BURNS McDONNELL

May 30, 2018

VIA ELECTRONIC FILING

Ms. Patricia Van Gerpen
Executive Secretary
South Dakota Public Utilities Commission
500 E Capitol Ave.
Pierre, SD 57501-5070

Re: Application to the South Dakota Public Utilities Commission for an Energy Facility Permit for the Prevailing Wind Park Project
EL 18-____

Dear Ms. Van Gerpen:

In connection with the above-referenced matter, Prevailing Wind Park, LLC submits the following documents:

1. Application to the South Dakota Public Utilities Commission for a Facility Permit ("Application");
2. Direct Testimony of James Damon, with exhibit;
3. Direct Testimony of Bridget Canty, with exhibit;
4. Direct Testimony of Keith Thorstad, with exhibit;
5. Direct Testimony of Aaron Anderson, with exhibit; and
6. Direct Testimony of Chris Howell, with exhibit.

Please note that the Application includes one confidential document – Appendix R (Cultural Resources Literature Search). Eleven hard copies of the Application and testimony will be provided under separate cover. If you have any questions, please let me know.

Sincerely,

Jennifer Bell
Senior Environmental Scientist
Burns & McDonnell

Enclosures

cc: James Damon, sPower Development Company (*via e-mail*)
Bridget Canty, sPower Development Company (*via e-mail*)
Mollie Smith, Fredrikson & Byron (*via e-mail*)
Lisa Agrimonti, Fredrikson & Byron (*via e-mail*)

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Application to the South Dakota Public Utilities Commission for a Facility Permit

Prevailing Wind Park, LLC

Prevailing Wind Park Energy Facility
Burns & McDonnell Project No. 104294

May 2018

Application to the South Dakota Public Utilities Commission for a Facility Permit

Prevailing Wind Park, LLC
Prevailing Wind Park Energy Facility
Bon Homme, Charles Mix, and Hutchinson Counties, South Dakota

Burns & McDonnell Project No. 104294

May 2018

prepared by

Burns & McDonnell Engineering Company, Inc.
Centennial, Colorado

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
ADT	Average Daily Traffic
AMSL	above mean sea level
Applicant	Prevailing Wind Park, LLC
ARSD	Administrative Rules of South Dakota
AWEA	American Wind Energy Association
BCC	Birds of Conservation Concern
BCI	Bat Conservation International, Inc.
BCR	Bird Conservation Region
BGEPA	Bald and Golden Eagle Protection Act
BMPs	Best Management Practices
CadnaA	Computer Aided Design for Noise Abatement
COD	commercial operation date
CWA	Clean Water Act
dB	decibel
dBA	A-weighted decibels
DoD	Department of Defense
DOE	U.S. Department of Energy
EA	Environmental Assessment
ECPG	Eagle Conservation Plan Guidance
EERE	Office of Energy Efficiency & Renewable Energy
EIA	U.S. Energy Information Administration

Abbreviation	**Term/Phrase/Name**
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FONSI	Finding of No Significant Impact
GE	General Electric
GIS	Geographic Information System
GLO	General Land Office
GPA	Game Production Area
GW	gigawatt
HDR	HDR, Inc.
Hz	hertz
IEC	International Electrotechnical Commission
IPaC	Information for Planning and Conservation
IRAC	Interdepartmental Radio Advisory Committee IRAC
ISO	International Organization for Standardization
JPO	Joint Program Office
Ksat	saturated hydraulic conductivity
kV	kilovolt
kW	kilowatt
L_{90}	the sound level exceeded 90 percent of the time period

Abbreviation	**Term/Phrase/Name**
L_{eq}	equivalent-continuous sound level
LWES	Large Wind Energy Systems
L_x	exceedance sound level
m/s	meters per second
MBTA	Migratory Bird Treaty Act
Mph	miles per hour
MW	megawatt
MWh	megawatt-hour
NAAQS	National Ambient Air Quality Standards
NDVER	non-dispatchable variable energy resource
NEPA	National Environmental Policy Act
NESC	National Electric Safety Code
NLEB	northern long-eared bat
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRI	Nationwide Rivers Inventory
NTIA	National Telecommunication Information Agency
NWCC	National Wind Coordinating Collaborative
NWR	National Wildlife Refuge
O&M	operations and maintenance

Abbreviation	**Term/Phrase/Name**
PEIS	Programmatic Environmental Impact Statement
PGA	peak ground acceleration
PLSS	Public Land Survey Section
PMU	phasor measurement units
PPA	Power Purchase Agreement
Prevailing Wind Park	Prevailing Wind Park, LLC
RD	rotor diameter
RF	radio frequency
Rpm	revolutions per minute
RPS	renewable portfolio standard
RUSLE	Revised Universal Soil Loss Equation
SCADA	supervisory control and data acquisition
SDARC	South Dakota Archaeological Research Center
SDCL	South Dakota Codified Laws
SDDENR	South Dakota Department of Environment and Natural Resources
SDDLR	South Dakota Department of Labor and Regulation
SDDOA	South Dakota Department of Agriculture
SDDOT	South Dakota Department of Transportation
SDGFP	South Dakota Game, Fish, and Parks
SDGS	South Dakota Geological Survey
SDPUC	South Dakota Public Utilities Commission
SGCN	Species of Greatest Conservation Need

Abbreviation	**Term/Phrase/Name**
SHPO	State Historic Preservation Office
sPower	sPower Development Company, LLC
SWPPP	Storm Water Pollution Prevention Plan
TCP	Traditional Cultural Properties
TMDL	total maximum daily load
TPWD	Texas Parks and Wildlife Department
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
WAPA	Western Area Power Administration
WCFZ	Worst Case Fresnel Zones
WEG	Wind Energy Guidelines
WEST	Western EcoSystems Technology, Inc.
WNS	white-nose syndrome
WPA	Waterfowl Production Area

COMPLETENESS CHECKLIST

The contents required for an application with the South Dakota Public Utilities Commission (SDPUC) are described in South Dakota Codified Laws (SDCL) 49-41B and further clarified in Administrative Rules of South Dakota (ARSD) 20:10:22:01(1) et seq. The SDPUC submittal requirements are listed in the Completeness Checklist with cross-references indicating where the information can be found in this Application.

Completeness Checklist

SDCL	ARSD	Required Information	Location
49-41B-11(1)	20:10:22:06	**Names of participants required.** The application shall contain the name, address, and telephone number of all persons participating in the proposed facility at the time of filing, as well as the names of any individuals authorized to receive communications relating to the application on behalf of those persons.	Section 4.0
49-41B-11(7)	20:10:22:07	**Name of owner and manager.** The application shall contain a complete description of the current and proposed rights of ownership of the proposed facility. It shall also contain the name of the project manager of the proposed facility.	Section 5.0
49-41B-11(8)	20:10:22:08	**Purpose of facility.** The applicant shall describe the purpose of the proposed facility.	Section 6.0
49-41B-11(12)	20:10:22:09	**Estimated cost of facility.** The applicant shall describe the estimated construction cost of the proposed facility	Section 7.0
49-41B-11(9)	20:10:22:10	**Demand for facility.** The applicant shall provide a description of present and estimated consumer demand and estimated future energy needs of those customers to be directly served by the proposed facility. The applicant shall also provide data, data sources, assumptions, forecast methods or models, or other reasoning upon which the description is based. This statement shall also include information on the relative contribution to any power or energy distribution network or pool that the proposed facility is projected to supply and a statement on the consequences of delay or termination of the construction of the facility.	Section 6.0
49-41B-11(2)	20:10:22:11	**General site description.** The application shall contain a general site description of the proposed facility including a description of the specific site and its location with respect to state, county, and other political subdivisions; a map showing prominent features such as cities, lakes and rivers; and maps showing cemeteries, places of historical significance, transportation facilities, or other public facilities adjacent to or abutting the plant or transmission site.	Section 8.0; Figures 1, 8, and 10 in Appendix A; Figures 2.1-2.11 in Appendix R

SDCL	ARSD	Required Information	Location
49-41B-11(6); 49-41B-21; 34A-9-7(4)	20:10:22:12	**Alternative sites.** The applicant shall present information related to its selection of the proposed site for the facility, including the following: (1) The general criteria used to select alternative sites, how these criteria were measured and weighed, and reasons for selecting these criteria; (2) An evaluation of alternative sites considered by the applicant for the facility; (3) An evaluation of the proposed plant, wind energy, or transmission site and its advantages over the other alternative sites considered by the applicant, including a discussion of the extent to which reliance upon eminent domain powers could be reduced by use of an alternative site, alternative generation method, or alternative waste handling method.	Section 9.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:13	**Environmental information.** The applicant shall provide a description of the existing environment at the time of the submission of the application, estimates of changes in the existing environment which are anticipated to result from construction and operation of the proposed facility, and identification of irreversible changes which are anticipated to remain beyond the operating lifetime of the facility. The environmental effects shall be calculated to reveal and assess demonstrated or suspected hazards to the health and welfare of human, plant and animal communities which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction. The applicant shall provide a list of other major industrial facilities under regulation which may have an adverse effect on the environment as a result of their construction or operation in the transmission site, wind energy site, or siting area.	Sections 10.0-15.0, 17.0, 18.0, and 20.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:14	**Effect on physical environment.** The applicant shall provide information describing the effect of the proposed facility on the physical environment. The information shall include: (1) A written description of the regional land forms surrounding the proposed plant or wind energy site or through which the transmission facility will pass; (2) A topographic map of the plant, wind energy, or transmission site; (3) A written summary of the geological features of the plant, wind energy, or transmission site using the topographic map as a base showing the bedrock geology and surficial geology with sufficient cross-	Section 11.0; Figures 2, 6a, 6b, and 7 in Appendix A

SDCL	ARSD	Required Information	Location
		sections to depict the major subsurface variations in the siting area; (4) A description and location of economic deposits such as lignite, sand and gravel, scoria, and industrial and ceramic quality clay existent within the plant, wind energy, or transmission site; (5) A description of the soil type at the plant, wind energy, or transmission site; (6) An analysis of potential erosion or sedimentation which may result from site clearing, construction, or operating activities and measures which will be taken for their control; (7) Information on areas of seismic risks, subsidence potential and slope instability for the plant, wind energy, or transmission site; and (8) An analysis of any constraints that may be imposed by geological characteristics on the design, construction, or operation of the proposed facility and a description of plans to offset such constraints.	
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:15	**Hydrology.** The applicant shall provide information concerning the hydrology in the area of the proposed plant, wind energy, or transmission site and the effect of the proposed site on surface and groundwater. The information shall include: (1) A map drawn to scale of the plant, wind energy, or transmission site showing surface water drainage patterns before and anticipated patterns after construction of the facility; (2) Using plans filed with any local, state, or federal agencies, indication on a map drawn to scale of the current planned water uses by communities, agriculture, recreation, fish, and wildlife which may be affected by the location of the proposed facility and a summary of those effects; (3) A map drawn to scale locating any known surface or groundwater supplies within the siting area to be used as a water source or a direct water discharge site for the proposed facility and all offsite pipelines or channels required for water transmission; (4) If aquifers are to be used as a source of potable water supply or process water, specifications of the aquifers to be used and definition of their characteristics, including the capacity of the aquifer to yield water, the estimated recharge rate, and the quality of groundwater;	Section 12.0; Figure 8 in Appendix A

SDCL	ARSD	Required Information	Location
		(5) A description of designs for storage, reprocessing, and cooling prior to discharge of heated water entering natural drainage systems; and (6) If deep well injection is to be used for effluent disposal, a description of the reservoir storage capacity, rate of injection, and confinement characteristics and potential negative effects on any aquifers and groundwater users which may be affected.	
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:16	**Effect on terrestrial ecosystems.** The applicant shall provide information on the effect of the proposed facility on the terrestrial ecosystems, including existing information resulting from biological surveys conducted to identify and quantify the terrestrial fauna and flora potentially affected within the transmission site, wind energy site, or siting area; an analysis of the impact of construction and operation of the proposed facility on the terrestrial biotic environment, including breeding times and places and pathways of migration; important species; and planned measures to ameliorate negative biological impacts as a result of construction and operation of the proposed facility.	Section 13.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:17	**Effect on aquatic ecosystems.** The applicant shall provide information of the effect of the proposed facility on aquatic ecosystems, and including existing information resulting from biological surveys conducted to identify and quantify the aquatic fauna and flora, potentially affected within the transmission site, wind energy site, or siting area, an analysis of the impact of the construction and operation of the proposed facility on the total aquatic biotic environment and planned measures to ameliorate negative biological impacts as a result of construction and operation of the proposed facility.	Section 14.0
49-41B-11(2,11); 49-41B-22	20:10:22:18	**Land use.** The applicant shall provide the following information concerning present and anticipated use or condition of the land: (1) A map or maps drawn to scale of the plant, wind energy, or transmission site identifying existing land use according to the following classification system: (a) Land used primarily for row and nonrow crops in rotation; (b) Irrigated lands; (c) Pasturelands and rangelands; (d) Haylands; (e) Undisturbed native grasslands; (f) Existing and potential extractive nonrenewable resources;	Sections 15.0 and 20.0; Figure 9 in Appendix A

SDCL	ARSD	Required Information	Location
		(g) Other major industries; (h) Rural residences and farmsteads, family farms, and ranches; (i) Residential; (j) Public, commercial, and institutional use; (k) Municipal water supply and water sources for organized rural water systems; and (l) Noise sensitive land uses; (2) Identification of the number of persons and homes which will be displaced by the location of the proposed facility; (3) An analysis of the compatibility of the proposed facility with present land use of the surrounding area, with special attention paid to the effects on rural life and the business of farming; and (4) A general analysis of the effects of the proposed facility and associated facilities on land uses and the planned measures to ameliorate adverse impacts.	
49-41B-11(2,11); 49-41B-28	20:10:22:19	**Local land use controls.** The applicant shall provide a general description of local land use controls and the manner in which the proposed facility will comply with the local land use zoning or building rules, regulations or ordinances. If the proposed facility violates local land use controls, the applicant shall provide the commission with a detailed explanation of the reasons why the proposed facility should preempt the local controls. The explanation shall include a detailed description of the restrictiveness of the local controls in view of existing technology, factors of cost, economics, needs of parties, or any additional information to aid the commission in determining whether a permit may supersede or preempt a local control pursuant to SDCL 49-41B-28.	Section 16.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:20	**Water quality.** The applicant shall provide evidence that the proposed facility will comply with all water quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.	Section 17.0
49-41B-11(2,11); 49-41B-21; 49-41B-22	20:10:22:21	**Air quality.** The applicant shall provide evidence that the proposed facility will comply with all air quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.	Section 18.0
49-41B-11(3)	20:10:22:22	**Time schedule.** The applicant shall provide estimated time schedules for accomplishment of major events in the commencement and duration of construction of the proposed facility.	Section 19.0

SDCL	ARSD	Required Information	Location
49-41B-11(11); 49-41B-22	20:10:22:23	**Community impact.** The applicant shall include an identification and analysis of the effects the construction, operation, and maintenance of the proposed facility will have on the anticipated affected area including the following: (1) A forecast of the impact on commercial and industrial sectors, housing, land values, labor market, health facilities, energy, sewage and water, solid waste management facilities, fire protection, law enforcement, recreational facilities, schools, transportation facilities, and other community and government facilities or services; (2) A forecast of the immediate and long-range impact of property and other taxes of the affected taxing jurisdictions; (3) A forecast of the impact on agricultural production and uses; (4) A forecast of the impact on population, income, occupational distribution, and integration and cohesion of communities; (5) A forecast of the impact on transportation facilities; (6) A forecast of the impact on landmarks and cultural resources of historic, religious, archaeological, scenic, natural, or other cultural significance. The information shall include the applicant's plans to coordinate with the local and state office of disaster services in the event of accidental release of contaminants from the proposed facility; and (7) An indication of means of ameliorating negative social impact of the facility development.	Section 20.0
49-41B-11(4)	20:10:22:24	**Employment estimates.** The application shall contain the estimated number of jobs and a description of job classifications, together with the estimated annual employment expenditures of the applicants, the contractors, and the subcontractors during the construction phase of the proposed facility. In a separate tabulation, the application shall contain the same data with respect to the operating life of the proposed facility, to be made for the first ten years of commercial operation in one-year intervals. The application shall include plans of the applicant for utilization and training of the available labor force in South Dakota by categories of special skills required. There shall also be an assessment of the adequacy of local manpower to meet temporary and permanent labor requirements during construction and operation of the proposed facility and the estimated percentage that will	Section 21.0

SDCL	ARSD	Required Information	Location
		remain within the county and the township in which the facility is located after construction is completed.	
49-41B-11(5)	20:10:22:25	**Future additions and modifications.** The applicant shall describe any plans for future modification or expansion of the proposed facility or construction of additional facilities which the applicant may wish to be approved in the permit.	Section 23.0
49-41B-35(3)	20:10:22:33.01	**Decommissioning of wind energy facilities.** Funding for removal of facilities. The applicant shall provide a plan regarding the action to be taken upon the decommissioning and removal of the wind energy facilities. Estimates of monetary costs and the site condition after decommissioning shall be included in the plan. The commission may require a bond, guarantee, insurance, or other requirement to provide funding for the decommissioning and removal of a wind energy facility. The commission shall consider the size of the facility, the location of the facility, and the financial condition of the applicant when determining whether to require some type of funding. The same criteria shall be used to determine the amount of any required funding.	Section 24.0
49-41B-11(2,11)	20:10:22:33.02	**Information concerning wind energy facilities.** If a wind energy facility is proposed, the applicant shall provide the following information: (1) Configuration of the wind turbines, including the distance measured from ground level to the blade extended at its highest point, distance between the wind turbines, type of material, and color; (2) The number of wind turbines, including the number of anticipated additions of wind turbines in each of the next five years; (3) Any warning lighting requirements for the wind turbines; (4) Setback distances from off-site buildings, right-of-ways of public roads, and property lines; (5) Anticipated noise levels during construction and operation; (6) Anticipated electromagnetic interference during operation of the facilities; (7) The proposed wind energy site and major alternatives as depicted on overhead photographs and land use culture maps; (8) Reliability and safety; (9) Right-of-way or condemnation requirements; (10) Necessary clearing activities;	Section 26.0

SDCL	ARSD	Required Information	Location
		(11) Configuration of towers and poles for any electric interconnection facilities, including material, overall height, and width; (12) Conductor configuration and size, length of span between structures, and number of circuits per pole or tower for any electric interconnection facilities; and (13) If any electric interconnection facilities are placed underground, the depth of burial, distance between access points, conductor configuration and size, and number of circuits.	
49-41B-22	N/A	**Applicant's burden of proof.** The applicant has the burden of proof to establish that: (1) The proposed facility will comply with all applicable laws and rules; (2) The facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area; (3) The facility will not substantially impair the health, safety or welfare of the inhabitants; and (4) The facility will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government	Section 3.0 and Section 27.4
49-41B-11	20:10:22:39	**Testimony and exhibits.** Upon the filing of an application pursuant to SDCL 49-41B-11, an applicant shall also file all data, exhibits, and related testimony which the applicant intends to submit in support of its application. The application shall specifically show the witnesses supporting the information contained in the application.	Section 28.0

1.0 INTRODUCTION

Prevailing Wind Park, LLC (Prevailing Wind Park or Applicant) is proposing to develop a wind energy facility (Prevailing Wind Park Project or Project) in Bon Homme, Charles Mix, and Hutchinson counties, South Dakota. The Project will consist of up to 61 wind turbines, with a nameplate capacity of 219.6 megawatts (MW). The Project Area is comprised of 50,364 acres of private land between the towns of Avon, Tripp, and Wagner (Figure 1 in Appendix A). Project components would include:

- Up to 61 wind turbines
- Access roads to each wind turbine
- Underground electrical power collector system and communications
- A collector substation
- Up to four permanent meteorological towers
- An operations and maintenance (O&M) facility
- Additional temporary construction areas, including crane paths, public road improvements, a laydown yard, and a concrete batch plant(s) (as needed)

The Project would interconnect with Western Area Power Administration's (WAPA's) existing Utica Junction Substation, located approximately 27 miles east of the Project. The Applicant is proposing to construct a new 115-kilovolt (kV) gen-tie line in Bon Homme and Yankton counties from the Project collector substation to the Utica Junction Substation. The gen-tie line is not under the jurisdiction of the SDPUC and will be permitted in Bon Homme and Yankton counties.

Prevailing Wind Park is a South Dakota limited liability company and a wholly owned subsidiary of sPower Development Company, LLC (sPower). sPower is an independent renewable energy company based in Salt Lake City, Utah. sPower is the largest private owner of operating solar assets in the United States. sPower owns and operates a portfolio of solar and wind assets greater than 1.3 gigawatts (GW) and has a development pipeline of more than 10 GW.. sPower has the experience, capabilities and personnel to successfully develop and operate the proposed Project.

2.0 PROJECT DEVELOPMENT SUMMARY

In October 2017, sPower acquired the Prevailing Wind Park, LLC assets and development rights to the Project from Prevailing Winds, LLC. Prevailing Winds, LLC was formed in 2014 by the same local group of investors that successfully developed the 80-MW B&H Wind Project (now Beethoven Wind Project). The local investors' goal was to build on B&H Wind's success and create additional sources of income for area landowners and economic growth for the local communities through wind energy. Development activities began with the preparation of an interconnection request with WAPA and Prevailing Winds, LLC's acquisition of the remaining B&H Wind assets. The assets included meteorological towers with over 5 years of continuous wind resource data, past WAPA interconnection and environmental studies, land leases, and the models used to study the wind resource in the area.

Prevailing Winds, LLC filed an application with the SDPUC in June 2016 for a 200-MW wind farm with up to 100 2.3-MW wind turbines. At that time, Prevailing Winds, LLC did not have all land rights secured for the Project and did not have an off-taker for the energy that would be produced. Prevailing Winds, LLC subsequently withdrew the application in August 2016. In its Motion to Withdraw Application Without Prejudice, Prevailing Winds, LLC explained it was "moving to withdraw the Application to allow Prevailing Winds to better inform the community on the wind project and allow Prevailing Winds to revisit its options regarding the project."

Since its October 2017 acquisition of the assets and development rights to the Project, Prevailing Wind Park has undertaken extensive development activities, consisting of landowner outreach and easement acquisition, detailed studies of resources in the Project Area, coordination with resource agencies, and design and refinement of the Project configuration.

Community Outreach and Land Acquisition: Prevailing Wind Park has obtained all of the private land rights necessary to construct the Project. Prevailing Wind Park held open house events for the community on December 13, 2017, and April 5, 2018. In addition, a landowner dinner was held on April 3, 2018.

Agency Coordination: The Applicant and its predecessor, Prevailing Winds, LLC, have coordinated with State and Federal agencies throughout Project planning and development. Coordination with the U.S. Fish and Wildlife Service (USFWS) and South Dakota Game, Fish, and Parks (SDGFP) has focused on protection of native grasslands; potential impacts to Endangered Species Act (ESA)-protected species including northern long-eared bat and whooping crane; and avian use of the Project Area, including bald eagles. Cultural resource survey work is being conducted in coordination with WAPA, which is the lead Federal agency for compliance with the National Environmental Policy Act (NEPA) and Section 106 of the National Historic Preservation Act of 1966, including tribal consultation (as discussed further in Section 3.1 below).

County Permitting: The Applicant conducted pre-application meetings in Bon Homme, Charles Mix, and Hutchinson counties in December 2017 (Bon Homme) and April 2018 (Bon Homme, Hutchinson, and Charles Mix). The Applicant will apply for county permits beginning in the second quarter of 2018. County permitting is discussed in Sections 16.0 and 27.1.

Purchase Agreement: In January 2018, Prevailing Wind Park entered into a 30-year power purchase agreement (PPA) with a South Dakota load serving entity. The PPA provides that the Project is to supply energy at the end of 2019.

Project Design: The results of the various studies and coordination activities listed above have been used to inform the site layout and design of the Project. Final micrositing of Project facilities is expected to occur in late 2018, based on the results of the completed cultural resource investigations, geotechnical analysis, and final engineering design. The remaining study work is not anticipated to affect the environmental analysis set forth in this Application, nor will it prevent the Project from meeting all applicable local, State and Federal permitting requirements.

Environmental Analysis: The environmental studies, technical studies, and surveys for the Prevailing Wind Park Project are listed below in Table 2-1.

Table 2-1: Environmental Studies and Surveys for the Prevailing Wind Park Project

Study	Dates	Status
Tiers 1 and 2 Report	June 2016	Complete
Raptor Nest Survey	April 2016	Complete
Avian Use Surveys – Year One	March 2015-February 2016	Complete
Avian Use Surveys – Year Two	May 2016-April 2017	Complete
Whooping Crane Habitat Review	August 2016	Complete
Bald Eagle Nest Monitoring	March-July 2015 May-September 2016	Complete
Bird and Bat Conservation Strategy	May 2018	Complete
Northern Long-Eared Bat Acoustic Survey	July-August 2015	Complete
Northern Long-Eared Bat Presence/Absence Survey	July-August 2016	Complete
Rare Plant Habitat Assessment	May-June 2018	In process
Native Grassland Field Verification	May-June 2018	In process

Study	**Dates**	**Status**
Wetland Desktop Determination	March 2018	Complete
Wetland Field Delineation	May-June 2018	In process
Cultural Resources Literature Search	April 2018	Complete
Cultural Resources Desktop Review and Construction Grid	April 2018	Complete
Cultural Resources Archeological Survey	June-July 2018	Pending
Historical/Architectural Survey	June-July 2018	Pending
Engineering Report on Effects to FCC-Licensed RF Facilities	April 2016	Complete
Sound Study	April 2018	Complete
Shadow Flicker Analysis	May 2018	Complete

3.0 FACILITY PERMIT APPLICATION

In accordance with SDCL Chapter 49-41B and ARSD Chapter 20:10:22, the Application provides information on the existing environment, potential Project impacts, and proposed avoidance, minimization, and/or mitigation measures for the following resources:

- Physical (geology, economic deposits, soils)
- Hydrology (surface water and groundwater)
- Terrestrial ecosystems (vegetation, wetlands, wildlife, threatened and endangered species)
- Aquatic ecosystems
- Land use (agriculture, residential, displacement, sound, aesthetics, electromagnetic interference, safety and health, real estate values)
- Water quality
- Air quality
- Communities (socioeconomics, transportation and emergency response, cultural resources)

3.1 Relationship to NEPA

WAPA is preparing an Environmental Assessment (EA) for the Project interconnection in accordance with the applicable requirements and standards of NEPA. The proposed interconnection of the Project to WAPA's transmission system is a Federal action under NEPA. In order to execute an interconnection agreement to connect the Project to WAPA's existing Utica Junction Substation, WAPA must analyze the potential environmental impacts of the wind facility and gen-tie line under NEPA. While WAPA must analyze impacts of the entire wind facility and gen-tie line, WAPA's Federal action is limited to the approval of the interconnection. Siting authority approval for the Project remains with the State and counties.

The EA will tier off the analysis conducted in the *Upper Great Plains Wind Energy Final Programmatic Environmental Impact Statement* (PEIS), prepared jointly by WAPA and the USFWS (WAPA and USFWS, 2015). The PEIS assesses environmental impacts associated with wind energy development and identifies management practices to address impacts. The EA for the Prevailing Wind Park Project would focus on site-specific issues that are not already addressed in sufficient detail in the PEIS. The EA is currently being prepared, and Prevailing Wind Park anticipates that WAPA will approve a final EA and issue a Finding of No Significant Impact (FONSI) in fourth quarter 2018.

3.2 Summary of Potential Impacts

Following is a summary of the potential impacts that could result from construction and operation of the Project.

Approximately 45 acres of permanent disturbance, representing less than 0.1 percent of the total acreage within the Project Area, would be broadly dispersed throughout the Project Area. Therefore, the Project is not expected to cause major changes in storm water runoff patterns or volume of runoff, nor is it expected to have adverse impacts on existing hydrology. Existing hydrology and potential impacts are discussed in Section 12.0.

The Project has avoided locating facilities in wetland areas, to the extent practicable. Wind turbines and access roads are generally located in upland areas, avoiding low-lying wetlands and drainage ways. Based on a desktop wetland determination, the Project would potentially result in permanent impacts to two wetlands (0.0042 acre and 0.0002 acre of impacts) and would cross three intermittent streams (62.4 linear feet of stream segments). Wetland and stream impacts would be authorized in compliance with Section 404 of the Clean Water Act (CWA). Information on existing wetlands and potential impacts are discussed in Section 13.3.

The majority of land proposed to be disturbed by the Project in the long-term is cropland (64 percent) and hayland (22 percent). Only approximately 1 acre (2 percent) of long-term Project disturbance would occur in potential untilled grasslands. Construction of Project facilities in cropland or hayland is not expected to negatively affect terrestrial ecosystems. Best Management Practices (BMPs) would be utilized to avoid or reduce impacts to the vegetation and water resources of the Project Area during construction. Existing vegetation resources and impacts are discussed in Section 13.1.

Eight species listed as threatened or endangered under the ESA have been documented in Bon Homme, Charles Mix, and/or Hutchinson counties: pallid sturgeon (*Scaphirhynchus albus*), Topeka shiner (*Notropis topeka*), interior least tern (*Sterna antillarum athalassos*), whooping crane (*Grus americana*), red knot (*Calidris canutus rufa*), piping plover (*Charadrius melodus*), northern long-eared bat (*Myotis septentrionalis*), and western prairie fringed orchid (*Pratanthera praceclara*). Five of these species have the potential to occur in the Project Area during some portion of the year: interior least tern, whooping crane, northern long-eared bat, red knot, and piping plover. The interior least tern, red knot, whooping crane, and piping plover could migrate through the Project Area during the spring and fall but are otherwise not expected to occur in the Project Area. The Project Area is located within the 95 percent migration corridor when considered specific to South Dakota; however, there have been no confirmed whooping crane sightings within the Project Area as of spring 2018. The Project Area is within the defined range of the northern long-eared bat, and the species could be present during the summer breeding period. The pallid sturgeon and Topeka shiner are federally listed fish species but have not been documented within the Project Area. The Project Area is also within the range of the federally listed western prairie fringed orchid; however, this species is believed to be extirpated from South Dakota and has not been observed in the Project Area. Sections 13.0 and 14.0 describe existing fish, wildlife, and plant resources and potential impacts to terrestrial and aquatic species. One federally listed species, northern long-eared bat, was qualitatively identified in the Project Area during analysis of acoustic survey data in 2015 but was not identified during 2016 surveys. No other federally listed species have been documented in the Project Area. The Applicant will comply with avoidance, minimization, and mitigation measures specified in the PEIS; therefore, the Project would not adversely impact listed species.

Migratory birds, including eagles and other raptors, have been observed in the Project Area. In addition, one active bald eagle nest is located approximately 0.5 mile from the Project Area. The results of pre-construction avian use and nest surveys and potential impacts are discussed in Section 13.4. If construction occurs during the migratory bird nesting season (typically April through September) nesting bird surveys will be conducted shortly before construction initiates. The Applicant prepared a Bird and Bat Conservation Strategy (BBCS) for the Project to address operational impacts to birds (Appendix L).

Existing land uses are not anticipated to be significantly changed or impacted by the Project. Sound from Project construction activities would be temporary and generally limited to daytime hours. Once the Project becomes operational, sound from the turbines and other facilities would be limited to 45 A-weighted decibels (dBA) at all habitable residences. Existing land use and potential impacts are described in Section 15.0.

Construction activities for this Project would be short-term, and, therefore, no long-term negative impact to the socioeconomics of the area is expected. Short-term construction effects likely would be beneficial to businesses in the region. Community impacts are discussed further in Section 20.0.

During Project construction, fugitive dust emissions would increase due to vehicle and equipment traffic in the area. The additional particulate matter emissions would not exceed the National Ambient Air Quality Standards (NAAQS). The wind turbines would not produce air emissions during operation. Air quality is discussed in Section 18.0.

Cultural resource Level I records review and site survey from public rights-of-way for the Project Area identified previously recorded archaeological and historic resources located within or near the Project

Area. The results of the Level I analysis are provided in Appendices R and S. Cultural resource field surveys of all areas disturbed by construction of Project facilities are planned to begin in June 2018. For cultural resources identified during the surveys, a recommendation of National Register of Historic Places (NRHP)-eligibility of the resource will be made. Sites determined to be NRHP-eligible will be avoided by the Project. If avoidance is not practicable, the Applicant will work with WAPA and the State Historic Preservation Office (SHPO) to develop appropriate minimization or mitigation measures. Cultural resources are discussed in Section 20.5.

Mitigation measures proposed for the Project include:

- Wind turbines will be illuminated as required by Federal Aviation Administration (FAA) regulations and recommendations;
- Existing roads will be used for construction and maintenance where possible;
- Access roads created for the Project will be located to limit cuts and fills;
- Temporarily disturbed uncultivated areas will be reseeded with certified weed-free seed mixes to blend in with existing vegetation;
- BMPs will be used during construction to control erosion and prevent or reduce impacts to drainage ways and streams by sediment runoff from exposed soils;
- Direct impacts to eligible or potentially eligible sites for the NRHP will be avoided to the extent practicable;
- The Applicant will avoid impacts to wetlands to the extent practicable;
- The Applicant will avoid impacts to undisturbed grasslands to the extent practicable;
- The Applicant will meet or exceed setbacks, conditions, and siting standards required by State and local governing bodies where the wind turbines are located;
- The Applicant will comply with all applicable avoidance, minimization, and mitigation measures in the PEIS; and
- If construction occurs during the migratory bird nesting season (typically April through September), the Applicant will conduct nesting bird surveys shortly before initiation of ground-disturbing activities.

In this Application, the Applicant has addressed each matter set forth in SDCL Chapter 49-41B and in ARSD Chapter 20:10:22 (Energy Facility Siting Rules) related to wind energy facilities. Included with this Application is a Completeness Checklist that sets forth where in the Application each rule requirement is addressed.

Pursuant to SDCL 49-41B-22, the information presented here establishes that:

- The proposed wind energy facility complies with applicable laws and rules;
- The facility will not pose a threat of serious injury to the environment or to the social and economic condition of inhabitants in, or near, the Project Area;
- The facility will not substantially impair the health, safety, or welfare of the inhabitants; and
- The facility will not unduly interfere with the orderly development of the region, having considered the views of the governing bodies of the local affected units of government.

4.0 NAMES OF PARTICIPANTS (ARSD 20:10:22:06)

ARSD 20:10:22:06. Names of participants required. *The application shall contain the name, address, and telephone number of all persons participating in the proposed facility at the time of filing, as well as the names of any individuals authorized to receive communications relating to the application on behalf of those persons.*

The Applicant, Prevailing Wind Park, LLC, is a South Dakota limited liability company and a wholly owned subsidiary of sPower Development Company, LLC. Individuals who are authorized to receive communications relating to the Application on behalf of the Applicant include:

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5.0 NAME OF OWNER AND MANAGER (ARSD 20:10:22:07)

ARSD 20:10:22:07. Name of owner and manager. *The application shall contain a complete description of the current and proposed rights of ownership of the proposed facility. It shall also contain the name of the project manager of the proposed facility.*

Prevailing Wind Park, LLC is a South Dakota limited liability company and a wholly owned subsidiary of sPower Development Company, LLC. Prevailing Wind Park will own, manage, and operate the Project. Prevailing Wind Park has obtained a Certificate of Authority from the South Dakota Secretary of State to conduct business in South Dakota. As a limited liability company, sole-member managed by sPower Development Company, LLC, Prevailing Wind Park, LLC does not have officers and directors. Sean McBride, Authorized Person, sPower Development Company, LLC, is managing development of the Project. James Damon, sPower Development Company, LLC, is the Project manager.

6.0 PURPOSE OF, AND DEMAND FOR, THE WIND ENERGY FACILITY (ARSD 20:10:22:08, 20:10:22:10)

ARSD 20:10:22:08. Purpose of facility. *The applicant shall describe the purpose of the proposed facility.*

ARSD 20:10:22:10. Demand for facility. *The applicant shall provide a description of present and estimated consumer demand and estimated future energy needs of those customers to be directly served by the proposed facility. The applicant shall also provide data, data sources, assumptions, forecast methods or models, or other reasoning upon which the description is based. This statement shall also include information on the relative contribution to any power or energy distribution network or pool that the proposed facility is projected to supply and a statement on the consequences of delay or termination of the construction of the facility.*

Prevailing Wind Park has entered into a 30-year PPA with a South Dakota load serving entity. The output from the facility, which could annually generate up to 933,116 megawatt-hours (MWh), will be used to meet the needs for South Dakota residential, commercial, and industrial customers. Demand for this renewable power and the benefits it provides are discussed further in Section 6.1.

The Project would provide significant needed local and regional economic benefits. The area where the Project is proposed is almost entirely dependent on an agricultural economy. Local agricultural economies are very sensitive to world commodity prices and weather. The primary driver to increase local agricultural economies is to add value to existing farming operations through increasing farming efficiency with larger farms and adding large livestock feeding operations. Both may benefit the individual farmer but generally do not increase jobs or population in the local communities. Wind energy adds significant revenue to existing farming operations and creates jobs in the local communities.

Prevailing Wind Park would directly benefit local workers and local business. During construction, up to 245 temporary construction jobs are anticipated at the peak of construction, and 8 to 10 permanent jobs will also be created in the community. Construction and operation of typical 200-MW wind project results in the injection of millions of dollars into the local economy throughout the life of the Project. These investments would benefit many local businesses in the community including hotels, restaurants, gas stations, mechanics, tire companies, grocery stores, and other local businesses.

In addition, the Project will result in a $297 million investment in Bon Homme, Hutchinson, and Charles Mix counties. Prevailing Wind Park will pay taxes on the Project, which will result in substantial revenue available for a variety of local needs.

6.1 Renewable Power Demand

Wind energy provides one of the most cost-effective energy sources for customers, making it desirable to utilities, as well as industrial and commercial entities. New wind energy facilities are less expensive to construction than new conventional energy sources, even without government subsidies. Table 6-1 provides a comparison of the unsubsidized levelized cost of energy for both alternative and conventional energy sources.

Table 6-1: Comparison of Energy Costs by Source

Energy Source		**Levelized Cost ($/MW hour)**
Alternative Energy	Wind	$30-60
	Solar PV - Thin Film Utility Scale	$43-48
	Solar PV – Crystalline Utility Scale	$46-53
	Biomass Direct	$55-114
	Geothermal	$77-117
	Solar Thermal Tower with Storage	$98-181
	Fuel Cell	$106-167
Conventional Energy	Coal	$60-143
	Natural Gas Reciprocating Engine	$68-106
	Nuclear	$112-183
	Gas Peaking	$156-210
	Diesel Reciprocating Engine	$197-281

Source: Lazard, 2016

6.1.1 National

In 2017, U.S. electricity customers consumed 3.7 billion MWh of energy (U.S. Energy Information Administration [EIA], 2018a). In its *Annual Energy Outlook 2017*, the EIA estimated that U.S. electricity demand would remain relatively flat and would rise 5 percent from 2016 to 2040 (EIA, 2017a). The U.S. Department of Energy (DOE)-Office of Energy Efficiency & Renewable Energy (EERE) *20% Wind Energy by 2030* report examined the technical feasibility of using wind energy to generate 20 percent of the nation’s electricity demand by 2030 (DOE-EERE, 2008). To meet 20 percent of that demand, U.S. wind power capacity would have to reach more than 300 GW. As of April 2018, the total amount of wind energy capacity in the U.S. had grown to 89.4 GW (American Wind Energy Association [AWEA], 2018). Reaching 300 GW requires an increase of more than 210 GW in 12 years, or 17.6 GW per year.

In March 2015, the DOE released its *Wind Vision* report, which builds on and updates the 2008 *20% Wind Energy by 2030* report (DOE, 2015). The *Wind Vision* report analyzes the benefits of a study scenario based on wind power penetration of 10 percent by 2020, 20 percent by 2030, and 35 percent by 2050, utilizing plausible variations from central values of wind power and fossil fuel costs. The Wind Vision study scenario is not designed to achieve any specific clean energy or carbon reduction goals. Nevertheless, the contributions of wind power in the study scenario support clean energy and carbon reduction goals.

The projected benefits associated with achieving the Wind Vision study scenario are:

- Avoidance of air pollution and reduction in greenhouse gas emissions (avoids 250,000 metric tons of air pollutants and 12.3 gigatons of greenhouse gases by 2050);
- Conservation of water resources (estimated at 260 billion gallons by 2050);
- Increased U.S. energy security by diversifying electricity portfolio;
- Reduced demand on fossil fuels and reduced energy costs to consumers ($280 billion dollars in consumer savings by 2050);
- Creation of new income for rural landowners and tax revenues for local communities ($3.2 billion annually in tax revenue by 2050); and
- Generation of well-paying jobs (600,000 jobs in manufacturing, installation, maintenance, and supporting services by 2050) (DOE, 2015).

The demand for renewable energy from wind is extremely high, with project costs declining and the capacity increasing (DOE-EERE, 2016). The lower cost of wind energy and wind energy fixed costs are driving need and demand. In many situations, wind energy and natural gas generation are being combined to produce the lowest cost baseload power. Wind energy is also being used as a long-term financial hedge against the price of electricity generated from natural gas. Most, if not all, of the region's power producers resource plans call for increasing use of fixed cost resources with zero fuel cost, zero pollution, and zero carbon emissions as a necessity to provide cost effective electricity to their customers. Demand is coming from power producers signing long-term PPAs with wind energy projects or purchasing wind projects outright. Electric utilities signed 60 percent of PPA capacity contracted for the year (3,317 MW) and announced plans to develop and own 4,190 MW of rate-based wind capacity (American Wind Energy Association, 2018). New demand for wind energy is also coming from non-utility buyers. Corporate and other non-utility customers, such as Microsoft, Google, IKEA, Apple, eBay, Facebook, General Motors, and Wal-Mart, all signed PPAs announced during the fourth quarter of 2017, comprising 40 percent of total capacity contracted for the year (2,178 MW), similar to the 39 percent share captured in 2016 (American Wind Energy Association, 2018).

Wind and natural gas are replacing aging coal and nuclear facilities that are being retired for regulatory and financial reasons. Between 2012 and 2016, net coal capacity declined by about 60 GW partly as a result of compliance with the U.S. Environmental Protection Agency's (EPA's) Mercury and Air Toxic Standards (EIA, 2018b). Coal-fired generating capacity may decrease by an additional 66 GW by the mid-2030s before leveling off in 2050, and virtually no new coal generation is planned for development. Similar to coal, more nuclear capacity is being retired than built. Nearly 30 GW of nuclear capacity are expected to be retired from 2018 through 2050 (EIA, 2017b). By contrast, the EIA projects that utility-scale wind capacity will grow by 20 GW from 2020 to 2050 (EIA, 2018b).

Wind energy is an inexhaustible source of clean, renewable electric power that can help fill this capacity shortfall. Operation of the wind turbines does not emit particulates, heavy metals, or greenhouse gases, and does not consume significant water resources. Long-term, fixed-price PPAs for wind generation reduce electric utilities' exposure to fuel price volatility and stabilize energy prices for consumers.

Beyond the market for wind energy, the public has also shown support for the use of renewable energy. According a Gallup National poll in March 2017, 73 percent of Americans "prefer an approach that focuses on developing alternative energy sources such as solar and wind power" compared to 21 in favor of emphasizing production of conventional energy sources (Gallup, Inc., 2018)

6.1.2 Regional and State

Over 25,000 MW of wind energy had been installed in the Midwest Wind Energy Center Region by the fourth quarter, including 977 MW in South Dakota [National Renewable Energy Laboratory (NREL), 2018a]. In 2016, wind energy provided 30 percent of all South Dakota in-state electricity production, enough to power over 290,000 homes. The DOE Wind Vision Scenario projects that South Dakota could produce enough wind energy by 2030 to power the equivalent of 895,000 average American homes. In 2016, the annual State water consumption savings were over 235 million gallons, the equivalent of 1.8 billon bottles of water saved (American Wind Energy Association, 2017).

Load growth for South Dakota and North Dakota was last projected to be at least 2,100 MW over the next 10 years. South Dakota's current electric generation is primarily from hydroelectric (approximately 40 percent), coal (approximately 30 percent), and wind power plants (approximately 30 percent) (EIA, 2018c). South Dakota relies on shipments of coal from Wyoming to meet its coal demand, and supplies of fossil fuels such as coal, oil, and natural gas are finite. Between 2011 and 2016, implementation of tighter EPA regulations on existing coal-fired plants accelerated retirements of outdated facilities. Since 2017, the decline in coal consumption has been attributed to availability of abundant, inexpensive natural gas

(EIA, 2018b). Construction of new coal, nuclear, or hydroelectric stations in the area is unlikely (EIA, 2018b).

South Dakota has one of the smallest populations of any state; however, due to its energy intensive industries (i.e., agriculture, manufacturing, and mining), hot summers, cold winters, and periodic droughts, the State is one of the top 10 in total energy consumption per capita. South Dakota is also one of the top seven states in wind potential. Although it is already ranked second in the nation after Iowa in the amount of net electricity generation provided by wind (approximately 30 percent in 2017), South Dakota's potential is just beginning to be developed (EIA, 2017c). The DOE's WIND Exchange platform indicates that South Dakota has approximately 418 GW of total potential wind capacity (NREL, 2018b); however, only 977 MW of wind energy generation has been installed as of the second quarter of 2017 (NREL, 2018b), which is less than 1 percent of its total potential capacity.

State legislatures and governors have adopted renewable portfolio standards (RPSs) in 29 states. These standards require utilities to sell a specified percentage or amount of renewable electricity. The requirement can apply only to investor-owned utilities, but many states also include municipalities and electric cooperatives, though their requirements are equivalent or lower. Eight states and one territory have voluntary renewable energy standards or targets. South Dakota falls into the latter category with a voluntary Renewable, Recycled and Conserved Energy Objective, established in 2008, with the goal that 10 percent of all electricity sold at retail within the State will be obtained from renewable energy and recycled energy sources by 2015 (SDCL 49-34A-101). The proposed Project would provide a new source of low cost energy in South Dakota and help the Nation move towards the goal of energy independence, while reducing pollution and carbon emissions. The SDPUC required that retail energy providers report annually on their attainment status; this requirement ended at the end of 2017.

6.1.3 Local

The Project would add significant revenue to the local economy. Rural landowners and farmers on whose land the Project is listed will receive annual lease payments for each turbine sited on their property plus payments based on acres in the Project Area. Because only a small portion of the land under lease will be used for the Project, farming operations can continue largely undisturbed.

The Project's use of only 45 acres within the larger Project Area would generate approximately $1.2 million annually in new income for landowners; approximately $742,500 in new annual tax revenues for

Bon Homme, Charles Mix, and Hutchinson counties, schools and townships[1]; and approximately $11.1 million in new tax revenues for State government[1] from Project operations.

As noted, construction, operations, and maintenance of the facility are expected to create approximately 245 jobs[2] during the peak construction phase and approximately 8 to 10 long-term operations and maintenance positions, which would benefit local businesses. Statewide and nationally, the wind industry generates well-paying jobs in the entire supply chain, including engineering, manufacturing, and construction.

6.2 Wind Resources Areas

To obtain an accurate representation of the wind resource within the Project Area, Prevailing Wind Park conducted a comprehensive analysis of the Project Area using the following data:

- Onsite data collected at the Project's 60-meter Roth meteorological tower
- Onsite data collected at the Project's 60-meter Link meteorological tower
- Onsite data collected at the Project's 60-meter Brandt meteorological tower
- Onsite data collected at the Project's 60-meter Burfeindt meteorological tower
- Long-term correlation from: Mitchell, Sioux Falls, Winner, SD, MERRA upper-air data points
- Project Area topographic and land cover data
- Up to 100 potential turbine locations within the Project Area
- Power curves from multiple turbine models and manufacturers
- State and County standards and setbacks

The Applicant used this data to develop a Wind Resource Analysis for the Project Area. The Applicant analyzed multiple hypothetical layouts for each representative turbine model to determine the potential energy output for the Project. Data from each unique hypothetical turbine layout and its energy output was used in a Project pro forma, along with Project indicative construction costs, operational costs, and costs of capital, to estimate Project energy costs for multiple scenarios. For any wind project to remain competitive, it must have the flexibility to use the latest technology at the lowest costs. This is due to the rapid changes in new turbine technology and price reductions in turbines.

Currently, the Applicant is considering turbines with an energy production range between 3.6 and 3.8 MW. The final decision will be made prior to construction to create the most viable, cost-effective, and

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[1] Based on current State statutes.

[2] Based on estimates from wind energy project contractor construction practices.

optimal design for the Project given the known conditions of the Project Area and the turbines that are commercially available when the Project is constructed. The Application contains information regarding two representative turbines, the General Electric (GE) 3.8-137 and the Vestas V136-3.6 turbine models. The turbine location configuration shown in Figure 2 in Appendix A would be used for the turbine finally selected for the Project, whether the GE model, the Vestas model, or another comparable turbine model. Turbine specifications are discussed in Section 8.2.

The following is an example of the data generated from the Wind Resource Analysis for the Project Area. The example uses a sample layout for the GE 3.8-137 turbine model to create potential energy output for the Project Area. The turbine's power curve is used together with the Project's correlated onsite data to determine the Project's annual gross energy production and capacity factor for the Project Area. Table 6-2 depicts the estimated mean annual wind speed for the Project Area in meters per second (m/s) for both turbine models. As shown in the table, the Project Area has an average wind speed of 8.69 to 8.78 m/s at turbine hub heights of 105 meters (345 feet) and 110 meters (361 feet), respectively, indicating winds between 37.5 to 42.5 meters per second.

Table 6-2: Wind Resource Analysis

Turbine	Normalized Monthly and Annual Wind Speed Averages (m/s)
GE 3.8-137	8.78 (110-m wind speed)
Vestas 136-3.6	8.69 (105-m wind speed)

6.3 Consequences of Delay

If the Prevailing Wind Park Project is delayed, the Project's benefits to the local communities would be deferred. Specifically, delay of construction would delay expected local benefits of increased employment and spending in the local community. Delayed operation would likewise put off tax revenue benefits to local school districts, the counties, and the State. Further, the PPA requires the Project to be operational by the end of 2019, and failure to meet this in-service date may impact the PPA. Additionally, Project costs are subject to commodity flux and rise. Therefore, if the Project is delayed, the construction costs may increase.

7.0 ESTIMATED COST OF THE WIND ENERGY FACILITY (ARSD 20:10:22:09)

ARSD 20:10:22:09. Estimated cost of facility. *The applicant shall describe the estimated construction cost of the proposed facility.*

The current estimated capital cost of the Project is approximately $297 million based on indicative construction and wind turbine pricing cost estimates. This estimate includes lease acquisition; permitting, engineering, procurement, and construction of turbines, access roads, underground electrical collector system, Project collector substation, interconnection facilities, O&M facility, supervisory control and data acquisition (SCADA) system, and meteorological towers; and project financing. Capital cost estimates could fluctuate for the Project, dependent on which turbine model is ultimately used, materials and labor costs, and interconnection costs.

8.0 GENERAL SITE AND PROJECT COMPONENT DESCRIPTION (ARSD 20:10:22:11, 20:10:22:33:02)

ARSD 20:10:22:11. General site description. *The application shall contain a general site description of the proposed facility including a description of the specific site and its location with respect to state, county, and other political subdivisions; a map showing prominent features such as cities, lakes and rivers; and maps showing cemeteries, places of historical significance, transportation facilities, or other public facilities adjacent to or abutting the plant or transmission site.*

The Project would be located within 50,364 acres of land in Bon Homme, Charles Mix, and Hutchinson counties. Table 8-1 shows the sections that intersect the Project Area.

Table 8-1: Sections that Intersect the Project Area Boundary

County	Township	Range	Sections
Bon Homme	95N	60W	6
	95N	61W	1-18, 20-24
	95N	62W	1, 12-13
	96N	61W	1-3, 9-21, 28-33
	96N	62W	13, 24-25, 36
	97N	61W	34-36
Charles Mix	95N	62W	1-3, 10-15
	96N	61W	18
	96N	62W	1-4, 10-15, 22-27, 34-36
	97N	62W	33-36
Hutchinson	97N	61 W	25-27, 34-36

Figure 1 in Appendix A shows the locations of the State, county, and city boundaries with respect to the Project Area, as well as the major highways and roads that extend through the area. Figure 8 in Appendix A shows the locations of water bodies and streams within the Project Area. Figure 10 in Appendix A shows the locations of cemeteries and other public facilities (i.e., churches, public lands) within or adjacent to the Project Area. Figures 2.1-2.11 in Appendix R show the locations of places of historical significance within or near the Project Area. There are no active transportation facilities (i.e., railroads, airports) within or adjacent to the Project Area.

8.1 Wind Farm Facility

The Project would consist of up to 61 wind turbines with an aggregate nameplate capacity of 219.6 MW. The Applicant proposes to use a wind turbine model of 3.6 to 3.8 MW. The two representative turbines are the GE 3.8-137 and the Vestas V136-3.6 MW. The permanent facilities for the Project would also include underground electric collector lines, a central collector substation, an O&M facility, access roads connecting to each turbine, up to four permanent meteorological towers, and a SCADA system (installed with the collector lines). Figure 2 in Appendix A shows the proposed layout of the Project facilities. Table 8-2 lists the sections within the Project Area containing proposed permanent wind farm facilities.

Table 8-2: Sections Containing Wind Farm Facilities

County	Township	Range	Sections
Bon Homme	95N	61W	1, 4-5, 9-12, 14-15, 22
	95N	62W	1
	96N	61W	1-2, 11-21, 28-33
	96N	62W	24, 36
	97N	61W	35-36
Charles Mix	95N	62W	1, 11-14
	96N	62W	10, 13, 15, 22-24, 26-27, 35-36
Hutchinson	97N	61 W	25, 35-36

Figure 2 in Appendix A shows 63 proposed wind turbine locations, of which only up to 61 turbines will be built.[3] As a result of final micrositing, minor shifts in the turbine locations may be necessary based on final design. For example, a shift may be needed to avoid newly identified cultural resources (cultural resource studies are expected to be completed in July 2018), or due to geotechnical evaluations of the wind turbine locations, landowner input, or other factors. Therefore, the Applicant requests that the permit allow turbines to be shifted within 500 feet of their currently proposed location, so long as specified noise and shadow flicker thresholds are not exceeded, cultural resource impacts and habitats for listed species are avoided, and wetland impacts are avoided to the extent practicable. If turbine shifts are greater than 500 feet, exceed the noted thresholds, or do not meet the other limitations specified, the Applicant would either use an alternate turbine location or obtain SDPUC approval of the proposed turbine location change. Alternate turbine locations are proposed to hedge against additional turbine locations becoming necessary during final micrositing. The alternate turbine locations prevent unforeseen findings from reducing the size of the Project or from significantly injuring the productivity of the Project. In all cases, the final turbine locations constructed will adhere to applicable local, State, and Federal regulations and requirements.

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[3] Note that the turbine numbers go from 1 to 58 and 60 to 64. The turbine location 59 was eliminated.

Figure 2 in Appendix A also shows the proposed access road and underground collection system locations. As a result of final micrositing, shifts in the access roads and collector system, as well as changes in the locations of the O&M facility, Project substation, meteorological towers, concrete batch plant, and laydown/staging areas, may be necessary.

Therefore, the Applicant requests that the permit allows those facilities to be modified, as needed, as long as the new locations are on land leased for the Project, cultural resources and habitats for listed species are avoided, wetland impacts are avoided to the extent practicable, and other applicable regulations and requirements are met.

8.2 Major Wind Turbine Components

The Applicant plans to install up to 61 wind turbines for the Project; 2 to 6 alternate turbine locations are also proposed, depending on the turbine model selected. The representative turbine models are the GE 3.8-137 and Vestas 136-3.6 turbines. Table 8-3 provides specific turbine characteristics for each turbine model.

Table 8-3: Wind Turbine Characteristics

Characteristic	**Turbine Model[a]**	
	GE 3.8-137	Vestas 136-3.6
Nameplate capacity	3.83 MW	3.6 MW
Hub height	110 meters (361 feet)	105 meters (344 feet)
Rotor diameter	137 meters (449 feet)	136 meters (446 feet)
Total height	178.5 +/- 1 meters (586 +/- 3 feet)	173 +/- 1 meters (568 +/- 3 feet)
Cut-in speed[b]	3 m/s	3 m/s
Rated speed[c]	12 m/s	12 m/s
Cut-out speed[d]	25 m/s over 600s 30 m/s over 30s 34 m/s over 3s	22.5 m/s or 27.5 m/s with HWO package[e]
Rotor area	14,741 m^2	14,527 m^2
Rotor speed	Variable – max is around 13.6 rpm	5.6 to 15.3 rpm

(a) MW = megawatt; m/s = meters per second; m^2 = square meters; rpm = revolutions per minute
(b) Cut-in wind speed = wind speed at which turbine begins operation
(c) Rated speed = wind speed at which turbine reaches its rated capacity
(d) Cut-out wind speed = wind speed above which turbine shuts down operation
(e) High Wind Operation package

The proposed wind turbines consist of a nacelle, hub, blades, tower, and foundation (Figure 3 in Appendix A). The nacelle houses the generator, gear box, controls, braking systems, cooling systems, hoist, cabling, transformer, lightning protection system, and other miscellaneous equipment. The hub consists of the blades, spinner, blade pitch motors, blade angle detection systems, and lightning protection system. The proposed turbine model has three blades composed of carbon fibers, fiberglass, and internal supports to provide a lightweight but strong component. The tip of each blade is equipped with a lightning receptor. The tower supports the nacelle, hub, and blades. The tower houses the nacelle access systems, power rail, controls, communication cables, control systems, and invertor, which are located at the base of the tower. Towers include a lift or lift assist systems for personnel accessing the nacelle. Towers are tubular steel (not latticed) and are painted a non-glare white per FAA requirements. Specialized electrical equipment is located at the base of each tower to condition the generated electricity to match the collection system requirements.

The expected turbine foundation would be a spread foundation design. Foundations for the towers would be approximately 2,700 square feet, with a depth of up to 10 feet. Except for approximately 12 inches that would remain aboveground to allow the tower to be appropriately bolted to the foundation, the tower foundation would be underground. A specific foundation design would be chosen based on soil borings conducted at each turbine location.

The excavated area for the turbine foundations would typically be approximately 65 feet in diameter (approximately 0.07 acre). During construction, a larger area (approximately 160-foot radius) may be used to lay down the rotors and maneuver cranes during turbine assembly. For purposes of calculating temporary impacts in this Application, the Applicant has assumed approximately 116 acres of total temporary disturbance from work/staging areas for 63 turbines. This is a conservative estimate, because a maximum of 61 turbines would be built. After construction, total permanent disturbance from the turbines would be reduced to approximately 3 acres, which would remain for the life of the Project.

The proposed turbine model also contains emergency power supplies to allow operation of the control systems, braking systems, yaw systems, and blade pitch systems and to shut the turbine down safely if grid power is lost. Wind turbine blades convert linear energy from wind into rotational energy, which the hub transfers to the gear box or directly to the generator located within the nacelle. The transferred mechanical force is converted into electrical energy by the generator. Heated mechanical and/or ultrasonic anemometers and weather vanes, located on the turbine nacelle, continuously collect real-time wind speed and direction data. Based on the data collected, the turbine yaw system constantly rotates the hub, blades, and nacelle into the wind, while the blade pitch system continuously adjusts the pitch of the blades to optimize the output of the generator. The pitch system also protects the turbine from over-speed events in high winds by pitching the blades perpendicular to the wind and aero-brakes the turbine to a stop in normal shutdown conditions. The mechanical braking system, located within the nacelle, is used to stop the turbine's rotation in the event of a storm or other turbine fault. The mechanical brake and lock-out system is used to lock the blade rotor to prevent the blades from spinning during maintenance periods or other times when the turbine is out of service. The gear box adjusts shaft speeds to maintain generator speed in low and high wind speeds. Electrical energy produced by the generator is transmitted through insulated cables in the power rail to a safety switch, and then to a transformer located internally in the tower or externally on the base of the tower.

8.3 Roads

Where practicable, existing public roads, private roads, and field paths are being utilized to access Project components. The existing roads may require improvements before, during, or following construction. Where necessary, new access roads will be constructed between existing roadways and Project components. The new and improved access roads would be all-weather, gravel surfaced, and generally 16 feet in width. During construction, some of the access roads would be widened to accommodate movement of the turbine erection crane, with temporary widths of approximately 60 feet.

Separate access may be required for the cranes used to erect the wind turbines. In such cases, temporary crane paths would be constructed between turbine locations. Following completion of construction, the temporary crane paths would be removed, and the area would be restored, to the extent practicable.

The final access road design would be dependent on geotechnical information obtained during the engineering phase. It is anticipated that the access road network for the Project would include approximately 17 miles of new private roads (as shown on Figure 2) and 40 miles of upgraded public roads. For purposes of calculating access road impacts in this Application, the Applicant has assumed approximately 103 acres of temporary disturbance and 33 acres of disturbance during the life of the Project for new private access roads. In addition, up to 3 acres of temporary disturbance is assumed for upgraded public roads.

8.4 O&M Facility

The O&M facility would be located within the Project Area, in a location with proper transportation, communications facilities, and easy access to Project facilities. One potential O&M facility location, as shown on Figure 2 in Appendix A, has been identified. As discussed in Section 8.1, the Applicant requests that the permit allow the O&M facility location to be modified, as needed, as long as the final location is on land leased for the Project, cultural resources and habitats for listed species are avoided, wetland impacts are avoided to the extent practicable, and all other applicable regulations and requirements are met.

The proposed O&M facility would house the equipment to operate and maintain the wind farm. A gravel parking pad would provide the building with a parking area and secured outside storage. For purposes of calculating temporary impacts in this Application, the Applicant has assumed approximately 6 acres of total temporary disturbance from O&M facility construction. After construction, total permanent disturbance from the O&M facility, including parking, would remain at approximately 6 acres.

Station power for Prevailing Wind Park facilities would be provided through the Project interconnection. Back-up power for the Project substation will be provided by the local electrical cooperative(s), providing power to operate communications, relaying, and control systems, indefinitely.

8.5 Meteorological Towers

The Applicant has deployed six temporary 60-meter meteorological towers within the Project Area, which are expected to be removed during or following Project construction. The Applicant anticipates that the Project would include permanent wind measurement equipment, which could consist of up to four permanent 80-meter meteorological towers. Four potential permanent meteorological tower locations, as shown on Figure 2 in Appendix A, have been identified. As discussed in Section 8.1, the Applicant requests that the permit allow the meteorological tower location to be modified, as needed, as long as the final locations are on land leased for the Project, cultural resources and habitats for listed species are avoided, wetland impacts are avoided to the extent practicable, and all other applicable regulations and requirements are met. The permanent meteorological towers would be self-supporting and would not have guy wires. The towers would be lighted and painted as necessary to comply with FAA guidelines and would be connected to the Project collection system for communications and power needs. The Applicant estimates that an area of approximately 200 feet by 200 feet would be required during construction to install each meteorological tower. Each tower would result in a permanent impact of approximately 42 feet by 42 feet. The four permanent meteorological towers combined would result in temporary impacts of approximately 4 acres and permanent impacts of 0.2 acre.

8.6 Temporary Laydown Areas/Batch Plant/Crane Walks

A temporary office trailer and laydown area has been selected within the Project Area. Construction materials, including turbine components, would be temporarily stored in an area covering approximately 12 acres before being installed or moved to the final turbine sites. The laydown area location, as shown on Figure 2 in Appendix A, has been identified. In addition, one or more temporary concrete batch plants may be necessary during construction in order to prepare concrete for foundations onsite. It has not been determined at this time if onsite batch plants will be necessary for the Project. If they are utilized, each would temporarily impact approximately 3 to 5 acres of land, and it is anticipated that they would be located within the temporary 12-acre laydown area.

In addition to the approximately 12-acre laydown/batch plant area, temporary crane walk disturbances would also be necessary for the Project. Crane walks are estimated to be 60 feet wide and would generally be located along the same route as the collector system and access roads, except where topography or soils conditions prevent safe crane travel. For purposes of calculating temporary impacts in this Application, the Applicant has assumed that the temporary disturbance from the crane walks would be 393 acres. As discussed in Section 8.1, the Applicant requests that the permit allow the temporary laydown/batch plant areas and crane walk locations to be modified, as needed, as long as the final locations are on land leased for the Project, cultural resources and habitats for listed species are avoided, wetland impacts are avoided to the extent practicable, and all other applicable regulations and requirements are met.

8.7 Project Electrical System

Each of the wind turbines would have a transformer either pad-mounted outside the tower at the base of the turbine, mounted in the nacelle, or mounted within the tower. The proposed turbines would be connected to the Project collector substation by an underground 34.5-kV electrical collection system, including an occasional aboveground junction box. At the collector substation, the power would be converted from 34.5 to 115 kV and then transmitted via an aboveground 115-kV transmission line to WAPA’s existing Utica Junction 230-kV substation, located approximately 27 miles east of the Project. A second 115-/230-kV substation would be constructed near the point of interconnection to step up the voltage to match that of WAPA’s interconnection facilities.

8.7.1 Collector System

Each wind turbine within the Project Area would be interconnected by communication and electrical power collection circuit facilities. These facilities would include underground feeder lines (collector lines) that would collect wind-generated power from each wind turbine and deliver it to the Prevailing Wind Park-owned substation (collector substation).

8.7.1.1 Underground 34.5-kV Collector System

An underground 34.5-kV collector system would be used to route the power from each turbine to the collector substation, where the electrical voltage would be stepped up from 34.5 to 115 kV. The underground collector system bundle (containing three conductors, ground wire, and fiber optic conduit) would be placed in one trench and connect each of the turbines to the collector substation. The estimated trench length is approximately 65 miles. The temporary disturbance associated with the underground collector system is estimated to be 30 feet wide. For purposes of calculating temporary impacts in this Application, the Applicant has assumed that the temporary disturbance from the collector system trenches would be 236 acres.

The underground collector circuits would consist of three power cables contained in an insulated jacket and bare copper ground wire, all buried at a minimum depth of 4 feet that would not interfere with farming operations. Access to the underground collector lines would be located at each turbine site, at junction boxes located at points where the underground collector system cables are spliced, and where the cables enter into the collector substation. Due to the power carrying limits and minimization of power losses, there would be eight underground collector line circuits connecting 7 to 14 turbines each to the collector substation.

The underground electrical collector and communication system cable bundle would be generally installed by open trenching. Using this method, the disturbed soils are typically replaced over the buried cable within 1 day, and the drainage patterns and surface topography are restored to pre-existing conditions. In grassland/rangeland areas, the Applicant would re-vegetate the disturbed soils with a weed-free native plant seed mix.

8.7.1.2 Underground Communication System

The fiber optic communication conduits and cables for the Project would be installed in the same trench as the underground electrical collector cables and would connect the communication channels from each turbine to control facilities in the collector substation, O&M facility, and offsite locations.

8.7.2 Collector Substation

A new collector substation would be constructed in the center of the Project Area, on private land, where the 34.5-kV electric collection grid and fiber optic communication network would terminate. One potential collector substation location, as shown on Figure 2 in Appendix A, has been identified. The collector substation would include a main transformer to step up the voltage of the collection grid from 34.5 to 115 kV, aboveground bus structures to interconnect the substation components, breakers, a control building, relays, switchgear, cable storage, communications and controls, and other related facilities required for delivery of electric power to the 115-kV transmission line.

The design of the collector substation is not finalized, but the Applicant expects it would be enclosed by a chain link fence with dimensions of roughly 350 feet by 450 feet (4 acres). The substation components would be placed on concrete and steel foundations. For purposes of calculating temporary impacts in this Application, the Applicant has assumed approximately 5 acres of total temporary disturbance and approximately 4 acres of permanent impacts from collector substation construction. The collector substation would be designed in compliance with Federal, State and local regulations; National Electrical Safety Code (NESC) standards; and other applicable industry standards.

8.7.3 Station Power

During operation, wind turbine power consumption is in the range of 15 to 25 kilowatts (kW) per turbine. Turbines peak when they yaw, but they would not do so simultaneously. On the other hand, turbines might consume power simultaneously for heating if they are idling during cold and windless days. Turbine demand/consumption is supplied by back-feed power from the point of interconnection. It is assumed that 20 kW for each of the up to 61 turbines would be the typical power requirement. The Applicant would work with the local electric cooperatives to determine the number of turbines within each cooperative's territory and enter into service agreements with the transmission operator and the local electric cooperatives for station power energy and demand charges. The collector substation back-up power and power for the O&M building would be supplied through local distribution systems.

9.0 ALTERNATE SITES AND SITING CRITERIA (ARSD 20:10:22:12)

ARSD 20:10:22:12. Alternative sites. *The applicant shall present information related to its selection of the proposed site for the facility, including the following:*

(1) The general criteria used to select alternative sites, how these criteria were measured and weighed, and reasons for selecting these criteria;
(2) An evaluation of alternative sites considered by the applicant for the facility;
(3) An evaluation of the proposed plant, wind energy, or transmission site and its advantages over the other alternative sites considered by the applicant, including a discussion of the extent to which reliance upon eminent domain powers could be reduced by use of an alternative site, alternative generation method, or alternative waste handling method.

In addition to access to electric transmission facilities and sufficient wind, a wind energy project must be located in an area where landowners are willing to grant various easements and leases on commercially reasonable terms and conditions and where land use provides sufficient space for optimum turbine spacing. Access to electric transmission must be such that the power generated by the project can be relatively easily delivered into the grid. The following sections further describe the criteria used in the selection of the Project Area and the criteria used to develop turbine configuration layout.

9.1 General Project Location Selection

When Prevailing Wind Park acquired the rights to develop the Project in 2017, feasibility studies had already been conducted for the purpose of siting a wind farm in the Project Area. Based on the information provided to Prevailing Wind Park, the purpose of the 2015 feasibility study was to identify a Project location. The initial Project feasibility studies first looked for potential wind energy locations along WAPA's Fort Randal to Utica Junction to Sioux City double-circuit 230-kV transmission line. The WAPA 230-kV line was chosen based on available transmission capacity identified in transmission studies completed previously and acquired from B&H Wind Holdings, LLC. The first objective was to find large contiguous areas of land with higher elevations near the WAPA 230-kV line that could support 200 MW of wind energy. Three locations identified were:

- Location #1 - Dry Choteau Creek Coteau near Avon, South Dakota
- Location #2 - Turkey Ridge Coteau south and southeast of Freeman, South Dakota
- Location #3 - Hills around Beresford, South Dakota

Figure 4 in Appendix A shows the locations of the alternative sites. Table 9-1 contains a summary of each alternative site evaluated by Prevailing Winds, LLC. The feasibility assessment of each site determined that Location #1 (Table 9-1, below) on the Dry Choteau Creek Coteau near Avon, South Dakota, was best suited for a 200-MW wind energy project interconnecting with WAPA's 230-kV line. Proximity to the

WAPA 230-kV line lowers Project costs, and the superior wind resource (because of elevation) increases Project energy output and revenues. Location #1 also has lower population density and lower environmental risks, which further reduce potential Project impacts. Combining these factors makes a wind project located at Location #1 more cost effective than the Location #2 and Location #3 alternative sites. Prevailing Winds completed further feasibility studies to determine the suitability of Location #1. Upon successful completion of the feasibility studies in February 2015, Prevailing Winds submitted an Interconnection Request to WAPA for 200 MW on the 230-kV line inside Location #1 and began development activities for the Project at this location.

Table 9-1: Summary of Alternative Sites

Factor	Location #1	Location #2	Location #3
Interconnection distance to WAPA 230-kV	0 miles	15 miles	26 miles
Area above 1,600 feet elevation	<60 square miles	36 square miles	0 square miles
Area above 1,700 feet elevation	<17 square miles	3 square miles	0 square miles
Highest elevation	1,880 feet	1,740 feet	1,550 feet
Population density	Low	Moderate	High
Primary ground cover	Tilled	Tilled	Tilled
Bat habitat	Low	Low/moderate	Moderate
Eagle habitat	Low	Low/moderate	Low/moderate
Avian habitat	Low	Low/moderate	Low
Wetlands	Low/moderate	Moderate	Low
Cultural resources sites	Low/none	Low/none	Low
Beam paths	Low	High	Moderate
Historical wind data	Yes	No	No

The Applicant also considered input from agencies and the public in siting the Project, specifically:

- Project distance from the Missouri River, where higher populations of many plant and animal species are present.
- Project distance from the Whooping Crane Migration Corridor.
- State and Federal lands within or near Project Area.
- Native grasslands, wetlands, and other habitats within or near Project Area.
- An existing eagle nest located near the Project Area.

9.2 Site Configuration Alternatives

The proposed configuration of turbine locations reflects an optimal configuration to best capture wind energy within the Project Area, while avoiding impacts to residences, known cultural resources, wetlands, grasslands, and sensitive species and their habitats.

As discussed in Section 8.1, final micrositing could result in minor turbine adjustments. However, the final Project layout will comply with applicable local, State, and Federal requirements and/or commitments. The local requirements include Large Wind Energy System (LWES) requirements established by Bon Homme County. Neither Charles Mix County nor Hutchinson County have wind energy facility-specific ordinance provisions. Prevailing Wind Park will meet the Bon Homme County requirements in Bon Homme County, and has also designed the Project to comply with the Bon Homme setback and noise level requirements in Charles Mix and Hutchinson counties.

With respect to shadow flicker, Bon Homme County's ordinance does not specify a standard, but indicates that the county may require the installation of a shadow flicker control system under certain circumstances. In lieu of a specific standard, Prevailing Wind Park commits to limit shadow flicker at non-participating residences in the Project Area to no more than 30 hours per year.

The buildable area for turbines, after considering the setbacks in Table 9-2, as well as further environmental setbacks, is visually depicted on the siting constraints map provided as Figure 5 in Appendix A.

Table 9-2: Prevailing Wind Park Siting Requirements/Commitments

Category	Requirements/Commitments
State Requirements	
Setbacks	Turbines shall be set back at least 500 feet or 1.1 times the height of the tower, whichever is greater, from any surrounding property line (SDCL 43-13-24).
Bon Homme County Requirements[a]	
Setbacks	(a) Distance from currently occupied off-site residences, business and public buildings shall be not less than one thousand (1,000) feet. Distance from the residence of the landowner on whose property the tower(s) are erected shall be not less than five hundred (500) feet or one point one (1.1) times the system height, whichever is greater. For the purposes of this section only, the term "business" does not include agricultural uses. (b) Distance from right-of-way of public roads shall be not less than five hundred (500) feet or one point one (1.1) times the system height, whichever is greater. (c) Distance from any property line shall be not less than five hundred (500) feet or one point one (1.1) times the system height, whichever is greater, unless appropriate easement has been obtained from adjoining property owner.

Category	Requirements/Commitments
Noise	Noise level produced by the LWES shall not exceed forty-five (45) dBA, average A-weighted sound pressure at inhabited dwelling existing at the time the permit application is filed, unless a signed waiver or easement is obtained from the owner of the dwelling. The permittees shall submit a report of predicted noise levels at habitable residential dwellings within one mile of proposed tower locations to the Board no less than forty-five (45) days prior to commencing construction.
Voluntary Commitments in Charles Mix and Hutchinson Counties	
Setbacks	(a) Distance from currently occupied off-site residences, business and public buildings will be not less than 1,000 feet. Distance from the residence of the landowner on whose property the tower(s) are erected will be not less than 500 feet or 1.1 times the system height, whichever is greater. The term “business” does not include agricultural uses. (b) Distance from right-of-way of public roads will be not less than 500 feet or 1.1 times the system height, whichever is greater. (c) Distance from any property line will be not less than 500 feet or 1.1 times the system height, whichever is greater, unless appropriate easement has been obtained from adjoining property owner.
Noise	Noise level produced by the wind turbines will not exceed 45 dBA, average A-weighted sound pressure at currently inhabited dwellings, unless a signed waiver or easement is obtained from the owner of the dwelling.
Shadow Flicker Commitment	
Shadow Flicker	Shadow flicker produced by the wind turbines will not exceed 30 hours per year at currently inhabited dwellings of non-participants.

(a) Bon Homme County, South Dakota, Zoning Ordinance (amended November 3, 2015)

As discussed in Section 8.1, final micrositing could result in minor turbine adjustments. However, the final Project layout will comply with all applicable local, State, and Federal requirements, including the State and local requirements and/or commitments set forth in Table 9-2.

9.3 Lack of Reliance on Eminent Domain Powers

Prevailing Wind Park will not use eminent domain powers to acquire easements for the wind energy facility. Thus, selection of an alternative site would not reduce reliance on eminent domain powers. Private land rights and public road rights-of-way would be used for all facilities. All private land rights required for the wind energy facility were obtained through voluntary leases with property owners. The Applicant will obtain necessary road permits from road authorities prior to construction. Further, the Applicant will coordinate with Federal, State, and local agencies to obtain appropriate permits for the Project.

10.0 ENVIRONMENTAL INFORMATION (ARSD 20:10:22:13)

ARSD 20:10:22:13. Environmental information. *The applicant shall provide a description of the existing environment at the time of the submission of the application, estimates of changes in the existing environment which are anticipated to result from construction and operation of the proposed facility, and identification of irreversible changes which are anticipated to remain beyond the operating lifetime of the facility. The environmental effects shall be calculated to reveal and assess demonstrated or suspected hazards to the health and welfare of human, plant and animal communities which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction. The applicant shall provide a list of other major industrial facilities under regulation which may have an adverse effect on the environment as a result of their construction or operation in the transmission site, wind energy site, or siting area.*

Sections 10.0 through 15.0 and Sections 17.0, 18.0, and 20.0 provide a description of the existing environment at the time of the Application submittal, the potential changes to the existing environment that are anticipated as a result of Project construction and operation, and the irreversible changes that are anticipated to remain beyond the operational lifetime of the facility. These sections also identify the avoidance, minimization, and mitigation measures that will be implemented for the Project. Section 22.0 provides a discussion of the environmental effects which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction.

For purposes of analyzing environmental impacts in this Application, all 63 proposed turbine locations are included, even though only up to 61 turbines would ultimately be constructed. Table 10-1 identifies the ground disturbance impacts (both temporary impacts during construction and operational impacts during the life of the Project) assumed for the Project.

Table 10-1: Summary of Prevailing Wind Park Ground Disturbance Impacts

Project Component	Construction Impacts (Temporary)		Operational Impacts (Long-Term)	
	Dimensions	Total Acreage	Dimensions	Total Acreage
Turbines[a]	160-foot radius	116 acres	25-foot radius	3 acres
Access roads[a]	50-foot wide	103 acres	16-foot wide	33 acres
Upgraded roads	N/A	3 acres	N/A	N/A
Crane paths[a]	60-foot wide	393 acres	N/A	N/A
Collector lines[a]	30-foot wide	236 acres	10-foot by 5-foot junction box	0.001 acre
Collection substation	5 acres	5 acres	4 acres	4 acres
Meteorological towers	200-foot by 200-foot area	4 acres	42-foot by 42-foot area	0.2 acre

Project Component	**Construction Impacts (Temporary)**		**Operational Impacts (Long-Term)**	
	Dimensions	**Total Acreage**	**Dimensions**	**Total Acreage**
O&M facility	6 acres	6 acres	6 acres	6 acres
Laydown/staging/ batch plant areas	12 acres	12 acres	N/A	N/A
	Total:	**734 acres**[b]	**Total:**	**45 acres**[b]

(a) Impact calculations are based on all 63 proposed turbine locations and associated facilities. These are conservative estimates, because a maximum of 61 turbines would be built.
(b) Total impact acreages are based on GIS calculations. Because there is some overlap in the disturbance areas for the individual Project components, the total impact acreages do not equal the sum of the impact acreages for the individual components presented in this table.

11.0 EFFECT ON PHYSICAL ENVIRONMENT (ARSD 20:10:22:14)

ARSD 20:10:22:14. Effect on physical environment. *The applicant shall provide information describing the effect of the proposed facility on the physical environment. The information shall include:*
(1) A written description of the regional land forms surrounding the proposed plant or wind energy site or through which the transmission facility will pass;
(2) A topographic map of the plant, wind energy, or transmission site;
(3) A written summary of the geological features of the plant, wind energy, or transmission site using the topographic map as a base showing the bedrock geology and surficial geology with sufficient cross-sections to depict the major subsurface variations in the siting area;
(4) A description and location of economic deposits such as lignite, sand and gravel, scoria, and industrial and ceramic quality clay existent within the plant, wind energy, or transmission site;
(5) A description of the soil type at the plant, wind energy, or transmission site;
(6) An analysis of potential erosion or sedimentation which may result from site clearing, construction, or operating activities and measures which will be taken for their control;
(7) Information on areas of seismic risks, subsidence potential and slope instability for the plant, wind energy, or transmission site; and
(8) An analysis of any constraints that may be imposed by geological characteristics on the design, construction, or operation of the proposed facility and a description of plans to offset such constraints.

The following sections describe the existing physical environment within the Project Area, the potential effects of the proposed Project on the physical environment, and measures that will be utilized to avoid, minimize, and/or mitigate potential impacts.

11.1 Geological Resources

The existing geological resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

11.1.1 Existing Geological Resources

This section describes the regional landforms, surficial geology, bedrock geology, economic deposits, seismic risk, and subsidence potential within the Project Area.

11.1.1.1 Regional Landforms/Surficial Geology

The topography within the Project Area is generally characterized by smooth hills and ridges with rounded tops. Relief within the Project Area is low to moderate with site elevations ranging from approximately 1,500 to 1,900 feet above mean sea level (AMSL). Within the Project Area, shallow local drainages bisect the terrain. The Project Area is located atop a local topographic high point, from which drainage occurs to the northeast, east, southeast, south, and southwest. A number of the shallow drainages within the Project Area have been dammed to create small stock water ponds.

The majority of the Project Area is located within the Central Lowland province of the Interior Plains physiographic region. The Central Lowland province is characterized by flat lands and geomorphic remnants of glaciation. The western edge of the Project Area is located within the Great Plains province of the Interior Plains physiographic region. The Great Plains province is characterized by plateau-like flat plains with little relief throughout the area (National Park Service [NPS], 2017a).

The physiographic features of the Project Area, including smooth hills and ridges and shallow meandering drainages, were formed as the underlying bedrock was eroded by the action of wind and water. The surficial geology of the Project Area can be described as a thin veneer of residual soils underlain by the Pierre Shale bedrock. Residual soils generally exhibit similar mineralogy to their underlying parent materials, although the high degree of weathering usually causes the overall soil structure to differ. The following surficial geologic units are mapped within the Project Area (South Dakota Geological Survey [SDGS], 2017):

- Qal – Alluvium (Quaternary) – Clay- to boulder-sized clasts with locally abundant organic material. Thickness up to 75 feet (23 meters).
- Qlts – Till, stagnation, moraine (Upper Wisconsin) – Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by hummocky terrain with abundant sloughs resulting from stagnation of ice sheets. Composite thickness of all Upper Wisconsin till may be up to 300 feet (91 meters).
- Qlte – Till, end moraine (Upper Wisconsin) - Compact, silty, clay-rich matrix with sand- to boulder-sized clasts of glacial origin. A geomorphic feature characterized by elevated linear ridges with hummocky terrain locally at former ice sheet margins. Composite thickness of all Upper Wisconsin till may be up to 300 ft (91 m).

Figure 6a in Appendix A illustrates the surficial geology within the Project Area (SDGS, 2017), and Figure 6b is a geologic cross section of the Project Area.

11.1.1.2 Bedrock Geology

The uppermost bedrock unit underlying most of the Project Area is the Pierre Shale. Pierre Shale, as described by the U.S. Geological Survey (USGS), is an Upper Cretaceous-aged blue-gray to dark-gray, fissile to blocky shale with persistent beds of bentonite, black organic shale, and light-brown chalky shale (USGS, 2017a). The Pierre Shale contains minor sandstone and conglomerate beds and abundant carbonate and ferruginous (iron-rich) concretions, and the unit ranges in thickness from 1,000 to 2,700 feet (205 to 823 meters).

The southeast and west sides of the Project Area are underlain by the Niobrara Formation. The Niobrara Formation, as described by the USGS (USGS, 2017b), is an Upper Cretaceous-aged white to dark gray argillaceous chalk, marl, and shale. It contains thin, laterally continuous bentonite beds, chalky carbonaceous shale, minor sand, and small concretions. The thickness of this formation ranges from 160 to 225 feet (49 to 69 meters).

The center-west side of the Project Area is underlain by the Carlile Shale. The Carlile Shale, as described by the SDGS Geologic Map of South Dakota (SDGS, 2017), is an Upper Cretaceous-aged dark gray to black, silty to sandy shale with several zones of septarial, fossiliferous, carbonate concretions. The Carlile Shale contains up to three sandstone beds near the middle of the formation and sandy calcareous marl at the base. The thickness of the Carlile Shale ranges from 345 to 620 feet (105 to 189 meters).

Siting of wind turbines is most likely to be within the higher elevations of the Project Area, thus within the Pierre Shale bedrock. Figure 6b in Appendix A depicts the geologic cross section information available for the Project Area.

11.1.1.3 Economic Deposits

Commercially viable mineral deposits within Charles Mix, Bon Homme, and Hutchinson counties include sand, gravel, and construction aggregates. Information from the South Dakota Department of Environment and Natural Resources (SDDENR) Minerals and Mining Program and a review of the USGS 7.5-minute quadrangle mapping indicates that a sand and gravel quarry was developed in the southern part of the Project Area, but it has been inactive since 1995. The nearest active gravel quarry is approximately 1.5 miles north of the Project Area (SDDENR, 2017a).

A review of information from the SDDENR Oil and Gas Initiative Program reveals that the majority of current and historic oil and gas development in South Dakota occurs in the western half of the State. The Project Area does not lie within an identified oil and gas field, and there are no active or historical oil and gas developments within or near the vicinity of the Project Area (SDDENR, 2017b).

11.1.1.4 Seismic Risks

The risk of seismic activity in the vicinity of the Project Area is low. The USGS Earthquake Hazards Program estimates a 1.1 to 1.4 percent probability that a magnitude 5 or greater earthquake will occur within 50 kilometers of the Project Area within the next 20 years. Further, the USGS 2014 Seismic Hazard Map for South Dakota indicates the peak ground acceleration (PGA) with a 2 percent chance of exceedance in 50 years is 0.06 to 0.1 g (USGS, 2017c).

According to the SDGS, no earthquakes have been recorded in the Project Area from 1872 to 2013 (SDGS, 2013). However, a magnitude 4.3 earthquake was recorded approximately 7 miles east of the Project Area in 1982. Available geologic mapping and information from the USGS Earthquake Hazards Program do not indicate any active or inactive faults within the Project Area (USGS, 2017d).

11.1.1.5 Subsidence Potential

The risk for subsidence within the Project Area is considered negligible. The Pierre Shale bedrock is present at the surface, or beneath a thin veneer of residual soil, throughout a vast majority of the Project Area and is not known to exhibit karst topography or contain layers or members susceptible to dissolution by water. No historic underground mining operations, which could lead to subsidence or collapse, exist within the Project Area.

11.1.2 Geological Resources Impacts/Mitigation

In general, the geological and geotechnical conditions within the Project Area are favorable and are not anticipated to limit or impact development of the Project. Excavation, bearing, and groundwater conditions associated with the shallow Pierre Shale bedrock throughout the Project Area are anticipated to be conducive to construction and operation of the wind turbine tower foundations and access roadways.

Soil borings are currently being completed at all wind turbine locations, the results of which will be used to develop the specific design and construction parameters. Laboratory testing of soil samples obtained from the site and geophysical surveys will be performed to determine the engineering characteristics of the site subgrade soils. If necessary, corrections to roadway and foundation subgrade will be prescribed for unsuitable soils.

As discussed in Section 24.0, the facility will be decommissioned after the end of the Project's operating life. Facilities would be removed in accordance with applicable State and county regulations, unless otherwise agreed to by the landowner. After decommissioning of the Project is complete, the portions of underground facilities located 48 inches below the surface will be abandoned in place and remain beyond the operational lifetime of the facility. However, these remaining facilities would not result in irreversible changes to the underlying geological conditions of the Project Area.

Due to the lack of developed or potential economic mineral resources within the Project Area, construction and operation of the proposed facility poses no impact to economic mineral resources. Therefore, no mitigation is required for impacts to mineral resources.

11.2 Soil Resources

The existing soil resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

11.2.1 Existing Soil Resources

This section describes the existing soil types, erosion potential and slopes, and prime farmland soils within the Project Area.

11.2.1.1 Soil Types

The soils within the Project Area primarily consist of loams, silty loams, and silty clay loams derived mostly from glacial till, alluvium, and the underlying Pierre Shale bedrock. The soils in the Project Area are not highly susceptible to erosion and are generally conducive to crop production (Natural Resources Conservation Service [NRCS], 2018).

Nearly half of the soils within the Project Area have the potential to be highly corrosive to buried steel, while nearly all the soils within the Project Area have the potential to be moderately corrosive to concrete. Soils are not interpreted to be expansive based upon indicated soil classifications. The majority of soils in the Project Area are well drained, and only approximately 7 percent of the soils have a significant hydric component (30 to 100 percent of the soil is hydric). Approximately 8 percent of the soils are considered to have a high potential for frost action (NRCS, 2017). Table 11-1 lists the soil types comprising more than 1 percent of the Project Area and the characteristics of these soils, and Figure 7 in Appendix A illustrates the soil types and distributions within the Project Area.

11.2.1.2 Erosion Potential and Slopes

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. The soils in the Project Area are moderately susceptible to erosion and have K Factors ranging from 0.05 to 0.37, with the majority between 0.24 and 0.32. The Project Area slope ranges from 0 to 40 percent, with the majority of slope at 1 to 6 percent.

Table 11-1: Soil Types Within the Project Area

Soil Type	Soil Taxonomy	Soil Texture	Parent Material	Natural Drainage Class	Depth to Restrictive Feature (inches)	Acres in Project Area	Percent of Project Area
HnB (Homme-Ethan-Onita complex, 1 to 6 percent slopes)	Fine-silty, mixed, superactive, mesic Typic Haplustolls	Silty clay loam	Periglacial loess over fine-loamy till	Well drained	Greater than 80	8,699	17.3
HmB (Homme-Ethan-Onita complex, 1 to 6 percent slopes)	Fine-silty, mixed, superactive, mesic Typic Haplustolls; fine-loamy, mixed, superactive, mesic Typic Calciustolls; and fine, smectitic, mesic Pachic Argiustolls	Silty clay loam	Glacial drift, glacial till, or alluvium	Well drained	Greater than 80	8,350	16.6
HpB (Homme-Ethan-Tetonka complex, 0 to 6 percent slopes)	Fine-silty, mixed, superactive, mesic Typic Haplustolls; Fine-loamy, mixed, superactive, mesic Typic Calciustolls; Fine, smectitic, mesic Argiaquic Argialbolls	Silty clay loam	Glacial drift, glacial till, or alluvium	Poorly to well drained	Greater than 80	3,401	6.8
EpC (Ethan-Homme complex, 6 to 9 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic Calciustolls and fine-silty, mixed, superactive, mesic Typic Haplustolls	Silty clay loam	Glacial till	Well drained	Greater than 80	2,869	5.7
EuC (Ethan-Homme complex, 6 to 9 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic Calciustolls	Loam	Fine-loamy till	Well drained	Greater than 80	2,450	4.9
EnC (Ethan-Bonilla loams, 1 to 9 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic Calciustolls and Pachic Haplustolls	Loam	Glacial till	Well drained	Greater than 80	2,116	4.2
HrB (Homme-Onita silty clay loams, 1 to 6 percent slopes)	Fine-silty, mixed, superactive, mesic, Typic Haplustolls and fine, smectitic, mesic Pachic Argiustolls	Silty clay loam	Glacial drift, alluvium	Well drained	Greater than 80	1,988	3.9

Soil Type	Soil Taxonomy	Soil Texture	Parent Material	Natural Drainage Class	Depth to Restrictive Feature (inches)	Acres in Project Area	Percent of Project Area
HoB (Homme-Onita silty clay loams, 1 to 6 percent slopes)	Fine-silty, mixed, superactive, mesic Typic Haplustolls	Silty clay loam	Periglacial loess over fine-loamy till	Well drained	Greater than 80	1,942	3.9
EoD (Ethan-Davis loams, 9 to 15 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic Calciustolls and Pachic Haplustolls	Loam	Glacial till	Well drained	Greater than 80	1,108	2.2
HoA (Homme-Onita silty clay loams, 0 to 2 percent slopes)	Fine-silty, mixed, superactive, mesic Typic Haplustolls	Silty clay loam	Periglacial loess over fine-loamy till	Well drained	Greater than 80	1,102	2.2
On (Mobridge silt loam, 0 to 2 percent slopes)	Fine-silty, mixed, superactive, mesic Pachic Argiustolls	Silt loam	Colluvial-alluvial sediments	Well drained	Greater than 80	1,092	2.2
EtD (Ethan-Betts loams, 9 to 15 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic Calciustolls	Loam	Fine-loamy till	Well drained	Greater than 80	974	1.9
HtB (Homme-Onita complex, 2 to 6 percent slopes)	Fine-silty, mixed, superactive, mesic Typic Haplustolls	Silty clay loam	Periglacial loess over fine-loamy till	Well drained	Greater than 80	953	1.9
CsB (Clarno-Ethan-Bonilla loams, 2 to 6 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic Haplustolls, Typic Calciustolls, Pachic Haplustolls	Loam	Glacial till	Well drained	Greater than 80	896	1.8
Te (Tetonka silt loam, 0 to 1 percent slopes)	Fine, smectitic, mesic Argiaquic Argialbolls	Silt loam	Alluvium	Poorly drained	Greater than 80	785	1.6

Soil Type	Soil Taxonomy	Soil Texture	Parent Material	Natural Drainage Class	Depth to Restrictive Feature (inches)	Acres in Project Area	Percent of Project Area
Bo (Bon loam, channeled)	Fine-loamy, mixed, superactive, mesic Cumulic Haplustolls	Loam	Local alluvium	Moderately well drained	Greater than 80	744	1.5
BeE (Betts-Ethan loams, 9 to 25 percent slopes)	Fine-loamy, mixed, superactive, messic Typic Cacliustepts, and Typic Calciustolls	Loam	Glacial till	Well drained	Greater than 80	725	1.4
CeB (Clarno-Ethan loams, 2 to 6 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic Haplustolls	Loam	Fine-loamy till	Well drained	Greater than 80	720	1.4
HmA	Fine-silty, mixed, mesic Typic Haplustolls	Silty clay loam	Silty drift over loamy till	Moderately well drained	Greater than 80	674	1.3
Tn (Tetonka-Chancellor silty clay loams)	Fine, smectitic, mesic Argiaquic Argialbolls and Vertic Argiaquolls	Silty clay loam	Alluvium	Poorly drained	Greater than 80	644	1.3
HtA	Fine-silty, mixed, superactive, mesic Typic Haplustolls	Silty clay loam	Periglacial loess over fine-loamy till	Well drained	Greater than 80	639	1.3
CmB (Clarno-Bonilla loams, 2 to 6 percent slopes)	Fine-loamy, mixed, superactive, mesic Typic and Pachic Haplustolls	Loam	Glacial till	Moderately to well drained	Greater than 80	545	1.1

Source: NRCS, 2018

11.2.1.3 Prime Farmland Soils

NRCS farmland classifications include "prime farmland" (land that has the best combination of physical and chemical characteristics for the production of crops), "farmland of statewide importance" (land other than prime farmland that has a good combination of physical and chemical characteristics for the production of crops), and "not prime farmland" (land that does not meet qualifications for prime farmland), among other classifications. The majority of the farmland in the Project Area is classified as either "prime farmland" (32 percent) or "farmland of statewide importance" (36 percent). Approximately 15 percent is categorized as "not prime farmland." The remaining 17 percent is divided among "prime farmland" categories with stipulations. Farmland types within the Project Area are shown in Table 11-2.

Table 11-2: Farmland Types Within the Project Area

Farmland Type	Area (acres)	Percentage of Project Area
Prime farmland	16,004	32%
Farmland of statewide importance	18,171	36%
Not prime farmland	7,409	15%
Prime farmland if drained	4,958	10%
Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season	632	1%
Prime farmland if irrigated	3,190	6%
Total	50,364	100%

11.2.2 Soil Resources Impacts/Mitigation

The following sections describe the potential effects of the proposed Project on soil resources. Where applicable, planned measures to avoid, minimize, or mitigate impacts are noted.

11.2.2.1 Potential for Impacts to Soil Resources

Construction of up to 61 wind turbine foundations and associated access roads, collector lines, substations, and O&M facilities would result in approximately 734 acres of temporary disturbance and approximately 45 acres of permanent impacts to soils within the Project Area. During construction, the minimum amount of existing vegetation would be removed in the areas associated with the proposed Project components, potentially temporarily increasing the risk of erosion, which is discussed in more detail below. As discussed in Section 24.0, the Project would be decommissioned after the end of the its operating life. Facilities would be removed in accordance with applicable State and County regulations, unless otherwise agreed to by the landowner. Disturbed surfaces would be graded, reseeded, and restored as nearly as possible to their preconstruction conditions. After decommissioning of the Project is complete, no irreversible changes to soil resources would remain beyond the operating life of the Project.

11.2.2.2 Erosion, Slope Stability, and Sedimentation

The Applicant will design the Project layout to limit construction cut and fill work and limit construction in steep slope areas. Wind turbines are generally located at higher elevations to maximize exposure to wind and sited to avoid steep slope areas for foundation installation. The current layout has sited access roads to avoid steep slopes as much as practicable, and the underground collector lines similarly avoid crossing steep ravines whenever feasible.

Surface disturbance caused by construction of the wind turbines and infrastructure improvements would result in the soil surface becoming temporarily more prone to erosion. Another potential issue is soil compaction, which can occur by use of heavy equipment. Silt and clay soils are especially susceptible to this. Measures to reduce impacts to soils would be implemented during construction. These may include the use of erosion and sediment control during and after construction, noxious weed control, segregating topsoil from subsurface materials, reseeding of disturbed areas, the use of construction equipment appropriately sized to the scope and scale of the Project, confirming access road grades fit closely with the natural terrain, proper onsite disposal of soil cuttings from turbine foundation construction, and maintaining proper drainage.

Construction of the Project would require coverage under the General Permit for Storm Water Discharges Associated with Construction Activities issued by the SDDENR. A condition of this permit is the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP would be developed during civil engineering design of the Project and would identify BMPs to control erosion and sedimentation. The BMPs may include silt fences, straw wattles, erosion control blankets, temporary storm water sedimentation ponds, re-vegetation, or other features and methods designed to control storm water runoff and mitigate erosion and sedimentation. The BMPs would be implemented to reduce the potential for impacts to drainage ways and streams by sediment-laden runoff. During the facility design life, storm water volume and flow erosion rates are not anticipated to increase from those of pre-development conditions.

12.0 EFFECT ON HYDROLOGY (ARSD 20:10:22:14, 20:10:22:15)

ARSD 20:10:22:15. Hydrology. *The applicant shall provide information concerning the hydrology in the area of the proposed plant, wind energy, or transmission site and the effect of the proposed site on surface and groundwater. The information shall include:*

(1) A map drawn to scale of the plant, wind energy, or transmission site showing surface water drainage patterns before and anticipated patterns after construction of the facility;
(2) Using plans filed with any local, state, or federal agencies, indication on a map drawn to scale of the current planned water uses by communities, agriculture, recreation, fish, and wildlife which may be affected by the location of the proposed facility and a summary of those effects;
(3) A map drawn to scale locating any known surface or groundwater supplies within the siting area to be used as a water source or a direct water discharge site for the proposed facility and all offsite pipelines or channels required for water transmission;
(4) If aquifers are to be used as a source of potable water supply or process water, specifications of the aquifers to be used and definition of their characteristics, including the capacity of the aquifer to yield water, the estimated recharge rate, and the quality of groundwater;
(5) A description of designs for storage, reprocessing, and cooling prior to discharge of heated water entering natural drainage systems; and
(6) If deep well injection is to be used for effluent disposal, a description of the reservoir storage capacity, rate of injection, and confinement characteristics and potential negative effects on any aquifers and groundwater users which may be affected.

The following sections describe the existing hydrology within the Project Area, the potential effects of the proposed Project on hydrology, and measures that will be utilized to avoid, minimize, and/or mitigate potential impacts.

12.1 Groundwater Resources

The existing groundwater resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and avoidance, minimization, and/or mitigation measures.

12.1.1 Existing Groundwater Resources

The groundwater system underlying the parts of South Dakota that are east of the Missouri River, including the Project Area, is nearly exclusively based on glacial outwash aquifers. According to the SDGS, there are approximately 444 public water supply systems east of the Missouri River, and 392 of them utilize glacial outwash aquifers (Iles, 2008). This is consistent with the types of the soils in the area, many of which were formed from glacial till or glacial drift. Glacial drift and alluvium aquifers in South Dakota vary in depth from 0 to 400 feet, with a range of yield from 3 to 50 gallons per minute (Chadima, 1994). Unlike bedrock-type aquifers, glacial outwash aquifers are extremely difficult to predict at the subsurface; however, the quality of water from glacial outwash aquifers tends to exceed that of water derived from bedrock-type aquifers.

12.1.2 Groundwater Resources Impacts/Mitigation

The construction of wind farm facilities can require dewatering of excavated areas as a result of shallow groundwater, particularly for wind turbine foundations or collector line trenches. Construction dewatering may temporarily lower the water table in the immediate area and may temporarily lower nearby surface water elevations, depending on the proximity and connectivity of groundwater and surface water and extent of the excavated area.

Groundwater dewatering is not anticipated to be a major concern within the Project Area, because wind turbines will most likely be placed at higher elevation where the water table tends to be deeper. Should groundwater be encountered that must be dewatered, the necessary permits would be obtained, and the duration of dewatering would be limited to the extent possible. Dewatered groundwater would be properly handled to allow sediments to settle out and be removed before the water is discharged, to reduce soil erosion and sedimentation of surface waters.

12.2 Surface Water Resources

The existing surface water resources within the Project Area are described below (and shown on Figure 8), followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures.

12.2.1 Existing Surface Water Resources

This section describes the existing hydrology, floodplains, NPS Nationwide Rivers Inventory (NRI) resources, and impaired waters within the Project Area.

12.2.1.1 Hydrology

The Project Area is located within the Missouri River Basin surface water drainage system. Based on information obtained from the U.S. Army Corps of Engineers' (USACE) *Final Environmental Impact Statement, Master Water Control Manual, Review and Update Study for the Missouri River*, this drainage system has a total drainage area of approximately 529,350 square miles, including approximately 9,700 square miles in Canada (USACE, 2004). The Missouri River flows from the confluence of the Jefferson, Madison, and Gallatin rivers in southwestern Montana, approximately 2,320 miles prior to converging with the Mississippi River directly upstream of St. Louis, Missouri (USACE, 2004). Six mainstem reservoir system dams (including the major streams and tributaries) are associated with the Missouri River Basin: (1) Fort Peck, (2) Garrison, (3) Oahe, (4) Big Bend, (5) Fort Randall, and (6) Gavins Point.

