limitation distance from a wind turbine was zero. In addition to modeling discrete points, shadow flicker was calculated at grid points in the area surrounding the modeled wind turbines to generate flicker isolines. A 20-meter spacing was used for this grid.

The terrain height contour elevations for the modeling domain were generated from elevation information derived from 2-meter 3X3 Digital Elevation Models (DEMs) provided by the North Dakota Department of Natural Resources. Conservatively, obstacles, i.e. buildings and vegetation, were excluded from the analysis. This is effectively a “bare earth” scenario which is conservative. When accounted for in the shadow flicker calculations, such obstacles may significantly mitigate or eliminate the flicker effect depending on their size, type, and location. In addition, shadow flicker durations were calculated only when the angle of the sun was at least 3° above the horizon.

Monthly sunshine probability values were input for each month from January to December. These numbers were obtained from a publicly available historical dataset for Fargo, North Dakota from the National Oceanic and Atmospheric Administration’s (NOAA) National Centers for Environmental Information (NCEI).<sup>1</sup> Table 3-1 shows the percentage of sunshine hours by month used in the shadow flicker modeling. These values are the percentages that the sun is expected to be shining during daylight hours.

The number of hours the wind turbines are expected to operate for the 16 cardinal wind directions was input into the model. Hourly wind speed and direction were provided by Langdon Wind from meteorological data collected from 2006 to 2007. Epsilon processed a subset of the data into a joint frequency distribution of wind speed and wind direction which allowed for the determination of operational hours per wind direction sector. Operational times were based upon the cut-in (3 m/s) and cut-out (31 m/s) wind speeds of the GE 1.6-91 turbine. These operating limits were based on the technical data provided by Atwell. These hours per wind direction sector are used by WindPRO to estimate the “wind direction” and “operation time” reduction factors. Based on this dataset, the wind turbines would operate 88% of the year due to cut-in and cut-out specifications of the proposed wind turbines. Table 3-2 shows the distribution of operational hours for the 16 wind directions.

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<sup>1</sup> NCEI (formerly NCDC), <https://www.ncdc.noaa.gov/ghcn/comparative-climatic-data>. Accessed in March 2017.

Table 3-1 Monthly Percent of Possible Sunshine

Month	Possible Sunshine
January	52%
February	54%
March	59%
April	57%
May	60%
June	64%
July	74%
August	71%
September	63%
October	51%
November	39%
December	39%

Table 3-2 Operational Hours per Wind Direction Sector

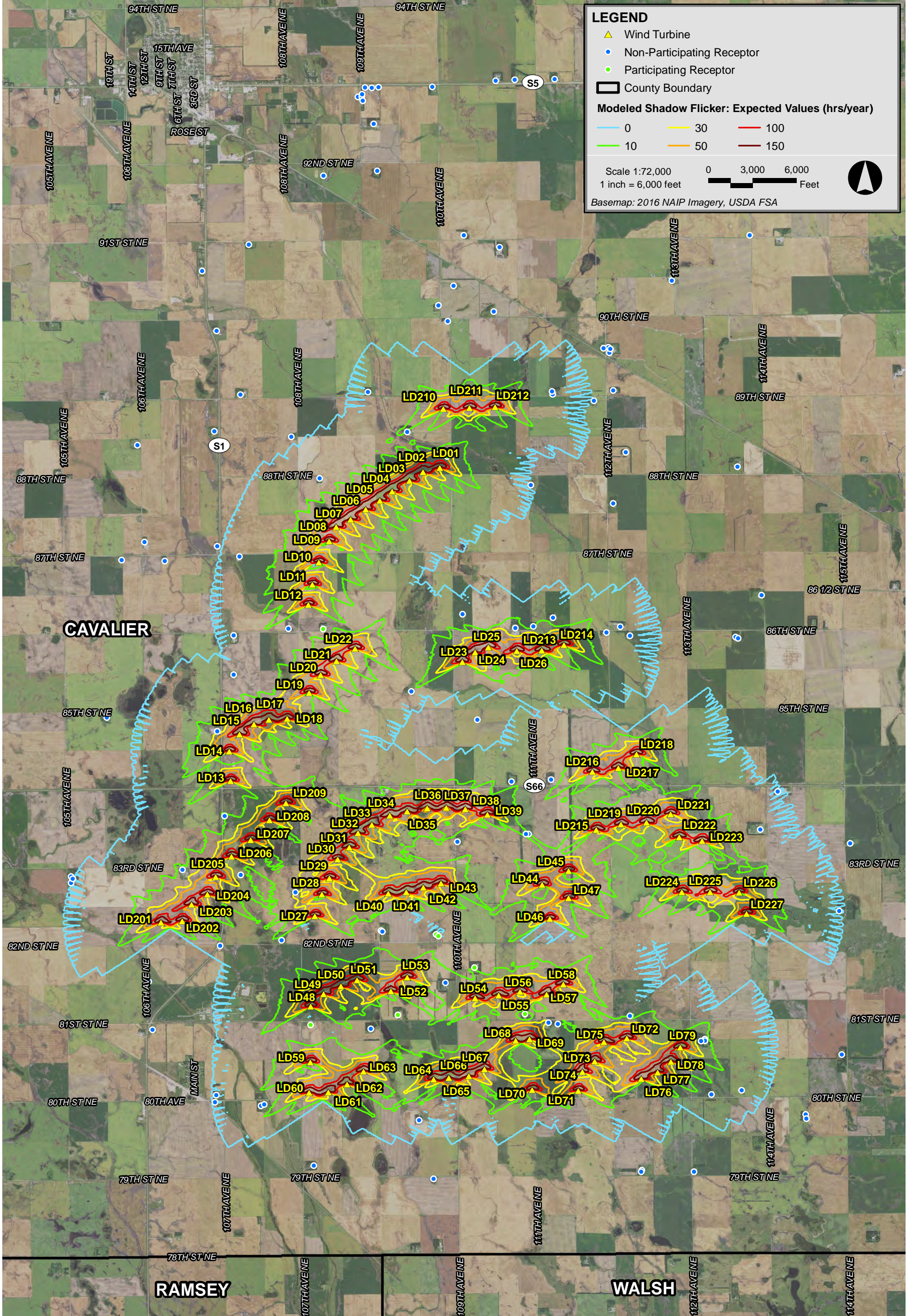
Wind Sector	Operational Hours
N	82
NNE	395
NE	472
ENE	544
E	563
ESE	536
SE	551
SSE	455
S	531
SSW	760
SW	868
WSW	571
W	528
WNW	373
NW	277
NNW	202
Annual	7,708

### 3.2 Results

Following the modeling methodology outlined in Section 3.1, WindPRO was used to calculate shadow flicker at the 120 discrete modeling points and generate shadow flicker isolines based on the grid calculations.

Table A-1 in Appendix A presents the modeling results for the 120 modeling receptor locations. The predicted expected annual shadow flicker duration ranged from 0 hours, 0 minutes per year to 48 hours, 6 minutes per year. The majority of the discrete modeling receptors (62) were predicted to experience no annual shadow flicker. 41 locations were predicted to experience some shadow flicker but less than 10 hours per year. The modeling results showed that 16 locations would be expected to have 10 to 30 hours of shadow flicker per year. One location was predicted to experience more than 30 hours per year. At this receptor, the maximum expected annual duration of shadow flicker is 48 hours, 6 minutes. This occurs at a participating parcel (ID# 38). The maximum expected shadow flicker at a non-participating structure is 28 hours, 8 minutes. (ID# 157).

Figures 3-2 displays the modeled flicker isolines over aerial imagery in relation to modeled wind turbines and sensitive receptors.



Langdon I and II Cavalier County, North Dakota

## 4.0 CONCLUSIONS

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Shadow flicker modeling was conducted to determine the location and duration of shadow flicker in the vicinity of the proposed Langdon Wind Energy Center Repower Project within Cavalier County. A total of 106 wind turbines are being re-powered via rotor replacement for this Project. Shadow flicker resulting from the operation of these 106 wind turbines was calculated at 120 discrete modeling points, and isolines were generated from a grid encompassing the area surrounding the wind turbines using the existing layout.

The existing layout repowered with new rotors results in a maximum expected annual duration of shadow flicker at a receptor of 48 hours, 6 minutes (ID# 38). This receptor is on a participating parcel. The maximum expected annual shadow flicker duration at a non-participating receptor is 28 hours, 8 minutes (ID# 157). The modeling results are conservative in that modeling receptors were treated as “greenhouses” and the surrounding area was assumed to be without vegetation or structures (“bare earth”). All of the non-participating sensitive receptors are predicted to be below 30 hours per year of shadow flicker.