The Missouri River Basin surface water drainage system consists of region, sub-region, basin, and sub-basin drainages. The Project Area is associated with the Missouri-Big Sioux Sub-Region of the Missouri Region. The Project Area is in the Lewis and Clark Lake Sub-Basin. Choteau Creek, located west of the Project Area, is part of the Lewis and Clark Lake Sub-Basin drainage system. Drainage generally flows from the northwest to the southeast within this Sub-Basin. Named streams of the Lewis and Clark Lake Sub-Basin that extend through the Project Area include Dry Choteau Creek and Little Emanuel Creek (Figure 8 in Appendix A).

12.2.1.2 National Park Service Nationwide Rivers Inventory

The NRI is a "listing of more than 3,400 free-flowing river segments in the U.S. that are believed to possess one or more "outstandingly remarkable" natural or cultural values judged to be of more than local or regional significance. Under a 1979 Presidential Directive, and related Council on Environmental Quality procedures, all Federal agencies must seek to avoid or mitigate actions that would adversely affect one or more NRI segments" (NPS, 2017b). There are no NRI-listed rivers within the Project Area. The nearest NRI-listed river is the James River, located approximately 16 miles east of the Project Area.

12.2.1.3 Impaired Waters

The CWA requires states to publish biannually a list of streams and lakes that are not meeting their designated uses because of excess pollutants. These streams and lakes are considered impaired waters (EPA, 2017a). The list, known as the 303(d) list, is based on violations of water quality standards. States establish priority rankings for waters on the 303(d) list and develop the total maximum daily load (TMDL) of a pollutant that the water can receive and still safely meet water quality standards. There are no 303(d)-listed water bodies within the Project Area, but the nearest downstream 303(d)-listed water body to the Project Area, Emanuel Creek, is located approximately 2 miles east and is within the Lewis and Clark Lake Sub-Basin (SDDENR, 2016).

12.2.1.4 Floodplains

Based on available Federal Emergency Management Agency (FEMA) flood maps, there are no FEMA-mapped floodplains within the Project Area. FEMA flood maps are available for Charles Mix and Hutchinson counties but have not been produced for Bon Homme County. The nearest mapped floodplains to the Project area are along Choteau Creek, over 1 mile southwest of the Project Area (Figure 8 in Appendix A).

12.2.2 Surface Water Resources Impacts/Mitigation

Potential impacts to water resources from the construction and operation of wind projects include deterioration of surface water quality through sedimentation, impacts to drainage patterns, impacts to flood storage areas, and increased runoff due to the creation of impervious surfaces. Project facilities have been designed to avoid impacts on surface water resources to the extent practicable. Therefore, the Project is not expected to cause significant changes in runoff patterns or volume of runoff, nor is it expected to have adverse impacts on existing hydrology. During construction, BMPs will be implemented to control erosion and reduce potential for sediment runoff from exposed soils during precipitation events.

In general, because wind turbines would be located at higher elevations within the Project Area to maximize wind exposure, impacts to ephemeral streams and drainage ways are not anticipated from turbine sites. The underground collection system may temporarily impact surface drainage patterns during construction if the collection system is trenched through drainage ways; however, these impacts would be short-term, and existing contours and drainage patterns are expected to be restored within 24 hours of trenching. Where stream/drainage crossings cannot be avoided for construction of access roads, appropriately designed culverts or low water crossings would be placed to maintain the free flow of water. The permanent use of approximately 45 acres of land for the wind farm facilities would be spread throughout the 50,364-acre Project Area and are not expected to change existing drainage patterns.

The creation of impervious surfaces reduces the capacity of an area to absorb precipitation into the soil and can increase the volume and rate of storm water runoff. The Project would create up to 45 acres of impermeable surface through the construction of turbine pads, access roads, meteorological equipment, the O&M facility, and the collector substation. The wind turbine pads, access roads, and O&M facility and substation yards would be constructed of compacted gravel and would not be paved. However, this level of compaction may inhibit infiltration and may increase runoff in these areas.

The 45 acres of permanent disturbance represents less than 0.1 percent of the total area within the Project Area. Therefore, the Project is not expected to cause significant changes in runoff patterns or volume. As noted above, appropriate storm water management BMPs would be implemented during the construction and operation of the Project. These BMPs are anticipated to adequately mitigate for runoff due to the increase in impervious surface.

12.2.2.1 Impacts to NRI-Listed Rivers and Mitigation

Due to the lack of NRI-listed rivers within the Project Area, construction and operation of the proposed facility poses no impact to these resources. Therefore, no mitigation is required for impacts to NRI-listed rivers.

12.2.2.2 Impacts to Impaired Waters and Mitigation

Due to the lack of 303(d)-listed water bodies within the Project Area, construction and operation of the proposed facility will not impact these resources. Therefore, no mitigation is required for impacts to 303(d)-listed water bodies. As discussed in Section 11.2.2.2, construction of the Project would require development and implementation of a SWPPP and BMPs in accordance with the General Permit for Storm Water Discharges Associated with Construction Activities issued by the SDDENR.

12.2.2.3 Impacts to Flood Storage Areas

In natural systems, floodplains serve several functions that include storing excess water during high-flow/high-runoff periods, moderating the release of water during high-flow/high-runoff periods, reducing flow velocity, and filtering out sediments and other pollutants. The placement of fill into floodplains reduces the effectiveness of these functions. As noted previously, Project facilities have been designed to avoid impacts on surface water resources to the extent practicable. No FEMA-mapped floodplains are located within the Project Area, and, therefore, no mitigation is proposed for impacts to flood storage areas.

12.2.3 Current and Planned Water Uses

The current and planned water uses within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures.

12.2.3.1 Current and Planned Water Uses within Project Area

B-Y Water District in Tabor supplies rural water to the Project Area and maintains a network of distribution lines within the Project Area. Private wells that supply water for domestic and irrigation purposes are also located throughout the Project Area. Streams within the Project Area, including Dry Choteau Creek and Little Emanuel Creek (Figure 8 in Appendix A), as well as lakes and ponds, provide habitat for fish and wildlife and support recreational activities, such as fishing.

12.2.3.2 Effect on Current or Planned Water Use

The proposed Project facilities would not have impacts on either municipal or private water uses in the Project Area. Water storage, reprocessing, or cooling is not required for either the planned construction or operation of the facilities. The Project facilities would not require deep well injection. The Project operation would not require the appropriation of surface water or permanent dewatering. The Applicant would connect the O&M facility to the rural water system. Water usage at the O&M facility would be similar to household volume, fewer than 5 gallons per minute.

The Applicant would coordinate with the B-Y Water District to locate and map its network of distribution lines within the Project Area and determine if a rural water supply connection is necessary for the Project. Disruption to existing water lines would be avoided by Project design and construction. The Applicant would obtain crossing permits or approvals from from the B-Y Water District, as needed.

Alternatively, a water supply well would be required if rural water service is not available. The Applicant would work with the SDDENR to obtain the necessary water rights permit. The specific aquifer to be used and the characteristics of that aquifer would depend on the location of the water supply well. Water usage at the O&M facility would be negligible (similar to household volume, as stated above). Therefore, regardless of the water supply well location and aquifer source, the Project would not affect aquifer recharge rates. The Project would comply with applicable permit requirements for water rights and the protection of groundwater quality.

The construction of wind farm facilities can interrupt the availability of groundwater through construction dewatering. Construction dewatering may temporarily lower the water table such that nearby wells may lose some of their capacity. However, the Project is not expected to require major dewatering; therefore, interruption of groundwater availability caused by dewatering is unlikely. In the event potential temporary dewatering wells are necessary during construction activities, the temporary wells would be installed and then decommissioned as required by South Dakota law.

The Project would have no impact on surface water availability or use for communities, agriculture, recreation, fish, or wildlife. As discussed in Section 13.3.2, minimal permanent impacts to wetlands and streams are anticipated. Following construction, temporary impacts to wetlands and streams would be restored to pre-construction conditions.

13.0 EFFECT ON TERRESTRIAL ECOSYSTEMS (ARSD 20:10:22:16)

ARSD 20:10:22:16. Effect on terrestrial ecosystems. *The applicant shall provide information on the effect of the proposed facility on the terrestrial ecosystems, including existing information resulting from biological surveys conducted to identify and quantify the terrestrial fauna and flora potentially affected within the transmission site, wind energy site, or siting area; an analysis of the impact of construction and operation of the proposed facility on the terrestrial biotic environment, including breeding times and places and pathways of migration; important species; and planned measures to ameliorate negative biological impacts as a result of construction and operation of the proposed facility.*

The following sections describe the existing terrestrial ecosystems within the Project Area, potential effects of the proposed Project on these terrestrial systems, and mitigation and minimization measures planned to lessen or avoid potential impacts to terrestrial systems. Terrestrial ecosystem data were collected from literature searches, Federal and State agency reports, natural resource databases, and field surveys completed for the Project. Specific resources discussed in the following sections include vegetation, wetlands, and wildlife, including federally and state-listed species.

13.1 Vegetation

The existing vegetation within the Project Area is described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

13.1.1 Existing Terrestrial Ecosystem

The Project Area is located within two Level IV Ecoregions: Southern Missouri Coteau and Southern Missouri Coteau Slope (Bryce, et al., 1996).

The Southern Missouri Coteau is located in the southern fringe of continental glaciation and exhibits muted coteau topography with gentle undulations rather than steep hummocks. It also contains a small amount of high wetland density and more stream erosion backcutting into areas of internal drainage. For this reason, there is more tilled land on the Southern Missouri Coteau because of the gentler topography. Specifically, soybeans and corn are major crops planted due to the gentler topography and milder climate with increased precipitation. Natural vegetation in the region includes western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella virifula*), needle and thread (*Hesperostipa comata*), and porcupine grass (*Miscanthus sinensis*). Prairie cordgrass (*Spartina pectinata*) and northern reedgrass (*Calamagrostis stricta*) are present in poorly drained areas.

The Southern Missouri Coteau Slope contains mesic soils rather than frigid soils and a substantial cap of rock-free loess. Sunflowers, wheat, millet, and barley are planted in the level to rolling uplands of the Southern Missouri Coteau Slope. Corn is a marginal crop that does well in wet years. Willows (*Salix* *spp.*), green ash (*Fraxinus pennsylvanica*), and elm (*Ulmus* spp.) grow in the riparian areas, and western wheatgrass, green needlegrass, big bluestem (*Andropogon gerardi*), and needle and thread are scattered throughout the region. Stream drainages tend to be grazed.

The majority of the Project Area has been converted to agricultural use, with crop production and livestock grazing as the main agricultural practices. Trees and woodlands are found mainly in planted shelter belts and within draws and on hillslopes. Wetlands are scattered throughout the Project Area.

13.1.1.1 Native Grassland

Native grasslands provide important habitat for various wildlife species including songbirds and ground-nesting raptors and owls. In the context of wind farm development, habitat fragmentation can occur during siting of access roads, which may bisect existing, larger areas of habitat. Wind turbines themselves do not generally pose the same concern for habitat fragmentation because they are not linear. The USFWS and SDGFP consider untilled grasslands, which include pastures and fallow fields, as native grasslands that may provide important wildlife habitat (USFWS and SDGFP pers comm, 2018)

In 2016, a desktop review of potential native/untilled grasslands was conducted by reviewing the U.S. Department of Agriculture (USDA) National Agriculture Imagery Program imagery (USDA, 2015a), the 2015 USDA Cropland Data Layer (USDA, 2015b) and the *Quantifying Undisturbed (Native) Lands in Eastern South Dakota: 2013* (Bauman et al., 2013) digital data layer to further evaluate potential for past disturbances. Untilled grasslands were then field verified in the fall of 2016 by visiting locations identified during the desktop review as potential untilled/native grasslands, which included pastures. In 2018, the Applicant completed an updated analysis to identify potential native grasslands within the current Project Area (Appendix B). Areas of untilled grasslands were again identified based on a review of the USDA National Agriculture Imagery Program imagery (USDA, 2016a), the latest available USDA Cropland Data Layer (USDA, 2016b) and the *Quantifying Undisturbed (Native) Lands in Eastern South Dakota: 2013* (Bauman et al., 2013) digital data layer. In 2018, a total of 4,882 acres of untilled grasslands within the Project Area were identified based on the desktop analysis. The 2018 potential untilled grassland areas are displayed on Figure 9 in Appendix A. Areas of potential untilled grasslands will be field verified again during the May-June 2018 wetland delineation surveys. Areas that were added to the Project Area since the 2016 field verification (primarily in the northwest and northeast corners) will be field verified, as well as areas that show recent signs of being tilled or disturbed based on the updated desktop analysis.

13.1.1.2 Noxious Weeds

Noxious weeds are regulated by State (SDCL 38-22) and Federal (U.S. CFR 2006) rules and regulations designed to stop the spread of plants that are detrimental to the environment, crops, livestock, and/or public health. According to the South Dakota Department of Agriculture (SDDOA), 14 listed species of noxious weeds have the potential to occur and are regulated within Charles Mix, Hutchinson and/or Bon Homme counties (SDDOA, 2012) (Table 13-1).

Table 13-1: State and Local Noxious Weeds of South Dakota

Common Name	Scientific Name	Weed Status
Canada thistle	*Cirsium arvense*	State noxious weed
Hoary cress	*Cardaria draba*	State noxious weed
Leafy spurge	*Euphorbia esula*	State noxious weed
Perennial sow thistle	*Sonchus arvensis*	State noxious weed
Purple loosestrife	*Lythrum salicaria*	State noxious weed
Russian knapweed	*Centaurea repens*	State noxious weed
Salt cedar	*Tamarix aphylla, T. chinensis, T. gallica, T. parviflora, and T. ramosissima*	State noxious weed
Absinth wormwood	*Artemisia absinthium*	Local noxious weed – Bon Homme/ Hutchinson counties
Bull thistle	*Cirsium vulgare*	Local noxious weed – Hutchinson County
Common mullein	*Verbascum thapsus*	Local noxious weed – Hutchinson County
Field bindweed	*Convolvulus arvensis*	Local noxious weed – Bon Homme/ Hutchinson counties
Musk thistle	*Carduus nutans*	Local noxious weed – Bon Homme/ Hutchinson counties
Plumeless thistle	*Carduus acnthoides*	Local noxious weed – Bon Homme/ Hutchinson counties
Spotted knapweed	*Centaurea maculosa*	Local noxious weed – Bon Homme/ Hutchinson counties

13.1.2 Vegetation Impacts/Mitigation

The proposed Project would result in approximately 734 acres of temporary disturbance and 45 acres of disturbance to vegetation (predominantly cropland and grassland/pasture) during the operational life of the Project. Direct impacts would occur due to construction of the wind turbine foundations, access roads, collector substation, meteorological equipment, O&M facility, and collector lines. These impacts would result in a temporary loss of production of crops and pasture grasses. Impacts that would occur to cultivated lands are not considered biologically significant, because these lands are frequently disturbed by tilling, planting, and harvesting activities associated with crop production. For further discussion of impacts to agricultural cropland, see Section 15.1.2.

Temporary impacts would be mitigated through BMPs, such as re-vegetation and erosion control measures. These measures would reduce temporary impacts to vegetative communities adjacent to the Project facilities. Specific BMPs would be used for any construction within grassland/pasture and would include the following measures:

- Crews will limit ground disturbance wherever possible during construction in untilled grasslands and limit the areas where construction vehicles drive through the Project Area.
- Exposed subgrade in areas where the native soil has been removed will be regraded to the original ground contour, and the soil will be replaced to follow the original soil profiles to the extent practicable.
- The Applicant will re-seed disturbed areas with a weed-free native plant seed mixture at an appropriate application rate.

The Project would not involve any major tree clearing activities. Turbines were sited in open upland areas. When feasible, access roads, collector lines and crane paths were sited to avoid crossing tree rows. Some minor clearing of brush may be required for collector lines and access roads. In areas where access roads may need to cross windrows due to engineering restrictions or the layout of leased lands, the Applicant would work with the landowner in order to develop an appropriate alignment that would be the least intrusive.

13.1.3 Native Grassland

The Project facilities have been sited to avoid native grasslands (i.e., untilled grasslands; primarily pastures), to the extent practicable. Based on the 2018 desktop review of potential untilled grassland areas, 1 of the 63 turbine locations is located in untilled grassland (Figure 9). Only approximately 1 acre (2 percent) of long-term Project disturbance would occur in untilled grasslands. In areas where impacts cannot be avoided, temporary impacts would be minimized through construction BMPs (i.e., re-vegetation and erosion control measures).

13.1.4 Noxious Weeds

Indirect impacts could include the spread of noxious weed species resulting from construction equipment introducing seeds into new areas, or erosion or sedimentation due to clearing ground in the construction areas. Noxious weeds would be controlled, and impacts would be minimized using weed-free seed mixes and controlled spraying, as necessary.

13.2 Special Status Plant Species

The special status plant species identified within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures.

13.2.1 Existing Special Status Plant Species

Based on initial Project scoping conducted for the Project on the USFWS Information for Planning and Conservation (IPaC) online review tool, one special status plant species, the western prairie fringed orchid, has the potential to occur in the Project Area (USFWS, 2018a). The western prairie fringed orchid is federally listed as threatened under the ESA. The orchid occurs in moist tallgrass prairies and sedge meadows and was historically found throughout the tallgrass regions of North America, including South Dakota.

13.2.2 Special Status Plant Species Impacts

No impacts are likely to occur to western prairie fringed orchid, as this species is possibly extirpated from South Dakota. However, a habitat assessment will be completed during the wetland delineation work scheduled to be completed in in June 2018; if suitable habitat is identified, areas of ground disturbance will be surveyed during the orchid's blooming period (July) prior to construction. If the species cannot be avoided, USFWS will be contacted for guidance.

13.3 Wetlands and Waterbodies

The wetlands and waterbodies identified within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project, and avoidance, minimization, and/or mitigation measures. While aquatic in nature, wetlands and waterbodies are important functional components of the terrestrial ecosystem and are thus discussed in this section.

13.3.1 Existing Wetlands and Waterbodies

Wetlands are defined in the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory, 1987) as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." The Manual identifies three wetland criteria that must be met in order for a wetland to be present: dominance of hydrophytic vegetation, hydric soils, and sufficient hydrology. Some wetlands, as well as other waterbodies are considered waters of the U.S. under Section 404 of the CWA and are, therefore, regulated by the USACE with respect to discharge of fill material into the water features.

The Applicant conducted desktop wetland determination reviews for the proposed Project to identify potential wetlands in the Project Area (see Appendix C). A total of 2,696 acres of known and potential wetlands were identified within the Project Area based on this review (Figure 8 in Appendix A). Table 13-2 summarizes the types and proportions of wetlands found within the Project Area, per the Cowardin Classification System.

Table 13-2: Wetland Types Mapped Within the Project Area

Cowardin Classification	Proportion
Palustrine Emergent (PEM)	75%
Palustrine Aquatic Bed (PAB)	11%
Riverine Intermittent/Ephemeral (R4/R5)	6%
Lacustrine Aquatic Bed (L2AB)	5%
Palustrine Forested (PFO)	3%
Palustrine Unconsolidated Bottom (PUB)	<1%

Source: Wetland Desktop Determination (Appendix C)

A field wetland delineation will be completed in June 2018 to confirm the presence or absence of wetlands and their boundaries where Project infrastructure (temporary and permanent) is proposed.

13.3.2 Wetland and Waterbody Impacts/Mitigation

Impacts to wetland resources could occur by directly filling wetlands due to Project construction, or by otherwise negatively altering their quality. The Applicant anticipates that the Project would avoid permanent impacts to most wetland areas. Based on the desktop wetland determination, the Project would potentially result in permanent impacts to two wetlands (0.0042 acre and 0.0002 acre of impacts, respectively) and would cross three intermittent streams (62.4 linear feet of stream segments). These permanent impacts are a result of access road crossings of these wetlands and streams. Culverts would be installed as needed at stream crossings to allow continued water flow. The Project would potentially result in temporary impacts to 62 wetlands and streams for a total of 3.7 acres of impacts. These temporary impacts are associated with temporary disturbance from installation of Project facilities. Following construction, temporarily disturbed areas in wetlands and streams would be restored to pre-construction conditions. To further protect wetlands, BMPs for sediment and erosion control, as prescribed by the Project SWPPP, would be implemented. In order to limit the risk of contamination of wetlands due to accidental spilling of fuels or other hazardous substances, construction equipment would be refueled in areas away from wetlands or drainage areas, and a spill kit would be available at the construction site.

The field wetland delineation will be completed in June 2018. If the results of the field delineation indicate that the Project will result in impacts to wetland or waters of the U.S., the Applicant will obtain necessary Section 404 permits from the USACE to authorize these impacts. Based on the desktop wetland determination, it is anticipated that Project impacts to wetlands and streams would be authorized under a USACE Nationwide Permit (NWP) 12.

13.4 Wildlife

In order to reduce the potential impacts of wind energy facilities on wildlife species and habitat, the USFWS has developed the Land-Based Wind Energy Guidelines (WEG; USFWS, 2012) and the Eagle Conservation Plan Guidance (ECPG; USFWS, 2013a). These voluntary guidelines provide a structured, scientific approach for assessing wildlife risks at wind energy facilities, promote communication between project proponents and Federal/State agencies, and provide a practical approach to address wildlife conservation concerns at all stages of land-based wind energy development. SDGFP, in cooperation with the South Dakota Bat Working Group, has also developed siting guidelines for wind energy projects to address potential impacts to natural resources (South Dakota Bat Working Group and SDGFP, undated). These guidelines are generally consistent with the WEG, but also provide guidance for other non-wildlife resources (e.g., land use, noise, visual resources, soil erosion and water quality).

The Applicant followed the processes outlined in the WEG, ECPG, and SD siting guidelines for developing, constructing, and operating wind energy projects. The Applicant has engaged in ongoing coordination with the USFWS and SDGFP to seek input on wildlife resources potentially occurring within the Project Area and to seek guidance on the appropriate studies to evaluate risk and inform development of impact avoidance and minimization measures for the Project. Summaries of coordination meetings are included in Section 27.2.

13.4.1 Existing Wildlife

The wildlife identified within the Project Area is described below, followed by a discussion of the potential effects of the proposed Project's construction and operation and mitigation and minimization measures.

13.4.1.1 Initial Site Assessment

In accordance with Tiers 1 and 2 of the WEG, Stage 1 of the ECPG, and the SD Siting Guidelines, a review of readily available desktop information was completed in 2015 to assess potential adverse effects to species of concern and their habitats. Data sources included the USFWS IPaC website; the South Dakota Natural Heritage Database; the USGS Breeding Bird Survey; aerial imagery; and non-governmental organization websites (e.g., Audubon Society, American Wind Wildlife Institute Landscape Assessment Tool, e-Bird, and the Hawk Migration Association of North America). The area covered by the desktop review was considerably larger than the 2015 Project boundary and covered the entire current Project Area and much of the surrounding areas.

Wildlife species associated with croplands, grasslands, and shrublands are the most common types of species observed and expected to occur within the Project Area. The information presented in this section and additional information on wildlife in the Project Area is provided in the *Tiers 1 and 2 Report for the Prevailing Winds Wind Project* included in Appendix D of this Application. The Project boundary at the time the Tiers 1 and 2 assessment was completed is shown on Figure 1 of the report in Appendix D. While the Project boundary has evolved and moved further north since 2015, the results of the 2015 Tiers 1 and 2 assessment are representative of the current Project Area given the topography, vegetation, and habitat types present.

Migratory Birds

Although not protected under the ESA, numerous bird species have been identified by the USFWS as Birds of Conservation Concern (BCC; USFWS, 2008). These are “species, subspecies, and populations of migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973” (USFWS, 2008). The Project Area lies within Bird Conservation Region (BCR) 11 (Prairie Potholes), a landscape dotted with many small depressional wetlands called potholes.

A total of 27 bird species are listed as BCC within BCR 11 (USFWS, 2008; Appendix B of the Tiers 1 and 2 Report, Appendix D), many of which would have potential for occurrence within the Project Area (Jennings et al., 2005). Three diurnal raptors are among the BCC within BCR 11 with potential to occur in the Project Area: bald eagle (*Haliaeetus leucocephalus*), Swainson’s hawk (*Buteo swainsoni*), and peregrine falcon (*Falco peregrinus*). In addition to bald eagles, golden eagles (*Aquila chrysaetos*) have the potential to occur in the Project Area during some time of the year. Bald and golden eagles are protected by the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA). Swainson’s hawks may breed in the Project Area, and peregrine falcons potentially migrate through the Project Area (Jennings et al., 2005). The remaining BCC species are a mix of shorebirds, waterbirds, owls, woodpeckers, and passerines, all of which likely have some potential for impacts from wind energy development (*Bird Species of Conservation Concern within the Prairie Potholes Region* in Appendix B of the Tiers 1 and 2 Report, Appendix D).

Raptors

The following diurnal raptor and vulture species could potentially breed in or near the Project Area: American kestrel (*Falco sparverius*), bald eagle, golden eagle, Cooper's hawk (*Accipiter cooperii*), northern harrier (*Circus cyaneus*), red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*B. regalis*), Swainson's hawk, broad-winged hawk (*B. platypterus*), peregrine falcon, osprey, and turkey vulture (*Cathartes aura*) (Jennings et al., 2005). Owls with the potential to breed in or near the Project Area include barn owl (*Tyto alba*), burrowing owl (*Athene cunicularia*), eastern screech owl (*Megascops asio*), long-eared owl (*Asio otus*), short-eared owl (*Asio flammeus*), and great horned owl (*Bubo virginianus*) (Jennings et al., 2005).

Diurnal raptor species that may also occur within the Project Area outside of the breeding season (migration, winter, or post-breeding dispersal) include northern goshawk (*Accipiter gentilis*), Cooper's hawk, golden eagle, bald eagle, merlin (*Falco columbarius*), peregrine falcon, prairie falcon (*F. mexicanus*), gyrfalcon (*F. rusticolus*), red-tailed hawk, rough-legged hawk (*Buteo lagopus*), and sharp-shinned hawk (*Accipiter striatus*) (Jennings et al., 2005). Owls that may occur outside of the breeding season include the eastern screech owl, great horned owl, northern saw-whet owl (*Aegolius acadicus*), long-eared owl, and short-eared owl (Jennings et al., 2005).

The Project Area has potential for raptor migration. Several factors influence the migratory pathways of raptors, the most significant of which is geography. Two geographical features often used by raptors during migration are ridgelines and the shorelines of large bodies of water (Liguori, 2005). Updrafts formed as wind hits the ridges, and thermals, created as warmer air rises, make for energy-efficient travel over long distances (Liguori, 2005). For this reason, raptors sometimes follow corridors or pathways, for example, along prominent ridges with defined edges, during migration. Raptors likely migrate through the Project Area in a broad front pattern with some potential for more localized use of the ridge on the southwestern portion of the Project Area (Figure 3 of the Tiers 1 and 2 Report, Appendix D). Trees, shrubs, and water impoundments, which are scattered throughout the Project Area and region, may provide some stopover habitat for migrating raptors (Figure 4 of the Tiers 1 and 2 Report, Appendix D).

Bats

Seven bat species are potential residents and/or migrants in the Project Area and include big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), silver-haired bat

(*Lasionycteris noctivagans*), northern long-eared bat, little brown bat (*Myotis lucifugus*), and western small-footed bat (*Myotis ciliolabrum*). Species occurring in South Dakota and potentially in the Project Area are listed in Table 13-3.

Table 13-3: Bat Species Occurring in South Dakota and Potentially in Project Area

Common Name	Scientific Name	Habitat	Presence in Project Area
Big brown bat	*Eptesicus fuscus*	Common in most habitats, abundant in deciduous forests and suburban areas with agriculture; maternity colonies beneath bark, tree cavities, buildings, barns, and bridges.	Likely
Eastern red bat	*Lasiurus borealis*	Abundant tree bat; roosts in trees; solitary.	Likely
Hoary bat	*Lasiurus cinereus*	Usually not found in man-made structures; roosts in trees; very wide-spread.	Likely
Silver-haired bat	*Lasionycteris noctivagans*	Common bat in forested areas, particularly old growth; maternity colonies in tree cavities or hollows; hibernates in forests or cliff faces.	Likely
Northern long-eared bat	*Myotis septentrionalis*	Associated with forests; chooses maternity roosts in buildings, under loose bark, and in the cavities of trees; caves and underground mines are their choice sites for hibernating. On western edge of range.	Unlikely
Little brown bat	*Myotis lucifugus*	Commonly forages over water; roosts in attics, barns, bridges, snags, and loose bark; hibernacula in caves and mines.	Probable
Western small-footed bat	*Myotis ciliolabrum*	Found in mesic conifer forest, also riparian woodland; roosts in rock outcrops, clay banks, loose bark, buildings, bridges, caves, and mines.	Probable

Source: Tiers 1 and 2 Report (Appendix D)

13.4.1.2 Federal and State Special-Status Terrestrial Species

Federal and State listed threatened and/or endangered species could potentially occur in the Project Area. Based on habitats found within the proposed Project Area, five animal species have the potential to occur in the Project Area during some portion of the year, including: federally endangered interior least tern (USFWS, 2013b) and whooping crane (USFWS, 2015a); and federally threatened piping plover (USFWS, 2013c), red knot (USFWS, 2014a), and northern long-eared bat (USFWS 2016, 2015c). Table 13-4 identifies the potential for each of the listed terrestrial species to occur in the Project Area. These species are discussed in further detail below.

Table 13-4: Federal and State-Listed Terrestrial Species Potentially Occurring in Project Area

Species	Scientific Name	Federal Status	State Status	Potential to Occur
Northern long-eared bat	*Myotis septentrionalis*	Threatened	--	Low. Limited suitable habitat in Project Area. None documented during 2016 acoustic surveys encompassing most current Project Area.
Interior least tern	*Sterna antillarum athalassos*	Endangered	Endangered	Low. No suitable habitat. None observed during avian surveys. Possible migrant.
Whooping crane	*Grus americana*	Endangered	Endangered	Low. Within the SD migration corridor when considered specific to South Dakota. None observed during avian surveys.
Piping plover	*Charadrius melodus*	Threatened	Threatened	Low. No suitable habitat. None observed during avian surveys. Possible migrant.
Red knot	*Calidris canutus rufa*	Threatened	--	Low. No suitable habitat. None observed during avian surveys. Possible migrant.

Sources: IPaC, April 2018; South Dakota Natural Heritage Database, April 2018

Interior Least Tern

The interior least tern nests along sand and gravel bars within wide, unobstructed river channels and open flats along shorelines of lakes and reservoirs (Texas Parks and Wildlife Department [TPWD], 2015). Unnatural water fluctuations, permanent flooding, or vegetation coverage of nesting habitat caused by water management may contribute to nest failure.

Whooping Crane

The whooping crane migrates from its breeding grounds in Wood Buffalo National Park, Canada, to its wintering areas in Aransas National Wildlife Refuge (NWR), Texas (USFWS, 2009). Threats to wild cranes include habitat destruction, chemical spills in its wintering habitat, lead poisoning, collisions with manmade objects such as fences and power lines, disease (e.g., avian cholera and parasites), and shooting (USFWS, 2015a). Cranes typically utilize shallow wetlands and marshes, the edges and sandbars of shallow rivers, and agricultural fields near a water source during migration (USFWS, 2015a).

Piping Plover

The piping plover is typically found on sandy beaches, mudflats, and exposed areas around wetlands and lakes. Suitable nesting habitat includes barren sandbars in large river systems and on alkaline lake shores (USFWS, 2002). Piping plover populations are threatened by habitat loss due to vegetation encroachment, shoreline development, anthropogenic and animal disturbances, and water management activities, such as dam construction and channelization.

Red Knot

The red knot is a medium-sized shorebird that migrates from its breeding grounds in Canada's Arctic region to multiple wintering grounds, including the northeast Gulf of Mexico, the southeastern U.S., northern Brazil, and Tierra del Fuego at the southern point of South America. During the breeding season, red knots are typically found in sparsely vegetated, dry tundra areas (Harrington, 2001; All About Birds, 2017). Outside of the breeding season, red knots are usually found along intertidal, marine beaches (Harrington, 2001). During migration, some red knots can be found flying over inland areas, but these cases are rare (Sibley, 2003). The red knot population is threatened by habitat loss in migration and wintering areas, reduction of quality and quantity of food resources, asynchronies in timing throughout its breeding and migration range, and high predation on the breeding grounds every 3 to 4 years (USFWS, 2014a).

Northern Long-Eared Bat

The NLEB was listed as a threatened species on April 2, 2015. It is found in the U.S. from Maine to North Carolina on the Atlantic Coast, westward to eastern Oklahoma, and north through part of South Dakota (Bat Conservation International, Inc. [BCI], 2015). The Project Area is on the western fringe of the estimated range for the species (BCI, 2015). This species hibernates in caves and abandoned mines during winter (BCI, 2015); however, no known hibernacula exist in the Project Area, with the closest being located in the Black Hills on the South Dakota/Wyoming border, approximately 275 miles west. During the summer, individuals may roost alone or in small colonies beneath exfoliating bark, or in cavities or crevices of both live and dead trees (BCI, 2015).

13.4.1.3 Studies Conducted to Date

Various wildlife studies were completed for the Project between 2015 and 2018. The Project boundary has evolved and moved further north since wildlife studies began in 2015. The wildlife surveys cover most of the current Project Area. In those portions of the current Project Area that have not been surveyed, the topography, vegetation, and habitat types present are very similar to the conditions within the surveyed areas. Therefore, the wildlife survey data is representative of conditions throughout the current Project Area. The Applicant met with USFWS and SDGFP in December 2017 to reintroduce the Project and provide updated survey results. At that meeting, neither agency recommended additional survey work.

Federal protection is provided for bald and golden eagles, as well as species of migratory birds, through the BGEPA and the MBTA. Both laws are intended to prohibit “take” and regulate impacts to eagles and other migratory birds from direct mortality, habitat degradation, and/or displacement of individual birds. To determine the presence of bird species that occur within the Project Area, the Applicant completed various surveys in accordance with Tier 3 of the WEG, Stage 2 of the ECPG, and USFWS and SDGFP guidance. Surveys included aerial raptor nest surveys and eagle/avian use surveys. In addition to avian surveys, surveys for the federally threatened northern long-eared bat (NLEB) were completed in summer 2015 and summer 2016. The reports detailing the methods and results of the bird and bat surveys are included in Appendices E through K and summarized below.

Raptor and Eagle Nest Surveys

Aerial raptor nest surveys were completed in April 2016 (Appendix E) to characterize the raptor nesting community and locate nests for all raptors within the Project boundary and 1-mile buffer, and for eagles within 10 miles of the Project. The Project boundary at the time the survey was completed is shown on Figure 2 of the report in Appendix E. The current Project Area is within the 10-mile survey buffer for eagles. Aerial surveys were completed prior to leaf-out and during the breeding season when raptors would be actively tending nests, incubating eggs, or brood-rearing. Raptor nest surveys focused on locating stick nest structures in suitable raptor nesting substrate (trees, transmission lines, cliff faces, etc.) within each respective survey area. The 2016 survey area for eagles included the current Project Area and the surrounding lands; the survey area in 2016 for other raptors covered much, but not all of the current Project Area. Unsurveyed areas will be surveyed for raptor nests prior to the re-initiation of construction in spring 2019.

During the April 2016 survey, a total of 44 non-eagle raptor nests (15 occupied and 29 unoccupied) were located within the Project Area and 1-mile buffer. The occupied nests were primarily common species (10 red-tailed hawk, 3 great horned owl, and 2 unknown non-eagle raptor), and none of the unoccupied nests exhibited characteristics of eagle nests.

Three occupied bald eagle nests were recorded during the April 2016 survey, all outside the current Project Area. A total of six bald eagle nests (three occupied; three unoccupied) were documented during the survey; with three occupied bald eagle nests corresponding to known historic nests. The nearest occupied bald eagle nest to the Project Area is located approximately 0.5 mile from the current Project Area boundary. The nest is located approximately 2 miles from the nearest proposed turbine. This nest was confirmed to be active in March 2018 (pers. comm. Clayton Derby, WEST, 2018).

Avian Use Surveys

Two years of avian/eagle use point-count surveys were completed for the Project from March 25, 2015, to April 19, 2017, to evaluate species composition, relative abundance, and spatial characteristics of avian use in accordance with agency recommendations (Appendices F and G). Due to changes in the Project boundary between the first and second years of the point-count surveys, several new point count locations were added in the northern portion of the updated Project boundary for the second year of surveys. Changes to the Project Area in 2018 included the addition of some lands in the northwest and northeast corners of the Project in Charles Mix and Hutchinson counties, respectively. The topography, vegetation, and habitat types present in these additional areas are very similar to the conditions within the surveyed areas. Therefore, the avian use survey data is representative of avian use in the current Project Area.

Fixed-point bird use surveys (variable circular plots) were conducted using methods described by Reynolds et al. (1980), to estimate the seasonal and spatial use of the study area by birds, particularly diurnal raptors (defined here as kites, accipiters, buteos, harriers, eagles, falcons, and osprey). The surveys recorded data for small and large bird species, eagles, and species of concern (i.e., federally or State-threatened and endangered species [Endangered Species Act 1973], USFWS Birds of Conservation Concern [BCC; USFWS, 2008], and South Dakota Species of Greatest Conservation Need [SGCN; SDGFP, 2014]).

Fixed-point bird use surveys were conducted approximately twice per month in the spring (March 4 – May 20) and fall (September 9 – November 28), and monthly during winter (November 29 – March 3) and summer (May 21 – September 8). Sixteen points were selected to survey representative habitats and topography of the Project, while achieving relatively even coverage of the survey area. In Year One, 271 surveys were conducted during 18 visits. In Year Two, 205 surveys were conducted during 13 visits. Each survey plot was an 800-meter (2,625-ft) radius circle centered on the point. Each survey plot was surveyed for 60 minutes. Analysis of the survey results included calculating bird diversity, species richness, mean use, percent of use, frequency of occurrence, flight height and spatial use.

During Year One of the fixed-point bird use surveys, 72 unique bird species including 8,194 observations in 914 separate groups (defined as one or more individuals), were recorded. Regardless of bird size, six identified species (8.3 percent of all species) accounted for approximately half (52 percent) of all observations: Canada goose (*Branta canadensis*; 858 observations in 10 groups), European starling (*Sturnus vulgaris*; 787 observations in 13 groups), sandhill crane (*Antigone canadensis*; 735 observations in four groups), Franklin's gull (*Leucophaeus pipixcan*; 713 observations in five groups), snow goose (*Chen caerulescens*; 590 observations in four groups), and red-winged blackbird (*Agelaius phoeniceus*;

574 observations in 42 groups). All other species each accounted for less than 6 percent of the total observations. Eighty-nine diurnal raptor observations within 83 groups were recorded, representing eight unique species. Red-tailed hawk (55 observations in 51 groups) and northern harrier (11 observations within 11 groups) were the most commonly observed raptor species, accounting for 61.8 percent and 12.4 percent of all raptor observations, respectively. No federally or State-listed species were observed during Year One fixed-point bird use surveys conducted at the Project. No golden eagles were observed during the survey; one bald eagle was recorded in the winter.

During Year Two of the fixed-point bird use surveys, 90 unique bird species including 9,276 observations in 1,090 separate groups. Regardless of bird size, two identified species (2.2 percent of all species) accounted for approximately one-third (29 percent) of all observations: common grackle (*Quiscalus quiscula*; 1,590 observations in 30 groups) and red-winged blackbird (1,105 observations in 84 groups). All other species each accounted for less than 6 percent of the total observations. Sixty-nine diurnal raptor observations within 61 groups were recorded during the first 20 minutes of the Year Two fixed-point bird use surveys conducted at the Project, representing five unique species. Red-tailed hawk (34 observations in 32 groups) and northern harrier (11 observations in 10 groups) were the most commonly observed raptor species, accounting for 49.3 percent and 15.9 percent of all raptor observations, respectively. One State-listed species (peregrine falcon) was recorded during Year Two of 60-minute fixed-point bird use surveys conducted at the Project; no federally listed species were observed during the study period. Seven bald eagles and one unidentified eagle were observed during the surveys.

Bald Eagle Nest Monitoring

Bald eagle nest monitoring surveys were conducted in accordance with agency recommendations to document flight paths and use within the vicinity of an active bald eagle nest identified during aerial raptor nest surveys conducted for the Project (Appendix H). The nest was located east of the Project (see Figure 1 in the Eagle Nest Monitoring Report in Appendix H) and corresponds with the active nest currently located approximately 0.5 mile from the current Project Area and 2 miles from the nearest proposed turbine. A fixed-point survey location was established to allow documentation of the activity of bald eagles utilizing the nest. Surveys commenced when adult eagles were incubating eggs and ended when eaglets fledged from the nest or the nest failed or otherwise was determined to be no longer occupied. Dates of survey were March 31 through July 21, 2015, and May 4 through September 7, 2016.

In 2015, bald eagles were observed during all but one survey. The first bald eagle observation occurred on March 31, 2015, and the last bald eagle was observed on July 7, 2015. A total of 27 eagle observations were made during the 12 hours of surveys (Table 1 in Appendix H); individual eagles, both adults and young-of-year birds, were observed multiple times. Of the bald eagles observed, most were perched on or near the nest. Eagles were observed flying for only 11 minutes. Flight paths were generally to the west of the nest, in a northern and northwesterly direction (Figure 3 in Appendix H).

In 2016, bald eagle nest monitoring began May 4 when other eagle/avian use surveys were initiated, missing the initial eagle activity at the nest. Once surveys began, bald eagles were observed in 6 of the 10 surveys. Eleven eagle observations were made during the 10 hours of surveys (Table 1 in Appendix H). As in 2015, individual eagles, both adults and young of year birds, were observed multiple times. Eagles were observed flying for 10 minutes. Most eagles were observed perched on or near the nest. The few flight paths were generally to the southwest of the nest and showed no apparent pattern (Figure 4 in Appendix H).

Whooping Crane Habitat Assessment

There is potential whooping crane habitat within the Project Area, but this habitat is not unique compared to adjacent areas. This conclusion is based on a 2016 desktop review and analysis of potential whooping crane habitat resources within the August 2016 Project boundary (covers most of current Project Area except for the northeastern portion in Hutchinson County). The 2016 analysis compared resources within the 2016 Project boundary to surrounding habitat to the north, south, east, and west (Appendix K). The analysis showed that both roosting (i.e., wetlands) and foraging (i.e., croplands) habitats are available in the 2016 Project boundary and outside the Project boundary (shown on Figure 1 in Appendix K). Potential whooping crane habitat within the 2016 Project boundary appears to be most similar to habitat outside of the Project Area to the north, east, and west, and is more suitable than habitat found to the south of the Project Area. Based on the USGS's recent determination of whooping crane stopover use sites adjacent to the proposed Project Area, whooping cranes will likely migrate over or through the Project Area during some migration period. The current Project Area is within the areas analyzed for the 2016 analysis, and, therefore, the whooping crane habitat assessment results can be applied to the current Project Area.

Bat Surveys

Of the seven bat species with potential to occur in the Project Area, the NLEB is the only State and federally listed bat with the potential to occur within the area. The NLEB was listed as a threatened species under the ESA in 2015. The Project Area is on the western fringe of the estimated range for the species (BCI, 2015). Two separate presence/absence surveys were completed in summer 2015 and summer 2016 (Appendices I and J). The surveys were conducted following the NLEB survey recommendations found in the USFWS Northern Long-eared Bat Interim Conference and Planning

Guidance (USFWS, 2014b) and 2015 Range-Wide Indiana Bat Summer Survey Guidelines (USFWS, 2015b).[4] The USFWS guidelines require one survey site for every 123 acres of suitable habitat for a minimum of four detector nights (USFWS, 2014b). Two sampling locations at each survey site should then be surveyed for a minimum of two detector/nights each. Bats were surveyed using SD1 or SD2 AnaBat™ ultrasonic detectors (Titley Electronics Pty Ltd., NSW, Australia), or SM2 Song Meter detectors (Wildlife Acoustics, Inc., Concord, Maine).

The 2015 acoustic survey was conducted in the 2015 Project boundary (see Figure 1 in Appendix I) consisting of approximately 1,180 acres of forested habitat, which equated to 20 survey locations. Acoustic surveys were conducted from July 21 to August 10, 2015. The NLEB was qualitatively verified as occurring at two acoustical survey stations surveyed in 2015. The surveys concluded that there is potential for NLEB to be present within suitable habitat within the 2015 Project boundary during the summer months.

The 2016 survey included eight locations due to the 440 acres of wooded habitat within the revised 2016 Project boundary, which moved the Project generally to the north and away from the forested riparian habitat along Missouri River. Acoustic surveys were conducted from July 12 to August 4, 2016. No northern long-eared bat calls were recorded at any station during the sampling period. Changes to the Project Area in 2018 included the addition of some lands in the northwest and northeast corners of the Project in Charles Mix and Hutchinson counties, respectively. Based on a lack of suitable woodland habitat in these additional areas, no additional bat surveys were warranted. In those portions of the current Project Area that have not been surveyed for bats, the topography, vegetation, and habitat types present are very similar to the conditions within the areas surveyed in 2016. Therefore, the 2016 bat acoustic surveys results are representative of conditions throughout the current Project Area.

13.4.2 Wildlife Impacts/Mitigation

Terrestrial wildlife species could be impacted at various spatial and temporal scales during the construction phase of the Project. Direct disruption of habitat and potentially direct mortality could occur during the construction phase of the Project. Permanent habitat loss due to construction of wind turbines would be minimal across the Project Area and localized.

Construction crews would be instructed to avoid disturbing or harassing wildlife, and direct mortalities would not likely impact wildlife populations. Following construction, wildlife species are expected to habituate to routine facility operation and maintenance activities in a manner similar to relationships with

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[4] The range of the Indiana bat does not include South Dakota.

existing ranching operations. BMPs would be practiced by construction personnel to reduce attractants to scavengers and would-be nest predators.

13.4.2.1 Federal and State Special-Status Terrestrial Species

This section describes the potential impacts of the proposed Project on the federally and State-listed terrestrial species that could potentially occur in the Project Area.

13.4.2.1.1 Interior Least Tern

No suitable nesting habitat was identified within the Project Area, but the interior least tern could potentially nest along the Missouri River, approximately 13 miles to the south, or pass through the Project Area during spring and fall migration.

13.4.2.1.2 Whooping Crane

Suitable whooping crane stopover habitat is present in the Project Area and includes shallow livestock ponds surrounded by agricultural and grassland parcels and freshwater emergent wetlands. However, this habitat is not unique compared to adjacent areas. The Applicant will comply with all applicable avoidance, minimization, and mitigation measures specified in the PEIS.

13.4.2.1.3 Piping Plover

No suitable piping plover habitat was observed in the Project Area. Piping plovers are unlikely to breed within the Project Area, but the species could potentially migrate through the Project Area. The nearest designated critical habitat for the piping plover is located approximately 13 miles south of the Project Area along the Missouri River (Figure 6 of the Tiers 1 and 2 Report, Appendix D; USFWS, 2015c).

13.4.2.1.4 Red Knot

No suitable red knot habitat was observed in the Project Area. Red knots are unlikely to breed within the Project Area, but the species could potentially migrate through the Project Area.

13.4.2.1.5 Northern Long-Eared Bat

The Project Area is on the western fringe of the estimated range for the NLEB (BCI, 2015). Some habitat features for the species are located in the Project Area. Although white-nose syndrome (WNS; caused by the fungus *Pseudogymnoascus destructans*) is the primary threat to NLEB populations (USFWS, 2015d), there is also concern about the impacts of wind facilities on bat species. However, under the final 4(d) rule published on January 14, 2016 (USFWS, 2016), it was determined that wind-energy development has not led to significant declines in this species, nor is there evidence that regulating the incidental take that is occurring would meaningfully change the conservation or recovery potential of the species in the face of WNS. In other words, take of the species by a wind facility is not currently considered a violation of Section 9 of the ESA. This will change if the species becomes listed as endangered or if the 4(d) rule is rescinded. The Applicant will comply with all applicable avoidance, minimization, and mitigation measures specified in the PEIS.

13.4.2.2 Birds

Potential impacts to avian species from the construction and operation of the Project include indirect impacts, such as the removal, degradation, and fragmentation of habitat; and direct impacts, such as turbine blade strikes. Indirect impacts will be minimized by siting facilities within previously disturbed areas and avoiding untilled grassland habitats and forested areas to the extent practicable. Additionally, all areas of temporary disturbance will be reclaimed by seeding with vegetation consistent with the surrounding vegetation types.

Direct impacts to birds, including special status species, from the operation of this Project are anticipated to be low based on pre-construction survey results. Seven BCC species and three SGCN[5] species were documented at relatively low numbers, indicating low risk of significant impacts to these species. The most commonly observed species during the avian use surveys represent common, widespread species. Raptor use documented for the Project Area was low compared to other wind project sites sited in similar habitat, and species documented consisted primarily of common raptors, suggesting risk of impacts are not likely to be significant at the local or regional population level (see data on bird use and fatality estimates in Avian Use Survey Reports [Appendices F and G]). To prevent potential bird strikes with electric lines, collector lines will be buried underground and the Project will incorporate other avian safe practices consistent with guidelines from the Avian Power Line Interaction Committee (APLIC, 2012). The majority of bird species observed during the surveys are widespread and abundant, and most are at low risk of collision with turbines or other impacts due to the high quantity of agricultural lands and localized habitat fragmentation. Analysis of the data collected during the avian surveys generally indicated that potential impacts to birds, including species of concern, diurnal raptors, grassland species and eagles are expected to be low as evidenced by data from regional wind projects operating in similar habitats (see Avian Use Survey Report [Appendices F and G]). Additional avoidance and minimization measures are identified in Section 13.4.2.4.

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[5] Bald eagle is both a BCC and a SGCN

13.4.2.3 Bats

Bat casualties have been reported from most wind energy faculties where post-construction fatality data are publicly available. Reported estimates of bat mortality at wind energy facilities have ranged from 0.01 to 47.5 fatalities per turbine per year (0.9 to 43.2 bats per MW per year) in the U.S., with an average of 3.4 per turbine or 4.6 per MW (National Wind Coordinating Collaborative [NWCC], 2004). The majority of the bat casualties at wind energy facilities to date are migratory species that undertake long migrations between summer roosts and wintering areas. The species most commonly found as fatalities at wind energy facilities include hoary bats, silver-haired bats, and eastern red bats (Johnson, 2005). The highest numbers of bat fatalities found at wind energy facilities to date have occurred in eastern North America on ridge tops dominated by deciduous forest (NWCC, 2004). However, Gruver et al. (2009), BHE Environmental (2010, 2011), Barclay et al. (2007), and Jain (2005) reported relatively high fatality rates from facilities in Wisconsin, Iowa, and Alberta, Canada, that were located in grassland and agricultural habitats. Unlike the eastern U.S. wind energy facilities that reported higher bat fatality rates, the Wisconsin, Alberta, and Iowa facilities are located in open grasslands and crop fields.

Construction of the Project may result in the mortality of some bats. Based on the data obtained to date, it is assumed that the magnitude of these fatalities and the degree to which bat species would be affected would be within the average range of bat mortalities found throughout the U.S. The Project Area was shifted to the north and away from the Missouri River, where more woodland habitat and higher populations bats are present.

13.4.2.4 Avoidance, Minimization, and Mitigation

Project facilities have been sited to avoid, to the extent practicable, impacts to federally listed and other special-status wildlife species. Project micrositing, as well as wetland delineations and cultural surveys for the Project, is ongoing. The Applicant would implement applicable avoidance, minimization, and mitigation measures in the PEIS. The Applicant would construct and operate the Project in accordance with Federal and State requirements.

As discussed in Section 3.0, WAPA is preparing an EA for the Project interconnection. As part of the EA process, the Applicant is coordinating with WAPA and the USFWS to identify additional mitigation measures that would be implemented for the Project as a condition of EA approval.

The Application has prepared a Bird and Bat Conservation Strategy (Appendix L) in accordance with the USFWS WEG that will be implemented to minimize impacts to avian and bat species during construction and operation of the Project. The following impact minimization and avoidance measures, in addition to those in the PEIS, will be implemented for the Project to ameliorate potential negative biological impacts as a result of design, construction, and operation of the proposed facility:

Design minimization and avoidance measures are:

- Turbines and roads will be sited mostly in cultivated fields and hayland. Standard, State and County-required, setbacks for non-participating landowners, residences, noise, airports, etc., will be implemented.
- Existing roads and field accesses will be used or improved for access roads when practicable.
- Electrical collection systems within the Project will be buried underground.
- Wind turbines designed with tubular towers and no external ladders or platforms on the towers or nacelles will be used so bird perching and nesting opportunities are minimized.
- The number of turbines with visibility lighting will be minimized, within FAA requirements.
- Implementation of FAA-approved lighting that uses the shortest allowable flash duration, the minimum allowed flashes per minute, and synchronized flashing, will reduce the potential for nocturnal migrating birds to be disoriented by lights.
- Lighting at the operations and maintenance facility, Project substation, and other installations will be minimized and designed such that light is directed downward (toward the access or work area), and is hooded to prevent light from shining into the sky and attracting or disorienting nocturnal migrants. Motion or heat-activated lighting will be used where practicable.
- Meteorological towers without guy wires will be used, installing the minimum number needed within the Project Area to minimize collision risk for birds.

Construction minimization and avoidance measures are:

- Ground disturbance/clearing of untilled grasslands will be minimized;
- Siting turbines in wetland/waterbodies will be avoided to the extent practicable;
- A Site Environmental Plan, specific to the operational activities of the Project, will be developed and implemented by the site supervisor or his/her designated environmental manager including, but not limited to:
    - Exhibits identifying sensitive resources and associated set-backs.
    - An employee orientation program to raise awareness of any wildlife issues on the site, as well as how to treat sensitive resource areas.
    - Instructions for employees and contractors to drive at an appropriate speed on all public and private roads within the Project Area, in consideration of potential wildlife that may be present and to promote general site safety.

  - Instructions for employees to avoid harassing or disturbing wildlife, especially during the breeding seasons.
  - Federal and State measures for handling toxic substances to minimize contamination of water and wildlife resources.
  - Local policies for noxious weed control (e.g., cleaning vehicles and equipment arriving from areas with known invasive species issues, using locally sourced topsoil, identification and annual removal, etc.).
  - Parts and equipment that may be used as cover by prey will not be stored in the vicinity of wind turbines.
- Tree removal will be avoided from June 1 through July 31 to minimize risk of impact to NLEB maternal roosts and other tree roosting habitat.

Operation minimization and avoidance measures are:

- During normal operational activities, if facility personnel discover carrion on or near Project facilities, reasonable measures will be taken to minimize attracting predators/scavengers such as raptors and vultures.
- A Wildlife Response and Reporting System or similar program will be implemented to establish protocols for identifying and communicating bird and bat fatalities.

14.0 EFFECT ON AQUATIC ECOSYSTEMS (ARSD 20:10:22:17)

***ARSD 20:10:22:17. Effect on aquatic ecosystems.** The applicant shall provide information of the effect of the proposed facility on aquatic ecosystems, and including existing information resulting from biological surveys conducted to identify and quantify the aquatic fauna and flora, potentially affected within the transmission site, wind energy site, or siting area, an analysis of the impact of the construction and operation of the proposed facility on the total aquatic biotic environment and planned measures to ameliorate negative biological impacts as a result of construction and operation of the proposed facility.*

The following sections describe the existing aquatic ecosystems within the Project Area and the potential impacts to aquatic ecosystems as a result of the Project.

14.1 Existing Aquatic Ecosystem

Surface waters are described in Section 12.2 and shown on Figure 8 in Appendix A. The Project facilities are located in the Lewis and Clark Lake Sub-Basin drainage system. As described in Section 13.3.1, approximately 2,696 acres of known and potential wetlands are within the Project Area (approximately 5.3 percent of the total Project Area). The wetlands in the Project Area consist of freshwater emergent and forested wetlands, freshwater ponds, and a small freshwater lake.

14.2 Federal and State Special-Status Aquatic Species

Federally listed threatened and/or endangered aquatic species could potentially occur in the Project Area (Table 14-5). Based on habitats found within the proposed Project Area, three aquatic species have the potential to occur in the Project Area during some portion of the year, including: the State threatened northern river otter (*Lontra canadensis*), the Federal and State endangered pallid sturgeon (USFWS, 2013d), and the federally endangered Topeka shiner (USFWS, 2013e).

Table 14-5: Federal and State-Listed Aquatic Species Potentially Occurring in Project Area

Species	Federal Status	State Status	Potential to Occur
Northern river otter	--	Threatened	Low. Riparian vegetation along wetland margins; low likelihood based on limited suitable habitat in Project
Pallid sturgeon	Endangered	Endangered	None. Limited to large, silty river bottoms with braided channels, sand bars, sand flats, and gravel bars.
Topeka shiner	Endangered	--	Low. Limited to the James River and tributaries. Topeka shiners live in small to mid-size prairie streams in the central United States where they are usually found in pool and run areas. Suitable streams tend to have good water quality and cool to moderate

14.2.1 Northern River Otter

The northern river otter (*Lontra canadensis*) is a semiaquatic mammal of the Mustelid family. River otters inhabit permanent water with abundant fish or crustacean prey and relatively high water quality (Boyle, 2006). Because of their high mobility and low densities, river otters require relatively long reaches of streams and rivers. Complexity of river and lake shorelines provides greater areas of shallow water and wetlands, which provide shallow water habitats for otter prey, including slower-swimming fish, amphibians, reptiles, and invertebrates (Boyle, 2006). The physical habitat attribute most important to river otters besides water is riparian vegetation, which provides security cover when they are feeding, denning, or moving on land (Boyle, 2006). Another essential habitat component is structural diversity and complexity provided by objects such as fallen trees, logjams, stumps, undercut banks, and rocks (Melquist and Dronkert, 1987). Principal threats are habitat destruction and degradation, and human-caused mortality. Habitat destruction and degradation include water development resulting in stream flow and channel morphology alteration, water pollution, loss of riparian vegetation, and human settlement and recreational use along rivers and lakes (Boyle, 2006).

14.2.2 Pallid Sturgeon

Pallid sturgeon (*Scaphirhynchus albus*) requires large, free-flowing, warm-water, and turbid rivers with a diverse assemblage of dynamic physical habitats (USFWS, 2014c). Pallid sturgeons evolved and adapted to living close to the bottom of large, silty rivers with natural a hydrograph. Their preferred habitat has a diversity of depths and velocities formed by braided channels, sand bars, sand flats, and gravel bars (USFWS, 2018b). It can be found in the Missouri River, which is located approximately 13 miles south of the Project.

14.2.3 Topeka Shiner

Topeka shiner (*Notropis topeka*) is a small minnow native to the streams of the prairie and prefers small, quiet streams with clean gravel or sand substrates and vegetated banks (Shearer, 2003). Suitable streams tend to have good water quality and cool to moderate temperatures. In Iowa, Minnesota, and portions of South Dakota, Topeka shiners also live in oxbows and off-channel pools. The shiner can be found in the James River and tributaries, which are about 17 miles northeast of the Project (SDGFP, 2015). The Topeka shiner is threatened by habitat destruction, degradation, modification, and fragmentation resulting from siltation (the buildup of silt), reduced water quality, tributary impoundment, stream channelization, and stream dewatering. The species also is impacted by introduced predaceous fishes (USFWS, 1998).

14.3 Impacts to Aquatic Ecosystems and Mitigation

As described in Section 13.3.2, impacts to wetlands would be minimal, because wetlands would be avoided to the extent practicable when locating access roads, collector lines, and other Project facilities. The primary potential for impact to aquatic ecosystems would be from increased sedimentation or increased TSS due to soil erosion from the Project construction sites. In general, surficial soils on flat areas are less prone to erosion than soils in sloped areas. Construction on or adjacent to steep slope areas can render soils unstable, accelerate natural erosion processes, and cause slope failure.

It is unlikely that the northern river otter, pallid sturgeon, or Topeka shiner would be affected by the development of and operations associated with a wind facility. The Project Area is unlikely to provide habitat for the northern river otter; however, removal of riparian vegetation will be avoided to the extent practicable. Although not in the Project Area, the Missouri River does have tributaries reaching into the Project Area. BMPs would be designed to control sedimentation and erosion during construction of the Project to prevent downstream water quality impacts to the Missouri River and any streams in the Project Area that may provide habitat for the northern river otter. The Project Area is not located within the James River watershed, and, therefore, no direct or indirect impacts to the Topeka shiner would occur. The Project Area is located approximately 13 miles from the Missouri River, and, therefore no direct or indirect impacts to the pallid sturgeon would occur.

15.0 LAND USE (ARSD 20:10:22:18)

ARSD 20:10:22:18. Land use. *The applicant shall provide the following information concerning present and anticipated use or condition of the land:*

(1) A map or maps drawn to scale of the plant, wind energy, or transmission site identifying existing land use according to the following classification system:
  (a) Land used primarily for row and nonrow crops in rotation;
  (b) Irrigated lands;
  (c) Pasturelands and rangelands;
  (d) Haylands;
  (e) Undisturbed native grasslands;
  (f) Existing and potential extractive nonrenewable resources;
  (g) Other major industries;
  (h) Rural residences and farmsteads, family farms, and ranches;
  (i) Residential;
  (j) Public, commercial, and institutional use;
  (k) Municipal water supply and water sources for organized rural water systems; and
  (l) Noise sensitive land uses;
(2) Identification of the number of persons and homes which will be displaced by the location of the proposed facility;
(3) An analysis of the compatibility of the proposed facility with present land use of the surrounding area, with special attention paid to the effects on rural life and the business of farming; and
(4) A general analysis of the effects of the proposed facility and associated facilities on land uses and the planned measures to ameliorate adverse impacts.

The following sections describe the existing land use, sound, and aesthetics within the Project Area and potential land use impacts of the Project, and measures that will be utilized to avoid, minimize, and/or mitigate potential impacts.

15.1 Land Use

The existing land uses within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project’s construction and operation on land use, and avoidance, minimization, and/or mitigation measures.

15.1.1 Existing Land Use

Land use within the Project Area is predominantly agricultural, consisting of a mix of cropland, hayland, pastureland, and rangeland. Occupied farm sites and rural residences are within the Project Area, and other scattered rural residences are adjacent to, but outside of, the Project Area. Figure 9 in Appendix A is a land use map of the Project Area based on the classification system specified in ARSD 20:10:22:18(1). The following land use classifications occur within the Project Area:

- Land used primarily for row and non-row crops in rotation

- Pasturelands and rangelands
- Haylands
- Undisturbed native grasslands
- Rural residences and farmsteads, family farms, and ranches
- Public, commercial, and institutional use
- Noise sensitive land uses

The following land use classifications were not identified within the Project Area:

- Irrigated lands
- Existing and potential extractive nonrenewable resources
- Other major industries
- Residential
- Municipal water supply and water sources for organized rural water systems

In Charles Mix County in 2012 (the latest available year for the USDA Census of Agriculture), approximately 64 percent of the land area was cropland, with soybeans for beans being the most common crop (USDA, 2012a). Corn was the second most common cultivated crop in the county. Cultivated cropland in Charles Mix County increased by 11 percent from 403,374 acres in 2007 to 448,940 acres in 2012 (USDA, 2012a). Specific acreages of different crops within the Project Area, which change from year to year, are not available. In Charles Mix County in 2012, approximately 33 percent of the land area was pastureland (USDA, 2012a, 2012b). Pastureland decreased 12 percent from 263,605 acres in 2007 to 231,622 acres in 2012.

In Bon Homme County in 2012, approximately 77 percent of the land area was cropland, with soybeans for beans being the most common crop (USDA, 2012c). Corn is the second most common cultivated crop in Bon Homme County. Cultivated cropland in Bon Homme County increased by 26 percent from 219,754 acres in 2007 to 277,172 acres in 2012 (USDA, 2012c). Specific acreages of different crops within the Project Area, which change from year to year, are not available. In Bon Homme County in 2012, approximately 16 percent of the land area was pastureland (USDA, 2012b, 2012c). Pastureland decreased 31 percent from 86,714 acres in 2007 to 59,285 acres in 2012.

In Hutchinson County in 2012, approximately 80 percent of the land area was cropland, with soybeans for beans being the most common crop (USDA, 2012d). Corn is the second most common cultivated crop in Hutchinson County. Cultivated cropland in Hutchinson County increased by 4 percent from 394,680 acres in 2007 to 409,677 acres in 2012 (USDA, 2012d). Specific acreages of different crops within the Project Area, which change from year to year, are not available. In Hutchinson County in 2012, approximately 17 percent of the land area was pastureland (USDA, 2012b, 2012d). Pastureland decreased 31 percent from 86,714 acres in 2007 to 59,285 acres in 2012.

15.1.2 Land Use Impacts/Mitigation

Construction of the Project will result in conversion of a small portion of the land within the Project Area from existing agricultural land uses into a renewable energy resource during the life of the Project. Temporary impacts associated with construction staging and laydown areas and underground collector lines will also result. Following construction, the areas will be returned to pre-construction land uses, which primarily consist of cultivated croplands and pastureland/grassland.

The proposed Project is compatible with the existing agricultural land uses in areas surrounding the Project facilities. Agricultural uses will continue within the Project Area during construction and operation. It is estimated that approximately 734 acres of land (676 acres agricultural land; 58 acres non-agricultural) would be temporarily impacted by Project construction, and 45 acres of land (41 acres agricultural land; 4 acres non-agricultural) would be permanently impacted (less than 0.1 percent of the total land within the Project Area). Areas disturbed due to construction that ultimately would not contain Project facilities would be re-vegetated with vegetation types matching the surrounding agricultural landscape. Agricultural impacts are discussed further in Section 20.2.2. As discussed in Section 24.0, the facility would be decommissioned after the end of the Project's operating life. Facilities would be removed in accordance with applicable State and county requirements, unless otherwise agreed to by the landowner. Disturbed surfaces would be graded, reseeded, and restored as nearly as possible to their preconstruction conditions. After decommissioning for the Project is complete, no irreversible changes to land use would remain beyond the operating life of the Project.

There are 83 occupied residences within the Project Area. Based on the proposed Project layout of turbines, access roads, collector lines, and associated facilities, there would be no displacement of residences or businesses due to construction of the Project facilities.

15.2 Public Lands and Facilities

The existing public lands and conservation easements within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project's construction and operation, and potential avoidance, minimization, and mitigation measures.

15.2.1 Existing Public Lands and Facilities

Figure 10 in Appendix A is a map showing public lands and facilities within the Project Area.

15.2.1.1 *USFWS Lands*

Based on correspondence with the USFWS Lake Andes NWR, three wetland and two grassland conservation easements managed by the USFWS are within the Project Area. The actual area of protected land is limited to the boundaries of the resource (e.g., wetland) within the mapped area (pers. comm. Bryant, 2018). USFWS wetland and grassland easements are part of the NWR System and are managed for the protection of wildlife and waterfowl habitat.

Two Waterfowl Production Areas (WPAs), managed by the USFWS Lake Andes Wetland Management District, are located within the Project Area. The Cosby WPA is located in Bon Homme County, and the Juran WPA is located in Charles Mix County. WPAs are satellite areas of the NWR System and are managed for the preservation of wetlands and grasslands critical to waterfowl and other wildlife.

15.2.1.2 *SDGFP Areas*

Two Game Production Areas (GPAs) are located within the Project Area – Mach GPA in Bon Homme County and Rolling Hills GPA in Hutchinson County. GPAs are State lands managed by the SDGFP for the production and maintenance of wildlife.

There are five parcels of privately owned lands within the Project Area that are leased for public walk-in hunting access by SDGFP (referred to as Walk-In Areas).

15.2.1.3 *Public Facilities*

Two cemeteries are located within the Project Area (Figure 10 in Appendix A). One church is located outside the Project Area, approximately 0.25 mile east (Figure 10 in Appendix A).

15.2.2 Impacts/Mitigation to Public Lands and Facilities

The Applicant coordinated with the USFWS regarding the exact boundaries of the USFWS wetland conservation easements within the larger easement parcels shown on Figure 10 in Appendix A. The actual easement area is a subset of these parcels (i.e., actual wetland areas for wetland easements and the area defined in the lease amendments for the conservation easements). The Project has been designed such that no Project facilities (e.g., turbines, collector lines, access roads) would be placed on these USFWS wetland or grassland easements, and thus, no direct impacts to these easement areas would occur. In addition, no Project facilities would be placed on the USFWS WPAs, SDGFP GPAs, or SDGFP Walk-In Areas identified above.

15.3 Sound

A sound study was conducted for the Project in April 2018 and is included in Appendix M. Following is information from the report on the existing sound levels within the Project Area, the potential effects of the proposed Project's construction and operation, and potential avoidance, minimization, and mitigation measures.

15.3.1 Acoustical Terminology

The term "sound level" is often used to describe two different sound characteristics: sound power and sound pressure. Every source that produces sound has a sound power level. The sound power level is the acoustical energy emitted by a sound source and is an absolute number that is not affected by the surrounding environment. The acoustical energy produced by a source propagates through media as pressure fluctuations. These pressure fluctuations, also called sound pressure, are what human ears hear and microphones measure.

Sound is physically characterized by amplitude and frequency. The amplitude of sound is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 microPascals). The reference sound pressure corresponds to the typical threshold of human hearing. To the average listener, a 3-dB change in a continuous broadband sound is generally considered "just barely perceptible"; a 5-dB change is generally considered "clearly noticeable"; and a 10-dB change is generally considered a doubling (or halving, if the sound is decreasing) of the apparent loudness.

Sound waves can occur at many different wavelengths, also known as the frequency. Frequency is measured in hertz (Hz) and is the number of wave cycles per second that occur. The typical human ear can hear frequencies ranging from approximately 20 to 20,000 Hz. Normally, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the lower and higher frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels, or dBA. For reference, the A-weighted sound pressure level and subjective loudness associated with some common sound sources are listed in Table 15-1.

Table 15-1: Typical Sound Pressure Levels Associated with Common Noise Sources

Sound Pressure Level (dBA)[a]	Subjective Evaluation	Environment	
		Outdoor	Indoor
140	Deafening	Jet aircraft at 75 feet	--
130	Threshold of pain	Jet aircraft during takeoff at a distance of 300 feet	--
120	Threshold of feeling	Elevated train	Hard rock band
110		Jet flyover at 1,000 feet	Inside propeller plane
100	Very loud	Power mower, motorcycle at 25 feet, auto horn at 10 feet, crowd noise at football game	--
90	--	Propeller plane flyover at 1,000 feet, noisy urban street	Full symphony or band, food blender, noisy factory
80	Moderately loud	Diesel truck (40 mph)[a] at 50 feet	Inside auto at high speed, garbage disposal
70	Loud	B-757 cabin during flight	Close conversation, vacuum cleaner
60	Moderate	Air-conditioner condenser at 15 feet, near highway traffic	General office
50	Quiet	--	Private office
40	--	Farm field with light breeze, birdcalls	Soft stereo music in residence
30	Very quiet	Quiet residential neighborhood	Bedroom, average residence (without TV and stereo)
20	--	Rustling leaves	Quiet theater, whisper
10	Just audible	--	Human breathing
0	Threshold of hearing	--	--

Source: Adapted from *Architectural Acoustics*, M. David Egan, 1988 and *Architectural Graphic Standards*, Ramsey and Sleeper, 1994.
(a) dBA = A-weighted decibels; mph = miles per hour

Sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound level. The exceedance sound level, L_x, is the sound level exceeded during "x" percent of the sampling period and is also referred to as a statistical sound level. L_{90} levels are presented throughout this study. The L_{90} is a common L_x value and represents the sound level with minimal influence from short-term, loud transient sound sources. The L_{90} represents the sound level exceeded for 90 percent of the time period during which sound levels are measured. The L_{90} value is regarded as the most accurate tool for measuring relatively constant background noise and for minimizing the influence of isolated spikes in sound levels (i.e., barking dog, door slamming).

15.3.2 Regulations

Bon Homme County has adopted a zoning ordinance that pertains to wind energy systems. The ordinance limits sound levels of WES to 45 dBA at occupied receptors unless the landowner provides a written waiver. Neither Charles Mix County nor Hutchinson County has an ordinance relating to turbine noise. Therefore, the Bon Homme County ordinance sound level limit was used as a design goal for all areas of the Project. The results of the sound study detailed below show a maximum sound level of 41.9 dBA within the Project Area.

15.3.3 Ambient Sound Survey

The Applicant conducted an ambient sound survey of surrounding Project areas on March 12 and 13, 2018. Ambient far-field measurements were made at 16 locations, labeled measurement point MP1 through MP16, as shown in Figure 4-1 of the Sound Study (Appendix M). The measurement points were selected because they were accessible and representative of existing ambient sound levels in the vicinity of noise-sensitive receivers.

The far-field sound level measurements were 5 minutes in duration, and measured values were logged by the sound meter at each measurement point. The sound levels varied at each measurement point due to the extraneous sounds that occurred during each measurement. The overall A-weighted L_{eq} and L_{90} sound levels collected during the ambient far-field measurements are shown in Table 4-1 of the Sound Study (Appendix M). Sound levels measured were in the range of 21.5 to 45.0 dBA L_{90}. Extraneous sounds during the measurement periods included high speed traffic, birds, wind noise, and farm equipment. The measured sound levels and noise sources are presented in Appendix A of the Sound Study.

15.3.4 Sound Impacts/Mitigation

Following is information on the anticipated sound levels from construction and operation of the Project.

15.3.4.1 Construction and Decommissioning

There would be increased sound levels associated with construction and decommissioning of the Project. Construction and decommissioning of the Project would involve site preparation, excavation, placement of concrete, and the use of typical industrial construction practices. Sound impacts would be reduced by scheduling heavy construction work during daylight hours, to the extent possible. Certain operations, due to their nature or scope, must be accomplished in part outside of normal working hours. Such work generally consists of activities that must occur continuously, once begun (such as pouring concrete, filling a transformer with oil, turbine erection, etc.). Construction and decommissioning sound levels would comply with applicable county and State requirements, regulations, and ordinances.

The impacts that various construction and decommissioning-related activities might have would vary considerably based on the proximity to the facilities. Generic sound data ranges are available for various types of equipment at certain distances. Table 15-2 lists generic activities and the associated sound levels at a distance of 50 feet.

Table 15-2: Range of Typical Construction Equipment Sound Levels (dBA)[a]

Generic Construction Equipment	Minimum Sound at 50 Feet	Maximum Sound at 50 Feet
Backhoes	74	92
Compressors	73	86
Concrete mixers	76	88
Cranes (movable)	70	94
Dozers	65	95
Front loaders	77	96
Generators	71	83
Graders	72	91
Jack hammers and rock drills	80	98
Pumps	69	71
Scrapers	76	95
Trucks	83	96

Source: FHWA Highway Construction Noise and the HEARS database
(a) dBA = A-weighted decibels

The types of equipment listed in Table 15-2 may be used at various times and for various amounts of time. Most activities would not occur at the same time. The Applicant expects that the maximum sound level during any of these activities would be between 85 and 95 dBA at 50 feet for a short duration. However, that sound level would quickly drop, similar to what happens when a car passes by. Sound levels are expected to be quieter for areas where activities are occurring at distances greater than 50 feet from the facilities.

15.3.4.2 Operation

The sound commonly associated with a wind turbine is described as a rhythmic “whoosh” caused by aerodynamic processes. This sound is created as air flow interacts with the surface of rotor blades. As air flows over the rotor blade, turbulent eddies form in the surface boundary layer and wake of the blade. These eddies are where most of the “whooshing” sound is formed.

Additional sound is generated from vortex shedding produced by the tip of the rotor blade. Air flowing past the rotor tip creates alternating low-pressure vortices on the downstream side of the tip, causing sound generation to occur. Older wind turbines, built with rotors which operate downwind of the tower (downwind turbines), often have higher aerodynamic impulse sound levels. This is caused by the interaction between the aerodynamic lift created on the rotor blades and the turbulent wake vortices produced by the tower. Modern wind turbine rotors are mostly built to operate upwind of the tower (upwind turbines). Upwind wind turbines are not impacted by wake vortices generated by the tower and, therefore, overall sound levels can be as much as 10 dBA less.

The rhythmic fluctuations of the overall sound levels are less perceivable the farther one gets from the turbine. Additionally, multiple turbines operating at the same time will create the whooshing sound at different times. These non-synchronized sounds will blend together to create a more constant sound to an observer at most distances from the turbines. Another phenomenon that reduces perceivable noise from turbines is the wind itself. Higher wind speed produces noise in itself that tends to mask (or drown out) the sounds created by wind turbines.

Advancement in wind turbine technology has reduced pure tonal emissions of modern wind turbines. Manufacturers have reduced distinct tonal sounds by reshaping turbine blades and adjusting the angle at which air contacts the blade. Pitching technology allows the angle of the blade to adjust when the maximum rotational speed is achieved, which allows the turbine to maintain a constant rotational velocity. Therefore, sound emission levels remain constant as the velocity remains the same.

Wind turbines can create noise in other ways as well. Wind turbines have a nacelle where the mechanical portions of the turbine are housed. The current generation of wind turbines uses multiple techniques to reduce the noise from this portion of the turbine: vibration isolating mounts, special gears, and acoustic insulation. In general, all moving parts and the housing of the current generation wind turbines have been designed to minimize the noise they generate.

Acoustical Model Inputs

Predicted sound levels were modeled using industry-accepted sound modeling software. The program used to model the turbines was the Computer Aided Design for Noise Abatement (CadnaA), Version 2017, published by DataKustik, Ltd., Munich, Germany. The CadnaA program is a scaled, three-dimensional program that accounts for air absorption, terrain, ground absorption, and ground reflection for each piece of noise-emitting equipment and predicts downwind sound pressure levels. The model calculates sound propagation based on International Organization for Standardization (ISO) 9613-2:1996, General Method of Calculation. ISO 9613, and therefore CadnaA, assesses the sound pressure levels based on the Octave Band Center Frequency range from 31.5 to 8,000 Hz. Compliance with the regulations for all turbines operating should equate to compliance for any combination of the turbines operating. Predictive modeling was conducted to determine the impacts at the occupied residences shown in Appendix B of the Sound Study.

Acoustical modeling was conducted for the entire Project for both of the representative turbine models (GE 3.8-137 and Vestas V136-3.6). Wind turbine heights and acoustical emissions were input into the model. The expected worst-case sound power levels for the modeled GE 3.8-137 and Vestas V136-3.6 turbines at each of the 63 proposed sites were contained in documents provided by GE and Vestas based on various wind speeds. The sound emissions data supplied was developed using the International Electrotechnical Commission (IEC) 61400-11 acoustic measurement standards.

Acoustical Modeling Results

Sound pressure levels were predicted for the identified receivers in the CadnaA noise modeling software using the manufacturer-specified sound power levels at each frequency and the assumptions listed in Section 5.2 of the Sound Study. CadnaA modeling results have been demonstrated in previous studies to conservatively approximate real-life measured noise from a source when extraneous noises are not present.

As previously mentioned, decibels are a logarithmic ratio of a sound pressure to a reference sound pressure. Therefore, they must be logarithmically added to determine a cumulative impact (i.e., logarithmically adding 50 dBA and 50 dBA results in 53 dBA). Logarithmically adding each of the individual turbine's impacts together at each receiver provides an overall Project impact at each receiver.

The maximum model-predicted L_{eq} sound pressure levels at each receiver (the logarithmic addition of sound levels from each frequency from every turbine) are included in Appendix C of the Sound Study. The results show a maximum sound level of 41.9 dBA. These values represent only the noise emitted by the wind turbines and do not include any extraneous noises (traffic, etc.) that could be present during physical noise measurements. There are no expected exceedances of the identified regulations due to operation of any of the proposed wind turbine locations of the Project.

Appendix D of the Sound Study contains graphical representation of the Project's impact on the surrounding area for both GE and Vestas turbines. The figure depicts the maximum sound levels attributable to the new turbines.

Because the wind turbines have been sited to avoid exceeding county regulatory sound level limits, no further mitigation for sound is required.

15.4 Visual Resources

The existing visual resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project's construction and operation and mitigation and minimization measures.

15.4.1 Existing Visual Resources

Cropland, grassland, large open vistas, and gently rolling topography visually dominate the Project Area landscape. Vegetation in and near the Project Area is predominantly cropland and grassland/pasture. Existing structures in the Project Area consist of occupied residences dispersed throughout as well as scattered farm buildings. Two WAPA transmission lines bisect the Project Area from east to west, and one East River Electric transmission line traverses the Project Area, also from east to west. State Highways 50, 46, and 37 extend through the Project Area. The existing Beethoven Wind Farm, comprised of 43 wind turbines, is located adjacent to the northern portion of the Project Area.

Visual impacts to the landscape attributable to the Project would depend on the extent to which the existing landscape is already altered from its natural condition, the number of viewers (residents, travelers, visiting recreational users, etc.) within visual range of the area, and the degree of public or agency concern for the quality of the landscape. There are 83 occupied residences (0.7 residence per square mile) within the Project Area and other scattered rural residences and towns that are near, but outside of, the Project Area (Figure 9 in Appendix A). Travelers through the Project Area would include local or regional traffic along State Highways 50, 46, and 37. USFWS and SDGFP public hunting areas (discussed in Section 15.2.1) are present within the Project Area.

15.4.2 Visual Impacts/Mitigation

Visual impacts can be defined as the human response to the creation of visual contrasts that result from the introduction of a new element into the viewed landscape. These visual contrasts interact with the viewer's perception, preferences, attitudes, sensitivity to visual change, and other factors that vary by individual viewer to cause the viewer to react negatively or positively to the changes in the viewed landscape.

Construction, operation, and decommissioning of the proposed Project would potentially introduce visual contrasts in the Project Area that would cause a variety of visual impacts. The types of visual contrasts of concern include the potential visibility of wind turbines, electric transmission structures and conductors, and associated facilities such as roads; marker lighting on wind turbines and transmission structures as well as security and other lighting; modifications to landforms and vegetation; vehicles associated with transport of workers and equipment for construction, operations and maintenance, and facility decommissioning; and the construction, operation, maintenance, and decommissioning activities themselves. A subset of potential visual impacts associated with wind turbine generator structures are blade movement, blade glinting[6], and shadow flicker[7]. Shadow flicker is discussed further in Section 15.5.

The primary visual impacts associated with the Project would result from the introduction of the numerous vertical lines of the wind turbines into the generally strongly horizontal landscape found in the Project Area. Based on the representative turbine models (Table 8-3), the total height of the turbines would be approximately 586 feet (GE 3.8-137 turbine) or 568 feet (Vestas 136-3.6 turbine). The visible structures would potentially produce visual contrasts by virtue of their design attributes (form, color, and line) and the reflectivity of their surfaces and potential glare. In addition, marker lighting could cause visual impacts at night.

For nearby viewers including the rural residences dispersed throughout the Project Area, the large sizes and strong geometric lines of both the individual turbines themselves and the array of turbines could dominate views, and the large sweep of the moving rotors would tend to command visual attention. Structural details, such as surface textures, could become apparent, and the O&M facility and other structures could be visible as well, as could reflections from the towers and moving rotor blades (blade glint).

As discussed above, viewers within the Project Area include the occupied residences, travelers along State Highways 50, 46, and 37, and hunters utilizing the public hunting areas. For these viewers, the magnitude of the visual impacts associated with the Project would depend on certain factors, including:

- Distance of the proposed wind energy facility from viewers
- Duration of views (highway travelers vs. permanent residents)
- Weather and lighting conditions
- The presence and arrangements of lights on the turbines and other structures
- Viewer attitudes toward renewable energy and wind power

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[6] Reflection of sunlight from moving wind turbine blades when viewed from certain angles under certain lighting conditions.

[7] As wind turbine blades spin under certain sunny conditions, they may cast moving shadows on the ground or nearby objects, resulting in alternating light intensity (flickering) as each blade shadow crosses a given point.

To minimize visual impacts of the Project, the Applicant has incorporated setback requirements and commitments into the design of the Project. As identified in Table 9-2, turbines would be set back at least 1,000 feet from currently occupied offsite residences, businesses, and public buildings and at least 500 feet or 1.1 times the turbine height from residences with turbines, per Bon Homme County requirements. Turbines would also be set back at least 500 feet or 1.1 times the height of the turbines from rights-of-way of public roads and from any surrounding property line. In accordance with FAA regulations, the towers would be painted off-white to reduce potential glare and minimize visual impact.

At the end of the Project's operating life, the facility would be decommissioned (see Section 24.0), and all wind turbines, electrical cabling, electrical components, roads, and any other associated facilities would be removed in accordance with applicable State and County regulations, unless otherwise agreed to by the landowner. As such, no visual impacts would remain beyond the operating life of the Project.

Scenic resources with sensitive viewsheds can include national parks, monuments, and recreation areas; national historic sites, parks, and landmarks; national memorials and battlefields; national wild and scenic rivers, national historic trails, national scenic highways, and NWRs; State- or locally designated scenic resources, such as State-designated scenic highways, State parks, and county parks; and other scenic resources that exist on Federal, State, and other non-Federal lands, including traditional cultural properties important to tribes. The nearest scenic resources to the Project Area are the Lake Andes NWR, located approximately 12 miles west of the Project Area, and the Missouri River, designated as a National Recreation River by the NPS, located approximately 13 miles south of the Project Area. At these distances, adverse visual impacts are not anticipated. Depending on topography and atmospheric conditions, the Project turbines could be visible from the NWR or the river. However, the Project would not cause large visual contrasts in the landscape at this distance and would not be noticeably visible, if visible at all.

15.5 Shadow Flicker

A shadow flicker analysis was conducted for the Project in May 2018 and is included in Appendix N. Following is information from the report on the potential shadow flicker effects of the Project and potential avoidance, minimization, and mitigation measures.

15.5.1 Shadow Flicker Overview

Shadow flicker occurs when wind turbine blades pass in front of the sun to create recurring shadows on an object. Such shadows occur only under very specific conditions, including sun position, wind direction, time of day, and other similar factors.

The intensity of shadow flicker varies significantly with distance, and as separation between a turbine and receptor increases, shadow flicker intensity correspondingly diminishes. Shadow flicker intensity for distances greater than 10 rotor diameters (i.e., 1,370 meters for the representative GE 3.8-137 layout and 1,360 meters for the representative V136-3.6 layout) is generally low and considered imperceptible. At such distances, shadow flicker is typically only caused at sunrise or sunset, when cast shadows are sufficiently long.

Shadow flicker impacts are not currently regulated in applicable State or Federal law, nor are there requirements in the current Charles Mix County or Hutchinson County ordinances. Section 1741 of the Bon Homme County zoning ordinance states the following:

> *When determined appropriate by the County, a Shadow Flicker Control System shall be installed upon all turbines which will cause a perceived shadow effect upon a habitable residential dwelling. Such system shall limit blade rotation at those times when shadow flicker exceeds thirty (30) minutes per day or thirty (30) hours per year at perceivable shadow flicker intensity as confirmed by the Zoning Administrator are probable.*

Thus, although the Project turbines fall within all three counties (Bonne Homme, Charles Mix, and Hutchinson), the existing Bon Homme County requirements of 30 hours per year and 30 minutes per day were used as a baseline for the shadow flicker study.

15.5.2 Shadow Flicker Impacts/Mitigation

Shadow flicker was modeled at the Project Site using WindPRO, an industry-leading software package for the design and planning of wind energy projects. This package models the sun's path with respect to every turbine location during every minute over a complete year. The model accounted for topography and obstacles with certain receptors. Each receptor was modeled in "green-house" mode within the WindPRO model. This approach provides a conservative estimate of the amount of time when shadow flicker could occur for each receptor. Any shadow flicker caused by each turbine is then aggregated for each receptor for the entire year. All 63 turbine positions were evaluated, although only up to 61 turbines would be installed.

Using the inputs and parameters defined in Section 2.0 of the Shadow Flicker Analysis, the WindPRO model was used to calculate shadow flicker for the receptors at the Project Site. Table 15-3 presents a summary of these results for the GE 3.8-137 turbine, and Table 15-4 presents a summary of these results for the V136-3.6 turbine; results in each table are presented by landowner status for the applicable receptor. Detailed tables are included within Appendix F of the Shadow Flicker Analysis that present shadow flicker durations by receptor, including estimated hours per year and maximum minutes per day. Additionally, maps are provided in Appendix G of the Shadow Flicker Analysis which illustrate the shadow flicker vectors (in hours per year) caused by each Project turbine.

Table 15-3: Summary of Shadow Flicker Analysis Results (GE 3.8-137)

Landowner Status	No. of Sites Studied[a]	No. of Receptors	No. of Receptors, Flicker > 30 hr/yr	No. of Receptors, Flicker > 30 min/day
Participating	63	46	2	12
Non-participating		92	1	13

(a) 63 turbine sites were studied; however, only up to 61 turbines would be installed

Table 15-4: Summary of Shadow Flicker Analysis Results (V136-3.6)

Landowner Status	No. of Sites Studied[a]	No. of Receptors	No. of Receptors, Flicker > 30 hr/yr	No. of Receptors, Flicker > 30 min/day
Participating	63	46	2	11
Non-participating		92	1	12

(a) 63 turbine sites were studied; however, only up to 61 turbines would be installed

As noted in Tables 15-3 and 15-4, one non-participating receptor exceeded 30 hours per year. This receptor is located in Charles Mix County. With the V136-3.6 turbine model, the annual shadow flicker duration at this receptor was 33.93 hours. With the GE 3.8-137 turbine model, the annual shadow flicker duration at this receptor was 34.73 hours. Prevailing Wind Park will be conducting additional shadow flicker modeling with more realistic assumptions for this receptor. For example, rather than modeling the home as having windows on all sides that are always perpendicular to the sun, actual window locations would be considered along with the actual angle of the sun. If updated modeling results still show more than 30 hours per year of shadow flicker, Prevailing Wind Park will work with the landowner to implement mitigation techniques, such as screening or implement operational controls to ensure experienced shadow flicker levels are below 30 hours per year.

15.6 Electromagnetic Interference

The Applicant completed an analysis of the effects upon Federal Communications Commission (FCC)-licensed radio frequency (RF) facilities (RF Impact Study) due to construction and operation of the Project (Appendix O). Using industry standard procedures and FCC databases, a search was conducted to determine the presence of any existing microwave paths crossing or near the Project Area. The study was conducted for 64 potential turbines sites; however, 1 turbine was subsequently dropped from further consideration resulting in the current layout consisting of 63 potential turbine sites. The analysis addressed the potential conflicts that may be caused by the proposed Project turbines. The analysis consisted of three sections: microwave point-to-point path analysis; airports, radar stations, and military aircraft operations; and National Telecommunication Information Agency (NTIA) notification.

15.6.1 Microwave Links

An extensive analysis was undertaken to determine the likely effect of the Project upon existing microwave paths, consisting of a Fresnel x/y/z axis study. For this microwave study, Worst Case Fresnel Zones (WCFZ) were calculated for each microwave path. In general, the WCFZ is defined by the cylindrical area whose axis is the direct line between the microwave link endpoints. This is the zone where the siting of obstructions should be avoided. Fifteen unique point-to-point microwave paths and three point-to-multipoint microwave links from the FCC database were identified within 0.5 mile of the Project Area. These microwave facilities are listed in Table 1 and mapped in Figures 1 and 2 of the RF Impact Study (Appendix O).

Eleven point-to-point microwave paths cross the Project Area. Three point-to-multipoint microwave link stations are inside the Project Area. As seen in Figures 3 through 7 of the RF Impact Study, several of the planned turbines would be located within 250 meters of the microwave paths (as measured from the turbine tower to the center of the path); however, as Figures 7 through 11 of the RF Impact Study show, the analysis strongly indicates that these turbines would not penetrate the microwave worst-case Fresnel zones.

15.6.2 Department of Defense Radar Concerns

The Department of Defense (DoD) and the Department of Homeland Security Long Range Radar Joint Program Office (JPO) has adopted a “pre-screening tool” to evaluate the impact of wind turbines on air defense long-range radar. This tool was applied to the Prevailing Wind Park area, and it returned a result of “no anticipated impact” (green) to Air Defense and Homeland Security radars.

15.6.3 NEXRAD

A pre-screening tool has been developed to evaluate the potential impact of obstructions to the NEXRAD Weather Surveillance Doppler Radar Stations. This tool was applied to the Prevailing Wind Park area, and it returned a result of “impacts not likely” to weather radar operations.

15.6.4 Military Airspace

A preliminary review of the Prevailing Wind Park proposal does not return any likely impacts to military airspace.

15.6.5 National Telecommunication Information Agency Notification

Operation of RF frequencies for Federal government use is managed by the NTIA, which is part of the U.S. Department of Commerce. The technical specifications for most government facilities are unavailable to the public. The NTIA has set in place a review process, wherein the Interdepartmental Radio Advisory Committee (IRAC), consisting of representatives from various government agencies, reviews new proposals for wind turbine projects for impact on government frequencies. In almost all cases, no adverse impact is found, and IRAC usually issues a determination in about 60 days.

On April 6, 2018, a notification of the Prevailing Wind Park was sent to the NTIA, and a determination is expected around the beginning of June 2018.

16.0 LOCAL LAND USE CONTROLS (ARSD 20:10:22:19)

ARSD 20:10:22:19. Local land use controls. *The applicant shall provide a general description of local land use controls and the manner in which the proposed facility will comply with the local land use zoning or building rules, regulations or ordinances. If the proposed facility violates local land use controls, the applicant shall provide the commission with a detailed explanation of the reasons why the proposed facility should preempt the local controls. The explanation shall include a detailed description of the restrictiveness of the local controls in view of existing technology, factors of cost, economics, needs of parties, or any additional information to aid the commission in determining whether a permit may supersede or preempt a local control pursuant to SDCL 49-41B-28.*

The Project would be constructed on agricultural land in Bon Homme, Charles Mix, and Hutchinson counties. Land use in Charles Mix County is not regulated by zoning regulations. Land use in Hutchinson County is regulated by the Hutchinson County Zoning Ordinance, adopted on April 4, 2000. Hutchinson's ordinance does not include regulation specific to wind energy systems. The Project will obtain Conditional Use Permits for the wind turbines under Section 509 of the ordinance. Land use in Bon Homme County is regulated by the Bon Homme County Zoning Ordinance, adopted on November 3, 2015, and effective December 9, 2015. Bon Homme's ordinance includes a wind energy system regulation for permitting of a wind energy system. Bon Homme's ordinance specifies standards for siting large wind energy systems in the County (Bon Homme County Zoning Ordinance, Article 17). Prevailing Wind Park has designed the Project to meet the setback and noise requirements set forth in the Bon Homme zoning ordinance and the shadow flicker commitment set forth in Table 9-2.

Prevailing Wind Park, LLC will comply with all terms and conditions of the land use permits from Hutchinson County and Bon Homme County. Prevailing Wind Park also plans to enter into road use and maintenance agreements with each county governing the use, improvement, repair, and restoration of roads within the applicable county, as needed. In addition, Prevailing Wind Park will obtain from each road authority any road crossing, approach, and/or utility permits required for the Project.

The Applicant met with each of the three counties between April 17 and 19, 2018 to introduce sPower, describe Project updates, and discuss road use agreement requirements. Additional details about county and agency coordination are provided in Section 27.2.

17.0 WATER QUALITY (ARSD 20:10:22:20)

ARSD 20:10:22:20. Water quality. *The applicant shall provide evidence that the proposed facility will comply with all water quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.*

Groundwater and surface water resources are discussed in Section 12.0. As discussed in Section 12.2.2, the excavation and exposure of soils during the construction and decommissioning of wind turbines, access roads, underground collector lines, and other Project facilities may temporarily cause sediment runoff during rain events. This sediment may temporarily increase the TSS loading in receiving waters. However, erosion control BMPs would keep sediments onsite that might otherwise increase sediment loading in receiving waters.

As discussed in Section 11.2.2.2, construction of the Project would require coverage under the General Permit for Storm Water Discharges Associated with Construction Activities issued by the SDDENR. A condition of this permit is the development and implementation of a SWPPP. The SWPPP would be developed during civil engineering design of the Project and would prescribe BMPs to control erosion and sedimentation. The BMPs may include silt fence, wattles, erosion control blankets, temporary storm water sedimentation ponds, re-vegetation, and/or other features and methods designed to control storm water runoff and mitigate erosion and sedimentation. The BMPs would be implemented to reduce the potential for impacts to drainage ways and streams by sediment runoff. Because erosion and sediment control would be in place for construction, operation, and decommissioning of the Project, impacts to water quality are not expected to be significant.

18.0 AIR QUALITY (ARSD 20:10:22:21)

ARSD 20:10:22:21. Air quality. *The applicant shall provide evidence that the proposed facility will comply with all air quality standards and regulations of any federal or state agency having jurisdiction and any variances permitted.*

The following sections discuss the existing air quality conditions within the Project Area and the potential air quality impacts from the Project.

18.1 Existing Air Quality

The entire State of South Dakota is in attainment for all NAAQS criteria pollutants (EPA, 2018). The nearest ambient air quality monitoring site to the Project Area is located near Santee, Knox County, Nebraska, which is south and east of the Project Area (EPA, 2017b). The primary emission sources that exist within the Project Area include agricultural-related equipment and vehicles traveling along State Highways 50, 46, and 37.

18.2 Air Quality Impacts/Mitigation

During construction of the Project, fugitive dust emissions would temporarily increase due to truck and equipment traffic in the Project Area. Additionally, there would be short-term emissions from diesel trucks and construction equipment. Air quality effects caused by dust would be short-term, limited to the time of construction or decommissioning, and would not result in NAAQS exceedances for particulate matter. Implementation of the Project components would not result in a violation to Federal, State, or local air quality standards and, therefore, would not result in significant impacts to air quality. Temporary minor sources of air pollution emissions from Project construction equipment, such as a concrete batch plant, would be permitted by the balance-of-plant contractor or concrete batch plant operator through the SDDENR. The operation of the Project would not produce air emissions that would impact the surrounding ambient air quality. Potential complaints regarding fugitive dust emissions would be addressed in an efficient manner (i.e., implementation of best management practices to suppress fugitive dust emissions during construction such as spraying the roads with water).

19.0 TIME SCHEDULE (ARSD 20:10:22:22)

ARSD 20:10:22:22. Time schedule. *The applicant shall provide estimated time schedules for accomplishment of major events in the commencement and duration of construction of the proposed facility.*

The Applicant expects to have the Project operational in the fourth quarter of 2019. A preliminary permitting and construction schedule is included in Table 19-1. Although conditions beyond the Applicant's control, such as, but not limited to, delays in interconnection studies, transmission upgrades, or Project financing may delay Project construction and operational date.

Table 19-1: Preliminary Permitting and Construction Schedule

Milestone[a]	Date
Submit SDPUC application	Second Quarter 2018
WAPA completes NEPA review	Fourth Quarter 2018
SDPUC permit award	Fourth Quarter 2018
Other Federal, State, and local permits	Fourth Quarter 2018
Sign wind turbine supply agreement	Second Quarter 2018
Commence construction	Fourth Quarter 2018
Trenching of underground collector system	Fourth Quarter 2018
Collector substation construction	Fourth Quarter 2018
115-kV transmission line construction	Fourth Quarter 2019
Wind turbine erection and pre-commissioning	Second-Third Quarters 2019
Back-feed station power	Second Quarter 2019
Testing and final assembly	Third Quarter 2019
COD	Fourth Quarter 2019

(a) SDPUC = South Dakota Public Utilities Commission, WAPA = Western Area Power Administration, NEPA = National Environmental Policy Act, kV = kilovolt, COD = commercial operation date

20.0 COMMUNITY IMPACT (ARSD (20:10:22:23)

ARSD 20:10:22:23. Community impact. *The applicant shall include an identification and analysis of the effects the construction, operation, and maintenance of the proposed facility will have on the anticipated affected area including the following:*

(1) A forecast of the impact on commercial and industrial sectors, housing, land values, labor market, health facilities, energy, sewage and water, solid waste management facilities, fire protection, law enforcement, recreational facilities, schools, transportation facilities, and other community and government facilities or services;
(2) A forecast of the immediate and long-range impact of property and other taxes of the affected taxing jurisdictions;
(3) A forecast of the impact on agricultural production and uses;
(4) A forecast of the impact on population, income, occupational distribution, and integration and cohesion of communities;
(5) A forecast of the impact on transportation facilities;
(6) A forecast of the impact on landmarks and cultural resources of historic, religious, archaeological, scenic, natural, or other cultural significance. The information shall include the applicant's plans to coordinate with the local and state office of disaster services in the event of accidental release of contaminants from the proposed facility; and
(7) An indication of means of ameliorating negative social impact of the facility development.

The following sections describe the existing socioeconomic and community resources within the Project Area, the potential community impacts of the proposed Project, and measures to avoid, minimize, and/or mitigate potential impacts.

20.1 Socioeconomic and Community Resources

The existing socioeconomic resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

20.1.1 Existing Socioeconomic and Community Resources

The Project Area is located in southeastern South Dakota in Charles Mix, Bon Homme, and Hutchinson counties. Charles Mix, Bon Homme and Hutchinson counties had estimated populations of 9,129, 7,070 and 7,368, respectively, in 2016 (U.S. Census Bureau, 2016). Wagner, with an estimated 2016 population of 1,566, is the largest city in Charles Mix County (U.S. Census Bureau, 2016). Wagner is located approximately 3.3 miles west of the Project Area. Tripp is the nearest municipality in Hutchinson County to the Project Area and is located approximately 2 miles northeast of the Project area. Avon is the nearest municipality to the Project Area in Bon Homme County and is located 1 mile south of the Project Area. Springfield is the largest municipality in Bon Homme County with a 2016 population estimate of 1,989. The populations of these communities, as well as other communities in Charles Mix, Bon Homme, and Hutchinson counties and their distances from the Project Area, are shown in Table 20-1.

Table 20-1: Population Estimates of Communities in Charles Mix, Bon Homme and Hutchinson Counties and Distance from Project Area

Community	2016 Population Estimate	County	Distance and Direction from Project Area
Dante	108	Charles Mix	1 mile west
Wagner	1,482	Charles Mix	6 miles west
Ravinia	98	Charles Mix	13 miles west
Lake Andes	846	Charles Mix	18 miles west
Pickstown	162	Charles Mix	18 miles west
Geddes	220	Charles Mix	26 miles northwest
Platte	1,531	Charles Mix	36 miles northwest
Avon	666	Bon Homme	1 mile south
Tyndall	1,067	Bon Homme	6 miles southeast
Springfield	1,938	Bon Homme	12 miles southeast
Scotland	791	Bon Homme	13 miles east
Tabor	390	Bon Homme	17 miles southeast
Tripp	668	Hutchinson	2 miles northeast
Kaylor	66	Hutchinson	7 miles east
Parkston	1,826	Hutchinson	13 miles north
Olivet	64	Hutchinson	16 miles northeast

Source: U.S. Census Bureau, 2016

The population in Charles Mix County is predominantly white (63.8 percent), while 32.0 percent of the population is American Indian, and 4.2 percent is some other race. In Bon Homme County, 89.2 percent of the population is white, while 5.0 percent is American Indian. The remaining 5.8 percent is some other race. The population in Hutchinson County is 96.5 percent white and 2.5 percent American Indian, and 1.0 percent is some other race. In the State of South Dakota as a whole, 84.8 percent of the population is white, 8.7 percent is American Indian, and 6.5 percent is some other race (U.S. Census Bureau, 2016).

The median household income in 2016 in Charles Mix, Bon Homme and Hutchinson counties was $43,376, $48,023 and $47,358, respectively. In 2016, 21.5, 10.8 and 13.4 percent of the population, respectively, were below the poverty level in Charles Mix, Bon Homme and Hutchinson counties. By comparison, the median household income for the State was higher ($52,078) than all three counties, and the poverty level (14.0 percent) was between the reported percentages for the counties.

In Charles Mix County, the top industries in terms of employment in 2013 were: (1) educational services, health care, and social services (comprising 25.9 percent of employment); (2) arts, entertainment, and recreation, and accommodation and food services (12.0 percent); and (3) agriculture, forestry, fishing and hunting, and mining (11.8 percent). In Bon Homme County, the top industries in terms of employment in 2016 were: (1) educational services, health care, and social services (comprising 25.1 percent of employment); (2) agriculture, forestry, fishing and hunting, and mining (14.9 percent); and (3) manufacturing (12.4 percent). In Hutchinson County, the top industries in terms of employment in 2016 were: (1) educational services, health care, and social services (comprising 23.9 percent of employment); (2) agriculture, forestry, fishing and hunting, and mining (17.6 percent); and (3) manufacturing (9.7 percent). The unemployment rates in Charles Mix, Bon Homme and Hutchinson counties in November 2017 were 3.8, 3.2 and 2.9 percent, respectively, and the South Dakota unemployment for that same month was 3.3 percent (South Dakota Department of Labor and Regulation [SDDLR], 2016).

20.1.2 Socioeconomic and Community Impacts

This section describes the potential impacts of the proposed Project on communities, property values, and emergency response.

20.1.2.1 Economic Impacts

The Project is expected to create both short-term and long-term positive impacts to the local economy. Impacts to social and economic resources from construction activities would be short-term. Local businesses, such as restaurants, grocery stores, hotels, and gas stations, would see increased business during this phase from construction-related workers. Local industrial businesses, including aggregate and cement suppliers, welding and industrial suppliers, hardware stores, automotive and heavy equipment repair, electrical contractors, and maintenance providers, would also likely benefit from construction of the Project.

The Project would generate approximately $60 million in direct economic benefits and would use approximately 45 acres of land to produce economic benefits for local landowners, local communities, and the State of South Dakota. Over the life of the Project (30 years), it would create direct payments of more than:

- Approximately $37 million to landowners, including an average of $1,230,000 annually from lease payments
- Approximately $6 million to Bon Homme County, or $201,000 annually from taxes paid
- Approximately $4.2 million to Charles Mix County, or $140,000 annually from taxes paid
- Approximately $913 thousand to Hutchinson County, or $30,500 annually from taxes paid
- Approximately $1.5 million to area school district(s), or $371,000 annually from taxes paid
- Approximately $11.1 million to the State of South Dakota, or $336,000 annually from taxes paid

The Project would purchase station power for the turbines, substation, and O&M building from two local rural electric cooperatives in a portion of their service territories where customers are decreasing and cost to maintain the systems continues to increase.

In addition to the direct payments, construction of the Project would create a $14.9 million boost to the local economy. Prevailing Wind Park estimates that $220,000 of food, supplies, and fuel would be purchased locally by the Project and Project staff annually (or $20.4 million over the life of the Project).

The construction crews would include skilled labor, such as foremen, carpenters, iron workers, electricians, millwrights, and heavy equipment operators, as well as unskilled laborers. This diverse workforce would be needed to install all of the Project components, including wind turbines, access roads, underground collector system, O&M building, collector substation, etc. Table 20-2 list the anticipated construction jobs for the Project. Job estimates are based on the recent construction of the Beethoven wind project and an estimate from a wind energy contractor's construction estimate.

Table 20-2: Anticipated Construction Jobs

Total construction days	195
Total man-hours	510,000
Peak construction jobs	245[a]

(a) Estimated peak construction jobs; average may be lower.

20.1.2.2 Population and Housing

The Applicant anticipates that there would not be sufficient trained local labor to fill the number of jobs available. The majority of the non-local construction workforce would probably travel within a 65-mile radius, and within that radius, the largest city that would provide workers would be Sioux Falls, South Dakota. Workers within the 65-mile radius would likely not need additional temporary or permanent housing at the Project Area but would commute to the jobs. The Project would have a less than significant impact on overall population and occupation distribution in the Project Area.

Construction activities for the Project would be short-term, and any short-term effects to local businesses would most likely be beneficial. No negative long-term impact to the socioeconomics of the Project Area are expected, and no adverse effects on the industrial sector, housing, labor market, health facilities, water and sewer systems, existing energy facilities, solid waste facilities, schools, fire protection, law enforcement, or other community, government, or recreational facilities are anticipated.

20.1.2.3 Property Value Impacts

Extensive statistical studies have demonstrated that large-scale wind energy facilities do not substantially affect the value of adjoining or abutting property. The Massachusetts Clean Energy Center published a report in January 2014 entitled *Relationship between Wind Turbines and Residential Property Values in Massachusetts*. This study analyzed more than 122,000 home sales near the current or future location of a wind farm in Massachusetts and found no net effect on prices attributed to the proximity of the dwelling to the wind energy project. Jennifer Hinman at Illinois State University completed a study based on 3,851 property transactions over a 9-year period near a 240-turbine wind energy facility in Illinois. This study, entitled *Wind Farm Proximity and Property Values: A Pooled Hedonic Regression Analysis of Property Values in Central Illinois* found a negative location effect on property values before the wind farm was approved, a concept known as anticipation stigma, but the study found that property values rebounded to levels higher in real terms than before the wind farm was approved (Hinman, 2010).

In 2009, the Ernest Orlando Lawrence Berkeley National Laboratory published a study entitled *The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis* (see Appendix P). This study analyzed data from approximately 7,500 sales of single-family homes within 10 miles of 24 existing wind facilities in nine different states and found "no evidence… that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities." The author of this study, Ben Hoen, completed a second study on this topic at the Ernest Orlando Lawrence Berkeley National Laboratory in 2013 entitled *A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States* (see Appendix Q). This study is based on more than 50,000 home sales within 10 miles of 67 different wind facilities in 27 states, and found "no statistical evidence that home prices near wind turbines were affected in either the post-construction or post-announcement/pre-construction periods."

In the Crocker Wind Farm, LLC docket, EL17-055, appraiser Mike MaRous completed a study evaluating the potential impact of an up to 400-MW wind farm on residential and agricultural land values. Mr. MaRous investigated property sales in six South Dakota counties where more than 25 turbines were operational, conducted a paired sales analysis, and concluded that there was no market evidence that proximity to a turbine would adversely impact land values [Rebuttal Testimony of Mike MaRous and Market Impact Analysis (April 13, 2018) and Sur-Surrebuttal Testimony of Mike MaRous (May 9, 2018)].

20.2 Commercial, Industrial, and Agricultural Sectors

No commercial or industrial sectors occur within the Project Area. The existing agricultural sector within the Project Area is described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

20.2.1 Existing Agricultural Sector

The Project Area is predominantly agricultural, consisting of a mix of cropland, rangeland, and pastureland. No commercial or industrial land uses are located within the Project Area. In 2012, Charles Mix County's 759 farms (totaling 692,319 acres of land) produced $227.9 million in agricultural products (USDA, 2012a). Fifty-five percent was from livestock sales, and 45 percent was crop sales. Turkeys were the top livestock inventory item in the county, and soybeans (for beans) was the top crop in terms of acreage. Charles Mix County ranked 14 out of the 66 South Dakota counties in total value of agricultural products sold (USDA, 2012a).

In 2012, Bon Homme County's 651 farms (totaling 351,596 acres of land) produced nearly $107.9 million in agricultural products (USDA, 2012c). Sixty-two percent was from livestock sales, and 38 percent was crop sales. Cattle and calves were the top livestock inventory item in the county, and soybeans (for beans) was the top crop in terms of acreage. Bon Homme County ranked 43 out of the 66 South Dakota counties in total value of agricultural products sold (USDA, 2012c).

In 2012, Hutchinson County's 802 farms (totaling 513,352 acres of land) produced $186.2 million in agricultural products (USDA, 2012d). Sixty-two percent was from livestock sales, and 38 percent was crop sales. Turkeys were the top livestock inventory item in the county, and soybeans (for beans) was the top crop in terms of acreage. Charles Mix County ranked 20 out of the 66 South Dakota counties in total value of agricultural products sold (USDA, 2012a).

20.2.2 Agricultural Impacts

Minimal existing agricultural land would be taken out of crop and forage production by the proposed Project, primarily the area around wind turbine foundations, access roads, and electric collection and interconnection facilities. Landowners would be compensated by the Applicant for losses to crop production during construction. Agricultural activities can occur up to the edge of access roads and turbine pads. The buried underground collection system would not alter agricultural activities.

Approximately 676 acres of agricultural land (including cropland and grassland) and 58 acres of non-agricultural land would be temporarily impacted by Project construction. It is estimated that approximately 41 acres of agricultural land and 4 acres of non-agricultural land would be impacted during the life of the Project, which constitutes less than 0.1 percent of the total land within the Project Area. Areas disturbed due to construction and that would not host permanent Project facilities would be re-vegetated with vegetation types matching the surrounding agricultural landscape.

20.3 Community Facilities and Services

The existing community facilities and services within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

20.3.1 Existing Community Facilities and Services

The majority of community facilities and services (hospitals, police, fire and ambulance services, schools, churches, and parks and recreational facilities) near the Project Area are located in the nearby towns identified in Table 20-1. Two cemeteries are located within the Project Area, and one church is located outside the Project Area, approximately 0.25 mile east (Figure 10).

Electrical service in the Project Area is provided by Charles Mix Electric, Bon Homme Yankton Electric, and Southeastern Electric Cooperative. The B-Y Water District supplies rural water to the Project Area and maintains a network of distribution lines within the Project Area.

20.3.2 Community Facilities and Services Impacts/Mitigation

Existing social services should be adequate to support the workforce during construction. The Project is not likely to increase the need for public services, including police and fire protection, due to the short-term duration of the construction activities. No significant increase in permanent population of local communities would be expected from construction and operation of the facility, and the construction workforce would not create any measurable impact to the local government, utilities, or community services.

20.3.3 Emergency Response

The proposed wind farm is located within a rural portion of Bon Homme, Charles Mix and Hutchinson counties. During the Project construction period and during subsequent operation, it is expected that the Project would have no significant impact on the security and safety of the local communities and the surrounding area. Some additional risk for worker or public injury may exist during the construction phase, as it would for any large construction project. However, work plans and specifications would be prepared to address worker and community safety during Project construction. During Project construction, the Project's general contractor would identify and secure all active construction areas to prevent public access to potentially hazardous areas.

During Project construction, the Project contractor would work with local and county emergency management to develop procedures for response to emergencies, natural hazards, hazardous materials incidents, manmade problems, and potential incidents concerning Project construction. The contractor would provide site maps, haul routes, Project schedules, contact numbers, training, and other requested Project information to local and county emergency management.

During Project operations, the Project operator would coordinate with local and county emergency management for the purpose of protecting the public and the property related to the Project during natural, manmade or other incidents. The Project would register each turbine location and the O&M building with the rural identification/addressing (fire number) system and 911 systems.

20.4 Transportation

The existing transportation resources within the Project Area are described below, followed by a discussion of the potential effects of the proposed Project and mitigation and minimization measures.

20.4.1 Existing Transportation

This section describes the existing surface transportation and aviation within the Project Area.

20.4.1.1 Surface Transportation

Table 20-3 lists the major roads that intersect the Project Area. The primary access to the Project Area is via U.S. Highway 18 and South Dakota State Highways 50, 46, and 37 (Figure 1 in Appendix A). The U.S. Highway as well as all three State highways are paved. Secondary access to turbine locations would be via existing county and township gravel roads. Paved county roads would be avoided wherever possible due to their light construction. Roads would be assessed for strength and condition prior to construction, and the condition of the roads would be documented through high-resolution video prior to construction. County and township gravel roads determined to be insufficient for construction use would be upgraded and strengthened prior to construction, at the Project’s expense. County and township gravel roads would be maintained by the Project’s contractor during construction, at the Project’s expense. Paved roads would be returned to preconstruction or better condition if damage occurs. The Project would enter into Road Use Agreements with each road authority to define use and restoration of roads utilized during construction of the Project.

Table 20-3: Project Area Roads

Road	Surface Type	Surface Width	Total Lanes
U.S. Highway 18	Paved asphalt	24 feet	2
State Highway 50	Paved asphalt	24 feet	2

Road	Surface Type	Surface Width	Total Lanes
State Highway 46	Paved asphalt	24 feet	2
State Highway 37	Paved asphalt	24 feet	2
Secondary County roads	Gravel or crushed rock / Bituminous	20 to 22	2
Secondary Township roads	Gravel or crushed rock	16 to 20	2

Source: South Dakota Department of Transportation (SDDOT), 2016

In 2016, Average Daily Traffic (ADT) volume was 1,246 trips along State Highway 50 through the Project Area, and 780 trips along State Highway 46. ADT along 292nd Street through the Project Area was 113 (collected in 2015), and ADT along 401st Avenue was not available (SDDOT, 2016).

20.4.1.2 Aviation

There are no airports located within the Project Area. The closest airport is Wagner Municipal Airport, which is a public airport located in Wagner, South Dakota, approximately 7 miles west of the Project Area. The closest private airport to the Project Area is the Plihal Farms airstrip, located near Tyndall, South Dakota, approximately 6 miles southeast of the Project Area. The nearest U.S. air military installation is Offutt Air Force Base, located approximately 170 miles southeast of the Project Area (U.S. Air Force, 2016). The nearest South Dakota National Guard Air National Guard installation is the 114th Fighter Wing, located approximately 68 miles northeast of the Project Area at Joe Foss Field Base, in Sioux Falls, South Dakota. The Project would be located inside and adjacent to the boundaries of the Lake Andes Military Operations Area, but below the operating floor of 6,000 feet AMSL.

20.4.2 Transportation Impacts/Mitigation

This section addresses the potential impacts of the proposed Project on ground transportation and air traffic.

20.4.2.1 Ground Transportation

The Project Area contains one two-lane paved U.S. Highway, three two-lane paved State Highways, three two-lane paved county roads, and several county and township roads. During construction, it is anticipated that several types of light, medium, and heavy-duty construction vehicles would travel to and from the site, as well as private vehicles used by the construction personnel. The movement of equipment and materials to the site would cause a relatively short-term increase in traffic on local roadways during the construction period. Most equipment (e.g., heavy earthmoving equipment and cranes) would remain at the site for the duration of construction activities. Shipments of materials, such as gravel, concrete, and water would not be expected to substantially affect local primary and secondary road networks. That volume would occur during the peak construction time when the majority of the foundation and tower assembly is taking place. At the completion of each construction phase, this equipment would be removed from the site or reduced in number.

The Project would not result in any permanent impacts to the area's ground transportation resources. There would be improvements to most gravel roads and temporary impacts to local roads during the construction phase of the Project. The Applicant would work with each county and township on road use agreements during the permitting process so that all parties understand how the Project would proceed prior to construction starting. Within the Project Area, oversized and overweight loads would be strictly confined to roads designated in a road use agreement. The Applicant would work with SDDOT; Charles Mix, Bon Homme and Hutchinson counties; and Choteau Creek and Lone Tree townships to obtain the appropriate access and use permits, and to reduce and mitigate the impacts to area transportation. The Application would be responsible for road repairs.

20.4.2.2 Air Traffic

The air traffic generated by the airports listed above would not be impacted by the proposed Project. The Applicant would follow FAA guidelines for marking towers and would implement the necessary safety lighting. Notification of construction and operation of the wind energy facility would be sent to the FAA, and steps would be taken to comply with FAA requirements. The FAA considers all structures above 499 feet (above ground level) to be obstructions until they have received feedback from the aviation community and completed aeronautical studies. If the aviation community and studies do not bring up any adverse impacts to aviation, the FAA will then issue Determinations of No Hazard on structures above this height.

The Applicant filed Notices of Proposed Construction (Form 7460-1) with the FAA for all wind turbines and permanent meteorological tower(s) locations. The total turbine heights of both turbine models exceeded 499 feet[8]. Prevailing Wind Park submitted Notices of Proposed Construction for an assumed turbine height of 590 feet. In accordance with its requirements for structures of this height, the FAA on May 17, 2018, issued a public notice advising that it is undertaking an aeronautical study (Appendix T). The study will include all 63 proposed representative turbine sites.[9] The notice provided a comment period through June 23, 2018. The notice further stated:

> *Preliminary FAA study indicates that the above-mentioned structure would:*

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[8] The GE 3.8-137 is 586 +/-4 feet, and the Vestas 136-3.6 is 568 +/-3 feet.

[9] At the time of the FAA Notice of Proposed Construction, the Project included turbine location 59 which is no longer being proposed.

- *have no effect on any existing or proposed arrival, departure, or en route instrument flight rules (IFR) operations or procedures.*
- *not exceed traffic pattern airspace.*
- *have no physical or electromagnetic effect on the operation of air navigation and communications facilities.*
- *have no effect on any airspace and routes used by the military.*

The Applicant would also file Tall Structures Aeronautical Hazard Applications with the South Dakota Aeronautics Commission for a permit approving the proposed wind turbines and permanent meteorological tower(s) locations.

Air traffic may be present near the Project Area for crop dusting of agricultural fields. Crop dusting is typically carried out during the day by highly maneuverable airplanes or helicopters. The installation of wind turbine towers in active croplands and installation of aboveground collector and transmission lines would create potential hazards for crop-dusting aircraft. However, aboveground collection and transmission lines are expected to be similar to existing distribution lines (located along the edges of fields and roadways), and the turbines and meteorological tower(s) themselves would be visible from a distance and lighted and marked according to FAA guidelines.

20.5 Cultural Resources

The following sections provide information on the cultural resources potentially affected by the construction, operation, and maintenance of Project facilities and how impacts to these resources will be avoided and/or minimized.

20.5.1 Existing Cultural Resources

The Applicant conducted a Level I Cultural Resources Records Search for the Project Area and 1-mile buffer (“Study Area”) in April 2018 (Appendix R). HDR, Inc. (HDR) contacted the South Dakota Archaeological Research Center (SDARC) to acquire data for previously recorded archaeological sites and surveys, bridges, cemeteries, structures, and miscellaneous cultural features within the Project’s cultural resources study area. In addition to examining the SDARC files, HDR also reviewed General Land Office (GLO) maps.

The cultural resources record search identified 24 cultural resources surveys within the Study Area (Table 2 and Figures 2.1–2.11 in the Literature Search Memo [Appendix R]). These surveys included investigations for a mortuary study, private land parcels, proposed home sites, shelterbelts, community building installations, bridge replacements, underground telephone lines, fiber optic lines, microwave facilities, water lines and pumping stations, and a wind farm and associated components.

SDARC’s files revealed 11 previously identified archaeological sites within the Study Area (Table 3 and Figures 2.1–2.11 in Appendix R). Sites include one school foundation, one railroad segment, one historic foundation and dump, one dump, one farmstead and Euro-American artifact scatter, two Euro-American burials, two precontact artifact scatters, and two precontact isolated finds. One site, a railroad segment (39BO2007), is considered eligible for the NRHP. The remaining sites have been determined not eligible or have not been evaluated.

SDARC’s files revealed 27 previously inventoried architectural structures within the study area (Table 4 and Figures 2.1–2.11 in Appendix R). These structures may be associated with as yet unrecorded districts, defined by the NRHP as a concentration of historic buildings, structures, sites, or objects united historically or aesthetically by plan or physical development (NPS, 1997:12). In rural South Dakota, structures associated with districts are usually part of farmsteads with multiple buildings.

Structures identified during the records search include school buildings, individual homes, and farmsteads. Of the 27 previously inventoried architectural structures, one structure (CH00000024) is eligible for the NRHP. Structure CH00000024 is the Wagner House (a.k.a., The Ferdinand Wagner & Ann Homestead), constructed in 1919. This structure is an excellent example of the Craftsman style and is eligible under Criterion C (“That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction”). Of the remaining 26 structures, 3 are determined not eligible and 23 are unevaluated.

The files provided by SDARC revealed the presence of seven previously inventoried cemeteries within the study area (Table 5 and Figures 2.1–2.11 in Appendix R). One of the seven previously inventoried cemeteries is determined not eligible for the NRHP and the remaining cemeteries have not been evaluated.

The files provided by SDARC revealed the presence of 20 previously inventoried bridges within the study area (Table 6 and Figures 2.1–2.11 in Appendix R). Of the 20 previously inventoried bridges, 2 are determined eligible for the NRHP (BO00000248 and CH00000261). The remaining 18 bridges are not eligible for the NRHP.

This information from the Literature Review (Appendix R) was used to develop a Geographic Information System-based (GIS-based) construction guidance grid (construction grid) (Appendix S). The purpose of the construction grid was to assist the Applicant with siting facilities in areas that have a lower likelihood for containing intact cultural resources. The construction grid also identifies areas that have a higher likelihood for containing intact cultural resources eligible for listing on the NRHP, including Traditional Cultural Properties (TCPs).

The cultural resources study area includes 245 Public Land Survey Section (PLSS) Sections, and a PLSS quarter-section layer was used as the base for the construction grid layout. In total, 980 quarter-sections were reviewed and assigned an alphanumeric attribute based on the presence or absence of previously identified cultural resources from the SDARC datasets, cultural features identified on GLO maps, and land use. Of the 980 quarter-sections, 41 were coded as Red (Area of Caution), 365 were coded as Yellow (Area of Concern), and 574 were coded as Green (Area of Minimal Concern) (Figures 2.1 and 2.2 of the Construction Grid Memo in Appendix S).

20.5.2 Cultural Resource Impacts/Mitigation

The Applicant used the results of the cultural resources Construction Grid analysis to inform siting of Project facilities. No Project facilities, including temporary disturbance during construction, are located in areas identified as Red (Area of Caution) on the Construction Grid.

As part of the NEPA process for approval of the WAPA interconnection, the Project will require compliance with Section 106 of the National Historic Preservation Act of 1966, as amended. As such, the Applicant is coordinating with WAPA to determine the most appropriate inventory strategy for the Project. WAPA is consulting with SHPO and interested tribes as part of the Section 106 compliance process.

The Applicant will conduct a Level III Archaeological Survey for all areas that will be physically impacted by the Project beginning in June 2018. These areas may include but are not limited to the proposed footprint of the turbines, substation, temporary work areas, staging areas, access roads, and cable routes. In accordance with WAPA requirements, the following minimum survey parameters will be followed:

- 250-foot radius from the center point of turbine locations
- 100-foot-wide corridor for collector lines and access roads
- Footprint of any building, laydown/staging areas, batch plant, etc. plus 200 feet

In addition to a Level III Archaeological Survey, the Applicant will conduct a Historic Architectural Resources Reconnaissance Survey using a 2-mile area of potential effect. The Historic Architectural Resources Reconnaissance Survey will focus on locating standing historic-era structures to assess the visual impacts of the Project on their integrity of setting.

All work will be conducted in accordance with the South Dakota Guidelines for Cultural Resource Surveys and Survey Reports (South Dakota State Historical Society, 2005), South Dakota Historic Resource Survey Manual (Rogers et al., 2006), and the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (National Park Service, 1983).

For cultural resources identified during the surveys, a recommendation of NRHP-eligibility of the resource will be made. Sites determined to be NRHP-eligible will be avoided by the Project. If avoidance is not practicable, the Applicant will work with WAPA and SHPO to develop appropriate minimization or mitigation measures.

21.0 EMPLOYMENT ESTIMATES (ARSD 20:10:22:24)

ARSD 20:10:22:24. Employment estimates. *The application shall contain the estimated number of jobs and a description of job classifications, together with the estimated annual employment expenditures of the applicants, the contractors, and the subcontractors during the construction phase of the proposed facility. In a separate tabulation, the application shall contain the same data with respect to the operating life of the proposed facility, to be made for the first ten years of commercial operation in one-year intervals. The application shall include plans of the applicant for utilization and training of the available labor force in South Dakota by categories of special skills required. There shall also be an assessment of the adequacy of local manpower to meet temporary and permanent labor requirements during construction and operation of the proposed facility and the estimated percentage that will remain within the county and the township in which the facility is located after construction is completed.*

As discussed in Section 20.1.2.1, the Project is expected to employ approximately 245 temporary workers at the peak of construction to support Project construction. It is likely that general skilled labor is available in Bon Homme, Hutchinson, or Charles Mix counties, or the State to serve the basic infrastructure and site development needs of the Project. Specialized labor will be required for certain components of Project construction. It is likely that this labor will be imported from other areas of the State or from other states, as the relatively short duration of construction makes special training of local or regional labor impracticable.

The estimated number of construction jobs by classification and annual employment expenditures during construction are included in Table 21-1; however, the number of jobs during the peak of construction may be higher.

Table 21-1: Anticipated Construction Jobs and Employment Expenditures

Job Classification	Number	Estimated Annual Salary
Crane operators	8	$90,000
Civil workers	50	$85,000
Construction managers	6	$110,000
Collection workers	12	$65,000
Tower erectors	72	$75,000
Transmission workers	12	$75,000
Substation workers	12	$80,000
Foundation workers	24	$70,000
Testing & inspections	12	$85,000
Design engineers	10	$140,000
Total:	**218**[a]	**$17,770,000**

(a) There may be as many as 245 workers during the peak of construction.

The estimated number of jobs by classification and annual employment expenditures during operation are included in Table 21-2. Annual employment expenditures are anticipated to be the same for each of the first 10 years of commercial operation.

Table 21-2: Anticipated Operation Jobs and Employment Expenditures

Job Classification	Number	Estimated Annual Salary
Facility managers	1	$80,000
Wind turbine technicians	6	$70,000
Operators	1	$65,000
Administrative	1	$35,000
Total:	**9**	**$600,000**

22.0 CUMULATIVE EFFECTS

Sections 10.0 through 15.0 and Sections 17.0, 18.0, and 20.0 provide a description of the potential environmental effects of Project construction and operation. Following is a discussion of the environmental effects which may be cumulative or synergistic consequences of siting the proposed facility in combination with any operating energy conversion facilities, existing or under construction.

One existing wind energy facility, the 80-MW Beethoven Wind Project, is located adjacent to the proposed Prevailing Wind Park Project Area. Although Beethoven Wind Project is technically excluded from the cumulative effects analysis because it generates fewer than 100 MW, the Applicant has chosen to include it here due to its proximity to the Prevailing Wind Park Project Area.

The construction and operation of the proposed Project, in combination with operation of the existing Beethoven Wind Project, could contribute to cumulative effects on environmental resources in the area. For purposes of the cumulative effects analysis, the information provided in Table 22-1 is assumed for the Beethoven Wind Project.

Table 22-1: Beethoven Wind Project Information

Location	Bon Homme, Hutchinson, and Charles Mix Counties
Owner	NorthWestern Energy
Total capacity	80 MW
Turbine model and size	GE 1.85-MW
Number of turbines	43
Hub height	80 meters
Rotor diameter	87 meters
Estimated total project area	8,300 acres
Estimated total length of access roads	44,000 feet
Estimated total length of collector lines	91,000 feet
Estimated total operational ground disturbance acreage	25 acres
Commercial operation date	May 2015
Estimated life of project	25 to 30 years

The Prevailing Wind Park Project, in combination with the 80-MW Beethoven Wind Project, would result in the construction and operation of up to 104 wind turbines and associated access roads, collector lines, and other facilities in Bon Homme, Hutchinson, and Charles Mix counties. The projects would result in an estimated 70 acres of cumulative ground disturbance during the life of the projects. This disturbance acreage represents less than 0.2 percent of the combined acreage of both project areas.

As discussed in this Application, impacts to the physical environment, hydrologic resources, terrestrial and aquatic ecosystems, and socioeconomic and community resources have been avoided or minimized during the siting and design of the Project. Furthermore, implementation of the mitigation measures identified in this Application would minimize potential impacts of the Project on all resources. Therefore, the cumulative effects of siting the proposed Project in combination with the Beethoven Wind Project on resources within Bon Homme, Hutchinson, and Charles Mix counties are not expected to be significant.

23.0 FUTURE ADDITIONS AND MODIFICATIONS (ARSD 20:10:22:25)

ARSD 20:10:22:25. Future additions and modifications. *The applicant shall describe any plans for future modification or expansion of the proposed facility or construction of additional facilities which the applicant may wish to be approved in the permit.*

No future additions and modifications are anticipated. Prevailing Wind Park does request the turbine location flexibility and other facility flexibility specified in Section 8.1.

24.0 DECOMMISSIONING OF WIND ENERGY FACILITIES (ARSD 20:10:22:33.01)

ARSD 20:10:22:33.01. Decommissioning of wind energy facilities -- Funding for removal of facilities. *The applicant shall provide a plan regarding the action to be taken upon the decommissioning and removal of the wind energy facilities. Estimates of monetary costs and the site condition after decommissioning shall be included in the plan. The commission may require a bond, guarantee, insurance, or other requirement to provide funding for the decommissioning and removal of a wind energy facility. The commission shall consider the size of the facility, the location of the facility, and the financial condition of the applicant when determining whether to require some type of funding. The same criteria shall be used to determine the amount of any required funding.*

The Applicant has entered into long-term lease and easement agreements for placement of the wind turbines and associated Project infrastructure with private landowners within the Project Area. The Applicant anticipates that the life of the Project would be approximately 30 years but reserves the right to extend the life of the Project as well as explore alternatives regarding Project decommissioning. One such option may be to retrofit the turbines and power system with upgrades based on new technology, which may allow the wind farm to produce efficiently and successfully for many more years.

The Project will be decommissioned in accordance with applicable State and County regulations. Current decommissioning requirements in Bon Homme County require that all towers, turbine generators, transformers, overhead collector and feeder lines, foundations, buildings, and ancillary equipment be dismantled and removed to a depth of 4 feet. To the extent possible, the site shall be restored and reclaimed to its pre-project topography and topsoil quality. All access roads shall be removed unless written approval is given by the landowner requesting roads be retained.

The Applicant estimates that the costs of decommissioning will be in the magnitude of the estimate provided for the up to 72-turbine Dakota Range Wind Project. The Dakota Range Wind Project developer estimated the cost per turbine (no resale) to be $38,900 per turbine. The Applicant has commissioned DNV-GL to provide a decommissioning plan with a cost estimate, which will be submitted to the SDPUC for review shortly after this application is submitted. The decommissioning plan will address the following activities:

- The Project will be decommissioned in accordance with applicable State and County regulations.
- Removal and salvage of turbines
- Removal of turbine foundations
- Removal and salvage of substation components
- Removal and salvage of aboveground components of 34.5-kV collection system
- Removal and salvage of below grade components of collection system foundations

- Removal and salvage of interconnection facilities
- Removal of access roads
- Removal of crane pad(s)
- Restoration and reclamation of the site

Prevailing Wind Park will restore and reclaim the site to its pre-Project topography and topsoil quality using BMPs consistent with those outlined by the 2012 USFWS Land-Based WEG. The goal of decommissioning will be to restore natural hydrology and plant communities to the extent practicable while minimizing new disturbance and removal of native vegetation. The decommissioning BMPs that will be employed on the Project to the extent practicable with the intent of meeting this goal include:

- Conduct survey, using qualified experts, to detect populations of invasive species, and implement and maintain comprehensive approaches to preventing and controlling invasive species as necessary.
- Remove any unnecessary overhead electrical lines and associated poles.
- After decommissioning, install erosion control measures in all disturbance areas where potential for erosion exists, consistent with storm water management objectives and requirements.
- Remove fencing unless the landowner requests it stay.
- Remediate any petroleum product leaks and chemical releases prior to completion of decommissioning. Decommissioning and restoration activities will be completed within 12 months after the date the Project ceases to operate.

25.0 RELIABILITY AND SAFETY (ARSD 20:10:22:33.02)

The following sections discuss the reliability and safety of the wind farm facility.

25.1 Reliability

Reliability (availability) is defined as the ability of the turbine to generate electricity when sufficient wind is available. GE has over 35,000 wind turbines (60 GW) currently installed globally. GE's current turbine availability rate is 98 percent. Vestas has installed over 3,500 of their 3MW Platform wind turbines globally. Their 3MW Platform global turbine availability has increased from just under 84 percent to just under 98 percent from the beginning of 2014 to week 13 of 2017. Turbine availability is now greater than 98 percent for their 3MW Platform. To further provide for reliability and to protect the Project financially, sPower requires availability guarantees from turbine manufacturers and O&M service providers to maintain the turbine at 98 percent availability or higher. If the turbine manufacturers and O&M service providers fail to maintain the required level of availability, then the turbine manufacturers and O&M service providers are required to pay a project liquidated damages for the lost revenue from lost energy production. Typically, the turbine manufacturer maintains the turbine for the first 2 years, then the turbines are maintained under O&M service contracts with terms of 5 or 10 years.

To further improve reliable operation of the region's power grid, wind energy projects are required to provide short-term forecasts of wind speed and energy that would be produced. Accurately anticipating weather conditions lets wind energy project owners and operators get the most out of the facilities. Transmission system operators need to know how much energy wind facilities can deliver and when to dispatch generators on the system to match load to generation. Typically, wind projects provide a next-day, next-hour, and next-15 minutes forecast, updated every 15 minutes to the off-taker, balancing authority, and/or regional transmission operator. These predictions of energy generation through in-depth, site-specific weather forecasting are used to integrate wind energy into the region's power grid and to schedule turbine and transmission maintenance windows, improving overall reliability.

25.2 Safety

The Project Area is located in an area of low population density. Construction and operation of the Project would have minimal impacts on the security and safety of the local population. The following safety measures would be taken to reduce the chance of physical and property damage, as well as personal injury, at the site:

- The towers would be placed at distances away from existing roadways and residences per the applicable planned setback requirements described in Section 9.2

- Security measures would be implemented during the construction and operation of the Project, including temporary (safety) and permanent fencing, warning signs, and locks on equipment and wind power facilities
- Turbines would sit on solid steel enclosed tubular towers; access to each tower would be only through a solid steel door that would be locked and accessed only by authorized personnel
- Tower exteriors would be designed to be unclimbable
- Turbines would conform to applicable industry standards
- A professional engineer would certify that the foundation and tower design of the turbines is within accepted professional standards, given local soil and climate conditions

26.0 INFORMATION CONCERNING WIND ENERGY FACILITIES (ARSD 20:10:22:33.02)

ARSD 20:10:22:33.02. Information concerning wind energy facilities. *If a wind energy facility is proposed, the applicant shall provide the following information:*

(1) Configuration of the wind turbines, including the distance measured from ground level to the blade extended at its highest point, distance between the wind turbines, type of material, and color;
(2) The number of wind turbines, including the number of anticipated additions of wind turbines in each of the next five years;
(3) Any warning lighting requirements for the wind turbines;
(4) Setback distances from off-site buildings, right-of-ways of public roads, and property lines;
(5) Anticipated noise levels during construction and operation;
(6) Anticipated electromagnetic interference during operation of the facilities;
(7) The proposed wind energy site and major alternatives as depicted on overhead photographs and land use culture maps;
(8) Reliability and safety;
(9) Right-of-way or condemnation requirements;
(10) Necessary clearing activities;
(11) Configuration of towers and poles for any electric interconnection facilities, including material, overall height, and width;
(12) Conductor configuration and size, length of span between structures, and number of circuits per pole or tower for any electric interconnection facilities; and
(13) If any electric interconnection facilities are placed underground, the depth of burial, distance between access points, conductor configuration and size, and number of circuits.

The following information requirements concerning wind energy facilities have been discussed in previous sections of this Application, as indicated below.

- Configuration of wind turbine – Section 8.2 and Appendix A, Figure 3
- Number of wind turbines – Section 8.1
- Warning lighting requirements for wind turbines – Section 20.4.2.2
- Setback distances – Section 9.2
- Sound levels during construction and operation – Section 15.3.4
- Electromagnetic interference – Section 15.6
- Site and major alternatives – Section 9.0 and Appendix A, Figures 2 and 4
- Reliability and safety – Section 25.0
- Right-of-way or condemnation requirements – Sections 8.0 and 9.3
- Clearing activities – Sections 8.0 and 13.1.2
- Configuration of interconnection towers and poles – Section 8.7
- Conductor and structure configurations – Section 8.7
- Underground electric interconnection facilities – Section 8.7

Please refer to the Completeness Checklist (ARSD 20:10:22:33.02, Information concerning wind energy facilities) at the beginning of this application for additional requirement details.

27.0 ADDITIONAL INFORMATION IN APPLICATION (ARSD 10:22:36)

The following sections discuss permits and approvals, agency coordination, public and agency comments, and burden of proof.

27.1 Permits and Approvals

The Project must comply with Federal, State, and local laws requiring permits or approvals. Table 27-1 lists the permits and approvals that are anticipated as part of the Project.

Table 27-1: List of Potential Permits or Approvals

Agency	Permit/Approval	Description	Status
WAPA	NEPA compliance	EA required for interconnection to WAPA transmission line	To be completed prior to approval of interconnection agreement
USFWS	Threatened and endangered species – Section 7 compliance	Determination of effect on federally listed species	To be completed in conjunction with WAPA EA
FAA	Form 7460-1, Notice of Proposed Construction or Alteration	Required if construction or alteration is within 6 miles of public aviation facility and for structures higher than 200 feet	Will be completed after final design is complete
USACE	Section 404 permit	Complete an application under the Clean Water Act for impacts to wetlands and waters of the U.S.	Unlikely, but to be determined once layout is finalized
South Dakota SHPO	Section 106 consultation	Determination of effect on archaeological and historical resources	To be completed in conjunction with EA
WAPA	Section 106 consultation with Native American tribes	Determination of effect on Native American cultural resources	To be completed in conjunction with EA
SDPUC	Energy Facility Site Permit	Application required for wind facilities with nameplate capacity greater than 100 megawatts	Submitted May 2018
SDGFP	Coordination	Voluntary coordination regarding wildlife	Ongoing
SDDENR	401 Water Quality Certification	Complete an application under the Clean Water Act, only if Individual Permit is required for Section 404	Not anticipated unless individual Section 404 permit is needed from USACE

Agency	Permit/Approval	Description	Status
	General Permit for Storm Water Discharges Associated with Construction Activities (NPDES)	Storm water permit required for construction activities	SWPPP will be prepared and Notice of Intent will be submitted after final design is complete
	Temporary Water Use Permit	Temporary permits for the use of public water for construction, testing, or drilling purposes; issuance of a temporary permit is not a grant of water right	If necessary, will be obtained prior to construction
	General Permit for Temporary Discharges	Temporary permit for the use of public water for construction dewatering	If necessary, will be obtained prior to construction
	Water Rights Permit for Nonirrigation Use	Needed if water will be appropriated for O&M facility	If necessary, will be obtained prior to construction
SDDOT, Aeronautics Commission	Aeronautical Hazard Permit	Permit lighting plan determined with FAA coordination	Will be completed after final design is complete
SDCL 49-32-3.1	Notice to telecommunications companies	Telecommunication companies review the preliminary electrical layout and may suggest revisions to reduce impact to their systems	Ongoing
SDDOT	Highway Access Permit	Permit required for any access roads abutting State roads	If necessary, will be obtained after final design is complete
	Utility Permit	Permit required for any utility crossing or use within State road right-of-way	If necessary, will be obtained after final design is complete
	Oversize & Overweight Permit	Permit required for heavy equipment transport over State roads during construction	Will be obtained prior to construction
Bon Homme County	Large Wind Energy System Permit	Permit required for construction of the Project	Will be obtained prior to construction
	Individual Building Permits	Permit required for construction of each turbine and building	Will be obtained prior to construction
Charles Mix County	Individual Building Permits	Permit required for construction of each turbine and building	Will be obtained prior to construction
Hutchinson County	Conditional Use Permit	Permit required for construction of the Project	Will be obtained prior to construction
	Individual Building Permits	Permit required for construction of each turbine and building	Will be obtained prior to construction

Agency	Permit/Approval	Description	Status
Counties and Townships	Road use and utility permits	Required for use and crossing of roads	Will be obtained prior to construction

27.2 Agency Coordination

Throughout Project planning and development, the Applicant and its predecessor, Prevailing Winds, LLC, have coordinated with various Federal, State, and local agencies and governmental authorities to identify potential concerns regarding the proposed Project. A summary of agency comments and coordination efforts are provided below.

27.2.1 USFWS and SDGFP

Prevailing Wind Park and its predecessor, Prevailing Winds, LLC, have coordinated closely with the USFWS and SDGFP through meetings, conference calls, electronic communications and site visits. The primary topics of these coordination efforts are summarized below, and Prevailing Wind Park provides a response to each such topic below and elsewhere (where noted) in this Application.

- USFWS easements: As discussed in Section 15.2.1, three wetland easements and two grassland conservation easements managed by USFWS Lake Andes NWR are within the Project Area. Additionally, two WPAs managed by the USFWS Lake Andes Wetland Management District are located within the Project Area. To determine the exact locations of these properties, Prevailing Winds, LLC and Prevailing Wind Park coordinated with the USFWS Lake Andes Complex to obtain grassland and wetland easement and WPA data, coordinate field reviews, and review various iterations of the Project design. The proposed configuration avoids USFWS wetland and grassland easements and WPAs and incorporated USFWS design suggestions to the extent practicable.
- Birds of Conservation Concern, Other Grassland Birds, and Related Native Grassland and Wetland Habitat Concerns: Primary threats to Birds of Conservation Concern in South Dakota include habitat loss and fragmentation. The agencies recommend avoidance, minimization, and if necessary, mitigation to reduce impacts to these species and habitat types. Prevailing Wind Park has adjusted the Project layout to avoid native grasslands, wetlands, and other habitats within the Project Area to the extent practicable. Section 13.4 and the BBCS discuss Birds of Conservation Concern and contain additional details about avoidance and minimization measures.
- Bald Eagles: Bald eagle use and nest monitoring surveys were completed in 2015 and 2016; an aerial nest survey was conducted in 2016. There are no bald eagle nests located within the Project

Area, and bald eagle use monitoring data suggests low use within the Project Area. The nearest active eagle nest is located approximately 0.5 mile from the Project Area. Additional data collected in connection with the nearby Beethoven Wind Project further supports these findings.

- NLEB: Acoustic presence/absence surveys for the NLEB were conducted in 2015 and 2016. During the 2015 surveys, the NLEB was qualitatively verified as occurring at two acoustical survey stations. Based, in part, on the results of the 2015 survey, the Project Area was shifted to the north and away from suitable woodland habitat located primarily along the Missouri River. During the 2016 surveys, no NLEB calls were recorded at the monitoring locations, which included one site in the southwest portion of the Project Area where an NLEB was recorded in 2015. The wind turbine located closest to this monitoring location is approximately 0.25 mile to the southeast. Prevailing Wind Park will comply with applicable avoidance, minimization, and mitigation measures specified in the PEIS.
- Whooping Crane. The Project Area is located within the 95 percent migration corridor when considered specific to South Dakota; however, there have been no confirmed whooping crane sightings within the Project Area. Prevailing Wind Park will comply with applicable avoidance, minimization, and mitigation measures specified in the PEIS.

Following is a list of the primary coordination meetings completed to date. Copies of USFWS and SDGFP correspondence are included in Appendix T.

- April 1, 2015: Prevailing Winds. LLC meeting with USFWS, SDGFP, and Western EcoSystems Technology, Inc. (WEST) to introduce agencies to the Prevailing Winds Project, review Tier 1-2 work to date, and discuss scope of planned Tier 3 field surveys.
- April 6, 2015: Prevailing Winds, LLC email communication from SDGFP with a partial list of breeding birds expected in the Project boundary.
- May 14, 2015: Prevailing Winds, LLC meeting with USFWS Lake Andes NWR/WMD staff to introduce Prevailing Winds Project, review work to date and discuss planned field surveys. Discussed and requested USFWS easements within Project Area.
- June 6, 2016: Prevailing Winds, LLC meeting with USFWS, Burns & McDonnell, and WEST to discuss project description, status of SDPUC permit application, status of wildlife surveys completed, and WAPA NEPA process.
- July 14, 2016: Prevailing Winds, LLC site visit with USFWS and SDGFP to tour points of interest in the Project boundary. Presentations were given on ongoing and completed studies

included bat acoustic surveys. The group also visited an active bald eagles nest and the adjacent Beethoven Wind Project.

- March 16–17, 2017: Prevailing Winds, LLC telephone and email communication between WEST and USFWS regarding proposed eagle nest status checks and merits of conducting further avian use surveys.
- May 17, 2017: Prevailing Winds, LLC biology meeting with USFWS, SDGFP, WAPA, Burns & McDonnell, and WEST to discuss wildlife surveys conducted to date.
- June 23, 2017: Email communication between WEST and USFWS regarding bat acoustic study plan.
- December 13, 2017: Prevailing Wind Park meeting with USFWS, SDGFP, WEST and sPower to introduce sPower, and restart permitting and coordination. Issues raised included protection of native grasslands; requirements for compliance with the PEIS regarding northern long-eared bat and whooping crane; and avian use of the Project Area, including bald eagles. No requests were made for additional surveys.
- January 2018: Prevailing Wind Park email communication between USFWS Lake Andes National Wildlife Refuge and sPower regarding USFWS wetland and grassland easements.
- March 16, 2018: Prevailing Wind Park telephone communication between USFWS, SDGFP, and sPower regarding definitions of grasslands.
- March 30, 2018: Prevailing Wind Park email communication between USFWS and sPower regarding pre-construction surveys for rare plants.

27.2.2 WAPA and SHPO

In connection with WAPA’s EA and pursuant to Section 106 of the National Historic Preservation Act of 1966, SHPO’s April 20, 2018, comments addressed the area of potential effects and identification of historic properties. SHPO also noted that it does not have the expertise to recommend an area of potential effects or assess the effects of the proposed Project to places of religious and cultural significance to American Indian tribes and encouraged WAPA to provide opportunities for other consulting parties to provide meaningful input on such matters. WAPA is the lead agency for tribal consultation under Section 106 and is coordinating with tribes regarding their participation in the tribal consultation process. As noted in Section 20.5.2 of this Application, the Applicant is consulting with WAPA to develop the most appropriate cultural resources inventory strategy for the Project and will conduct a Level III Archaeological Survey for all areas that will be physically impacted by the Project and a Historic Architectural Resources Reconnaissance Survey within a 2-mile area of potential effect. For cultural resources identified during the surveys, a recommendation of NRHP-eligibility of the resource will be made. Sites determined to be NRHP-eligible will be avoided by the Project. If avoidance is not practicable, the Applicant will work with WAPA and SHPO to develop appropriate minimization or mitigation measures.

Following is a list of the primary coordination meetings completed to date. Copies of WAPA and SHPO correspondence are included in Appendix T.

- April 27, 2017: Prevailing Winds, LLC EA Kickoff Meeting with WAPA, Prevailing Winds, LLC, Burns & McDonnell, HDR, and WEST to discuss the proposed project, wildlife surveys conducted to date, and status of PUC permit process.
- May 18, 2017: Prevailing Winds, LLC cultural resources meeting with SHPO, Burns & McDonnell, and HDR to discuss Section 106 coordination and survey protocols.
- November 3, 2017: Prevailing Wind Park call with WAPA and Burns & McDonnell to discuss NEPA process.
- February 16, 2018: Prevailing Wind Park call with WAPA, Burns & McDonnell to discuss Section 106 status and survey planning.
- February 28, 2018: Prevailing Wind Park call with WAPA and Burns & McDonnell to discuss status of NEPA process.

27.2.3 Counties

To date, Prevailing Wind Park's correspondence with Bon Homme, Charles Mix, and Hutchinson counties has centered on local permitting requirements and road use agreements – none of the counties have raised significant concerns regarding the Project. Prevailing Wind Park has also met with local officials in each county to discuss the Project. Prevailing Wind Park will apply for local permits beginning in the second quarter of 2018. Discussions regarding road use agreements are ongoing.

Following is a list of the primary coordination meetings completed to date.

- 2015 to October 2017: Prevailing Winds, LLC meetings with Bon Homme County officials numerous times each year to update the county officials on the progress of the Project. Prevailing Winds, LLC met with Charles Mix County officials as the project achieved development milestones to provide updates on the progress of the Project.
- June 1, 2015: Prevailing Winds, LLC conducted a tour of the Crow Lake Wind Farm for local residents and Bon Homme County and Charles Mix County staff and officials.

- December 13, 2017: Prevailing Wind Park meeting with Bon Homme County to introduce sPower and restart the Project permitting.
- March 2018: Prevailing Wind Park email communications between Bon Homme County Zoning Administrator and sPower regarding County permitting requirements for wind energy projects.
- February, March, and April 2018: Prevailing Wind Park email and telephone communications between Hutchinson County and sPower regarding county permitting requirements for wind energy projects.
- March 7, 2018: Prevailing Wind Park telephone and email communications between Charles Mix County Building Permit Administrator and sPower regarding county permitting requirements for wind energy projects.
- April 17, 2018: Prevailing Wind Park attended Bon Homme County Commissioners Meeting to introduce project manager, describe project schedule, and road use agreements.
- April 17, 2018: Prevailing Wind Park telephone communications between Bon Homme County Road Engineer and sPower regarding road use agreements.
- April 17, 2018: Prevailing Wind Park attended Hutchinson County Commissioners Meeting to introduce project manager, describe project schedule, and road use agreements.
- April 17, 2018: Prevailing Wind Park met with Hutchinson County Road Engineer to discuss road use agreements.
- April 19, 2018: Prevailing Wind Park attended Charles Mix County Commissioners Meeting to introduce project manager, describe project schedule, and road use agreements.
- April 19, 2018: Prevailing Wind Park left voice message for Charles Mix County Road Engineer regarding road use agreements.

27.3 Public and Agency Comments

As discussed in Section 9.0, several potential Project sites in South Dakota were considered before the existing site was selected. Prevailing Winds, LLC and the Applicant considered input from agencies and the public in siting the Project Area and in identifying potential turbine locations. Some of the adjustments made during Project siting and design, in response to comments, included:

- Moving the Project away from the Missouri River, where more woodland habitat and higher populations of many plant and animal species, including northern long-eared bats, are present.
- Avoidance of impacts to State and Federal lands within or near Project Area.
- Avoidance of native grasslands, wetlands, and other habitats within or near Project Area to the extent practicable.

- Avoidance of an existing eagle nest located near the Project Area.

27.4 Applicant's Burden of Proof (49-41B-22)

As described in Sections 1.0 through 3.0, the Applicant has addressed the matters set forth in SDCL Chapter 49-41B and in ARSD Chapter 20:10:22 (Energy Facility Siting Rules), related to wind energy facilities.

The Applicant's burden of proof is set forth in SDCL 49-41B-22. The information presented in this Application establishes that:

- The proposed wind energy and transmission facilities would comply with applicable laws and rules
- The facilities would not pose a threat of serious injury to the environment or to the social and economic condition of inhabitants in or near the Project Area
- The facilities would not substantially impair the health, safety, or welfare of the inhabitants
- The facilities would not unduly interfere with the orderly development of the region, having given consideration to the views of the governing bodies of the local affected units of government

28.0 TESTIMONY AND EXHIBITS (ARSD 20:10:22:39)

The Applicant is submitting testimony and exhibits in support of this Application. The individuals identified in Table 28-1 are providing testimony in support of the Application. Prevailing Wind Park reserves the right to provide supplemental and/or rebuttal testimony, as needed, to further support this Application.

Table 28-1: List of Individuals Providing Testimony

Individual	Title	Company	Subject Matter
James Damon	Senior Project Manager	sPower	Project development
Bridget Canty	Permitting Project Manager	sPower	Environmental
Keith Thorstad	President	Thorstad Companies	Construction
Aaron Anderson	Senior Mechanical Engineer	Burns & McDonnell	Shadow flicker
Chris Howell	Senior Noise Specialist	Burns & McDonnell	Noise

28.1 Applicant Verification

Sean McBride, being duly sworn, deposes and states that he is the Authorized Representative of the Applicant and is authorized to sign this Application on behalf of the Project Owner/Applicant, Prevailing Wind Park, LLC.

He further states that he does not have personal knowledge of all the facts recited in the Application and Exhibits and Attachments attached hereto, but the information has been gathered from employees and agents of the Owner/Applicant, and the information is verified by him as being true and correct on behalf of the Owner/Applicant.

Dated this 30th day of May 2018.

Mr. Sean McBride

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APPENDIX A – FIGURES

APPENDIX B – GRASSLANDS ANALYSIS

APPENDIX C – WETLAND DESKTOP DETERMINATION

APPENDIX D – TIERS 1 AND 2 WILDLIFE REPORT

APPENDIX E – RAPTOR NEST SURVEY REPORT

APPENDIX F – AVIAN USE SURVEYS – YEAR ONE

APPENDIX G – AVIAN USE SURVEYS – YEAR TWO

APPENDIX H – BALD EAGLE NEST MONITORING

APPENDIX I – NORTHERN LONG-EARED BAT ACOUSTIC SURVEY

APPENDIX J – NORTHERN LONG-EARED BAT PRESENCE/ABSENCE SURVEY

APPENDIX K – WHOOPING CRANE HABITAT REVIEW

APPENDIX L – BIRD AND BAT CONSERVATION STRATEGY

APPENDIX M – SOUND STUDY

APPENDIX N – SHADOW FLICKER ANALYSIS

APPENDIX O – RF IMPACT REPORT

APPENDIX P – 2009 BERKELEY PROPERTY VALUES STUDY

APPENDIX Q – 2013 BERKELEY PROPERTY VALUES STUDY

APPENDIX R – CULTURAL RESOURCES LITERATURE SEARCH (NOT FOR PUBLIC DISCLOSURE)

APPENDIX S – CULTURAL RESOURCES DESKTOP REVIEW AND CONSTRUCTION GRID

APPENDIX T – AGENCY CORRESPONDENCE

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Centennial, CO 80112
O 303-721-9292
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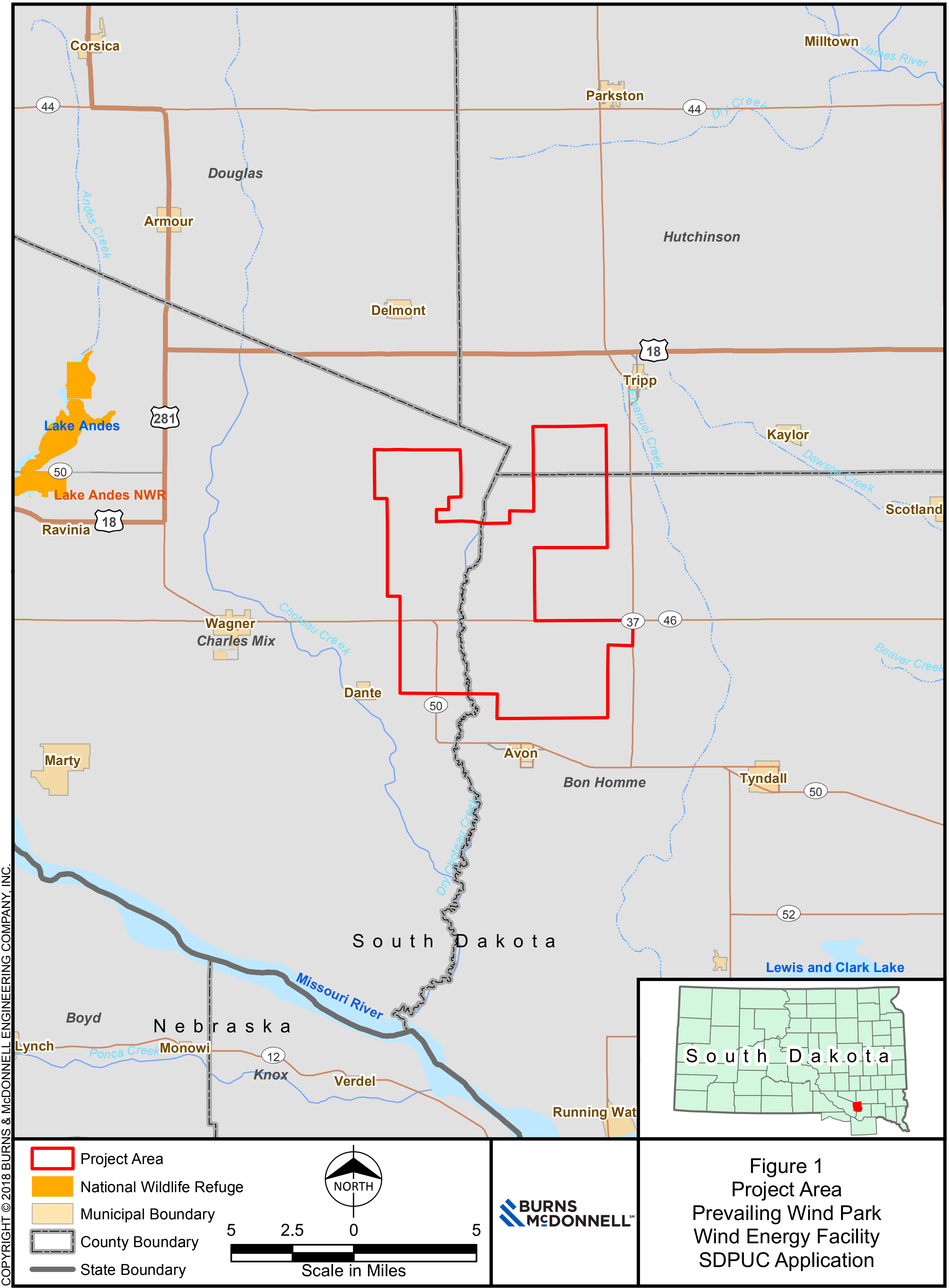

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Figure 1
Project Area
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

Source: ESRI, FWS, Burns & McDonnell Engineering Company, Inc., South Dakota GIS

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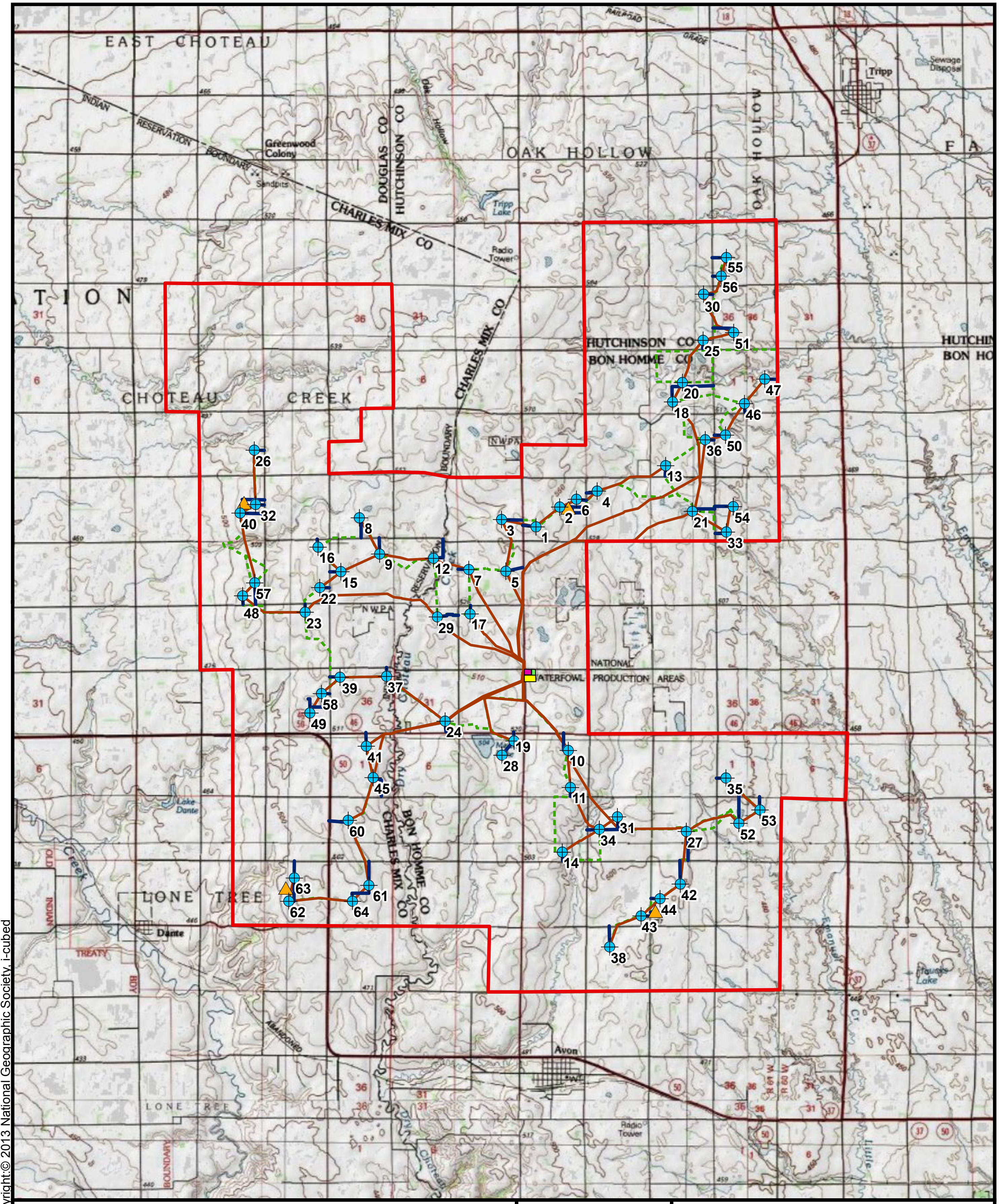

▭ Project Area
⊕ Turbine
🟨 Laydown Yard
🟪 O&M
🟩 Project Substation
▲ MET Tower
— Access Road
— Collector Line
- - - Crane Path

NORTH

1 0.5 0 1

Scale in Miles

Figure 2
Configuration/Topographic Map
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

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Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

Source: ESRI, sPower Development Company, LLC, Burns & McDonnell Engineering Company, Inc.,

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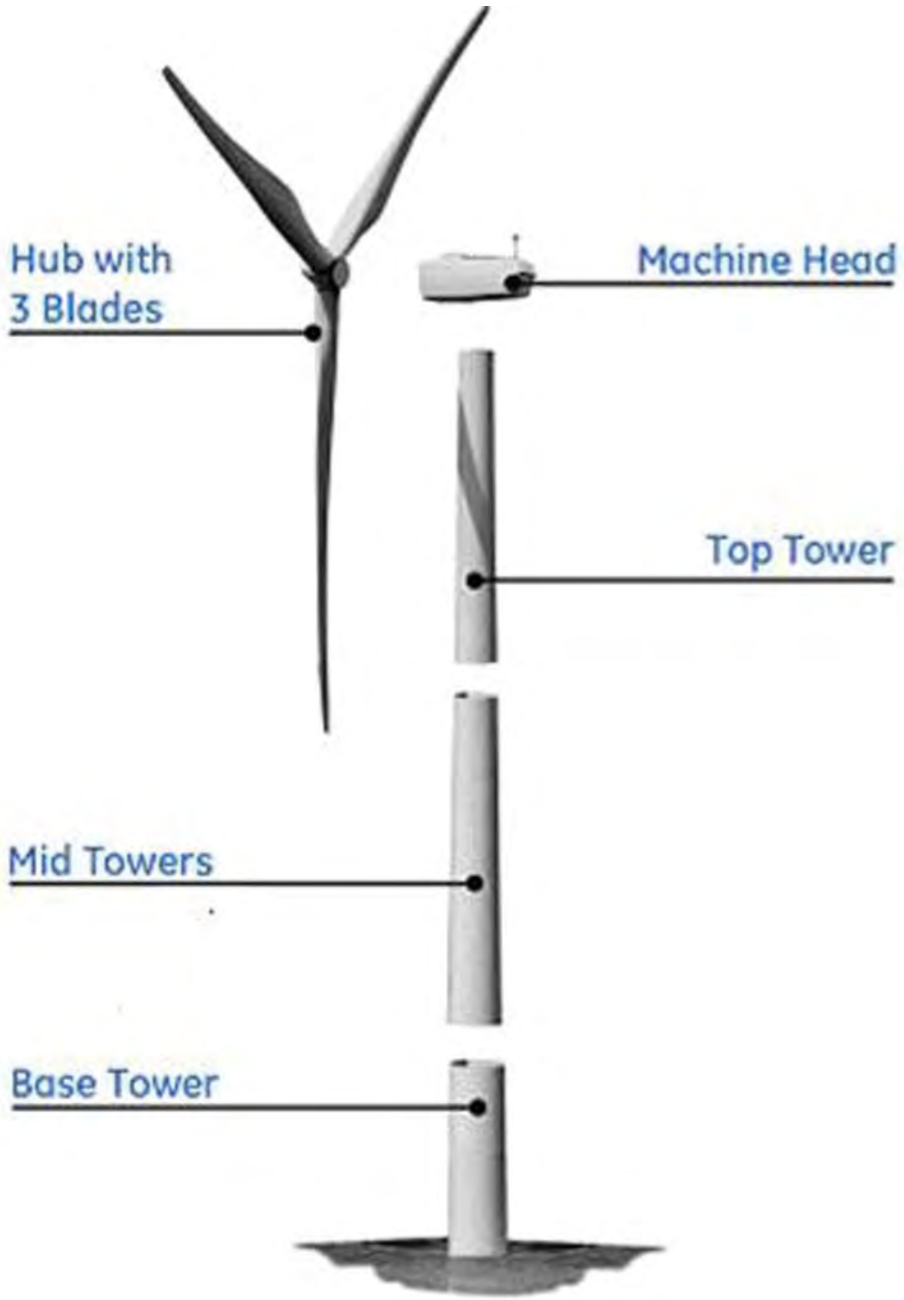
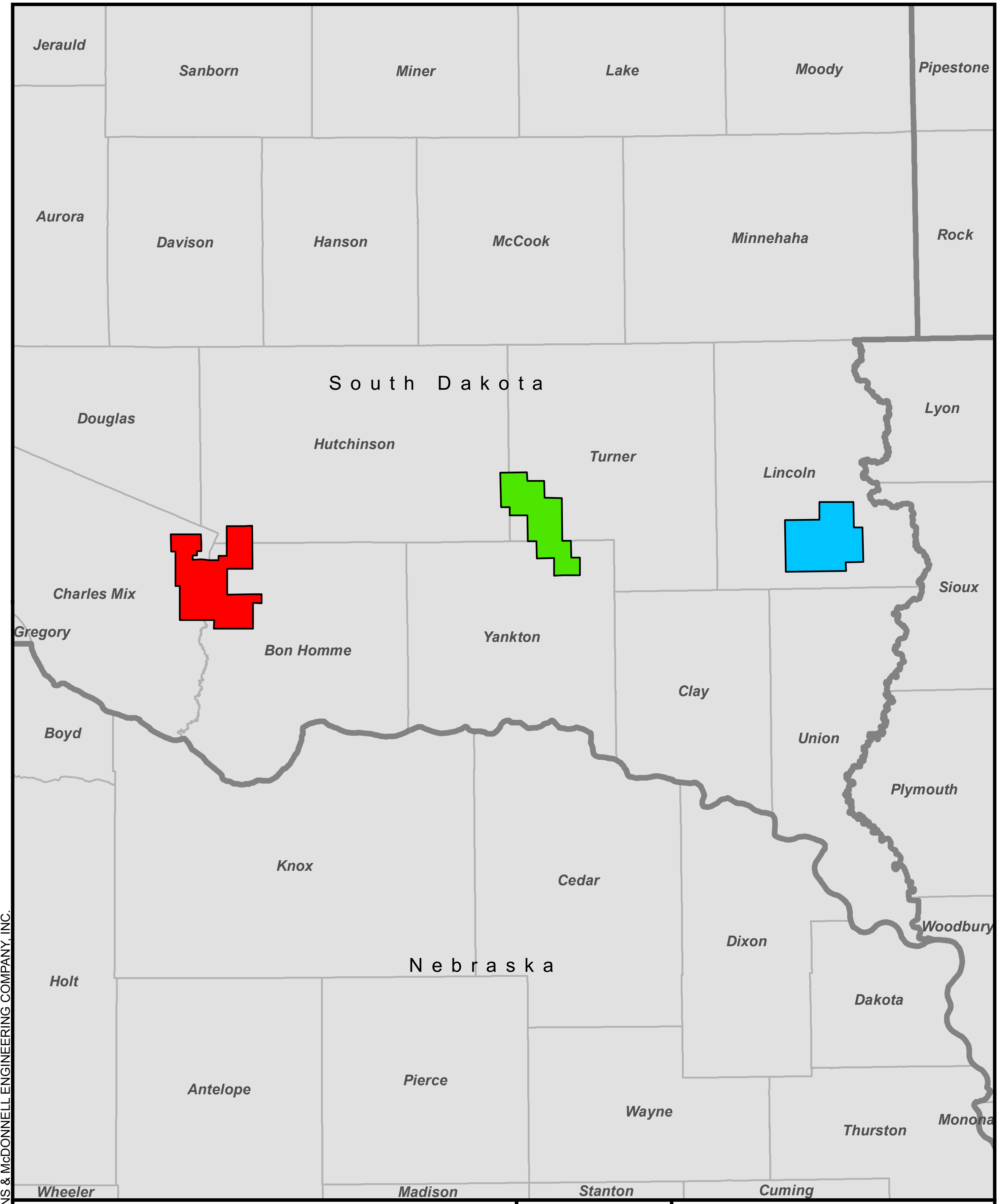
Figure 3
Representative Wind Turbine Components
Prevailing Wind Park





🟥 Project Area (Location #1)

🟩 Alternative Location #2

🟦 Alternative Location #3

☐ County Boundary

▬ State Boundary

BURNS McDONNELL

Figure 4
Alternative Sites
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

Source: ESRI, Prevailing Winds, LLC, Burns & McDonnell Engineering Company, Inc.

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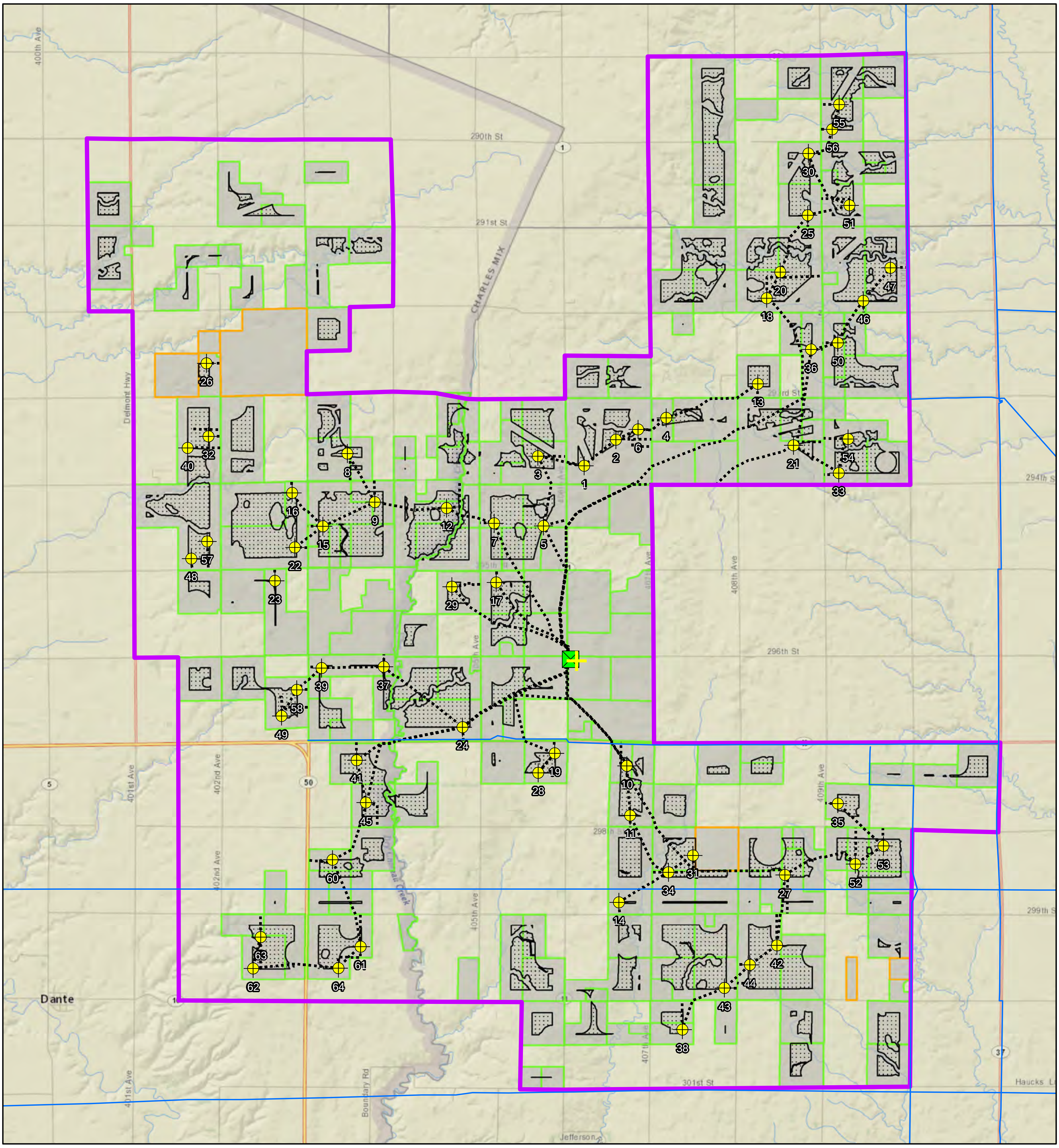
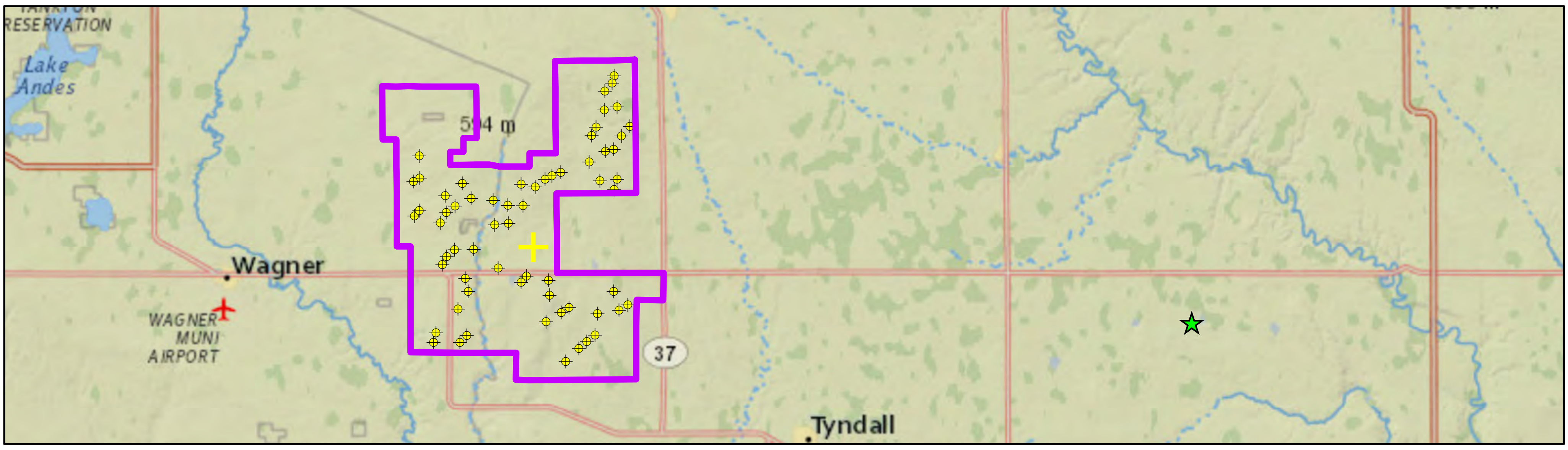
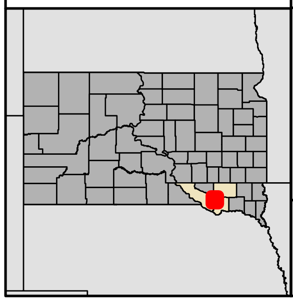




Multiple Counties, SD



Map Details

N

Proposed Project

- Project Boundary
- Feeders & Access Roads
- Turbines
- Project Substation
- O&M Building
- Buildable Area
- Leased Land
- Setback Waivers

Existing

- Transmission
- ★ Utica Substation

0 1.25 2.5 5 Mi

Map Description

Figure 5
Prevailing Wind is located on private land in Bon Homme, Charles Mix, and Hutchinson Counties

Cartographer: JL
Date: 5/1/2018
Version: 1.0
Type: Exhibit

S·POWER
An AES and AIMCo Company

Prevailing Wind Park

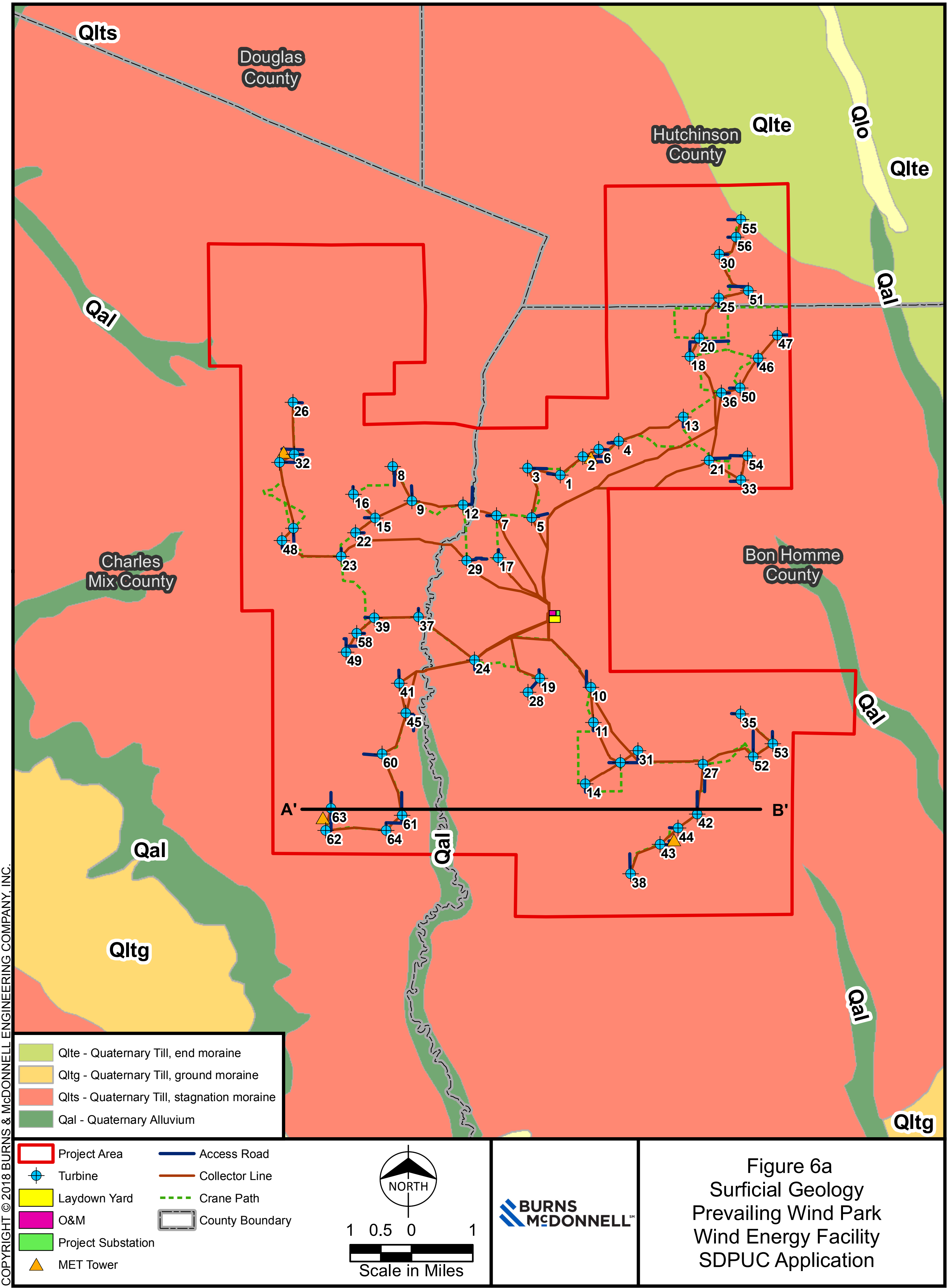


Figure 6a
Surficial Geology
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

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Source: ESRI, Burns & McDonnell Engineering Company, Inc., South Dakota GIS

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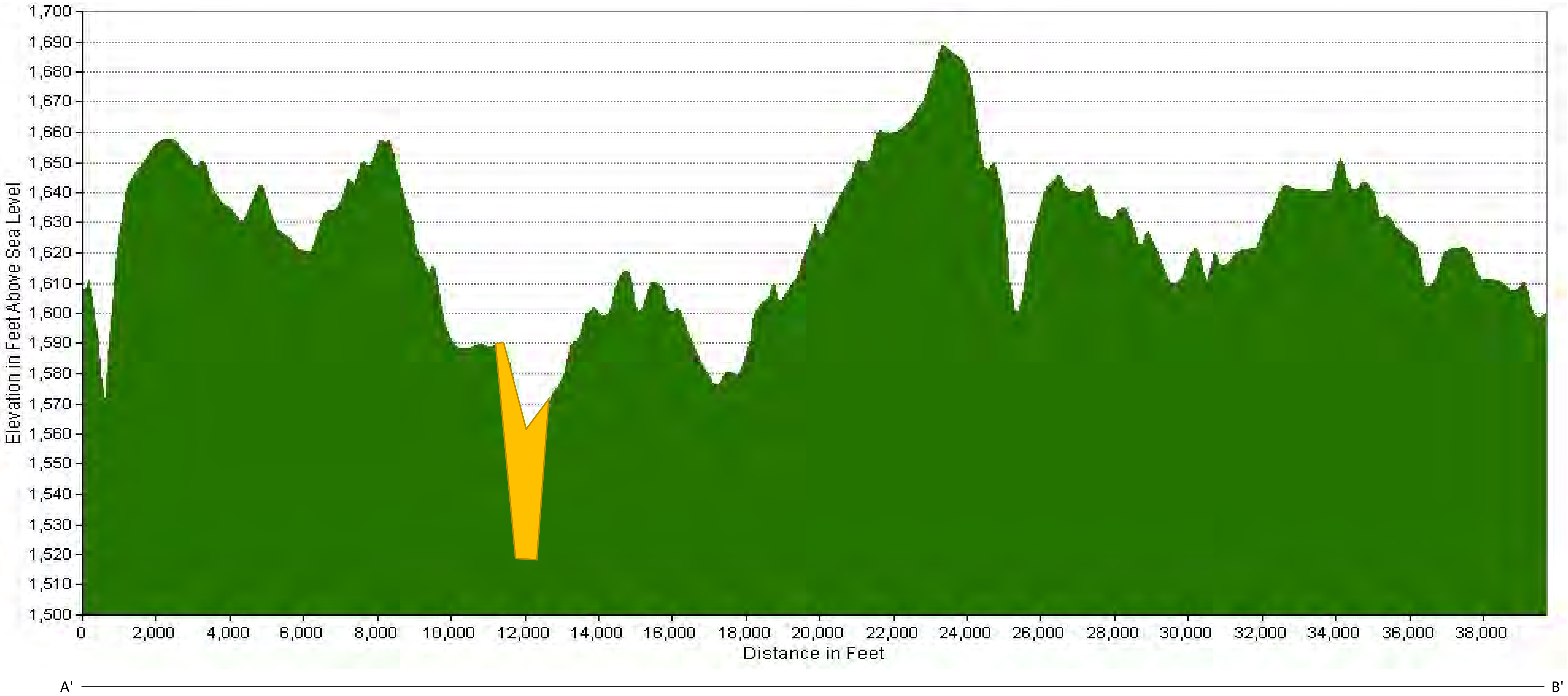


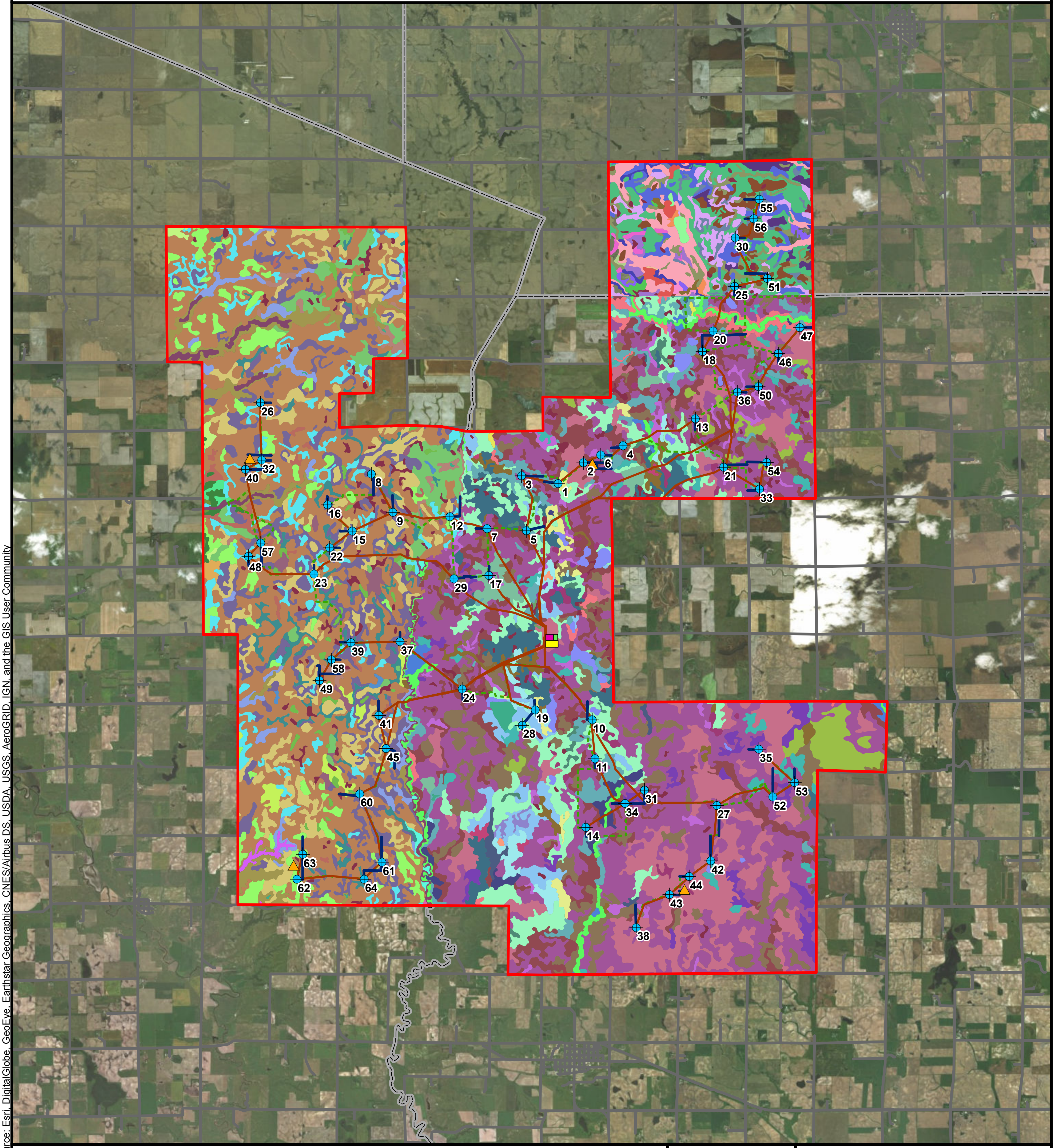
Legend

🟨 Qal
🟩 Qlts

Figure 6b
Geologic Cross Section
of Project Area
Prevailing Wind Park

Map Unit Symbol & Name

🟪 BdF - Betts loam, 25 to 40 percent slopes
🟥 BeE - Betts and Ethan loams, 15 to 40 percent slopes
🟫 BeE - Betts-Ethan loams, 9 to 25 percent slopes
🟦 Bn - Bon loam
🟦 Bn - Bon silt loam
🟩 Bo - Bon loam, channeled
🟪 Bo - Bon silt loam, channeled
🟩 Br - Bonilla-CrosspIain complex
🟪 Ca - Chaska silt loam
🟦 Cb - Chaska silt loam, channeled
🟩 CeB - Clarno-Ethan loams, 2 to 6 percent slopes
🟫 CeC - Clarno-Ethan loams, 6 to 9 percent slopes
🟨 CmA - Clarno-Bonilla loams, 0 to 2 percent slopes
🟦 CmB - Clarno-Bonilla loams, 2 to 6 percent slopes
🟥 CnA - Clarno-Crossplain-Davison complex, 0 to 3 percent slopes
🟪 CnC - Clarno-Ethan loams, 6 to 9 percent slopes
🟦 CsB - Clarno-Ethan-Bonilla loams, 2 to 6 percent slopes
🟦 DaB - Davis loam, 0 to 6 percent slopes
🟧 DaB - Davis loam, 2 to 6 percent slopes
🟫 DcB - Davison-Onita complex, 2 to 6 percent slopes
🟧 DeA - Delmont loam, 0 to 3 percent slopes
🟪 DlC - Delmont-Talmo loams, 6 to 9 percent slopes
🟩 DnD - Delmont-Talmo complex, 6 to 12 percent slopes
🟩 EaA - Eakin silt loam, 0 to 2 percent slopes
🟩 EdA - Enet-Delmont loams, 0 to 2 percent slopes
🟦 EdB - Enet-Delmont loams, 2 to 6 percent slopes
🟩 EeB - Eakin-Ethan complex, 2 to 6 percent slopes
🟥 EmE - Ethan-Betts loams, 15 to 40 percent slopes
🟩 EnC - Ethan-Bonilla loams, 1 to 9 percent slopes
🟦 EoD - Ethan-Davis loams, 9 to 15 percent slopes
🟫 EpC - Ethan-Homme complex, 6 to 9 percent slopes
🟪 EtC2 - Ethan-Betts loams, 6 to 9 percent slopes, eroded
🟪 EtD - Ethan-Betts loams, 9 to 15 percent slopes
🟦 EtD - Ethan-Clarno loams, 9 to 15 percent slopes
🟪 EuC - Ethan-Homme complex, 6 to 9 percent slopes
🟪 EwC - Ethan-Homme complex, 6 to 9 percent slopes
🟩 HaA - Hand loam, 0 to 2 percent slopes
🟪 HaB - Hand loam, 3 to 6 percent slopes
🟩 HaC - Hand loam, 6 to 9 percent slopes
🟧 HgA - Highmore silt loam, 0 to 2 percent slopes
🟩 HhB - Highmore silt loam, 2 to 6 percent slopes
🟩 HmA - Homme-Davison-Tetonka complex, 0 to 3 percent slopes
🟫 HmB - Homme-Ethan-Onita complex, 1 to 6 percent slopes
🟪 HnB - Homme-Ethan-Onita complex, 1 to 6 percent slopes
🟩 HoA - Homme-Onita silty clay loams, 0 to 2 percent slopes
🟨 HoB - Homme-Onita silty clay loams, 1 to 6 percent slopes
🟦 HoC - Homme-Ethan complex, 6 to 9 percent slopes
🟥 HpB - Homme-Ethan-Tetonka complex, 0 to 6 percent slopes
🟩 HpC - Homme-Ethan-Tetonka complex, 0 to 9 percent slopes
🟦 HrA - Homme-Onita silty clay loams, 0 to 2 percent slopes
🟫 HrB - Homme-Onita silty clay loams, 1 to 6 percent slopes
🟪 HtA - Homme-Onita complex, 0 to 2 percent slopes
🟪 HtA - Homme-Onita-Tetonka complex, 0 to 3 percent slopes
🟩 HtB - Homme-Onita complex, 2 to 6 percent slopes
🟦 La - Lamo silt loam
🟩 Ma - Worthing silty clay loam, ponded, 0 to 1 percent slopes
🟦 OaA - Mobridge silt loam, 0 to 2 percent slopes
🟪 OcA - Onita-Chancellor silty clay loams
🟦 On - Mobridge silt loam, 0 to 2 percent slopes
🟩 Oo - Onita-Davison complex
🟥 Ot - Onita-Tetonka silt loams
🟥 Ps - Prosper and Crossplain complex
🟫 Sa - Salmo silty clay loam
🟦 Sm - Salmo-Napa complex
🟪 TaC - Talmo gravelly sandy loam, 2 to 9 percent slopes
🟪 TaE - Talmo-Delmont loams, 15 to 40 percent slopes
🟨 TbE - Talmo-Ethan very stony complex, 6 to 40 percent slopes
🟥 Te - Tetonka silt loam, 0 to 1 percent slopes
🟧 ThC - Thurman loamy sand, 6 to 15 percent slopes
🟦 Tn - Tetonka-Chancellor silty clay loams
🟫 Tw - Tetonka and Whitewood silty clay loams
🟩 W - Water
🟪 Wg - Worthing silty clay loam, 0 to 1 percent slopes
🟩 Wo - Worthing silty clay loam, 0 to 1 percent slopes
🟦 Wo - Worthing silty clay loam, ponded, 0 to 1 percent slopes
🟪 Wp - Worthing silty clay loam, ponded, 0 to 1 percent slopes



🟥 Project Area
⌖ Turbine
🟨 Laydown Yard
🟪 O&M
🟩 Project Substation
▲ MET Tower
— Access Road
— Collector Line
--- Crane Path
▢ County Boundary

NORTH

1.5 0.75 0 1.5

Scale in Miles

BURNS McDONNELL

Figure 7
Soil Types
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

Path: Z:\Clients\ENS\SPowerGroup\104294_PrevailingWindStudies\Geospatial\DataFiles\ArcDocs\Report\104294_PW_Fig8_Soils.mxd jbell 5/26/2018

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: Source: ESRI, Burns & McDonnell Engineering Company, Inc., South Dakota GIS, USGS - SSURGO

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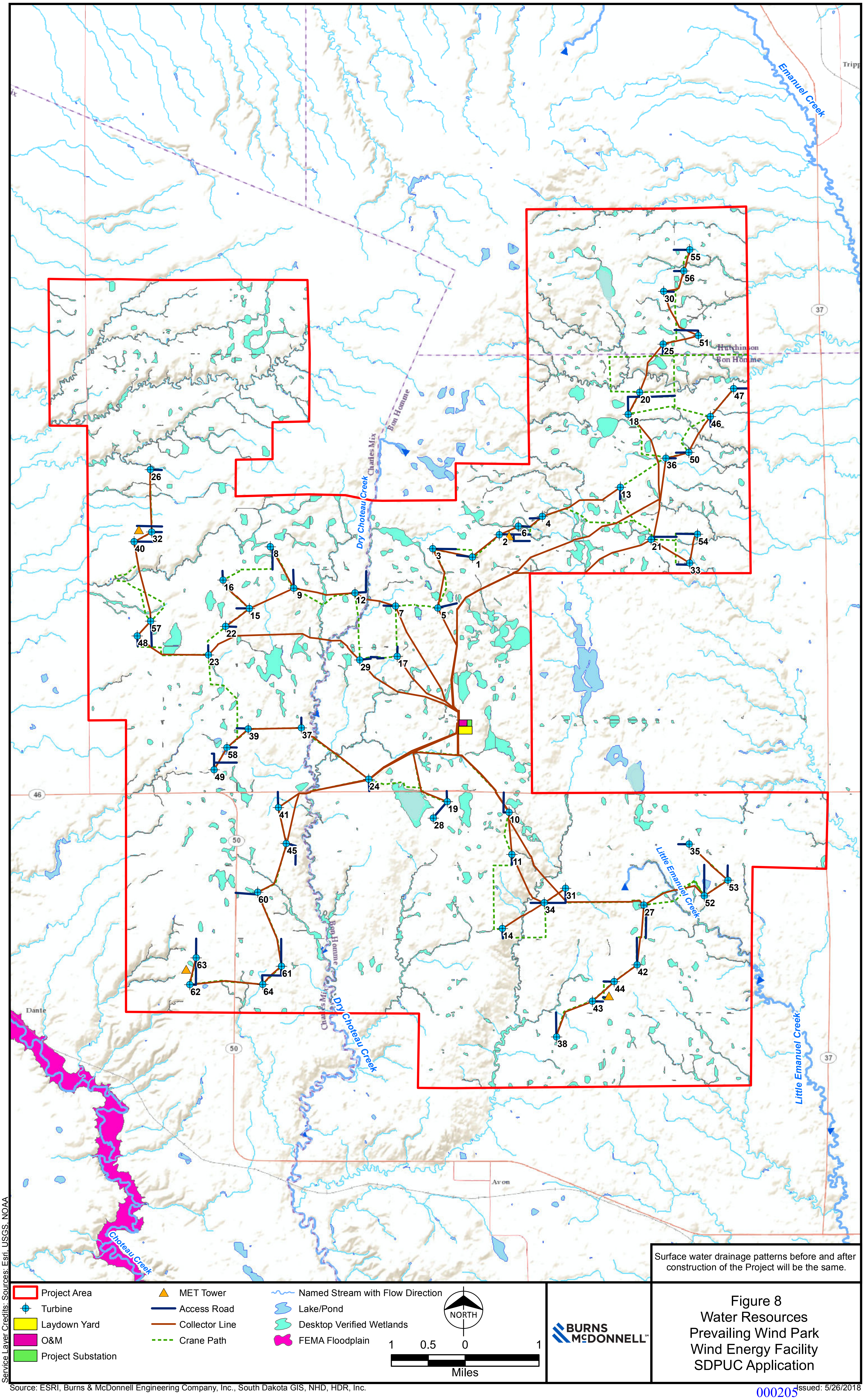

Surface water drainage patterns before and after construction of the Project will be the same.

Figure 8
Water Resources
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

Path: Z:\Clients\ENS\SPowerGroup\104294_PrevailingWindStudies\Geospatial\DataFiles\ArcDocs\Report\104294_PW_Fig9_WaterResources.mxd jbell 5/26/2018

Service Layer Credits: Sources: Esri, USGS, NOAA

Source: ESRI, Burns & McDonnell Engineering Company, Inc., South Dakota GIS, NHD, HDR, Inc.

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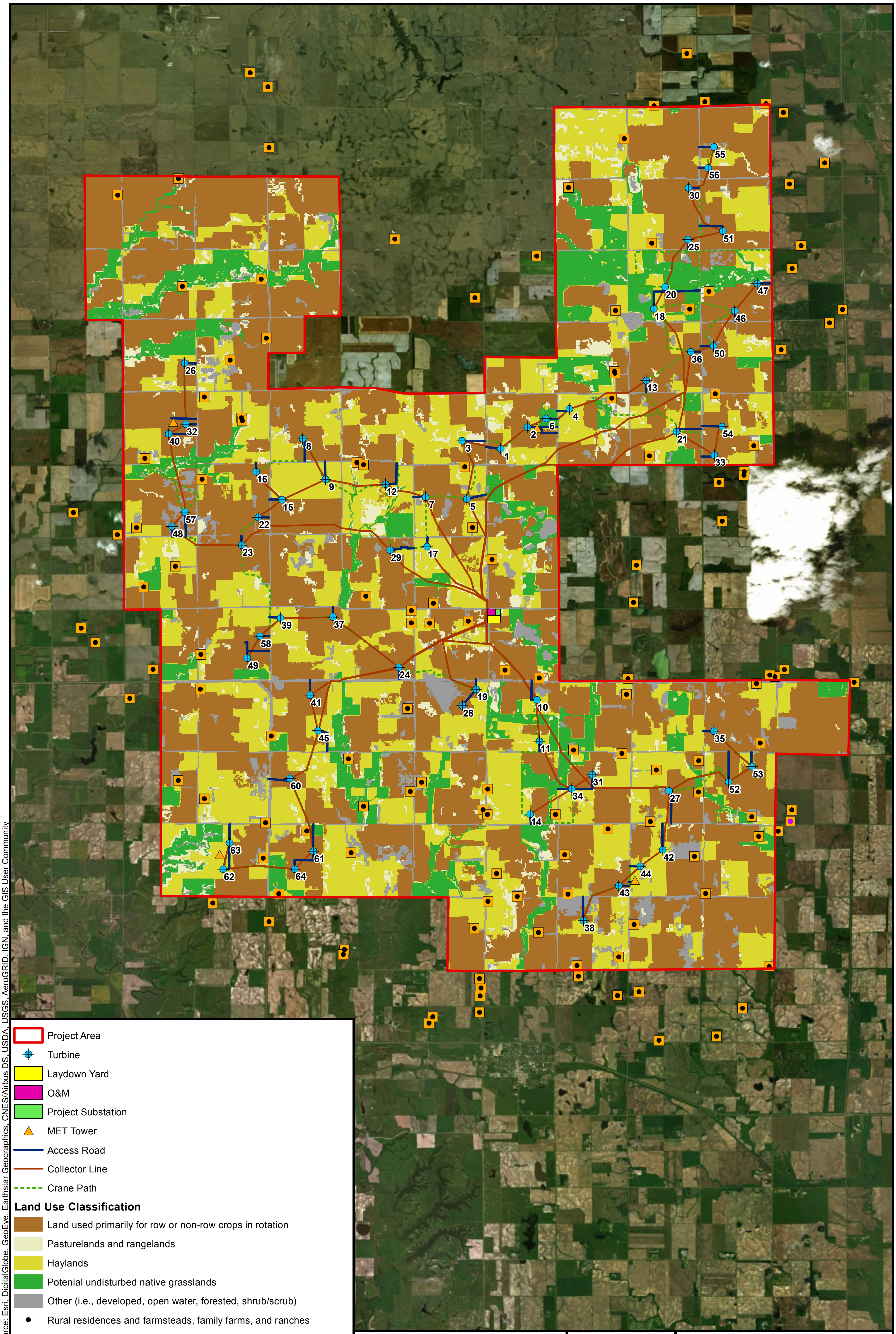

▭ Project Area
⌖ Turbine
🟨 Laydown Yard
🟪 O&M
🟩 Project Substation
▲ MET Tower
— Access Road
— Collector Line
--- Crane Path

Land Use Classification

🟫 Land used primarily for row or non-row crops in rotation
▭ Pasturelands and rangelands
🟨 Haylands
🟩 Potenial undisturbed native grasslands
▨ Other (i.e., developed, open water, forested, shrub/scrub)
● Rural residences and farmsteads, family farms, and ranches
● Public, commercial, and institutional use (i.e., church)
🟧 Noise sensitive land uses

The following land use classifications were not identified within the Project Area: irrigated lands; existing and potential extractive nonrenewable resources; other major industries; residential; municipal water supply and water sources for organized rural water systems.