Appendix A

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Shadow Flicker Modeling Results: Discrete Points

Table A-1: Shadow Flicker Modeling Results at Discrete Points - Sorted by Modeling ID

Modeling Receptor ID	Participation Status	Coordinates UTM NAD83 Zone 14N		Expected Annual Shadow Flicker
		X (m)	Y (m)	(HH:MM/year)
1	Non-Participating	551,489	5,396,568	0:00
6	Non-Participating	551,800	5,396,971	0:00
7	Non-Participating	551,680	5,396,241	0:00
8	Non-Participating	552,632	5,396,443	0:00
10	Non-Participating	555,004	5,395,704	0:00
11	Non-Participating	554,902	5,395,684	0:00
12	Non-Participating	555,025	5,395,593	0:00
13	Non-Participating	555,038	5,395,668	0:00
21	Non-Participating	550,035	5,394,778	0:27
25	Non-Participating	553,848	5,394,734	1:11
26	Non-Participating	553,840	5,394,795	1:12
31	Non-Participating	554,701	5,394,598	0:00
35	Non-Participating	555,099	5,394,812	0:00
37	Non-Participating	555,363	5,393,534	0:00
38	Participating	551,672	5,393,446	48:06
39	Non-Participating	550,842	5,393,952	6:39
44	Non-Participating	546,861	5,393,967	0:00
46	Non-Participating	549,037	5,392,994	2:58
50	Non-Participating	553,400	5,392,854	0:06
54	Non-Participating	555,099	5,392,476	0:00
60	Non-Participating	547,382	5,391,381	1:38
62	Non-Participating	546,923	5,391,594	0:00
64	Non-Participating	551,989	5,390,192	1:04
66	Non-Participating	553,857	5,390,116	5:47
72	Non-Participating	555,248	5,389,929	1:08
73	Non-Participating	557,627	5,389,717	0:00
74	Non-Participating	557,679	5,389,689	0:00
78	Non-Participating	555,446	5,389,741	0:51
81	Non-Participating	554,959	5,389,809	2:50
83	Non-Participating	553,455	5,389,940	10:27
84	Non-Participating	553,079	5,389,902	17:03
90	Participating	549,109	5,389,885	3:48
96	Non-Participating	548,389	5,389,890	2:00
101	Non-Participating	547,260	5,388,937	1:58
102	Non-Participating	547,260	5,389,748	1:41
106	Non-Participating	550,929	5,388,592	6:59
107	Non-Participating	552,297	5,388,011	0:00
109	Non-Participating	546,919	5,387,771	24:13
111	Non-Participating	547,073	5,386,020	11:44
112	Non-Participating	553,001	5,386,731	3:16
116	Non-Participating	553,817	5,386,769	5:35

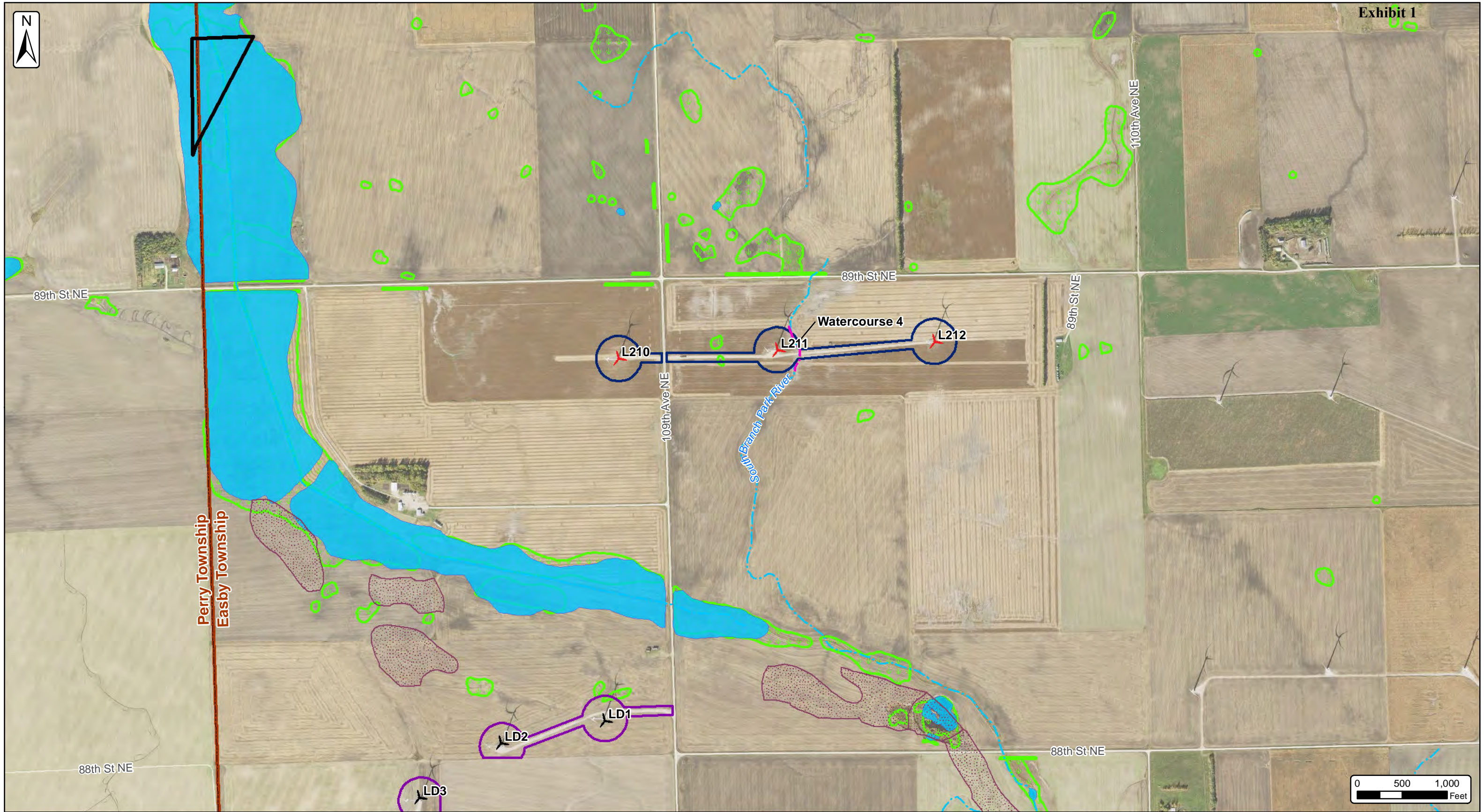
Table A-1: Shadow Flicker Modeling Results at Discrete Points - Sorted by Modeling ID

Modeling Receptor ID	Participation Status	Coordinates UTM NAD83 Zone 14N		Expected Annual Shadow Flicker
		X (m)	Y (m)	(HH:MM/year)
122	Non-Participating	558,140	5,385,743	1:27
126	Non-Participating	558,501	5,386,526	0:08
132	Non-Participating	559,994	5,385,451	0:00
135	Non-Participating	553,352	5,385,648	12:25
136	Non-Participating	553,302	5,385,647	13:40
140	Non-Participating	551,885	5,385,488	5:20
146	Non-Participating	547,407	5,384,802	15:36
147	Non-Participating	546,203	5,384,909	15:26
152	Non-Participating	543,900	5,384,769	0:00
153	Non-Participating	543,901	5,384,638	0:00
157	Non-Participating	548,538	5,384,445	28:08
158	Non-Participating	543,938	5,384,722	0:00
161	Non-Participating	559,768	5,384,056	0:07
166	Participating	552,232	5,382,887	7:52
172	Participating	551,440	5,383,574	0:10
173	Participating	551,488	5,383,536	0:07
177	Non-Participating	550,306	5,383,654	2:43
178	Non-Participating	550,335	5,383,633	2:26
182	Non-Participating	548,254	5,383,454	2:02
186	Non-Participating	546,979	5,383,342	2:02
188	Non-Participating	545,502	5,382,599	0:00
191	Non-Participating	545,586	5,381,605	0:00
195	Participating	550,650	5,381,911	3:20
199	Non-Participating	551,638	5,382,577	13:04
202	Non-Participating	553,767	5,381,750	26:37
206	Non-Participating	555,445	5,381,887	11:21
209	Non-Participating	559,820	5,381,094	0:00
212	Non-Participating	556,995	5,381,408	13:30
213	Non-Participating	557,000	5,381,381	13:49
214	Non-Participating	556,916	5,381,374	18:38
216	Non-Participating	546,903	5,380,257	0:15
217	Non-Participating	546,872	5,380,106	0:14
220	Non-Participating	547,825	5,380,033	4:12
224	Non-Participating	547,894	5,380,060	5:09
227	Non-Participating	557,131	5,380,269	3:03
233	Non-Participating	557,754	5,380,353	0:59
234	Non-Participating	559,076	5,379,857	0:00
235	Non-Participating	559,089	5,379,766	0:00
239	Non-Participating	556,767	5,378,671	0:00
241	Non-Participating	555,690	5,378,701	0:00
242	Non-Participating	555,679	5,378,674	0:00

Table A-1: Shadow Flicker Modeling Results at Discrete Points - Sorted by Modeling ID

Modeling Receptor ID	Participation Status	Coordinates UTM NAD83 Zone 14N		Expected Annual Shadow Flicker
		X (m)	Y (m)	(HH:MM/year)
244	Non-Participating	551,391	5,378,526	0:00
246	Non-Participating	548,917	5,378,800	0:00
247	Non-Participating	547,575	5,397,822	0:00
248	Non-Participating	556,310	5,397,082	0:00
249	Non-Participating	548,454	5,393,855	0:00
250	Non-Participating	553,961	5,381,723	14:48
251	Participating	553,281	5,381,927	2:56
252	Non-Participating	550,093	5,381,623	2:28
253	Non-Participating	551,091	5,379,735	0:49
254	Participating	548,852	5,381,704	2:04
255	Non-Participating	547,403	5,394,726	0:00
256	Non-Participating	546,908	5,396,042	0:00
257	Non-Participating	546,609	5,397,280	0:00
258	Non-Participating	545,274	5,393,681	0:00
259	Non-Participating	545,840	5,391,288	0:00
260	Non-Participating	544,945	5,391,310	0:00
261	Non-Participating	558,169	5,390,579	0:00
262	Non-Participating	557,670	5,393,237	0:00
263	Non-Participating	552,015	5,398,016	0:00
264	Non-Participating	552,751	5,397,768	0:00
265	Non-Participating	557,920	5,398,016	0:00
266	Non-Participating	554,785	5,401,284	0:00
267	Non-Participating	553,894	5,401,246	0:00
268	Non-Participating	553,067	5,401,229	0:00
269	Non-Participating	552,677	5,401,207	0:00
270	Non-Participating	551,365	5,401,081	0:00
271	Non-Participating	550,251	5,401,077	0:00
272	Non-Participating	550,115	5,401,066	0:00
273	Non-Participating	549,974	5,401,069	0:00
274	Non-Participating	549,826	5,400,879	0:00
275	Non-Participating	549,905	5,400,880	0:00
276	Non-Participating	549,930	5,400,795	0:00
277	Non-Participating	549,917	5,400,932	0:00
278	Non-Participating	550,156	5,400,317	0:00
279	Non-Participating	549,113	5,399,246	0:00
280	Non-Participating	550,225	5,399,350	0:00
281	Non-Participating	545,416	5,391,682	0:00
282	Non-Participating	544,638	5,388,052	0:00

**Appendix 3. Aquatic Resource Maps**



**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
**Page 1 of 17**  
Cavalier County, North Dakota  
Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
Atwell, LLC Project:  
17001949 & 17002362

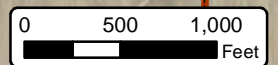
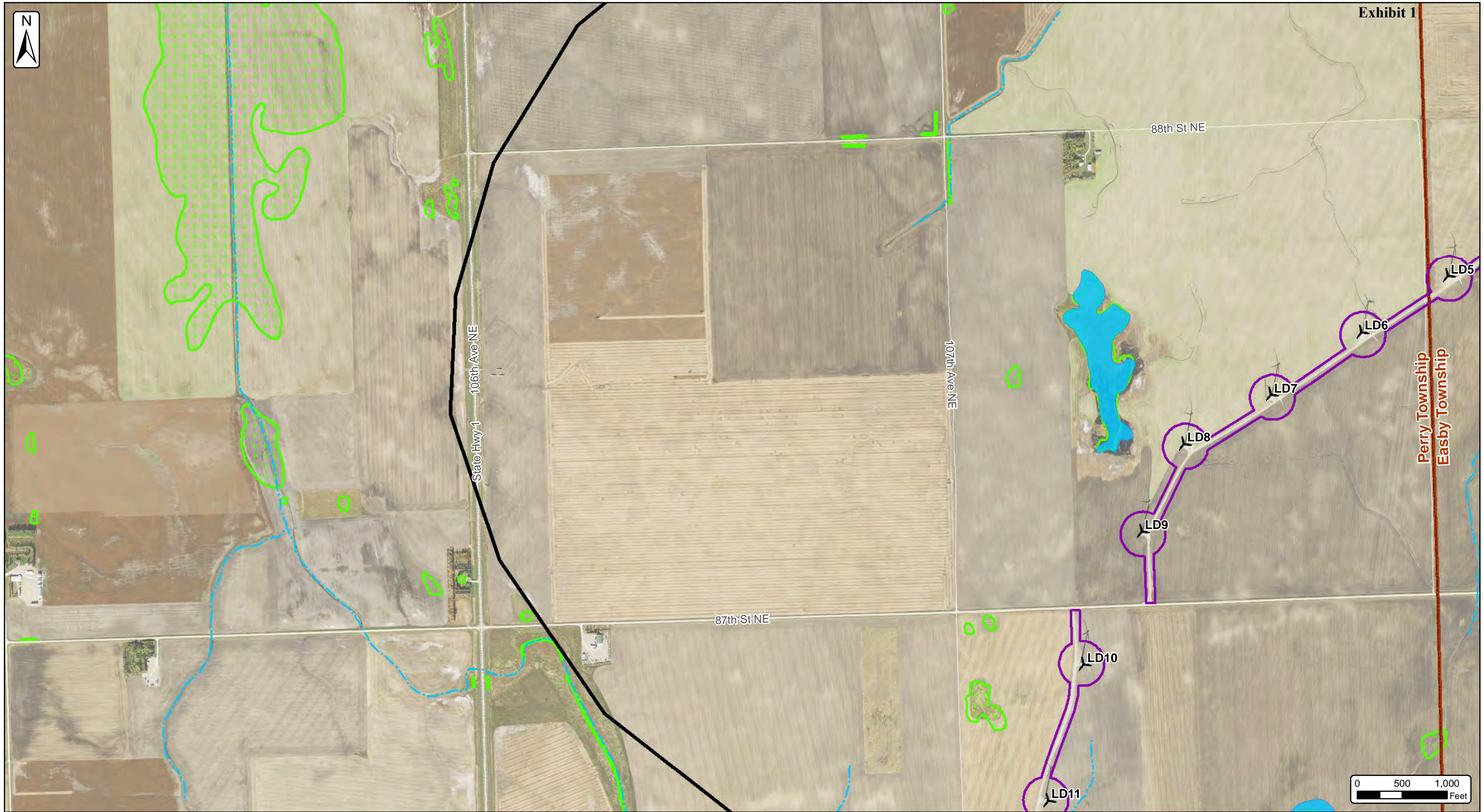
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SOURCE: USDA NAIP 2017 IMAGERY



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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 2 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

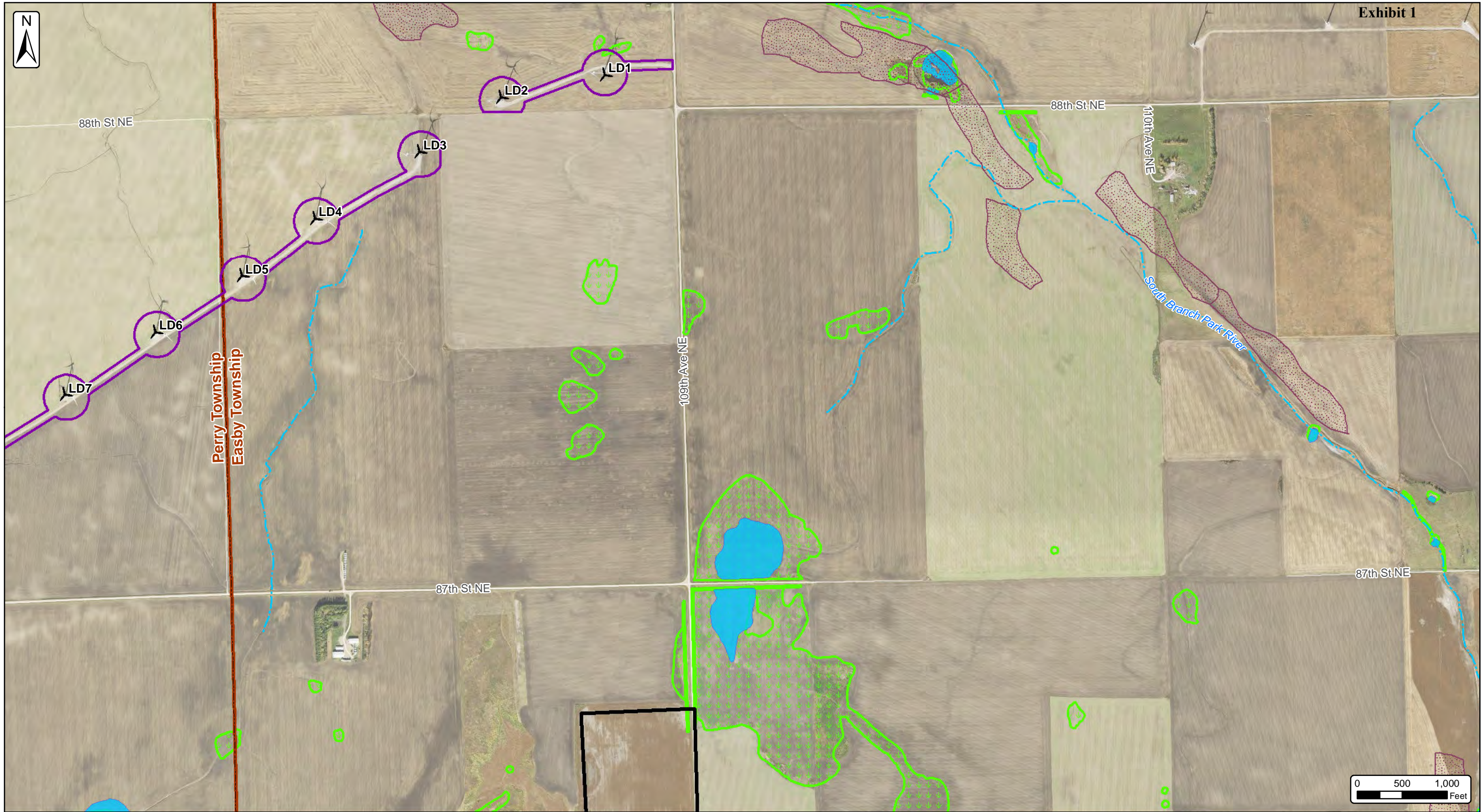
Client:  
**Langdon Wind, LLC**  
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 17001949 & 17002362

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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 3 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