Figure 9
Land Use Culture Map
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

Issued: 5/26/2018

Source: ESRI, Burns & McDonnell Engineering Company, Inc., South Dakota GIS, NLCD, Prevailing Winds, LLC

Path: Z:\Clients\ENS\SPowerGroup\104294_PrevailingWind\Studies\Geospatial\DataFiles\ArcDocs\Report\104294_PW_Fig10_LandUse.mxd jbell 5/26/2018

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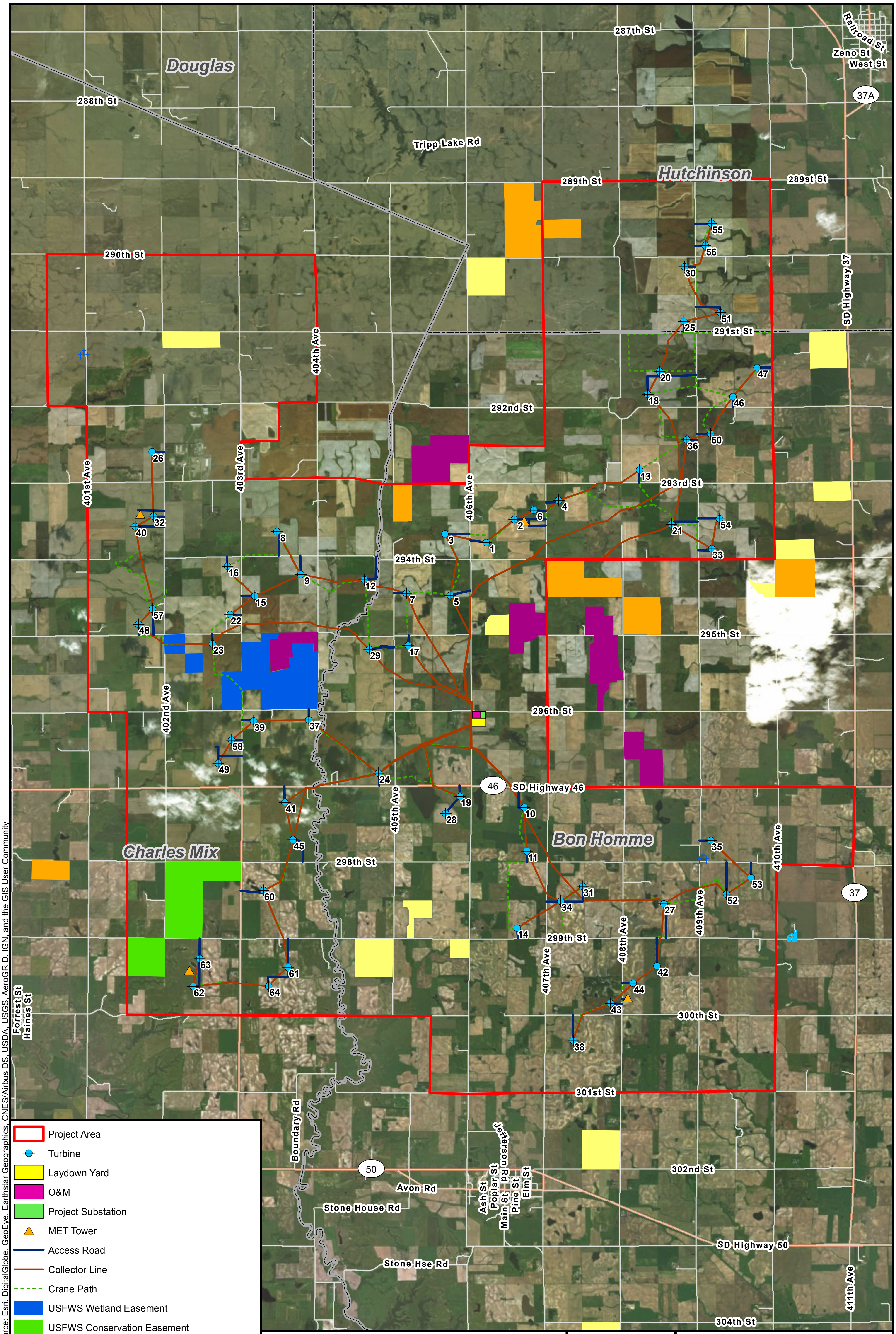


- ▭ Project Area
- ⌖ Turbine
- 🟨 Laydown Yard
- 🟪 O&M
- 🟩 Project Substation
- ▲ MET Tower
- — Access Road
- — Collector Line
- - - - Crane Path
- 🟦 USFWS Wetland Easement
- 🟩 USFWS Conservation Easement
- 🟪 USFWS Waterfowl Production Area
- 🟧 SDGFP Game Production Area
- 🟨 SDGFP Walk-In Hunting Area
- ✝ Cemetery
- ⛪ Church

NORTH

6,000 3,000 0 6,000

Feet

BURNS McDONNELL

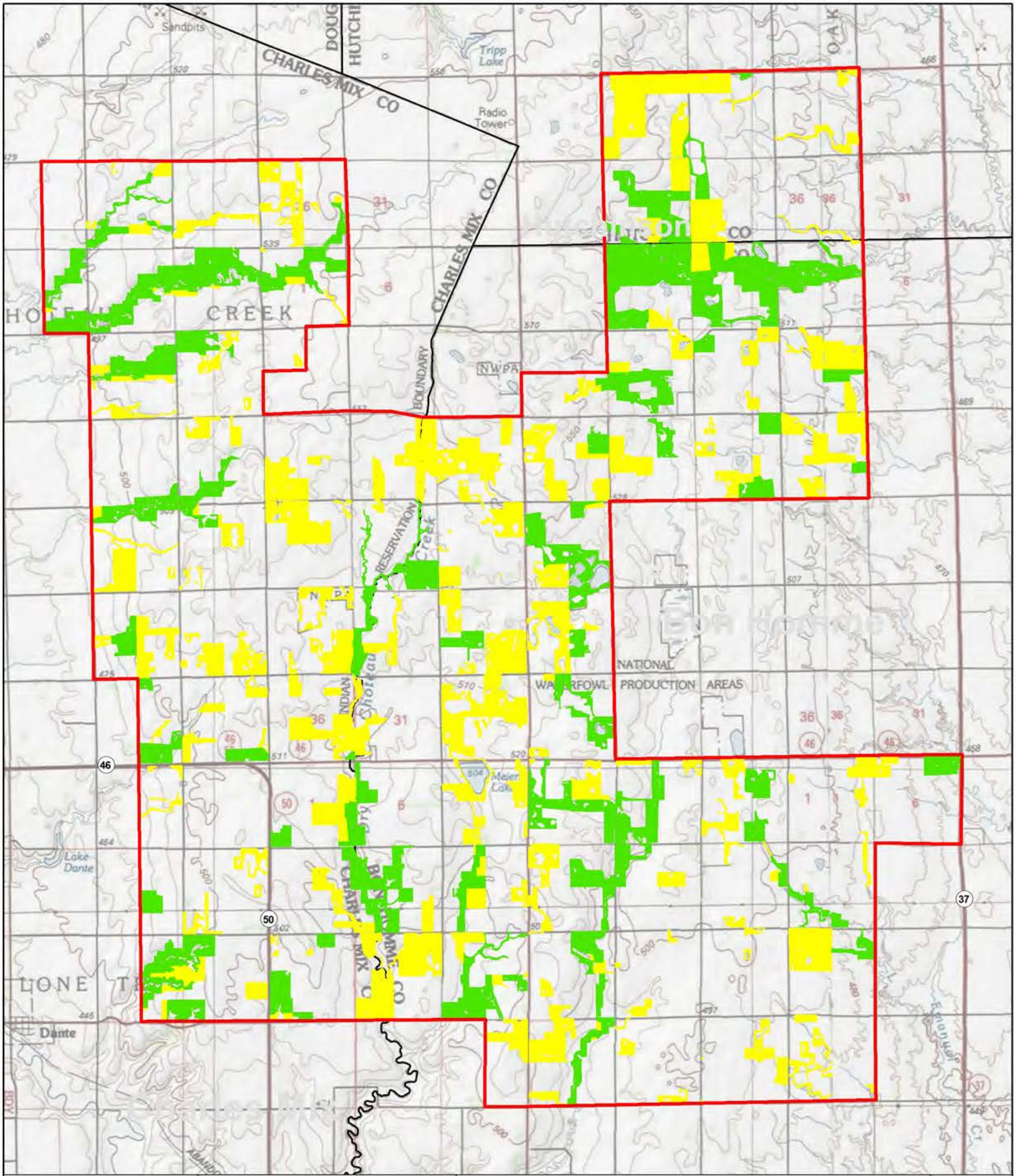
Figure 10
Public Lands and Facilities
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

Source: Source: ESRI, Burns & McDonnell Engineering Company, Inc., South Dakota GIS

Issued: 5/26/2018

Path: Z:\Clients\ENS\SPowerGroup\104294_PrevailingWindStudies\Geospatial\DataFiles\ArcDocs\Report\104294_PW_Fig11_PublicLands.mxd jbell 5/26/2018

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Prevailing Winds Wind Project

Digitized Grasslands

Data Source: ESRI USA Topo Maps 2-13
Coordinate System: NAD83, UTM, zn14 n
Map produced on 04/25/2017 by T. Thorn

0 1 2 mi
0 1 2 km

Map Features

🟥 **Project Boundary**

Grasslands

🟨 **Tilled**

🟩 **Untilled**

N
W E
S

WEST

Memo

Date:	Wednesday, April 11, 2018
Project:	Prevailing Wind Park
To:	Bridget Canty, sPower
From:	HDR Engineering
Subject:	Wetland Desktop Determination

Introduction

HDR Engineering previously completed desktop wetland determinations and field verification for the proposed Prevailing Wind Park in 2015, 2016, 2017, and March 2018 for various Project footprints. Recently additional Project Area has been added to the footprint. This memo summarizes the results of the desktop wetland determination review of the current Project Area provided by sPower on 3/28/2018 (see Figure 1):

Methodology

The desktop wetland survey was conducted using a time series of aerial imagery captured during the growing season and available on Google Earth, USGS Topographic Maps, National Wetlands Inventory (NWI), in addition to the USGS National Hydrography Dataset (NHD). These data sources were used in conjunction to identify potential wetland areas. Areas with wetland signatures on aerial imagery such as surface water, flooded/saturated soils, stressed crops, and patches of greener vegetation were considered to be wetland if present during most years. Small portions of the project area were field delineated as part of past projects. Though these will require new field verification, they were also used to assist in the desktop determinations.

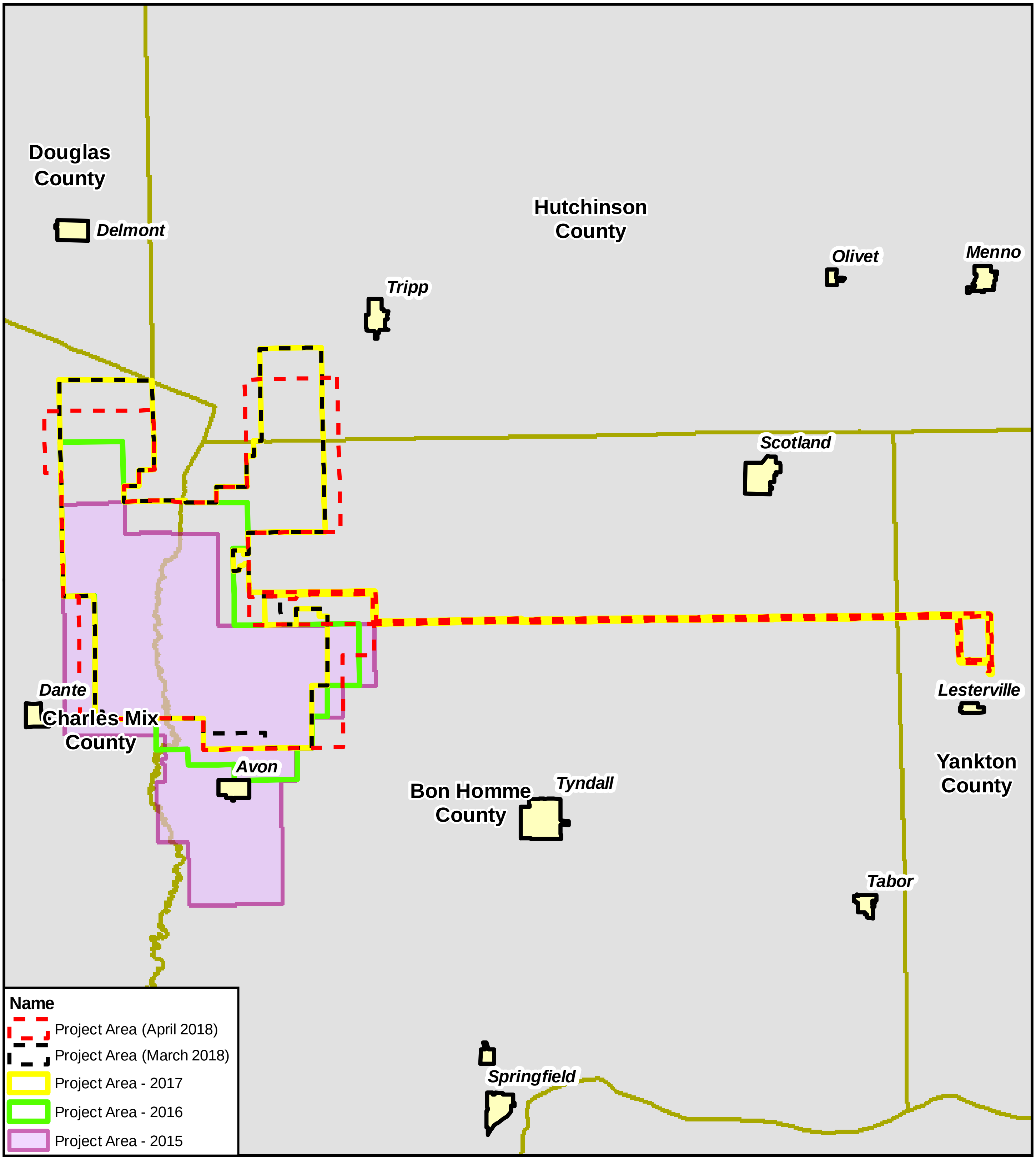
Results

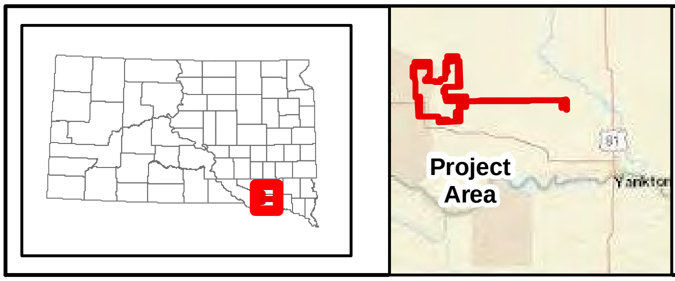
The portion of the Project Area encompassing the wind park footprint contains approximately 2,696 acres of known and potential wetlands while the portion of the Project Area encompassing the proposed transmission line corridor contains approximately 181 acres of known and potential wetlands. Table 1 summarizes the types and proportions of wetlands per the Cowardin classification given to the National Wetland Inventory within the Project Area.

Cowardin Class	Proportion
Lacustine Aquatic Bed (L2AB)	5.34%
Palustrine Aquatic Bed (PAB)	10.65%
Palustrine Emergent (PEM)	74.69%
Palustrine Forested (PFO)	2.94%
Palustrine Unconsolidated Bottom (PUB)	0.02%
Riverine Intermittent/Ephemeral (R4/R5)	6.35%

Discussion

These wetland boundaries will be used in the site planning and construction planning phases so that the windfarm can be developed in a manner that would minimize impacts to aquatic resources. A field wetland delineation will be conducted to confirm the presence or absence of wetlands and their boundaries where infrastructure (temporary and permanent) is proposed. By doing so, the Federal wetland mitigation sequencing provisions of avoidance, minimization, and compensation as required under Section 404 of the Clean Water Act may be attained.

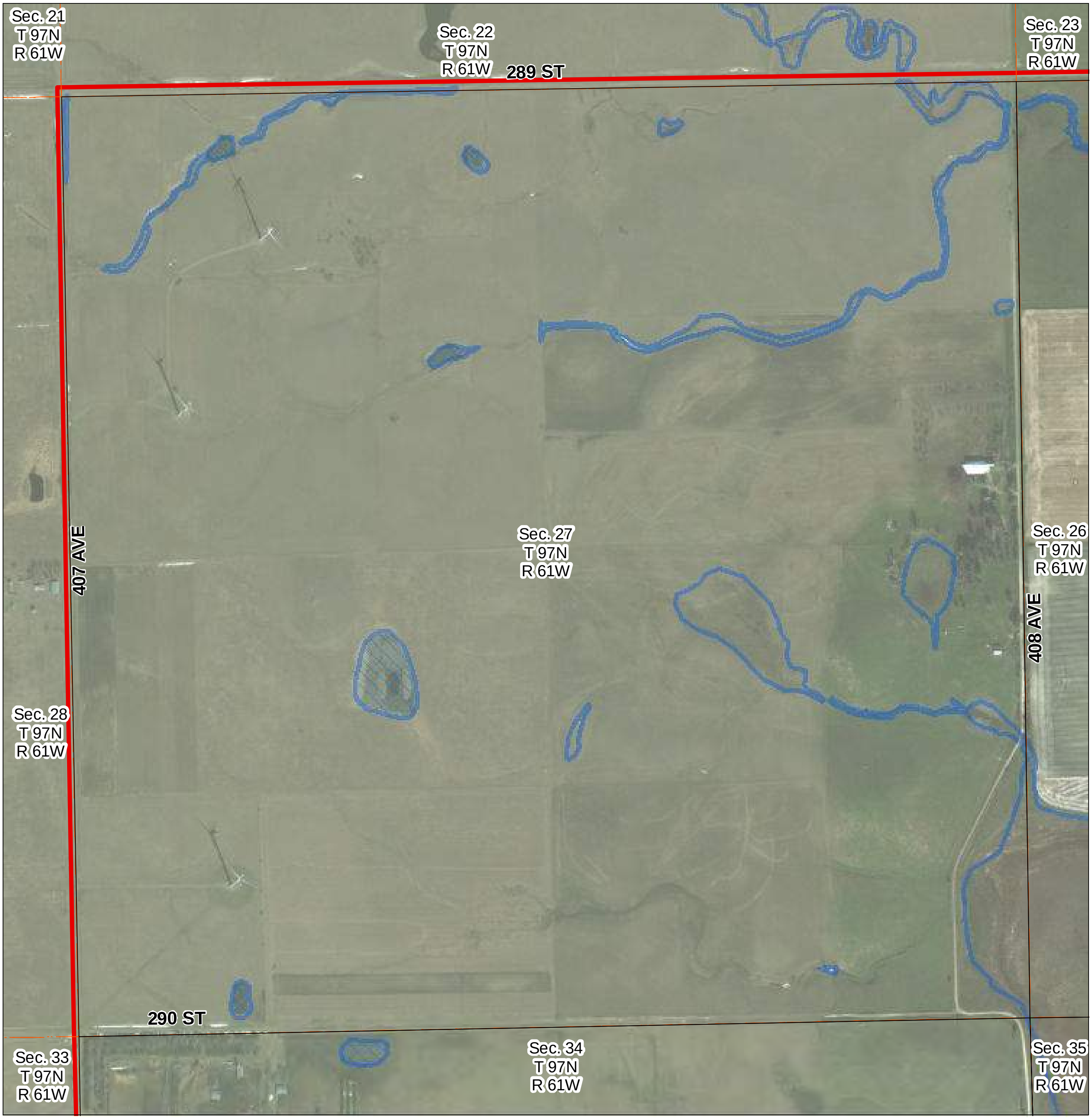


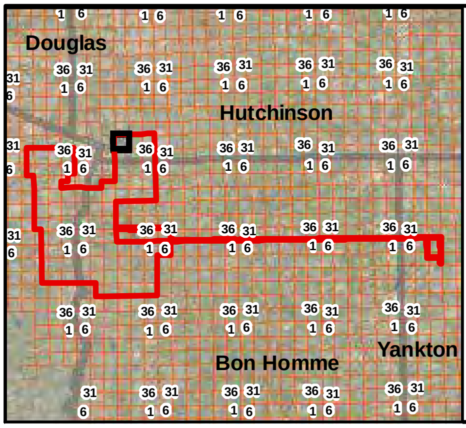


Wetland Determination - 2018 Overview
Prevailing Wind Park

Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota

Figure 1





Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 1

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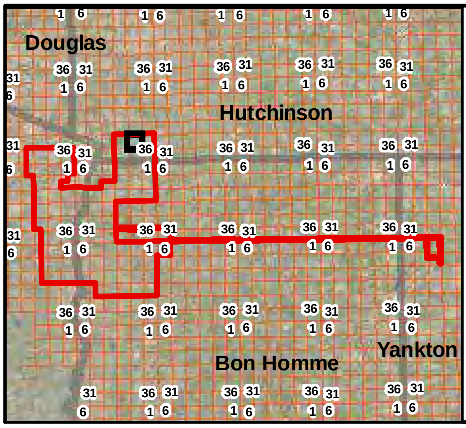

Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

N

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 2

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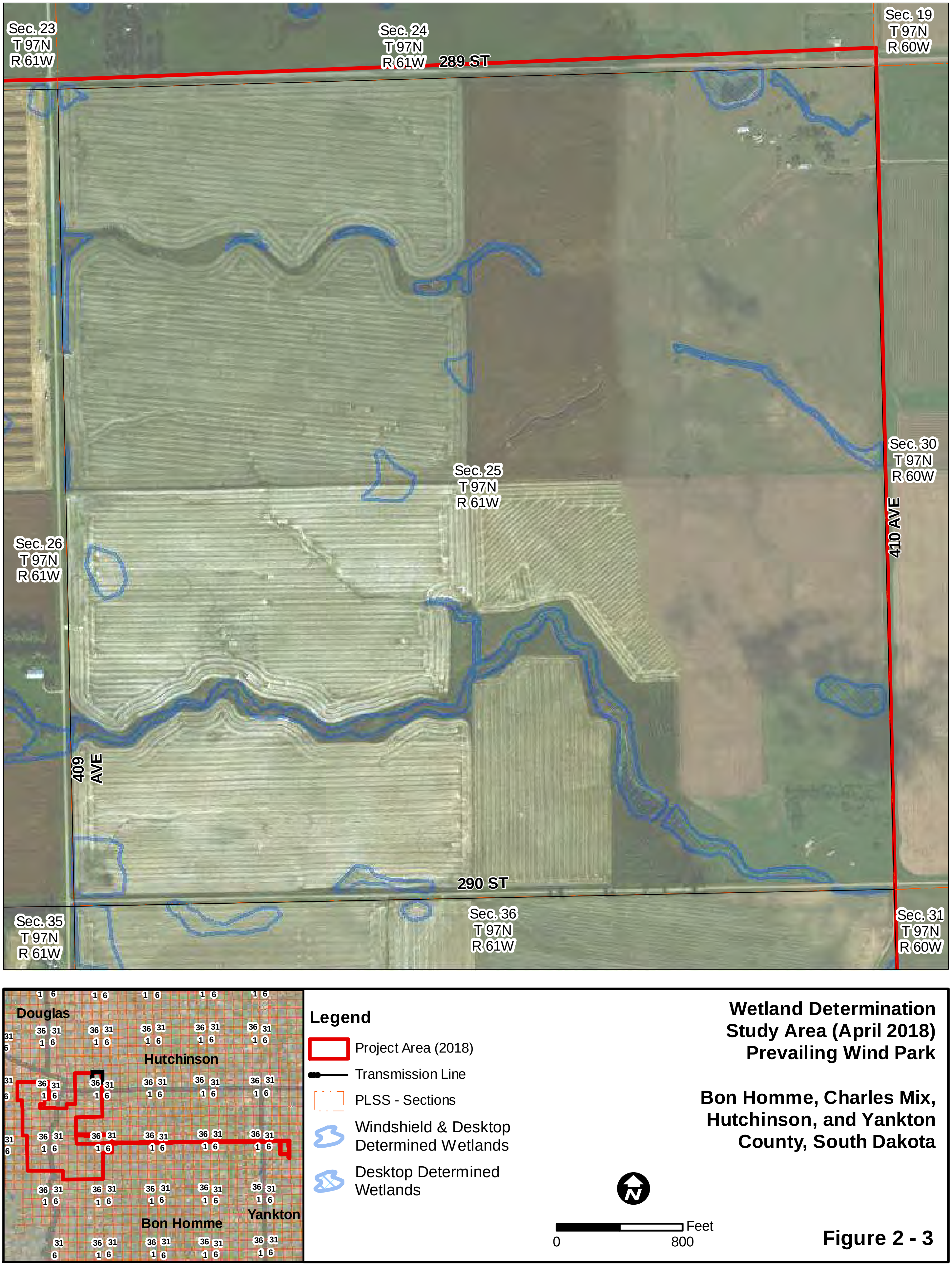

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

**Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota**

Figure 2 - 3

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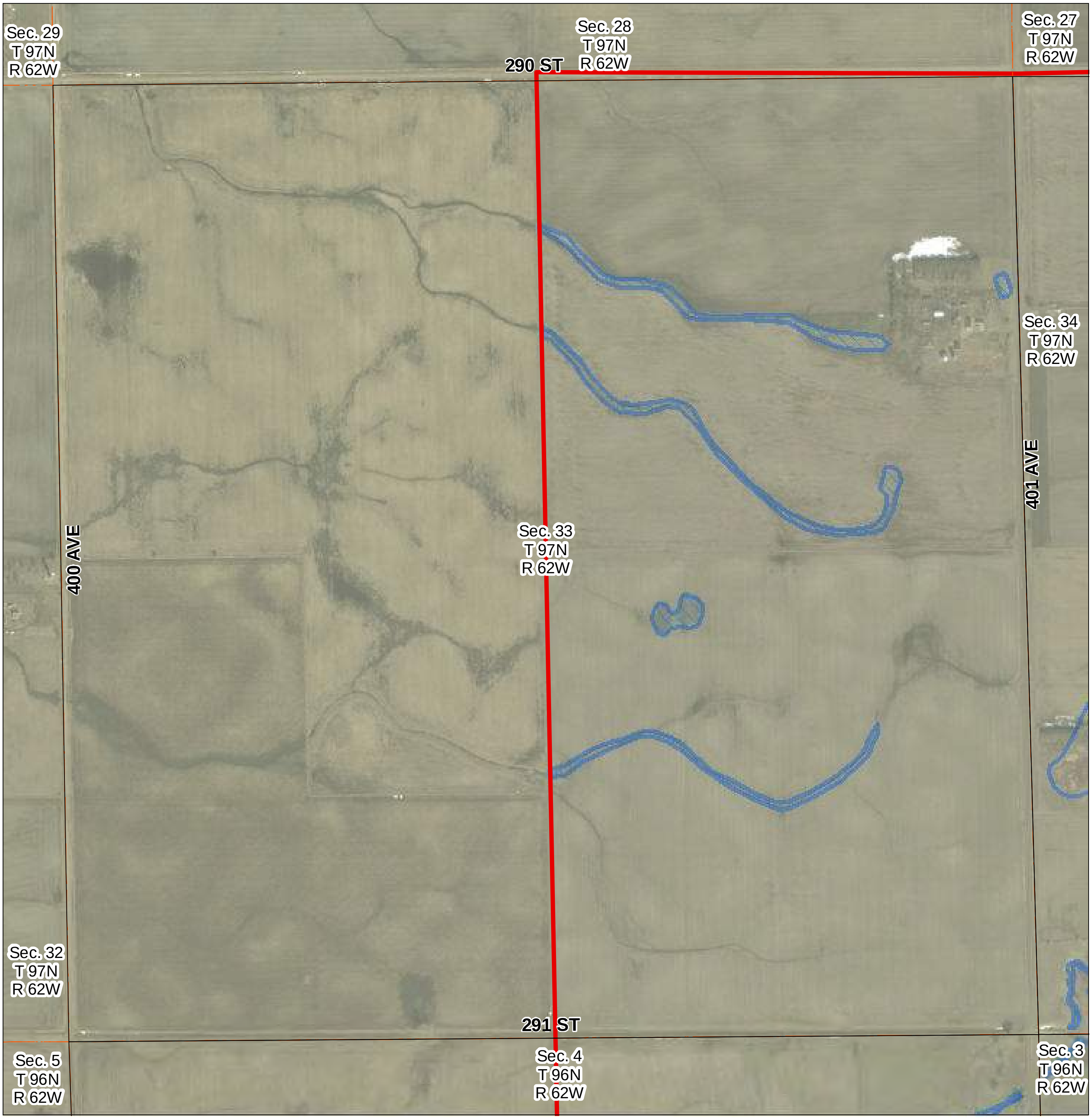

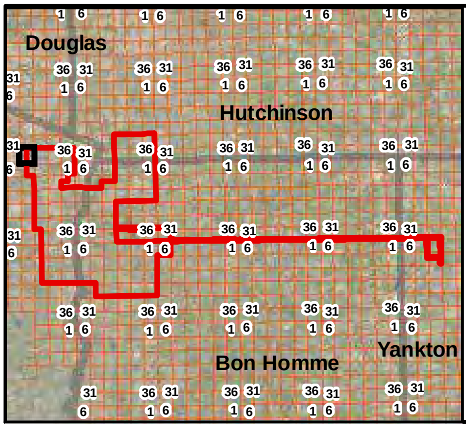

Legend

- ▭ Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota

Feet
0 800

Figure 2 - 4

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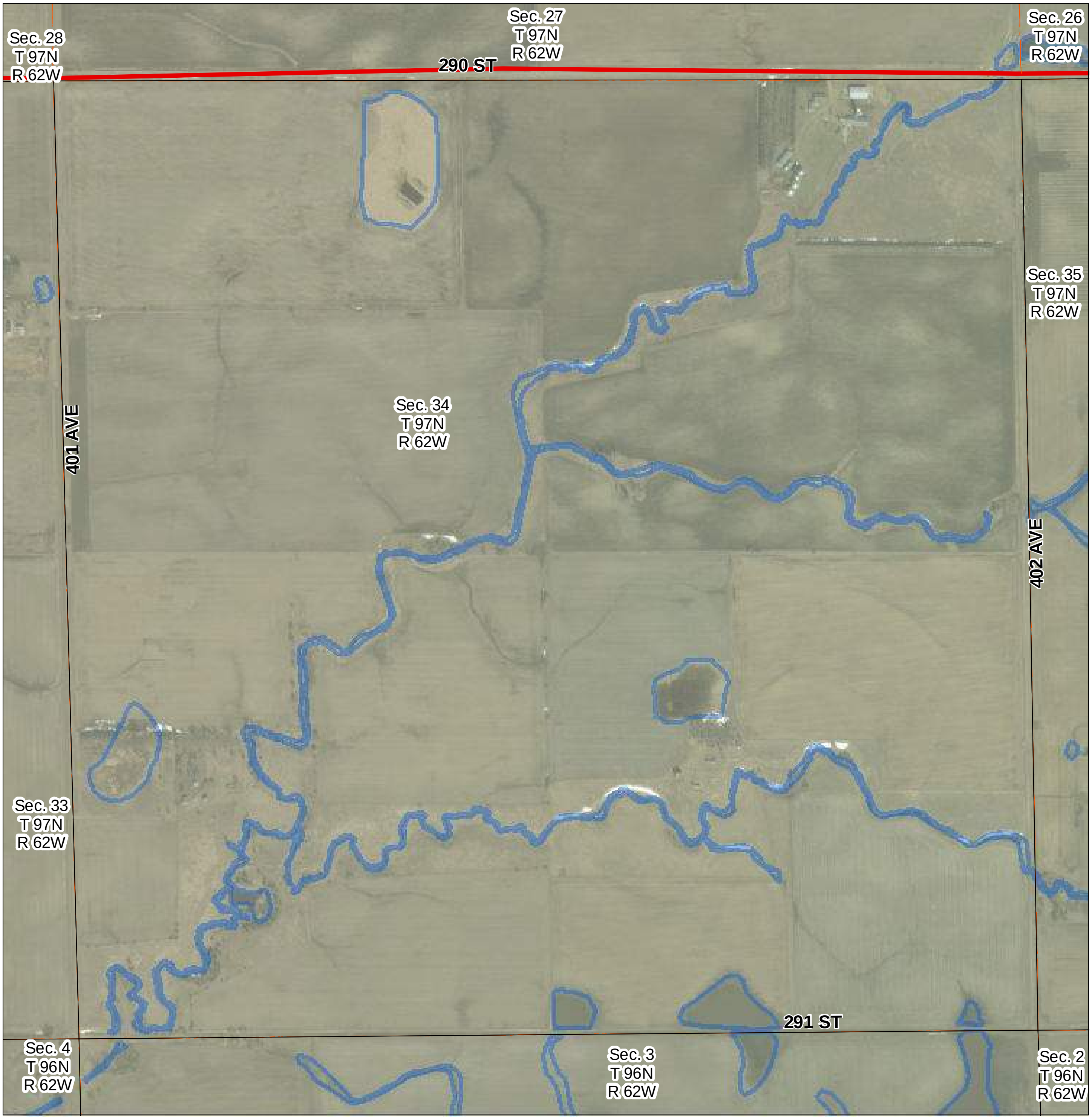

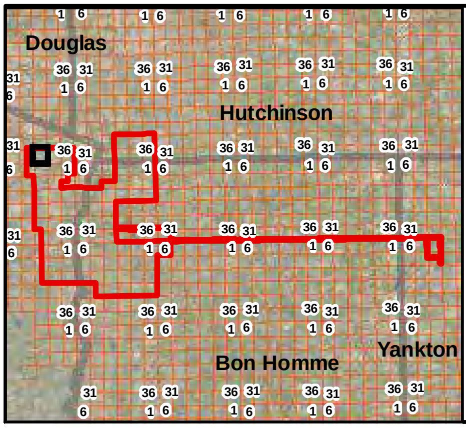

Legend

🟥 Project Area (2018)

Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

N

Feet
0 800

Figure 2 - 5

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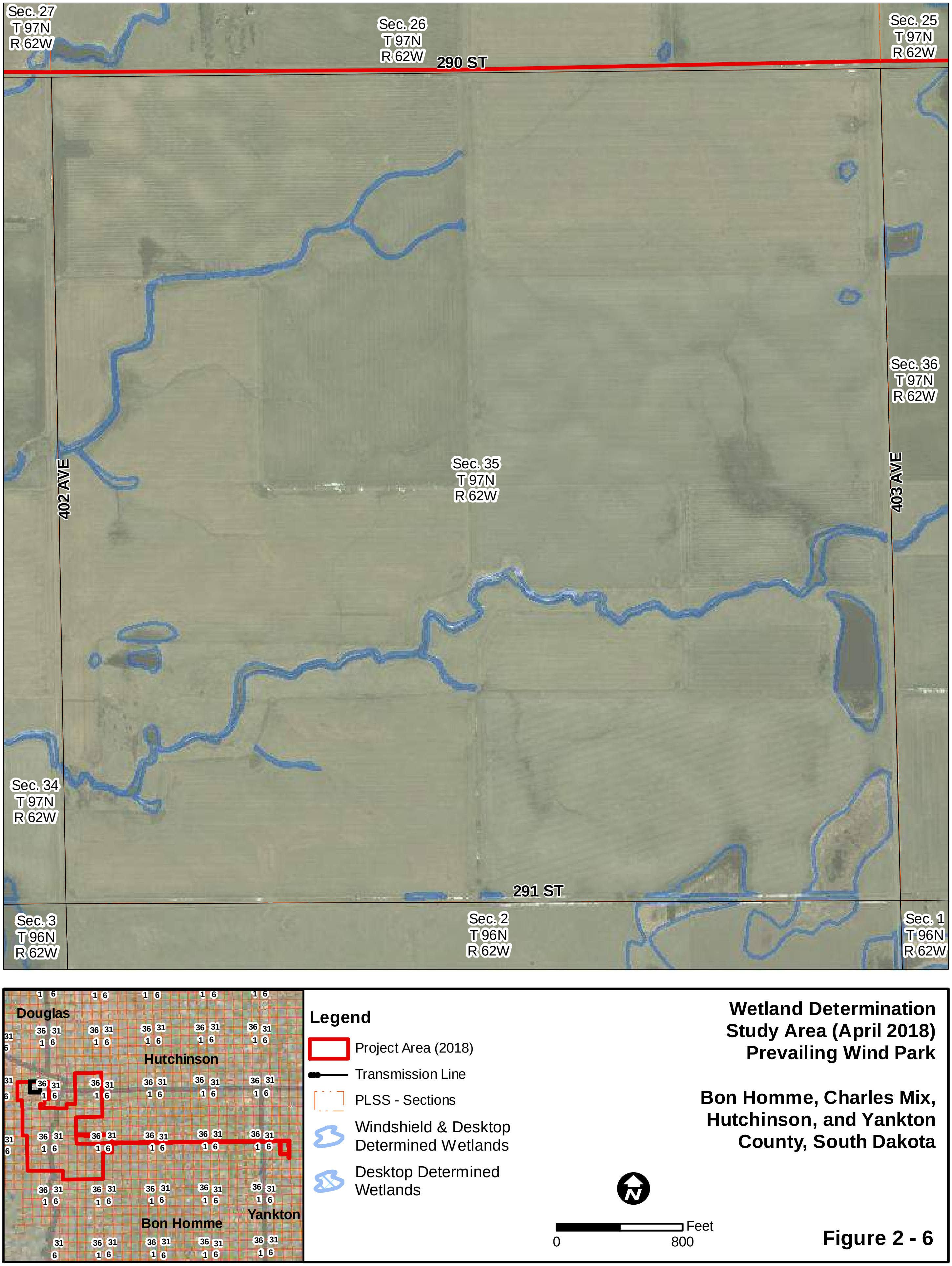

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 6

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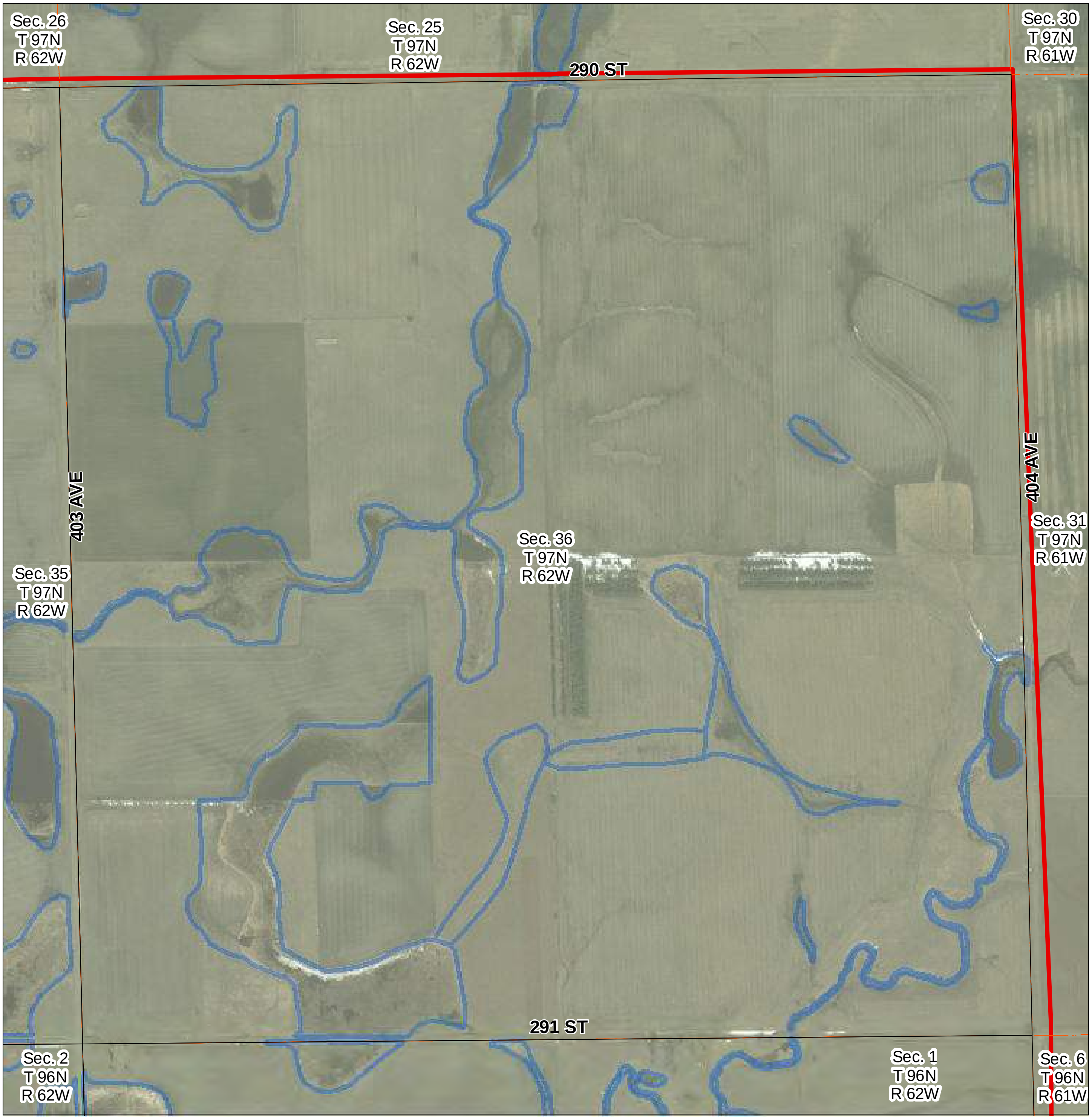

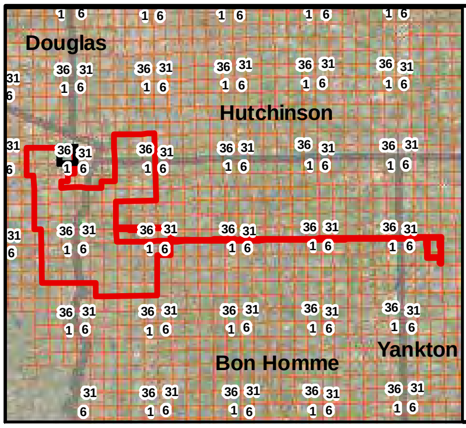

Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

0 800 Feet

Figure 2 - 7

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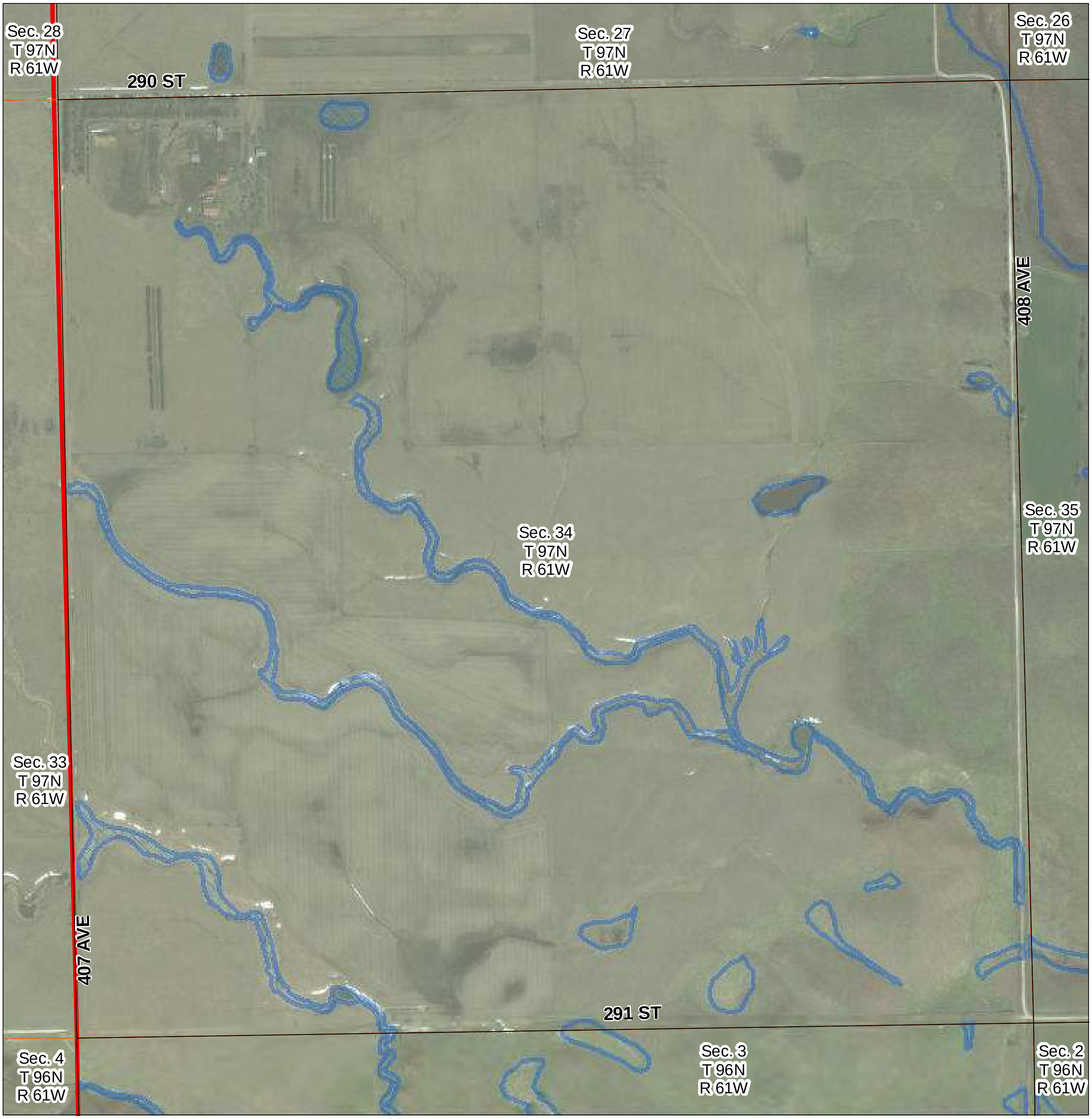

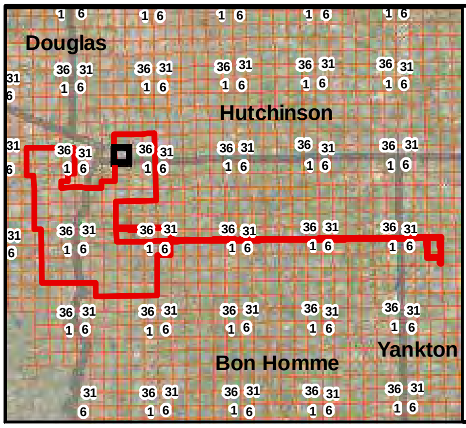

Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Feet
0 800

Figure 2 - 8

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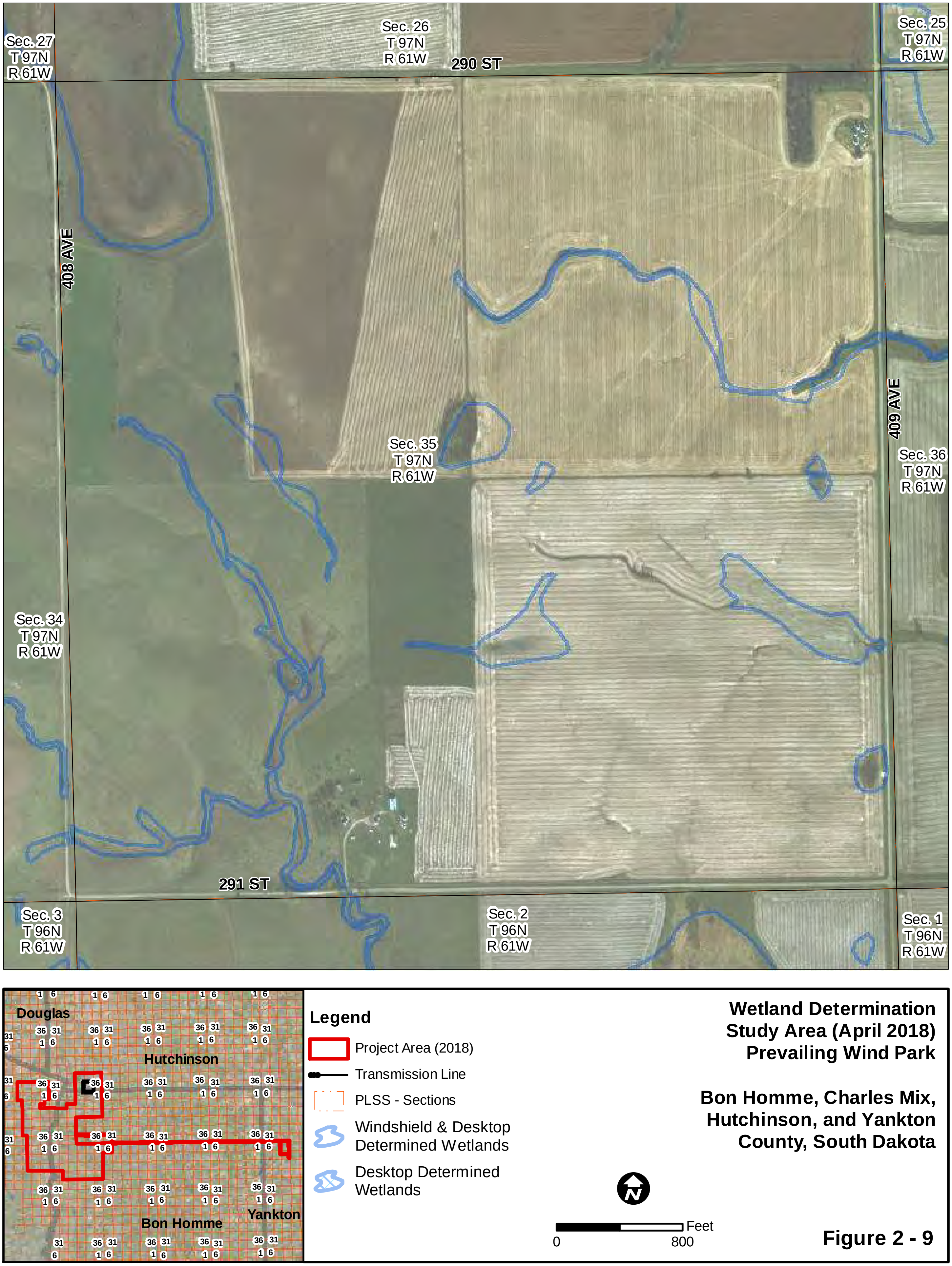


Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

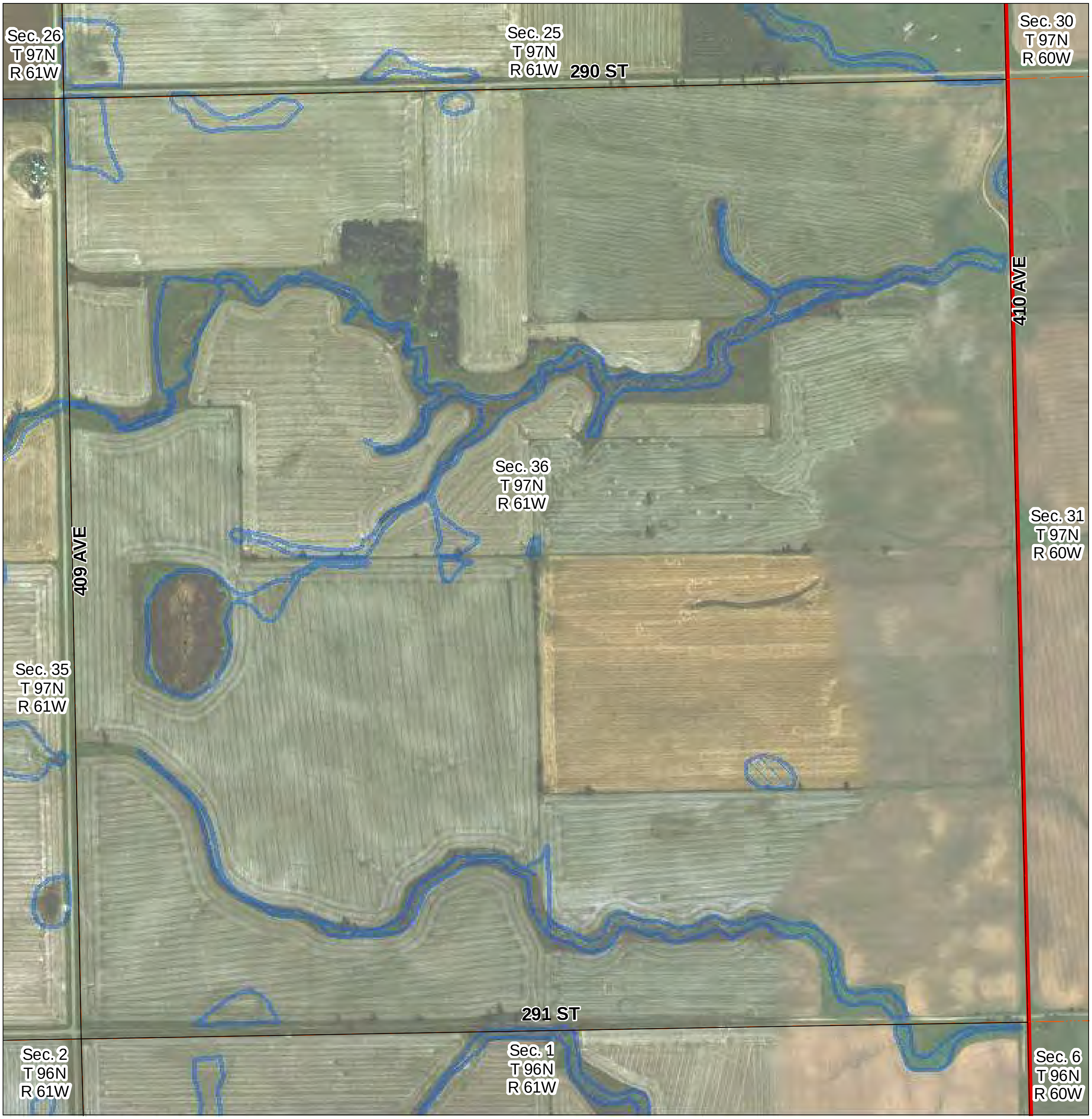
Windshield & Desktop Determined Wetlands

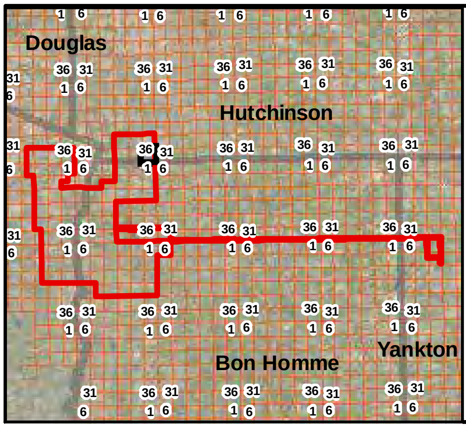
Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 9





Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 10

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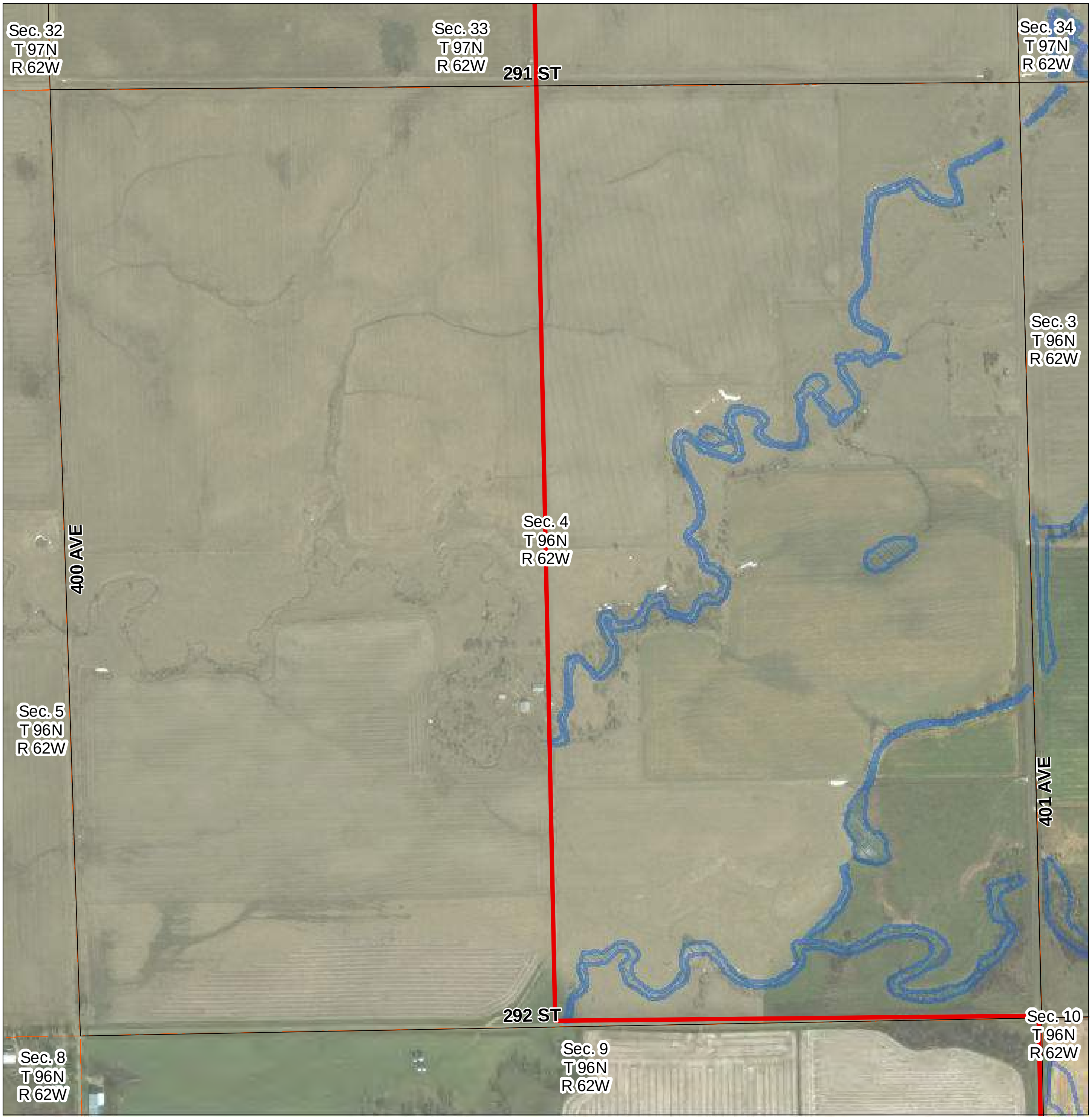

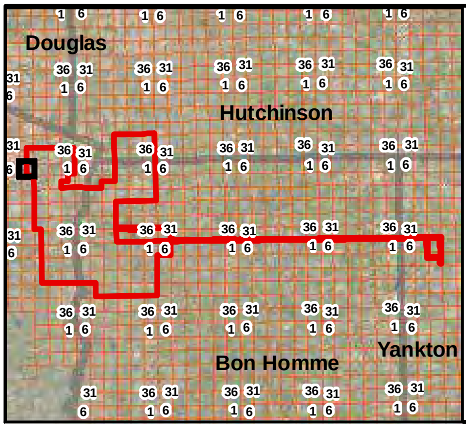

Legend

🟥 Project Area (2018)

●— Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

N

Feet
0 800

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

**Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota**

Figure 2 - 11

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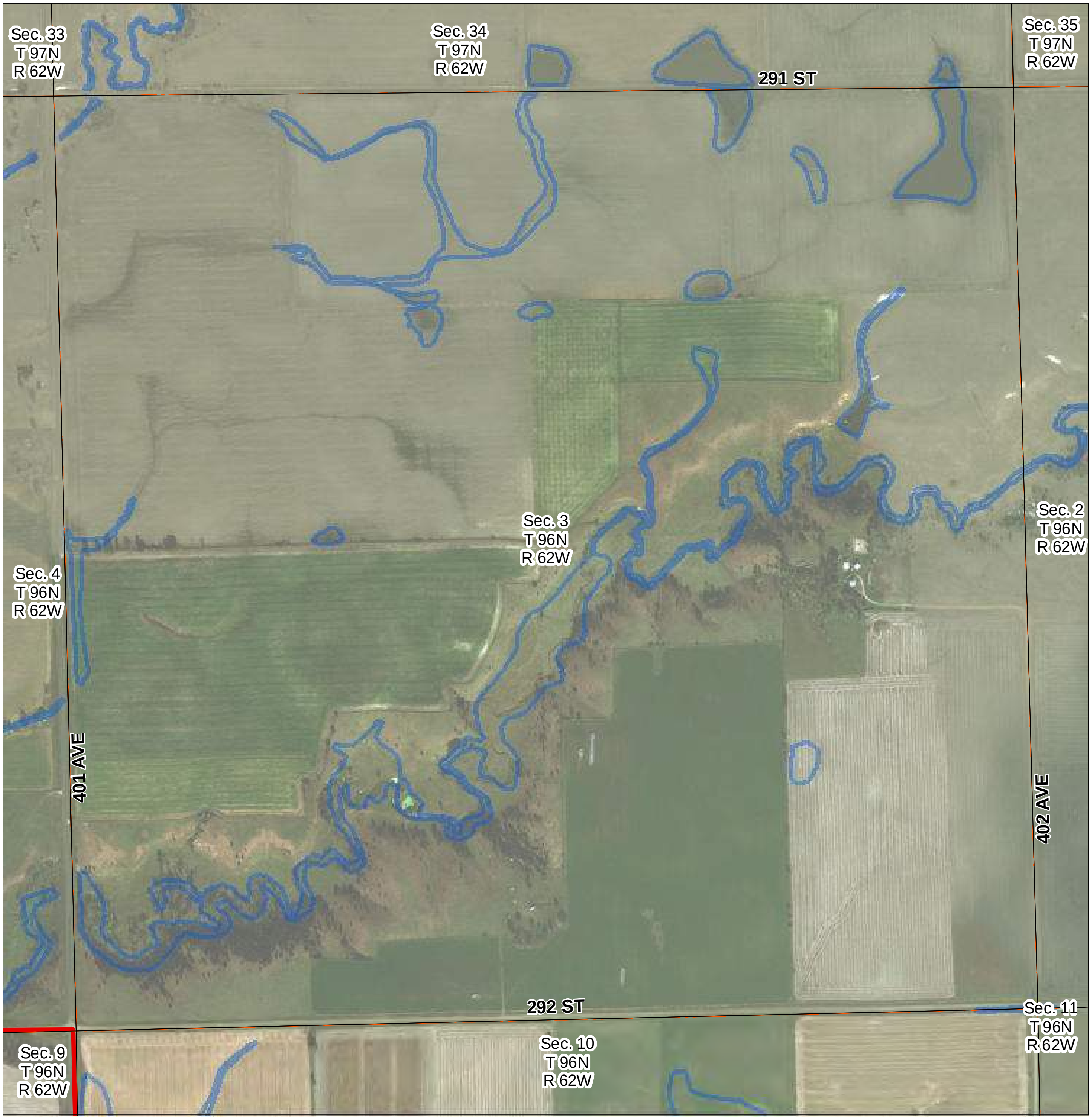

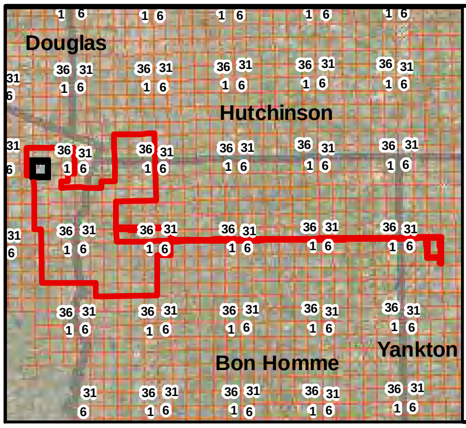

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 12

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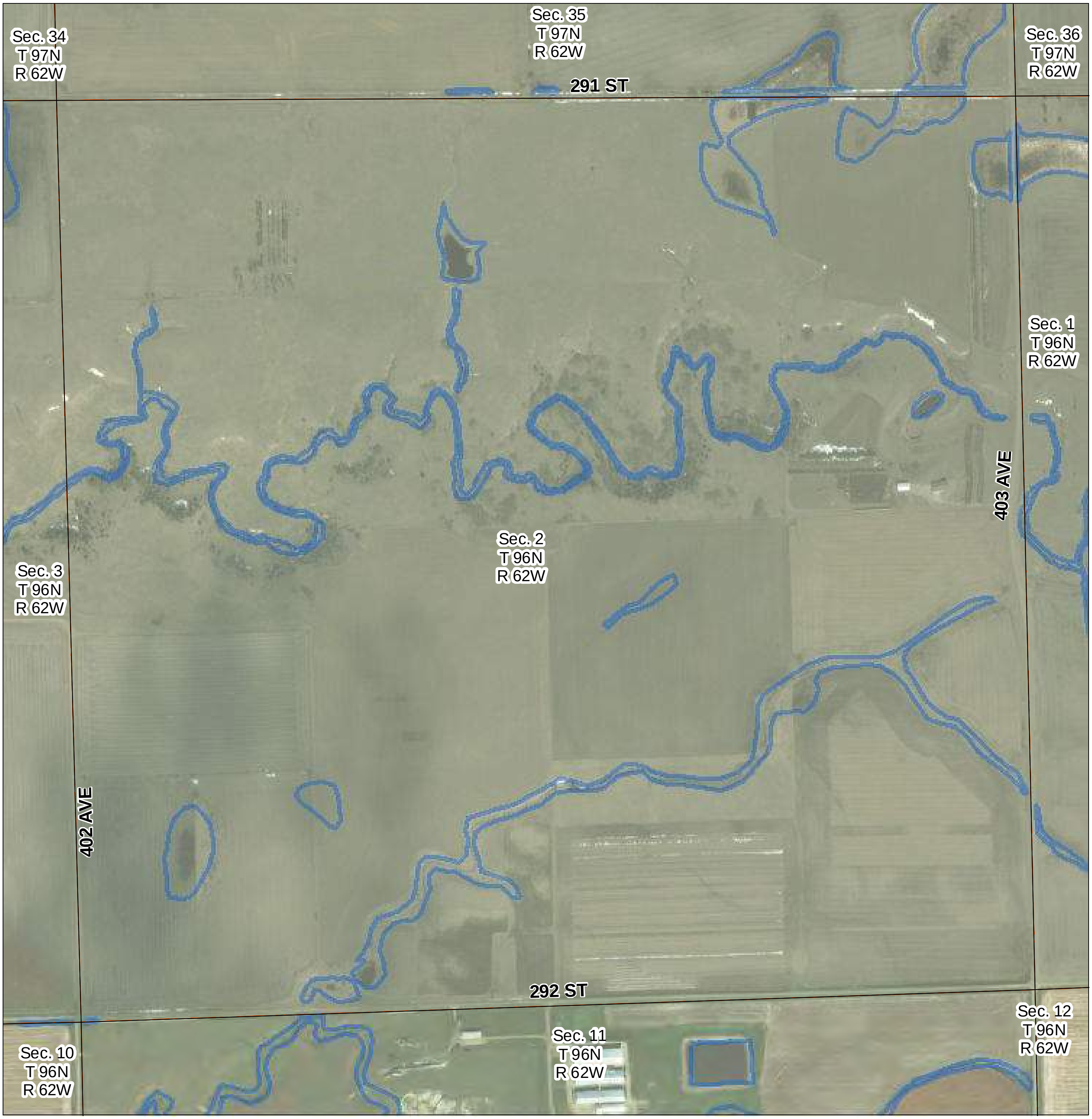

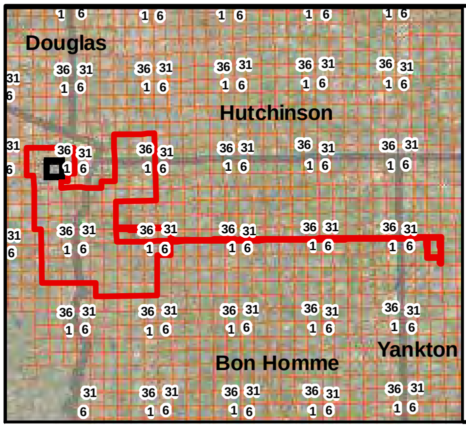

Legend

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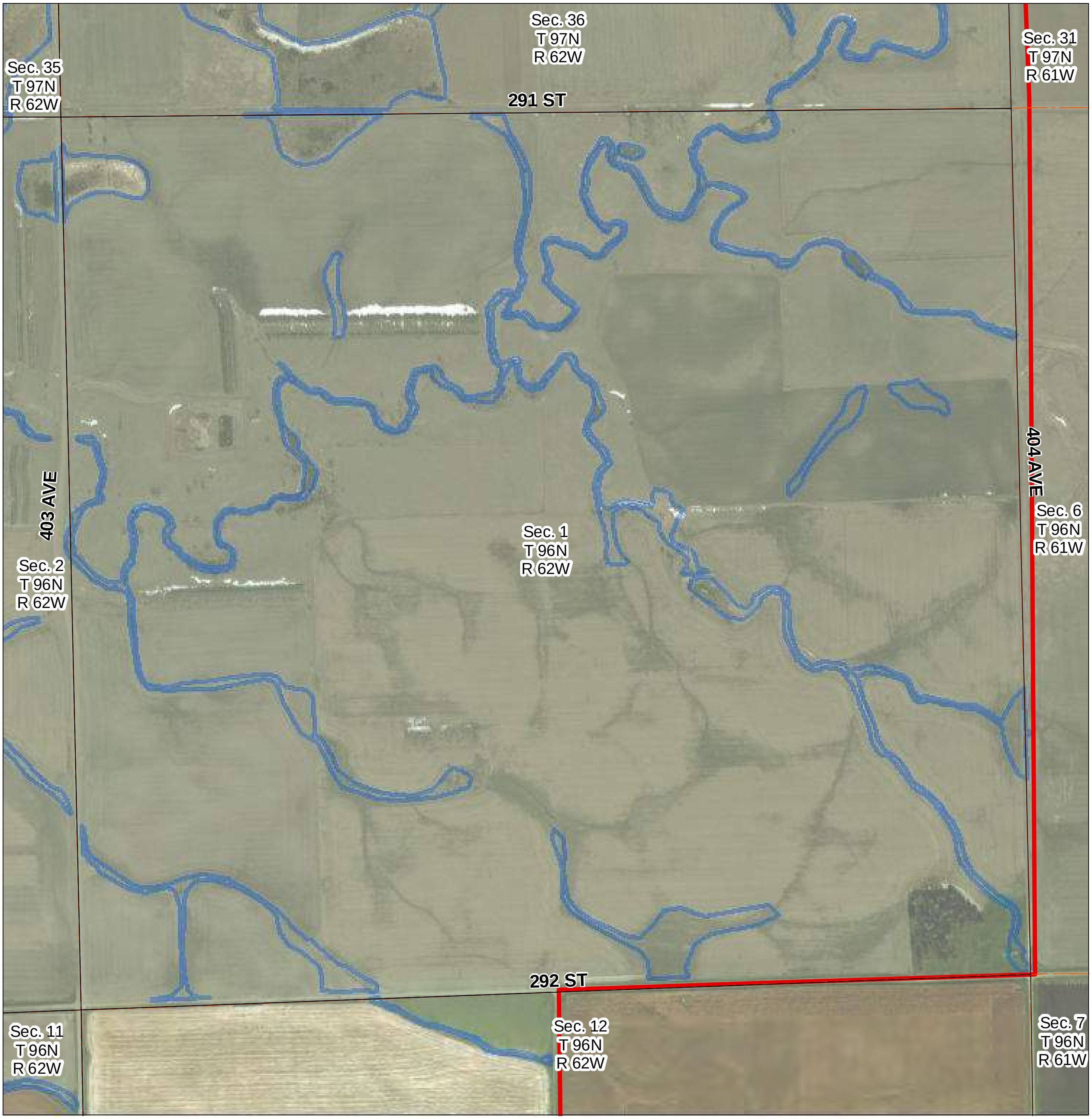
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

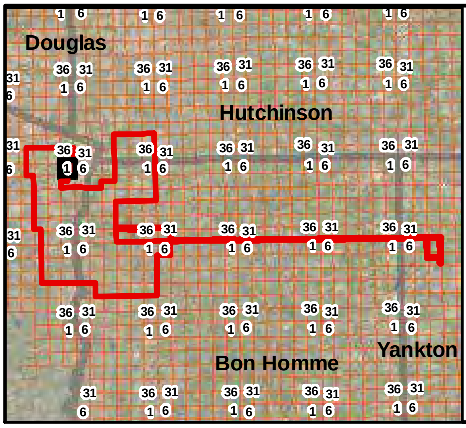
Feet
0 800

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

**Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota**

Figure 2 - 13





Legend

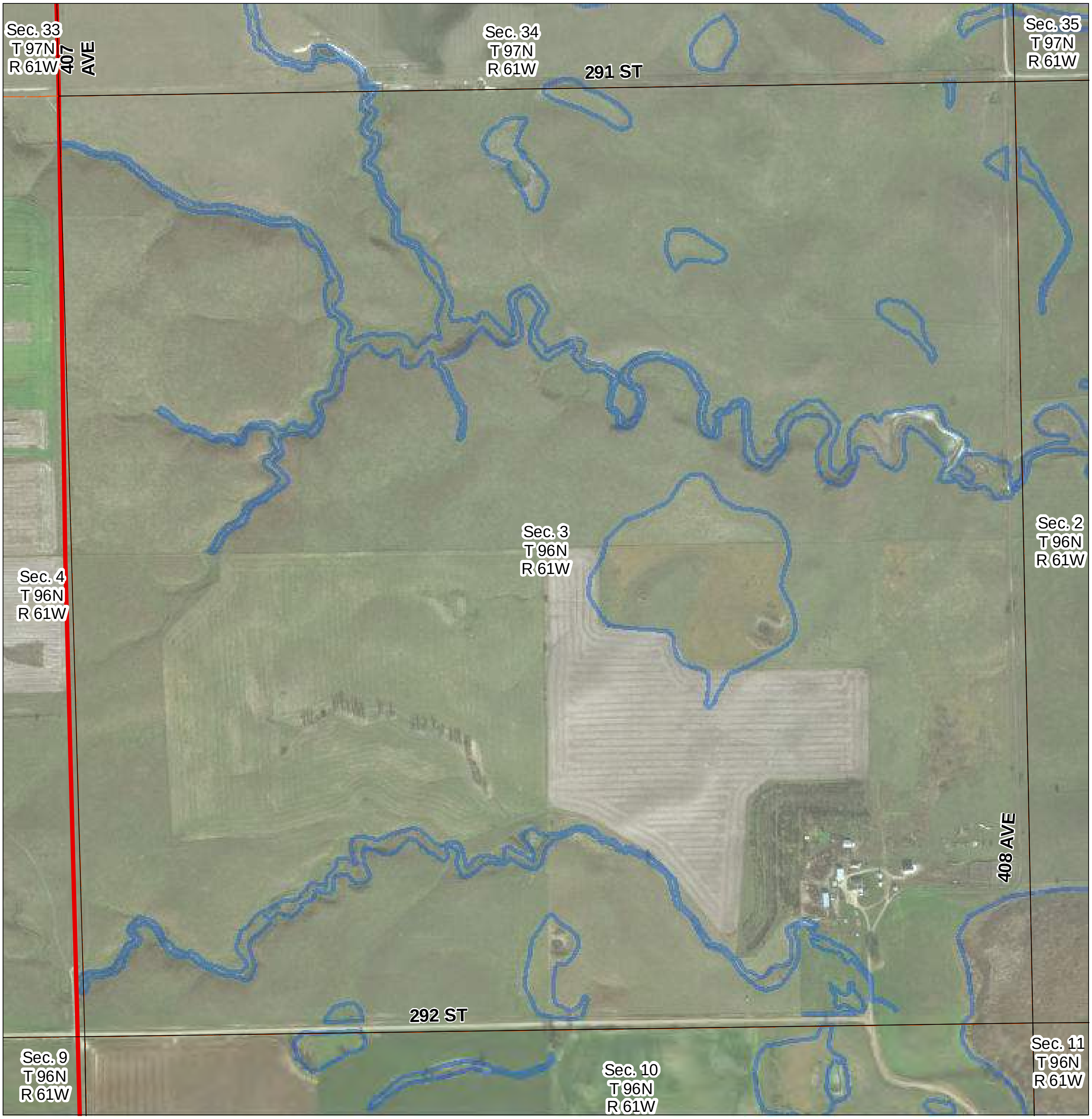
- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

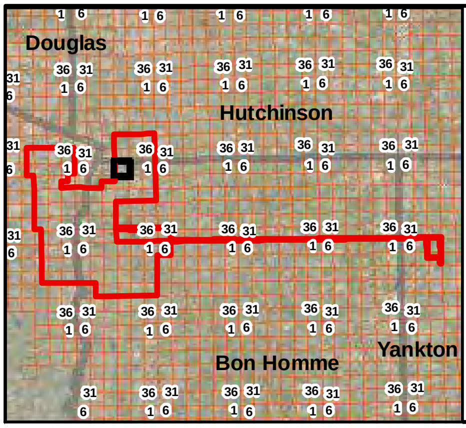
Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Feet
0 800

Figure 2 - 14





Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 15

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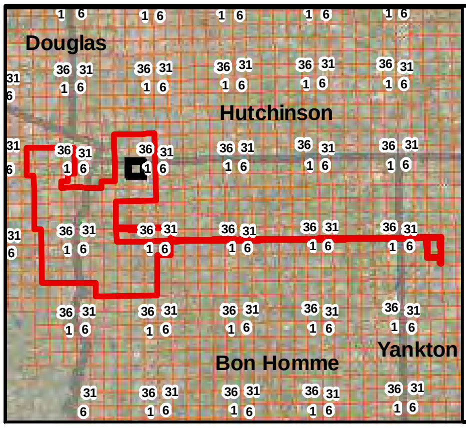


Legend

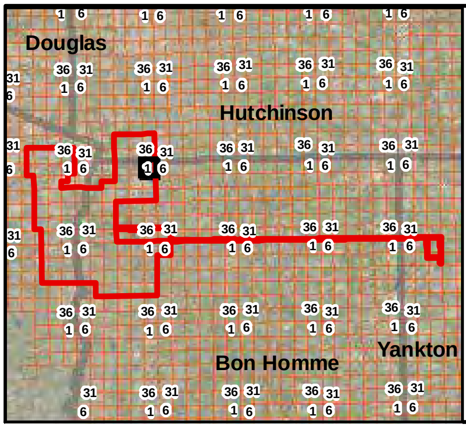
- Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 16



Legend

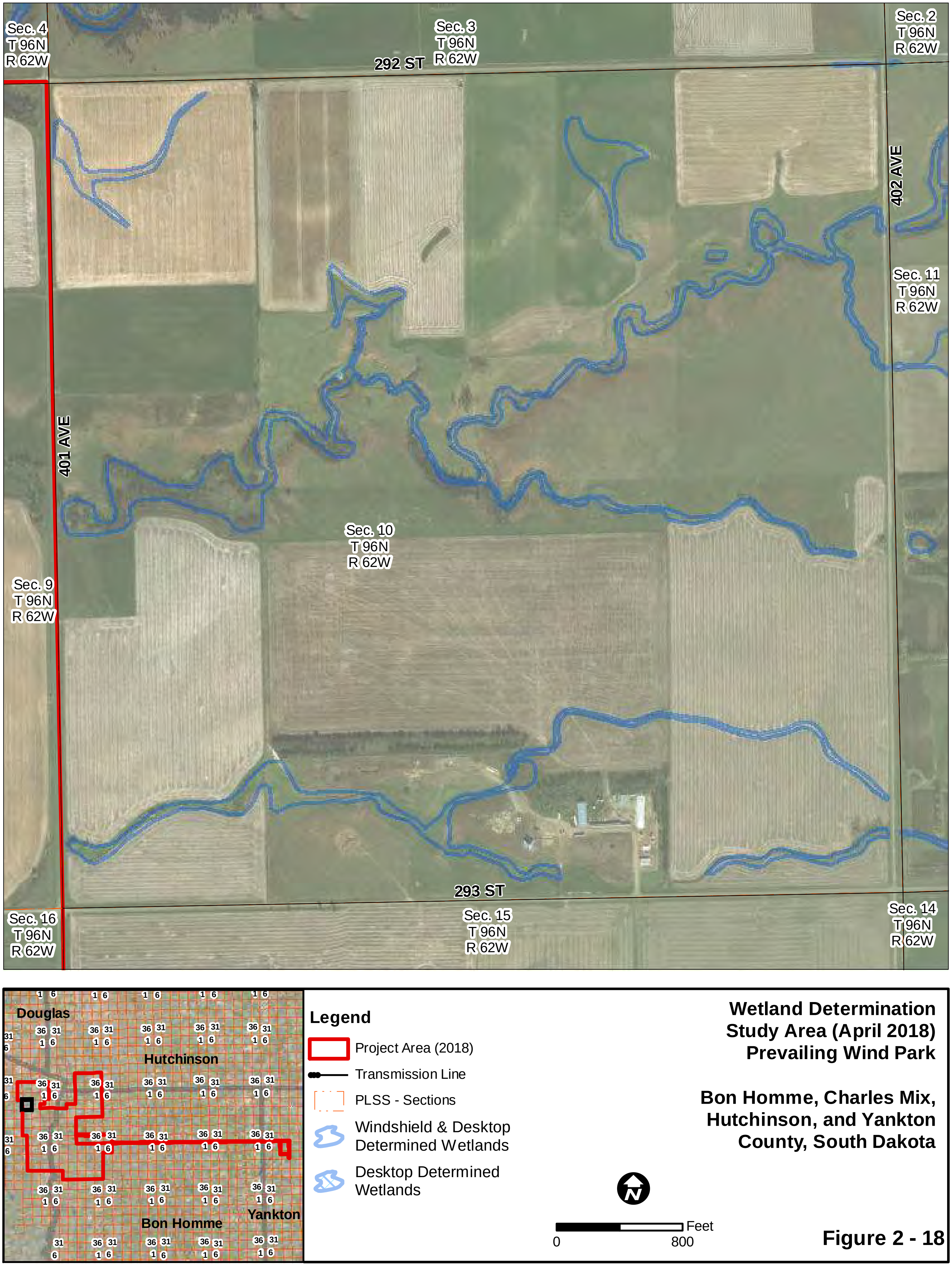
- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 17



Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 18

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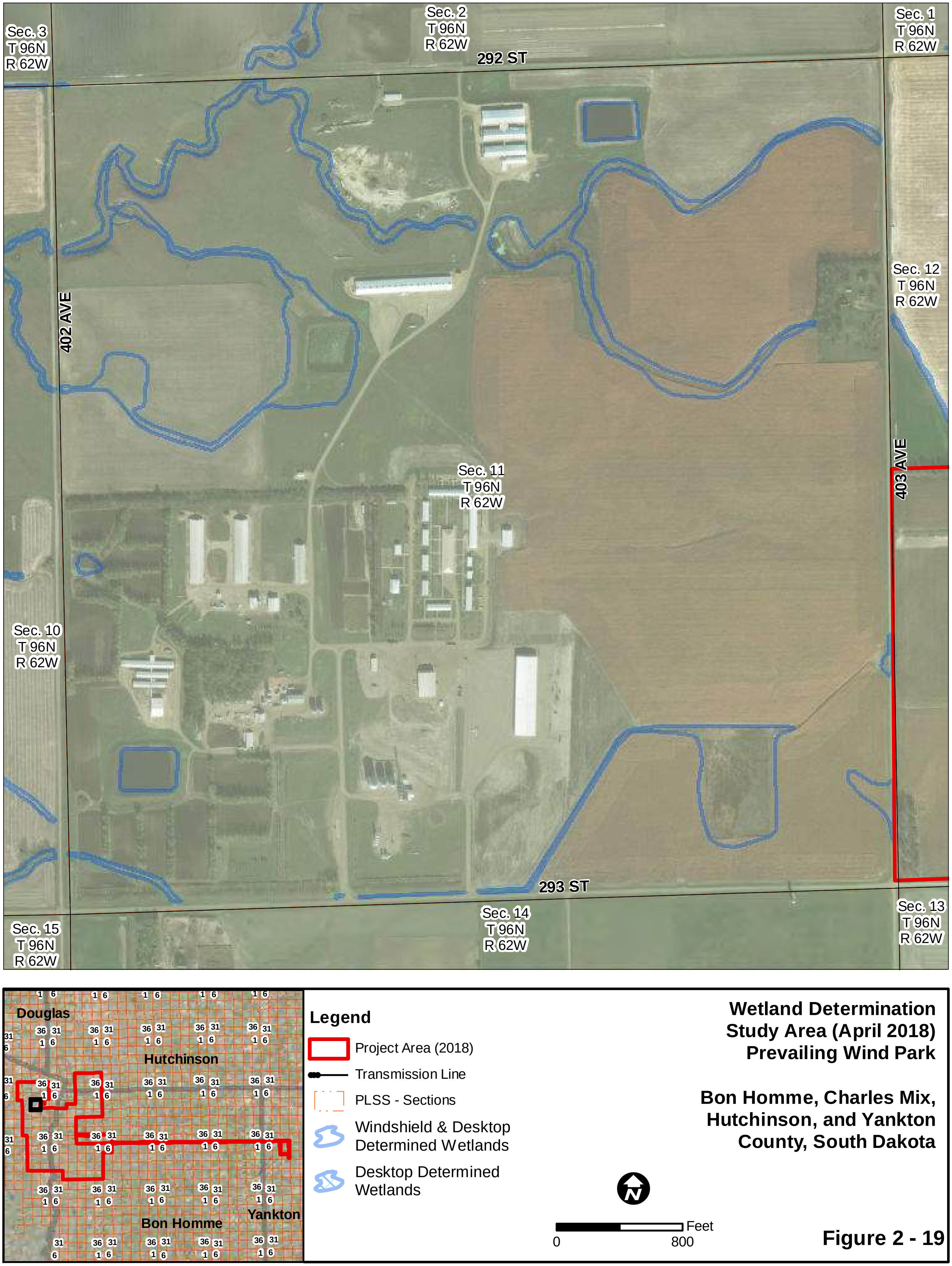

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 19

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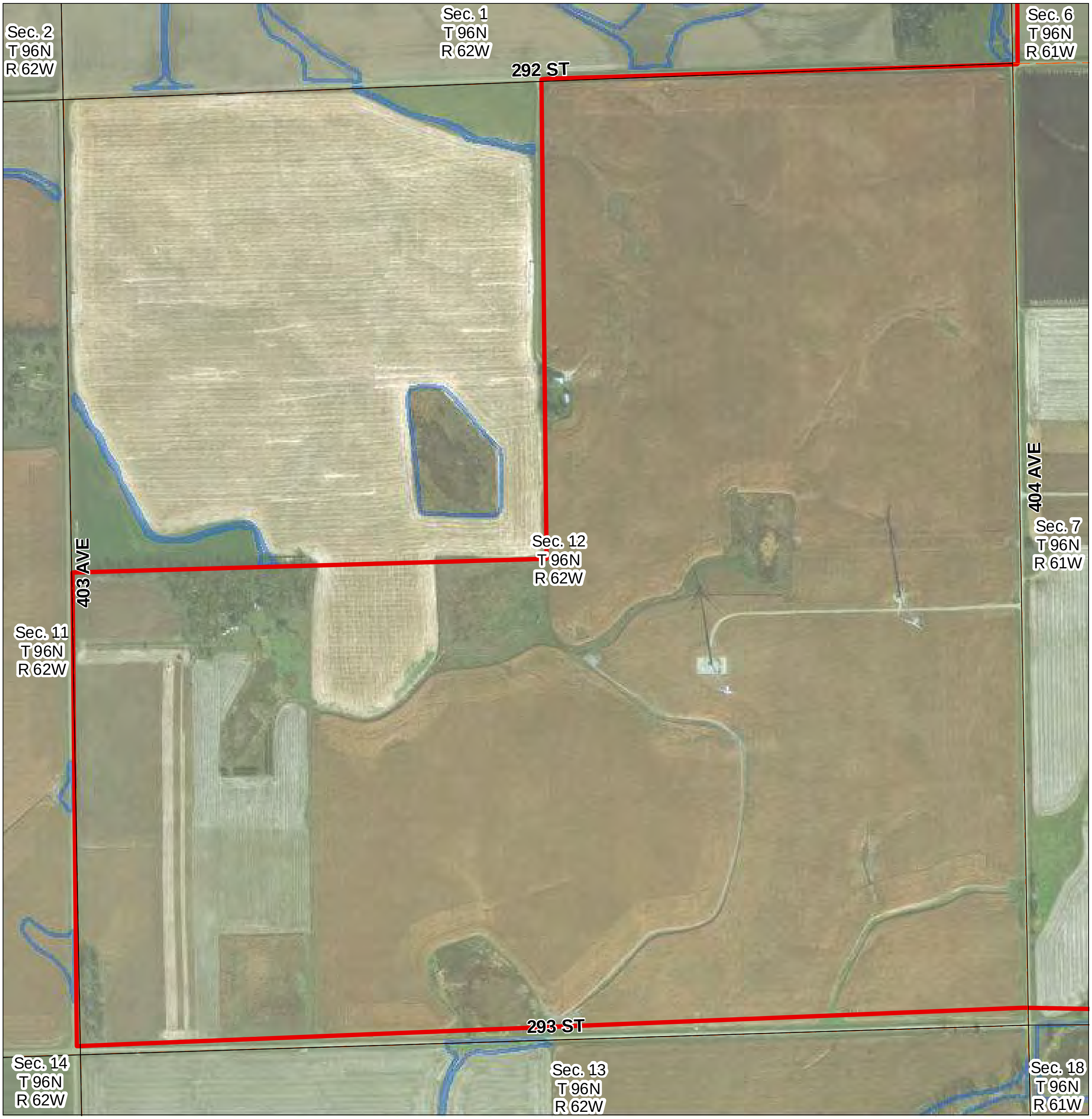
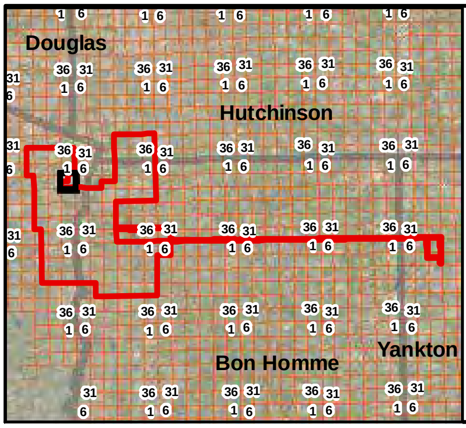




Legend

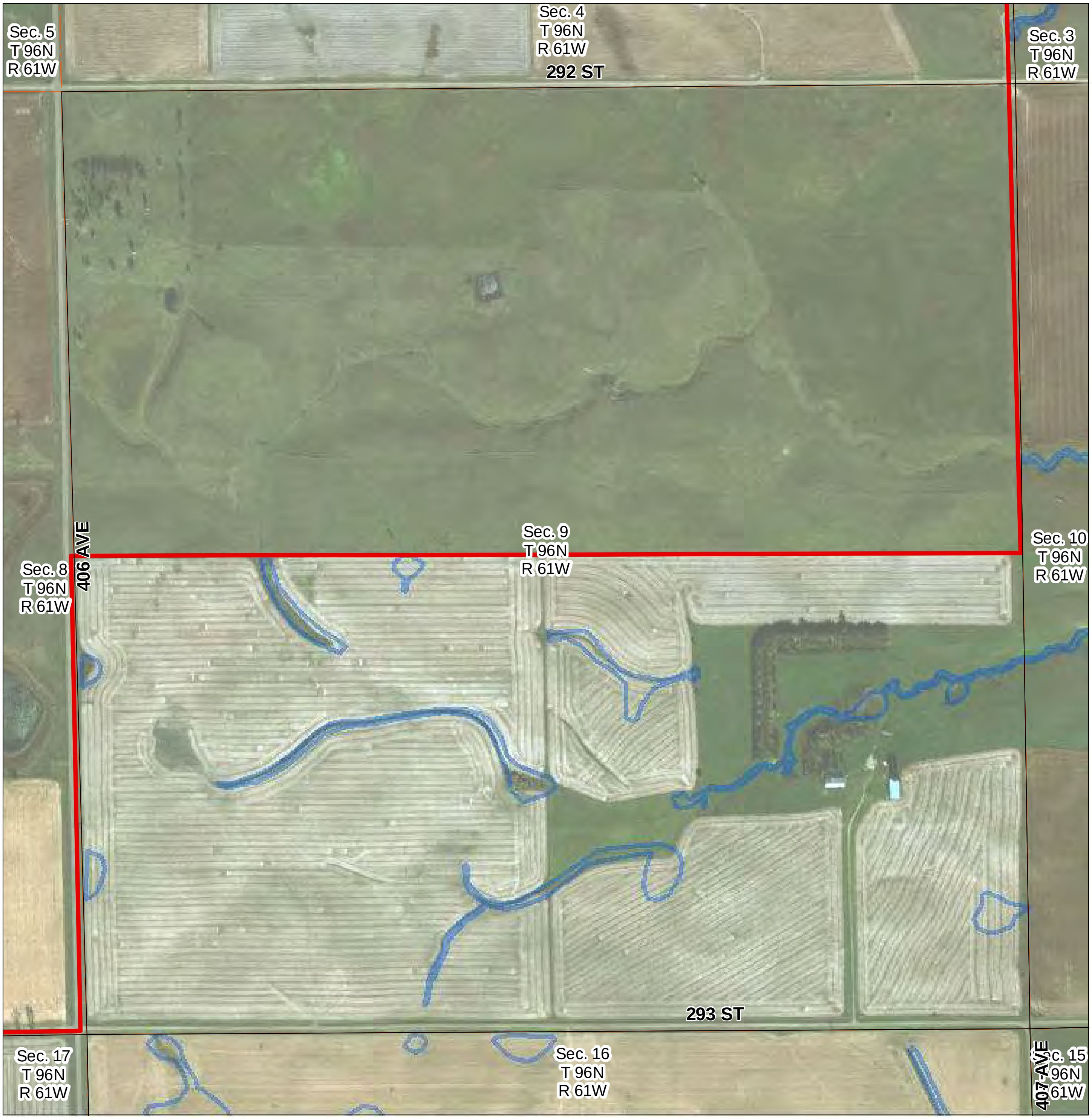
- Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

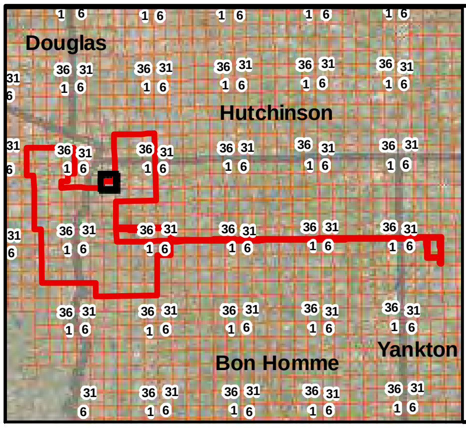
Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 20





Legend

🟥 Project Area (2018)

●● Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

N

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 21

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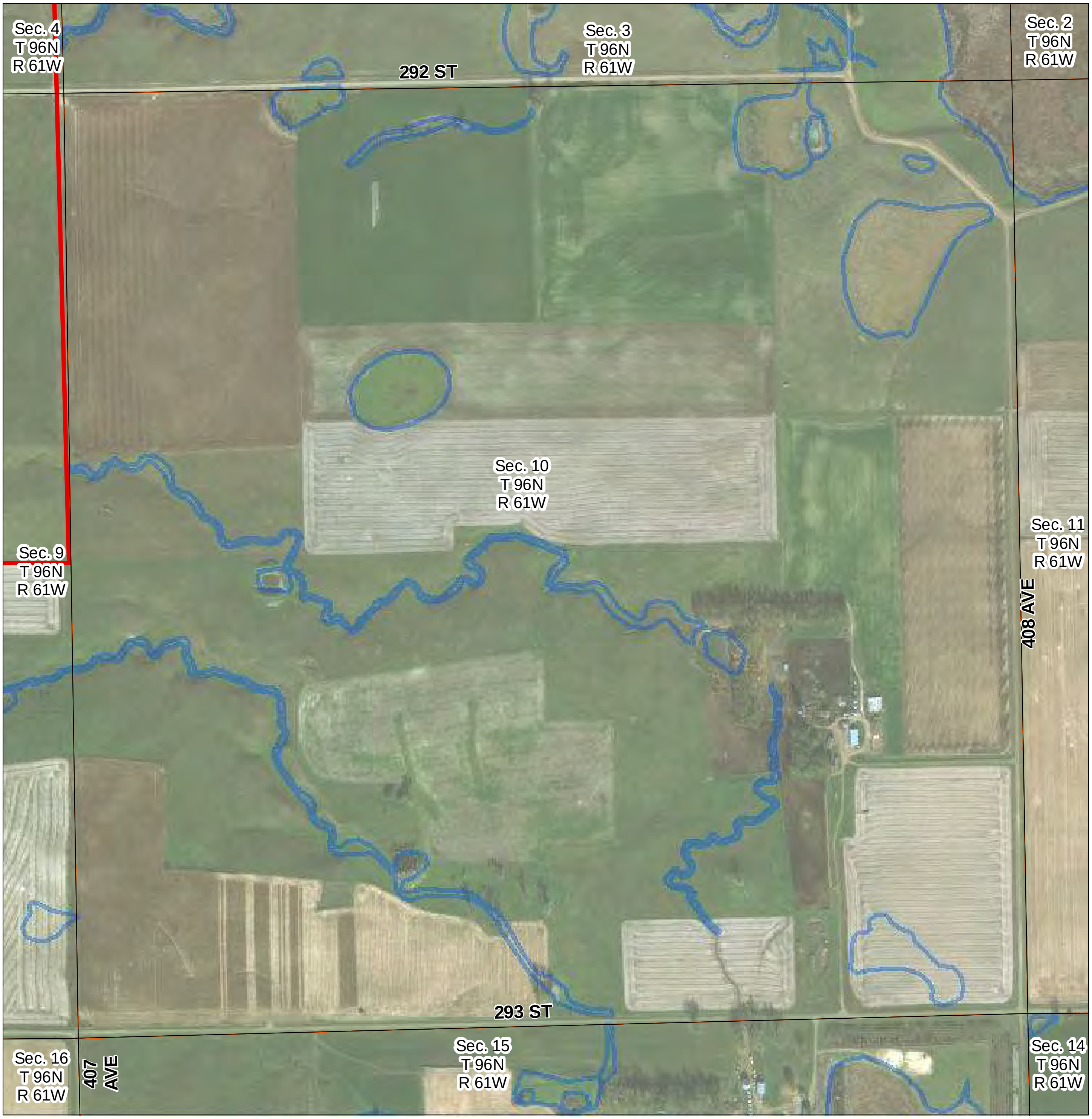

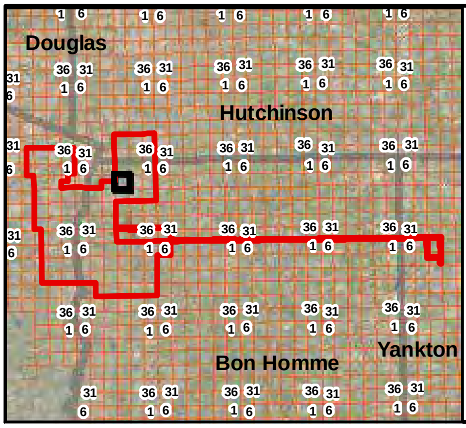

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🟥 Project Area (2018)

●— Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Feet
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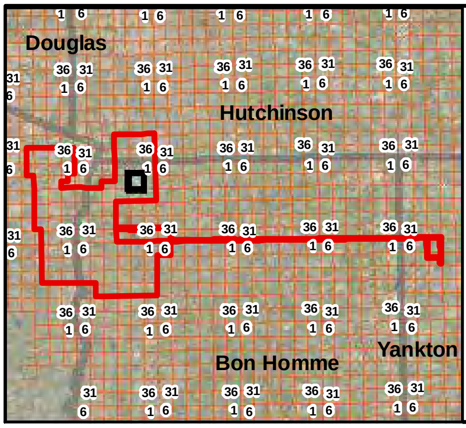
Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 22



Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 23

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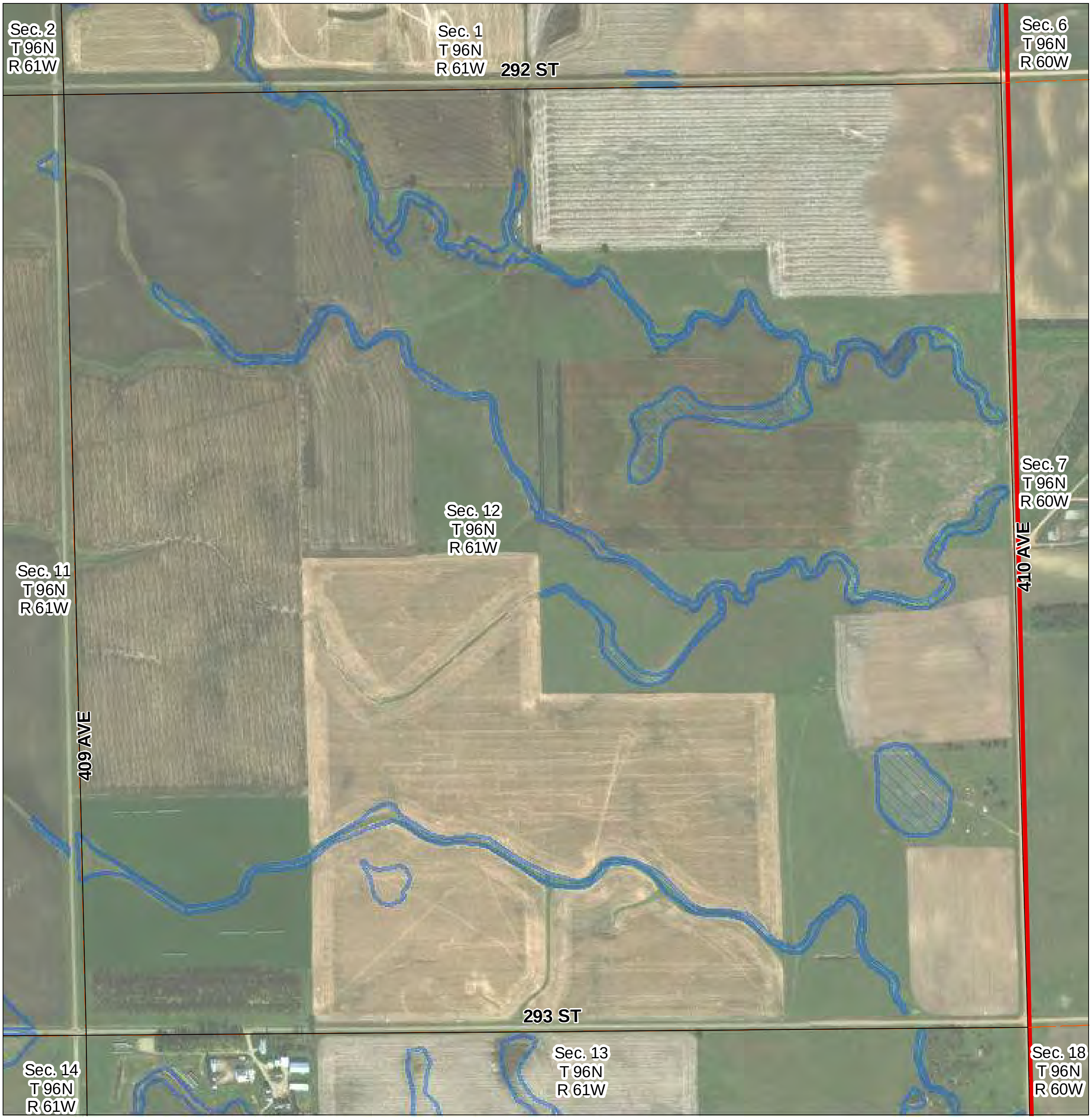

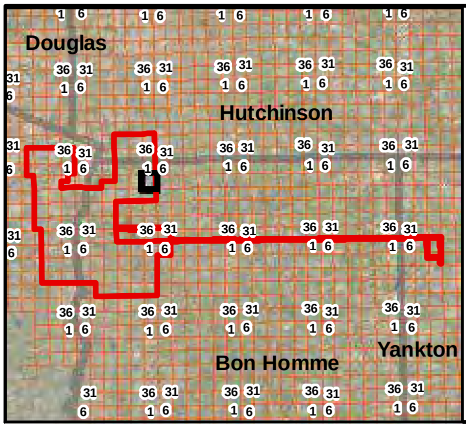

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 24

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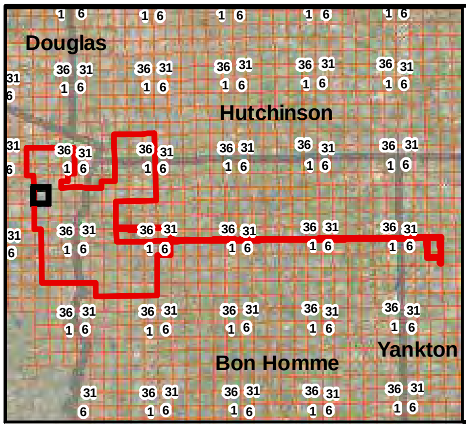

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 25

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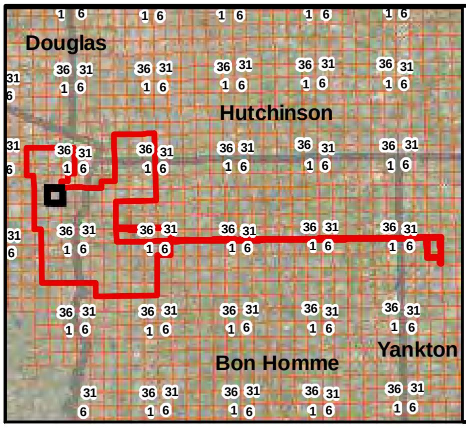


Legend

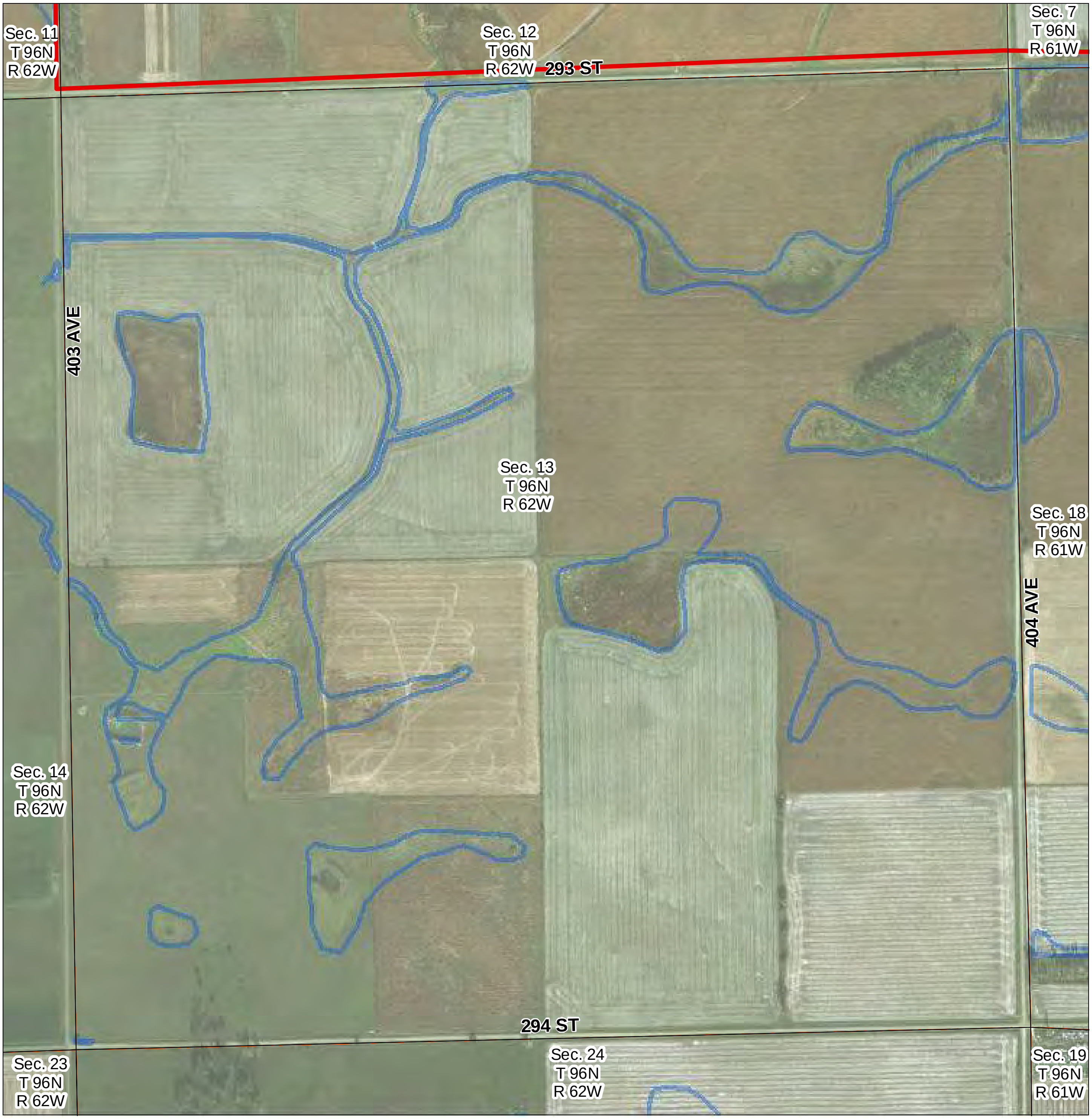
- ▭ Project Area (2018)
- —●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

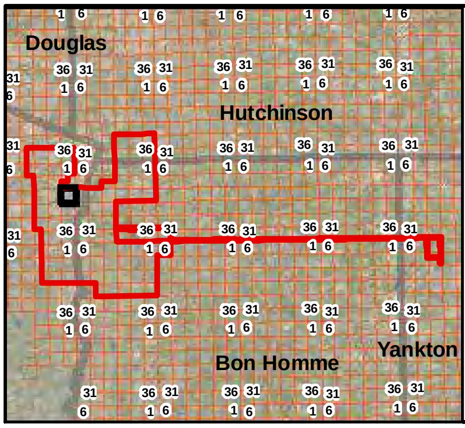
0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 26





Legend

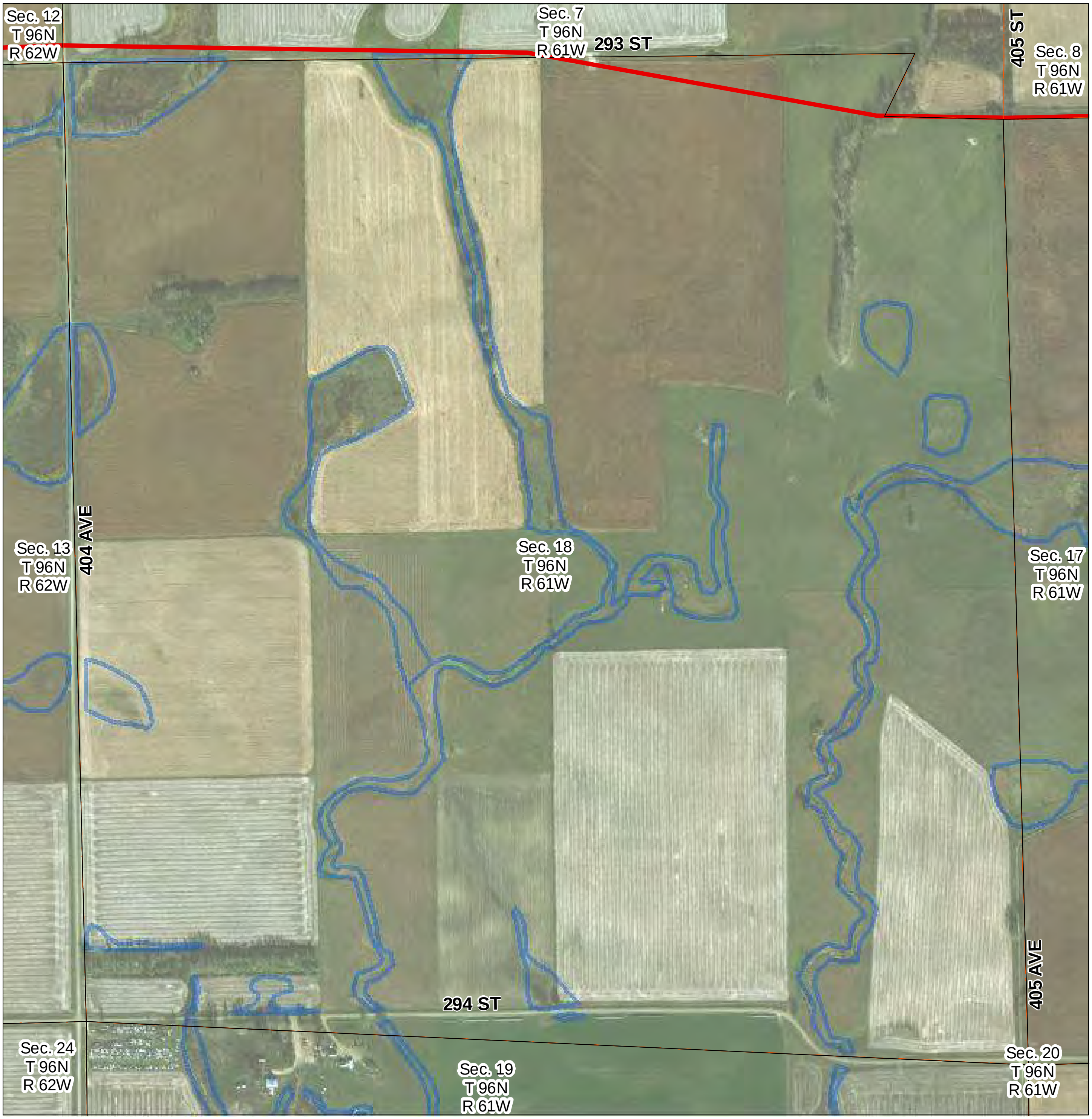
- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

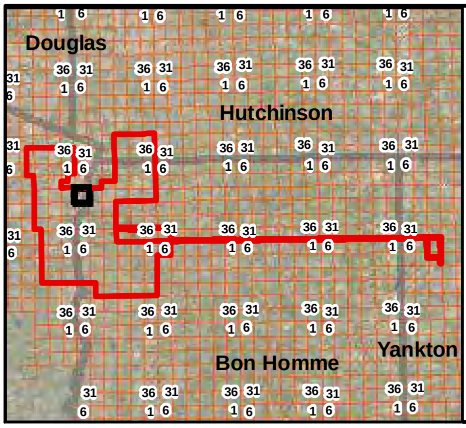
Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 27





Legend

🟥 Project Area (2018)

Transmission Line

PLSS - Sections

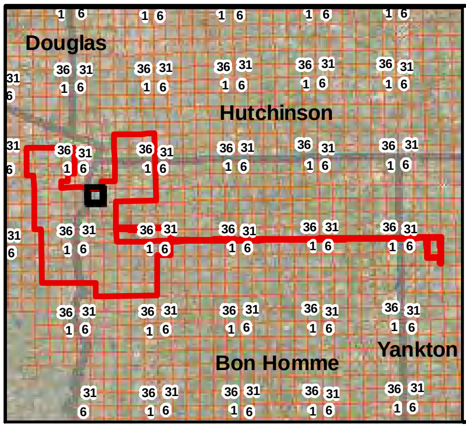
Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 28



Legend

- Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 29

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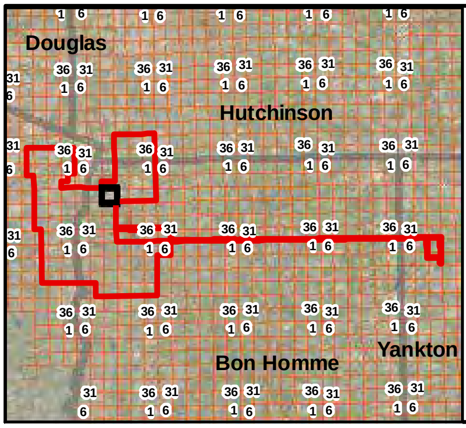

Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 30

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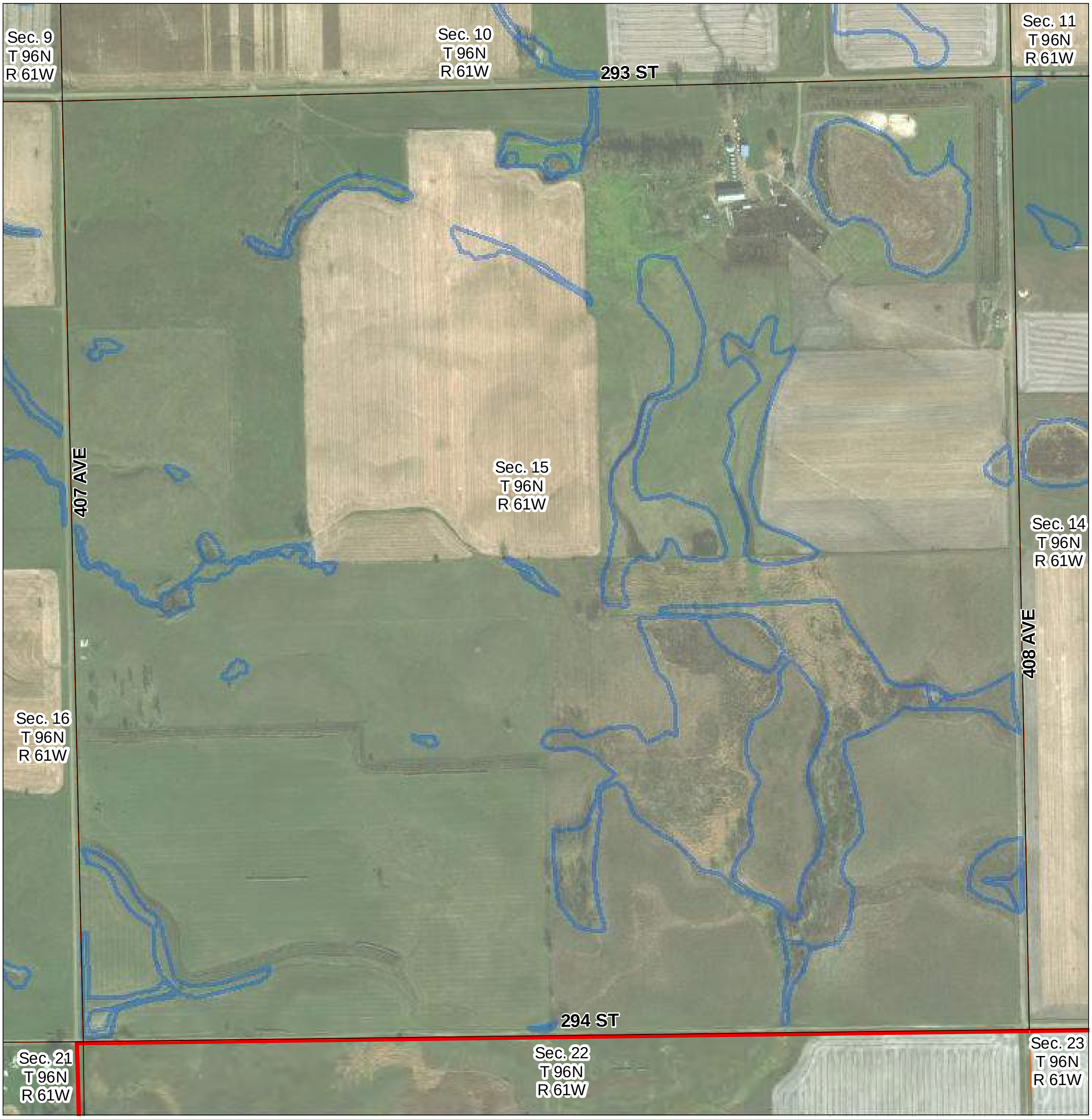

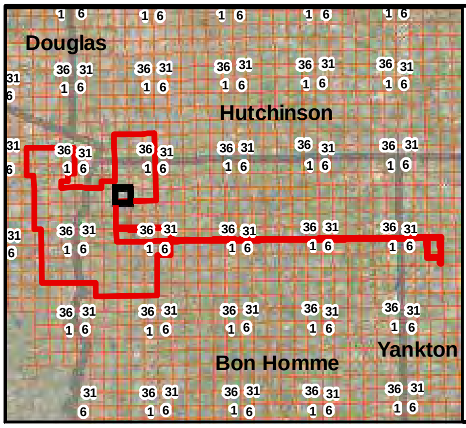

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

N

0 800 Feet

Figure 2 - 31

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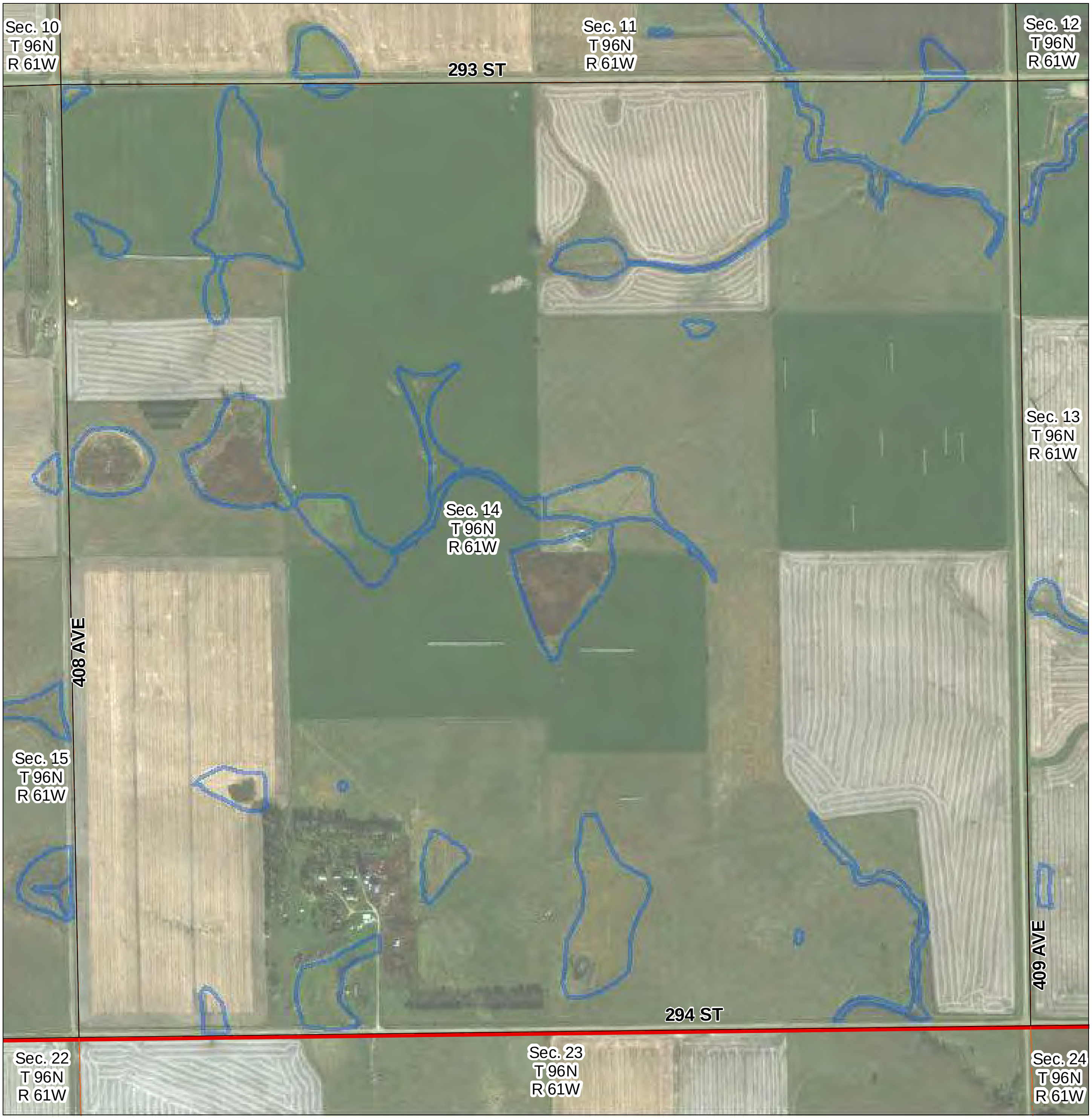

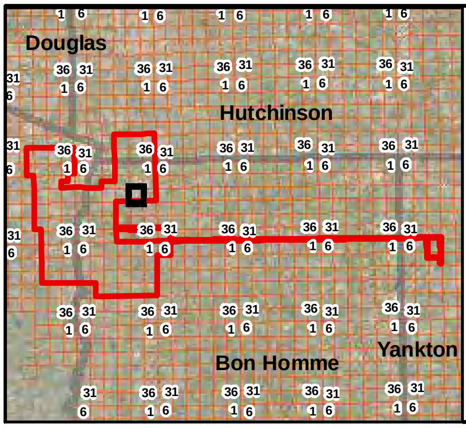

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

0 800 Feet

Figure 2 - 32

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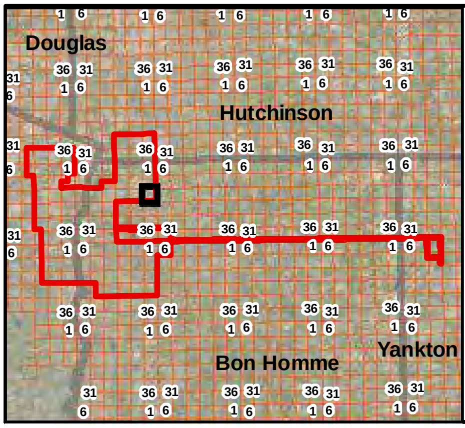


Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ┆ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

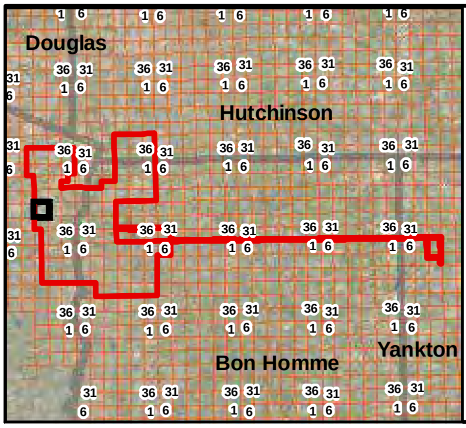
Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

**Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota**

N

0 800 Feet

Figure 2 - 33



Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

N

0 800 Feet

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota

Figure 2 - 34

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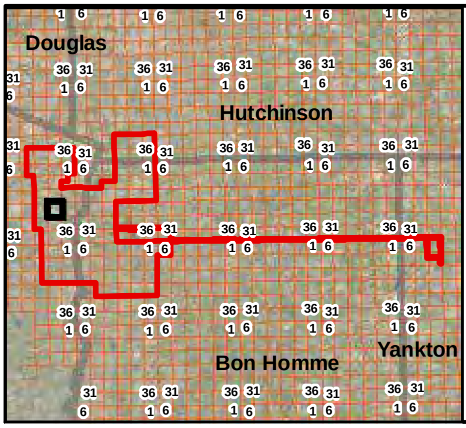


Legend

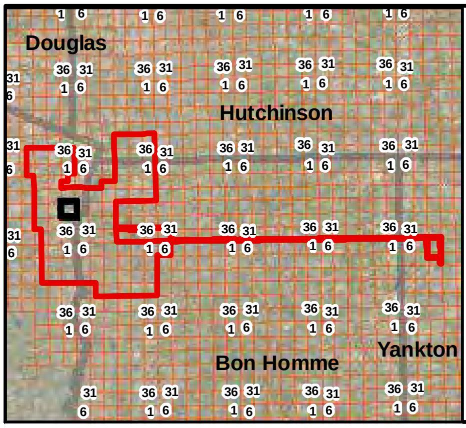
- Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 35



Legend

🟥 Project Area (2018)

Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

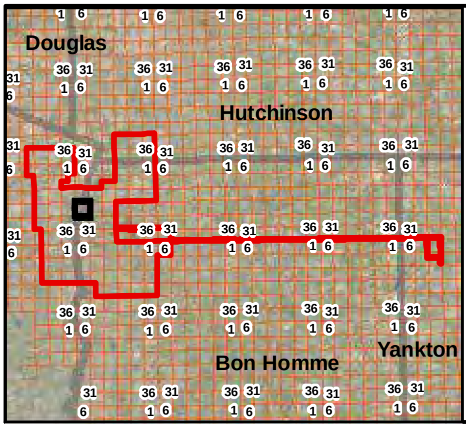
Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 36



Legend

- ▭ Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

0 800 Feet

Figure 2 - 37

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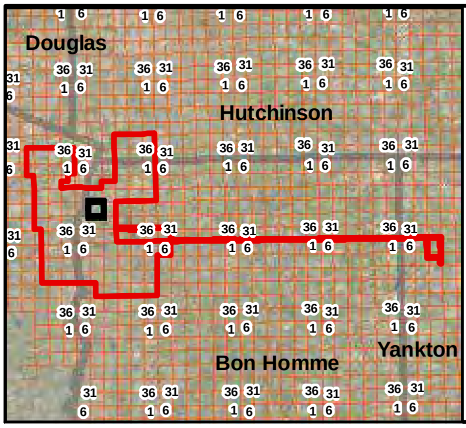


Legend

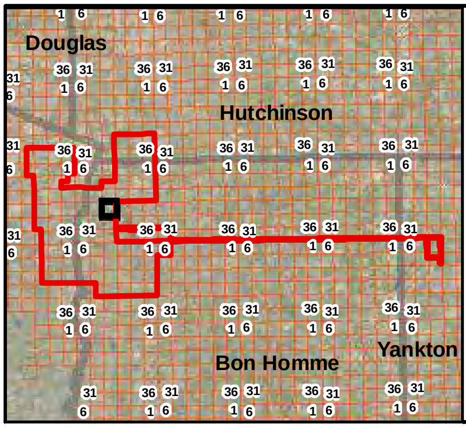
- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 38



Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

▨ Windshield & Desktop Determined Wetlands

▨ Desktop Determined Wetlands

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota

0 800 Feet

Figure 2 - 39

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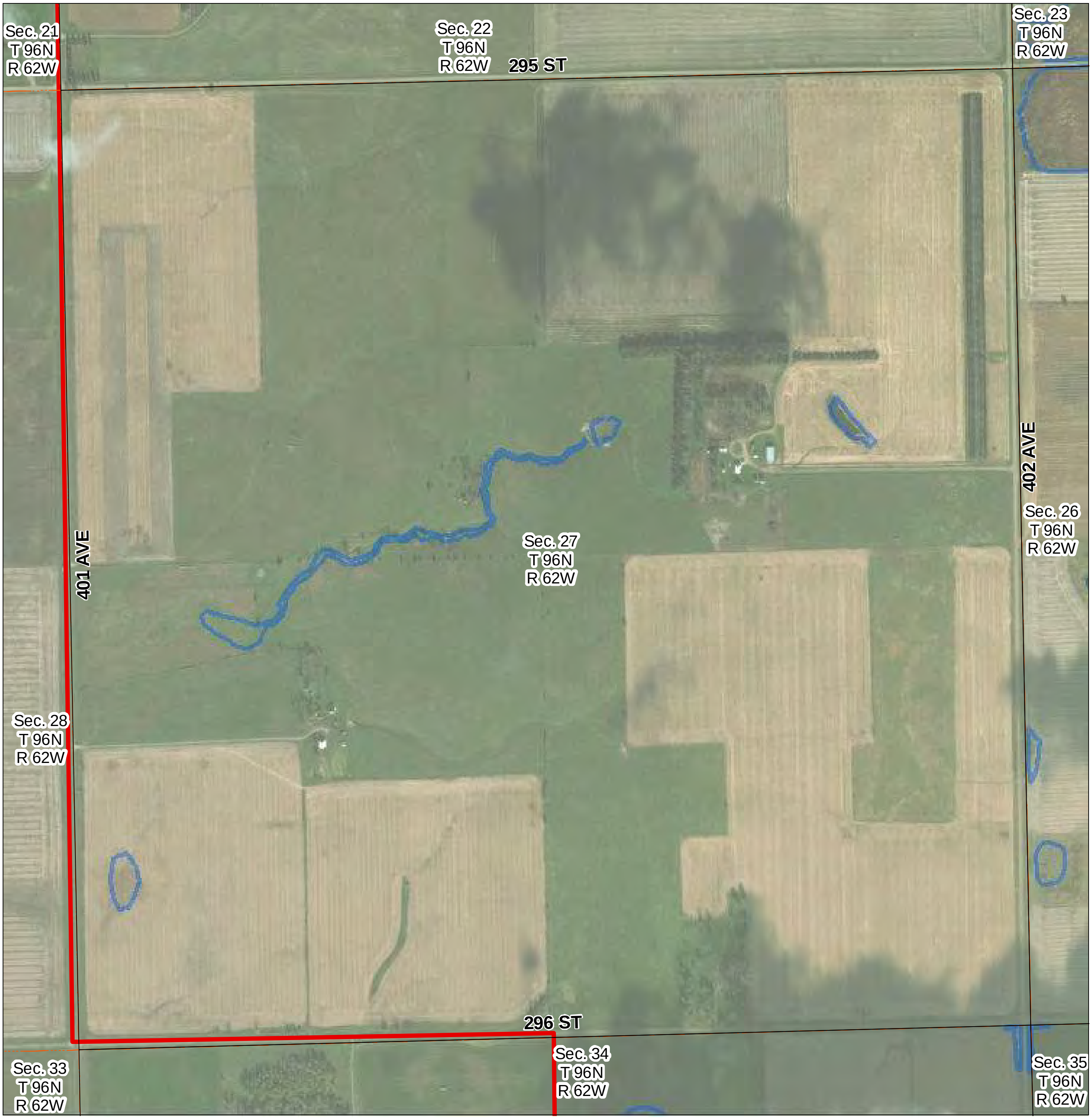

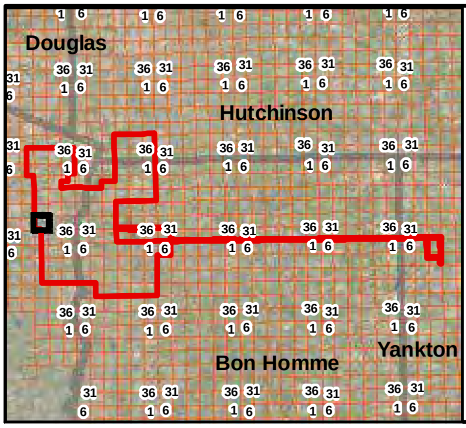

Legend

- 🟥 Project Area (2018)
- ●─ Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Feet
0 800

Figure 2 - 40

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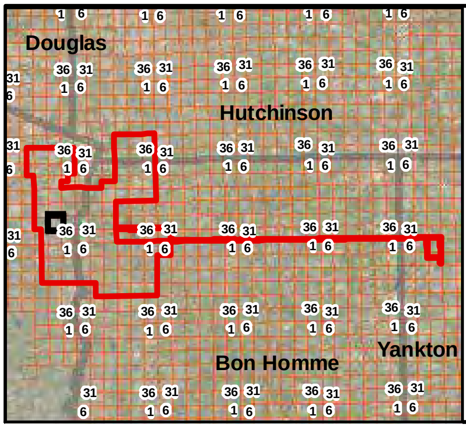

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 41

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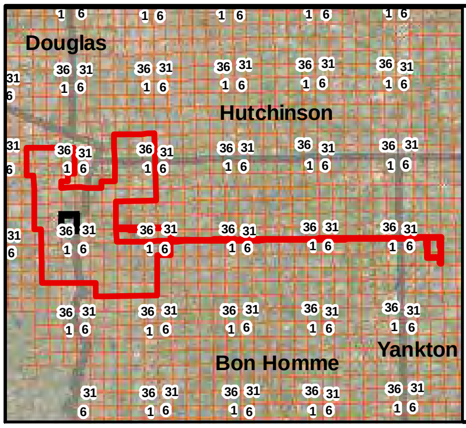

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🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 42

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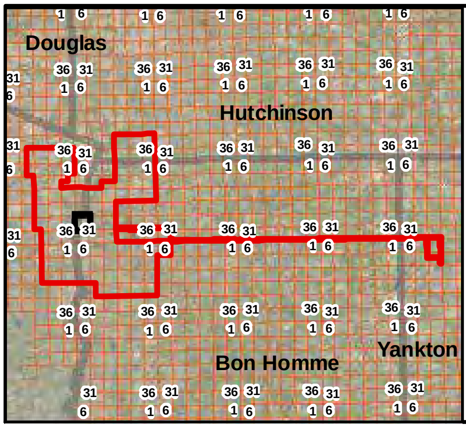

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 43

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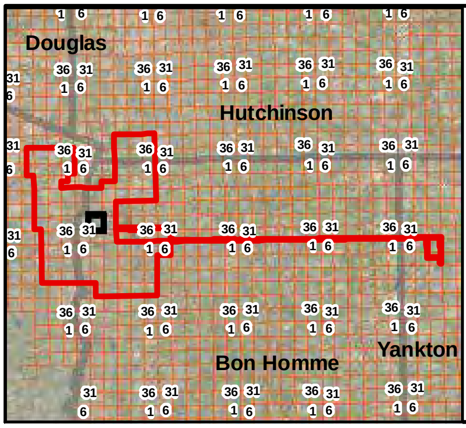

Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 44

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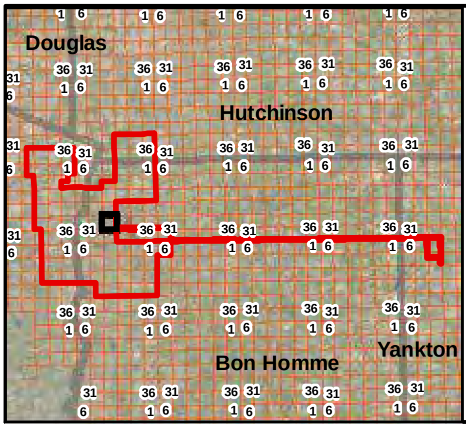


Legend

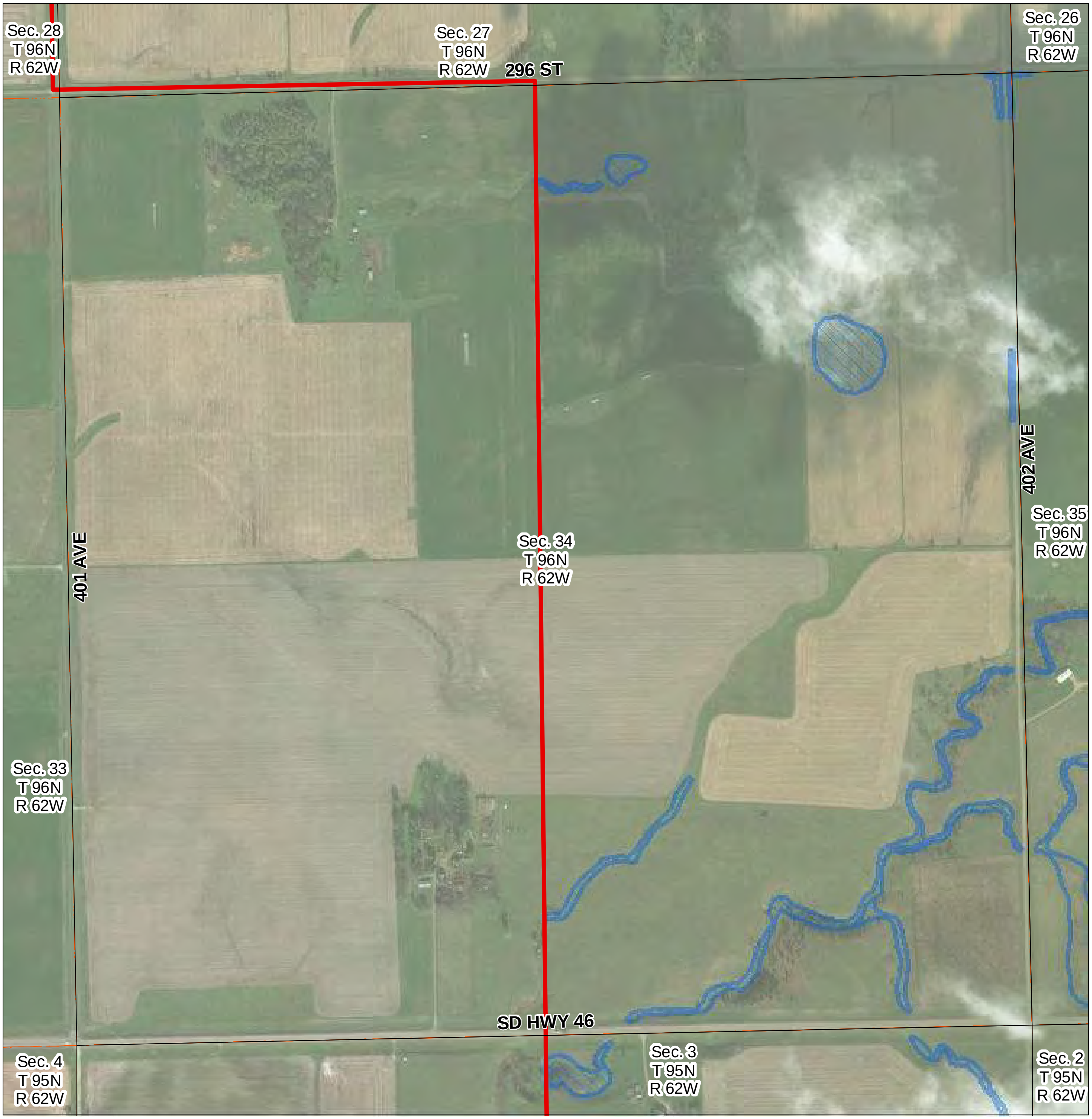
- 🟥 Project Area (2018)
- ●●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

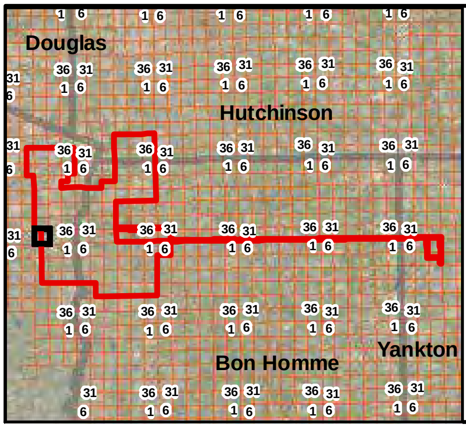
0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 45





Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

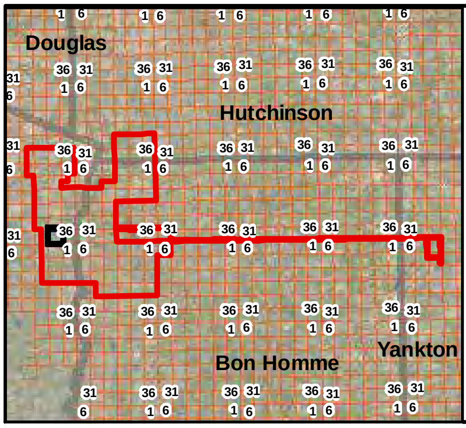
Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Feet
0 800

Figure 2 - 46

Document Path: H:\GIS\Projects\Carstensen_Energy\Prevailing_Winds\Map_Docs\Desktop_Survey_2018\Prevailing_Winds_2018_DesktopWetlands_Fig2_2018_04.mxd



Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

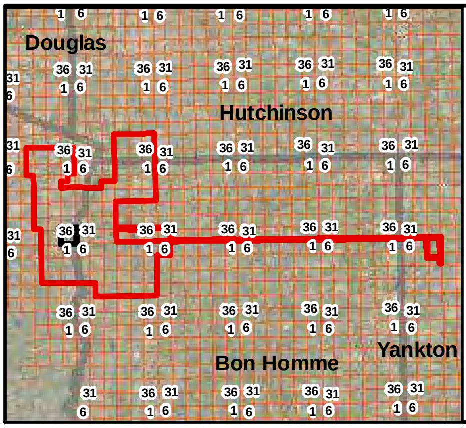
Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 47



Legend

🟥 Project Area (2018)

Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

N

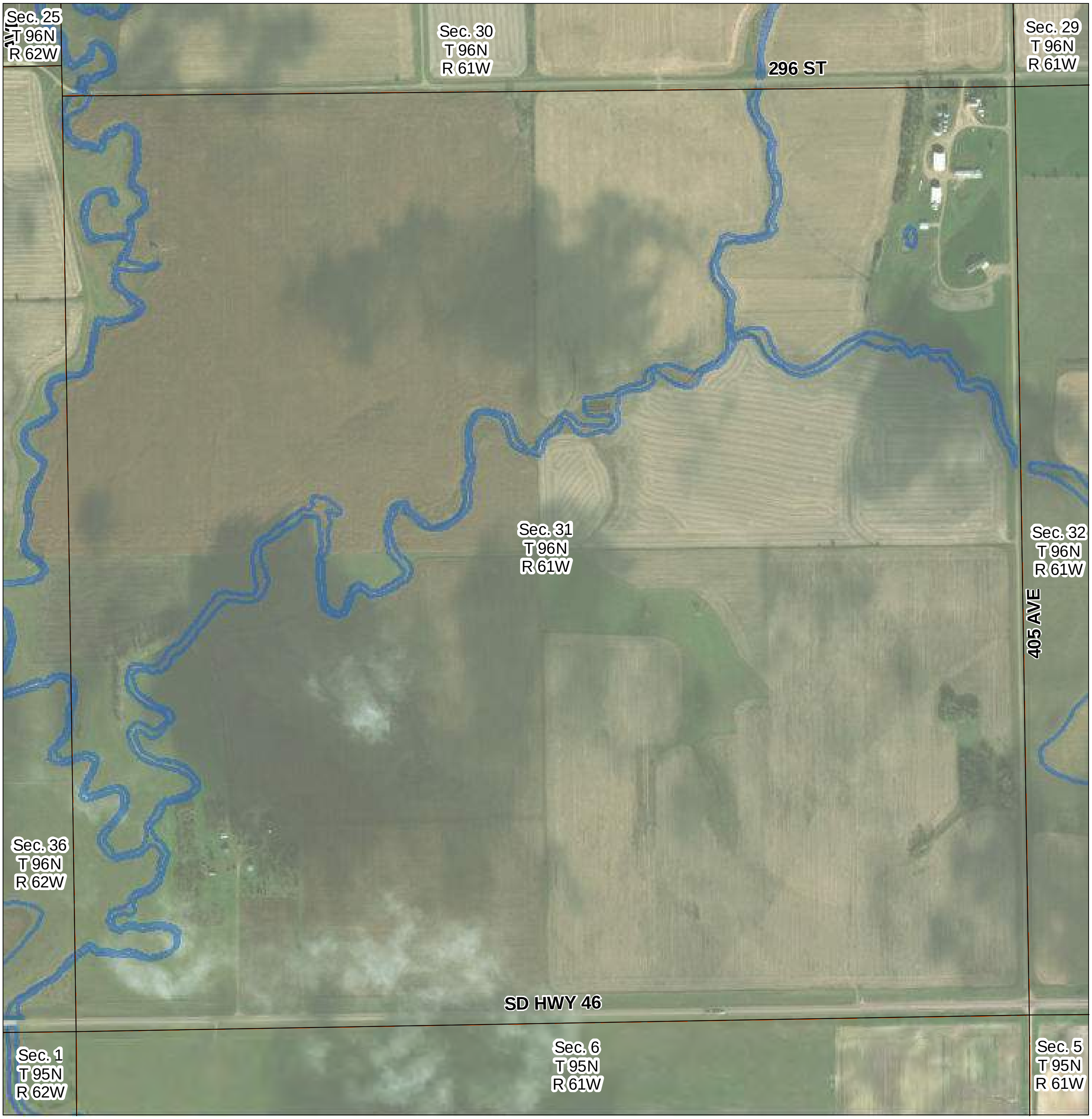
Feet
0 800

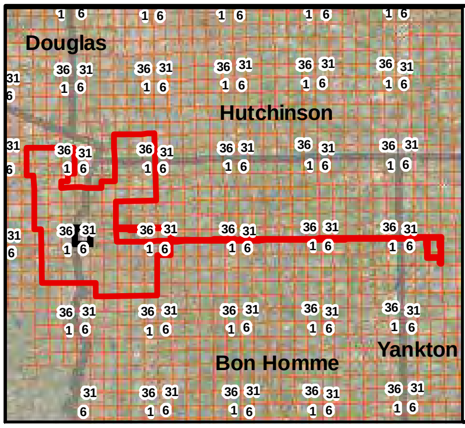
Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 48

Document Path: H:\GIS\Projects\Carstensen_Energy\Prevailing_Winds\Map_Docs\Desktop_Survey_2018\Prevailing_Winds_2018_DesktopWetlands_Fig2_2018_04.mxd





Legend

🟥	Project Area (2018)
●—	Transmission Line
⬚	PLSS - Sections
▨	Windshield & Desktop Determined Wetlands
▨	Desktop Determined Wetlands

N

0 800 Feet

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota

Figure 2 - 49

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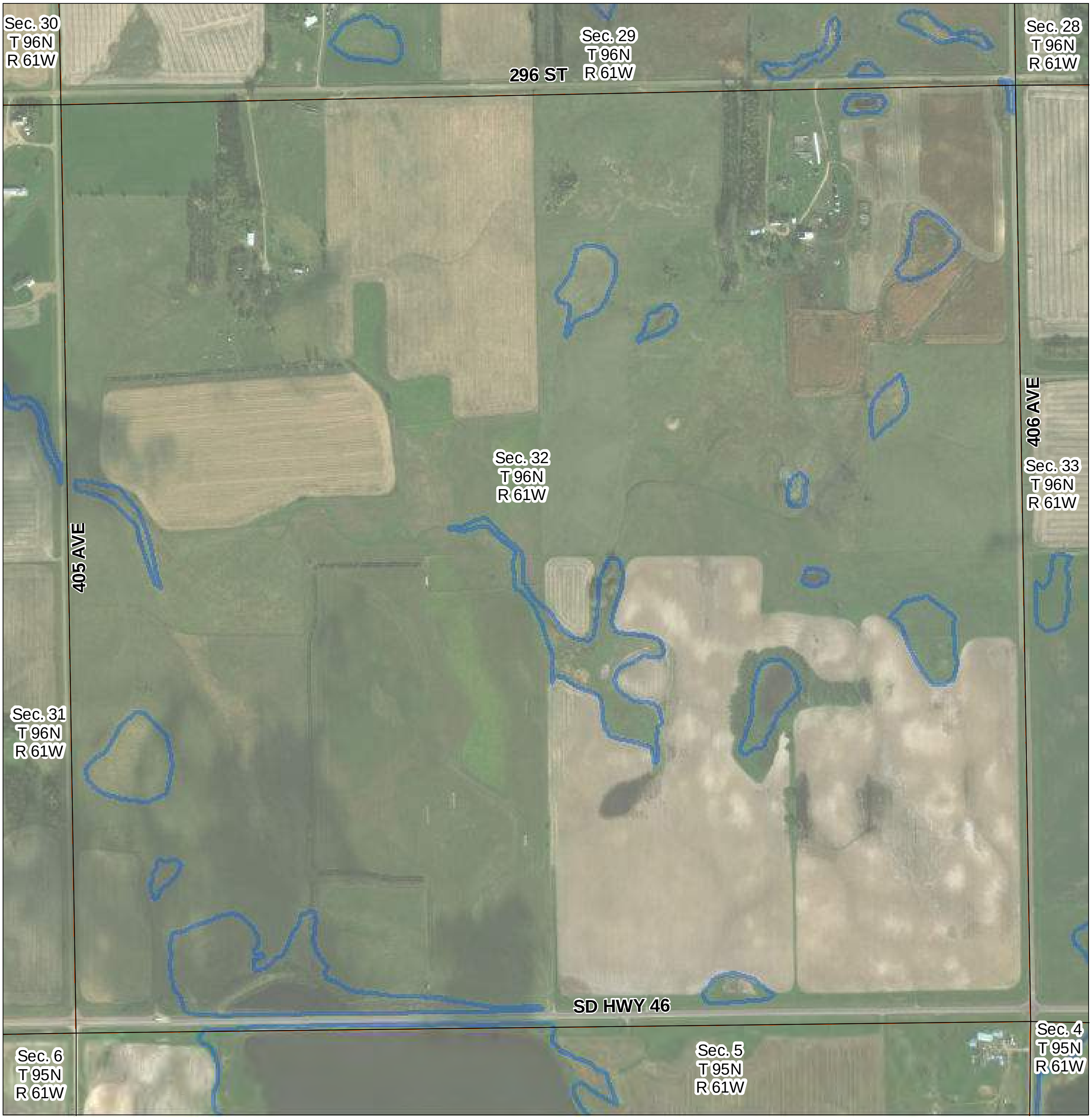
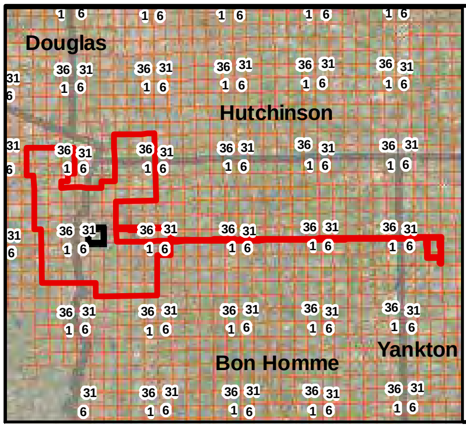




Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

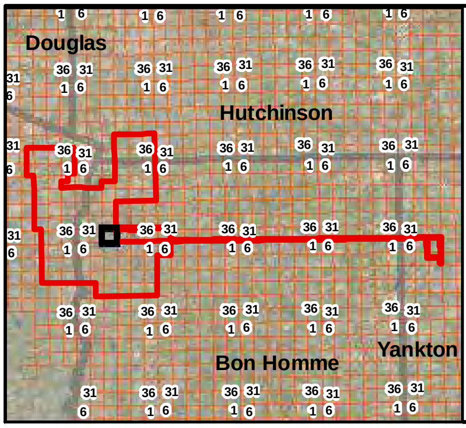
0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 50

Document Path: H:\GIS\Projects\Carstensen_Energy\Prevailing_Winds\Map_Docs\Desktop_Survey_2018\Prevailing_Winds_2018_DesktopWetlands_Fig2_2018_04.mxd



Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

N

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 51

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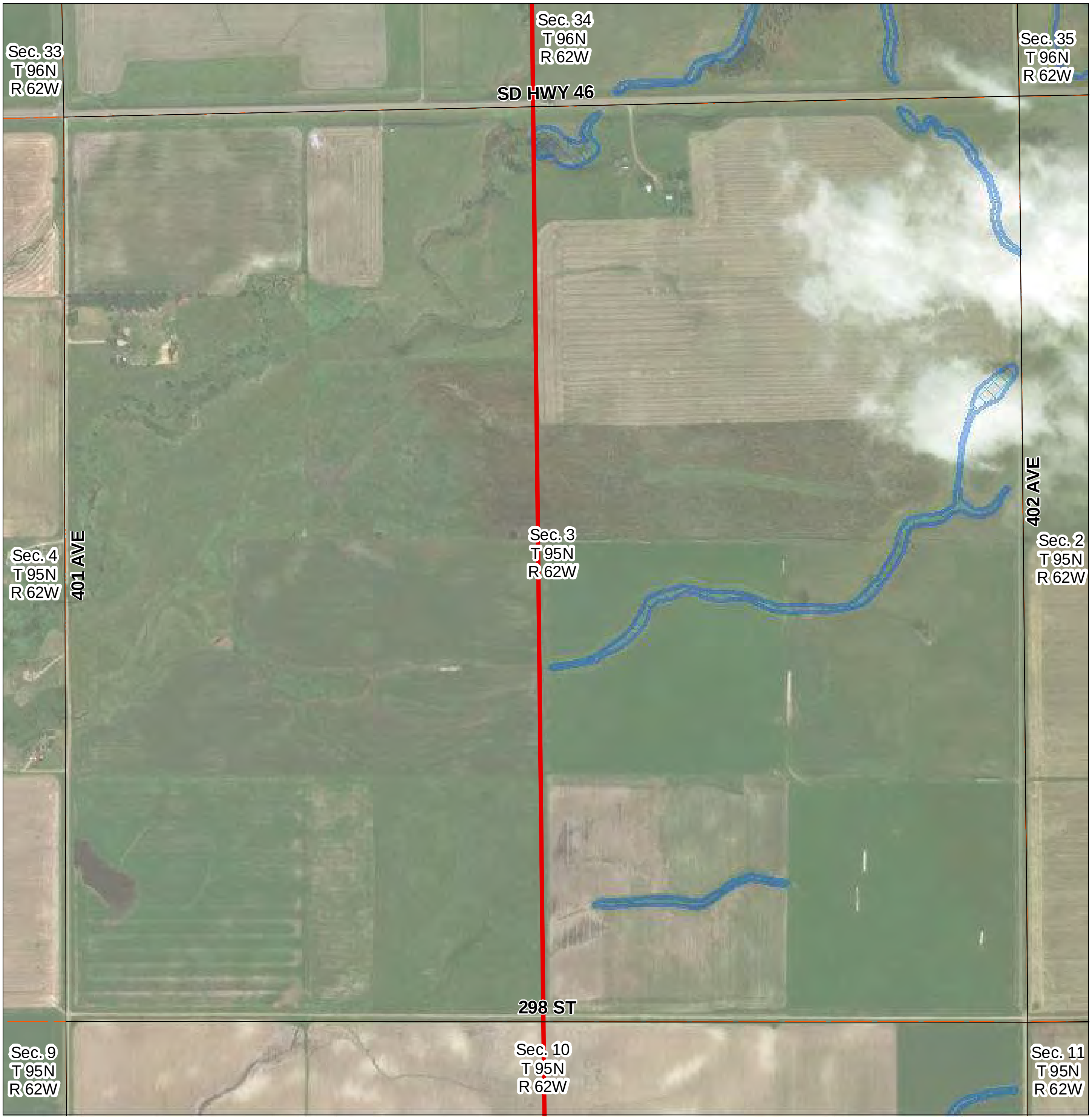

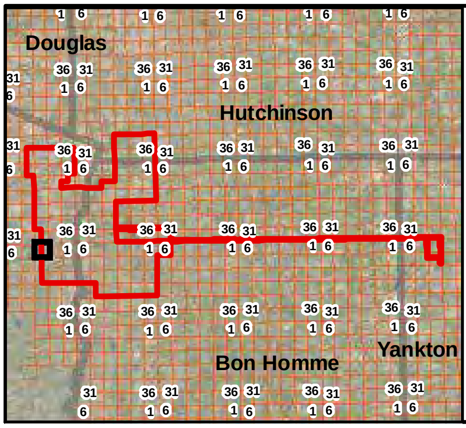

Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 52

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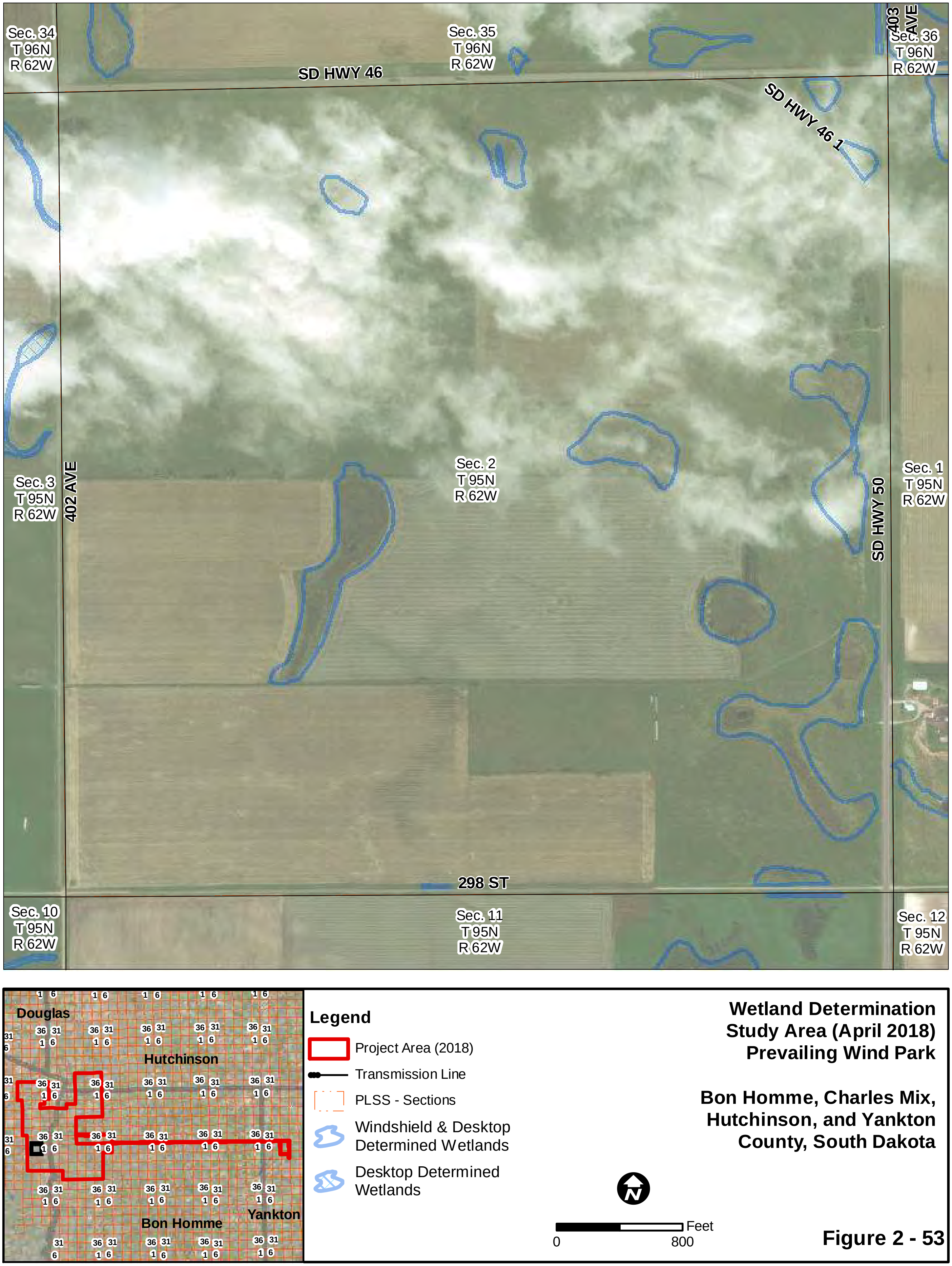

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 53

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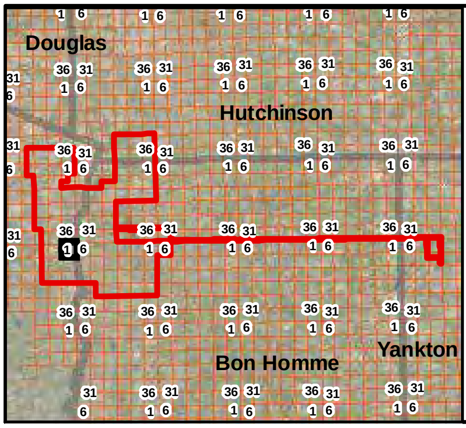


Legend

- ☐ Project Area (2018)
- ●— Transmission Line
- ☐ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

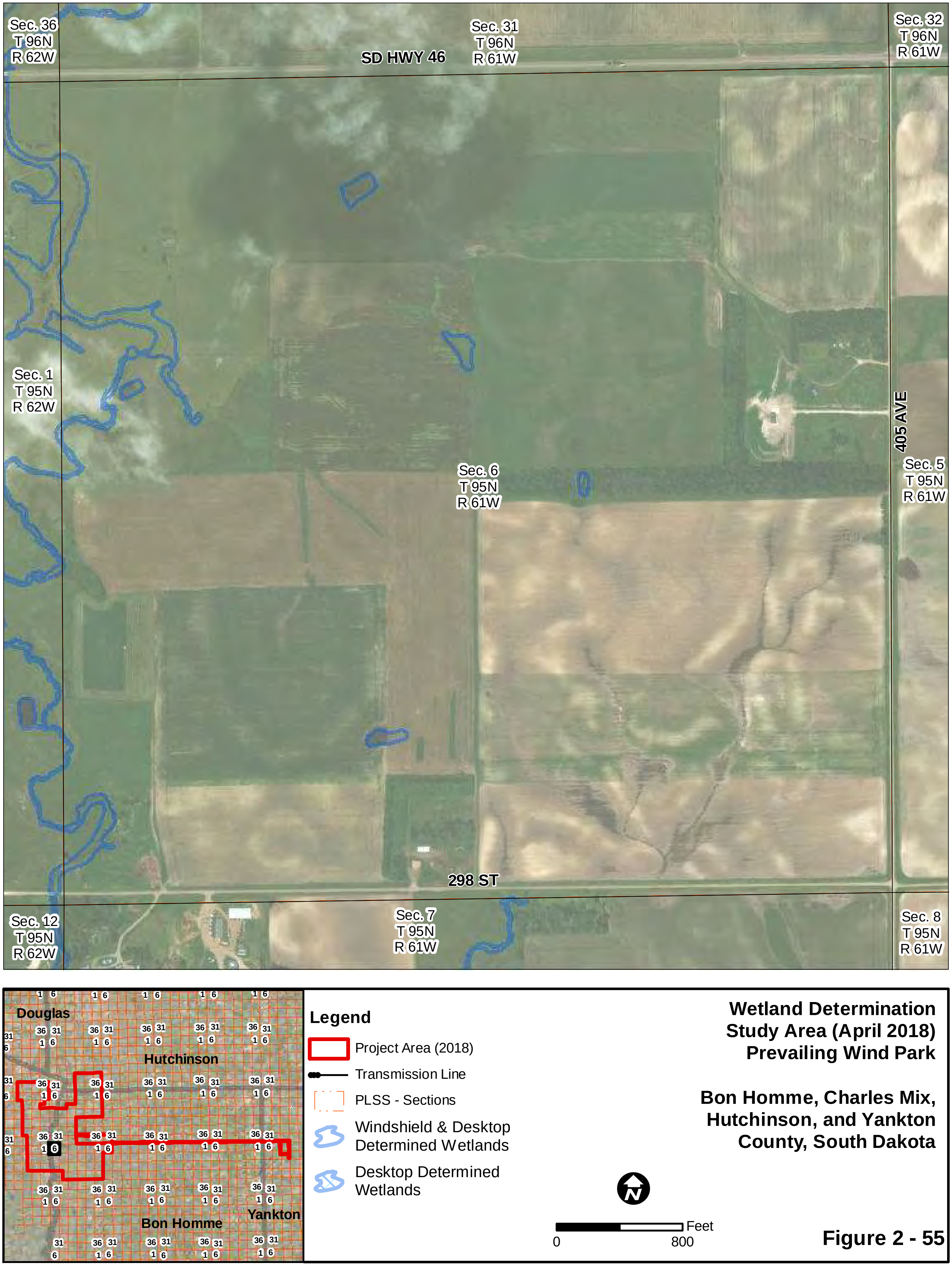
Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota

Feet
0 800

Figure 2 - 54

Document Path: H:\GIS\Projects\Carstensen_Energy\Prevailing_Winds\Map_Docs\Desktop_Survey_2018\Prevailing_Winds_2018_DesktopWetlands_Fig2_2018_04.mxd



Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 55

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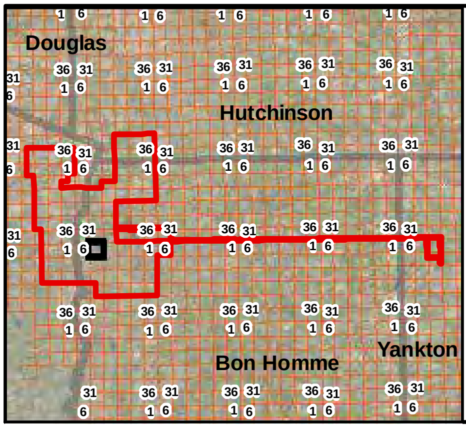


Legend

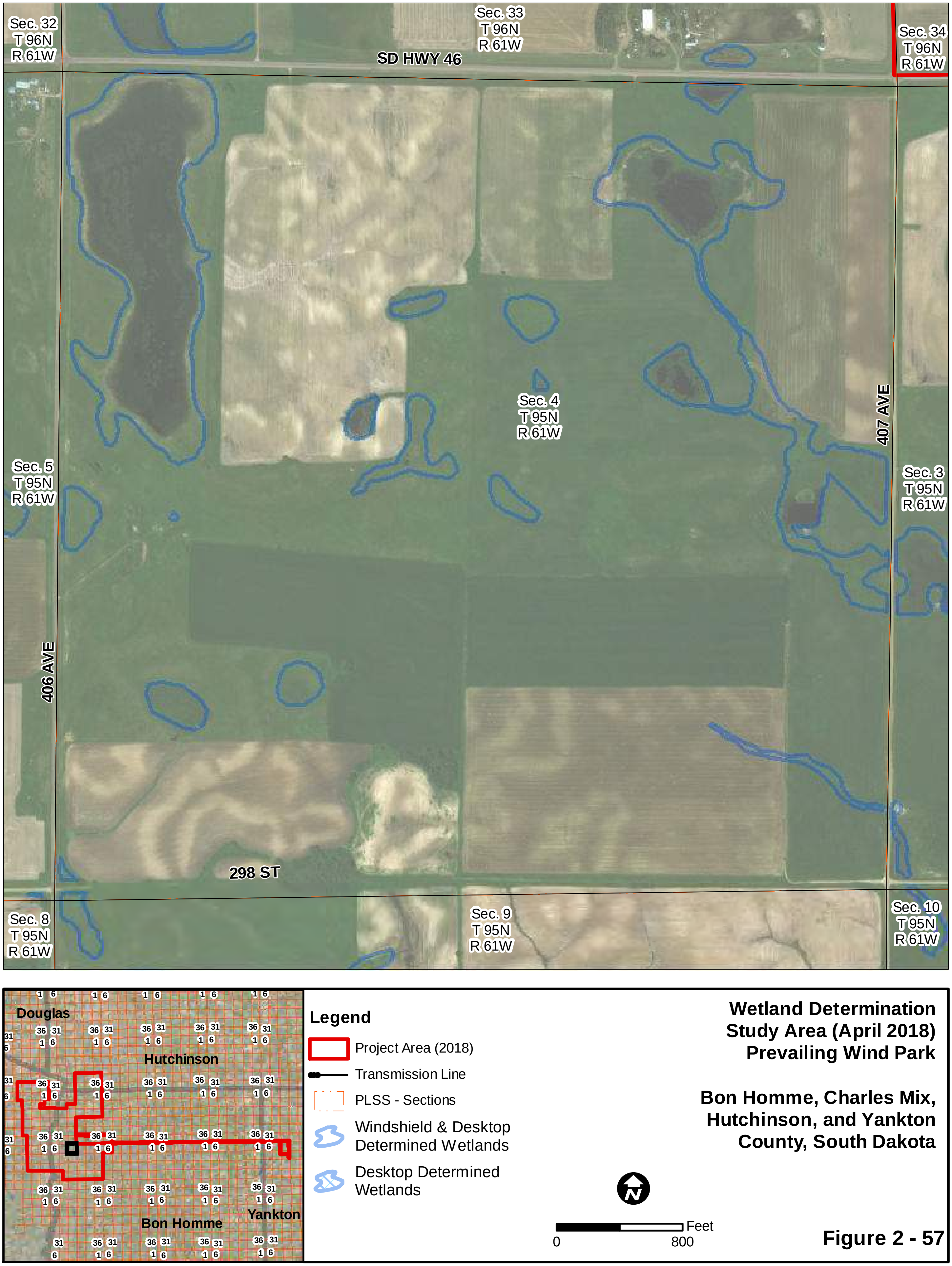
- Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 56



Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 57

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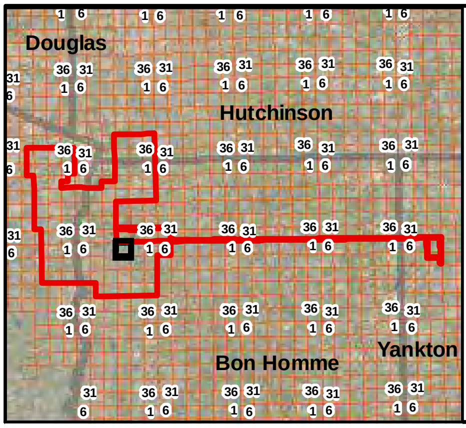

Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ┆ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

N

0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 58

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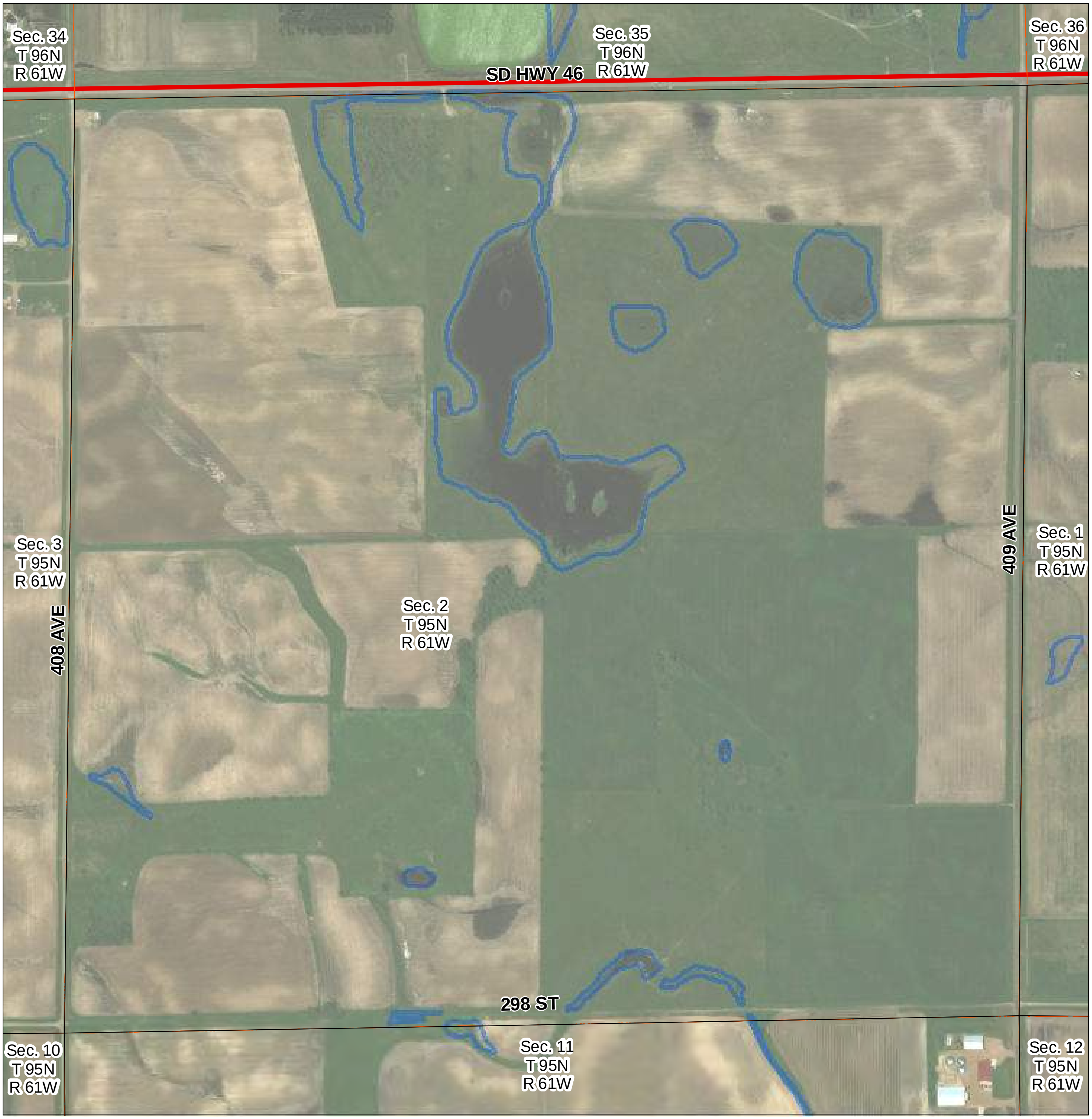
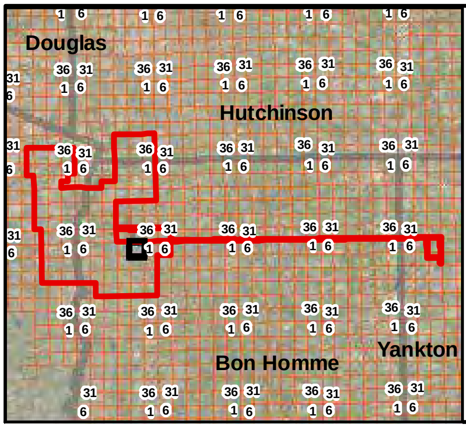




Legend

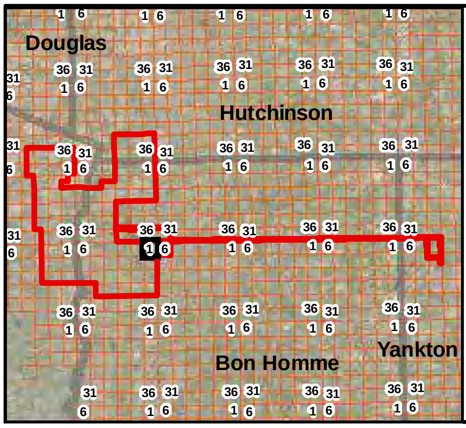
- 🟥 Project Area (2018)
- ●— Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 59



Legend

🟥 Project Area (2018)

●●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

N

0 800 Feet

Figure 2 - 60

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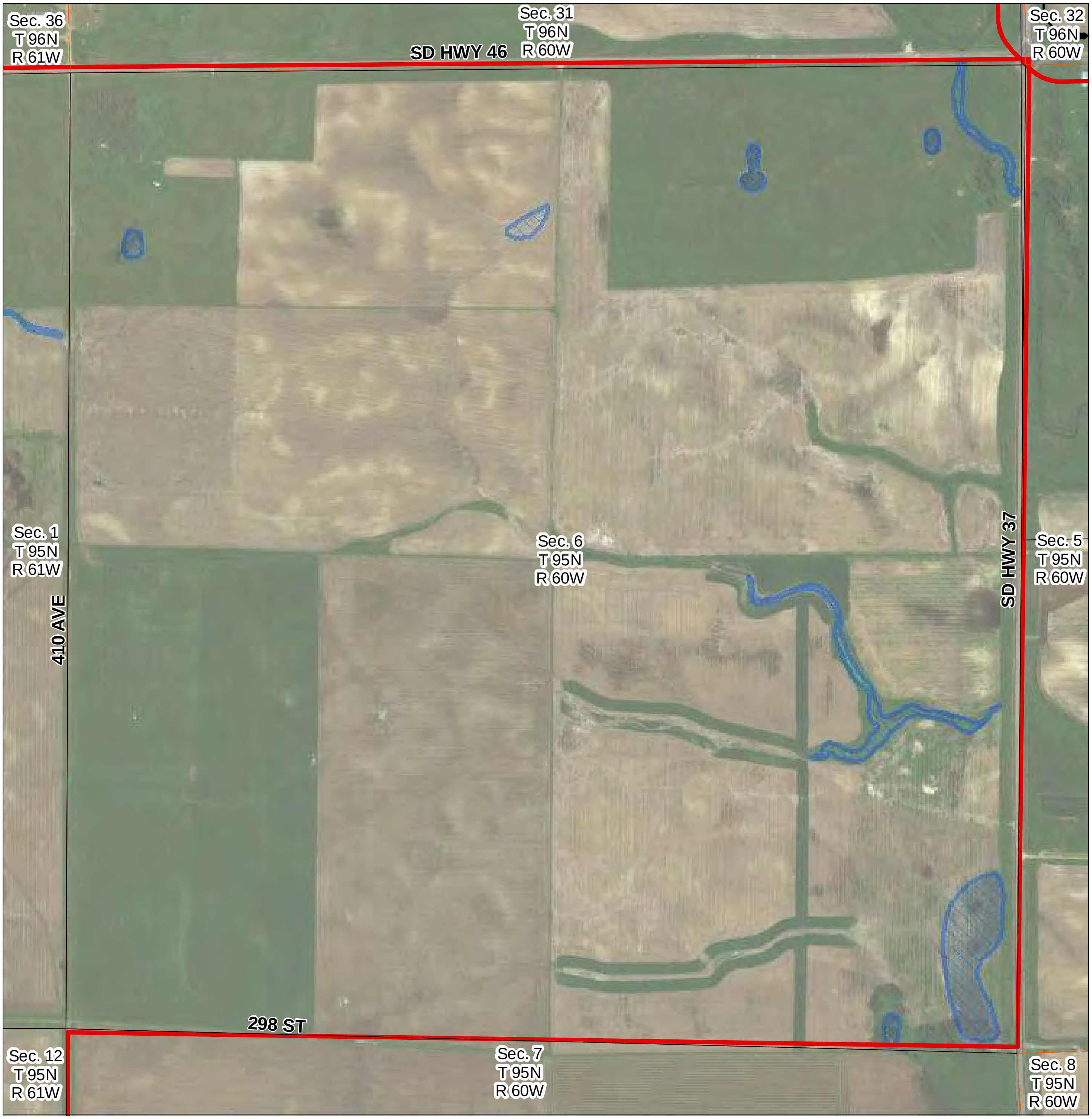
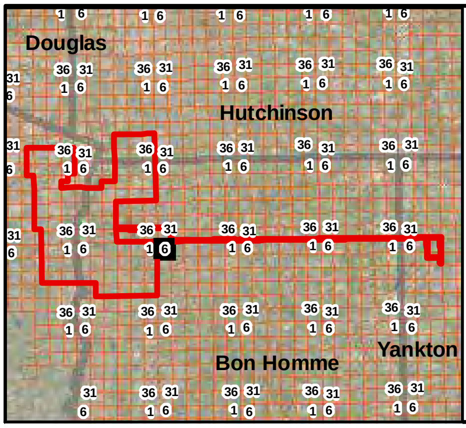




Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

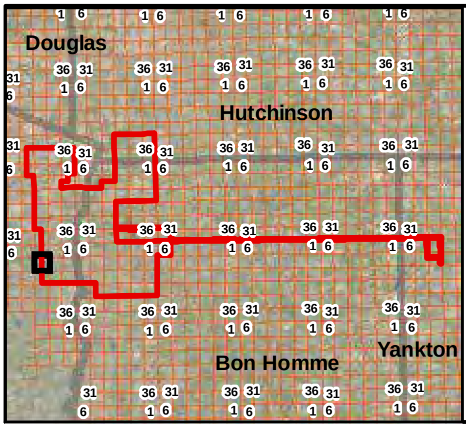
Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 61



Legend

🟥 Project Area (2018)

●●— Transmission Line

⬚ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

N

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 62

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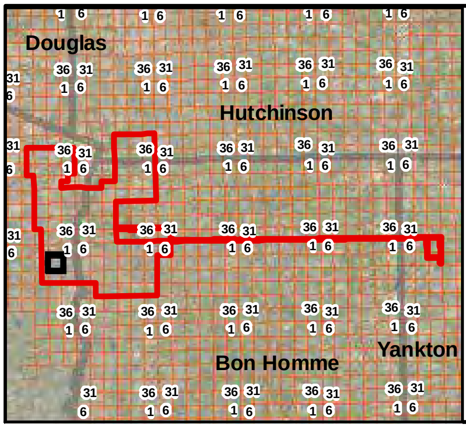


Legend

🟥 Project Area (2018)

Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

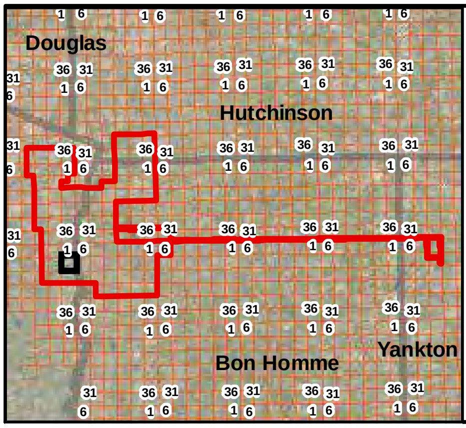
N

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 63



Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 64

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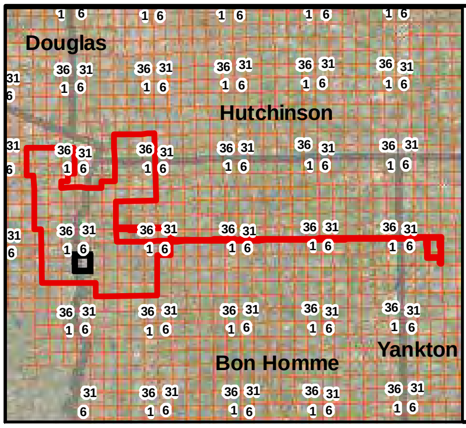

Legend

- 🟥 Project Area (2018)
- ●● Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Feet
0 800

Figure 2 - 65

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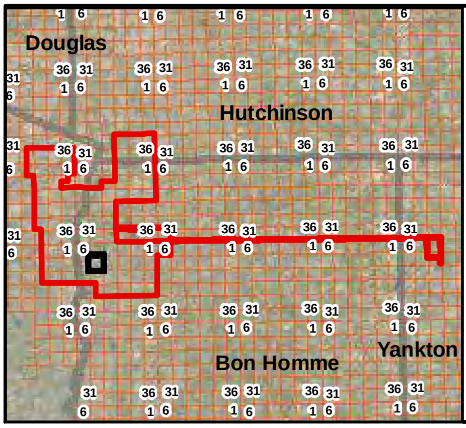

Legend

🟥 Project Area (2018)

●●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 66

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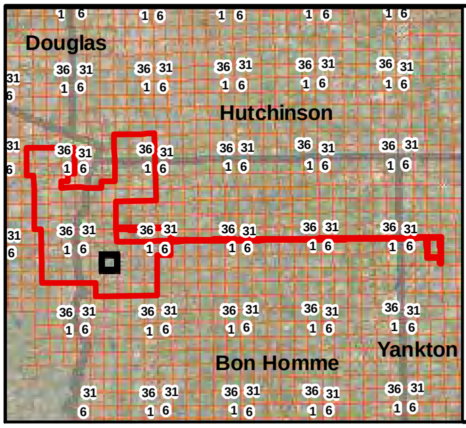

Legend

Project Area (2018)

Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 67

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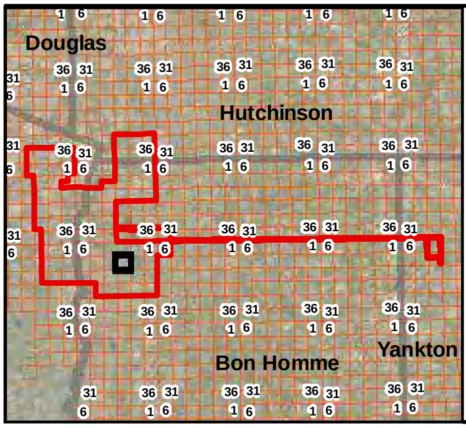


Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- ▨ Windshield & Desktop Determined Wetlands
- ▨ Desktop Determined Wetlands

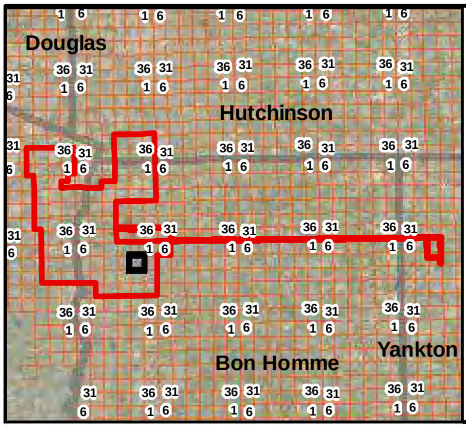
N

Feet
0 800

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 68



Legend

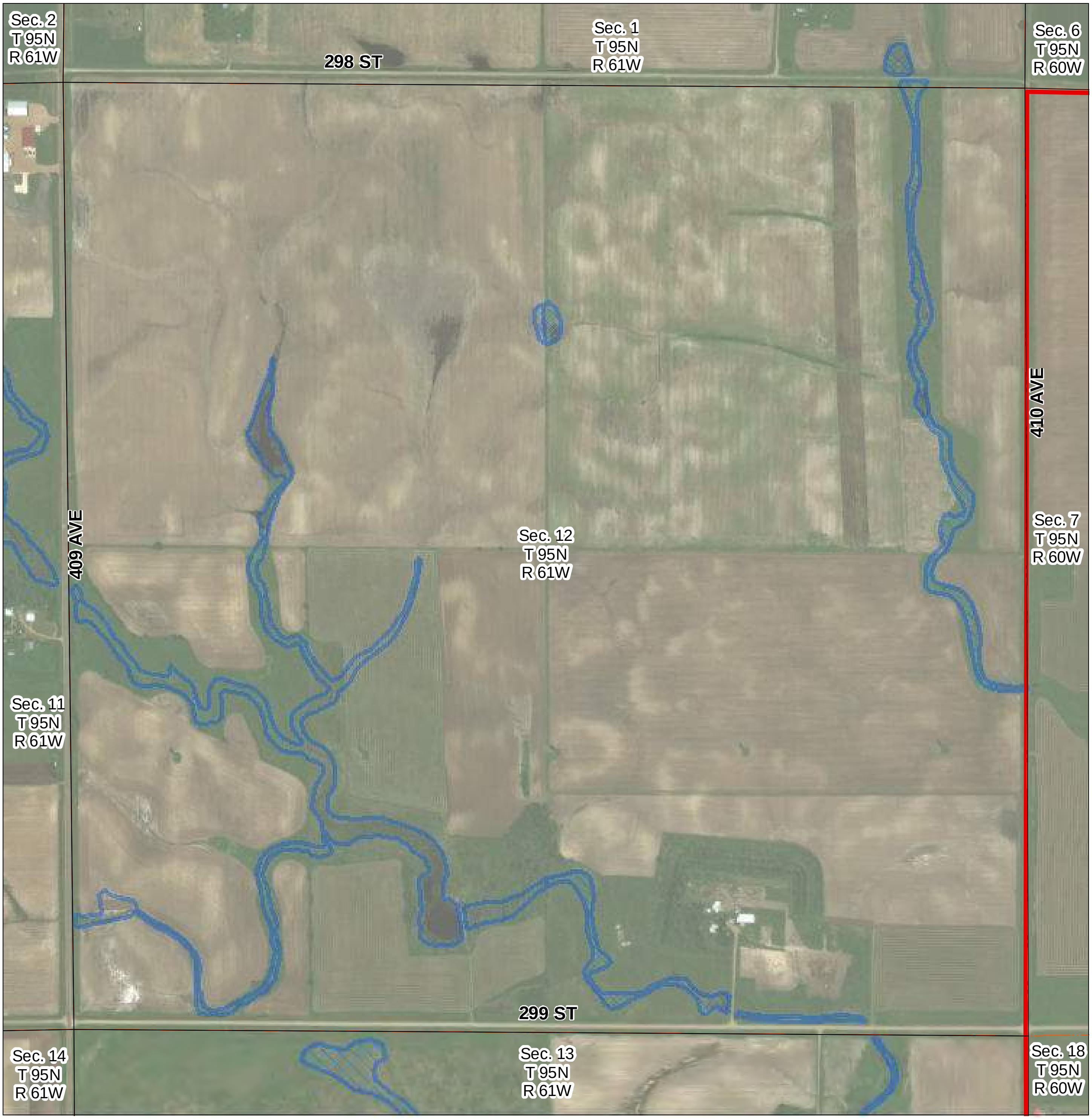
- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

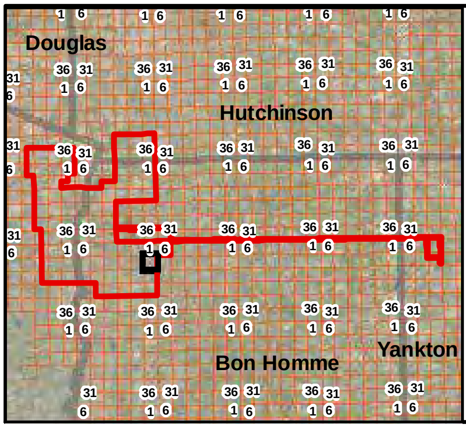
Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 69





Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 70

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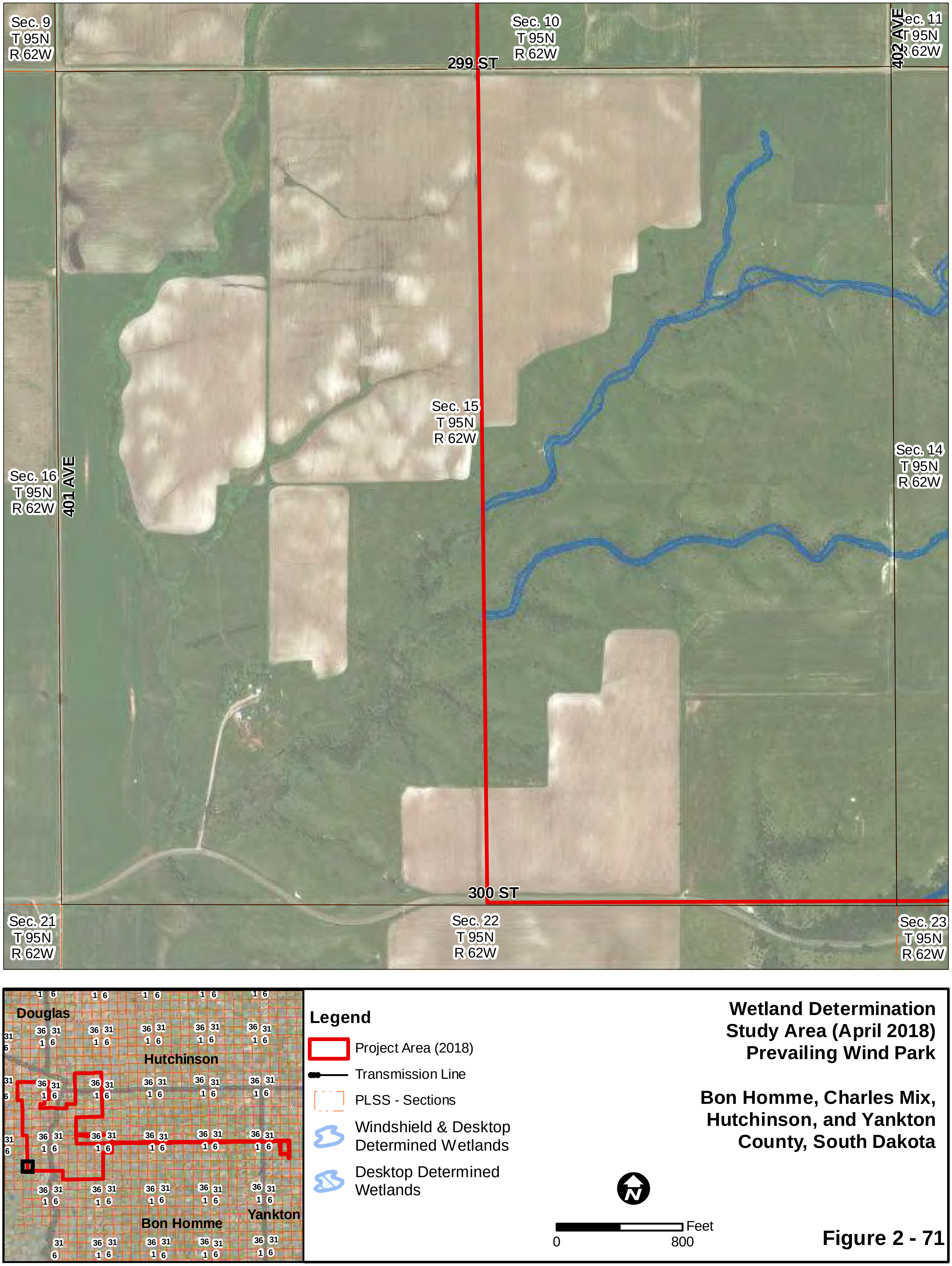

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 71

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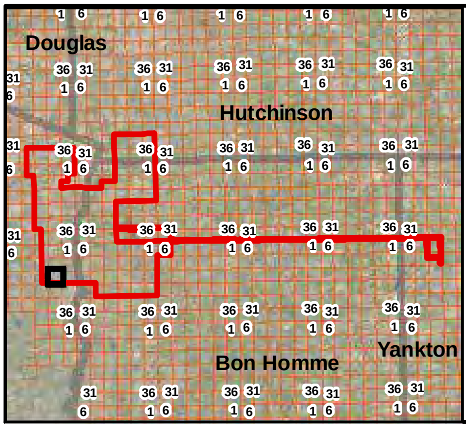

Legend

🟥 Project Area (2018)

Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 72

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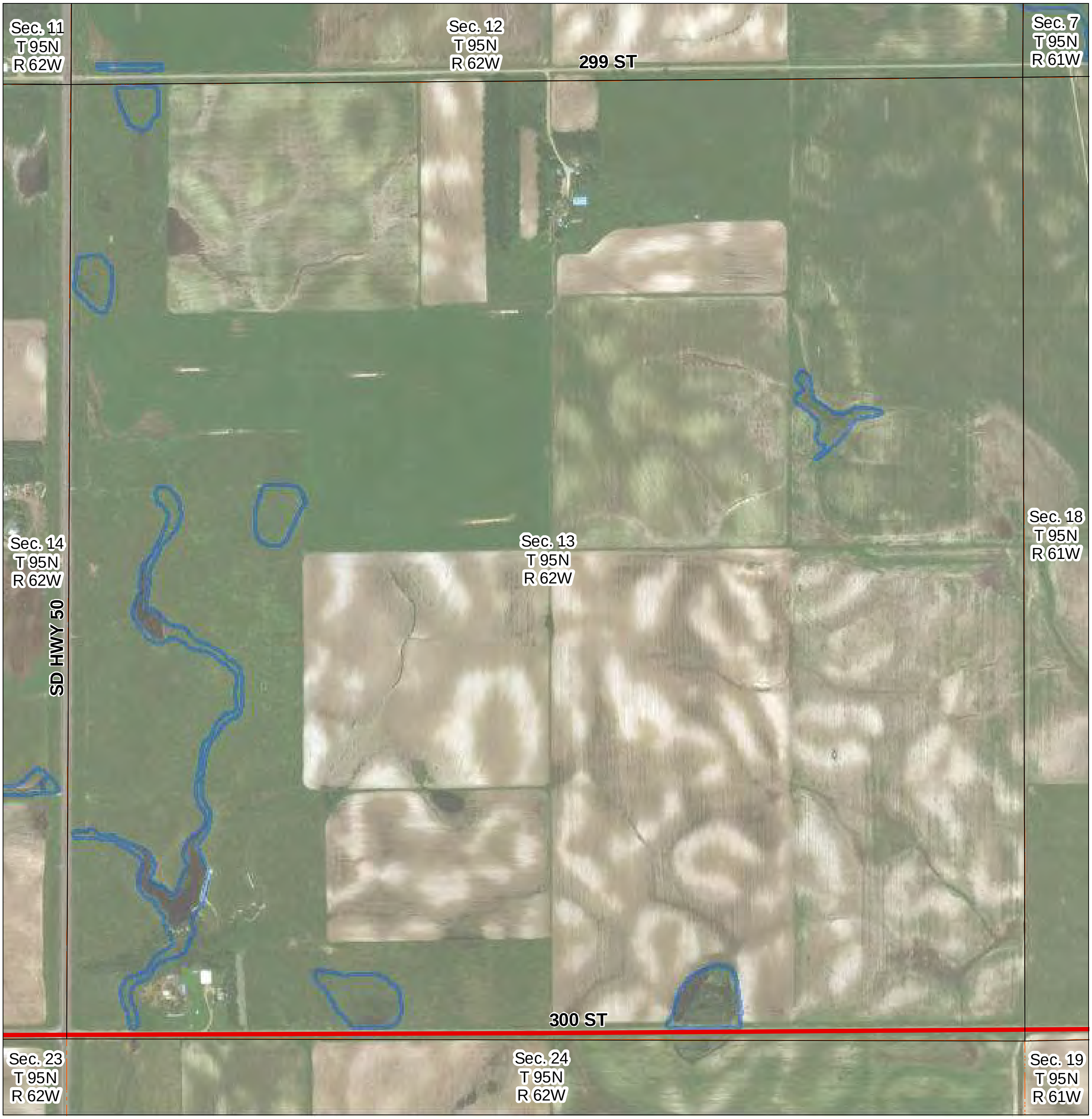

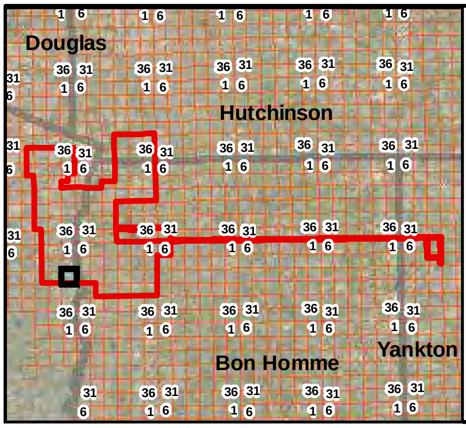

Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Feet
0 800

Figure 2 - 73

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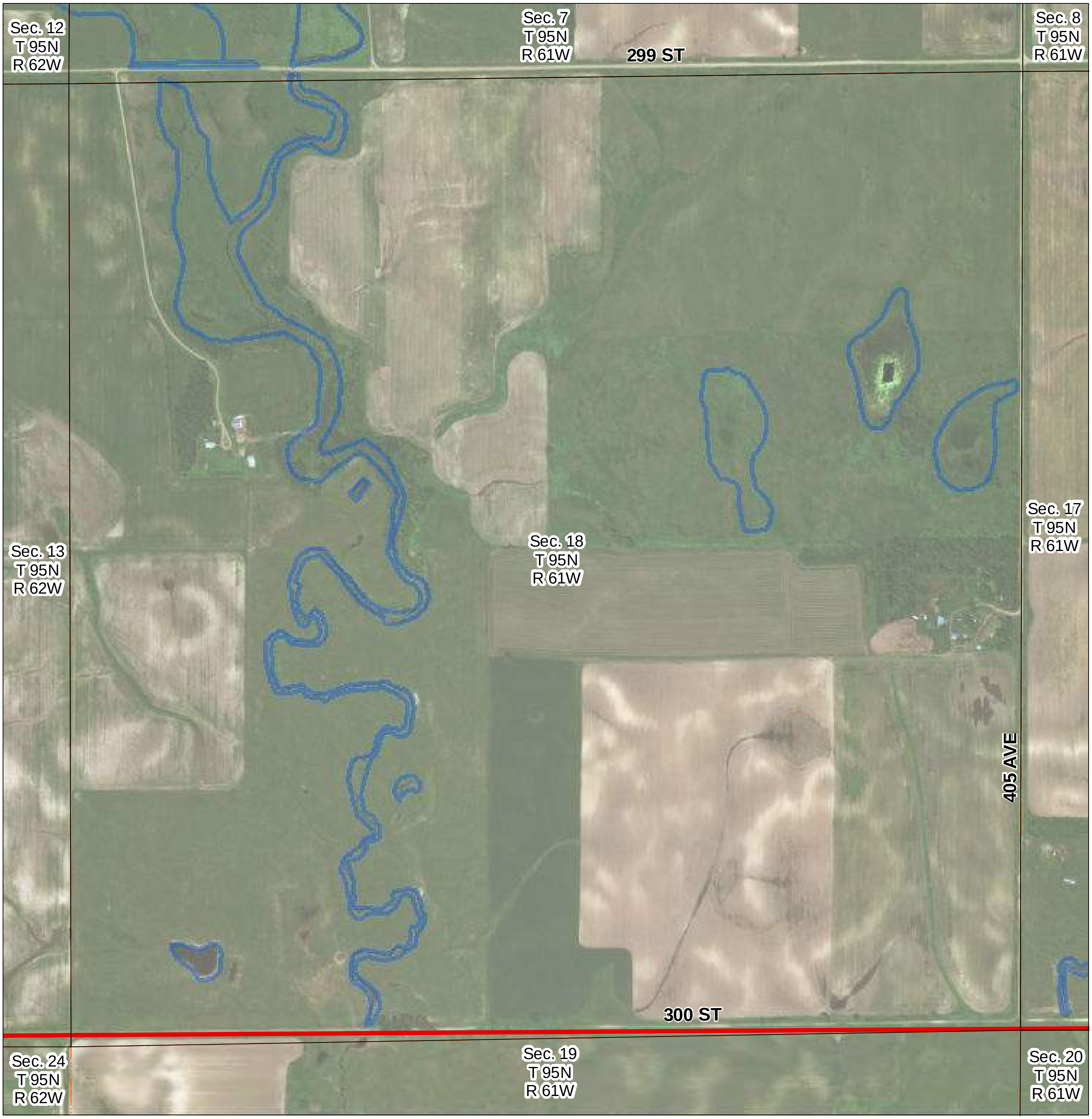
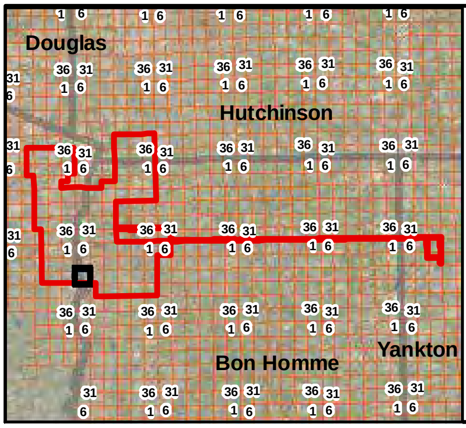