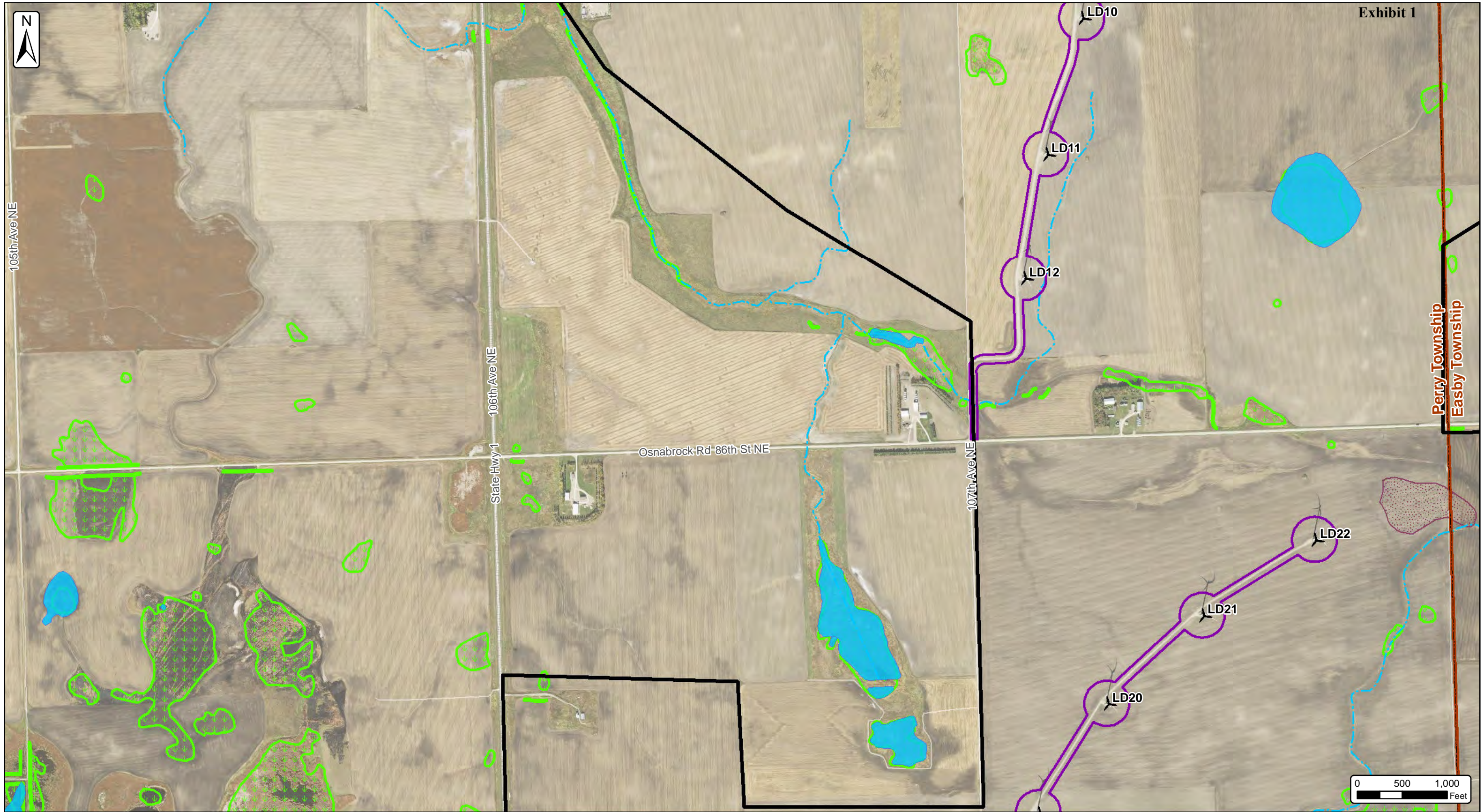
Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 4 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

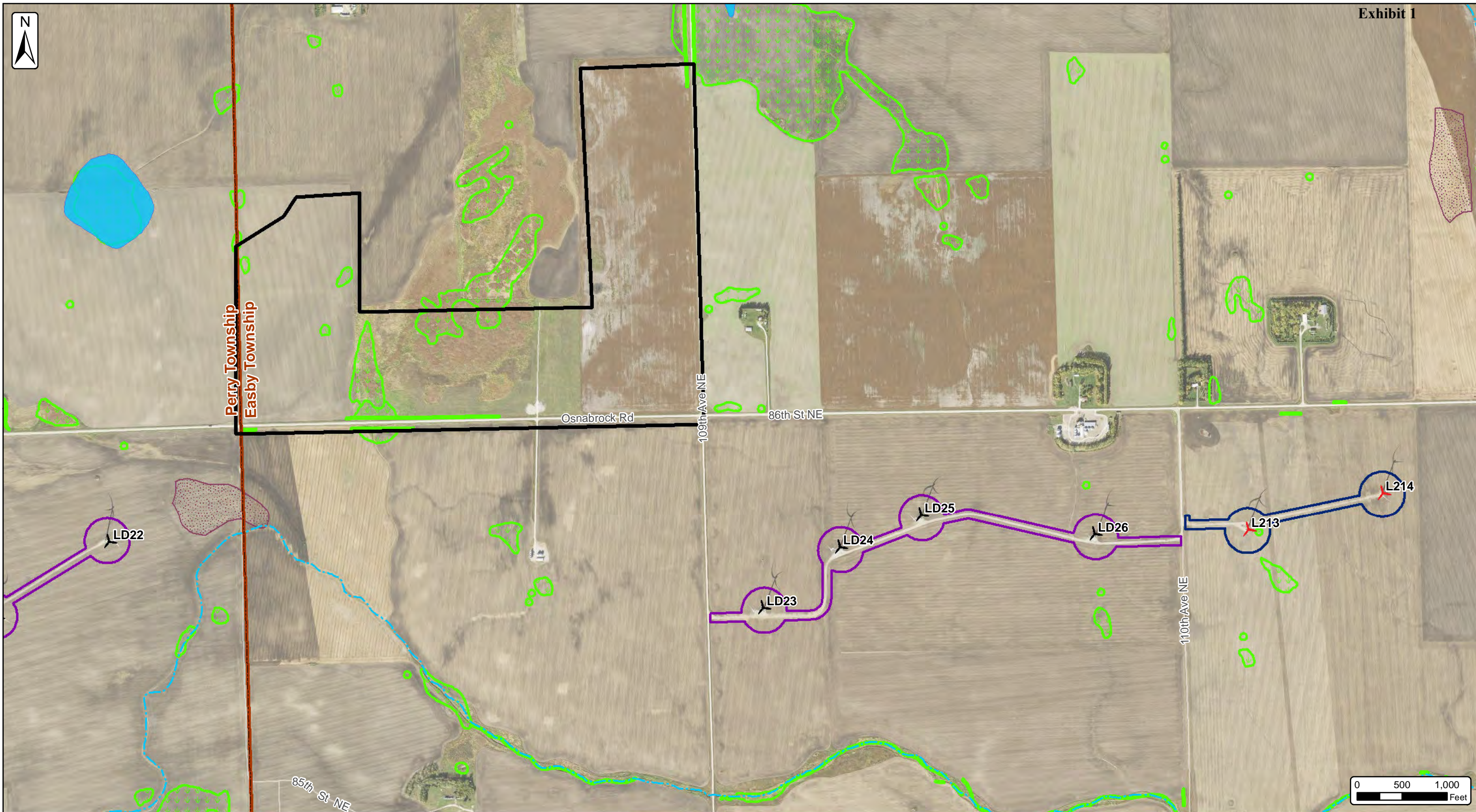
Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

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**Langdon Wind Energy Center**  
Aquatic Resource Map  
Page 5 of 17  
Cavalier County, North Dakota  
Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
Atwell, LLC Project:  
17001949 & 17002362

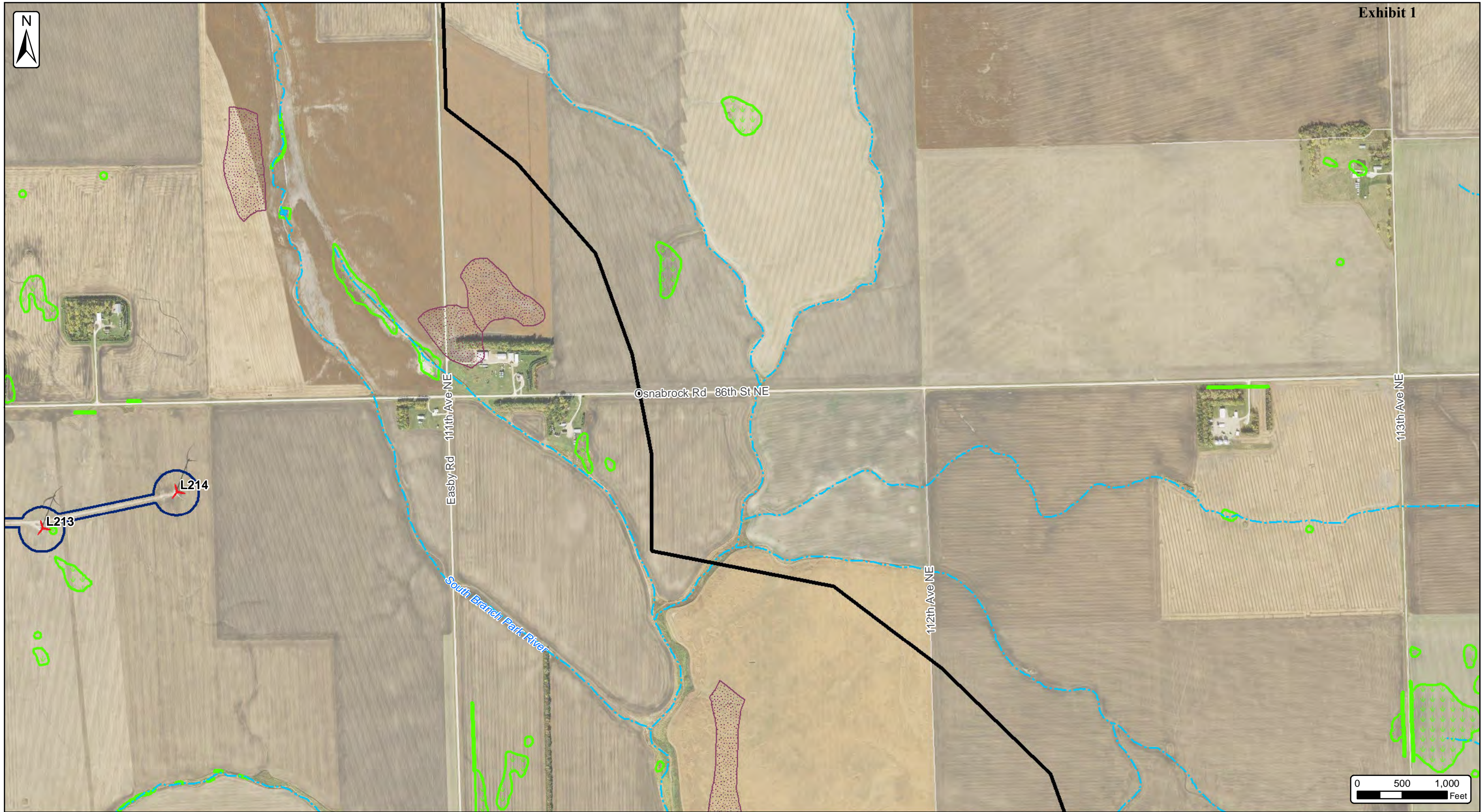
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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 6 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

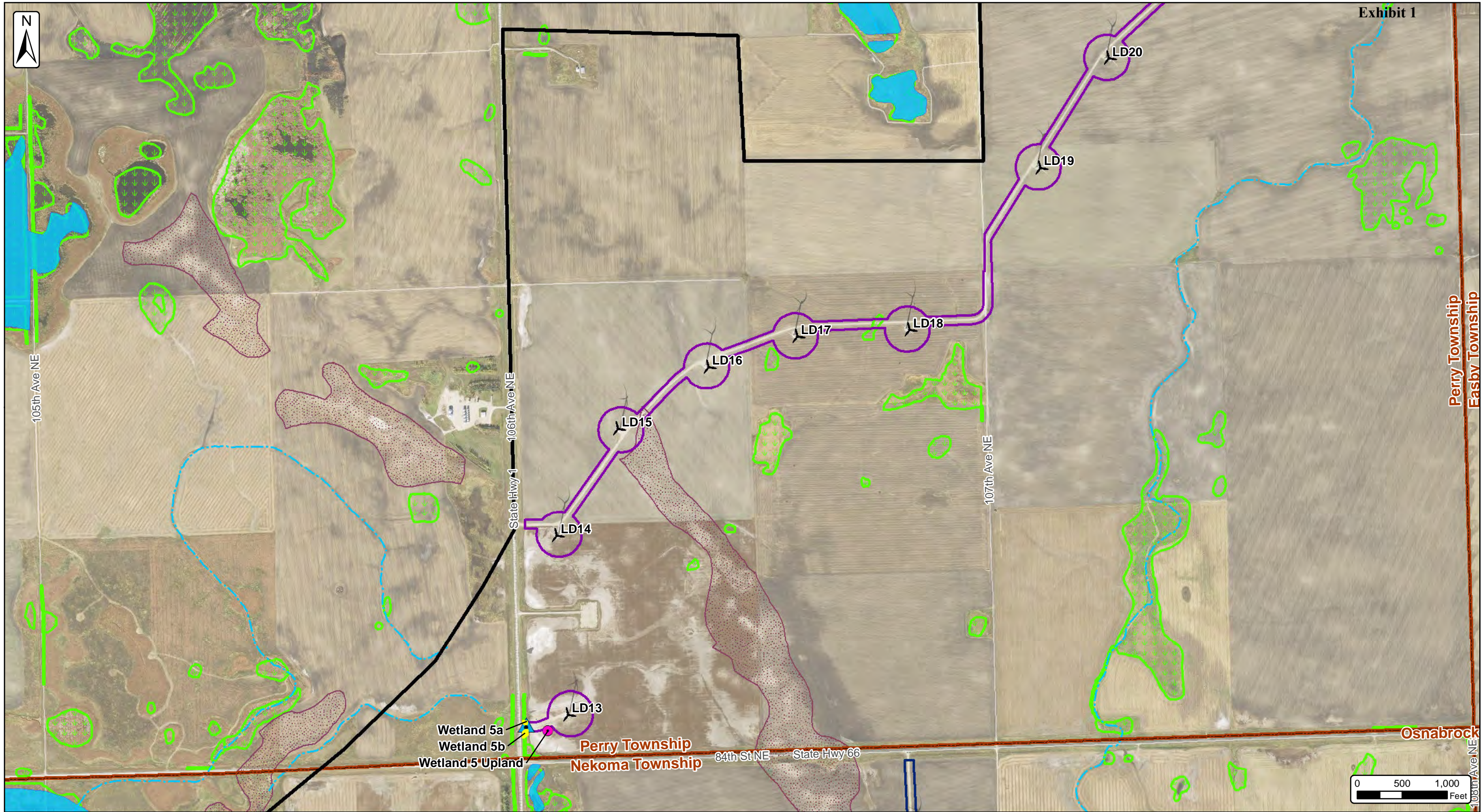
Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 7 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

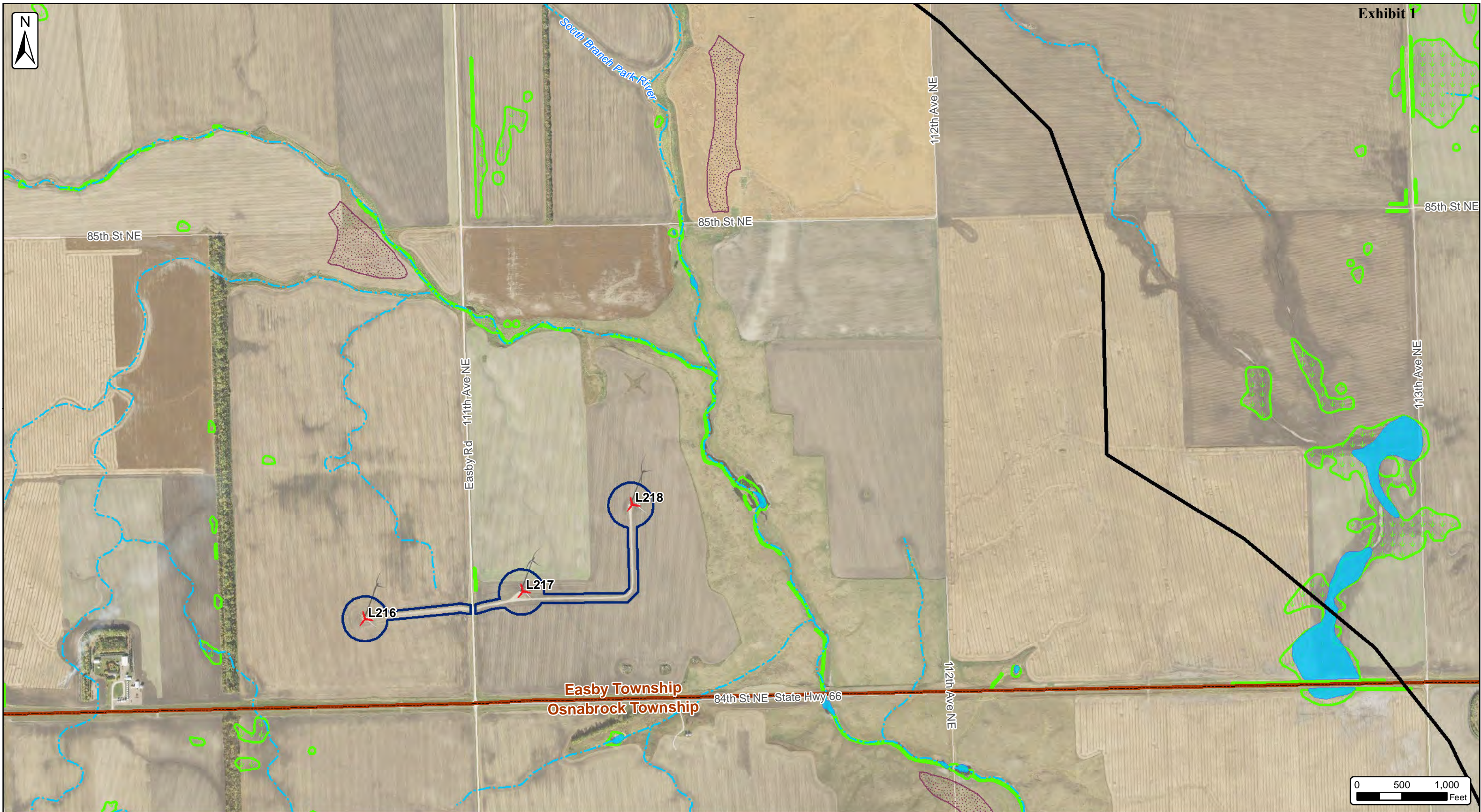
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SOURCE: USDA NAIP 2017 IMAGERY



**Langdon Wind Energy Center**  
Aquatic Resource Map  
Page 8 of 17  
Cavalier County, North Dakota  
Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
Atwell, LLC Project:  
17001949 & 17002362

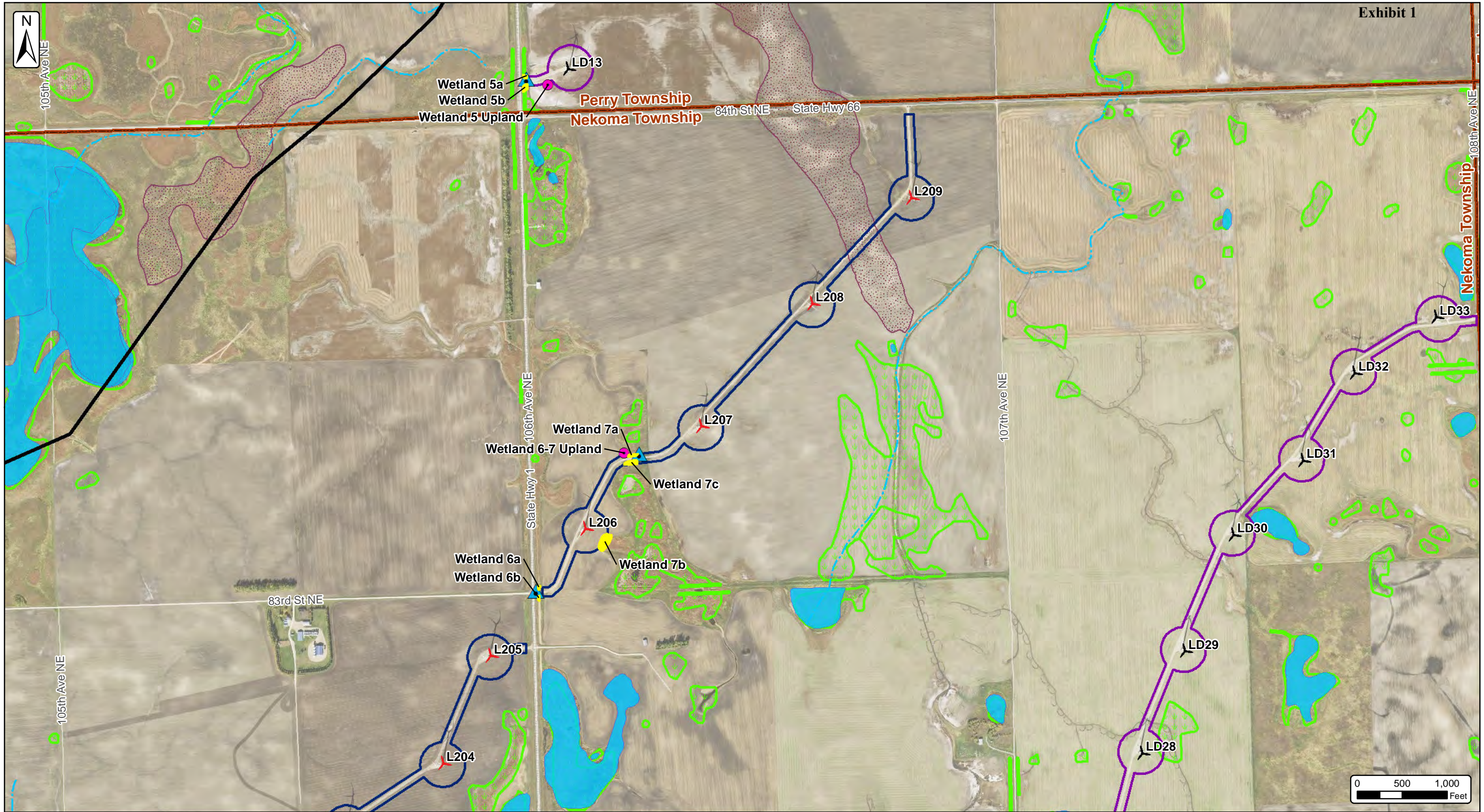
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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 9 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
**Page 10 of 17**  
 Cavalier County, North Dakota  
 Date: 5/23/2018