Legend

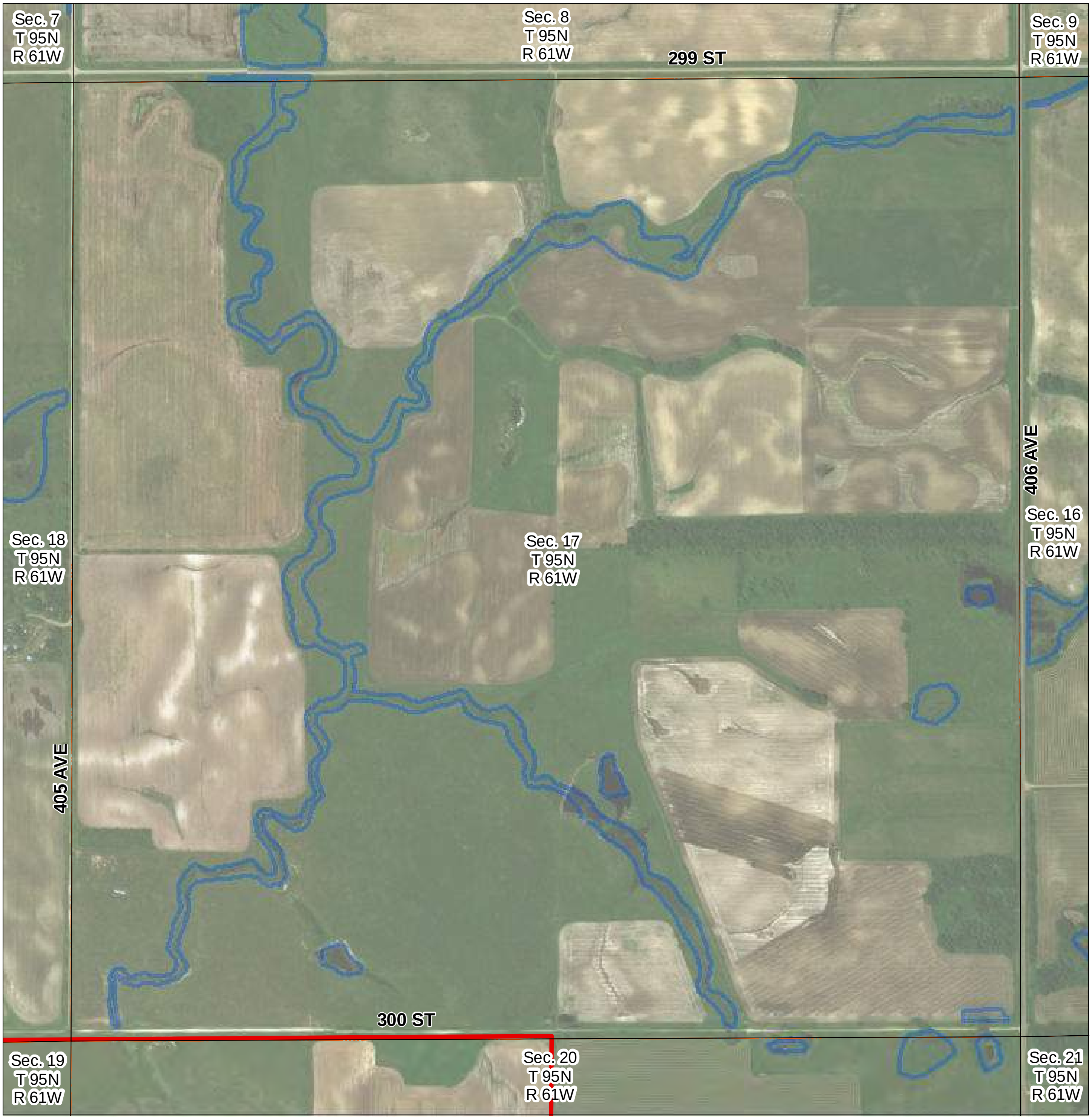
- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

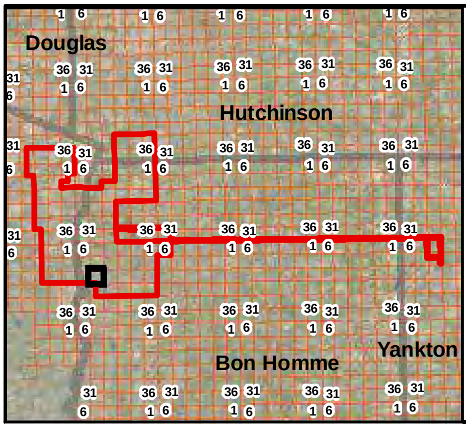
0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 74





Legend

🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

N

Feet
0 800

**Wetland Determination
Study Area (April 2018)
Prevailing Wind Park**

**Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota**

Figure 2 - 75

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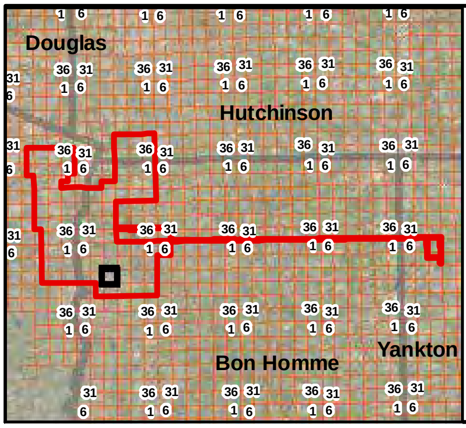

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 76

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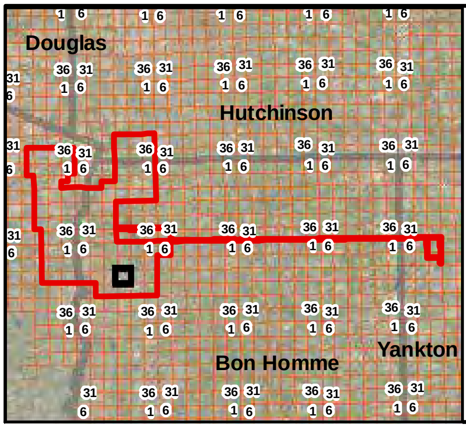

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 77

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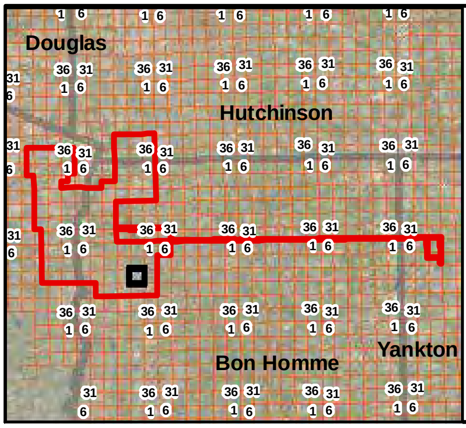

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 78

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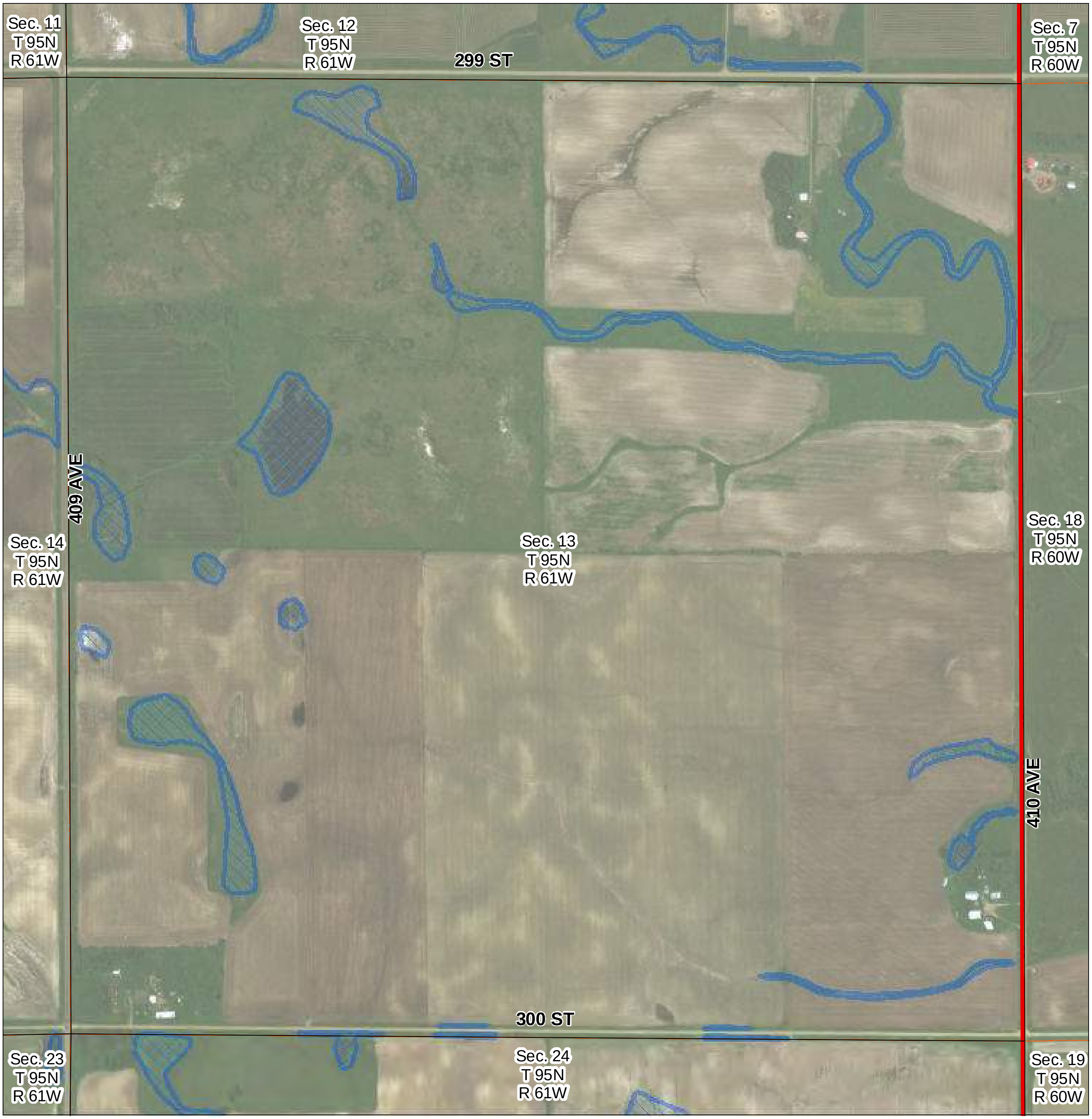
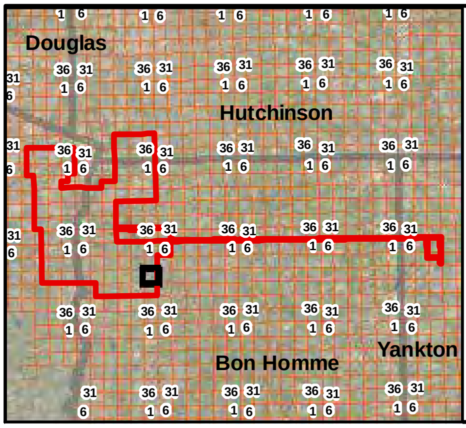




Legend

🟥 Project Area (2018)

●— Transmission Line

┆ PLSS - Sections

Windshield & Desktop Determined Wetlands

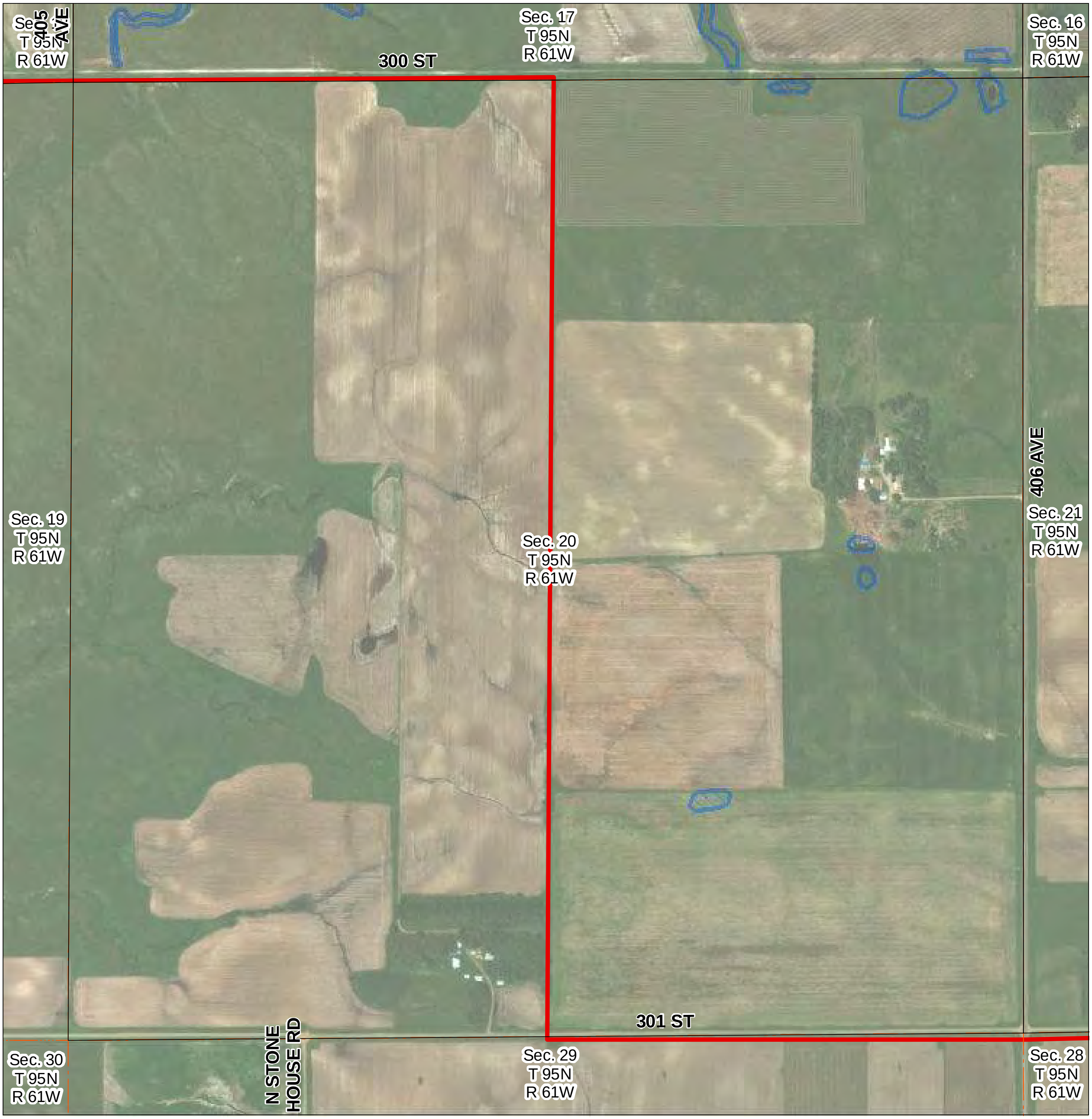
Desktop Determined Wetlands

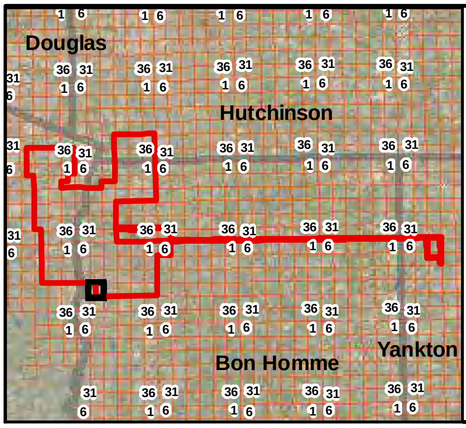
0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 79





Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

N

0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 80

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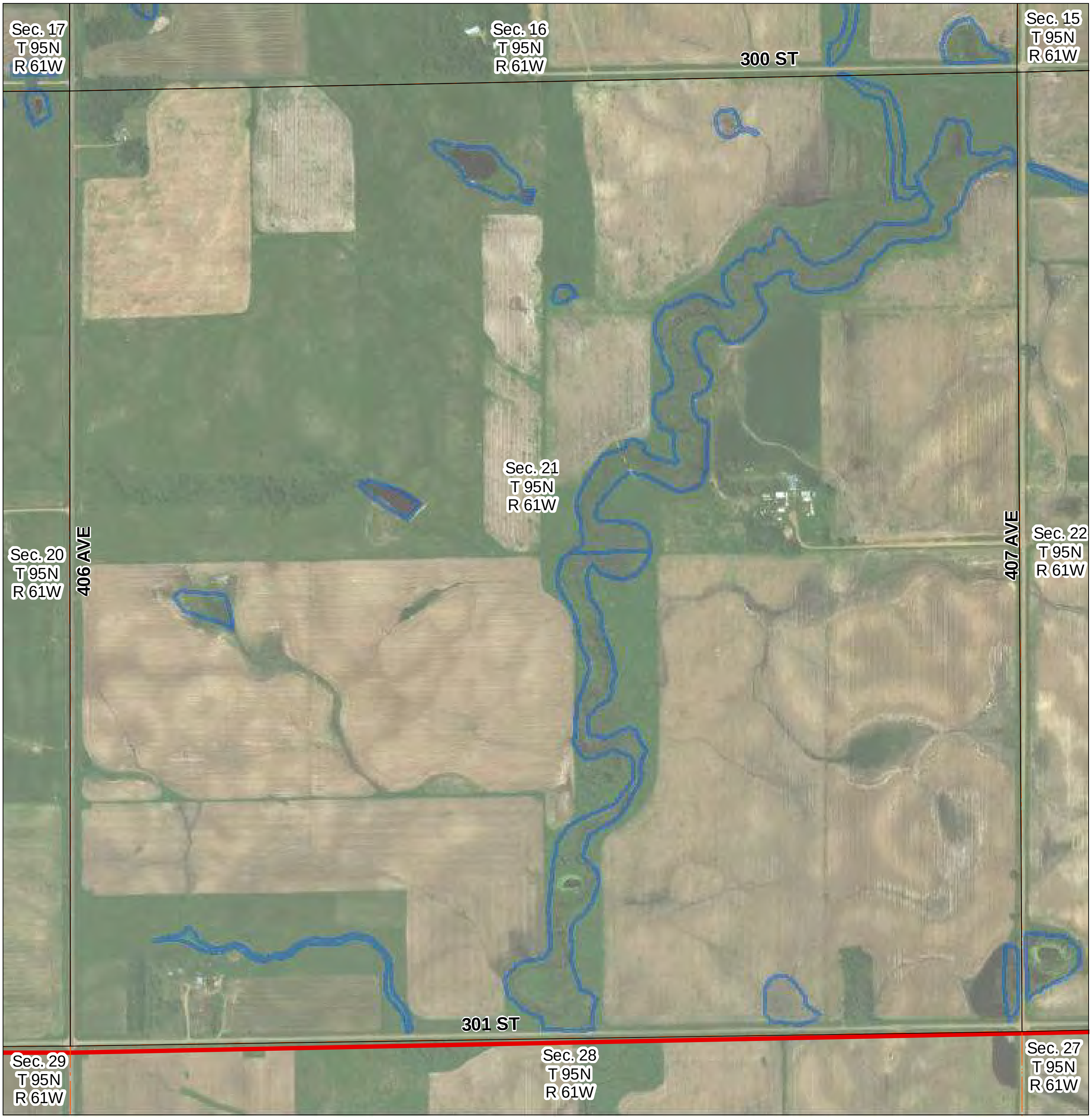

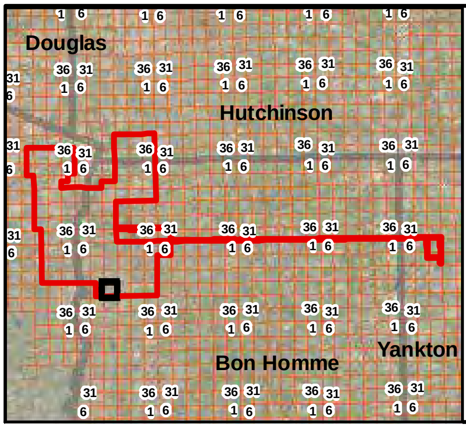

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🟥 Project Area (2018)

●● Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 81

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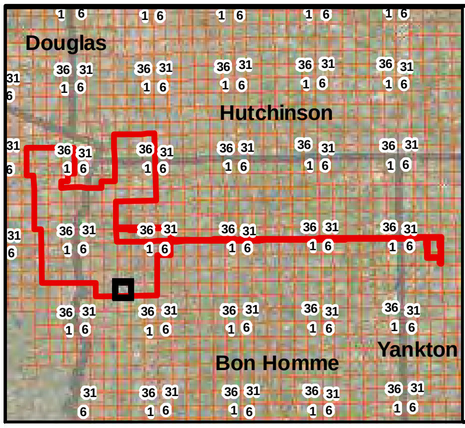


Legend

🟥 Project Area (2018)

Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

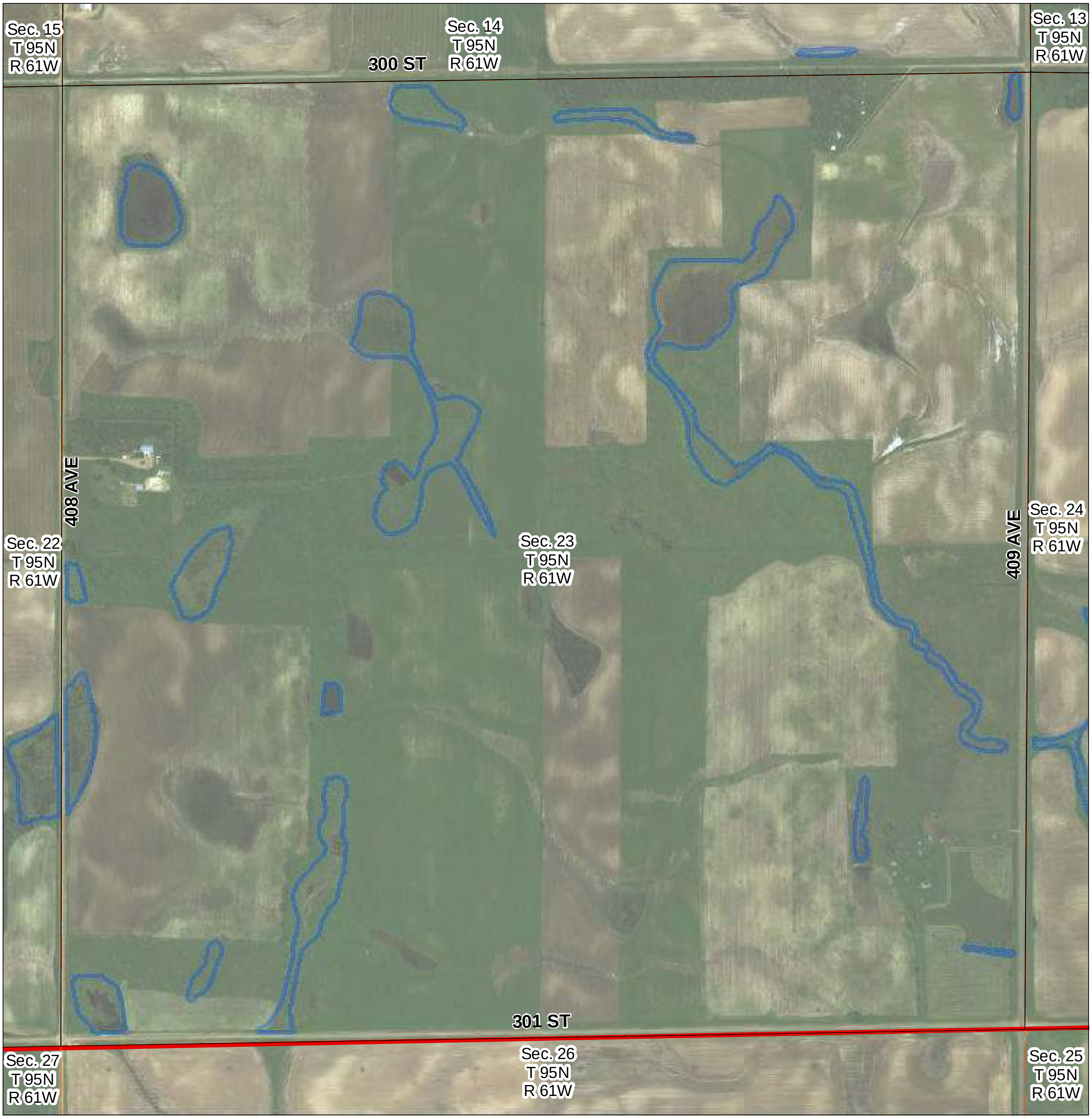
Desktop Determined Wetlands

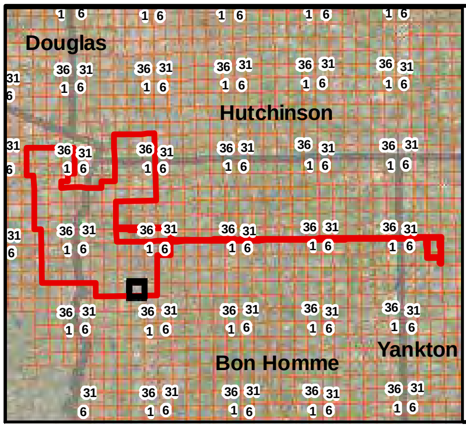
0 800 Feet

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 82





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🟥 Project Area (2018)

●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 83

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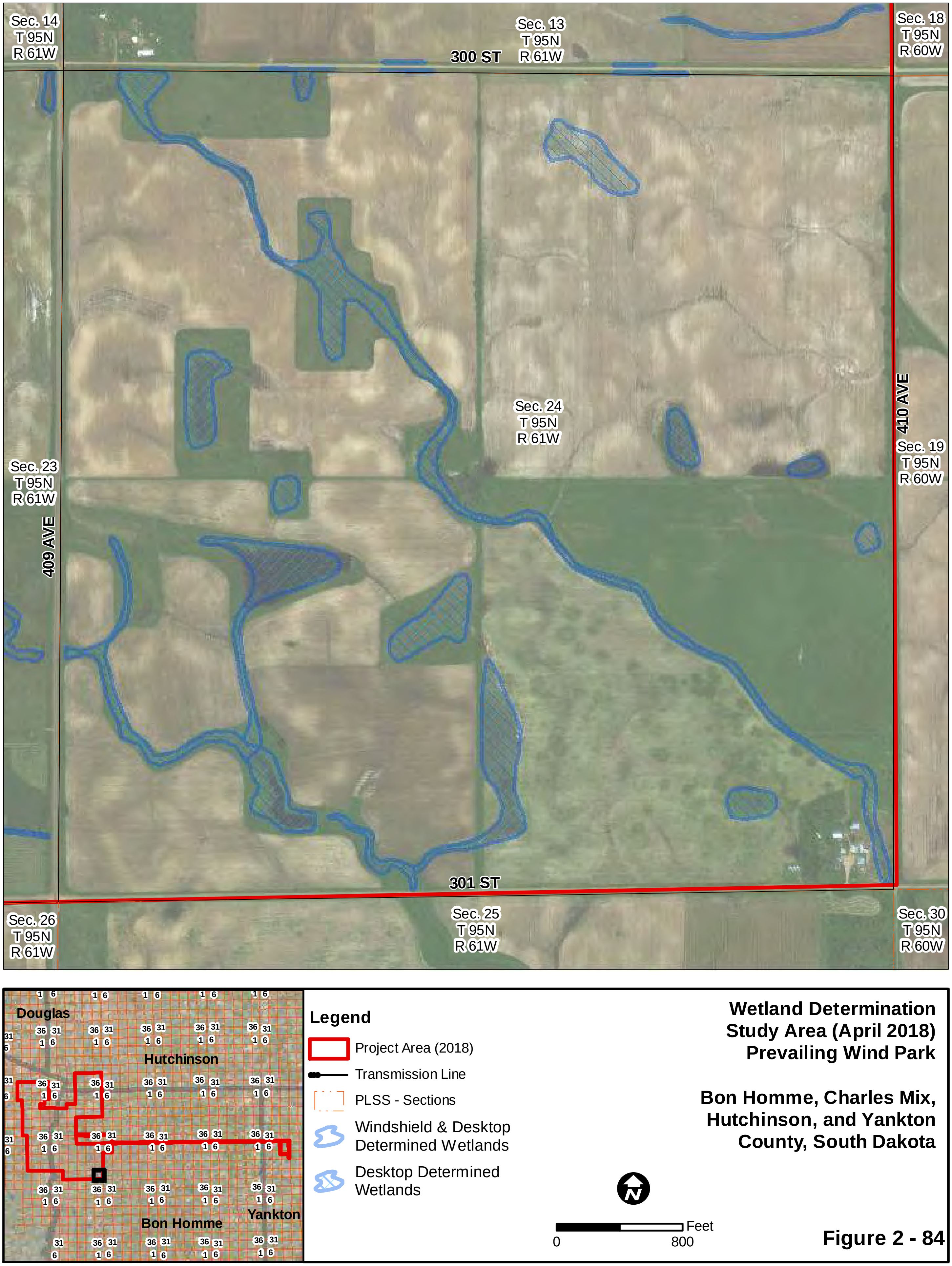

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 84

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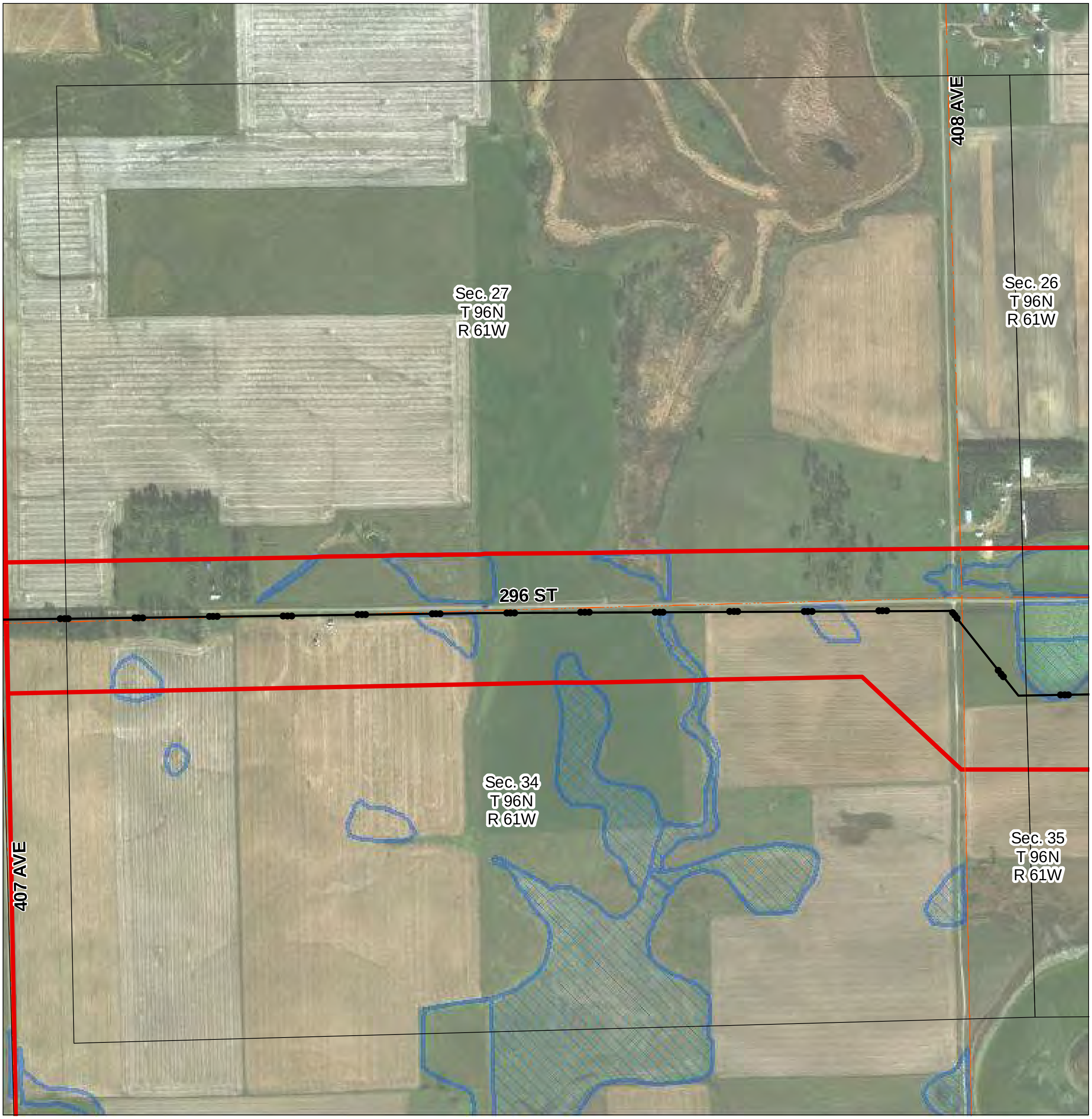

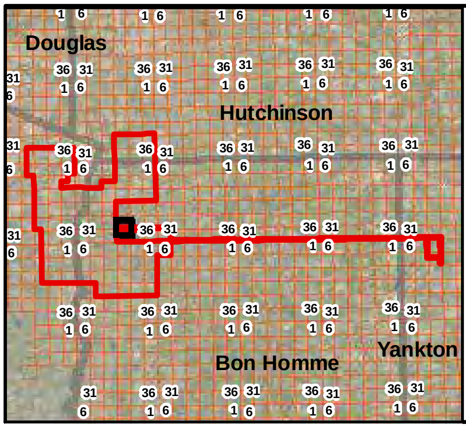

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 85

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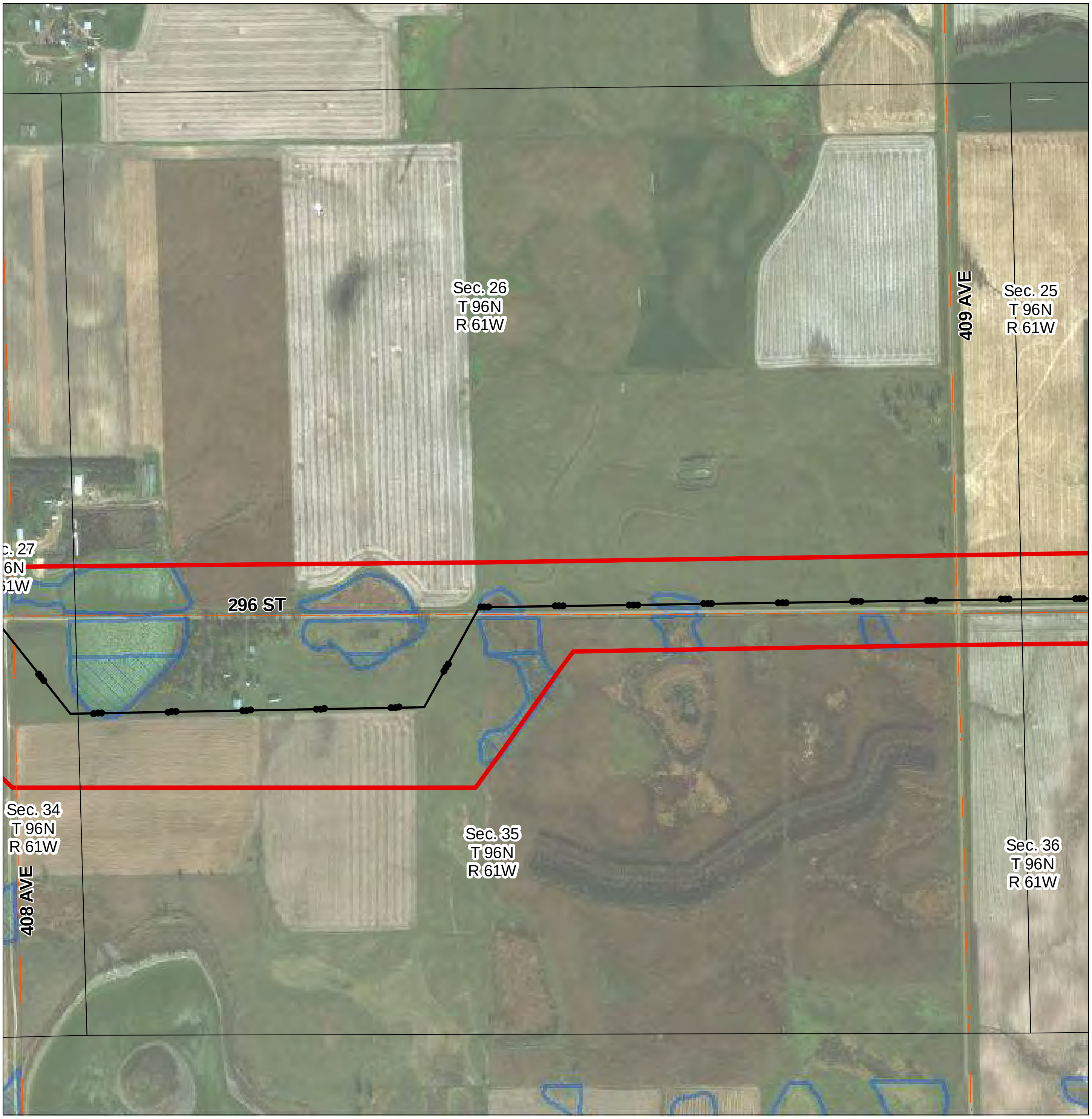

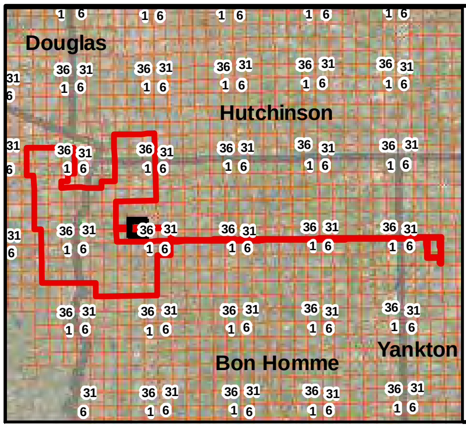

Legend

🟥 Project Area (2018)

●— Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 86

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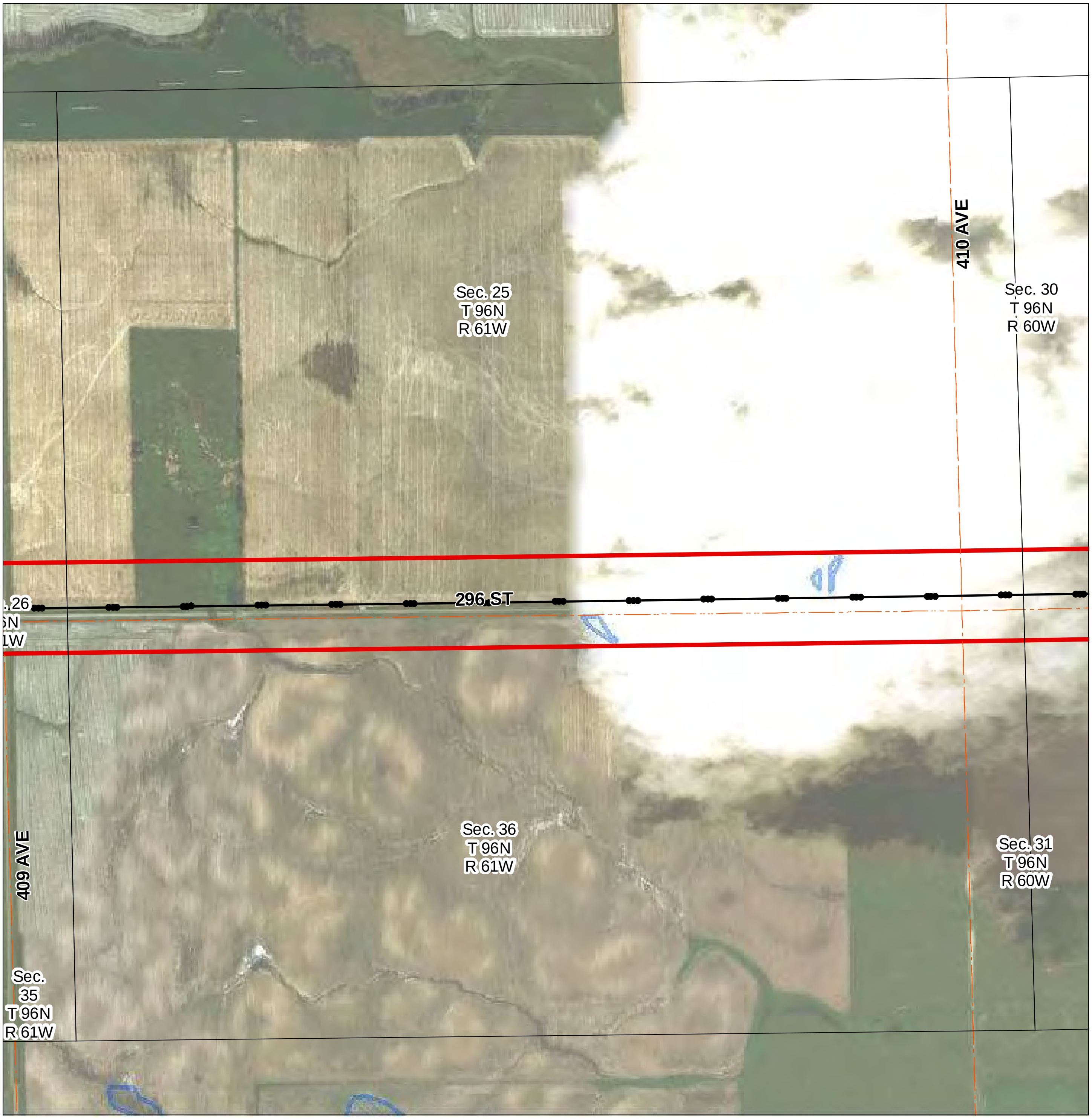

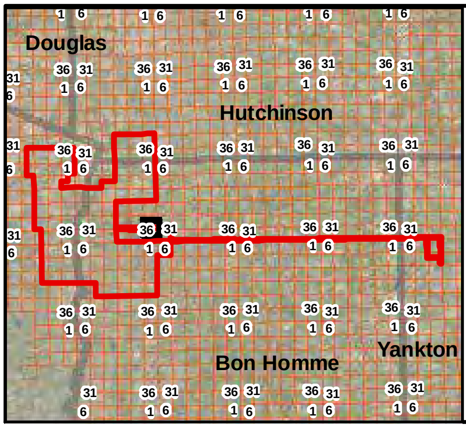

Legend

- 🟥 Project Area (2018)
- ●●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018)

Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Feet
0 800

Figure 2 - 87

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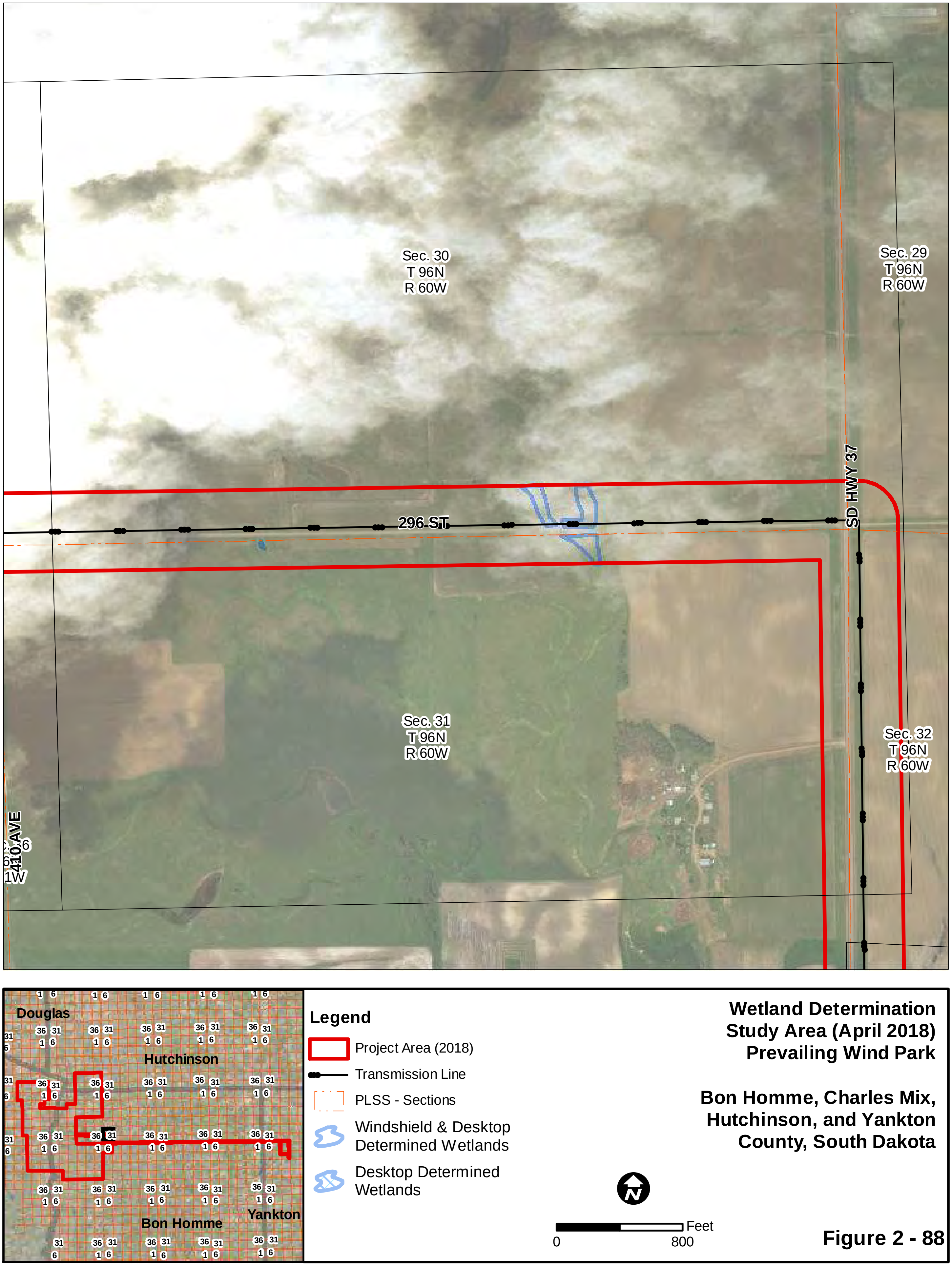


Legend

🟥 Project Area (2018)

●●— Transmission Line

▭ PLSS - Sections

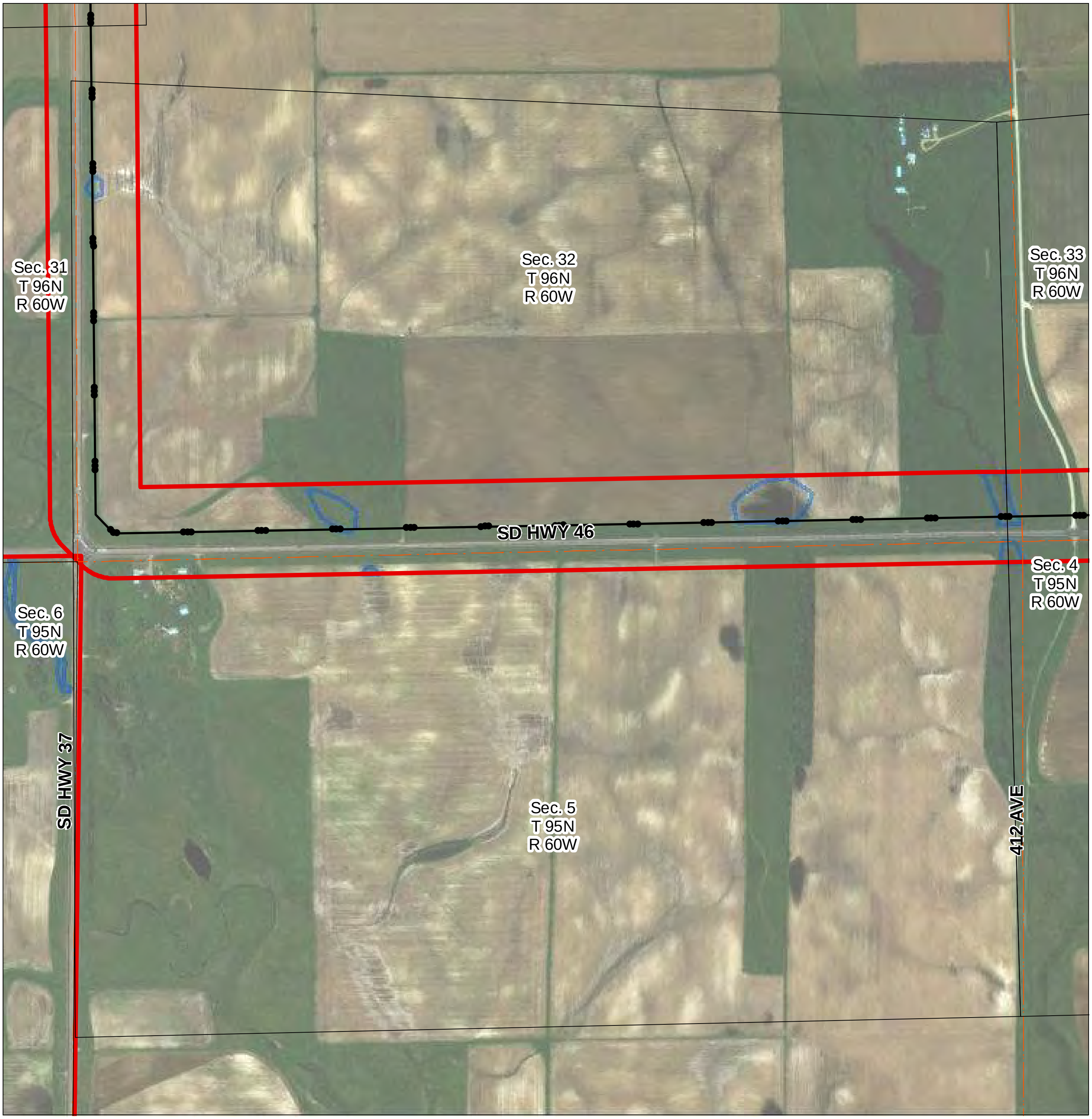
Windshield & Desktop Determined Wetlands

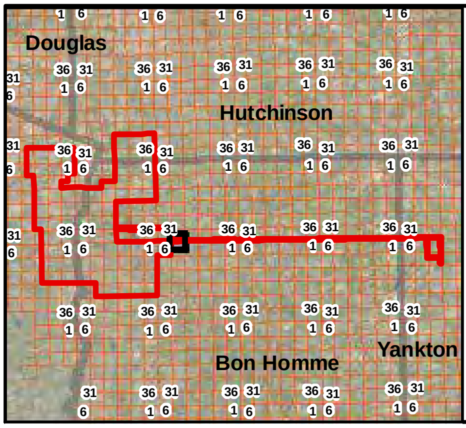
Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 88





Legend

🟥 Project Area (2018)

●● Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

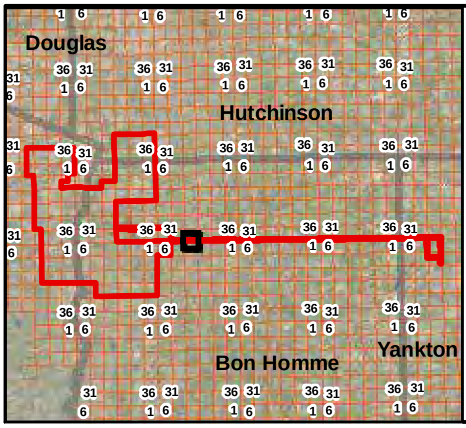
Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 89



Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 90

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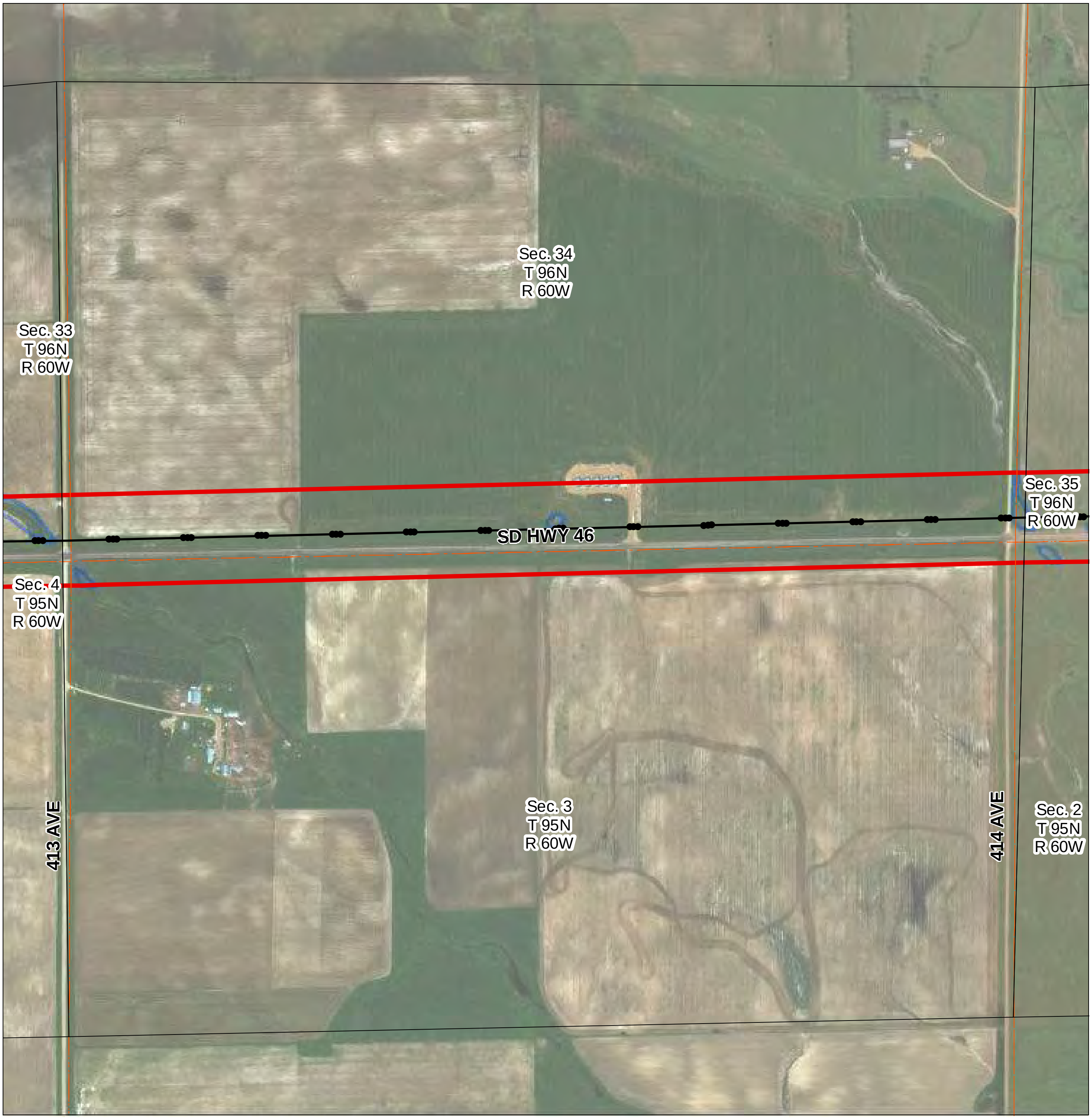

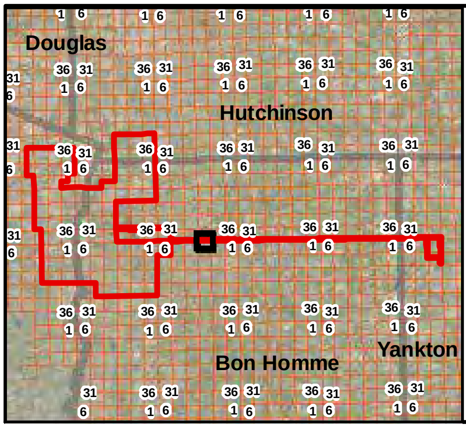

Legend

🟥 Project Area (2018)

●●— Transmission Line

▭ PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 91

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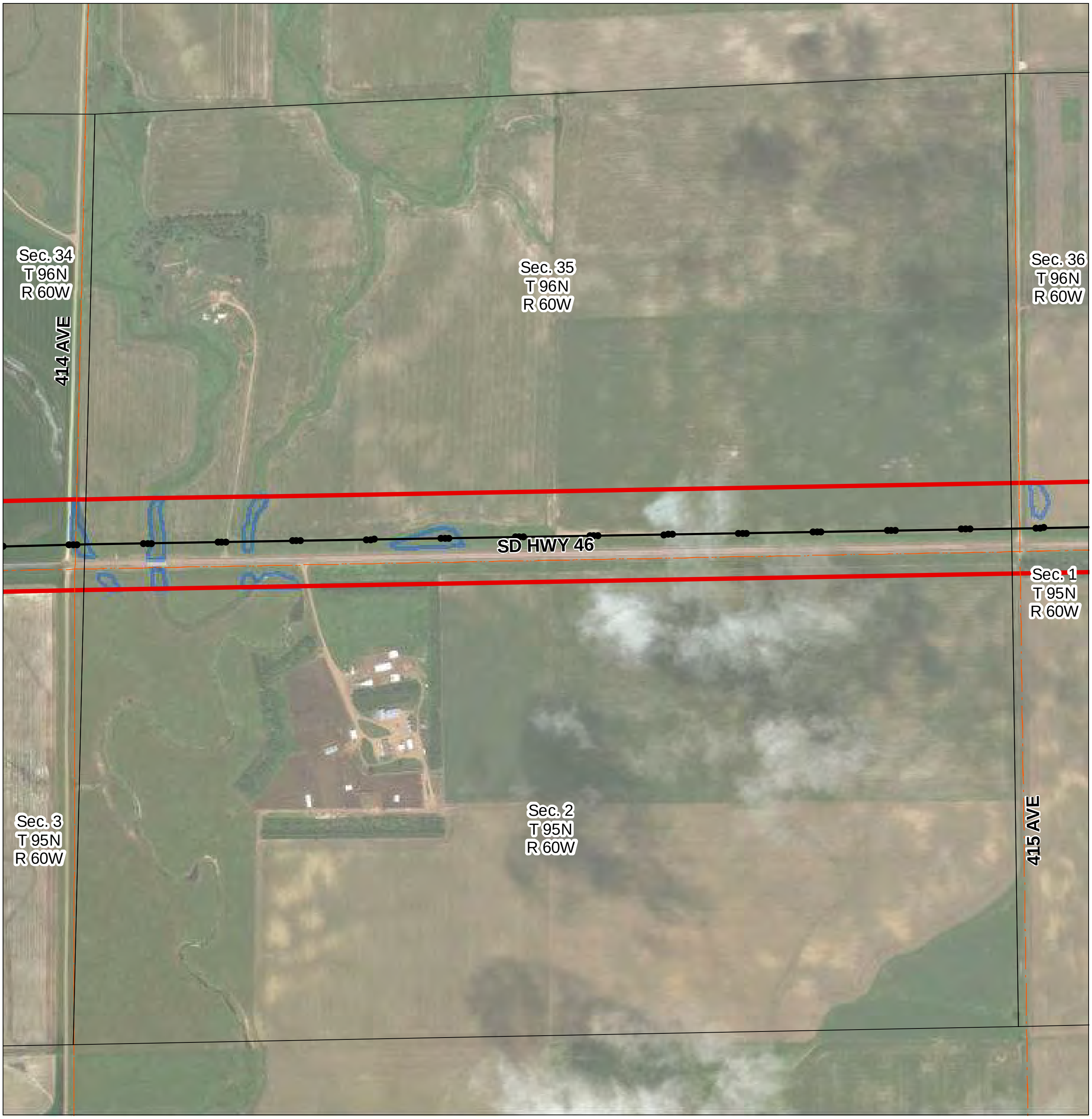

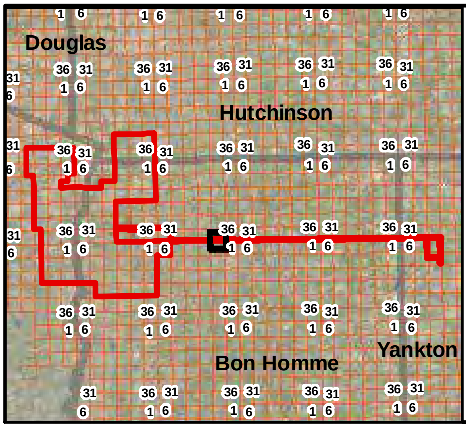

Legend

- 🟥 Project Area (2018)
- ●— Transmission Line
- ⬚ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 92

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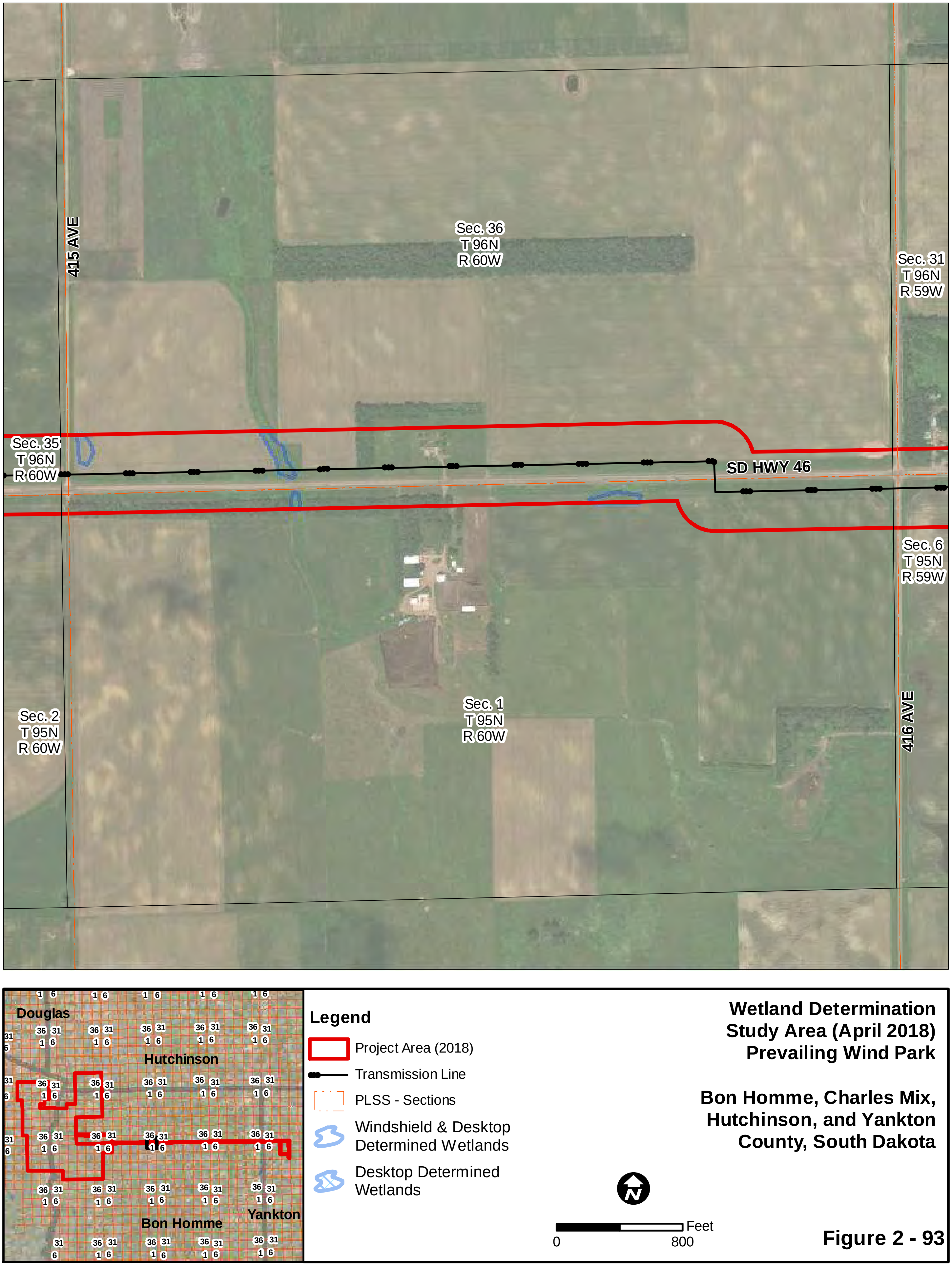

Legend

- 🟥 Project Area (2018)
- ●● Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 93

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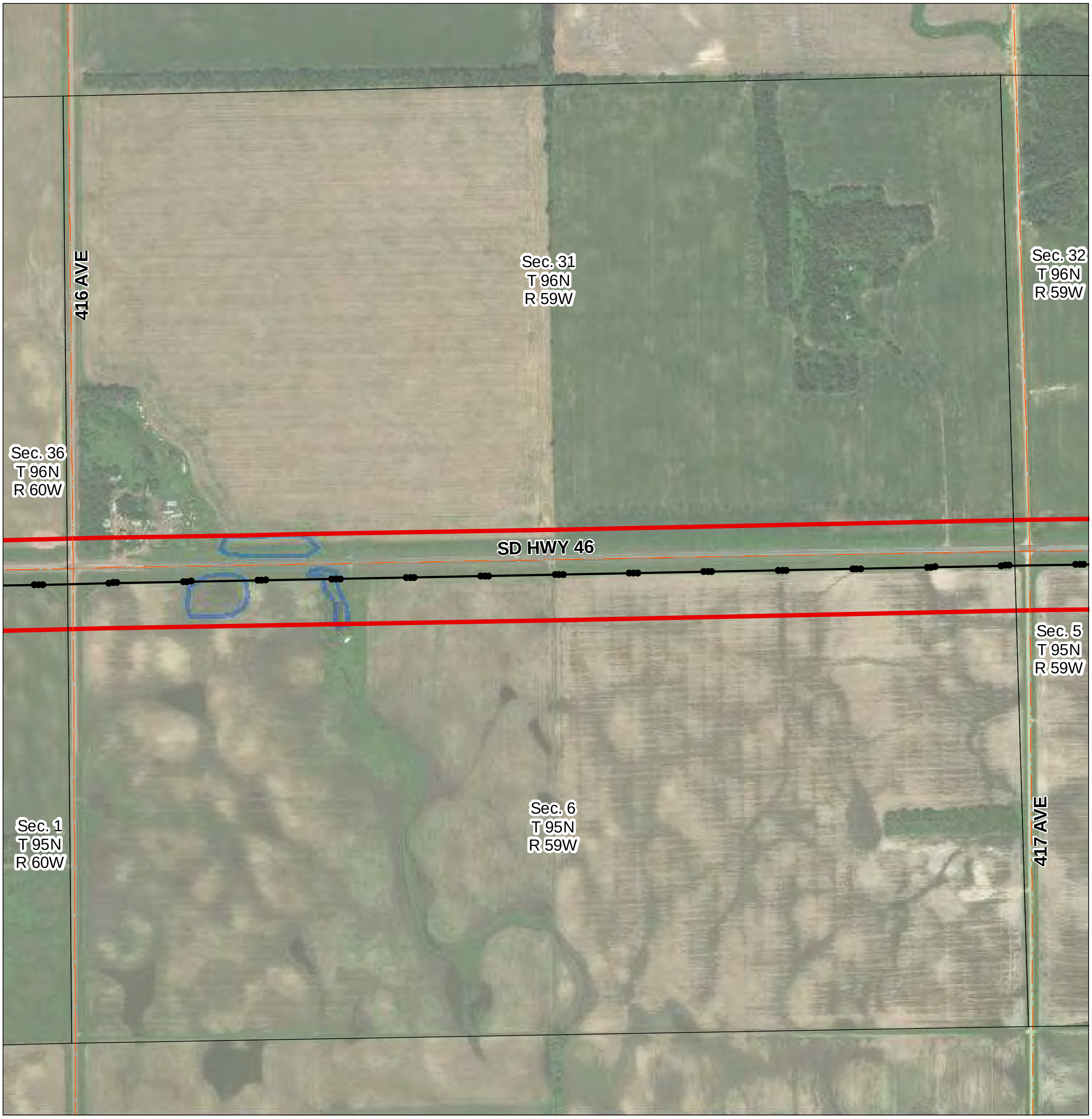

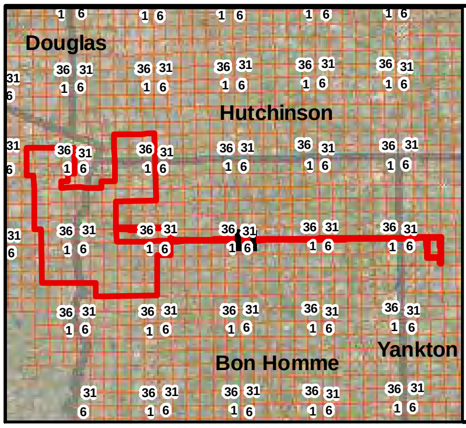

Legend

- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

N

0 800 Feet

Figure 2 - 94

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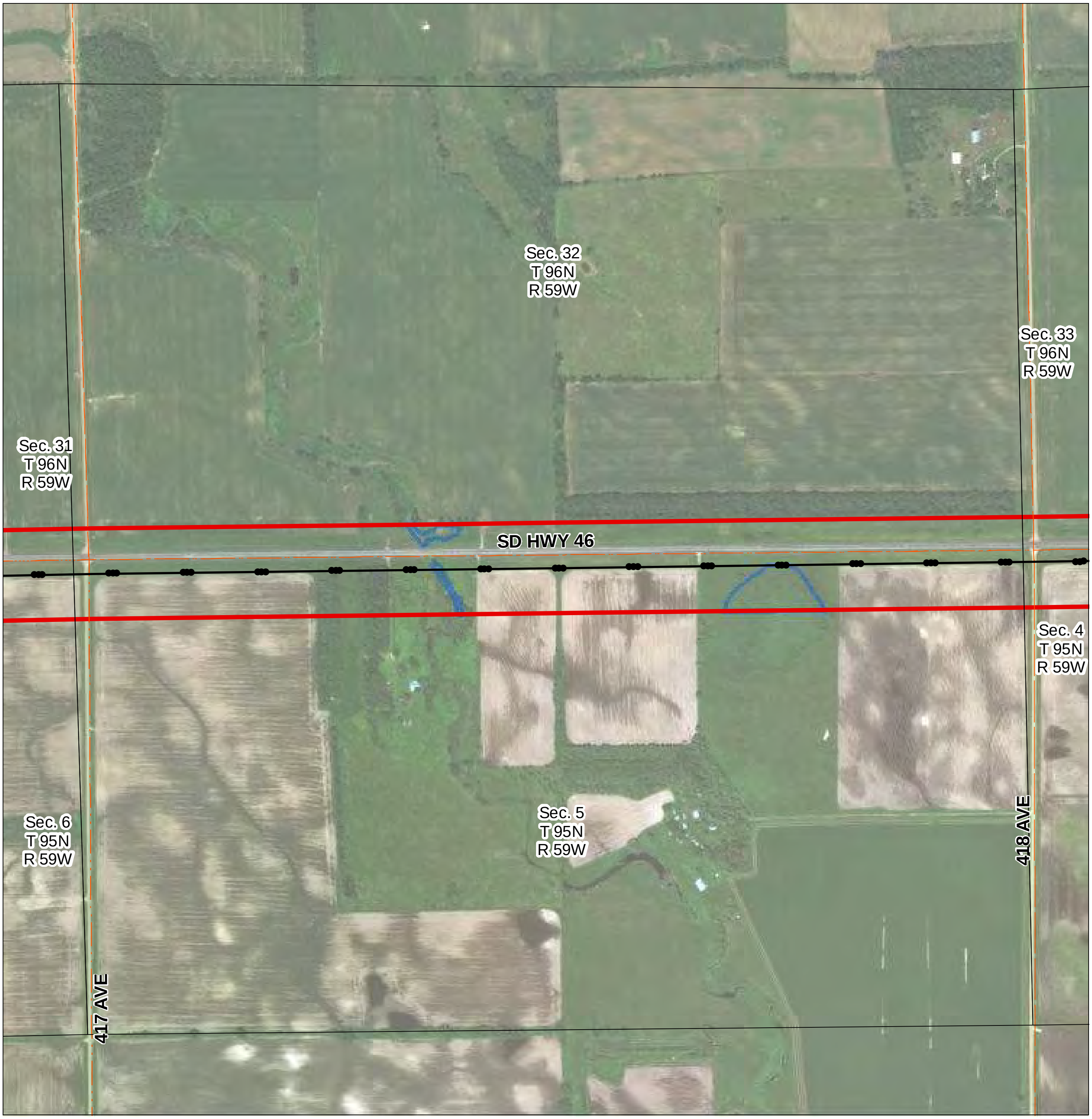

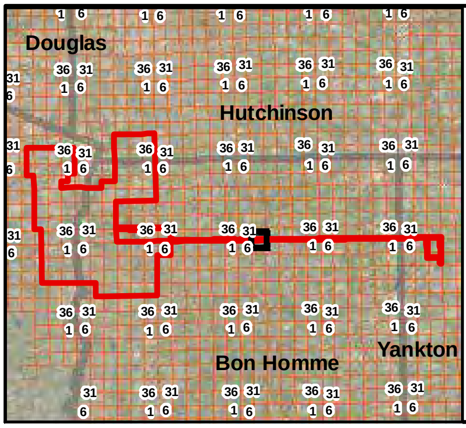

Legend

- 🟥 Project Area (2018)
- ●● Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

N

0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 95

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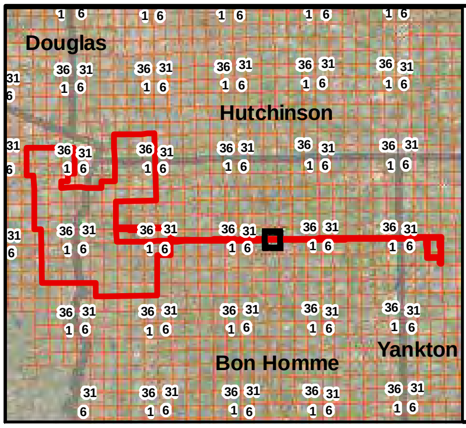


Legend

- 🟥 Project Area (2018)
- ●●— Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

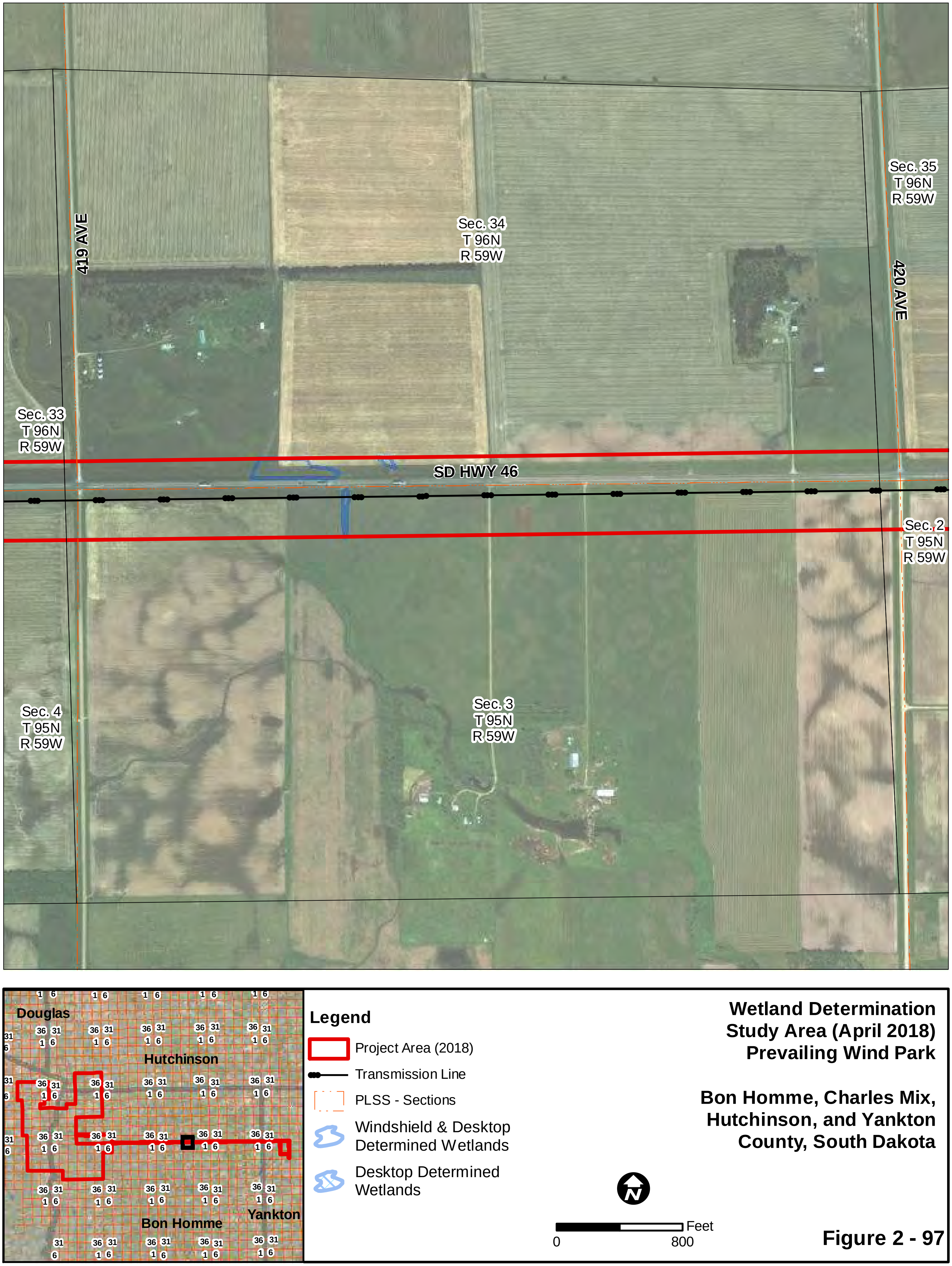
Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

N

Feet
0 800

Figure 2 - 96



Legend

🟥 Project Area (2018)

●●— Transmission Line

PLSS - Sections

Windshield & Desktop Determined Wetlands

Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 97

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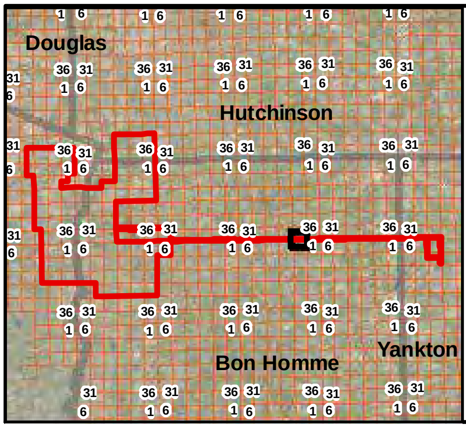


Legend

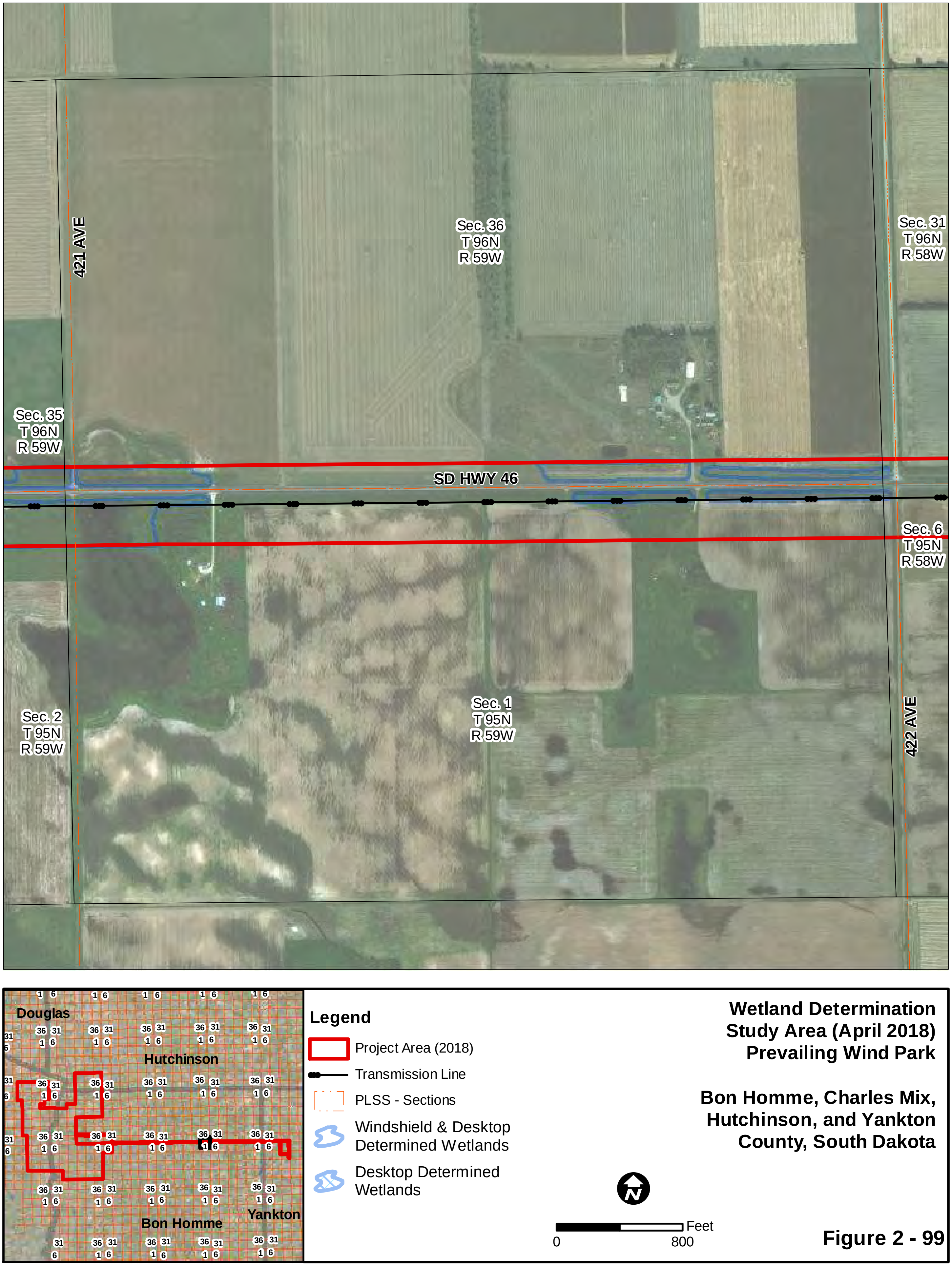
- 🟥 Project Area (2018)
- Transmission Line
- PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

Feet
0 800

Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 98



Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 99

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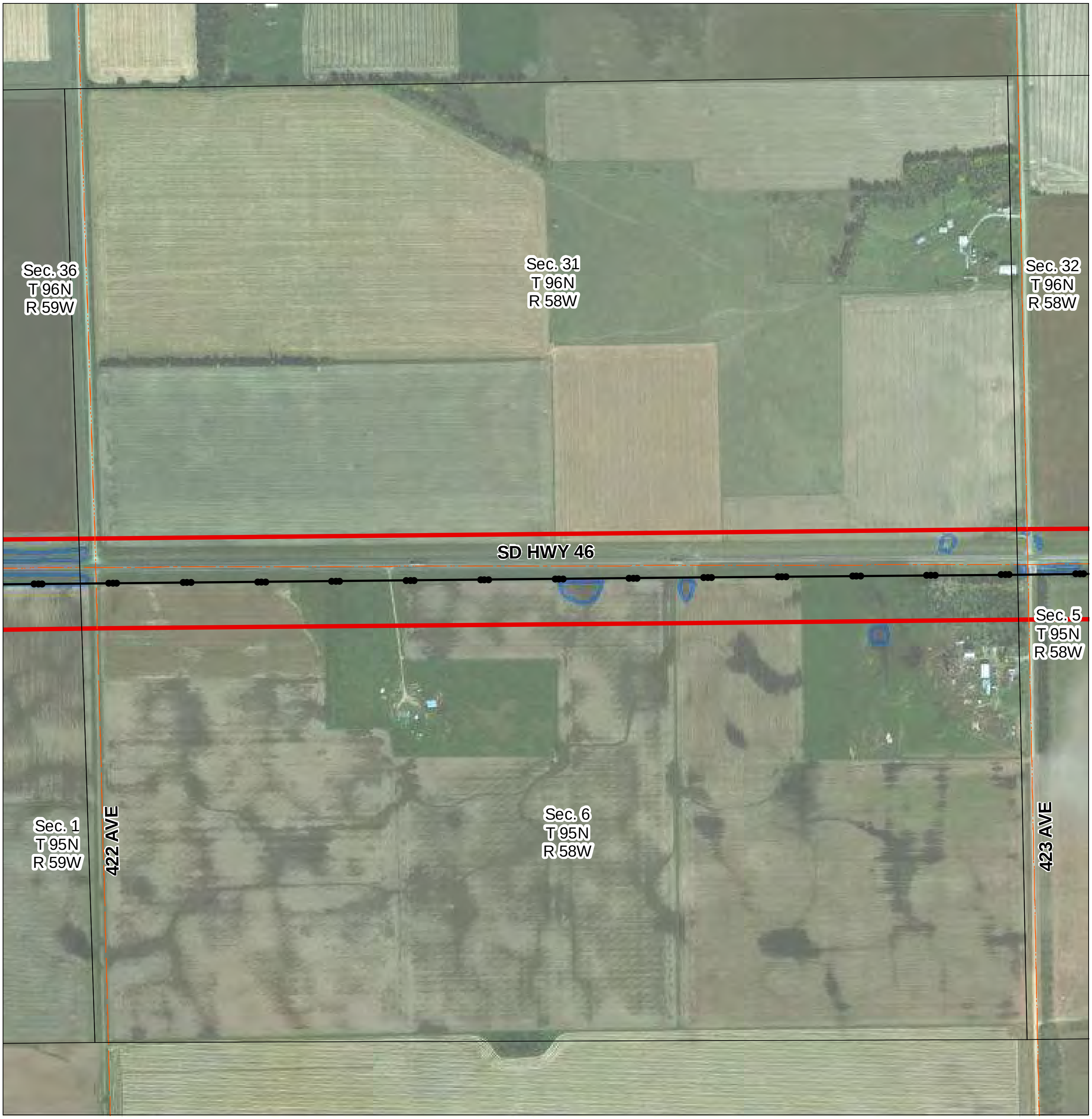

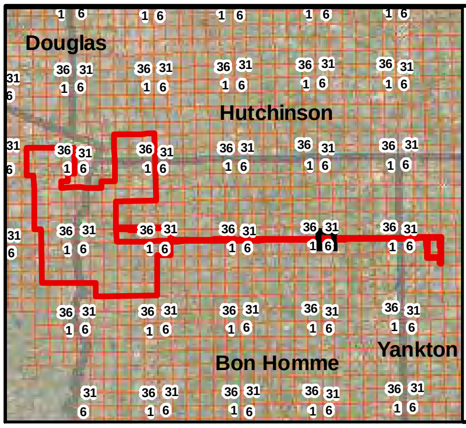

Legend

- 🟥 Project Area (2018)
- ●●— Transmission Line
- ▭ PLSS - Sections
- Windshield & Desktop Determined Wetlands
- Desktop Determined Wetlands

0 800 Feet

Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 100

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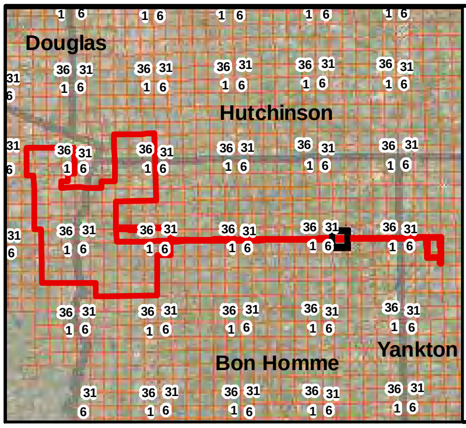

Legend

🟥	Project Area (2018)
●●—	Transmission Line
▭	PLSS - Sections
◌	Windshield & Desktop Determined Wetlands
◌	Desktop Determined Wetlands

Feet
0 800

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 101

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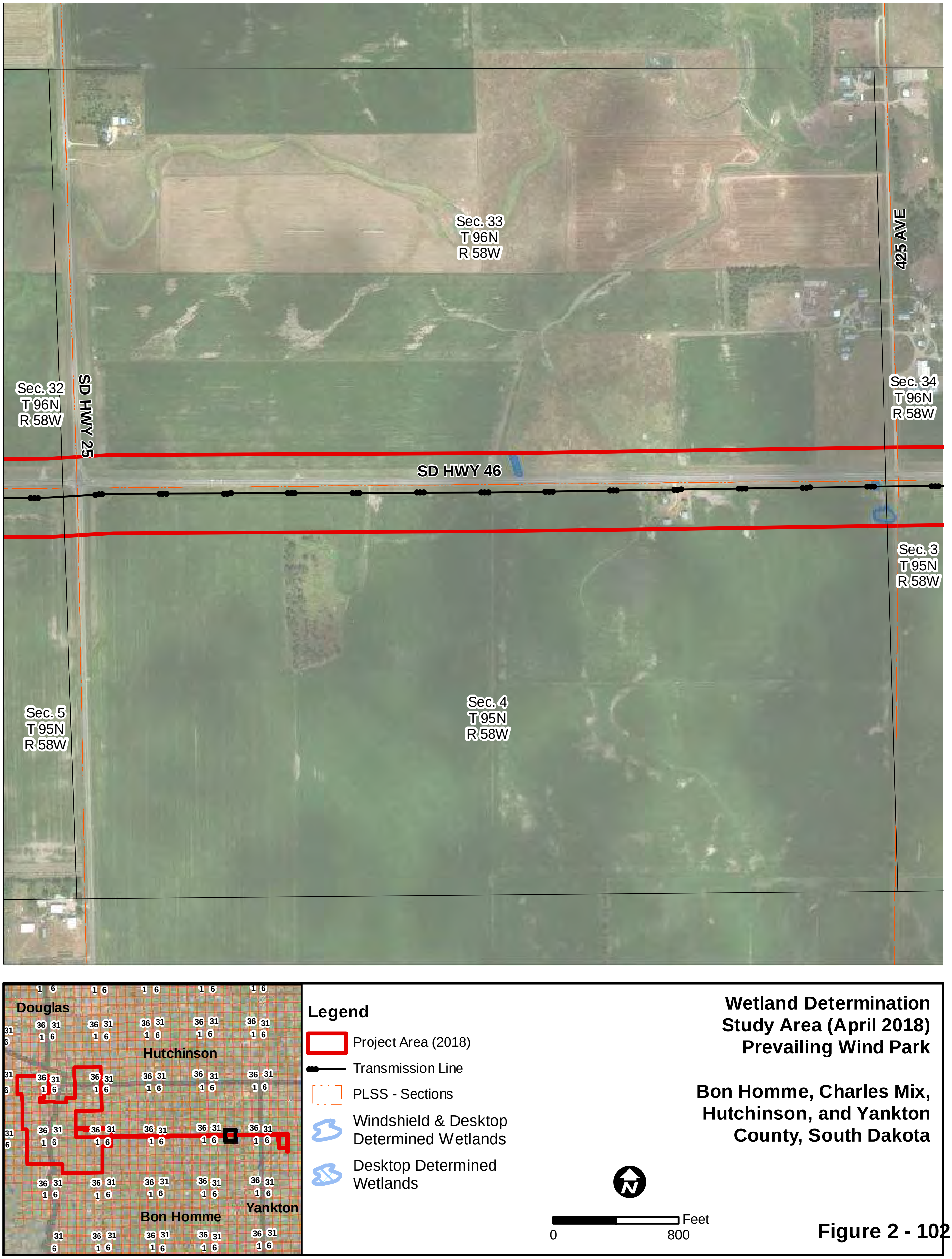

Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 102

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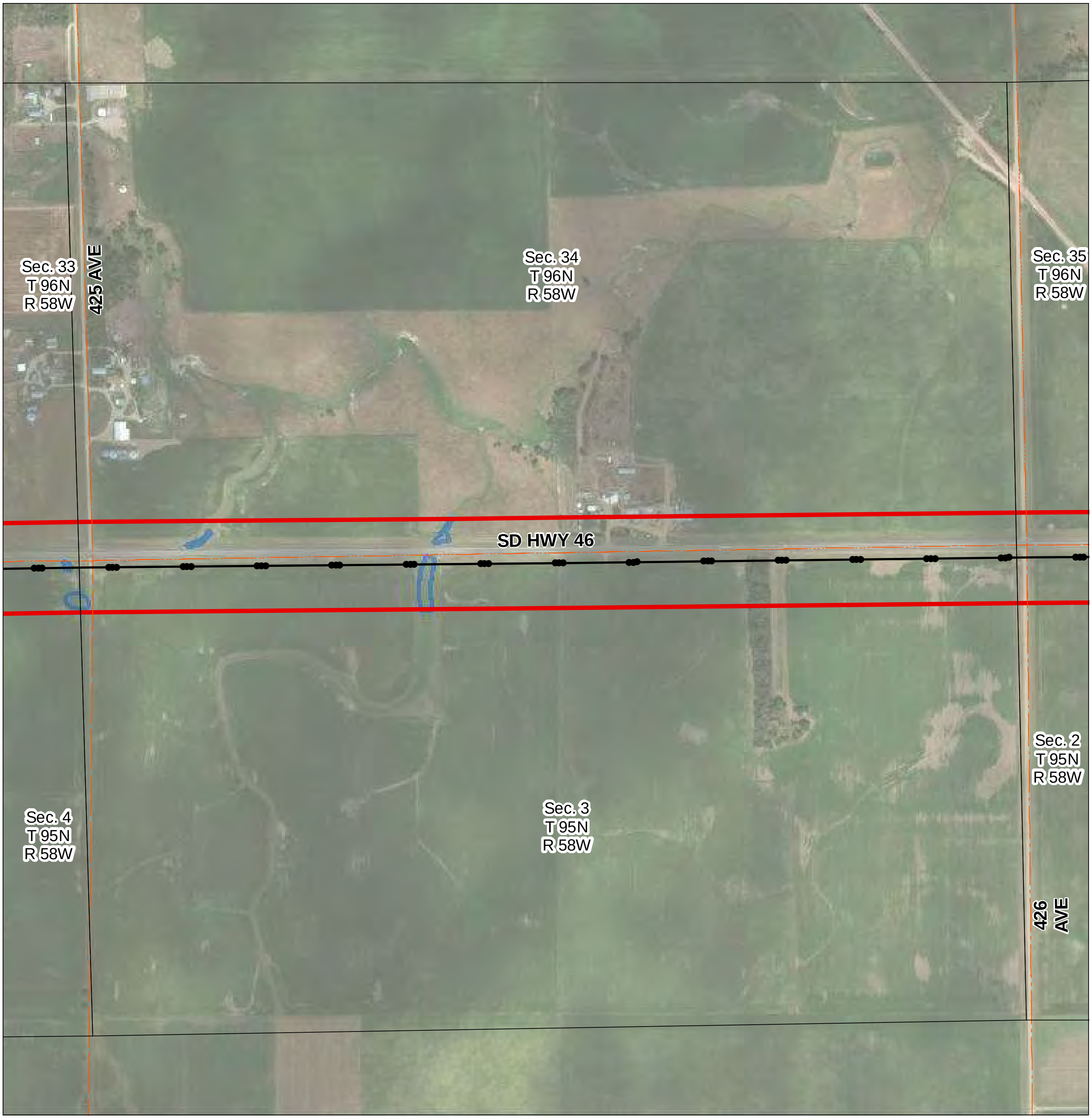

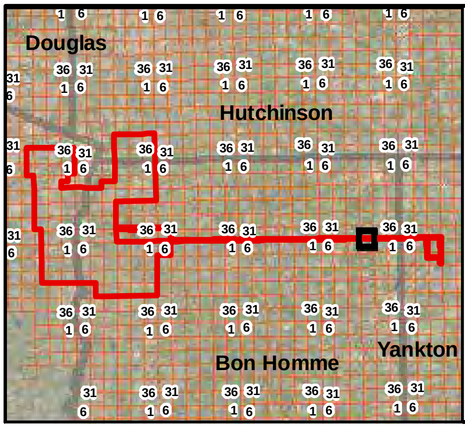

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Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 103

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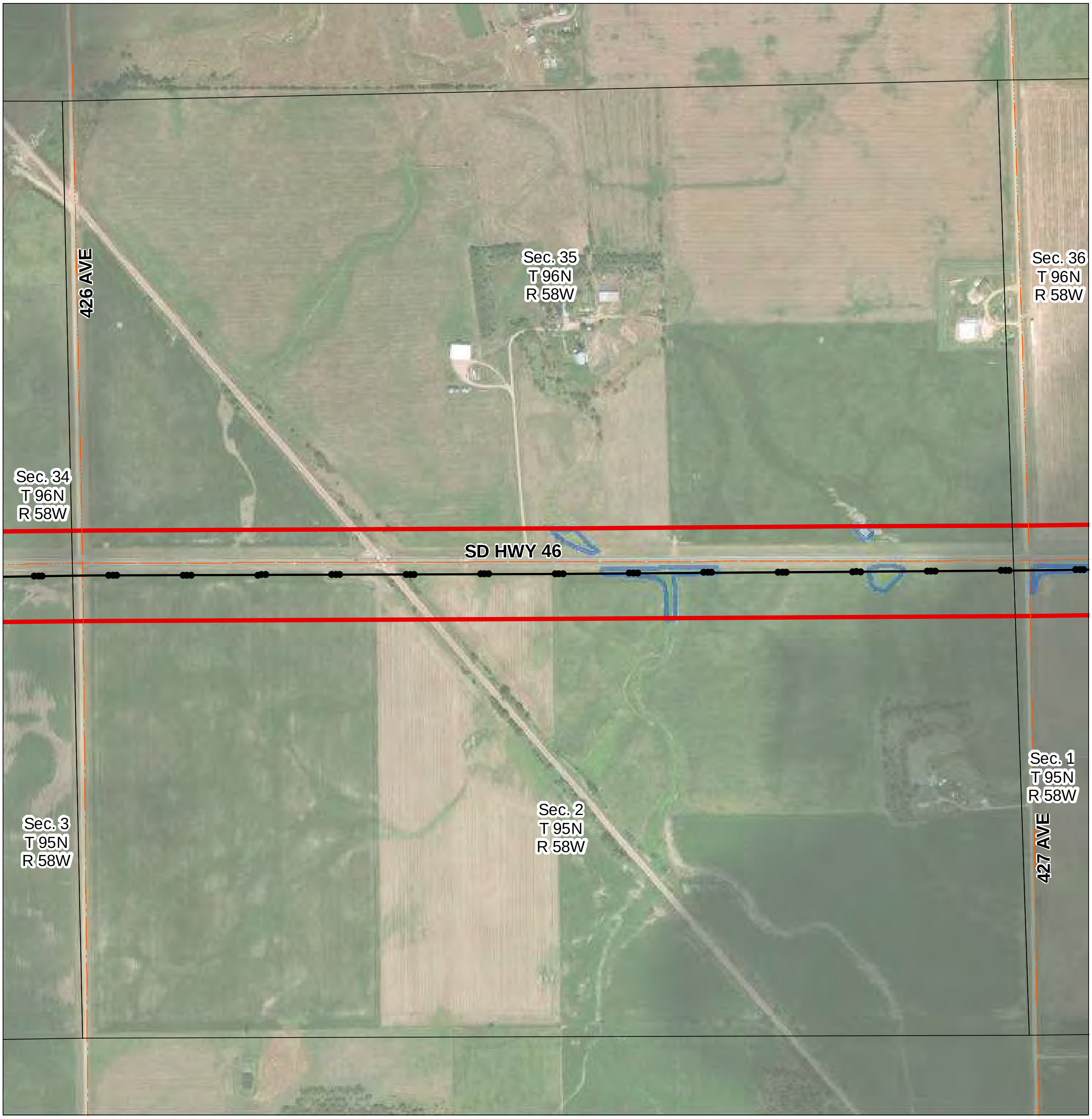