**Client:**  
**Langdon Wind, LLC**  
**Atwell, LLC Project:**  
 17001949 & 17002362

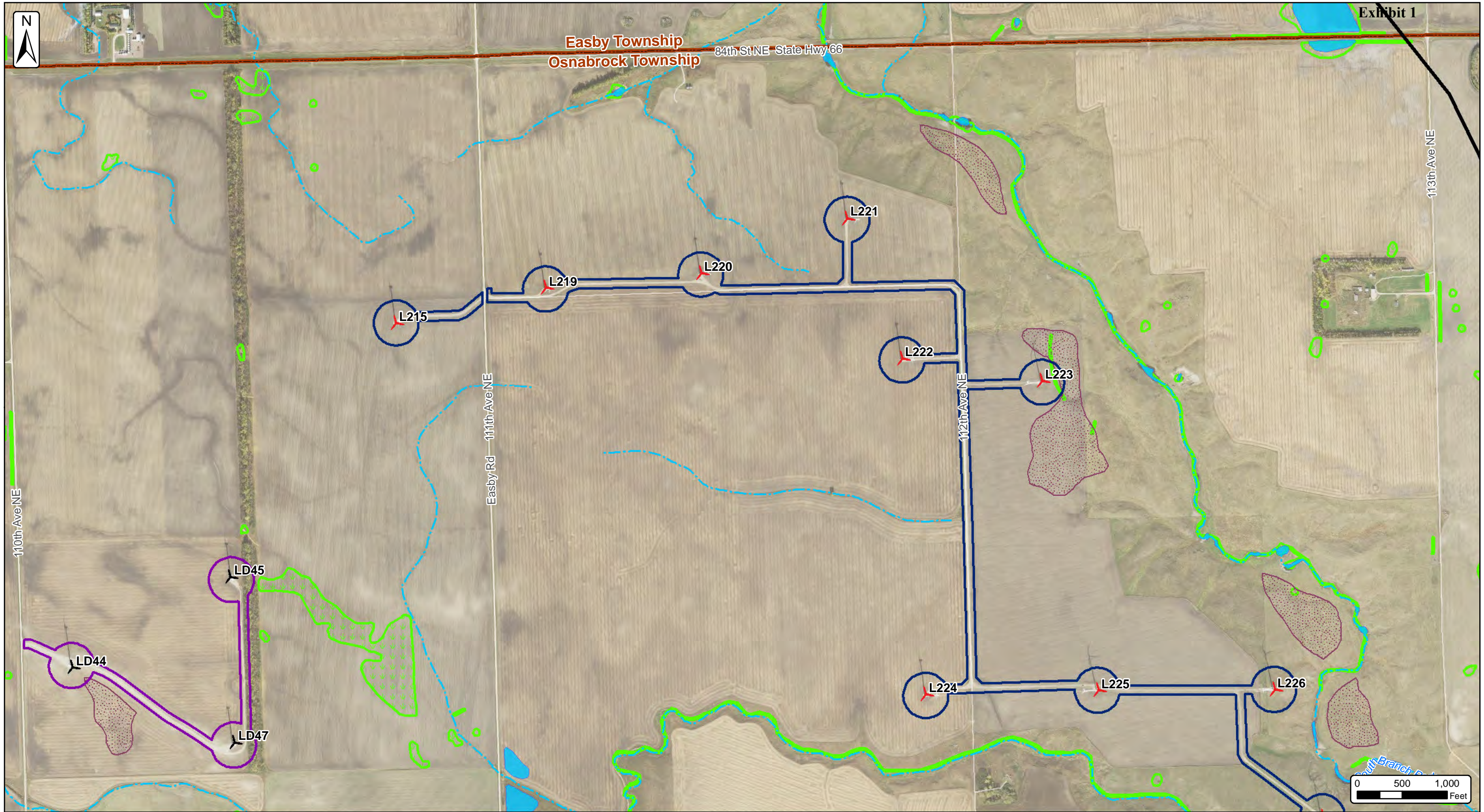
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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 11 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

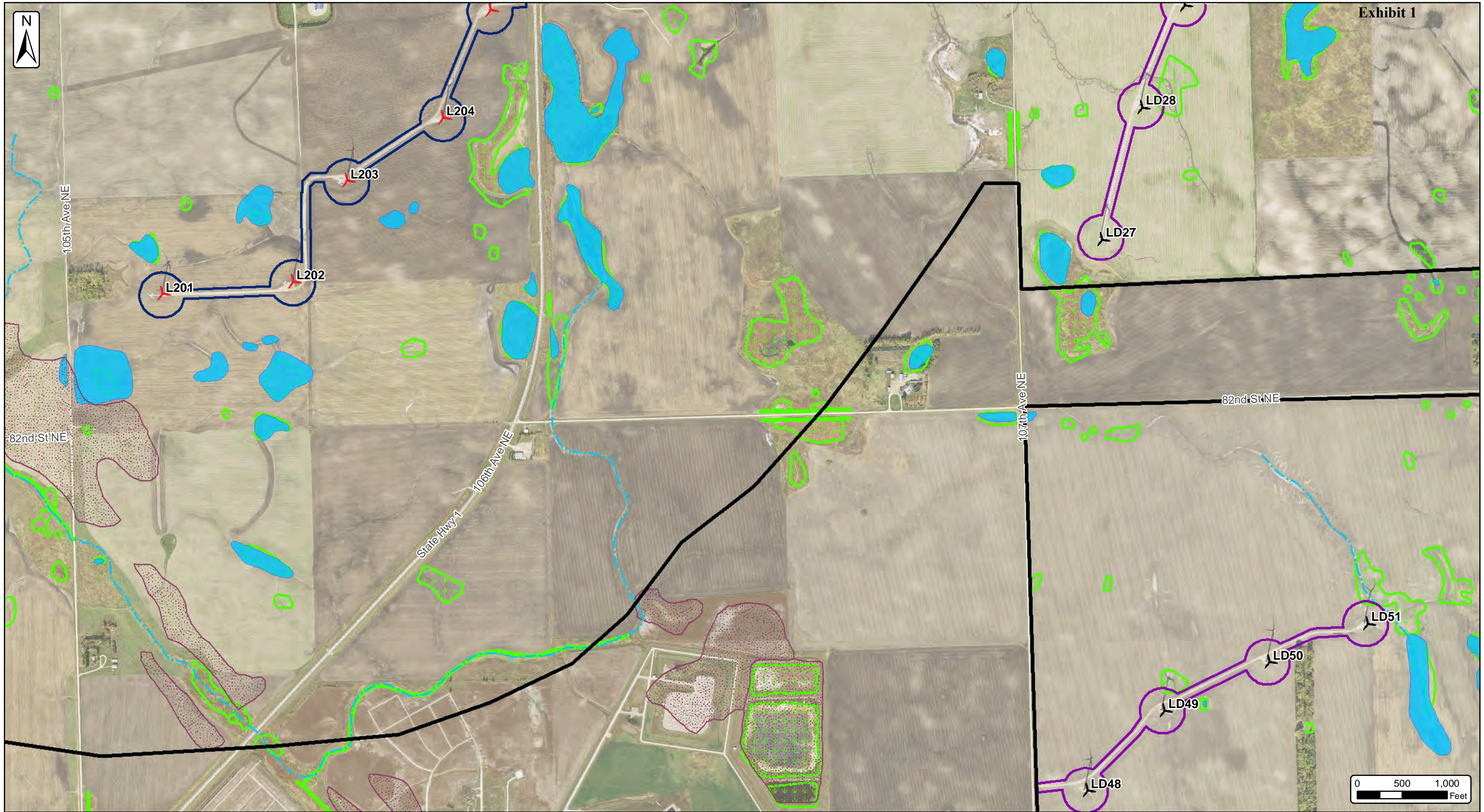
**Client:**  
**Langdon Wind, LLC**  
**Atwell, LLC Project:**  
 17001949 & 17002362

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**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 12 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

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**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

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**ATWELL**

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SOURCE: USDA NAIP 2017 IMAGERY

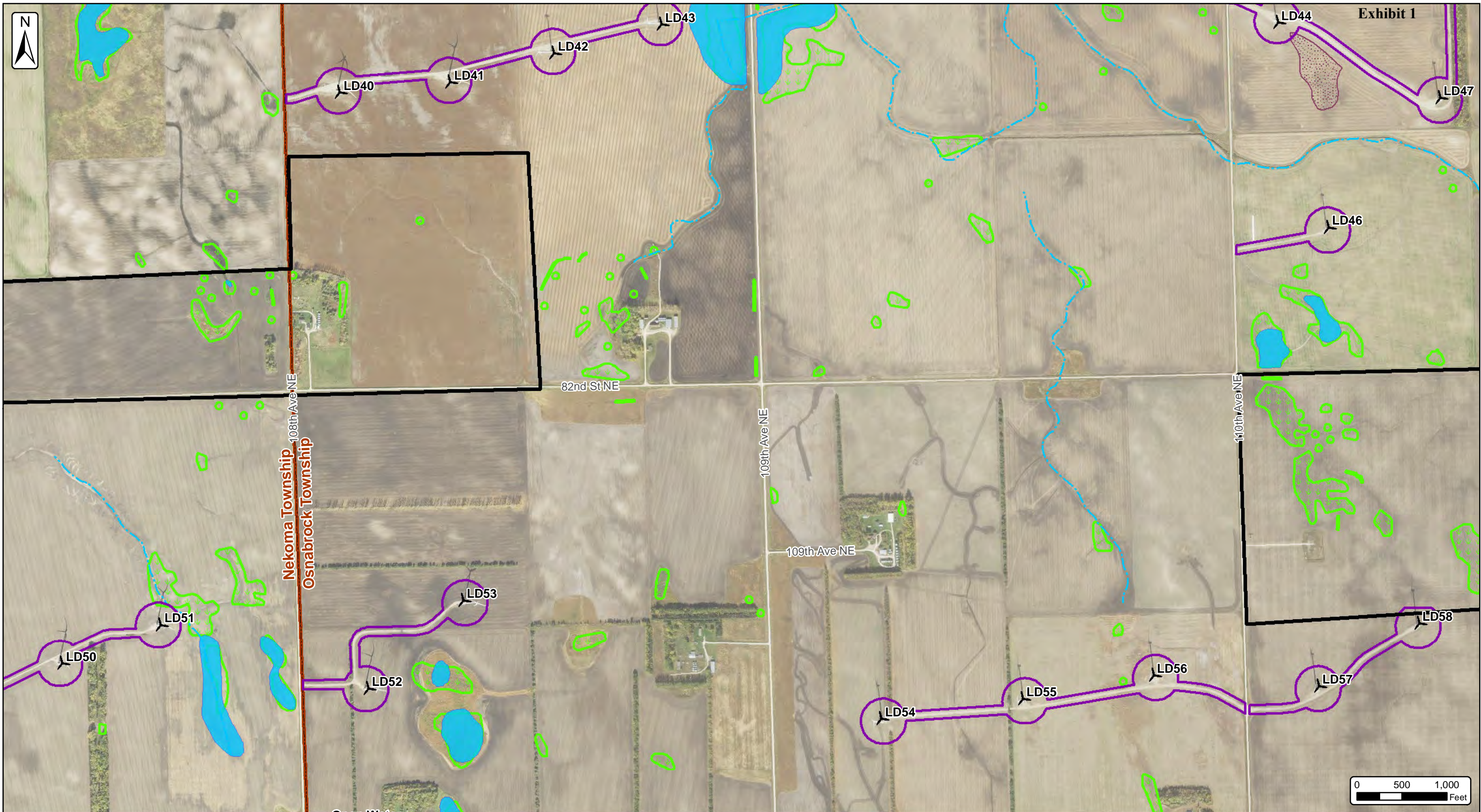


Exhibit 1


**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 13 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

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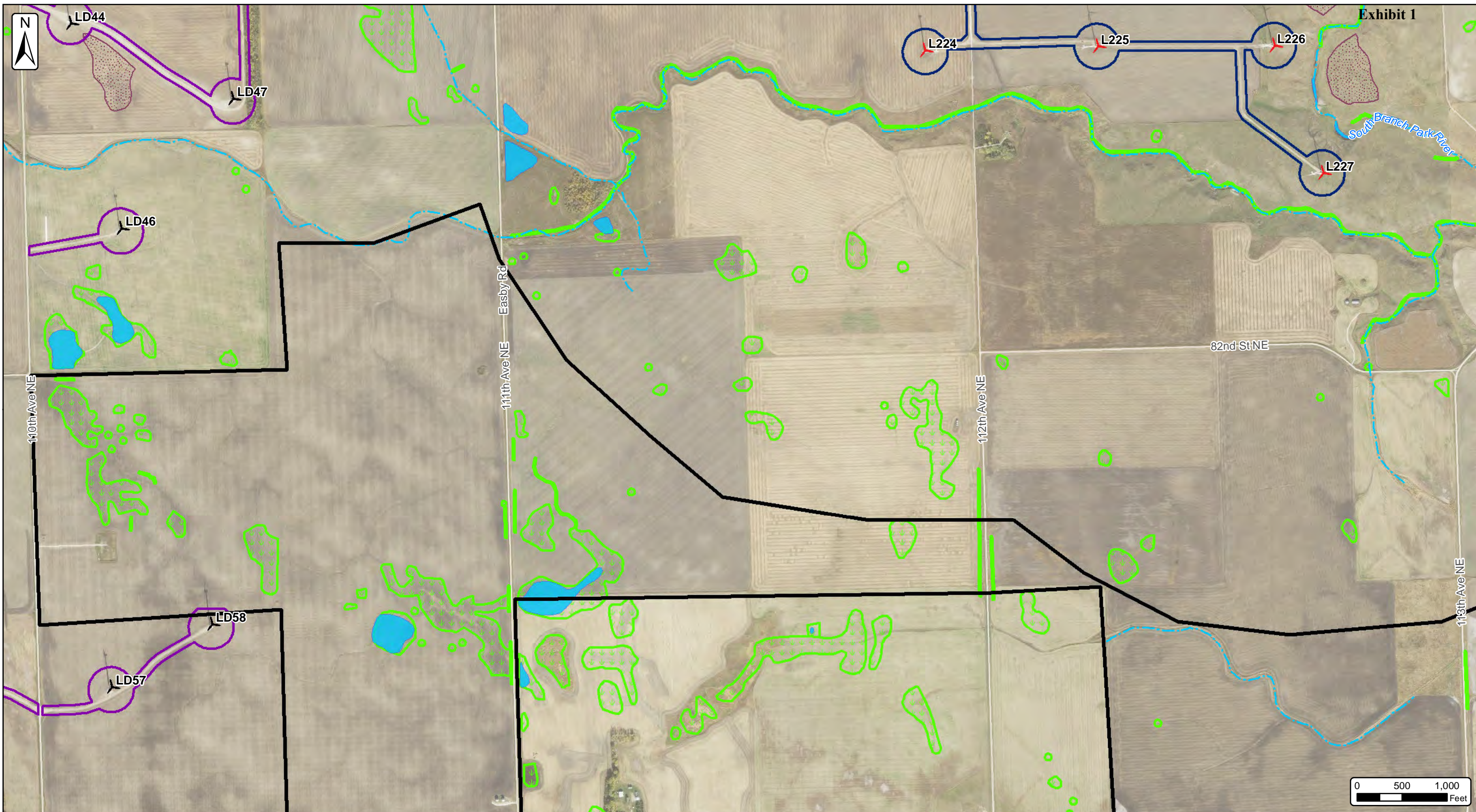


Exhibit 1


**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 14 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
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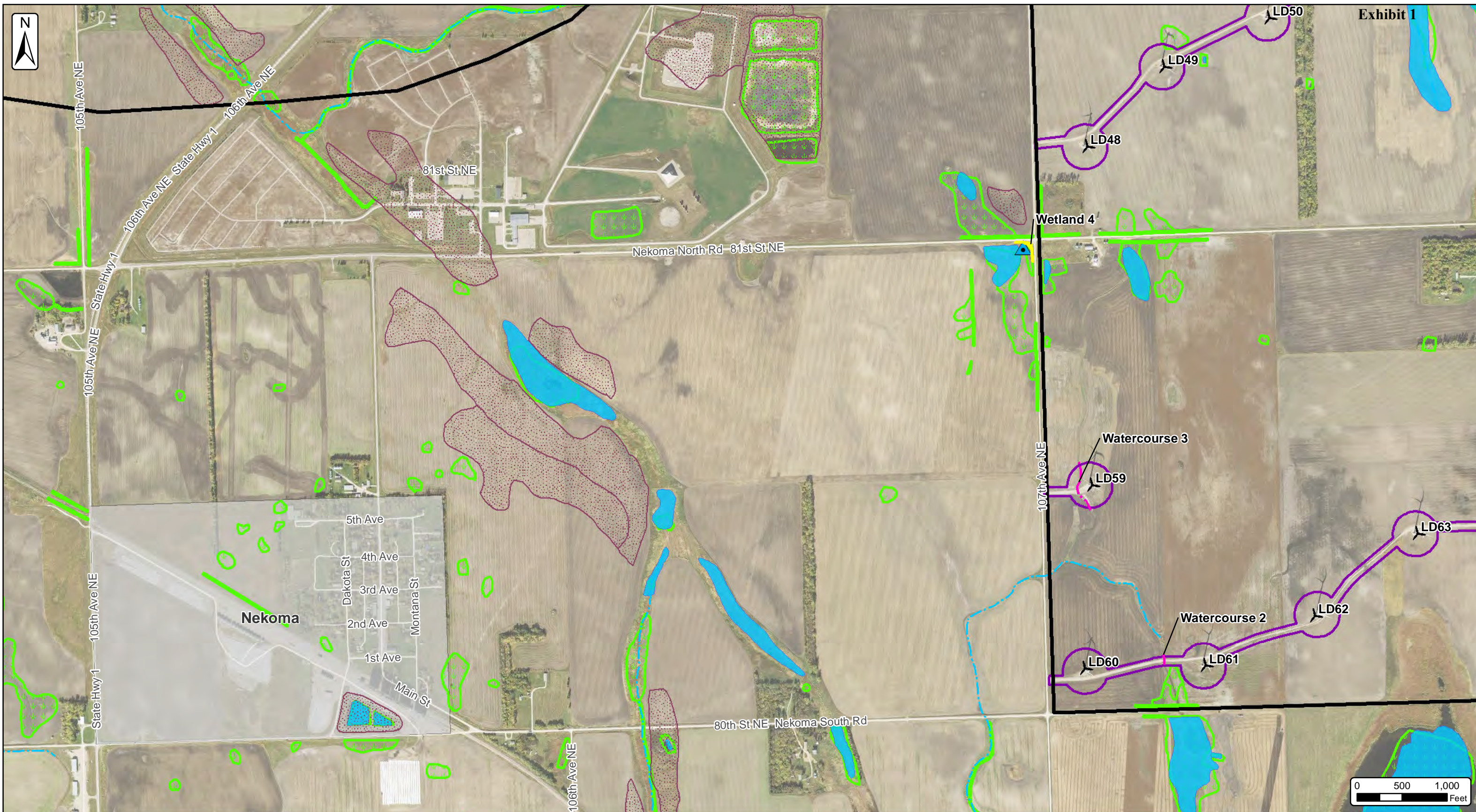