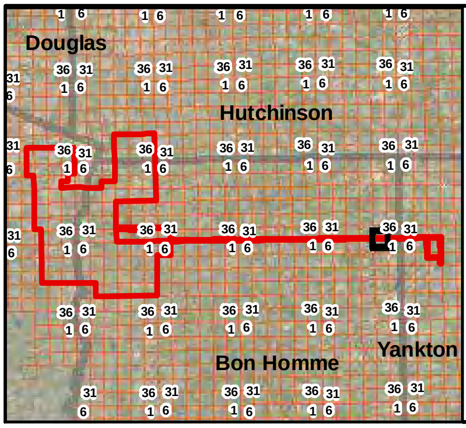

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Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

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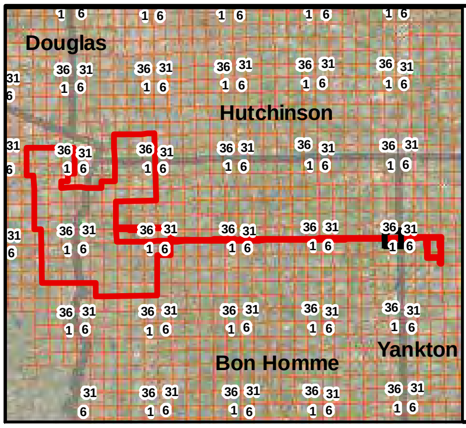

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Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

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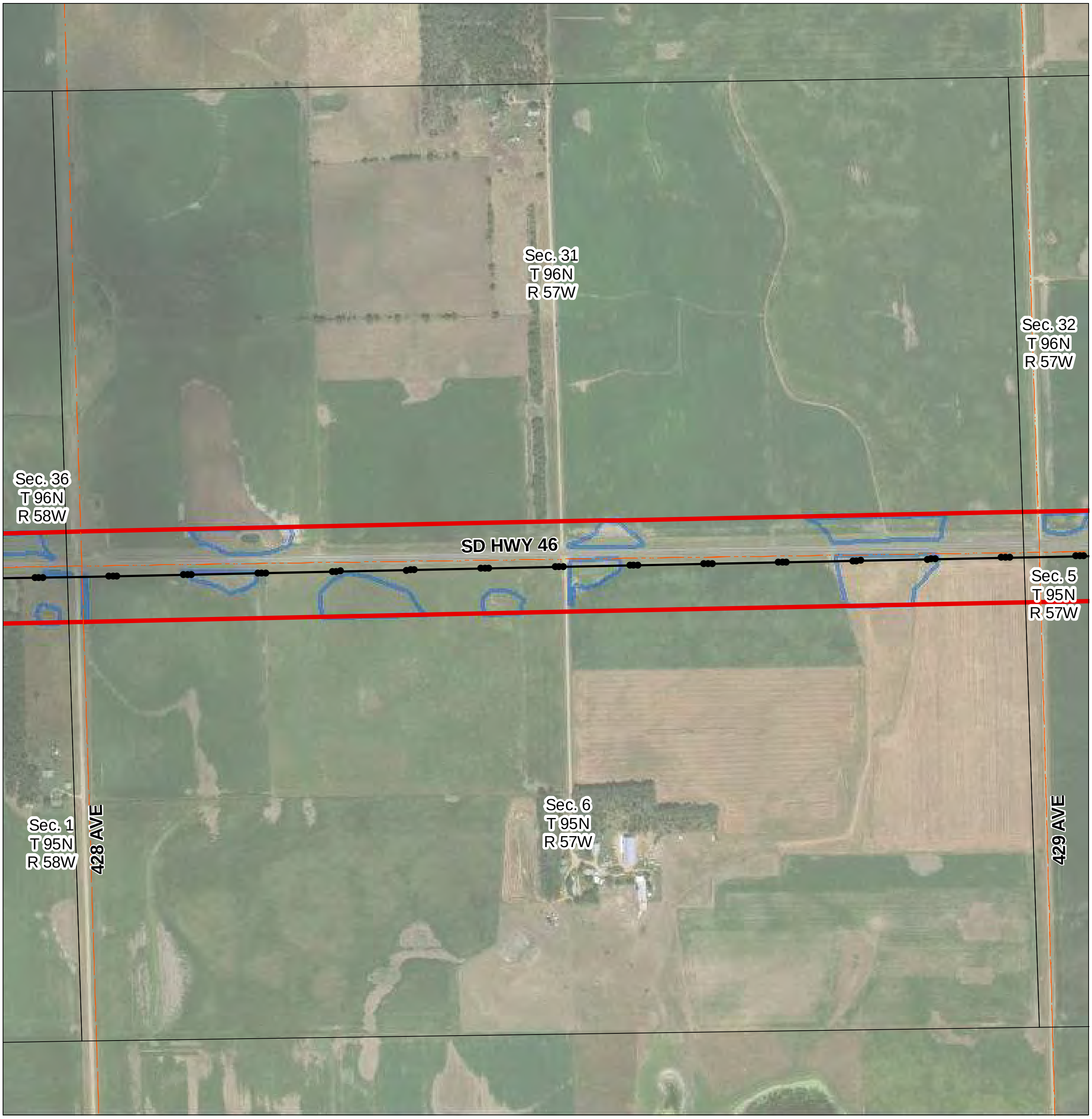

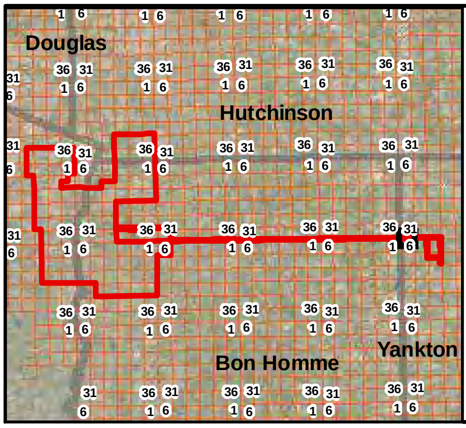

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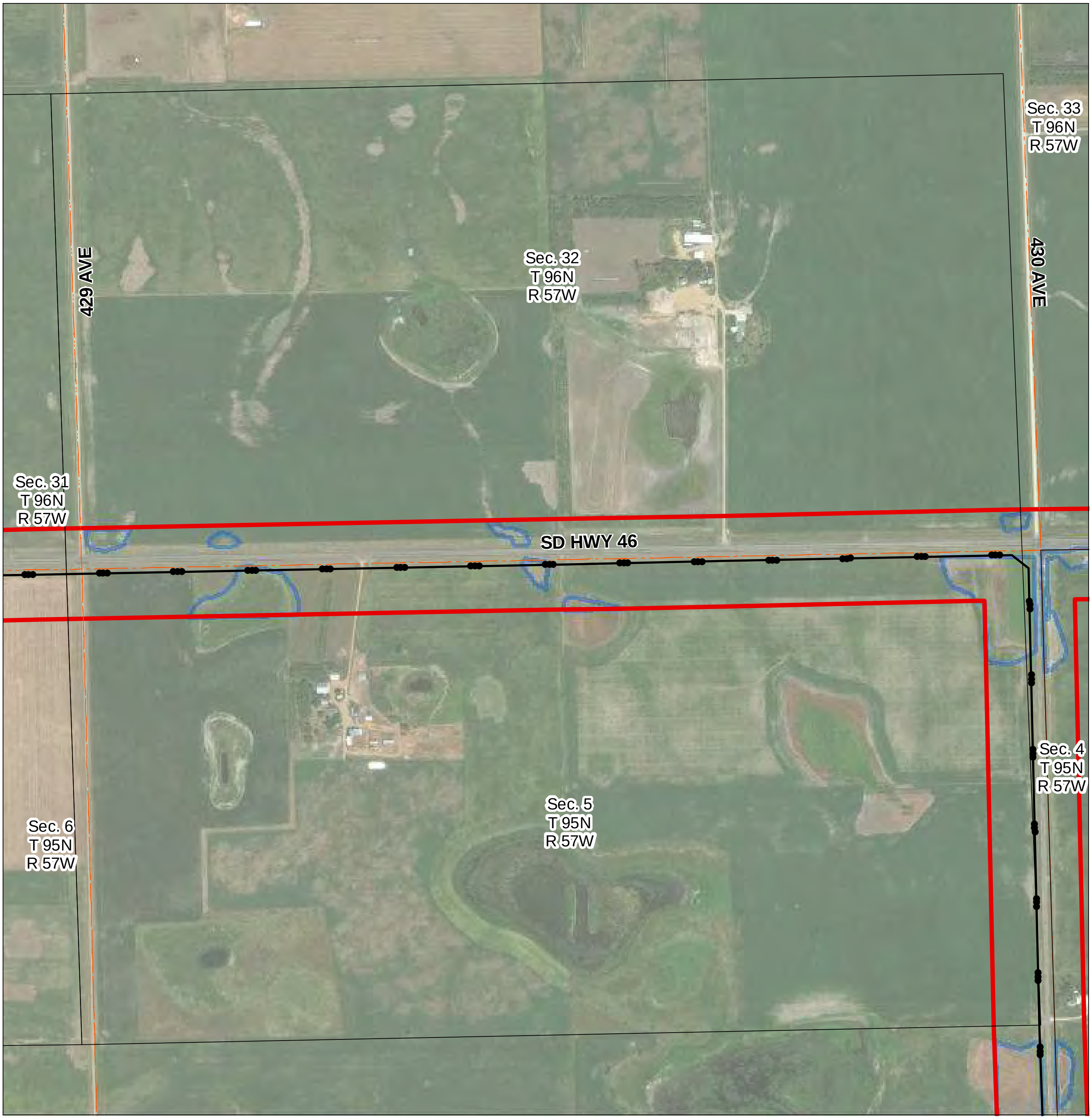
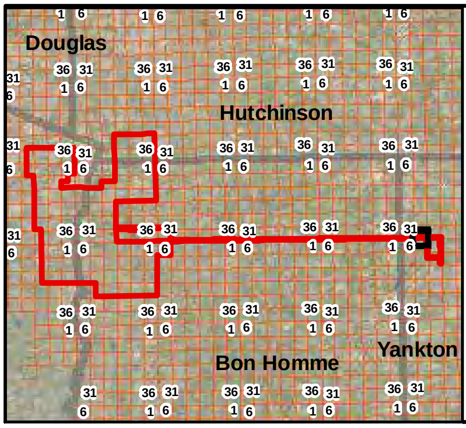
Wetland Determination Study Area (April 2018) Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 106





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Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 107

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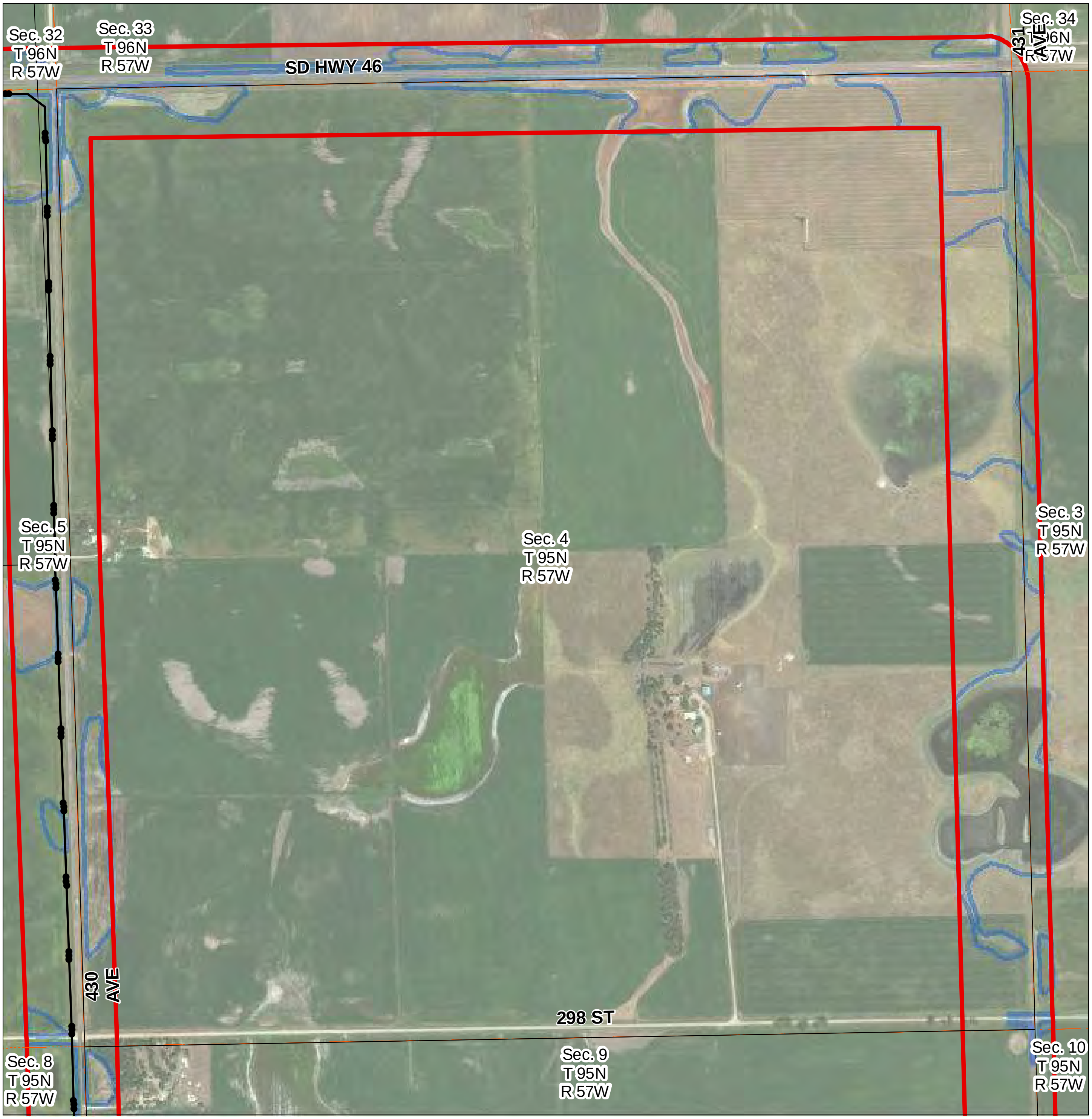

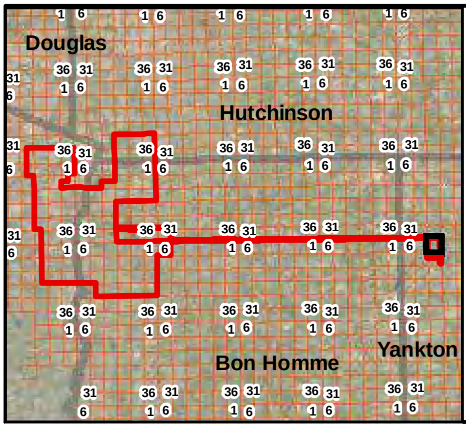

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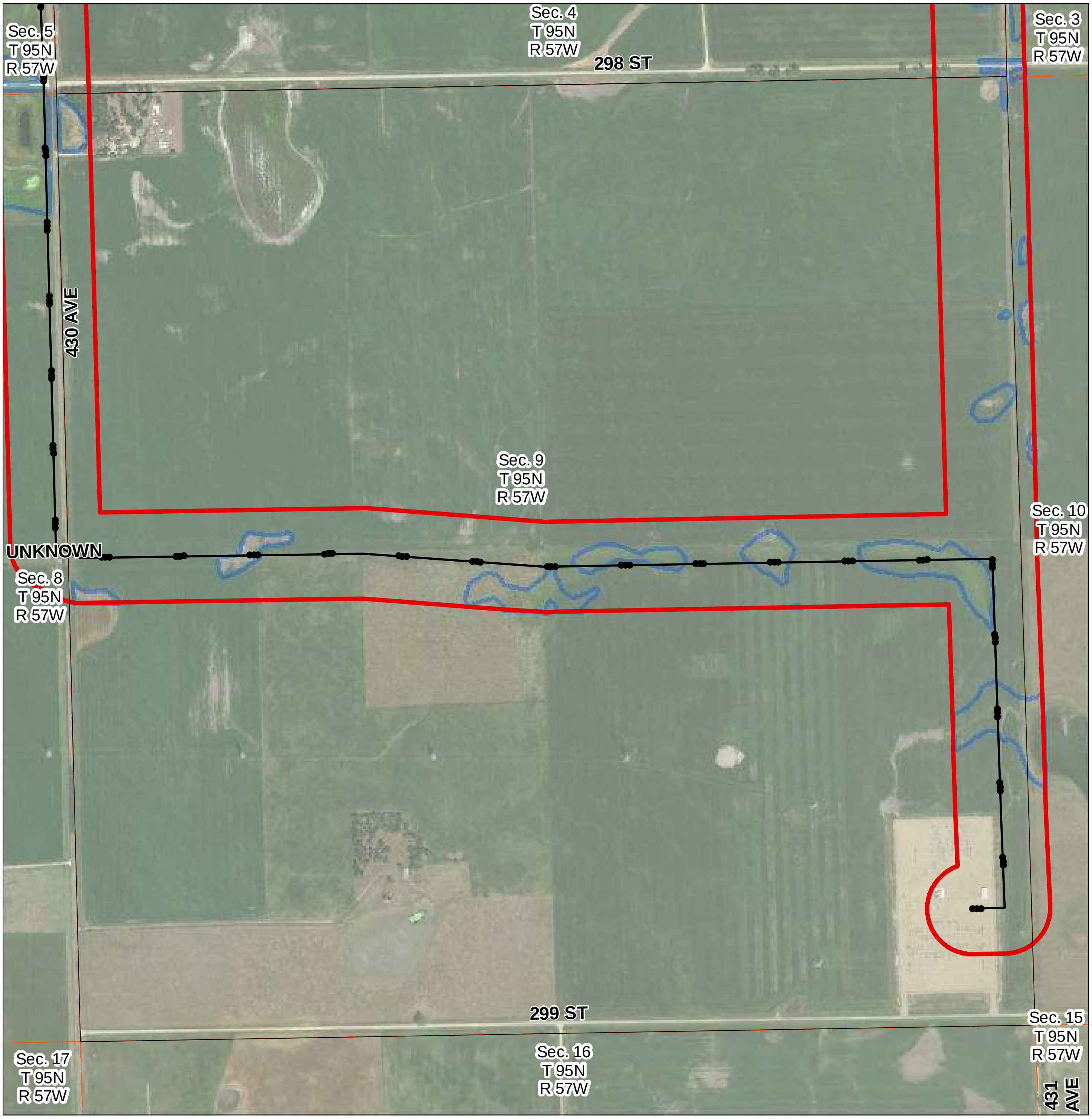
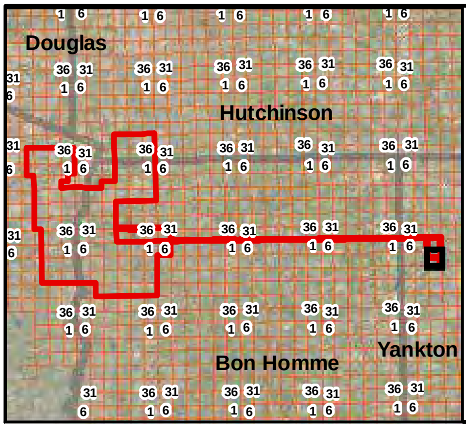
Wetland Determination Study Area (April 2018)
Prevailing Wind Park

Bon Homme, Charles Mix, Hutchinson, and Yankton County, South Dakota

Figure 2 - 108





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Wetland Determination
Study Area (April 2018)
Prevailing Wind Park

**Bon Homme, Charles Mix,
Hutchinson, and Yankton
County, South Dakota**

Figure 2 - 109

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Tiers 1 and 2 Report
for the Prevailing Winds Wind Project
Bon Homme and Charles Mix
Counties, South Dakota

Prepared for:

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4007 State Street, Suite 109
Bismarck, North Dakota 58503

June 1, 2016

EXECUTIVE SUMMARY

The Prevailing Winds Wind Project (Project) is located in Bonne Homme and Charles Mix counties, South Dakota. The purpose of this report is to: 1) characterize biological resources throughout the proposed Project as well as identify the needs and timing of recommended future studies based on the species of concern, and 2) to summarize the results of Tier 1 and Tier 2 studies. The Project area was evaluated during a February 2015 visit.

The majority of the Project is located in the Southern Missouri Coteau Slope, while a small portion is located in the Southern Missouri Coteau Level IV Ecoregions. Historically, the Project and surrounding area was mixed grass prairie consisting of grama, needlegrass, and wheatgrass species, with numerous wetlands scattered throughout. Today, the majority of the Project has been converted to agricultural use with crop production and livestock grazing as the main agricultural practices. There are trees and woodlands found mainly in planted shelter belts and within draws and on hillslopes. Wetlands are scattered throughout the Project.

One of the main concerns regarding impacts from wind energy facilities in South Dakota is development in native grasslands and other native prairie habitats and displacement of wildlife from these areas. Approximately 45% of the Project is categorized as grassland (grass/herbaceous/pasture/hay). Because the Project includes grasslands (native or planted), it is possible that some grassland-dependent wildlife species may be displaced. The magnitude and significance of the displacement will depend on the affected species and the plan for development of the site.

Based on National Wetland Inventory (NWI) data, there are approximately 1,305.8 acres (528.8 hectares) of wetlands found within the Project. Freshwater emergent wetlands (77.5%) accounted for the majority of the wetlands, followed by freshwater ponds (14.7%), lakes (4.4%), and freshwater forested/shrub wetlands (3.4%).

Seven animal species listed as threatened, endangered, or proposed endangered under the federal Endangered Species Act have been documented in Bonne Homme and/or Charles Mix counties, including: pallid sturgeon, Topeka shiner, interior least tern, whooping crane, northern long-eared bat, red knot, and piping plover. Five of these species have the potential to occur in the Project during some portion of the year: interior least tern, whooping crane, northern long-eared bat, red knot, and piping plover. The interior least tern, red knot, whooping crane, and piping plover could migrate through the Project area during the spring and fall, but are otherwise not expected to occur in the Project. The Project is located outside of the defined national whooping crane migration corridor, and there have been no confirmed whooping crane sightings within the Project as of fall 2010. The Project is with the defined range of the northern long-eared bat, and while unlikely, the species could be present during the summer breeding period. The pallid sturgeon and Topeka shiner are federally-listed fish species, but have not been found within the Project. There are no known occurrences of federally-listed plant species within the Project.

Western EcoSystems Technology, Inc. (WEST) conducted a preliminary review of the birds and bats listed as threatened or endangered by the state of South Dakota, as birds and bats are most likely impacted by wind facility development. WEST identified two bird species, bald eagle and osprey, that are listed as threatened by the state of South Dakota that may occur within the Project. Bald eagles are also protected under the Bald and Golden Eagle Protection Act.

The following diurnal raptor and vulture species could potentially breed in or near the Project: American kestrel, bald eagle, golden eagle, Cooper's hawk, northern harrier, red-tailed hawk, Swainson's hawk, ferruginous hawk, broad-winged hawk, peregrine falcon, osprey, and turkey vulture. Owls with the potential to breed in or near the Project include barn owl, burrowing owl, eastern screech owl, long-eared owl, short-eared owl, and great horned owl. Diurnal raptor species that may also occur within the Project outside of the breeding season (migration, winter, or post-breeding dispersal) include northern goshawk, Cooper's hawk, red-tailed hawk, golden eagle, bald eagle, merlin, peregrine falcon, prairie falcon, gyrfalcon, rough-legged hawk, and sharp-shinned hawk. Four red-tailed hawk and two unidentified raptor observations were recorded at the Project during the site visit in February 2015. Potential nest structures for above ground nesting species were present in the form of living and dead trees; grassland areas could also provide nesting habitats for ground-nesting raptors and owls, such as the northern harrier and burrowing owl.

Colonial rodents are known to attract feeding raptors but were not observed during the site visit. It is likely that some bird species migrate through the proposed Project, including passerines, raptors, and waterfowl. Harvested crop fields located in the Project could serve as feeding areas for migrating birds. During the site visit, approximately 70 mallards were seen throughout the area and feeding in crop fields.

Two US Geological Survey (USGS) Breeding Bird Survey (BBS) routes are located in the vicinity of the Project. The Tripp BBS route is approximately 13 miles (20.9 kilometers [km]) northeast of the Project, and the Sparta BBS route is approximately 21.5 miles (34.6 km) southeast of the Project. Seventy bird species have been recorded along the Tripp BBS route from 2011 to 2014, of which three are considered Species of Conservation Concern by the US Fish and Wildlife Service (USFWS): dickcissel, grasshopper sparrow, and red-headed woodpecker. Along the Sparta BBS route, 65 bird species were recorded in 2011 and 2013, of which four are considered Species of Conservation Concern by the USFWS: dickcissel, grasshopper sparrow, red-headed woodpecker, and upland sandpiper.

Seven bat species are potential residents and/or migrants in the Project, including big brown bat, eastern red bat, hoary bat, silver-haired bat, northern long-eared bat, little brown bat, and western small-footed bat. Potential roosting habitat within the Project is found in the form of scattered trees, wooded hillslopes, and abandoned buildings; no caves were observed during the site visit. No known caves were documented in a literature search; however, karst formations may be found within the Project. Although the operation of the proposed wind energy facility will likely result in the mortality of some bats, the magnitude of these fatalities and the degree to which bat species will be affected is difficult to predict.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

The Prevailing Winds Wind Project (hereafter referred to as Project) is located in Bonne Homme and Charles Mix Counties, South Dakota (Figure 1). Identification of potential biological resource issues early in the development phase of wind energy facilities helps the industry identify, avoid, and minimize future problems. This Tier 1 and 2 report involved a desktop review of publicly available information gathered from a variety of data sources, including US Fish and Wildlife Service (USFWS) websites; South Dakota Game, Fish and Parks (SDGFP) websites; US Geological Survey (USGS) Gap Analysis datasets; and various field guides, maps, and aerial imagery; and non-governmental organization (NGO) websites (e.g., The Nature Conservancy, Audubon, American Wind Wildlife Institute). This report is intended to meet the requirements described in Chapters 2-3 of the USFWS Land-Based Wind Energy Guidelines (USFWS 2012b).

STUDY AREA

The proposed Project (37,016.6 acres [ac]; 14,980.1 hectares [ha]) is located in the southeastern South Dakota counties of Bon Homme and Charles Mix (Figure 1). The landscape of the Project is flat to rolling hills, with elevations ranging from 454.5 to 573.7 meters (m; 1,491.2 to 1,882.3 feet [ft]) above sea level (Figures 2).

The majority of the Project is located in the Southern Missouri Coteau Slope, with the rest of the Project in the Southern Missouri Coteau Level IV Ecoregions (US Environmental Protection Agency [USEPA] 2013). Historically, the Project and surrounding area was mixed grass prairie consisting of grama (*Bouteloua* spp.), needlegrass (*Stipa* spp.), and wheatgrass (*Agropyron* spp.) species with numerous wetlands scattered throughout. Today, the majority of the Project has been converted to agricultural use, with crop production and livestock grazing as the main agricultural practices (Figure 4; USGS National Land Cover Data [NLCD] 2011). There are trees and woodlands found mainly in planted shelter belts and within draws and on hillslopes. Wetlands are scattered throughout the Project.

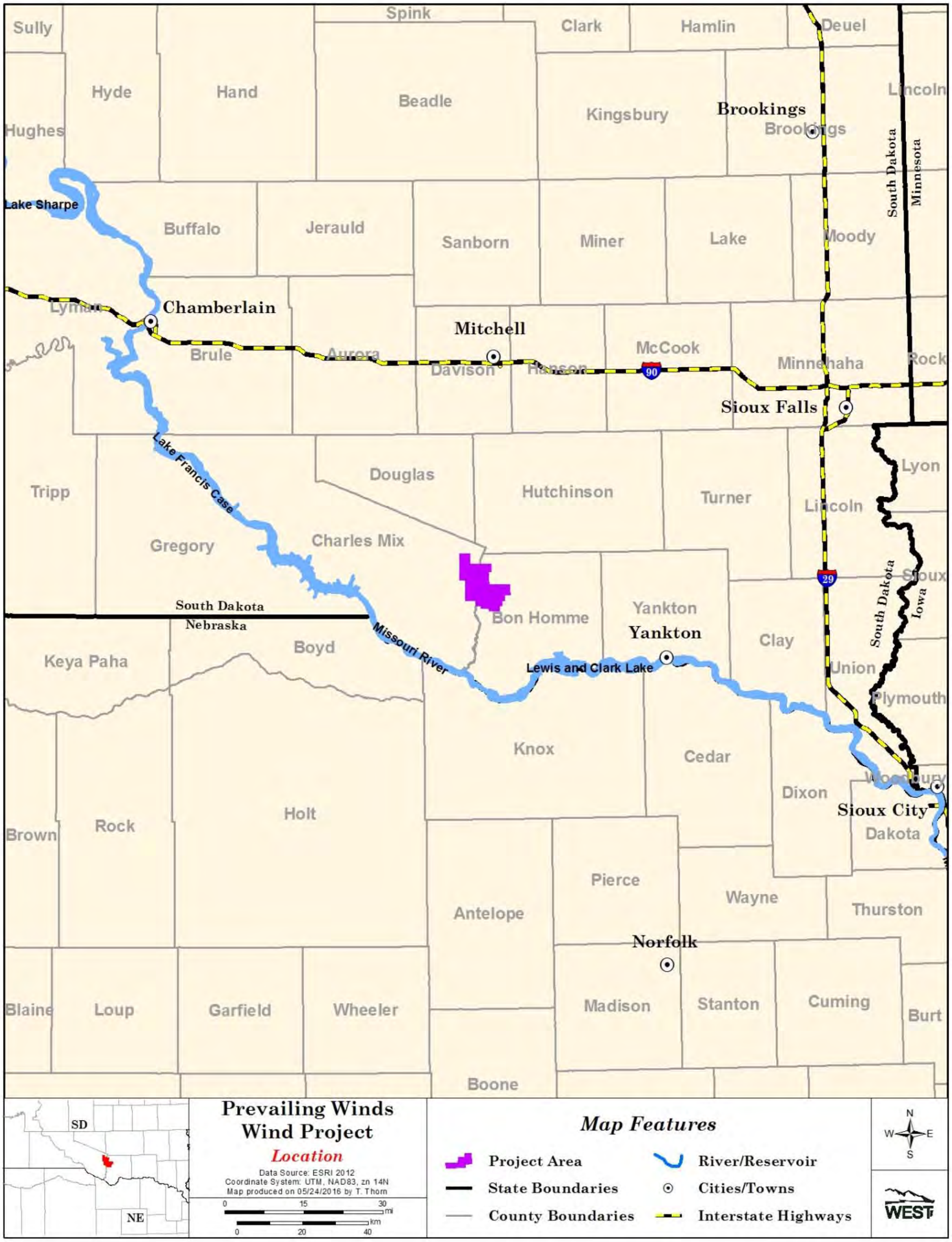

Figure 1. Location of the Prevailing Winds Wind Project.

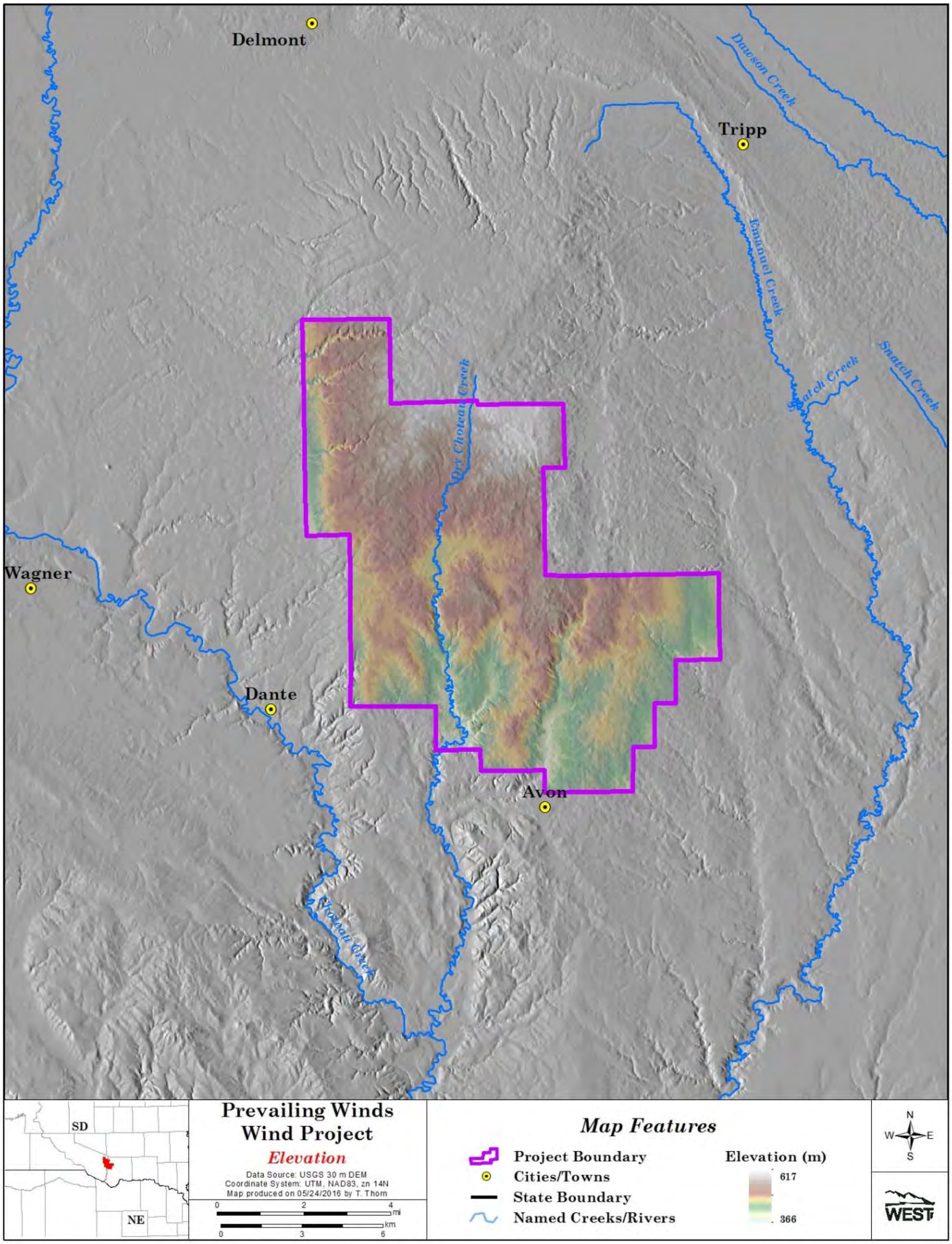

Figure 2. Elevation of the Prevailing Winds Wind Project.

METHODS

Tier 1 and 2 Study

Desktop review of publicly available information was gathered from a variety of data sources; including USFWS websites, SDGFP websites, USGS Gap Analysis datasets, various field guides, maps and aerial imagery, and NGO websites. In addition, biological resources within the Project were evaluated through a site reconnaissance visit conducted from public roads on February 25 and 26, 2015. Biological features and potential wildlife habitat, including plant communities, topographic features, and potential raptor nesting habitat and prey populations, were identified during the site visit. Photographs representative of the Project were also taken (Appendix A). All wildlife species observed were recorded (see Wildlife section below). Information about the presence and locations of sensitive species may be requested from the SDGFP and the USFWS.

Land Use/Land Cover

Approximately 47.5% of the Project is cultivated crops (Table 1, Figure 3; USGS NLCD 2011). The next most common land use is pasture/hay (37.6%). Grassland/herbaceous cover within the Project accounts for 6.7% of the land cover, followed by developed areas (4.3%) and wetlands/open water (2.7%). All other land cover types each account for less than 2% of the Project (Table 1).

Table 1. Land use/land cover within the Prevailing Winds Wind Project.

Land Use/Cover	Project Acres	% Total
Cultivated Crops	17,594.9	47.5
Pasture/Hay	13,901.8	37.6
Grassland/Herbaceous	2,479.6	6.7
Developed	1,575.1	4.3
Wetlands/Open Water	1,013.1	2.7
Deciduous Forest	368.3	1.0
Shrub/Scrub	67.5	0.2
Barren Land	14.7	<0.1
Evergreen Forest	1.1	<0.1
Total	**37,016.1**	**100**

Data Source: USGS NLCD 2011

For overall comparison of Land Use/Cover, the sole data source was USGS NLCD (2011). However, a more refined assessment was conducted by digitizing grasslands (pasture, hay, grassland, and herbaceous land cover) in ArcGIS 10.3 using 2014 National Agriculture Imagery Program (NAIP) aerial imagery. This method determined grassland acreage within the Project to be 9,949.97 acres (4,026.61 ha; 26.9%) in 2014, while USGS NLCD (2011) reported 16,381.40 acres (6,629.32 ha), indicating there has been a reduction in grassland in the Project since 2011.

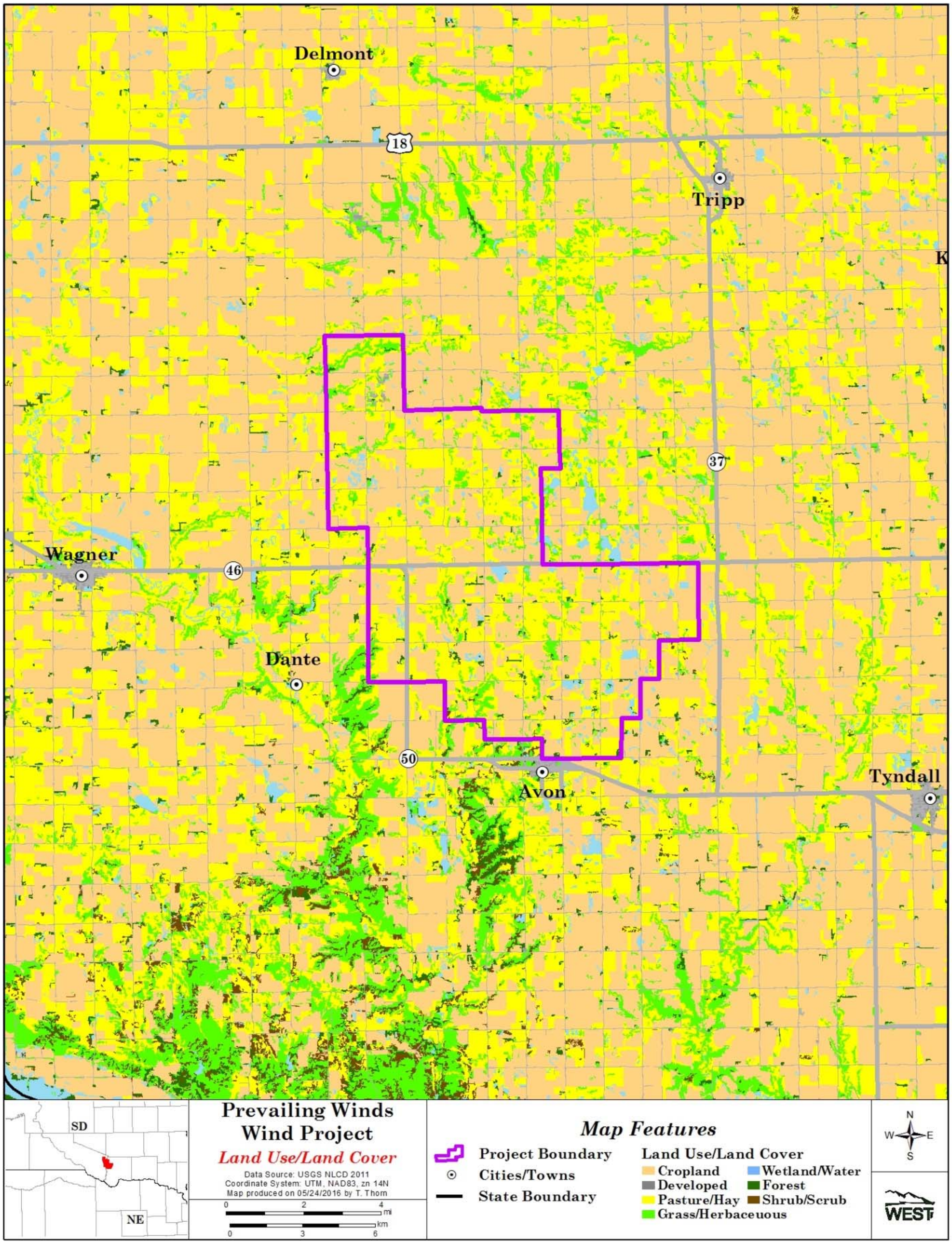

Figure 3. Land Use/Land Cover within and around the Prevailing Winds Wind Project.

Sensitive Habitats

Concern has been expressed by the USFWS and SDGFP on all projects in South Dakota regarding the potential impacts development of the Project may have on grasslands, particularly native grasslands and the impact to nesting grassland birds in these areas. Only 6.7% of the Project's area is categorized as grassland/herbaceous, but another 37.6% of the Project is considered pasture/hay, which may also contain native grass (Table 1, Figure 3; USGS NLCD 2011). If construction takes place within these areas, it is possible that some grassland and/or shrub-dependent species could be displaced (see the Breeding Bird section for more discussion on displacement). Project development is being planned to minimize impacts and disturbances to grasslands.

Wetlands and Riparian Areas

Based on National Wetland Inventory (NWI) data (USFWS NWI 2009), there are approximately 1,305.8 ac (528.8 ha) of wetlands within the Project. Freshwater emergent (77.5%) accounted for the majority of the wetlands, followed by freshwater ponds (14.7%), lakes (4.4%), and freshwater forested/shrub wetlands (3.4%; Table 2, Figure 4). A portion of Dry Choteau Creek is found within the Project. WEST did not conduct wetland delineations for the Project.

Table 2. National Wetland Inventory (NWI) wetlands present within the Prevailing Winds Wind Project (USFWS NWI 2009).

Wetland Type	Project Acres	Percent Total
Freshwater Emergent Wetland	1,011.7	77.5
Freshwater Pond	192.3	14.7
Lake	57.4	4.4
Freshwater Forested/Shrub Wetland	44.4	3.4
Total	**1,305.8**	**100**

Data Source: USFWS NWI 2009

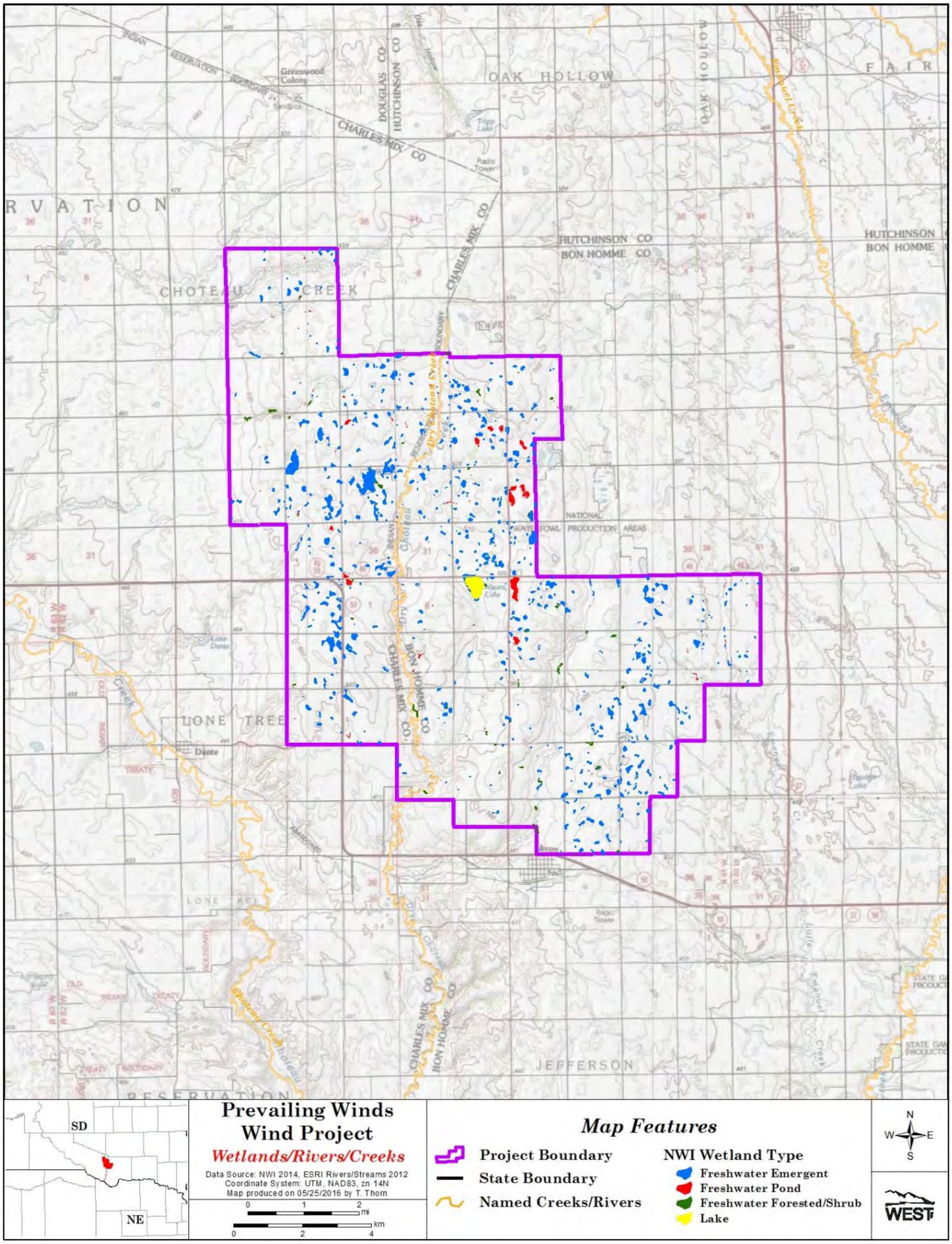

Figure 4. NWI wetlands within and around the Prevailing Winds Wind Project.

Wildlife

Wildlife species associated with croplands, grasslands, and shrublands are the most common types of species observed and expected to occur at the Project. A list of the species observed during the site visit on February 25 and 26, 2015, is provided in Table 3.

Table 3. Wildlife species observed at the Prevailing Winds Wind Project during a site visit on February 25 and 26, 2015.

Common Name	Scientific Name
Birds	
American robin	*Turdus migratorius*
European starling	*Sturnus vulgaris*
horned lark	*Eremophila alpestris*
mallard	*Anas platyrhynchos*
northern flicker	*Colaptes auratus*
red-tailed hawk	*Buteo jamaicensis*
ring-necked pheasant	*Phasianus colchicus*
rock pigeon	*Columba livia*
unidentified raptor	

Federally-Listed Species

A total of seven animal species listed as threatened, endangered, or proposed under the federal Endangered Species Act (ESA 1973) have been documented in Bonne Homme and/or Charles Mix counties (USFWS 2015c). Based on habitats found within the proposed Project during desktop evaluation and the site visit, five of the animal species have the potential to occur in the Project during some portion of the year, including: federally-endangered interior least tern (*Sterna antillarum athalassos*; USFWS 2013c) and whooping crane (*Grus americana*; USFWS 2013), federally-threatened piping plover (*Charadrius melodus*; USFWS 2013e), red knot (*Calidris canutus rufa*; USFWS 2014), and northern long-eared bat (*Myotis septentrionalis*; USFWS 2013b, 2015b). These species are discussed in further detail below.

The pallid sturgeon (*Scaphirhynchus albus*) is a federally-endangered fish species (USFWS 2013d) listed in all counties that are contiguous with the Missouri River. It can be found in the Missouri River, which is located approximately six miles (9.66 kilometers [km]) south of the Project. The federally-endangered Topeka shiner (*Notropis topeka*; USFWS 2013f) is a small minnow native to the streams of the prairie and prefers small, quiet streams with clean gravel or sand substrates and vegetated banks (Shearer 2003). The shiner can be found in the James River and tributaries, which is about 17.1 miles (27.5 km) to the northeast of the Project (SDGFP 2015c). It is unlikely that the pallid sturgeon or Topeka shiner will be affected by the development of and operations associated with a wind facility.

No federally-listed species were observed during the site visit.

Table 4. Species listed as endangered, threatened, or proposed endangered by the US Fish and Wildlife Service (USFWS) with the potential to occur within the Prevailing Winds Wind Project.

Common Name	Scientific Name	Federal Status
Birds		
interior least tern	*Sterna antillarum athalassos*	E
whooping crane	*Grus americana*	E
piping plover	*Charadrius melodus*	T
red knot	*Calidris canutus rufa*	T
Bats		
northern long-eared bat	*Myotis septentrionalis*	PE

E=endangered, T=threatened, PE=Proposed Endangered
Data Source: USFWS 2015c

Interior Least Tern

The interior least tern is a federally-endangered species (USFWS 2013c) that nests along sand and gravel bars within wide, unobstructed river channels and open flats along shorelines of lakes and reservoirs (TPWD 2015). Unnatural water fluctuations, permanent flooding or vegetation coverage of nesting habitat caused by water management may contribute to nest failure. No suitable nesting habitat was identified within the Project, but the least interior tern could potentially nest along the Missouri River or pass through the Project during spring and fall migration.

Whooping Crane

The federally-endangered whooping crane (USFWS 2013) migrates from its breeding grounds in Wood Buffalo National Park, Canada, to its wintering areas in Aransas National Wildlife Refuge, Texas (USFWS 2009). Threats to wild cranes include habitat destruction, chemical spills in its wintering habitat, lead poisoning, collisions with manmade objects such as fences and power lines, disease (e.g., avian cholera and parasites), and shooting (USFWS 2015d). Cranes typically utilize shallow wetlands and marshes, the edges and sandbars of shallow rivers, and agricultural fields near a water source during migration (USFWS 2015d). Thus, suitable whooping crane stopover habitat includes shallow livestock ponds surrounded by agricultural and grassland parcels and freshwater emergent wetlands. Some of these habitat features are scattered throughout the Project. Additionally, the Project is located 2.2 miles (3.5 km) east of the eastern edge of the 220-mile (354.1-km) wide whooping crane migration corridor, based on national flyway information (Figure 6), but it is within the 95% migration corridor when considered specific to South Dakota. Therefore, it is possible but unlikely that whooping cranes could occur in the Project.

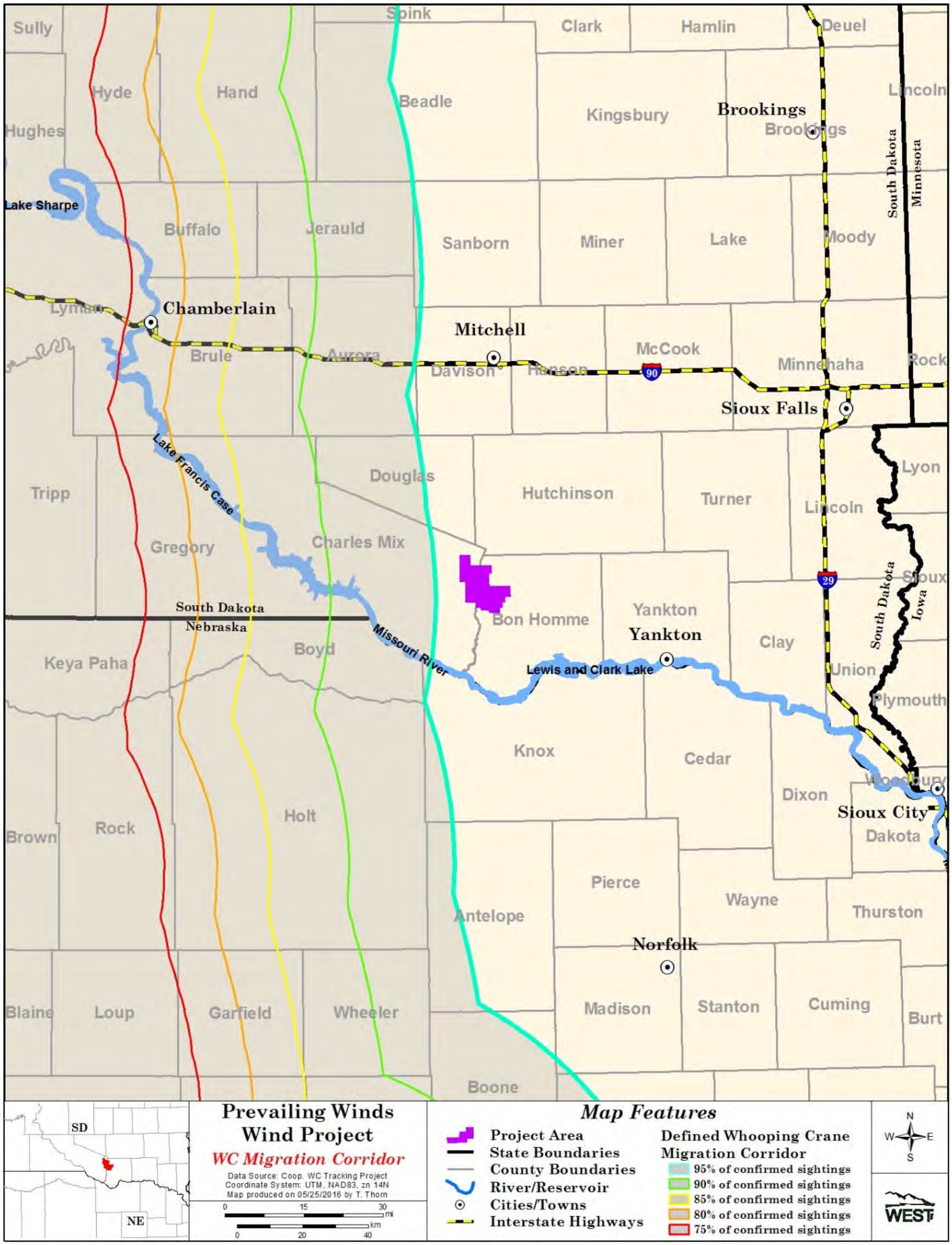

Figure 5. Designated Whooping Crane migration corridor.

Piping Plover

The federally-threatened piping plover (USFWS 2013e) is typically found on sandy beaches, mudflats, and exposed areas around wetlands and lakes. Suitable nesting habitat includes barren sandbars in large river systems and on alkaline lake shores (USFWS 2002). Piping plover populations are threatened by habitat loss due to vegetation encroachment, shoreline development, anthropogenic and animal disturbances, and water management activities, such as dam construction and channelization. Designated critical habitat for the piping plover is located approximately six miles (9.66 km) south of the Project along the Missouri River (Figure 6; USFWS 2015a). No suitable piping plover habitat was observed in the Project during the site visit. Piping plovers are unlikely to breed within the Project, but the species could potentially migrate through the Project.

Red Knot

The federally-threatened red knot is a medium-sized shorebird that migrates from its breeding grounds in Canada’s Arctic region to multiple wintering grounds, including the Northeast Gulf of Mexico, the Southeastern US, northern Brazil, and Tierra del Fuego at the southern point of South America. During the breeding season, red knots are typically found in sparsely vegetated, dry tundra areas (Harrington 2001, All About Birds 2015b). Outside of the breeding season, red knots are usually found along intertidal, marine beaches (Harrington 2001). During migration, some red knots can be found flying over inland areas, but these cases are rare (Sibley 2003). The red knot population is threatened by habitat loss in migration and wintering areas, reduction of quality and quantity of food resources, asynchronies in timing throughout its breeding and migration range, and high predation on the breeding grounds every three to four years (USFWS 2014). No suitable red knot habitat was observed in the Project during the site visit. Red knots are unlikely to breed within the Project, but the species could potentially migrate through the Project.

Figure 6. Designated Piping Plover critical habitat.

Northern Long-Eared Bat

The northern long-eared bat was listed as a threatened species on April 2, 2015. It is found in the U.S. from Maine to North Carolina on the Atlantic Coast, westward to eastern Oklahoma and north through part of South Dakota (BCI 2015a). The Project is on the western fringe of the estimated range for the species (BCI 2015a). This species hibernates in caves and abandoned mines during winter (BCI 2015a); however, no known hibernacula exist in the Project, with the closes being in the Black Hills on the South Dakota/Wyoming border. During the summer, individuals may roost alone or in small colonies beneath exfoliating bark, or in cavities or crevices of both live and dead trees (BCI 2015a). Some of these habitat features are located in the Project. Although white-nose syndrome (WNS; caused by the fungus *Pseudogymnoascus destructans*) is the primary threat to northern long-eared bat populations (USFWS 2015b), there is concern about the impacts of wind facilities on bat species. However, under the final 4(d) rule published on January 14, 2016 (USFWS 2016), it was determined that wind-energy development has not led to significant declines in this species, nor is there evidence that regulating the incidental take that is occurring would meaningfully change the conservation or recovery potential of the species in the face of WNS. In other words, take of the species by a wind facility is not currently considered a violation of Section 9 of the ESA. This will change if the species becomes listed as endangered or if the 4(d) rule is rescinded. Bat acoustic surveys will be conducted to determine presence/absence of the northern long-eared bat within the Project.

State-Listed Species

Twelve species listed by the SDGFP as state-threatened or endangered have records of occurrence in the two counties in which the Project is located (SDGFP 2015b, Table 5). Eight of these species (northern river otter [*Lontra Canadensis*], false map turtle [*Graptemys pseudogeographica*], banded killifish [*Fundulus diaphanus*], blacknose shiner [*Notropis heterolepis*], northern redbelly dace [*Chrosomus eos*], pallid sturgeon [*Scaphihynchus albus*], sicklefin chub [*Macrhybopsis meeki*], and sturgeon chub [*Macrhybopsis gelida*]) are only associated with the Missouri River and would not occur in the Project. State-threatened or endangered species that have potential to occur in the Project are described below. Interior least tern, whooping crane, and piping plover, are both state- and federally-listed species and are only described in the Federally-Listed Species section of this report.

Table 5. Species listed as endangered or threatened by the state of South Dakota that occur in Bon Homme and Charles Mix Counties.

Common Name	*Scientific Name*	Status
Mammals		
northern river otter	*Lontra canadensis*	State-Threatened
Birds		
bald eagle	*Haliaeetus leucocephalus*	State-Threatened
interior least tern	*Sterna antillarum athalassos*	Federally-Endangered, State-Endangered
piping plover	*Charadrius melodus*	Federally-Threatened, State-Threatened
whooping crane	*Grus americana*	Federally-Endangered, State-Endangered
Reptiles		
false map turtle	*Graptemys pseudogeographica*	State-Threatened

Table 5. Species listed as endangered or threatened by the state of South Dakota that occur in Bon Homme and Charles Mix Counties.

Common Name	*Scientific Name*	Status
Fish		
banded killifish	*Fundulus diaphanus*	State-Endangered
blacknose shiner	*Notropis heterolepis*	State-Endangered
northern redbelly dace	*Chrosomus eos*	State-Threatened
pallid sturgeon	*Scaphihynchus albus*	Federally-Endangered, State-Endangered
sicklefin chub	*Macrhybopsis meeki*	State-Endangered
sturgeon chub	*Macrhybopsis gelida*	State-Threatened

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is listed as a state-threatened species in South Dakota (SDGFP 2015b). Bald eagles are typically found near rivers, marshes, lakes, reservoirs, and coasts (Buehler 2000). They usually nest in forested places close to water bodies, avoiding heavily developed areas when possible (Buehler 2000). According to the SDGFP, and confirmed during the site visit, a bald eagle nest is located approximately 1.8 miles (2.9 km) north of the Project. Additionally, bald eagles could move through/over the Project year-round.

Grassland-Dependent Bird Species of Concern

Displacement of grassland nesting birds is often one of the primary concerns of wildlife agencies in regards to the siting of wind facilities in and near grasslands. Recent research has focused on the potential displacement of grassland passerines at wind energy facilities, and some uncertainty currently exists over the effects of wind energy facilities on the breeding success of these birds. In Minnesota, researchers found that breeding passerine density on Conservation Reserve Program (CRP) grasslands was reduced in the immediate vicinity of wind turbines (Leddy et al. 1999), but changes in density at broader scales was not detected (Johnson et al. 2000a). Erickson et al. (2004) documented a decrease in density of some native grassland passerines, such as grasshopper sparrow (*Ammodramus savannarum*), near wind turbines in Washington; however, it was not determined if the decreased density of grassland birds after the project was operating was the result of behavioral disturbance or habitat loss. Piorkowski (2006) conducted a displacement study at a wind energy facility in Oklahoma where, of the grassland species present in the wind resource area, only the western meadowlark (*Sturnella neglecta*) showed significantly lower densities near wind turbines. Piorkowski (2006) suggested that habitat characteristics were more important to determining passerine breeding densities than the presence of wind turbines. Shaffer and Buhl (2015) documented avoidance by grasshopper sparrows out to 300 m (984 ft) over time at wind projects in North and South Dakota.

Sharp-tailed grouse (*Tympanuchus phasianellus*), greater prairie chicken (*T. cupido*), Nelson’s sparrow (*Ammodramus nelsoni*), Le Conte’s sparrow (*A. leconteii*), chestnut-collared longspur (*Calcarius ornatus*), and bobolink (*Dolichonyx oryzivorus*) are dependent on grassland habitat, particularly large blocks of grassland (Johnson and Igl 2001), and may occur in the Project (Jennings et al. 2005). These species could be susceptible to adverse effects of grassland habitat fragmentation if this type of disturbance occurs as a result of facility construction. The Project has previously been subjected to fragmentation, primarily due to the conversion of grassland to areas of cultivated cropland (Table 1, Figure 4). Grassland areas that may support grassland birds are located throughout the Project, especially in the western portion of the Project where the landscape is more bisected by ravines. Facility development in the areas with less native grasslands, wetlands, and shrublands would likely have lower direct (e.g., habitat loss) and indirect impacts (e.g., displacement) to wildlife and plants, particularly to grassland-nesting bird species and native grassland plants. Limiting the footprint of any proposed developments, as well as utilizing previously developed roads and/or transmission corridors, could help to minimize any additional fragmentation.

Prairie Grouse

Sharp-tailed grouse and greater prairie chicken are prairie-obligate species that require relatively undisturbed or natural tallgrass prairie. These species tolerate some agricultural land interspersed with prairie, but both species generally become less numerous as the amount of agricultural land increases. Sharp-tailed grouse and greater prairie chicken are lekking species; leks are typically located on knolls or gentle rises. Male grouse and chickens may begin defending their territories on lekking grounds in late February, with peak hen attendance in early April.

Depending on findings during point counts and ultimately turbine placement, agencies may recommend that surveys for grouse species be conducted pre- and post-construction, with lek surveys for prairie grouse species conducted in the spring.

Birds of Conservation Concern

Although not protected under the ESA (1973), numerous bird species have been identified by the USFWS as Birds of Conservation Concern (BCC; USFWS 2008). These are “species, subspecies, and populations of migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973” (USFWS 2008). The Project lies within Bird Conservation Region (BCR) 11 (Prairie Potholes), a landscape dotted with many small depressional wetlands called potholes.

Twenty-seven bird species are listed as BCC within BCR 11 (USFWS 2008, Appendix B), many of which would have potential for occurrence within the Project (Jennings et al. 2005). Four diurnal raptors are among the BCC within BCR 11 with potential to occur in the Project (bald eagle [also a state-threatened species], Swainson’s hawk [*Buteo swainsoni*], and peregrine falcon. In addition to bald eagles, golden eagles (*Aquila chrysaetos*) have the potential to occur in the Project during some time of the year. The bald and golden eagles are protected by the Migratory Bird Treaty Act (MBTA 1918) and the Bald and Golden Eagle Protection Act (BGEPA 1940). Swainson’s hawks may breed in the Project, and peregrine falcons potentially migrate through the Project (Jennings et al. 2005). The remaining BCC species are a mix of shorebirds, waterbirds, owls, woodpeckers, and passerines, all of which likely have some potential for impacts from wind energy development (Appendix B).

Raptors

Species Likely to Occur in the Area

The following diurnal raptor and vulture species could potentially breed in or near the Project: American kestrel (*Falco sparverius*), bald eagle, golden eagle, Cooper's hawk (*Accipiter cooperii*), northern harrier (*Circus cyaneus*), red-tailed hawk (*Buteo jamaicensis*), ferruginous hawk (*B. regalis*), Swainson's hawk, broad-winged hawk (*B. platypterus*), peregrine falcon, osprey, and turkey vulture (*Cathartes aura;* Jennings et al. 2005). Owls with the potential to breed in or near the Project include barn owl (*Tyto alba*), burrowing owl (*Athene cunicularia*), eastern screech owl (*Otus asio*), long-eared owl (*Asio otus*), short-eared owl (*Asio flammeus*) and great horned owl (*Bubo virginianus;* Jennings et al. 2005).

Diurnal raptor species that may also occur within the Project outside of the breeding season (migration, winter, or post-breeding dispersal), include northern goshawk (*Accipiter gentilis*), Cooper's hawk, golden eagle, bald eagle, merlin (*Falco columbarius*), peregrine falcon, prairie falcon (*F. mexicanus*), gyrfalcon (*F. rusticolus*), red-tailed hawk, rough-legged hawk (*Buteo lagopus*), and sharp-shinned hawk (*Accipiter striatus*; Jennings et al. 2005). Owls that may occur outside of the breeding season include the eastern screech owl, great horned owl, northern saw-whet owl (*Aegolius acadicus*), long-eared owl, and short-eared owl (Jennings et al. 2005). During the site visit, four red-tailed hawk observations and two unidentified diurnal raptor observations were recorded at the Project (Table 3).

Potential for Raptor Migration in the Area

Several factors influence the migratory pathways of raptors, the most significant of which is geography. Two geographical features often used by raptors during migration are ridgelines and the shorelines of large bodies of water (Liguori 2005). Updrafts formed as the wind hits the ridges, and thermals, created over land and not water, make for energy-efficient travel over long distances (Liguori 2005). It is for this reason that raptors sometimes follow corridors or pathways, for example, along prominent ridges with defined edges, during migration.

It is likely that raptors migrate through the proposed Project in a broad front pattern with some potential for more localized use of ridge on the southwestern portion of the Project (Figure 3). Trees, shrubs, and water impoundments may provide some stopover habitat for migrating raptors; which are scattered throughout the Project and region (Figure 4).

Potential Raptor Nesting Habitat

During the site visit, small scattered woodlots, wooded farmsteads, shelter belts, and wooded draws and hillsides were observed that could provide raptor nesting habitat for species such as red-tailed hawk and Swainson's hawk. Grassland areas could provide nesting habitats for ground-nesting raptors and owls, such as the northern harrier and burrowing owl.

One known bald eagle nest is located approximately 1.8 mile north of the Project area. Additional surveys should focus on determining how or if eagles from this nest utilize the Project.

Potential Prey

Areas with colonial rodents or other prey species, such as rabbits and other birds, tend to attract foraging raptors. Small mammal colonies could potentially exist within the Project, but were not visible from public roads. No colonial rodents were observed during the site visit in February 2015. It is difficult to assess potential prey densities during a short-term site visit, and prey densities can fluctuate dramatically based on habitat and climatic factors. If roost sites and food resources are available, it is likely that raptors will use the area. However, it is not likely that raptors will use the area to a greater degree than the surrounding areas with similar habitat and resources.

Does the Topography of the Site Increase the Potential for Raptor Use?

At wind energy facilities located on prominent ridges with defined edges (e.g., rims of canyons, steep slopes), raptors often fly along the rim edges, using updrafts to maintain altitude while hunting, migrating or soaring (Johnson et al. 2000b, Hoover and Morrison 2005). Topography in the Project is relatively flat in the east but with slightly steep slopes in the western half of the Project Area (Figure 3). In addition, the Missouri River is approximately 6 miles south of the Project, which could increase overall raptor migration potential in the region.

Bird Migration

Although many species of passerines migrate at night and may collide with tall human-made structures, few large mortality events at wind energy facilities in North America have been documented on the same scale as those seen at communication towers (National Wind Coordinating Collaborative [NWCC] 2004). Large numbers of passerines have collided with lighted communication towers and buildings when foggy conditions occur at night during spring or fall migration. Birds appear to become confused by the lights during foggy or low cloud ceiling conditions, flying circles around lighted structures until they become exhausted or collide with the structure (Erickson et al. 2001). Most collisions at communication towers are attributed to the guy wires on these structures, which wind turbines do not have. Additionally, the large mortality events observed at communication towers have occurred at structures greater than 500 ft (152 m) in height (Erickson et al. 2001), likely because most small birds migrate at elevations of 500 to 1,000 ft (152.4 to 304.8 m) above the ground (USFWS 1998), which is higher than most modern turbines. Migrating passerines are likely more at risk of turbine collision when ascending and descending from stopover habitat, locations where migrating birds stop to rest or refuel, or during foggy conditions when they fly lower and may become confused by lights.

It is likely that birds such as passerines, raptors, and waterfowl may migrate through the proposed Project. Wetlands, woodlots, and grasslands, which are found throughout the Project, may provide stopover habitat for migrants or individuals during post-breeding dispersal. The combination of wetlands, ponds, lakes, and grasslands found in the Project may be attractive to a broader suite of bird species than when only one of these land cover types occurs. Harvested crop fields could also serve as feeding areas for migrating and wintering cranes and waterfowl.

These land cover types are found throughout the region, so use by these species should not be more concentrated in the Project than compared to adjacent areas.

Breeding Birds

Important Bird Areas

The National Audubon Society (Audubon) lists Important Bird Areas (IBAs) that are sites providing essential habitat for one or more species of birds (Audubon 2015). There are no Audubon IBAs or The Nature Conservancy (TNC) protected lands (USGS 2012) within the Project; however, there are two IBAs located south of the Project. The Missouri National Recreational River IBA is approximately 10 miles (16.1 km) south of the Project, while the Lower Missouri River Channel IBA is about 10.5 miles (16.9 km) south of the Project (Audubon 2013).

USGS Breeding Bird Survey

Two U.S. Geological Survey Breeding Bird Survey (BBS) routes are located in the vicinity of the Project (Figure 7; USGS 2013). The west end of the Tripp BBS route is approximately 13 miles (20.9 km) northeast of the northeast corner of the Project. The north end of the Sparta BBS route is south of the Missouri River, approximately 21.5 miles (34.6 km) southeast of the southeast corner of the Project. Each BBS route is about 25 miles (40.2 km) long, and all birds seen or heard are tallied for a 3-minute period every half-mile (0.8 km) along the route (USGS 1998).

A total of 70 bird species were recorded along the Tripp BBS route from 2011 to 2014 (Pardieck et al. 2014) and three of these species are listed as USFWS BCC (USFWS 2008; Appendix B). All three of these species were observed each year, from 2011-2014: red-headed woodpecker (*Melanerpes erythrocephalus*), grasshopper sparrow, and dickcissel (*Spiza americana*; Pardieck et al. 2014). In 2014, 915 individual bird observations of 56 species were made on the Tripp Route (Pardieck et al. 2014). The most abundant birds observed were the western meadowlark, brown-headed cowbird (*Molothrus ater*), mourning dove (*Zenaida macroura*), barn swallow (*Hirundo rustica*), and dickcissel. No federally- or state-listed threatened or endangered species have been recorded at the Tripp BBS route.

A total of 65 bird species have been recorded along the Sparta BBS route in 2011 and 2013 (Pardieck et al. 2014) and four of these species are listed as USFWS BCC (USFWS 2008; Appendix B). All four of these species were observed in 2011 and 2013: red-headed woodpecker, grasshopper sparrow, dickcissel, and upland sandpiper (*Bartramia longicauda*; Pardieck et al. 2014). In 2013, 1,392 individual bird observations of 56 species were made on the Sparta Route (Pardieck et al. 2014). The most abundant birds observed were the dickcissel, red-winged blackbird (*Agelaius phoeniceus*), common grackle (*Quiscalus quiscula*), mourning dove, and western meadowlark. No federally- or state-listed threatened or endangered species have been recorded at the Sparta BBS route.

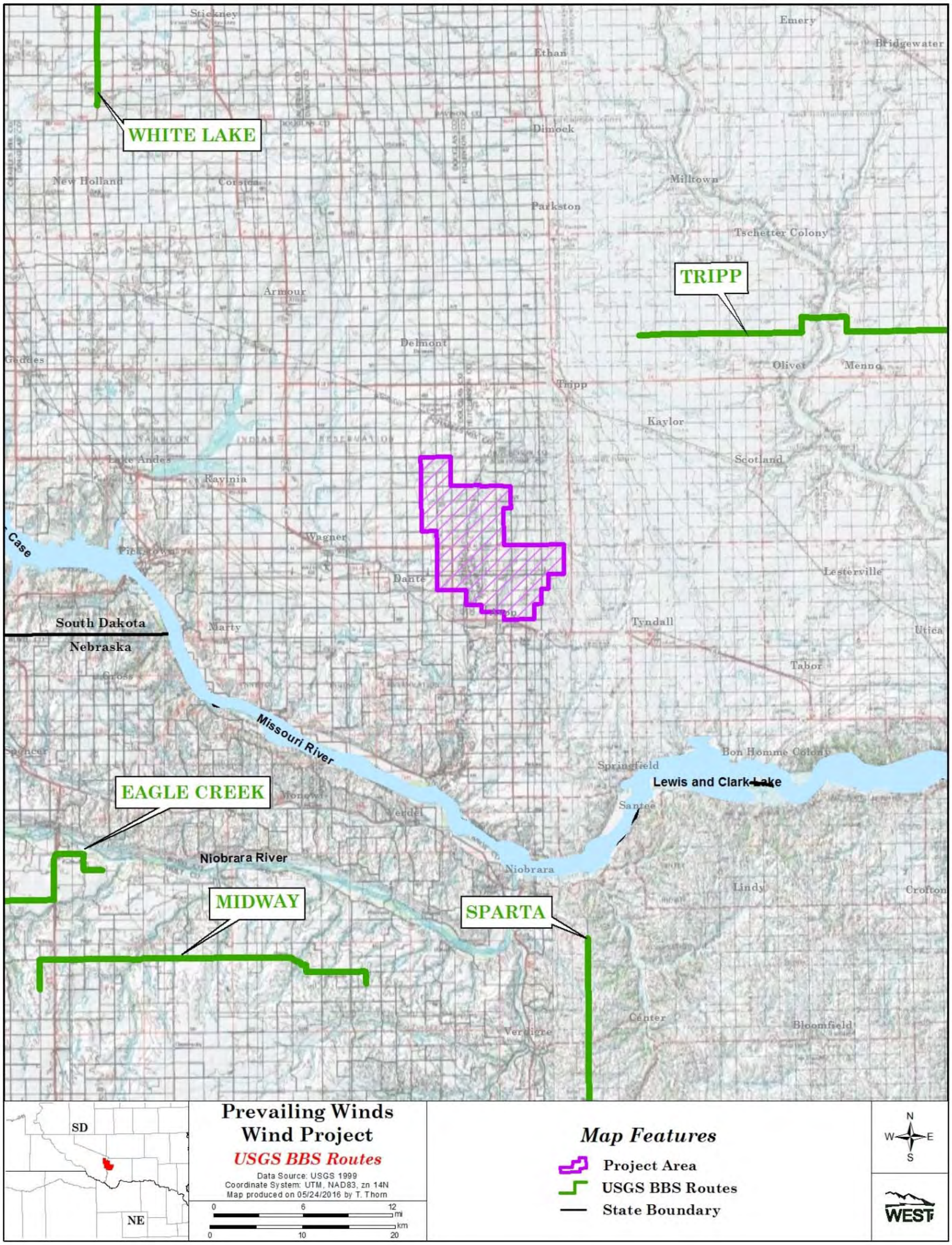

Figure 7. USGS Breeding Bird Survey routes.

Bats

At least 19 bat species have been documented as fatalities at wind energy facilities throughout the U.S. (Table 6). Up to 13 species of bats occur in South Dakota, and seven of these species are likely residents and/or migrants in the Project (Table 7, based on range maps [International Union for Conservation of Nature (IUCN) 2014]), including big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), northern long-eared bat (*Myotis septentrionalis*), little brown bat (*M. lucifugus*), and western small-footed bat (*M. ciliolabrum*).

Table 6. Summary of bat fatalities (by species) from wind energy facilities in North America.

Common Name	Scientific Name	# Fatalities[1]	% Composition
hoary bat[2]	*Lasiurus cinereus*	5,027	36.5
eastern red bat[2]	*Lasiurus borealis*	3,179	23.1
silver-haired bat[2]	*Lasionycteris noctivagans*	2,500	18.2
little brown bat[2]	*Myotis lucifugus*	1,121	8.1
tricolored bat	*Perimyotis subflavus*	625	4.5
big brown bat[2]	*Eptesicus fuscus*	517	3.8
Mexican free-tailed bat	*Tadarida brasiliensis*	377	2.7
unidentified bat		325	2.4
unidentified myotis	*Myotis* spp.	32	0.2
northern long-eared bat[2]	*Myotis septentrionalis*	15	0.1
Seminole bat	*Lasiurus seminolus*	12	0.1
western red bat	*Lasiurus blossevillii*	9	0.1
big free-tailed bat	*Nyctinomops macrotis*	5	<0.1
evening bat	*Nycticeius humeralis*	5	<0.1
western yellow bat	*Lasiurus xanthinus*	3	<0.1
eastern small-footed bat	*Myotis leibii*	2	<0.1
Indiana bat	*Myotis sodalis*	2	<0.1
pocketed free-tailed bat	*Nyctinomops femorosacca*	2	<0.1
canyon bat	*Pipistrellus hesperus*	1	<0.1
cave bat	*Myotis velifer*	1	<0.1
long-legged bat	*Myotis volans*	1	<0.1
unidentified free-tailed bat		1	<0.1
unidentified Lasiurus bat	*Lasiurus* spp.	1	<0.1
Total	**19 species***	**13,763**	**100**

[1] These are raw data and are not corrected for searcher efficiency or scavenging.

[2] Potential resident or migrant in the BWP (BCI 2003).

Cumulative fatalities and species from data compiled by Western EcoSystems Technology, Inc. from publicly available fatality documents (listed in Appendix C). Indiana bat fatalities are reported by USFWS (2010, 2011c). Three additional Indiana bat fatalities (USFWS 2011b, 2012a, 2012c) are not included in this total.

* One incidental long-eared bat (*Myotis evotis*) was recorded at Tehachapi, California (Anderson et al. 2004), but is not included in the total fatalities. An additional 677 bat fatalities (evening bat, eastern red bat, hoary bat, tricolored bat, Mexican free-tailed bat, and unidentified bat) have been found in Texas (Hale and Karsten 2010), but the number of fatalities by species was not reported.

Canyon bat formerly known as western pipistrelle (*Pipistrellus hesperus*), and tricolored bat formerly known as eastern pipistrelle (*Pipistrellus subflavus*; BCI 2015b, 2015c).

Table 7. Bat species, based on International Union for Conservation of Nature (IUCN) 2014 range maps, with the potential to occur in the Prevailing Winds Wind Project.

Species	Scientific Name	State Status/ Federal Status	Habitat	Likelihood of Occurrence
northern long-eared bat	*Myotis septentrionalis*	PE[a]/FT	Associated with forests; chooses maternity roosts in buildings, under loose bark, and in the cavities of trees; caves and underground mines are their choice sites for hibernating. On western edge of range.	Unlikely
big brown bat	*Eptesicus fuscus*		Common in most habitats, abundant in deciduous forests and suburban areas with agriculture; maternity colonies beneath bark, tree cavities, buildings, barns, and bridges.	Likely
silver-haired bat	*Lasionycteris noctivagans*	S4[b]	Common bat in forested areas, particularly old growth; maternity colonies in tree cavities or hollows; hibernates in forests or cliff faces.	Likely
eastern red bat	*Lasiurus borealis*		Abundant tree bat; roosts in trees; solitary.	Likely
hoary bat	*Lasiurus cinereus*		Usually not found in man-made structures; roosts in trees; very wide-spread.	Likely
western small-footed bat	*Myotis ciliolabrum*		Found in mesic conifer forest, also riparian woodland; roosts in rock outcrops, clay banks, loose bark, buildings, bridges, caves, and mines.	Probable
little brown bat	*Myotis lucifugus*		Commonly forages over water; roosts in attics, barns, bridges, snags, and loose bark; hibernacula in caves and mines.	Probable

[a] Status from SDGFP 2015
PE = Proposed Endangered
[b] Status from SDGFP 2014
S4 = Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. Cause for long term concern.
FT = Federally Endangered

Potential roosting habitat (i.e. trees and buildings) exists within the Project as there are many abandoned structures scattered throughout the area. No caves or mines have been reported in the literature, and none were observed by a WEST biologist during the site visit. However, karst formations (characterized by sinkholes, caves, and underground drainage systems; Encyclopædia Britannica 2015) have been found within the Project according to the USGS National Atlas of the US (Tobin and Weary 2004).

Bats generally forage over water and open spaces, such as agricultural fields, grasslands, streams, and wetlands/ponds. Bats may prey on insects that are likely to concentrate over water in wetlands and streams, thus these types of areas found in the Project are most likely to attract foraging bats. Bats may forage over the entire Project, although the extent of use is not known.

Bat casualties have been reported from most wind energy faculties where post-construction fatality data are publicly available. Reported estimates of bat mortality at wind energy facilities have ranged from 0.01 – 47.5 fatalities per turbine per year (0.9 – 43.2 bats per MW per year) in the US, with an average of 3.4 per turbine or 4.6 per MW (NWCC 2004). The majority of the bat casualties at wind energy facilities to date are migratory species that undertake long migrations between summer roosts and wintering areas. The species most commonly found as fatalities at wind energy facilities include hoary bats, silver-haired bats, and eastern red bats (Johnson 2005). The highest numbers of bat fatalities found at wind energy facilities to date have occurred in eastern North America on ridge tops dominated by deciduous forest (NWCC 2004). However, Gruver et al. (2009), BHE Environmental (2010, 2011), Barclay et al. (2007), and Jain (2005) reported relatively high fatality rates from facilities in Wisconsin, Iowa, and Canada that were located in grassland and agricultural habitats. Unlike the eastern US wind energy facilities that reported higher bat fatality rates, the Wisconsin, Alberta, and Iowa facilities are in open grasslands and crop fields.

Construction of the proposed Project will likely result in the mortality of some bats. The magnitude of these fatalities and the degree to which bat species will be affected is difficult to determine, but they should be within the average range of bat mortalities found throughout the US based on general vegetation and landscape characteristics.

CONCLUSIONS

A summary of the potential for wildlife and habitat conflicts in the proposed wind energy facility development area is presented in Table 8.

Table 8. A summary of the potential (VH=Very High, H=High, M=Medium, and L=Low) for wildlife and habitat conflicts at the Prevailing Winds Wind Project.

Issue	VH	H	M	L	Notes
Potential for raptor nest sites			✓		Few tree rows and woodlots exist on the Project; few very small forests
Concentrated raptor flight potential			✓		The slightly steep slopes in the western half of the Project Area increases the potential for raptor use along the north/south ridges in the western half of the Project Area.
Potential for migratory pathway		✓			The Project is close to the Missouri River, thereby increasing potential for migratory pathway. The Project is close to the whooping crane migration corridor.
Potential for raptor prey species			✓		Suitable habitat for small mammals exists.
Potential for protected species to occur		✓			Protected species may occur in the area (e.g., bald eagle); There is concern about grassland fragmentation for prairie grouse and grassland birds.
Potential for State Issues		✓			Protection of native grasslands; likely state species issues exist as well
Uniqueness of habitat at wind energy facility			✓		Grasslands and shrublands found in the region. Displacement of grassland animals and plants may occur.
Potential for rare plants to occur			✓		Grasslands make up a moderate proportion of the Project; there is some likelihood that rare plants are present in grasslands that occur in the Project Area but impacts would depend on turbine siting.
Potential for use by bats			✓		The Project has scattered trees, buildings, and wetlands.

Seven animal species listed as federally-endangered, threatened, or proposed species have the potential to occur in Bon Homme and/or Charles Mix counties. These include the federally-endangered pallid sturgeon, Topeka shiner, interior least tern, and whooping crane; federally-threatened piping plover, red knot; and northern long-eared bat. Five of the seven species (interior least tern, whooping crane, piping plover, red knot, and northern long-eared bat) could potentially occur in the Project.

WEST conducted a preliminary review of the birds listed as threatened or endangered by the state of South Dakota and found four bird species with the potential to occur in or near the Project: interior least tern, whooping crane, piping plover, and bald eagle. Additionally, the northern long-eared bat is listed as a Species of Concern by SDGFP.

In general, native land cover, including wetlands, in most of the Project is not unique in the region, but their presence raises concerns regarding loss of native prairie. As the land cover is not unique to the region, these characteristics are not likely to attract or concentrate bird or bat species compared to surrounding areas. Habitat suitability may decrease for grassland birds in terms of increased habitat fragmentation and behavior modification (avoidance) if areas of intact grassland are impacted by construction. Greater prairie chickens and sharp-tailed grouse are of particular conservation interest to SDGFP, may be found in the Project, and may be susceptible to grassland fragmentation. Large areas of intact grassland should be avoided to minimize impacts to grassland dependent species.

Several raptor and vulture species could potentially breed in or near the Project as well as occur outside of the breeding season (migration, winter, or post-breeding dispersal Small scattered woodlots, wooded farmsteads, shelter belts, and wooded draws and hillsides are present in the Project that could provide raptor nesting habitat for species such as the red-tailed hawk, bald eagle, and Swainson's hawk. Grassland areas could provide nesting habitats for ground-nesting raptors, such as the northern harrier and burrowing owl.

Deciduous trees and buildings in the Project may provide potential roosting habitat and hibernacula for bats. Research to date on the impacts of wind energy facilities on bats has shown that species that conduct long distance migrations usually make up the vast majority of bat fatalities at wind energy facilities. Additionally, the timing of bat fatalities at wind energy facilities indicates that most bats are killed by turbines during the migration season (Johnson 2005, Arnett et al. 2008). Relatively few bat fatalities have been recorded at most wind energy facilities during spring or summer, although bat use at wind energy facilities has been recorded during those seasons. Risk of collision of resident bat species that may breed near wind energy facilities is not known. The Project is on the western edge of the range for the federally-threatened northern long-eared bat. Because it is possible that northern long-eared bat occupies the Project given the amount of trees, ponds, and lakes in the Project, acoustic surveys to investigate presence/absence are recommended. Further the northern long-eared bat is currently covered by a 4(d) rule determination as it pertains to wind energy development. An additional six bat species are likely to occur in the Project, including big brown bat, eastern red bat, hoary bat, silver-haired bat, little brown bat, and western small-footed bat (IUCN 2014).

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Appendix A. Photographs of the Prevailing Winds Wind Project

Photo 1. Typical cropland habitat with a small woodlot in the distance in the Prevailing Winds Wind Project.

Photo 2. Typical hay field and wooded draw within the Prevailing Winds Wind Project.

Photo 3. Typical wooded hillside in southwestern portion of the Prevailing Winds Wind Project.

Photo 4. Typical grassland with scattered deciduous trees in the Prevailing Winds Wind Project.

Photo 5. Typical grassland in the Prevailing Winds Wind Project.

Photo 6. Mixed species grassland in the Prevailing Winds Wind Project.

Appendix B. Bird Species of Conservation Concern within the Prairie Potholes Region

Appendix B. US Fish and Wildlife Service (USFWS) Birds Conservation Concern (BCC) within the Bird Conservation Region (BCR) 11 (Prairie Potholes) and their presence/absence in the vicinity of the Prevailing Winds Wind Project (Pardieck et al. 2014, USFWS 2008).

Species	Recorded from 2011 to 2014 on Tripp Breeding Bird Survey Route?	Recorded in 2011 and 2013 on Sparta Breeding Bird Survey Route?
horned grebe	No	No
American bittern	No	No
least bittern	No	No
bald eagle	No	No
Swainson's hawk	No	No
peregrine falcon	No	No
yellow rail	No	No
mountain plover	No	No
solitary sandpiper	No	No
upland sandpiper	No	Yes
long-billed curlew	No	No
Hudsonian godwit	No	No
marbled godwit	No	No
buff-breasted sandpiper	No	No
short-billed dowitcher	No	No
black tern	No	No
black-billed cuckoo	No	No
short-eared owl	No	No
red-headed woodpecker	Yes	Yes
Sprague's pipit	No	No
grasshopper sparrow	Yes	Yes
Baird's sparrow	No	No
Nelson's sharp-tailed sparrow	No	No
McCown's longspur	No	No
Smith's longspur	No	No
chestnut-collared longspur	No	No
dickcissel	Yes	Yes

Appendix C. Summary of Publicly Available Reports from North American Wind Energy Facilities that have Reported Bat Fatalities

Appendix C. Summary of publicly available reports from North American wind energy facilities that have reported bat fatalities (Table 6).

Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Alite, CA (09-10)	Chatfield et al. 2010	Klondike IIIa (Phase II), OR (08-10)	Gritski et al. 2011
Alta Wind I, CA (11-12)	Chatfield et al. 2012	Leaning Juniper, OR (06-08)	Gritski et al. 2008
Alta Wind II-V, CA (11-12)	Chatfield et al. 2012	Lempster, NH (09)	Tidhar et al. 2010
Barton I & II, IA (10-11)	Derby et al. 2011a	Lempster, NH (10)	Tidhar et al. 2011
Barton Chapel, TX (09-10)	WEST 2011	Linden Ranch, WA (10-11)	Enz and Bay 2011
Beech Ridge, WV (12)	Tidhar et al. 2013b	Locust Ridge, PA (Phase II; 09)	Arnett et al. 2011
Big Horn, WA (06-07)	Kronner et al. 2008	Locust Ridge, PA (Phase II; 10)	Arnett et al. 2011
Big Smile, OK (12-13)	Derby et al. 2013b	Madison, NY (01-02)	Kerlinger 2002b
Biglow Canyon, OR (Phase I; 08)	Jeffrey et al. 2009a	Maple Ridge, NY (06)	Jain et al. 2007
Biglow Canyon, OR (Phase I; 09)	Enk et al. 2010	Maple Ridge, NY (07)	Jain et al. 2009a
Biglow Canyon, OR (Phase II; 09-10)	Enk et al. 2011a	Maple Ridge, NY (07-08)	Jain et al. 2009d
Biglow Canyon, OR (Phase II; 10-11)	Enk et al. 2012b	Maple Ridge, NY (12)	Tidhar et al. 2013a
Biglow Canyon, OR (Phase III; 10-11)	Enk et al. 2012a	Marengo I, WA (09-10)	URS Corporation 2010b
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Marengo II, WA (09-10)	URS Corporation 2010c
Buena Vista, CA (08-09)	Insignia Environmental 2009	Mars Hill, ME (07)	Stantec 2008
Buffalo Gap I, TX (06)	Tierney 2007	Mars Hill, ME (08)	Stantec 2009a
Buffalo Gap II, TX (07-08)	Tierney 2009	McBride, Alb (04)	Brown and Hamilton 2004
Buffalo Mountain, TN (00-03)	Nicholson et al. 2005	Melancthon, Ont (Phase I; 07)	Stantec Ltd. 2008
Buffalo Mountain, TN (05)	Fiedler et al. 2007	Meyersdale, PA (04)	Arnett et al. 2005
Buffalo Ridge, MN (94-95)	Osborn et al. 1996, 2000	Moraine II, MN (09)	Derby et al. 2010d
Buffalo Ridge, MN (00)	Krenz and McMillan 2000	Mount Storm, WV (Fall 08)	Young et al. 2009b
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000a	Mount Storm, WV (09)	Young et al. 2009a, 2010b
Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000a	Mount Storm, WV (10)	Young et al. 2010a, 2011b
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000a	Mount Storm, WV (11)	Young et al. 2011a, 2012b
Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000a	Mountaineer, WV (03)	Kerns and Kerlinger 2004
Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000a	Mountaineer, WV (04)	Arnett et al. 2005
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000a	Munnsville, NY (08)	Stantec 2009b
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Nine Canyon, WA (02-03)	Erickson et al. 2003
Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004	Noble Altona, NY (10)	Jain et al. 2011b
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000a	Noble Bliss, NY (08)	Jain et al.2009e
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	Noble Bliss, NY (09)	Jain et al. 2010a
Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004	Noble Bliss/Wethersfield, NY (11)	Kerlinger et al. 2011
Buffalo Ridge I, SD (09-10)	Derby et al. 2010b	Noble Chateaugay, NY (10)	Jain et al. 2011c
Buffalo Ridge II, SD (11-12)	Derby et al. 2012a	Noble Clinton, NY (08)	Jain et al. 2009c
Casselman, PA (08)	Arnett et al. 2009	Noble Clinton, NY (09)	Jain et al. 2010b
Casselman, PA (09)	Arnett et al. 2010	Noble Ellenburg, NY (08)	Jain et al. 2009b
Castle River, Alb. (01)	Brown and Hamilton 2006a	Noble Ellenburg, NY (09)	Jain et al. 2010c
Castle River, Alb. (02)	Brown and Hamilton 2006a	Noble Wethersfield, NY (10)	Jain et al. 2011a
Cedar Ridge, WI (09)	BHE Environmental 2010	NPPD Ainsworth, NE (06)	Derby et al. 2007
Cedar Ridge, WI (10)	BHE Environmental 2011	Oklahoma Wind Energy Center, OK (04; 05)	Piorkowski and O'Connell 2010
Cohocton/Dutch Hill, NY (09)	Stantec 2010	Pebble Springs, OR (09-10)	Gritski and Kronner 2010b
Cohocton/Dutch Hills, NY (10)	Stantec 2011	PGC site 6-3 (07)	Capouillez and Librandi-Mumma 2008, Librandi-Mumma and Capouillez 2011
Combine Hills, OR (Phase I; 04-05)	Young et al. 2006	Pine Tree, CA (09-10)	BioResource Consultants 2010
Combine Hills, OR (11)	Enz et al. 2012	Pioneer Prairie I, IA (Phase II; 11-12)	Chodachek et al. 2012
Condon, OR	Fishman Ecological Services 2003	PrairieWinds ND1 (Minot), ND (10)	Derby et al. 2011c
Crescent Ridge, IL (05-06)	Kerlinger et al. 2007	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012c
Criterion, MD (11)	Young et al. 2012a	PrairieWinds SD1 (Crow Lake), SD (11-12)	Derby et al. 2012d
Criterion, MD (12)	Young et al. 2013	PrairieWinds SD1 (Crow Lake), SD (12-13)	Derby et al. 2013a
Crystal Lake II, IA (09)	Derby et al. 2010a	Prince Wind Farm, Ont (06)	Natural Resource Solutions 2008
Diablo Winds, CA (05-07)	WEST 2006, 2008	Prince Wind Farm, Ont (07)	Natural Resource Solutions 2009
Dillon, CA (08-09)	Chatfield et al. 2009	Prince Wind Farm, Ont (08)	Natural Resource Solutions 2009
Dry Lake I, AZ (09-10)	Thompson et al. 2011	Red Canyon, TX (06-07)	Miller 2008
Dry Lake II, AZ (11-12)	Thompson and Bay 2012	Red Hills, OK (12-13)	Derby et al. 2013c
Elkhorn, OR (08)	Jeffrey et a. 2009b	Ripley, Ont (08)	Jacques Whitford 2009
Elkhorn, OR (10)	Enk et al. 2011b	Ripley, Ont (08-09)	Golder Associates 2010
Elm Creek, MN (09-10)	Derby et al. 2010c	Rugby, ND (10-11)	Derby et al. 2011b
Elm Creek II, MN (11-12)	Derby et al. 2012b	Searsburg, VT (97)	Kerlinger 2002a

Appendix C. Summary of publicly available reports from North American wind energy facilities that have reported bat fatalities (Table 6).

Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003	Shiloh I, CA (06-09)	Kerlinger et al. 2009
Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003	Shiloh II, CA (09-10)	Kerlinger et al. 2010
Foote Creek Rim, WY (Phase I; 01-02)	Young et al. 2003	SMUD Solano, CA (04-05)	Erickson and Sharp 2005
Forward Energy Center, WI (08-10)	Grodsky and Drake 2011	Stateline, OR/WA (01-02)	Erickson et al. 2004
Fowler I, IN (09)	Johnson et al. 2010a	Stateline, OR/WA (03)	Erickson et al. 2004
Fowler III, IN (09)	Johnson et al. 2010b	Stateline, OR/WA (06)	Erickson et al. 2007
Fowler I, II, III, IN (10)	Good et al. 2011	Steel Winds I, NY (07)	Grehan 2008
Fowler I, II, III, IN (11)	Good et al. 2012	Stetson Mountain I, ME (09)	Stantec 2009c
Fowler I, II, III, IN (12)	Good et al. 2013	Stetson Mountain I, ME (11)	Normandeau Associates 2011
Goodnoe, WA (09-10)	URS Corporation 2010a	Stetson Mountain II, ME (10)	Normandeau Associates 2010
Grand Ridge I, IL (09-10)	Derby et al. 2010g	Summerview, Alb (05-06)	Brown and Hamilton 2006b
Harrow, Ont (10)	Natural Resource Solutions 2011	Summerview, Alb (06; 07)	Baerwald 2008
Harvest Wind, WA (10-12)	Downes and Gritski 2012a	Top of Iowa, IA (03)	Jain 2005
Hay Canyon, OR (09-10)	Gritski and Kronner 2010a	Top of Iowa, IA (04)	Jain 2005
High Sheldon, NY (10)	Tidhar et al. 2012a	Tuolumne (Windy Point I), WA (09-10)	Enz and Bay 2010
High Sheldon, NY (11)	Tidhar et al. 2012b	Vansycle, OR (99)	Erickson et al. 2000
High Winds, CA (03-04)	Kerlinger et al. 2006	Vantage, WA (10-11)	Ventus Environmental Solutions 2012
High Winds, CA (04-05)	Kerlinger et al. 2006	Wessington Springs, SD (09)	Derby et al. 2010f
Hopkins Ridge, WA (06)	Young et al. 2007	Wessington Springs, SD (10)	Derby et al. 2011d
Hopkins Ridge, WA (08)	Young et al. 2009c	White Creek, WA (07-11)	Downes and Gritski 2012b
Jersey Atlantic, NJ (08)	NJAS 2008a, 2008b, 2009	Wild Horse, WA (07)	Erickson et al. 2008
Judith Gap, MT (06-07)	TRC 2008	Windy Flats, WA (10-11)	Enz et al. 2011
Judith Gap, MT (09)	Poulton and Erickson 2010	Winnebago, IA (09-10)	Derby et al. 2010e
Kewaunee County, WI (99-01)	Howe et al. 2002	Wolfe Island, Ont (May-June 09)	Stantec Ltd. 2010a
Kibby, ME (11)	Stantec 2012	Wolfe Island, Ont (July-December 09)	Stantec Ltd. 2010b
Kittitas Valley, WA (11-12)	Stantec Consulting 2012	Wolfe Island, Ont (January-June 10)	Stantec Ltd. 2011a
Klondike, OR (02-03)	Johnson et al. 2003	Wolfe Island, Ont (July-December 10)	Stantec Ltd. 2011b
Klondike II, OR (05-06)	NWC and WEST 2007	Wolfe Island, Ont (January-June 11)	Stantec Ltd. 2011c
Klondike III (Phase I), OR (07-09)	Gritski et al. 2010	Wolfe Island, Ont (July-December 11)	Stantec Ltd. 2012

Two Indiana bat fatalities are reported by USFWS (2010, 2011c), among other reports. Three additional Indiana bat fatalities have been reported (2011b, 2012a, 2012c), but are not included in this list of public reports. One incidental long-eared bat (*Myotis evotis*) was recorded at Tehachapi, California (Anderson et al. 2004), but is not included in this list of public reports. Additional bat fatalities (evening bat, eastern red bat, hoary bat, tri-colored bat, Mexican free-tailed bat, and unidentified bat) have been found in Texas (Hale and Karsten 2010), but the number of fatalities by species was not reported.

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P.O. Box 321
Chokio, Minnesota 56221

RE: Prevailing Winds Raptor Nest Survey

Dear Mr. Jurgens,

As part of agency approved baseline survey efforts, one aerial raptor nest survey was conducted by a biologist from Western EcoSystems Technology, Inc. (WEST) on April 21, 2016, at the Prevailing Winds Wind Energy Project (Project) near Avon, South Dakota. Surveys were completed from the air in a helicopter before trees had leaves and when most raptors would be actively tending to a nest or incubating eggs. Aerial surveys were conducted in accordance with the guidance provided in the U.S. Fish and Wildlife Service Inventory and Monitoring Protocols[1]. Raptors are defined here as kites, accipiters, buteos, harriers, eagles, falcons, and owls. Surveys focused on locating large, stick nest structures in suitable raptor nesting substrate (trees, cliffs, etc.) within the proposed Project and 10-mi buffer. All raptor nests were recorded within the Project boundary with only eagle or potential eagle nests located out to the 10-mi buffer.

Known historic eagle nests locations were surveyed for nest status and condition as well as a survey for new or unknown nest locations. In general, all potential eagle and raptor nest habitat was surveyed by flying meandering transects at speeds of 60 - 75 miles per hour (mph) throughout the proposed Project area and associated 10-mi buffer. To the greatest extent possible, care was taken to minimize disturbance to raptors at nest sites during surveys.

All potential and confirmed raptor nests detected during surveys, regardless of their activity status, were assigned a unique identification number and their locations were recorded using a hand-held Global Positioning System (GPS). Data on raptor species, nest type, nest status, nest condition, and substrate, were recorded at each nest location to the extent possible. To determine the status of a nest, the biologist relied on clues that included behavior of adults and presence of eggs, young, or whitewash. Unoccupied raptor nests, including old nests or nests that could become suitable for raptors, were

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[1] Pagel, J.E., D.M. Whittington, and G.T. Allen. 2010. Interim Golden Eagle Technical Guidance: Inventory and Monitoring Protocols; and Other Recommendations in Support of Golden Eagle Management and Permit Issuance. US Fish and Wildlife Service (USFWS). February 2010. Available online at: http://steinadlerschutz.lbv.de/fileadmin/www.steinadlerschutz.de/terimGoldenEagleTechnicalGuidanceProtocols25March2010_1_.pdf

documented in order to populate a nest database to ensure that future surveys include all potentially suitable nest sites. Photographs were taken of eagle nests and potential eagle nests and are available to you upon request.