Exhibit 1

**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 15 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
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 17001949 & 17002362

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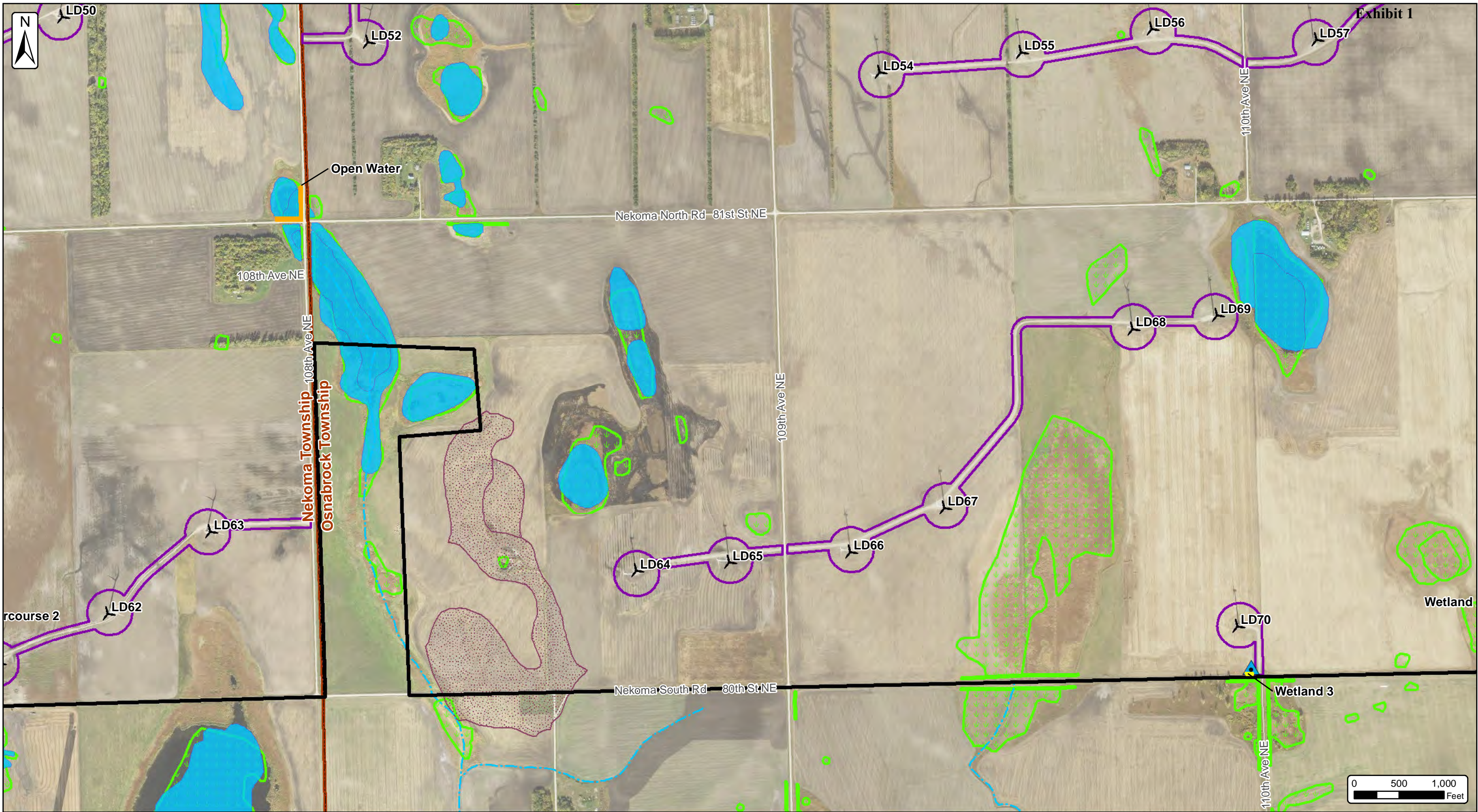


Exhibit 1

**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
 Page 16 of 17  
 Cavalier County, North Dakota  
 Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
 17001949 & 17002362

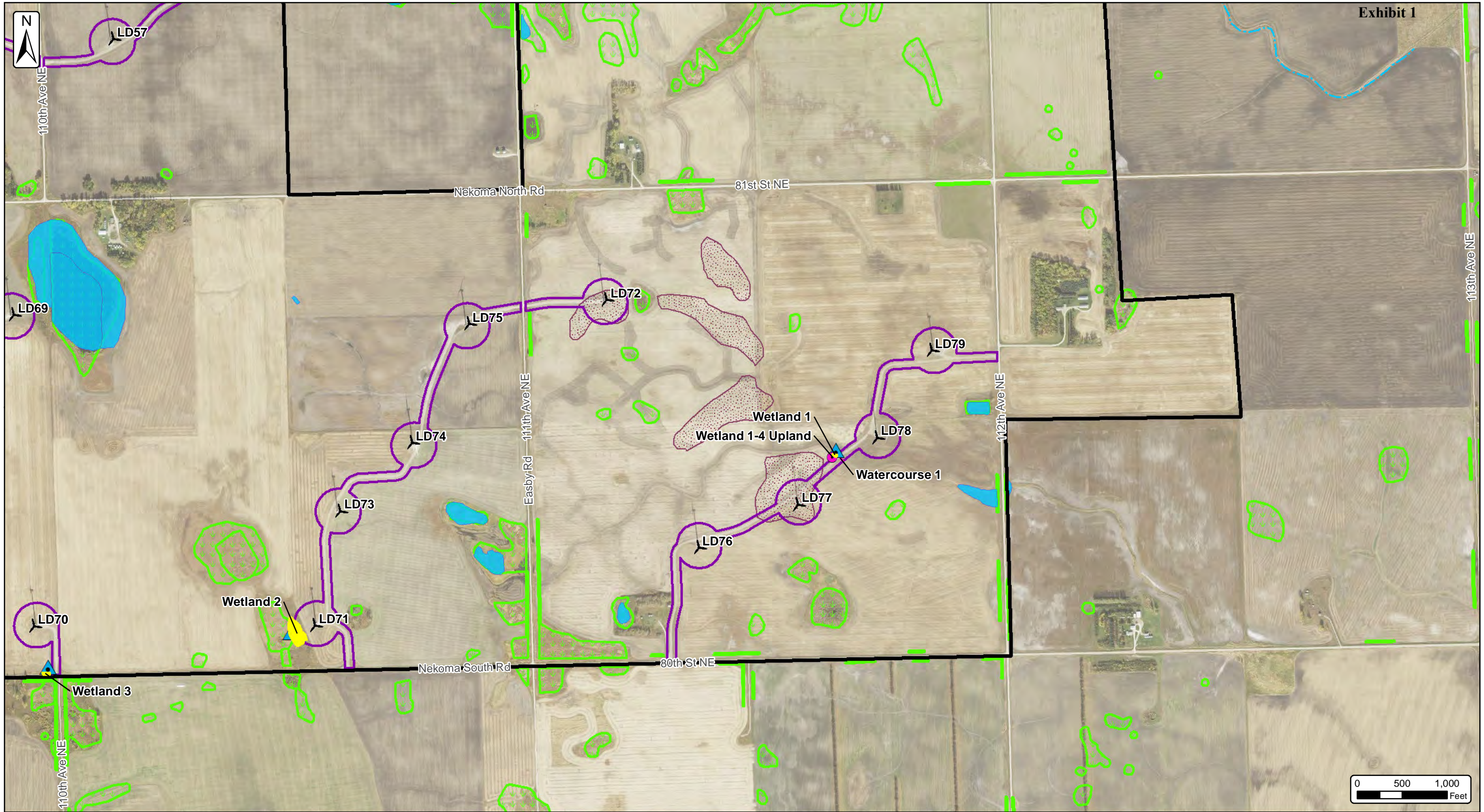
- Upland Point (10/01/2017)
- ▲ Wetland Point (10/01/2017)
- Field Delineated Watercourse (10/01/2017)
- Watercourse (NHD)
- Field Delineated Open Water (10/01/2017)
- Waterbody (NHD)
- Field Delineated Wetland (10/01/2017)
- Wetland (NWI)
- Non-Hydric Soil (SSURGO)
- Langdon I Turbine Layout (06/22/2017)
- Langdon II Turbine Layout (07/07/2017)
- LWEC Boundary
- Langdon I Project Area (06/22/2017 (±503 Ac.))
- Langdon II Project Area (07/07/2017 (±194 Ac.))
- Township Boundary

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ATWELL

The information contained on this map is proprietary and confidential. The use or disclosure of this information by you to third parties is prohibited by law and may give rise to civil or criminal liability.

SOURCE: USDA NAIP 2017 IMAGERY




**Langdon Wind Energy Center**  
**Aquatic Resource Map**  
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 Cavalier County, North Dakota  
 Date: 5/23/2018

Client:  
**Langdon Wind, LLC**  
 Atwell, LLC Project:  
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