Nest status was categorized consistent with definitions in the USFWS Eagle Conservation Plan Guidance.[2] Nests were classified as occupied if any of the following were observed at the nest structure: (1) an adult in an incubating position; (2) eggs; (3) nestlings or fledglings; (4) occurrence of a pair of adults (or, sometimes sub-adults); (5) a newly constructed or refurbished stick nest in the area where territorial behavior of a raptor was observed or had been observed early in the breeding season; or (6) a recently repaired nest with fresh sticks (clean breaks) or fresh boughs on top, and/or droppings and/or molted feathers on its rim or underneath. When possible, occupied nests were further classified as active if an egg or eggs had been laid or nestlings were observed, or inactive if no eggs or chicks were present. A nest that did not meet the above criteria for “occupied” was classified as “unoccupied.

A total of 50 occupied and/or unoccupied raptor nests representing three species were documented within the Project area and associated 10-mi buffer (Figures 1 and 2, Tables 1 and 2). Excluding eagles, 44 non-eagle raptor nests were documented within the Project area (Figure 1; Table 1). The identified raptor nests were categorized as follows: three occupied great horned owl (*Bubo virginianus*) nests; 10 occupied red-tailed hawk (*Buteo jamaicensis*) nests; and 31 unknown raptor nests (two occupied; 29 unoccupied). A total of six bald eagle (*Haliaeethus leucocephalus*) nests (three occupied; three unoccupied) were documented during the survey; with three occupied bald eagle nests corresponded to known historic nests (Figure 2; Table 2).

If you have any questions or require additional information, please call me at 701-250-1756.

Sincerely,

Clayton Derby
CSO/Senior Manager

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[2] US Fish and Wildlife Service (USFWS). 2013. Eagle Conservation Plan Guidance. Module 1 - Land-Based Wind Energy. Version 2. Division of Migratory Bird Management, USFWS. April 2013. Available online at: http://www.fws.gov/migratorybirds/Eagle_Conservation_Plan_Guidance-Module%201.pdf

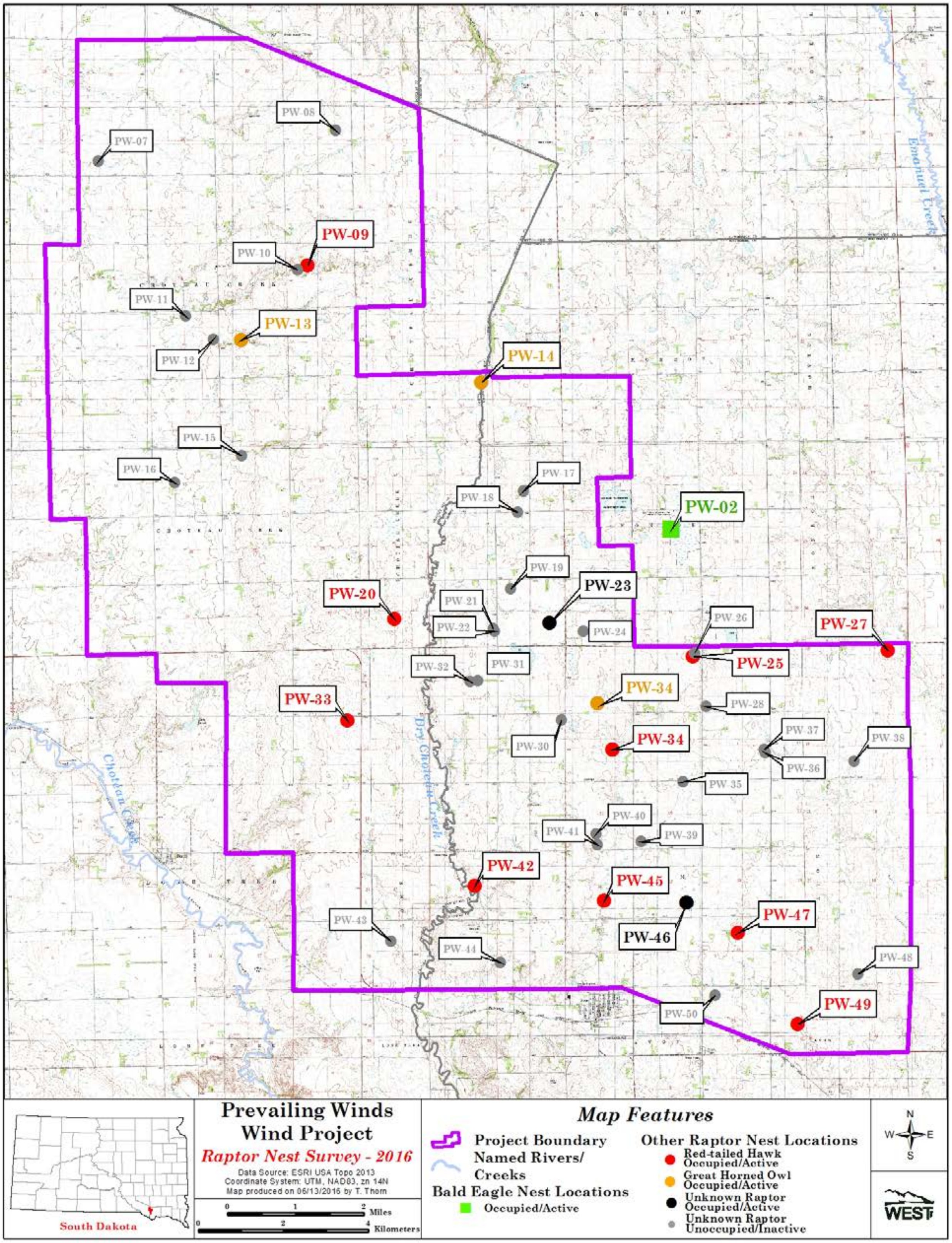

Figure 1. Locations of raptor nests (excluding eagles) recorded during the aerial survey conducted on April 21, 2016, within the Prevailing Winds Wind Energy Project, South Dakota.

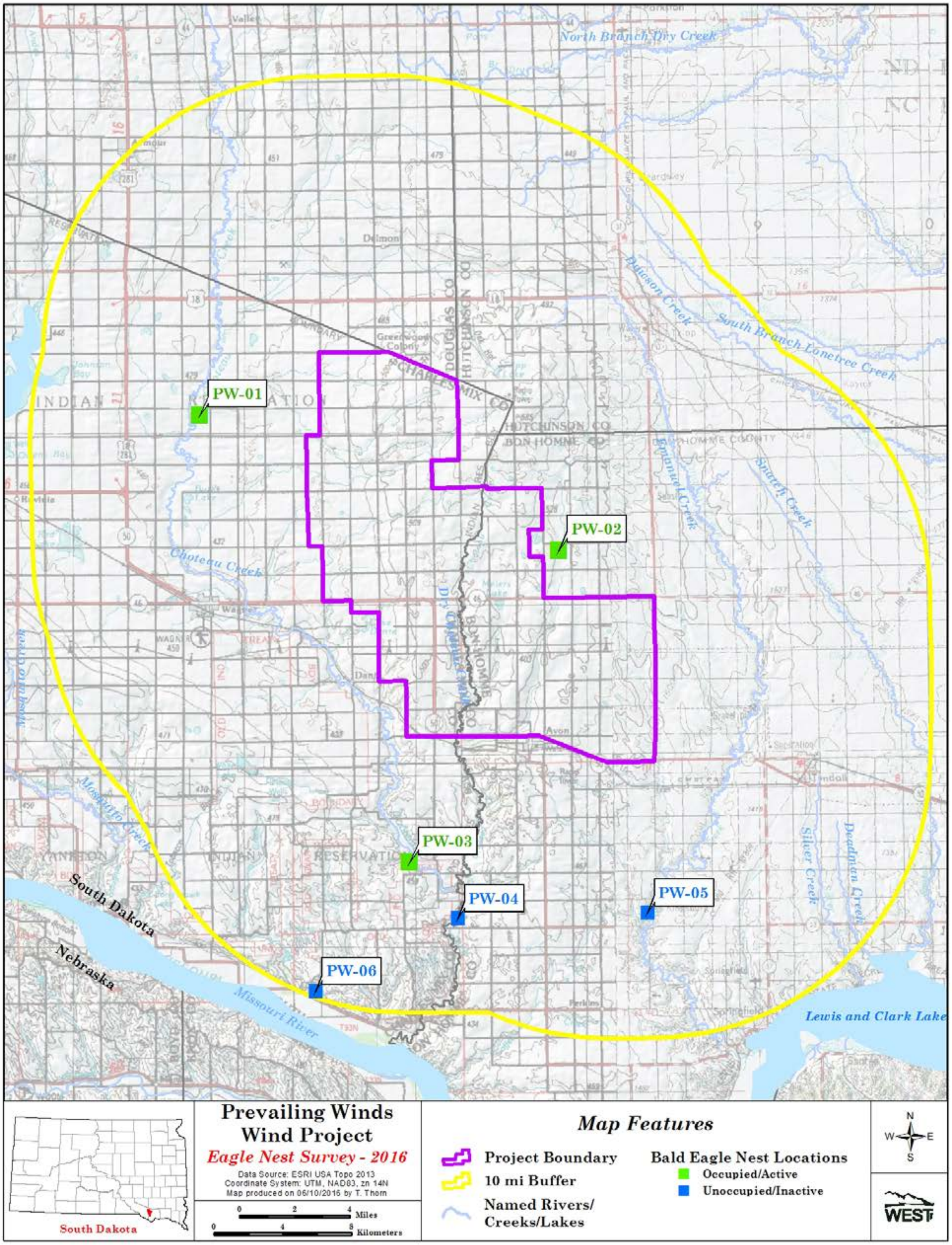

Figure 2. Locations of eagle nests recorded during the aerial survey conducted on April 21, 2016, within the Prevailing Winds Wind Energy Project area, South Dakota, and associated 10-mile buffer.

Table 1. Raptor nests (excluding eagle nests) identified during aerial surveys conducted on April 21, 2016, within the Prevailing Winds Wind Energy Project area, South Dakota. Raptor nest Unique ID (ID), locations (NAD83, Zone 14), and nest features are included.

ID	Species	Easting	Northing	Nest Type	Status at Time of Survey	Condition	Substrate
PW-07	UNKN	564811	4781827	stick/medium	unoccupied	good	tree
PW-08	UNKN	570395	4782547	stick/medium	unoccupied	fair	tree
PW-09	RTHA	569739	4779367	stick/medium	occupied	excellent	tree
PW-10	UNKN	569502	4779268	stick/medium	unoccupied	good	tree
PW-11	UNKN	566861	4778176	stick/medium	unoccupied	fair	tree
PW-12	UNKN	567520	4777624	stick/medium	unoccupied	good	tree
PW-13	GHOW	568181	4777616	stick/medium	occupied	excellent	tree
PW-14	GHOW	573826	4776621	stick/medium	occupied	excellent	tree
PW-15	UNKN	568182	4774885	stick/medium	unoccupied	fair	tree
PW-16	UNKN	566612	4774253	stick/medium	unoccupied	excellent	tree
PW-17	UNKN	574813	4774054	stick/medium	unoccupied	good	tree
PW-18	UNKN	574674	4773552	stick/medium	unoccupied	fair	tree
PW-19	UNKN	574516	4771760	stick/medium	unoccupied	good	tree
PW-20	RTHA	571792	4771048	stick/medium	occupied	excellent	tree
PW-21	UNKN	574105	4770818	stick/small	unoccupied	good	tree
PW-22	UNKN	574140	4770757	stick/small	unoccupied	good	tree
PW-23	UNKN	575444	4770951	stick/medium	occupied	excellent	tree
PW-24	UNKN	576219	4770748	stick/medium	unoccupied	fair	tree
PW-25	RTHA	578806	4770170	stick/medium	occupied	excellent	tree
PW-26	UNKN	578846	4770235	stick/medium	unoccupied	good	tree
PW-27	RTHA	583400	4770300	stick/medium	occupied	excellent	tree
PW-28	UNKN	579119	4768991	stick/medium	unoccupied	poor	tree
PW-29	GHOW	576574	4769059	stick/medium	occupied	excellent	tree
PW-30	UNKN	575714	4768671	stick/medium	unoccupied	dilapidated	tree
PW-31	UNKN	573746	4769595	stick/medium	unoccupied	poor	tree
PW-32	UNKN	573555	4769572	stick/medium	unoccupied	excellent	tree
PW-33	RTHA	570679	4768649	stick/medium	occupied	excellent	tree
PW-34	RTHA	576918	4767976	stick/medium	occupied	excellent	tree
PW-35	UNKN	578572	4767214	stick/medium	unoccupied	good	tree
PW-36	UNKN	580501	4767890	stick/medium	unoccupied	fair	tree
PW-37	UNKN	580485	4767967	stick/medium	unoccupied	fair	tree
PW-38	UNKN	582594	4767702	stick/medium	unoccupied	fair	tree
PW-39	UNKN	577594	4765802	stick/medium	unoccupied	poor	tree
PW-40	UNKN	576525	4765992	stick/medium	unoccupied	good	tree
PW-41	UNKN	576556	4765731	stick/medium	unoccupied	fair	tree
PW-42	RTHA	573679	4764757	stick/medium	occupied	excellent	tree
PW-43	UNKN	571701	4763454	stick/medium	unoccupied	fair	tree
PW-44	UNKN	574264	4762960	stick/medium	unoccupied	excellent	tree
PW-45	RTHA	576728	4764411	stick/medium	occupied	excellent	tree
PW-46	UNKN	578657	4764367	stick/medium	occupied	excellent	tree
PW-47	RTHA	579872	4763654	stick/medium	occupied	excellent	tree
PW-48	UNKN	582691	4762686	stick/medium	unoccupied	good	tree
PW-49	RTHA	581273	4761506	stick/medium	occupied	excellent	tree
PW-50	UNKN	579326	4762188	stick/medium	unoccupied	good	tree

GHOW = great-horned owl; RTHA = red-tailed hawk; UNKN = unknown.

Table 2. Bald eagle nests identified during the aerial surveys conducted on April 21, 2016, within the Prevailing Winds Wind Energy Project area, South Dakota, and associated 10-mile buffer. Raptor nest Unique ID (ID), locations (NAD83, Zone 14), and nest features are included.

ID	Species	Easting	Northing	Nest Type	Status at Time of Survey	Condition	Substrate
PW-01	BAEA*	557360	4781031	stick	occupied	excellent	tree
PW-02	BAEA*	578296	4773142	stick	occupied	excellent	tree
PW-03	BAEA*	569596	4754952	stick	occupied	excellent	tree
PW-04	BAEA	572404	4751687	stick	unoccupied	good	tree
PW-05	BAEA	583471	4752028	stick	unoccupied	excellent	tree
PW-06	BAEA	564112	4747459	stick	unoccupied	good	tree

BAEA = bald eagle; * Denotes historical BAEA nest

Avian Use Surveys for the
Prevailing Winds Wind Project
Bon Homme and Charles Mix Counties, South Dakota

Year One Final Draft Report

March 2015 – February 2016

Prepared for:

Prevailing Winds, LLC

Prepared by:

Clayton Derby, Sofia Agudelo, and Terri Thorn

Western EcoSystems Technology, Inc.
4007 State Street
Bismarck, North Dakota 58503

February 16, 2018

EXECUTIVE SUMMARY

Prevailing Winds, LLC. (Prevailing Winds), has proposed a wind energy facility in Bon Homme and Charles Mix counties, South Dakota, referred to as the Prevailing Winds Wind Project (Project). Prevailing Winds contracted Western EcoSystems Technology, Inc. (WEST) to conduct field surveys developed in coordination with the United States (US) Fish and Wildlife Service (USFWS) and South Dakota Game Fish and Parks (SDGFP). Surveys were designed to assess wildlife resources in the Project area and assess risk to special-status species by addressing the issues posed under Tier 3 of the USFWS Final Land-Based Wind Energy Guidelines. The following document contains results for the general fixed-point bird use surveys and incidental wildlife observations. A summary of all data collected is contained in the document, but the overall body of the report focuses on a smaller group of species – diurnal raptors, eagles, state/federally listed species, and South Dakota Sensitive Species (State Species of Concern [SSC] and State Species of Greatest Conservation Need [SGCN]).

The principal objectives of the fixed-point bird use surveys were to: 1) assess the relative abundance and spatial distribution of species in the Project area during all seasons, and 2) identify and assess the potential risk of adverse impacts to species or groups.

Fixed-point bird use surveys were conducted at 16 survey points from March 25, 2015 – February 21, 2016. Each survey plot was surveyed for 60 minutes (min). Every bird and/or unique bird species group observed during the first 20 min of each fixed-point bird use survey was recorded using two viewsheds: 800-meter (m; 2,625-feet [ft]) radius plot for large birds and 100-m (328-ft) radius plot for small birds, observations beyond the radius plots were excluded from analysis. Large birds included waterbirds, waterfowl, rails and coots, grebes and loons, gulls and terns, shorebirds, diurnal raptors, owls, vultures, upland game birds, doves/pigeons, large corvids (e.g., ravens, magpies, and crows), and goatsuckers. Passerines (excluding large corvids), kingfishers, swifts/hummingbirds, woodpeckers, and most cuckoos were considered small birds. During the next 40 min of the survey period, only eagles and state/federally listed species were recorded out to the 800-m radius.

A total of 271 fixed-point bird use surveys were conducted during 18 visits. During all surveys and incidental observations, no federally or state-listed species were detected. Seven bird species (great blue heron, bald eagle, Cooper's hawk, ferruginous hawk, northern goshawk, sharp-shinned hawk, and Swainson's hawk) listed as South Dakota SGCN and/or SSC were observed during fixed-point surveys and incidentally.

Diurnal raptor use at the Project was low (was 0.31 raptors/800-m plot/20-min survey), compared to other US wind facilities and comparable to other wind energy facilities in the Midwest with publicly available data. Fatality monitoring data collected at wind projects in the Midwest suggest that some collision risk exists for individual raptors, but the level of impact is not likely to cause significant adverse impacts to overall species populations.

Significant adverse impacts to overall bird populations are not anticipated at the Project based on data collected at the site, review of available literature, and results of post-construction fatality monitoring at other wind energy facilities. Further post-construction survey effort should be determined in consultation with appropriate agencies to confirm the anticipated impacts.

STUDY PARTICIPANTS

Western EcoSystems Technology

Clayton Derby	Project Manager
Carmen Boyd	Data Manager
Wendy Bruso	Technical Editing Manager
Katie Wynne	Technical Editing Coordinator
Mandy Kauffman	Data Analyst
Terri Thorn	GIS Specialist
Sofia Agudelo	Report Writer/Technical Editor
Karen Seginak	Field Technician
Brenda Jarski-Weber	Field Technician
Cathy Clayton	Field Technician

REPORT REFERENCE

Derby, C., S. Agudelo, and T. Thorn. 2018. Avian Use Surveys for the Prevailing Winds Wind Project, Bon Homme and Charles Mix Counties, South Dakota. Year One Final Report: March 2015 – February 2016. Prepared for Prevailing Winds, LLC. Prepared by Western EcoSystems Technology, Inc. (WEST), Bismarck, North Dakota. 34 pages + appendices

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

In 2015, Prevailing Winds LLC. (Prevailing Winds) contracted Western EcoSystems Technology, Inc. (WEST) to conduct field surveys in accordance with agency recommendations to quantify wildlife resources within the Prevailing Winds Wind Project (Project) in Bon Homme and Charles Mix counties, South Dakota. Year-round surveys were conducted by WEST in 2015 – 2016 to address the issues posed under Tier 3, following guidance in the United States (US) Fish and Wildlife Service (FWS) *Final Land-Based Wind Energy Guidelines* (Guidelines; USFWS 2012) and *Eagle Conservation Plan Guidance* (Guidance; USFWS 2013), within the Project area as delineated in 2015 (Figure 1).

Fixed-point bird use surveys were conducted to achieve these principal objectives: 1) assess the relative abundance and spatial distribution of species in the Project area during an entire year, with emphasis on eagles, non-eagle raptors, and state/federally listed species, and 2) identify and assess the potential risk of adverse impacts to special-status species or groups.

The following document contains results for the general fixed-point bird use surveys and incidental wildlife observations for the study period 2015 – 2016 (Year One), with focus on eagles, non-eagle diurnal raptors, state/federally listed species, and South Dakota special-status species (i.e., State Species of Greatest Conservation Need [SGCN] and State Species of Concern [SSC]). A second year of survey (Year Two) was conducted in 2016-2017 and is reported separately as the Project area changed.

STUDY AREA

The Project area used for surveys conducted in 2015 – 2016 encompassed approximately 18,139.5 hectares (ha; 44,823.7 acres [ac]) in Bon Homme and Charles Mix counties, adjacent to the town of Avon in southeastern South Dakota (Figure 1). The Project, located in a higher elevated area within the greater landscape, is characterized by a generally flat topography, with elevation ranging from 432.0 meters (m; 1,417.3 feet [ft]) – 573.7 m (1,882.2 ft; US Geological Survey [USGS] Digital Elevation Model 2017). The Project area, historically dominated by grasslands, has extensively been converted to agricultural use, with crop production and livestock grazing the primary practices (Bryce et al. 1998). Approximately 40% of the proposed Project area is cropland followed by pasture/hay land (37%); grassland/herbaceous cover represents approximately 8% of the Project area while all other land cover/land use types compose less than 5% each of the Project area (USGS National Land Cover Database 2011). As evidenced during the site visit conducted by WEST in 2015, trees and woodlands are found mainly in planted shelter belts and within draws and on hillslopes; wetlands are scattered throughout the Project area (Figure 2), with the USFWS National Wetland Inventory (NWI) indicating approximately 676 ha (1,670 ac) of wetlands (USFWS NWI 2015).

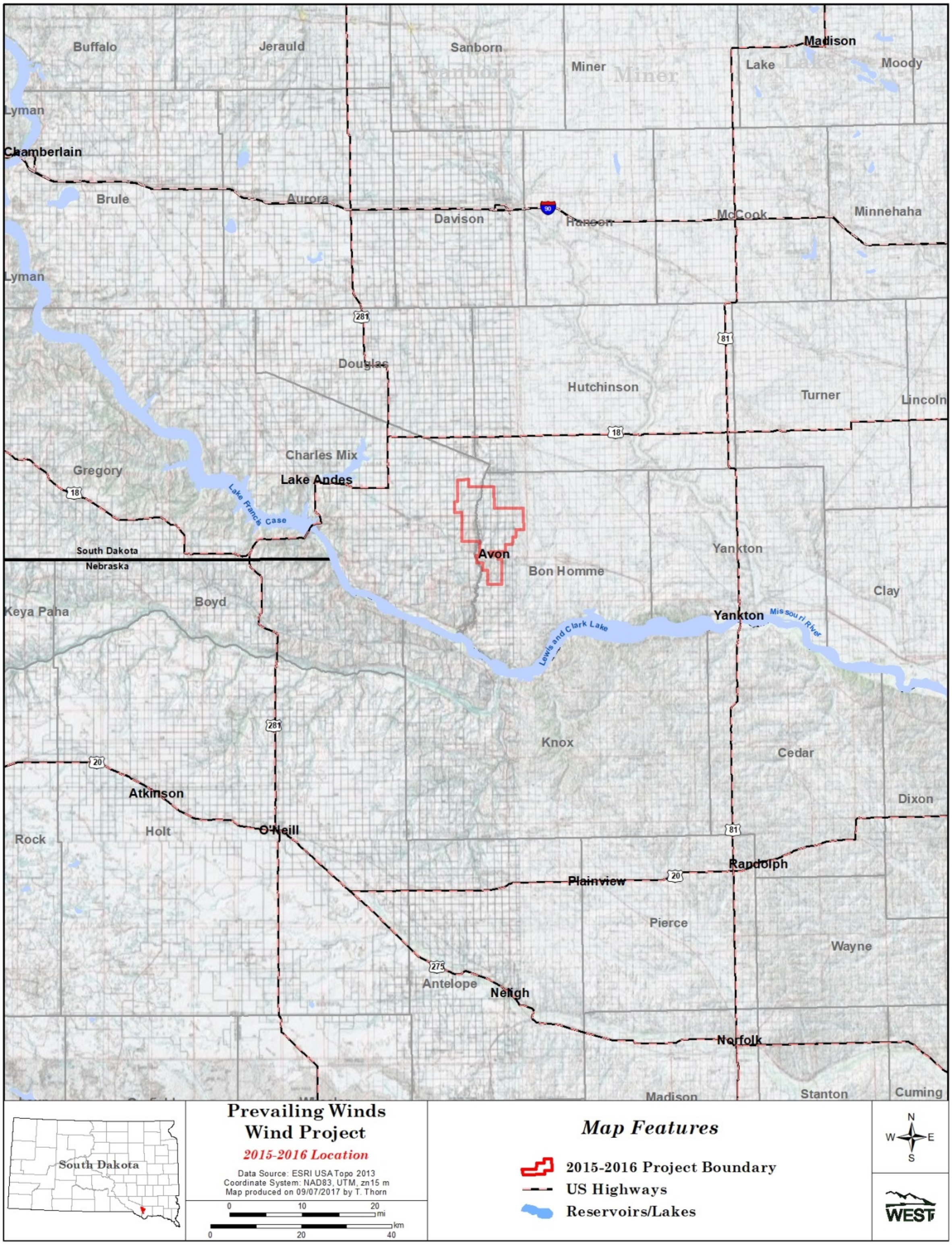

Figure 1. Location of the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, for surveys conducted in 2015 – 2016.

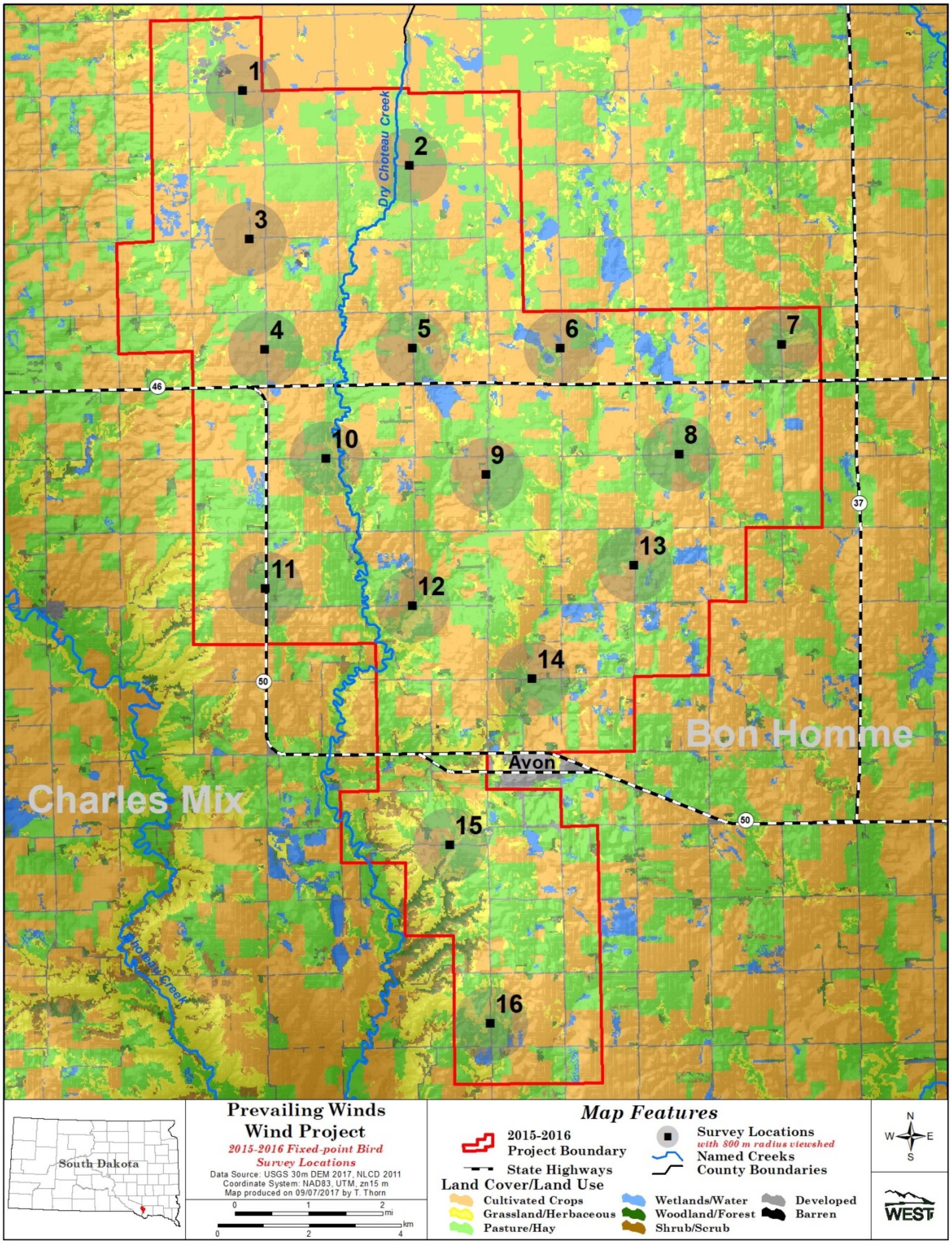

Figure 2. Land cover/Land use and location of the fixed-point plots selected for the Year One bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016 (USFWS NLCD 2011, Homer et al. 2015).

METHODS

Fixed-Point Bird Use Surveys

Fixed-point bird use surveys (variable circular plots) were conducted using methods described by Reynolds et al. (1980), to estimate the seasonal and spatial use of the study area by birds, particularly diurnal raptors (defined here as kites, accipiters, buteos, harriers, eagles, falcons, and osprey [*Pandion haliaetus*]). Methodologies employed during avian use surveys conducted at the Project are generally comparable to those used at past wind energy facilities in South Dakota.

Survey Plots

Sixteen points were selected to survey representative habitats and topography of the Project, while achieving relatively even coverage of the study area (Figure 2). Each survey plot was an 800-m (2,625-ft) radius circle centered on the point; for analysis purposes, only birds within the 800-m radius plot were considered for analysis to allow comparison to other projects that used similar analyses.

Survey Methods

Each survey plot was surveyed for 60 minutes (min). Every bird and/or unique bird species group observed during the first 20 min of each fixed-point bird use survey was recorded by a unique observation number. During the next 40 min of the survey period, only eagles and state/federally listed species and state species of concern were recorded out to the 800-m radius. In some cases, the tally of observations may represent repeated sightings of the same individual. Observations of large birds beyond the 800-m radius were recorded but were not included in statistical analyses. For small birds, observations beyond the 100-m (328-ft) radius were excluded. Large birds included waterbirds, waterfowl, rails and coots, grebes and loons, gulls and terns, shorebirds, diurnal raptors, owls, vultures, upland game birds, doves/pigeons, large corvids (e.g., ravens, magpies, and crows), and goatsuckers. Passerines (excluding large corvids), kingfishers, swifts/hummingbirds, woodpeckers, and most cuckoos were considered small birds.

The date, start and end time of the survey period, and weather information (e.g., temperature, wind speed and direction, and cloud cover) were recorded for each survey. Species or best possible identification, number of individuals, sex and age class (if possible), distance from plot center when first observed, closest distance, altitude above ground, activity (behavior), and habitat(s) were recorded for each observation. Bird behavior and habitat type were recorded based on the point of first observation. Approximate flight height and distance from plot center at first observation were recorded to the nearest 5-m (16-ft) interval. Other information collected included whether the observation was auditory only and the 10-min interval of the survey in which the detection first occurred. Locations and flight paths, if applicable, of large birds were recorded during fixed-point bird use surveys on field maps by unique observation number. Data on eagle flight paths and habitat use (i.e., distance from observer, activity, and flight height) were recorded on a per min basis; comments were made when appropriate. Incidental wildlife observations were recorded while conducting all surveys, moving between fixed-point locations, and traveling within the Project. All raptors, state and federal special-status bird species were documented.

Observation Schedule

Survey intensity (i.e., number of fixed-point circular plots and frequency of monitoring) was designed to document year-round use and behavior of birds in the Project area. Fixed-point bird use surveys were conducted approximately twice per month in the spring (March 4 – May 20) and fall (September 9 – November 28), and monthly during winter (November 29 – March 3) and summer (May 21 – September 8). Surveys were carried out during daylight hours and survey periods varied to approximately cover all daylight hours during a season. To the extent practicable, each point was surveyed roughly the same number of times.

Statistical Analysis

For analysis purposes, a visit was defined as the required length of time, in days, to survey all of the plots once within the Project area. Under certain circumstances, such as extreme weather conditions, all plots may not have been surveyed during a visit. In these cases, a visit might not have constituted a survey of all plots.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures were implemented at all stages of the study, including in the field, during data entry and analysis, and report writing. Following field surveys, observers were responsible for inspecting data forms for completeness, accuracy, and legibility. Potentially erroneous data were identified using a series of database queries. Irregular codes or data suspected as questionable were discussed with the observer and/or project manager. Errors, omissions, and/or problems identified in later stages of analysis were traced back to the raw data forms, and appropriate changes in all steps were made.

Data Compilation and Storage

A Microsoft® MSSQL database was developed to store, organize, and retrieve survey data. Data were keyed into the electronic database using a pre-defined protocol to facilitate subsequent QA/QC and data analysis. All data forms and electronic data files were retained for reference.

Fixed-Point Bird Use Surveys

Bird Diversity and Species Richness

Bird diversity was illustrated by the total number of unique species observed. Species lists and counts, with the number of observations and the number of groups, were generated by season and included all observations of birds detected, regardless of their distance from the observer. In some cases, the tally of observations may represent repeated sightings of the same individual. Species richness was calculated for each season by first averaging the total number of species observed within each plot during a visit, then averaging across plots within each visit, followed by averaging across visits within each season. Overall species richness was calculated as a weighted average of seasonal values by the number of days in each season.

Mean Use, Percent of Use, and Frequency of Occurrence

Large birds detected within the 800-m radius plot and small birds recorded within the 100-m radius plot were used to calculate mean use and frequency of occurrence. The metric used for mean bird use was number of birds per plot (100-m radius plot for small birds, 800-m radius plot for large birds) per 20-min survey. Seasonal mean use was calculated by first averaging the total number of birds seen within each plot during a visit, then averaging across plots within each visit, followed by averaging across visits within each season. Overall mean use was calculated as a weighted average of seasonal values by the number of days in each season. Percent of use was calculated as the proportion of large or small bird use that was attributable to a particular bird type or species, and frequency of occurrence was calculated as the percent of surveys in which a particular bird type or species was observed. Frequency of occurrence, calculated as the percent of surveys in which a particular bird type or species was observed, provides a relative measure of species exposure to the proposed Project.

Bird Flight Height and Behavior

Bird flight heights are important metrics to assess potential exposure. Flight height information was used to calculate the percentage of birds observed flying within the rotor-swept heights (RSH; estimated to be between 25 – 200 m [82 – 656 ft] above ground level). The flight height recorded during the initial observation was used to calculate the percentage of birds flying within the RSH and mean flight height. The percentage of birds flying within the RSH at any time was calculated using the lowest and highest flight heights recorded. Auditory only observations were excluded from flight height calculations.

Spatial Use

Spatial use of the Project area was evaluated using mean use by survey point. For each species and bird group, the number of individuals observed at each point during the 20-min survey was divided by the total number of surveys at that point.

RESULTS

Year 1 Surveys were completed within the Project area from March 25, 2015 – February 21, 2016. Summary statistics for the full suite of species observed in the Project area are presented in Appendix A. Results related to eagles, non-eagle raptors, federally/state-listed species (Endangered Species Act [ESA] 1973, South Dakota Game, Fish and Parks [SDGFP] 2016, USFWS 2017), and State non-listed special-status species (SGCN [SDGFP 2014] and SSC [SDGFP 2017]), are more thoroughly covered in the body of this report.

Fixed-Point Bird Use Surveys

Bird Diversity and Species Richness

A total of 271 fixed-point bird use surveys were conducted during 18 visits to the Project area during Year One of surveys: 63 surveys in spring, 77 in summer, 78 in fall, and 53 in winter (Table 1). Seventy-two unique bird species were observed during the entire duration (60 min) of the fixed-point bird use surveys (Table 1). Bird diversity (the number of unique species observed for entire 60-min survey) was highest during the summer (43 species), followed by fall (38), spring (36), and winter (23). Overall species richness (mean number of species/plot/20-min survey) was higher for small birds (1.64) compared to large birds (1.20), being lowest in the winter compared to all other seasons, for both large and small birds (0.96 and 0.54 species/plot/20-min survey, respectively).

Table 1. Number of visits, surveys, bird diversity (number of unique species for entire 60-minute [min] survey), and species richness (species/plot[a]/20-min survey) by season and overall, observed during the Year One fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

Season	Number of Visits	Number of Surveys Conducted	Bird Diversity	Bird Species Richness Large Birds	Bird Species Richness Small Birds
Spring	4	63	36	1.11	1.25
Summer	5	77	43	1.42	2.22
Fall	5	78	38	1.33	2.46
Winter	4	53	23	0.96	0.54
Overall	**18**	**271**	**72**	**1.20**	**1.64**

[a] 800-meter [m] radius plot for large birds and 100-m radius plot for small birds.

A total of 8,194 observations in 914 separate groups (defined as one or more individuals) were recorded during the first 20 min of the Year One of the fixed-point bird use surveys (Appendix A1). Regardless of bird size, six identified species (8.3% of all species) accounted for approximately half (52%) of all observations: Canada goose (*Branta canadensis*; 858 observations in 10 groups), European starling (*Sturnus vulgaris*; 787 observations in 13 groups), sandhill crane (*Antigone canadensis*; 735 observations in four groups), Franklin's gull (*Leucophaeus pipixcan*; 713 observations in five groups), snow goose (*Chen caerulescens*; 590 observations in four groups), and red-winged blackbird (*Agelaius phoeniceus*; 574 observations in 42 groups). All other species each accounted for less than 6% of the total observations.

Waterfowl accounted for the majority (2,145 observations within 44 groups) of large bird observations, with Canada goose being the most abundant waterfowl species; waterbirds composed 9% (736 observations) of the total bird observations, with only two waterbird species (sandhill cranes and great blue herons) being recorded during bird use surveys (Appendix A1). Passerines accounted for the majority (3,890 observations within 532 groups) of small bird observations, with European starling being the most abundant passerine species.

Eighty-nine diurnal raptor observations within 83 groups were recorded during the first 20 min of the Year One fixed-point bird use surveys conducted at the Project, representing eight unique species (Table 2; Appendix A1). Red-tailed hawk (*Buteo jamaicensis*; 55 observations in 51 groups) and northern harrier (*Circus cyaneus*; 11 observations within 11 groups) were the most commonly observed raptor species, accounting for 61.8% and 12.4% of all raptor observations, respectively. No federally (ESA 1973) or state-listed (SDGFP 2016) species were observed during Year One fixed-point bird use surveys conducted at the Project.

Table 2. Number of groups and individuals of diurnal raptors observed, regardless of distance from observer, during the first 20 minutes of the Year One fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

		Spring		Summer		Fall		Winter		Total	
Raptor Subtype/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
Accipiters		*0*	*0*	*0*	*0*	*2*	*2*	*3*	*3*	*5*	*5*
Cooper's hawk[a]	*Accipiter cooperii*	0	0	0	0	2	2	2	2	4	4
northern goshawk[a,b]	*Accipiter gentilis*	0	0	0	0	0	0	1	1	1	1
Buteos		*6*	*7*	*8*	*8*	*30*	*34*	*13*	*14*	*57*	*63*
red-tailed hawk	*Buteo jamaicensis*	6	7	8	8	28	30	9	10	51	55
rough-legged hawk	*Buteo lagopus*	0	0	0	0	0	0	3	3	3	3
Swainson's hawk[a]	*Buteo swainsoni*	0	0	0	0	2	4	0	0	2	4
unidentified buteo	*Buteo spp*	0	0	0	0	0	0	1	1	1	1
Northern Harrier		*2*	*2*	*4*	*4*	*5*	*5*	*0*	*0*	*11*	*11*
northern harrier	*Circus cyaneus*	2	2	4	4	5	5	0	0	11	11
Eagles		*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*1*	*1*
bald eagle[a,b]	*Haliaeetus leucocephalus*	0	0	0	0	0	0	1	1	1	1
Falcons		*0*	*0*	*0*	*0*	*0*	*0*	*2*	*2*	*2*	*2*
American kestrel	*Falco sparverius*	0	0	0	0	0	0	2	2	2	2
Other Raptors		*1*	*1*	*2*	*2*	*4*	*4*	*0*	*0*	*7*	*7*
unidentified hawk		1	1	1	1	2	2	0	0	4	4
unidentified raptor		0	0	1	1	2	2	0	0	3	3
Overall Diurnal Raptors		**9**	**10**	**14**	**14**	**41**	**45**	**19**	**20**	**83**	**89**

Grps = Number of groups, # Obs = Number of observations

[a.] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b.] State Species of Greatest Conservation Need (SDGFP 2014)

Mean Use, Percent of Use, and Frequency of Occurrence

Mean bird use, percent of use, and frequency of occurrence by season for all bird types and species observed during the first 20 min of surveys are shown in Appendix A2; Table 3 shows a summary of mean use and frequency of occurrence by major bird type and species of concern. The highest overall large bird use occurred during spring (30.43 birds/800-m plot/20-min survey), followed by winter (14.56), fall (8.43), and summer (2.40; Appendix A2). In general, seasonal use by large bird use was primarily driven by waterfowl use (Appendix A2). Small bird use was highest in the fall and winter (15.71 and 11.53 birds/100-m plot/20-min survey, respectively), compared to summer and spring (6.90 and 6.01, respectively); seasonal small bird use was largely driven by passerine use (Appendix A3).

Waterbird use was restricted to the migration periods (10.17 and 0.44 birds/800-m plot/20-min survey for spring and fall surveys, respectively; Table 3), with two species (sandhill crane and great blue heron [*Ardea herodias*]) comprising the totality of observations recorded during the study period (Appendix A2). Great blue heron, a SSC, was observed in spring only (0.02 birds/800-m plot/20-min survey); sandhill cranes were observed in both spring (10.16 birds/800-m plot/20-min survey) and fall (0.44). Waterbirds were observed more frequently during the spring (3.2%) compared to fall (1.2%; Table 3).

Diurnal raptor use was highest in the fall at 0.52 raptors/800-m plot/20-min survey, followed by winter (0.45), summer (0.18), and spring (0.10; Table 3). Higher raptor use during the fall was primarily due to relatively high use of the Project area by red-tailed hawks (0.36). Red-tailed hawks were observed year round and had the highest use of any other diurnal raptor species during all seasons (0.05, 0.10, and 0.21 during spring, summer, and winter, respectively); northern harrier use was observed in all seasons but winter, ranging from 0.03 – 0.06 birds/800-m plot/20-min survey; Table 3).

Use by Cooper's hawk (*Accipiter cooperii*; a SSC) was observed during fall (0.03 birds/800-m plot/20-min survey) and winter (0.06). Use by American kestrel (*Falco sparverius*), rough-legged hawk (*Buteo lagopus*), northern goshawk (*Accipiter gentilis*; SSC and SGCN), and bald eagle (*Haliaeetus leucocephalus*; SGCN), was observed exclusively during the winter during the first 20 min of fixed-point bird use surveys, ranging from 0.02 – 0.07 birds/800-m plot/20-min survey (Table 3). Bald eagle was the only eagle observed during surveys conducted at the Project (Appendix A1 and A2). Bald eagles were observed during 1.6% of winter surveys (Table 3). Diurnal raptors were observed during 37.4% of winter and 35.9% of fall surveys compared to 13.9% of summer and 7.9% of spring surveys (Table 3; Appendix A2).

Passerine use was higher during the fall and winter (15.59 and 11.48 birds/100-m plot/20-min survey, respectively), compared to the summer and spring (6.83 and 5.88, respectively; Table3). Brown-headed cowbird (*Molothrus ater*) had the highest passerine use during the spring (1.52 birds/100-m plot/20-min survey; Appendix A3); red-winged blackbird (*Agelaius phoeniceus*) had the highest use (1.54) of passerine species observed in summer; unidentified blackbirds had the highest use in the fall (5.50); and horned lark (*Eremophila alpestris*) had the highest use in the winter (7.15; Appendix A3).

Passerines were observed during 90.6% of the surveys during spring, 90.0% during summer, 65.0% during fall, and 39.6% during winter (Table 3).

Table 3. Seasonal bird mean use and frequency of occurrence for waterbirds, waterfowl, passerines, diurnal raptor species, and special-status species observed during the first 20 minutes of Year One fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

	Mean Use[1]				**Frequency of Occurrence (%)**			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Waterbirds	**10.17**	**0**	**0.44**	**0**	**3.2**	**0**	**1.2**	**0**
great blue heron[a]	0.02	0	0	0	1.7	0	0	0
Waterfowl	**8.21**	**0.18**	**4.01**	**11.66**	**22.1**	**5.5**	**5.2**	**7.8**
Diurnal Raptors	**0.10**	**0.18**	**0.52**	**0.45**	**7.9**	**13.9**	**35.9**	**37.4**
Accipiters	*0*	*0*	*0.03*	*0.1*	*0*	*0*	*2.7*	*10*
Cooper's hawk[a]	0	0	0.03	0.06	0	0	2.7	5.8
northern goshawk[a,b]	0	0	0	0.04	0	0	0	4.2
Buteos	*0.05*	*0.10*	*0.41*	*0.3*	*4.7*	*8.9*	*32*	*24.2*
red-tailed hawk	0.05	0.10	0.36	0.21	4.7	8.9	29.3	15.2
rough-legged hawk	0	0	0	0.07	0	0	0	7.4
Swainson's hawk[a]	0	0	0.06	0	0	0	2.7	0
unidentified buteo	0	0	0	0.02	0	0	0	1.6
Northern Harrier	*0.03*	*0.05*	*0.06*	*0*	*3.2*	*5*	*6.4*	*0*
northern harrier	0.03	0.05	0.06	0	3.2	5	6.4	0
Eagles	*0*	*0*	*0*	*0.02*	*0*	*0*	*0*	*1.6*
bald eagle[a,b]	0	0	0	0.02	0	0	0	1.6
Falcons	*0*	*0*	*0*	*0.03*	*0*	*0*	*0*	*3.3*
American kestrel	0	0	0	0.03	0	0	0	3.3
Other Raptors	*0.02*	*0.02*	*0.01*	*0*	*1.7*	*2.5*	*1.4*	*0*
unidentified hawk	0.02	0.01	0.01	0	1.7	1.2	1.4	0
unidentified raptor	0	0.01	0	0	0	1.2	0	0
Passerines	**5.88**	**6.83**	**15.59**	**11.48**	**90.6**	**90.0**	**65.0**	**39.6**

Note: Totals by bird type and overall might not correspond to the sum of individual species due to rounding

[1] 800-meter (m; 2,625-foot [ft]) radius plot for large birds; 100-m (328-ft) radius plot for small birds

[a] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b] State Species of Greatest Conservation Need (SDGFP 2014)

State and Federal Special-status Species Observations

No federally (ESA 1973) or state-listed (SDGFP 2016) species were observed during Year One of bird use surveys conducted in the Project area from March 25, 2015 – February 21, 2016 (Table 4). Seven non-listed special-status species were recorded during fixed-point bird use surveys and incidentally, including seven bald eagles within six groups (Table 4). The bald eagle, a State SGCN and SSC, is further protected under the Bald and Golden Eagle Protection Act (1940). Two additional South Dakota SGCN were observed, both of which were raptors (one incidental ferruginous hawk [*Buteo regalis*] observation, and one northern goshawk observation during fixed-point surveys). The other five non-listed special-status species were three SSC raptors (five Cooper's hawk observations [one incidental, four during fixed-point surveys], one incidental sharp-shinned hawk [*Accipiter striatus*] observation, and six Swainson's hawk [*Buteo swainsoni*] observations [two incidental, four during fixed-point surveys]), and one SSC waterbird (one great blue heron observation during fixed-point surveys); see Species Specific Summaries section for a detailed discussion of these species..

Table 4. Non-listed special-status species observed during fixed-point bird use surveys (FP)[a] and Incidentally (Inc.) within the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

			FP		**Inc.**		**Total**	
Species	**Scientific Name**	**Status**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
great blue heron	*Ardea herodias*	SSC	1	1	0	0	1	1
bald eagle	*Haliaeetus leucocephalus*	SGCN, SSC, BGEPA	4	4	2	3	6	7
Cooper's hawk	*Accipiter cooperii*	SSC	4	4	1	1	5	5
ferruginous hawk	*Buteo regalis*	SGCN	0	0	1	1	1	1
northern goshawk	*Accipiter gentilis*	SGCN; SSC	1	1	0	0	1	1
sharp-shinned hawk	*Accipiter striatus*	SSC	0	0	1	1	1	1
Swainson's hawk	*Buteo swainsoni*	SSC	2	4	2	2	4	6

Grps = Number of groups, # Obs = Number of observations

[a.] Within 60-minute (min) survey for large birds and 20-min survey for small birds

BGEPA = Bald and Eagle Protection Act (1940)

SGCN = State Species of Greatest Conservation Need (SDGFP 2014)

SSC = State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

Bird Flight Height and Behavior

Flight height characteristics, based on initial flight height observations (i.e., only observations with the first activity not equal to perched were included) and estimated use, were estimated for both bird types and species (Tables 5 and 6). During the 60-min fixed-point bird use surveys, 182 groups of large birds were observed flying within the 800-m radius plot, totaling 2,313 individuals. Overall, 53.8% of flying large birds were recorded within the RSH, 18.1% were below the RSH, and 28.1% were flying above the RSH for collision with turbine blades of 25 – 200 m (82 – 656 ft) above ground level. The majority (94.8%) of waterbirds observed were recorded flying above the estimated RSH, while most (96.4%) of the waterfowl observations were recorded flying within the estimated RSH (Table 5). More than half (58.2%) of flying diurnal raptors were observed below the RSH, while 41.8% were within the RSH and none were above the RSH (Table 5). Eagles and other raptors represented the highest percentage of flying diurnal raptors recorded within the RSH (66.7%), followed by buteos (51.4%).

During the first 20 min of the fixed-point bird use surveys, 218 groups of small birds were observed flying within the 100-m radius plot, totaling 1,660 individuals, mostly passerines (Table 5). Overall, 91.9% of flying small birds were recorded below the RSH (Table 5).

Table 5. Flight height (meters [m] above ground level), based on initial observation, characteristics by bird types and raptor subtypes observed during Year One of the fixed-point bird use surveys[a] conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

Bird Type/Subtype	# Groups Flying	# Obs Flying	Mean Flight Height (m)	% Obs Flying	% Within Flight Height Categories < 25 m	25 - 200 m[b]	> 200 m
Waterbirds	4	686	476.00	100	5.20	0	94.80
Waterfowl	30	1,075	45.27	67.0	3.60	96.40	0
Shorebirds	28	108	8.39	66.7	77.80	22.20	0
Gulls/Terns	4	184	43.75	25.0	33.70	66.30	0
Diurnal Raptors	50	55	29.90	66.3	58.20	41.80	0
Accipiters	3	3	10.67	60.0	100.00	0	0
Buteos	30	35	34.00	61.4	48.60	51.40	0
Northern Harrier	11	11	8.73	100	90.90	9.10	0
Eagles	3	3	43.33	75.0	33.30	66.70	0
Falcons	0	0	0.00	0	0	0	0
Unidentified Raptors	3	3	72.33	75.0	33.30	66.70	0
Vultures	8	17	68.12	89.5	5.90	94.10	0
Upland Game Birds	1	1	1.00	1.4	100.00	0	0
Doves/Pigeons	46	141	8.35	59.0	90.80	9.20	0
Large Corvids	9	44	15.78	64.7	81.80	18.20	0
Goatsuckers	2	2	25.00	66.7	0	100.00	0
Large Birds Overall	182	2,313	34.55	63.0	18.10	53.80	28.10
Passerines[c]	212	1,653	5.58	62.0	91.80	8.20	0
Woodpeckers	6	7	4.00	28.0	100.00	0	0
Small Birds Overall	218	1,660	5.54	61.7	91.90	8.10	0

Obs = Observations

[a] 800-meter (m; 2,625-foot [ft]) radius plot and 60-minute (min) survey for large birds; 100-m (328-ft) radius plot and 20 min survey for small birds

[b] The likely rotor-swept height for potential collision with a turbine blade, or 25 – 200 m (82 – 656 ft) above ground level

[c] Excluding large corvids

Three of four total bald eagles observed were first observed in flight. Based on initial observation, the majority (66.7%) of bald eagle groups observed during the full 60-min survey were observed within the RSH. No other special-status species were observed flying within the RSH at any time (Table 6).

Table 6. Flight characteristics for special-status species observed[a] during Year One of the fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

Species	# Groups Flying	Overall Mean Use	% Flying	% Flying within RSH[b] Based on Initial Observation	% Within RSH at Anytime
bald eagle	3	0.01	75.0	66.7	66.7
Cooper's hawk	3	0.02	75.0	0	0
great blue heron	1	<0.01	100	0	0
northern goshawk	0	0.01	0	0	0
Swainson's hawk	1	0.01	75.0	0	0

[a] 800-meter (m; 2,625-foot [ft]) radius plot and 60-minute (min) survey for large birds; 100-m (328-ft) radius plot and 20 min survey for small birds

[b] The likely rotor-swept height (RSH) for potential collision with a turbine blade, or 25 – 200 m (82-656 ft) above ground level

Spatial Use

For all large bird species combined, use (focused within 800 m) was highest at Point 1 (73.35 birds/20-min survey) largely due to high waterbird use at this point (38.24 birds/20-min survey); waterbirds were observed at two other points, with use ranging from 0.06 – 1.94 (Table 7). Large bird use at other points ranged from 1.41 – 34.11 birds/20-min survey. Diurnal raptors were observed at all points with use largely driven by buteos and harriers (Table 7). Waterfowl use was recorded at all but two points, ranging from 0.06 – 29.88 birds/20-min survey, and shorebird use was recorded at all points, ranging from 0.06 – 2.28 birds/20-min survey. Diurnal raptor use was highest at Point 10 (0.50 birds/20-min survey), and ranged from 0.12 – 0.47 birds/20-min survey at other points. Eagle use (for the observations included in the overall avian analysis that includes just the first 20-min of survey at each point) occurred at Point 2 only (0.06 birds/20-min survey), while falcons were only observed at Points 11 and 16 (0.06 birds/20-min survey at each point). Small bird use (focused within 100 m), was highest at Point 6 (28.28 birds/20-min survey), and ranged from 4 – 14.71 birds/20-min surveys at all other points; small bird use at all points was largely due to use by passerines (Table 7).

Table 7. Mean use recorded at each survey point during the first 20 minutes of Year One fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

	Mean Use (number of birds/20-minute survey)[a] by Survey Point															
Bird Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Waterbirds	**38.24**	**0**	**0**	**0**	**0**	**1.94**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.06**	**0**	**0**
Waterfowl	**0.12**	**11.78**	**0.12**	**0.28**	**0.12**	**28.61**	**2.00**	**29.88**	**0**	**0.17**	**0.35**	**0.06**	**0.27**	**18.06**	**0**	**1.11**
Shorebirds	**0.47**	**0.17**	**0.59**	**0.39**	**0.29**	**2.28**	**0.20**	**0.31**	**0.71**	**0.28**	**0.29**	**0.38**	**0.60**	**1.61**	**0.06**	**0.72**
Gulls/Terns	**33.65**	**0**	**0**	**0**	**3.65**	**0**	**0**	**0**	**0.06**	**0**	**0**	**1.25**	**0**	**0**	**5**	**0**
Diurnal Raptors	**0.18**	**0.22**	**0.12**	**0.39**	**0.12**	**0.22**	**0.33**	**0.38**	**0.12**	**0.50**	**0.24**	**0.38**	**0.47**	**0.33**	**0.38**	**0.39**
Accipiters	*0*	*0*	*0*	*0*	*0.06*	*0*	*0.07*	*0*	*0*	*0.06*	*0*	*0*	*0*	*0.06*	*0*	*0.06*
Buteos	*0.12*	*0.17*	*0*	*0.28*	*0*	*0.22*	*0.27*	*0.19*	*0.12*	*0.39*	*0.18*	*0.38*	*0.47*	*0.22*	*0.25*	*0.17*
Northern Harrier	*0.06*	*0*	*0.06*	*0.11*	*0.06*	*0*	*0*	*0.12*	*0*	*0.06*	*0*	*0*	*0*	*0.06*	*0*	*0.11*
Eagles	*0*	*0.06*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Falcons	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.06*	*0*	*0*	*0*	*0*	*0.06*
Other Raptors	*0*	*0*	*0.06*	*0*	*0*	*0*	*0*	*0.06*	*0*	*0*	*0*	*0*	*0*	*0*	*0.12*	*0*
Vultures	**0**	**0.11**	**0**	**0.17**	**0.06**	**0.17**	**0**	**0**	**0.06**	**0.06**	**0**	**0.25**	**0**	**0.06**	**0**	**0.17**
Upland Game Birds	**0.29**	**0.11**	**0.18**	**0.17**	**0.12**	**0.06**	**0.07**	**0.12**	**0.18**	**0.33**	**0**	**0.06**	**0.07**	**0.67**	**1.69**	**0**
Doves/Pigeons	**0.41**	**0.06**	**0.06**	**0.61**	**1**	**0.83**	**0.47**	**0.81**	**0.29**	**3.78**	**0.53**	**0.81**	**0.6**	**1.28**	**0.19**	**2.06**
Large Corvids	**0**	**0**	**0.35**	**0.06**	**0.47**	**0**	**0.13**	**0**	**0.18**	**0**	**0.06**	**0.06**	**0.07**	**0.11**	**1.75**	**0.83**
Goatsuckers	**0**	**0**	**0**	**0**	**0.06**	**0**	**0.07**	**0.06**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Overall large birds	**73.35**	**12.44**	**1.41**	**2.06**	**5.88**	**34.11**	**3.27**	**31.56**	**1.59**	**5.11**	**1.47**	**3.25**	**2.07**	**22.17**	**9.06**	**5.28**
Passerines	**14.71**	**10.39**	**5.35**	**12.28**	**6.06**	**28**	**7.93**	**4.94**	**11.47**	**8.44**	**4**	**7.81**	**7.4**	**3.17**	**10.19**	**13.44**
Woodpeckers	**0.06**	**0.06**	**0**	**0.06**	**0.06**	**0.28**	**0.07**	**0**	**0.35**	**0.06**	**0**	**0.12**	**0**	**0.22**	**0.06**	**0.06**
Overall small birds	**14.76**	**10.44**	**5.35**	**12.33**	**6.12**	**28.28**	**8.00**	**4.94**	**11.82**	**8.50**	**4.00**	**7.94**	**7.40**	**3.39**	**10.25**	**13.50**

[a] 800-m (m; 2,625-foot [ft]) radius plot for large birds; 100-m (328-ft) radius plot for small birds

Eagle Use and Flight Paths

Overall, there were 271 hours (16,260 min) of eagle fixed-point use surveys (60-min surveys) conducted at the Project (Table 8). During this time, four bald eagles (only eagle species recorded) were visible for 15 min regardless of behavior (e.g., perching, flying, etc); 11 of those total minutes were risk minutes (i.e., within 800 m and below 200 m; Table 8). The bald eagles recorded at points 6 and 14 were observed after the initial 20-min survey period. The individual recorded at Point 14 was perched when first observed, and then flew within 800 m and below 200 m (Figure 4); this individual was not included in Tables 5 and 6 due to its behavior when first observed, but was included in the eagle risk minutes analysis (Table 8). Of the two bald eagles recorded at Point 2, one was observed after the initial 20-min survey period. The few flight paths for bald eagles at the Project showed no apparent pattern (Figure 3).

Table 8. Survey effort, number of bald eagle observations and groups, total eagle minutes, risk minutes, and eagle use by season, observed during the Year One of the 60-min bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

Season	Survey Effort (hours)	Number of Eagle Observations	Number of Groups	Total Eagle Minutes	Risk Minutes[a]	Eagle Use[b]
Spring	63	0	0	0	0	0
Summer	77	1	1	5	5	0.01
Fall	78	2	2	8	5	0.02
Winter	53	1	1	2	1	0.02
Overall	**271**	**4**	**4**	**15**	**11**	

[a] Where eagles flew below 200 meters (m) above ground level and within 800 m of the observer

[b] Eagles/800-m plot/60 minutes

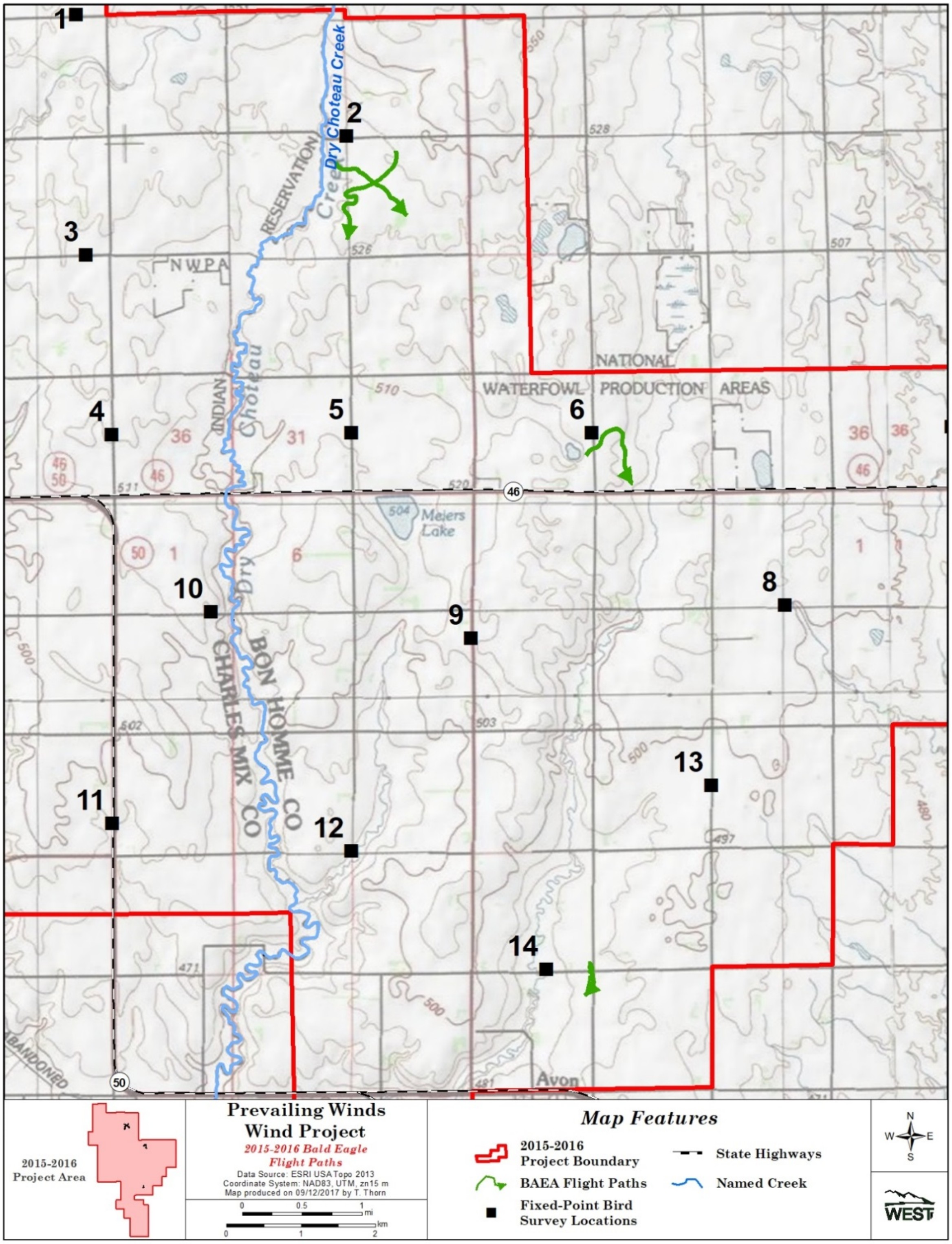

Figure 3. Bald eagle flight paths observed during the Year One 60-minute fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

Incidental Observations

Sixteen unique bird species and two unidentified species were observed incidentally at the Project, totaling 2,153 birds within 73 separate groups (Table 9). Sandhill crane (1,054 birds within eight groups) and snow goose (950 birds within three groups) were the most abundant incidental species observed at the Project (Table 9). Eight unique and two unidentified diurnal raptor species were recorded incidentally, totaling 51 observations within 47 groups. Red-tailed hawk was the most abundant raptor species observed incidentally at the Project (29 birds within 27 groups); ferruginous hawk, sharp-shinned hawk, great horned owl (*Bubo virginianus*), and snowy owl (*Bubo scandiacus*) were only observed incidentally within the Project area.

Table 9. Incidental wildlife observed while conducting all surveys at the at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

Species	Scientific Name	#Groups	# Individuals
sandhill crane	*Antigone canadensis*	8	1,054
snow goose	*Chen caerulescens*	3	950
Franklin's gull	*Leucophaeus pipixcan*	1	75
bald eagle	*Haliaeetus leucocephalus*	2	3
Cooper's hawk	*Accipiter cooperii*	1	1
ferruginous hawk[a]	*Buteo regalis*	1	1
northern harrier	*Circus cyaneus*	7	8
rough-legged hawk	*Buteo lagopus*	1	1
red-tailed hawk	*Buteo jamaicensis*	27	29
sharp-shinned hawk[a]	*Accipiter striatus*	1	1
Swainson's hawk	*Buteo swainsoni*	2	2
unidentified buteo	*Buteo spp*	1	1
unidentified hawk		4	4
great horned owl[a]	*Bubo virginianus*	1	1
snowy owl[a]	*Bubo scandiacus*	1	1
turkey vulture	*Cathartes aura*	8	13
wild turkey	*Meleagris gallopavo*	2	5
American crow	*Corvus brachyrhynchos*	2	3
Total		**73**	**2,153**

[a] Observed incidentally only

DISCUSSION

The Guidelines use a tiered approach to assess impacts to species and their habitats, and avian use surveys are one of a suite of Tier 3 studies used to inform risk at the Project. Tier 3 studies were targeted to address questions regarding impact that could not be sufficiently addressed using available literature (i.e., Tiers 1 and 2 desktop analyses). These studies provide additional data that, when combined with available literature reviewed in previous Tiers, allow for a confident assessment of the risk of significant population-level adverse impacts to special-status species; identify measures to mitigate significant adverse impacts, if necessary; and/or identify a need for more field studies, if the current survey effort did not provide sufficient data to adequately characterize the potential for significant adverse impacts to such species. While the avian use surveys reported herein were conducted across all species observed, the report focuses on a smaller group of species – diurnal raptors, eagles, listed species, and State non-listed special-status species.

The impact of wind energy development on birds can be direct or indirect. Direct impacts include fatalities or injury associated with facility infrastructure and the loss of habitat where infrastructure is placed. Indirect impacts include the displacement of wildlife and rendering habitat unsuitable through fragmentation of the landscape.

The focus of this study was mainly to document large bird use with an emphasis on eagles and diurnal raptors. Approximately two thirds of all bird observations during this study were waterfowl or passerine species. The most common waterfowl species were snow and Canada geese, while the most common passerine species were European starling and red-winged blackbird. Waterbirds composed a small percentage of the total bird observations, with only two waterbird species (sandhill cranes and great blue herons) being recorded during bird use surveys. Relatively few (89 observations) diurnal raptors were observed during standardized surveys and 51 were recorded incidentally. The most common diurnal raptor species recorded was red-tailed hawk, documented both incidentally and during scheduled surveys; bald eagle was the only eagle species documented during surveys conducted at the Project. Diurnal raptors and non-listed special-status species are discussed in more detail below; no federally or state-listed species were documented during the Year One survey period.

Diurnal Raptors

Annual mean diurnal raptor use at the Project was 0.31 raptors/800-m plot/20-min survey, with highest use in the fall, likely from an influx of migrating raptors. Mean raptor use was compared with other wind energy facilities that implemented similar protocols and had data covering similar seasons, ranking 34th from the highest use compared to the 47 other wind energy facilities in North America (Figure 4).

Publicly available data containing both mean raptor use and raptor fatality information in the Midwest is scarce, while data having this information for four seasons is even rarer (Table 10). The Beethoven Project, immediately adjacent to the Project, had a mean raptor use of 0.103 raptors/800-m plot/20-min survey (Derby and Thorn 2014) and a raptor fatality rate of 0.07 fatalities/MW/year (WEST 2016; Table 10). The Wessington Springs Project, approximately 80 miles north of the project, in South Dakota had a mean raptor use of 0.23 raptors/800-m plot/20-min survey and raptor fatality rates of 0.06 and 0.07 fatalities/MW/year during two separate years of fatality monitoring (Derby et al. 2010f, 2011d). Raptor fatality rates reported at other South Dakota wind energy facilities have ranged from 0 – 0.20 fatalities/MW/year (Table 10). Raptor fatality rates throughout the Midwest have ranged from zero at numerous facilities to 0.47 fatalities/MW/year at Buffalo Ridge, Phase I (Johnson et al. 2000a).

In the Midwest states, 55 diurnal raptor fatalities representing seven species have been documented at wind energy facilities in publicly available fatality studies. Red-tailed hawks represented most of the fatalities (38 fatalities; 69.1% of raptor fatalities), followed by American kestrel (five fatalities; 9.1% of raptor fatalities), sharp-shinned hawk (four fatalities; 7.3% of raptor fatalities), rough-legged hawk (three fatalities; 5.5% of raptor fatalities), and Cooper's hawk (two fatalities; 3.6% of raptor fatalities). Each of the remaining species (merlin [*Falco columbarius*], Swainson's hawk, and unidentified raptor) accounted for one fatality each. These are unadjusted, raw data. Cumulative fatalities and species are from data compiled by WEST from publicly available fatality studies (a list of facilities and references are available from WEST). Based on the currently available data, raptor fatality rates in the Project will likely be similar to other wind energy facilities in the Midwest that also have low raptor use and are likely to consist of the relatively common and widespread species documented in this survey.

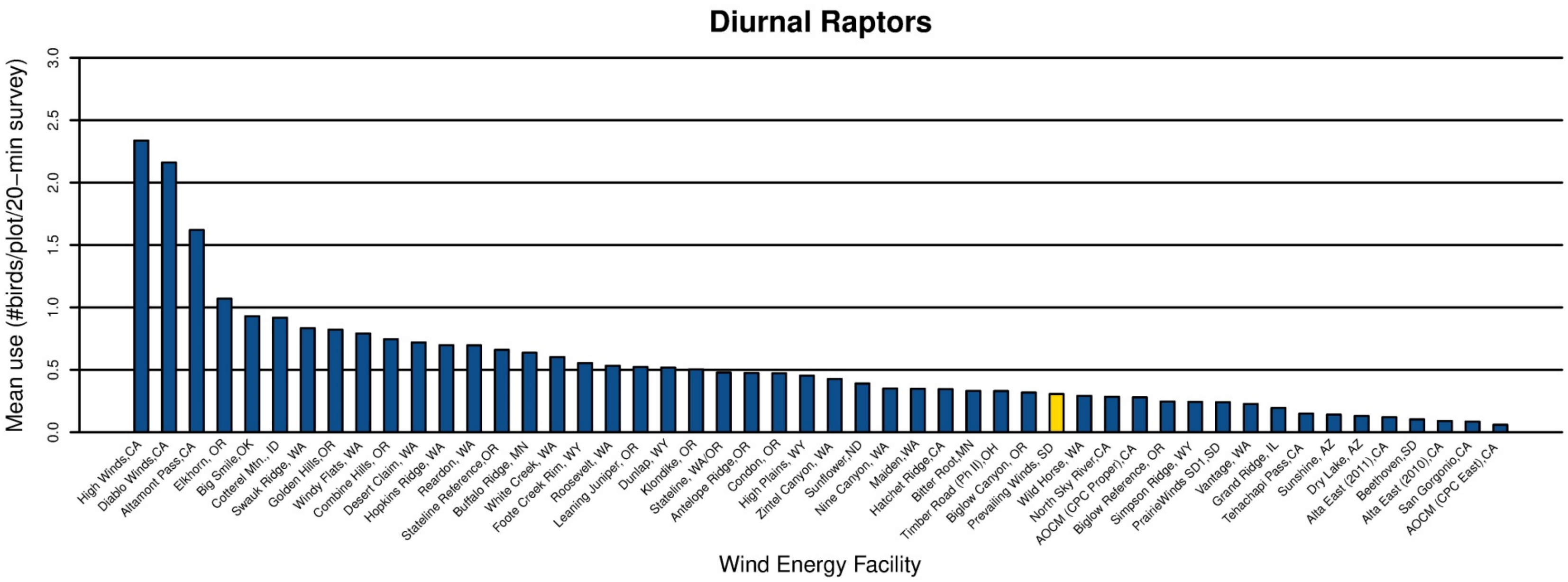

Figure 4. Comparison of estimated annual diurnal raptor use during the Year One fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016, and diurnal raptor use at other US wind resource areas with comparable raptor use data.

Data from the following sources:

Study and Location	**Reference**	**Study and Location**	**Reference**	**Study and Location**	**Reference**
Prevailing Winds, SD	This study.				
High Winds, CA	Kerlinger et al. 2005	Foote Creek Rim, WY	Johnson et al. 2000b	Wild Horse, WA	Erickson et al. 2003d
Diablo Winds, CA	WEST 2006	Roosevelt, WA	NWC and WEST 2004	North Sky River, CA	Erickson et al. 2011
Altamont Pass, CA	Orloff and Flannery 1992	Leaning Juniper, OR	Kronner et al. 2005	AOCM (CPC Proper), CA	Chatfield et al. 2010
Elkhorn, OR	WEST 2005a	Dunlap, WY	Johnson et al. 2009a	Biglow Reference, OR	WEST 2005c
Big Smile (Dempsey), OK	Derby et al. 2010a	Klondike, OR	Johnson et al. 2002	Simpson Ridge, WY	Johnson et al. 2000b
Cotterel Mtn., ID	BLM 2006	Stateline, WA/OR	Erickson et al. 2003a	Vantage, WA	Jeffrey et al. 2007
Swauk Ridge, WA	Erickson et al. 2003b	Antelope Ridge, OR	WEST 2009	Grand Ridge, IL	Derby et al. 2009
Golden Hills, OR	Jeffrey et al. 2008	Condon, OR	Erickson et al. 2002b	Tehachapi Pass, CA	Anderson et al. 2000, Erickson et al. 2002b
Windy Flats, WA	Johnson et al. 2007	High Plains, WY	Johnson et al. 2009b	Sunshine, AZ	WEST and the CPRS 2006
Combine Hills, OR	Young et al. 2003c	Zintel Canyon, WA	Erickson et al. 2002a, 2003c	Dry Lake, AZ	Young et al. 2007b
Desert Claim, WA	Young et al. 2003b	Nine Canyon, WA	Erickson et al. 2001	Alta East (2011), CA	Chatfield et al. 2011
Hopkins Ridge, WA	Young et al. 2003a	Maiden, WA	Young et al. 2002	Alta East (2010), CA	Chatfield et al. 2011
Reardon, WA	WEST 2005b	Hatchet Ridge, CA	Young et al. 2007a	San Gorgonio, CA	Anderson et al. 2000, Erickson et al. 2002b
Stateline Reference, OR	URS et al. 2001	Bitter Root. MN	Derby and Dahl 2009	AOCM (CPC East), CA	Chatfield et al. 2010
Buffalo Ridge, MN	Johnson et al. 2000a	Timber Road (Phase II), OH	Good et al. 2010	Beethoven, SD	Derby and Thorn 2014
White Creek, WA	NWC and WEST 2005	Biglow Canyon, OR	WEST 2005c		

Table 10. Raptor use (number of raptors/plot/20-minute survey) and fatality (number of bird fatalities/megawatt/year) estimates for wind-energy facilities in the Midwest with publicly available data.

Project Name	Raptor Use Estimate	Raptor Fatality Estimate	Total #of Turbines	Total MW	Use Reference	Fatality Reference
Barton I & II, IA (2010-2011)	NA	0	80	160.0		Derby et al. 2011a
Beethoven (2016-2016)	0.103	0.07	43	80.0	Derby and Thorn 2014	WEST 2016
Big Blue, MN (2013)	NA	0	18	36.0		Fagen Engineering 2014
Big Blue, MN (2014)	NA	0	18	36.0		Fagen Engineering 2015
Blue Sky Green Field, WI (2008; 2009)	NA	0	88	145.0		Gruver et al. 2009
Buffalo Ridge I, SD (2009-2010)	NA	0.20	24	50.4		Derby et al. 2010b
Buffalo Ridge II, SD (2011-2012)	NA	0	105	210.0		Derby et al. 2012a
Buffalo Ridge, MN (Phase I; 1996)	NA	0	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase I; 1997)	NA	0	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase I; 1998)	NA	0	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase I; 1999)	NA	0.47	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase II; 1998)	NA	0	143	107.3		Johnson et al. 2000a
Buffalo Ridge, MN (Phase II; 1999)	NA	0	143	107.3		Johnson et al. 2000a
Buffalo Ridge, MN (Phase III; 1999)	NA	0	138	103.5		Johnson et al. 2000a
Cedar Ridge, WI (2009)	NA	0.18	41	67.6		BHE Environmental 2010
Cedar Ridge, WI (2010)	NA	0.13	41	68.0		BHE Environmental 2011
Elm Creek II, MN (2009-2010)	NA	0	67	100.0		Derby et al. 2010c
Elm Creek, MN (20011-2012)	NA	0	62	148.8		Derby et al. 2012b
Fowler I, IN (2009)	NA	0	162	301.0		Johnson et al. 2010
Grand Ridge I, IL (2009-2010)	0.2	0	66	99.0	Derby et al. 2009	Derby et al. 2010g
Kewaunee County, WI (1999-2001)	NA	0	31	20.5		Howe et al. 2002
Moraine II, MN (2009)	NA	0.37	33	49.5		Derby et al. 2010d
NPPD Ainsworth, NE (2006)	NA	0.06	36	20.5		Derby et al. 2007
Pioneer Prairie II, IA (2011-2012)	NA	0	62	102.3		Chodachek et al. 2012
PrairieWinds ND1 (Minot), ND (2010)	NA	0.05	80	115.5		Derby et al. 2011c
PrairieWinds ND1 (Minot), ND (2011)	NA	0.05	80	115.5		Derby et al. 2012c
PrairieWinds SD1, SD (2011-2012)	NA	0	108	162.0		Derby et al. 2012d
PrairieWinds SD1, SD (2012-2013)	NA	0.03	108	162.0		Derby et al. 2013
PrairieWinds SD1, SD (2013-2014)	NA	0.17	108	162.0		Derby et al. 2014
Rail Splitter, IL (2012-2013)	NA	0	67	100.5		Good et al. 2013
Ripley, Ont (2008)	NA	0.10	38	76.0		Jacques Whitford 2009
Rugby, ND (2010-2011)	NA	0.06	71	149.0		Derby et al. 2011b
Top of Iowa, IA (2003)	NA	0	89	80.0		Jain 2005
Top of Iowa, IA (2004)	NA	0.17	89	80.0		Jain 2005
Wessington Springs, SD (2009)	0.23	0.06	34	51.0	Derby et al. 2008	Derby et al. 2010f

Table 10. Raptor use (number of raptors/plot/20-minute survey) and fatality (number of bird fatalities/megawatt/year) estimates for wind-energy facilities in the Midwest with publicly available data.

Project Name	Raptor Use Estimate	Raptor Fatality Estimate	Total #of Turbines	Total MW	Use Reference	Fatality Reference
Wessington Springs, SD (2010)	0.23	0.07	34	51.0	Derby et al. 2008	Derby et al. 2011d
Winnebago, IA (2009-2010)	NA	0.27	10	20.0		Derby et al. 2010e

This fixed-point bird use survey was designed to provide a relative index of use by raptors during all seasons at the Project. While mean diurnal raptor use was higher during the fall (0.52 raptors/800-m plot/20-min survey), probably due to an influx of migrant birds, the Project is not located within a known raptor migration corridor, and there are no features unique to the Project area, compared to adjacent areas, that would appear to attract large numbers of diurnal raptors. Furthermore, raptor fatality rates reported from studies in the Midwest are typically low. Site-specific and regional data suggest there is some potential for raptor mortality, but these potential impacts to individuals are unlikely to cause significant adverse impacts to raptor populations. Likewise, there is some potential for habitat loss and displacement of individuals, but the resources available within the Project area are widely available at the local landscape level; therefore, any diurnal raptor habitat loss and displacement attributable to the Project is unlikely to result in significant adverse population-level impacts to raptors.

While abundance is intuitively connected to raptor fatality risk to some degree, risk is likely influenced by other factors as well, such as species-specific flight behaviors. More than half (58.2%) of all diurnal raptors at the Project were observed below the RSH. A higher proportion of unidentified raptors, buteos, and eagles flew within the RSH compared to other raptor types, potentially indicating that some species may have a higher risk for collision; however, many of these are based on a few individual observations.

Species Specific Summaries

Great blue heron

One great blue heron, a common summer resident and migrant in South Dakota, was recorded during the surveys conducted at the Project. Site-specific data indicate that use of the Project area by this species is low and population-level effects from Project development are unlikely.

Bald Eagle

A total of seven bald eagle observations (four during 60-min surveys and regardless of distance from observer, and three incidentally) were recorded within the Project area during Year One surveys conducted from March 25, 2015 – February 21, 2016 (Table 4). The majority (66.7%) of flying bald eagles recorded during fixed-point bird use surveys were observed within the RSH (Table 5). Bald eagles are generally uncommon during migration, summer, and winter throughout South Dakota; however, they are locally common below the Missouri River dams in winter and nesting within the State is increasingly reported (South Dakota Birds, Birding, and Nature 2017). An April 2015 raptor nest survey conducted by WEST found one occupied/active bald eagle nest recorded within one mi (1.6 km) of the Project boundary. There were also five occupied/active bald eagle nests, one occupied/active eagle nest (species unknown), and one unoccupied eagle nest (species unknown) recorded within or next to the 10-mi (16-km) buffer during the April 2015 raptor nest survey.

The limited eagle observations during this bird use survey and the raptor nest survey conducted in 2015 suggest that the Project does not fall within a major bald eagle migration route, wintering area, or breeding home range of current nests, but the presence of active bald eagle nests in the vicinity of the Project indicates bald eagles are present in the general area for an extended period of time (breeding season). Thus, development of the Project may influence individuals moving through or using the Project area, but potential impact to bald eagle populations appears minimal.

Swainson's and Ferruginous Hawk

There were four observations of Swainson's and one ferruginous hawk were recorded during the study period (Table 4). Seventy-five percent of the Swainson's hawk observations were of flying individuals, but none of those hawks were observed flying within the RSH (Table 6). Swainson's hawks are common in South Dakota and utilize a variety of habitats, including open grasslands with occasional trees and shrubs, wetland edges, and agriculture fields, nesting in trees, shrubs, or occasionally on the ground (South Dakota Birds, Birding, and Nature 2017). The one ferruginous hawk was not observed flying. Ferruginous hawk, an uncommon migrant and summer resident, is rarely observed in winter, and inhabits grasslands and open areas (South Dakota Birds, Birding, and Nature 2017).

The potential for individual mortality does exist for both species; however, the low number of fatalities reported throughout projects in the Midwest (one Swainson's hawk and no ferruginous hawk fatalities out of 55 total reported fatalities) suggests that these species are not particularly susceptible to turbine collisions. Collision mortality may affect a few individuals, but are unlikely to cause significant adverse impacts to either populations of the species.

Goshawk and Sharp-shinned and Cooper's Hawk

One goshawk, one sharp-shinned hawk and four Cooper's hawks were recorded during the study period. All are an uncommon migrant in South Dakota, generally preferring wooded areas (South Dakota Birds, Birding, and Nature 2017). Only two Cooper's hawks and no sharp-shinned or goshawks have been found as fatalities through projects in the Midwest. Collision mortality may affect a few individuals of these species, but significant population-level impacts are unlikely.

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Appendix A. Descriptive Statistics for Bird Species Recorded during Year One of Fixed-Point Bird Use Surveys Conducted at the Prairie Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year One fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

		Spring		**Summer**		**Fall**		**Winter**		**Total**	
Type/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
Waterbirds		**4**	**701**	**0**	**0**	**1**	**35**	**0**	**0**	**5**	**736**
great blue heron[a]	*Ardea herodias*	1	1	0	0	0	0	0	0	1	1
sandhill crane	*Antigone canadensis*	3	700	0	0	1	35	0	0	4	735
Waterfowl		**21**	**725**	**6**	**53**	**4**	**321**	**13**	**1,046**	**44**	**2,145**
Canada goose	*Branta canadensis*	3	402	2	41	0	0	5	415	10	858
greater white-fronted goose	*Anser albifrons*	1	50	0	0	0	0	1	6	2	56
lesser scaup	*Aythya affinis*	1	6	0	0	0	0	0	0	1	6
mallard	*Anas platyrhynchos*	11	59	3	8	2	4	3	35	19	106
northern shoveler	*Anas clypeata*	1	2	0	0	1	17	0	0	2	19
snow goose	*Chen caerulescens*	0	0	0	0	0	0	4	590	4	590
unidentified duck		4	206	0	0	0	0	0	0	4	206
unidentified goose		0	0	0	0	1	300	0	0	1	300
wood duck	*Aix sponsa*	0	0	1	4	0	0	0	0	1	4
Shorebirds		**31**	**34**	**32**	**76**	**11**	**52**	**0**	**0**	**74**	**162**
killdeer	*Charadrius vociferus*	24	27	13	23	6	10	0	0	43	60
unidentified shorebird		0	0	4	36	5	42	0	0	9	78
upland sandpiper	*Bartramia longicauda*	7	7	15	17	0	0	0	0	22	24
Gulls/Terns		**4**	**693**	**0**	**0**	**2**	**42**	**0**	**0**	**6**	**735**
Franklin's gull	*Leucophaeus pipixcan*	4	693	0	0	1	20	0	0	5	713
unidentified gull		0	0	0	0	1	22	0	0	1	22
Diurnal Raptors		**9**	**10**	**14**	**14**	**41**	**45**	**19**	**20**	**83**	**89**
Accipiters		*0*	*0*	*0*	*0*	*2*	*2*	*3*	*3*	*5*	*5*
Cooper's hawk[a]	*Accipiter cooperii*	0	0	0	0	2	2	2	2	4	4
northern goshawk[a,b]	*Accipiter gentilis*	0	0	0	0	0	0	1	1	1	1
Buteos		*6*	*7*	*8*	*8*	*30*	*34*	*13*	*14*	*57*	*63*
red-tailed hawk	*Buteo jamaicensis*	6	7	8	8	28	30	9	10	51	55
rough-legged hawk	*Buteo lagopus*	0	0	0	0	0	0	3	3	3	3
Swainson's hawk[a]	*Buteo swainsoni*	0	0	0	0	2	4	0	0	2	4
unidentified buteo	*Buteo spp*	0	0	0	0	0	0	1	1	1	1
Northern Harrier		*2*	*2*	*4*	*4*	*5*	*5*	*0*	*0*	*11*	*11*
northern harrier	*Circus cyaneus*	2	2	4	4	5	5	0	0	11	11
Eagles		*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*1*	*1*
bald eagle[a,b,c]	*Haliaeetus leucocephalus*	0	0	0	0	0	0	1	1	1	1

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year One fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

		Spring		Summer		Fall		Winter		Total	
Type/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
Falcons		*0*	*0*	*0*	*0*	*0*	*0*	*2*	*2*	*2*	*2*
American kestrel	*Falco sparverius*	0	0	0	0	0	0	2	2	2	2
Other Raptors		*1*	*1*	*2*	*2*	*4*	*4*	*0*	*0*	*7*	*7*
unidentified hawk		1	1	1	1	2	2	0	0	4	4
unidentified raptor		0	0	1	1	2	2	0	0	3	3
Vultures		**2**	**2**	**3**	**9**	**5**	**8**	**0**	**0**	**10**	**19**
turkey vulture	*Cathartes aura*	2	2	3	9	5	8	0	0	10	19
Upland Game Birds		**12**	**14**	**13**	**13**	**4**	**26**	**4**	**16**	**33**	**69**
gray partridge	*Perdix perdix*	0	0	0	0	0	0	1	5	1	5
ring-necked pheasant	*Phasianus colchicus*	11	13	12	12	3	3	2	2	28	30
sharp-tailed grouse	*Tympanuchus phasianellus*	1	1	0	0	0	0	0	0	1	1
wild turkey	*Meleagris gallopavo*	0	0	1	1	1	23	1	9	3	33
Doves/Pigeons		**12**	**16**	**37**	**55**	**17**	**105**	**8**	**63**	**74**	**239**
Eurasian collared-dove	*Streptopelia decaocto*	0	0	1	1	0	0	0	0	1	1
mourning dove	*Zenaida macroura*	10	13	35	53	14	80	0	0	59	146
rock pigeon	*Columba livia*	2	3	1	1	3	25	8	63	14	92
Large Corvids		**6**	**6**	**1**	**2**	**12**	**33**	**6**	**27**	**25**	**68**
American crow	*Corvus brachyrhynchos*	6	6	1	2	12	33	6	27	25	68
Passerines		**158**	**370**	**217**	**623**	**129**	**2,116**	**28**	**781**	**532**	**3,890**
American goldfinch	*Spinus tristis*	1	1	5	5	1	1	0	0	7	7
American robin	*Turdus migratorius*	22	47	10	15	10	75	0	0	42	137
Baltimore oriole	*Icterus galbula*	0	0	1	1	0	0	0	0	1	1
bank swallow	*Riparia riparia*	0	0	0	0	1	4	0	0	1	4
barn swallow	*Hirundo rustica*	3	10	39	98	10	61	0	0	52	169
blue jay	*Cyanocitta cristata*	0	0	0	0	2	3	0	0	2	3
bobolink	*Dolichonyx oryzivorus*	1	1	4	4	0	0	0	0	5	5
Brewer's blackbird	*Euphagus cyanocephalus*	0	0	0	0	1	150	0	0	1	150
brown-headed cowbird	*Molothrus ater*	20	96	19	47	3	23	0	0	42	166
brown thrasher	*Toxostoma rufum*	1	1	1	1	0	0	0	0	2	2
chipping sparrow	*Spizella passerina*	1	1	0	0	0	0	0	0	1	1
cliff swallow	*Petrochelidon pyrrhonota*	0	0	4	16	0	0	0	0	4	16
common grackle	*Quiscalus quiscula*	11	22	6	7	3	14	0	0	20	43
common yellowthroat	*Geothlypis trichas*	0	0	2	2	0	0	0	0	2	2
dark-eyed junco	*Junco hyemalis*	0	0	0	0	0	0	1	30	1	30

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year One fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

		Spring		Summer		Fall		Winter		Total	
Type/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
dickcissel	*Spiza americana*	0	0	15	18	0	0	0	0	15	18
eastern bluebird	*Sialia sialis*	1	1	0	0	1	4	0	0	2	5
eastern kingbird	*Tyrannus tyrannus*	0	0	23	34	0	0	0	0	23	34
European starling	*Sturnus vulgaris*	2	2	1	19	8	553	2	213	13	787
field sparrow	*Spizella pusilla*	0	0	0	0	0	0	3	11	3	11
grasshopper sparrow	*Ammodramus savannarum*	1	2	0	0	0	0	0	0	1	2
Harris' sparrow	*Zonotrichia querula*	0	0	0	0	1	1	0	0	1	1
horned lark	*Eremophila alpestris*	9	14	1	2	5	69	15	402	30	487
house wren	*Troglodytes aedon*	0	0	0	0	1	1	0	0	1	1
Lapland longspur	*Calcarius lapponicus*	0	0	0	0	0	0	2	40	2	40
loggerhead shrike	*Lanius ludovicianus*	1	2	0	0	0	0	0	0	1	2
northern rough-winged swallow	*Stelgidopteryx serripennis*	0	0	1	2	0	0	0	0	1	2
orchard oriole	*Icterus spurius*	0	0	1	2	0	0	0	0	1	2
red-winged blackbird	*Agelaius phoeniceus*	16	85	15	138	11	351	0	0	42	574
Savannah sparrow	*Passerculus sandwichensis*	0	0	7	9	3	5	0	0	10	14
snow bunting	*Plectrophenax nivalis*	0	0	0	0	0	0	2	23	2	23
song sparrow	*Melospiza melodia*	0	0	1	1	3	13	0	0	4	14
tree swallow	*Tachycineta bicolor*	0	0	5	6	0	0	0	0	5	6
unidentified blackbird		0	0	1	1	5	659	0	0	6	660
unidentified passerine		2	3	2	24	8	15	1	7	13	49
unidentified sparrow		0	0	0	0	8	20	0	0	8	20
unidentified swallow		1	1	2	45	0	0	0	0	3	46
vesper sparrow	*Pooecetes gramineus*	3	3	1	1	0	0	0	0	4	4
western kingbird	*Tyrannus verticalis*	0	0	4	6	0	0	0	0	4	6
western meadowlark	*Sturnella neglecta*	62	78	44	68	43	93	2	55	151	294
yellow-headed blackbird	*Xanthocephalus xanthocephalus*	0	0	2	51	0	0	0	0	2	51
yellow warbler	*Setophaga petechia*	0	0	0	0	1	1	0	0	1	1
Goatsuckers		**0**	**0**	**3**	**3**	**0**	**0**	**0**	**0**	**3**	**3**
common nighthawk	*Chordeiles minor*	0	0	3	3	0	0	0	0	3	3
Woodpeckers		**8**	**8**	**6**	**7**	**6**	**9**	**4**	**7**	**24**	**31**
hairy woodpecker	*Picoides villosus*	1	1	0	0	0	0	0	0	1	1
northern flicker	*Colaptes auratus*	7	7	4	4	5	8	4	7	20	26

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year One fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

		Spring		Summer		Fall		Winter		Total	
Type/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
red-headed woodpecker	*Melanerpes erythrocephalus*	0	0	2	3	1	1	0	0	3	4
Unidentified Birds		**0**	**0**	**0**	**0**	**0**	**0**	**1**	**8**	**1**	**8**
unidentified bird (small)		0	0	0	0	0	0	1	8	1	8
Overall		**267**	**2579**	**332**	**855**	**232**	**2,792**	**83**	**1,968**	**914**	**8,194**

Grps = Number of groups, # Obs = Number of observations

[a.] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b.] State Species of Greatest Conservation Need (SDGFP 2014)

[c.] Bald and Golden Eagle Protection Act (1940)

Appendix A2. Mean large bird use (number of large birds/800-meter radius plot/20-minute survey), percent of total use, and frequency of occurrence for each large bird type and species by season during Year One of the fixed-point bird use surveys conducted at the Prairie Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

	Mean Use				Percent of Use (%)				Frequency of Occurrence (%)			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Waterbirds	**10.17**	**0**	**0.44**	**0**	**33.4**	**0**	**5.2**	**0**	**3.2**	**0**	**1.2**	**0**
great blue heron[a]	0.02	0	0	0	<0.1	0	0	0	1.7	0	0	0
sandhill crane	10.16	0	0.44	0	33.4	0	5.2	0	1.6	0	1.2	0
Waterfowl	**8.21**	**0.18**	**4.01**	**11.66**	**27**	**7.6**	**47.6**	**80.1**	**22.1**	**5.5**	**5.2**	**7.8**
Canada goose	6.28	0.01	0	3.36	20.6	0.5	0	23.1	3.1	1.2	0	6.2
greater white-fronted goose	0.78	0	0	0.09	2.6	0	0	0.6	1.6	0	0	1.6
lesser scaup	0.09	0	0	0	0.3	0	0	0	1.6	0	0	0
mallard	0.92	0.11	0.05	0.55	3	4.8	0.6	3.8	17.2	4.3	2.7	4.7
northern shoveler	0.03	0	0.21	0	0.1	0	2.5	0	1.7	0	1.2	0
snow goose	0	0	0	7.66	0	0	0	52.6	0	0	0	3.1
unidentified duck	0.09	0	0	0	0.3	0	0	0	4.8	0	0	0
unidentified goose	0	0	3.75	0	0	0	44.5	0	0	0	1.2	0
wood duck	0	0.06	0	0	0	2.4	0	0	0	1.4	0	0
Shorebirds	**0.54**	**0.98**	**0.65**	**0**	**1.8**	**40.7**	**7.7**	**0**	**41**	**35.5**	**12.5**	**0**
killdeer	0.43	0.3	0.12	0	1.4	12.6	1.5	0	34.8	16	7.5	0
unidentified shorebird	0	0.45	0.52	0	0	18.7	6.2	0	0	3.8	5	0
upland sandpiper	0.11	0.22	0	0	0.4	9.3	0	0	9.4	18.7	0	0
Gulls/Terns	**10.83**	**0**	**0.56**	**0**	**35.6**	**0**	**6.7**	**0**	**6.2**	**0**	**2.7**	**0**
Franklin's gull	10.83	0	0.25	0	35.6	0	3	0	6.2	0	1.2	0
unidentified gull	0	0	0.31	0	0	0	3.7	0	0	0	1.4	0
Diurnal Raptors	**0.10**	**0.18**	**0.52**	**0.45**	**0.3**	**7.4**	**6.1**	**3.1**	**7.9**	**13.9**	**35.9**	**37.4**
Accipiters	*0*	*0*	*0.03*	*0.10*	*0*	*0*	*0.3*	*0.7*	*0*	*0*	*2.7*	*10*
Cooper's hawk[a]	0	0	0.03	0.06	0	0	0.3	0.4	0	0	2.7	5.8
northern goshawk[a,b]	0	0	0	0.04	0	0	0	0.3	0	0	0	4.2
Buteos	*0.05*	*0.10*	*0.41*	*0.30*	*0.2*	*4.2*	*4.9*	*2.1*	*4.7*	*8.9*	*32*	*24.2*
red-tailed hawk	0.05	0.10	0.36	0.21	0.2	4.2	4.2	1.4	4.7	8.9	29.3	15.2
rough-legged hawk	0	0	0	0.07	0	0	0	0.5	0	0	0	7.4
Swainson's hawk[a]	0	0	0.06	0	0	0	0.7	0	0	0	2.7	0
unidentified buteo	0	0	0	0.02	0	0	0	0.1	0	0	0	1.6
Northern Harrier	*0.03*	*0.05*	*0.06*	*0*	*0.1*	*2.1*	*0.8*	*0*	*3.2*	*5*	*6.4*	*0*
northern harrier	0.03	0.05	0.06	0	0.1	2.1	0.8	0	3.2	5	6.4	0
Eagles	*0*	*0*	*0*	*0.02*	*0*	*0*	*0*	*0.1*	*0*	*0*	*0*	*1.6*
bald eagle[a,b,c]	0	0	0	0.02	0	0	0	0.1	0	0	0	1.6
Falcons	*0*	*0*	*0*	*0.03*	*0*	*0*	*0*	*0.2*	*0*	*0*	*0*	*3.3*

Appendix A2. Mean large bird use (number of large birds/800-meter radius plot/20-minute survey), percent of total use, and frequency of occurrence for each large bird type and species by season during Year One of the fixed-point bird use surveys conducted at the Prairie Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

	Mean Use				Percent of Use (%)				Frequency of Occurrence (%)			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
American kestrel	0	0	0	0.03	0	0	0	0.2	0	0	0	3.3
Other Raptors	*0.02*	*0.02*	*0.01*	*0*	*<0.1*	*1*	*0.2*	*0*	*1.7*	*2.5*	*1.4*	*0*
unidentified hawk	0.02	0.01	0.01	0	<0.1	0.5	0.2	0	1.7	1.2	1.4	0
unidentified raptor	0	0.01	0	0	0	0.5	0	0	0	1.2	0	0
Vultures	**0.03**	**0.12**	**0.10**	**0**	**0.1**	**5.1**	**1.2**	**0**	**3.1**	**4.1**	**6.4**	**0**
turkey vulture	0.03	0.12	0.10	0	0.1	5.1	1.2	0	3.1	4.1	6.4	0
Upland Game Birds	**0.22**	**0.17**	**0.33**	**0.64**	**0.7**	**7.2**	**3.9**	**4.4**	**17.4**	**17.4**	**5.2**	**10.0**
gray partridge	0	0	0	0.21	0	0	0	1.4	0	0	0	4.2
ring-necked pheasant	0.21	0.16	0.04	0.06	0.7	6.6	0.5	0.4	17.4	16	3.9	5.8
sharp-tailed grouse	0.02	0	0	0	<0.1	0	0	0	1.6	0	0	0
wild turkey	0	0.01	0.29	0.38	0	0.6	3.4	2.6	0	1.4	1.2	4.2
Doves/Pigeons	**0.25**	**0.70**	**1.41**	**1.37**	**0.8**	**29.3**	**16.7**	**9.4**	**17.2**	**41.0**	**17.3**	**17.8**
Eurasian collared-dove	0	0.01	0	0	0	0.5	0	0	0	1.2	0	0
mourning dove	0.20	0.68	1.09	0	0.7	28.2	13	0	14.1	41	16.1	0
rock pigeon	0.05	0.01	0.31	1.37	0.2	0.5	3.7	9.4	3.1	1.2	3.8	17.8
Large Corvids	**0.09**	**0.02**	**0.41**	**0.44**	**0.3**	**1**	**4.9**	**3**	**9.4**	**1.2**	**12.5**	**9.7**
American crow	0.09	0.02	0.41	0.44	0.3	1	4.9	3	9.4	1.2	12.5	9.7
Goatsuckers	**0**	**0.04**	**0**	**0**	**0**	**1.7**	**0**	**0**	**0**	**4**	**0**	**0**
common nighthawk	0	0.04	0	0	0	1.7	0	0	0	4	0	0
Overall	**30.43**	**2.40**	**8.43**	**14.56**	**100**	**100**	**100**	**100**				

Note: Totals by bird type and overall might not correspond to the sum of individual species due to rounding

[a.] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b.] State Species of Greatest Conservation Need (SDGFP 2014)

[c.] Bald and Golden Eagle Protection Act (1940)

Appendix A3. Mean small bird use (number of large birds/100-meter plot/20-minute survey), percent of total use, and frequency of occurrence for each small bird type and species by season during Year One of the fixed-point bird use surveys conducted at the Prairie Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

	Mean Use				Percent of Use (%)				Frequency of Occurrence (%)			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Passerines	**5.88**	**6.83**	**15.59**	**11.48**	**97.9**	**99.1**	**99.2**	**99.6**	**90.6**	**90.0**	**65.0**	**39.6**
American goldfinch	0.02	0.07	0.01	0	0.3	1	<0.1	0	1.6	6.6	1.2	0
American robin	0.76	0.2	0.91	0	12.6	2.9	5.8	0	31.9	12	7.7	0
Baltimore oriole	0	0.01	0	0	0	0.2	0	0	0	1.4	0	0
bank swallow	0	0	0.05	0	0	0	0.3	0	0	0	1.2	0
barn swallow	0.16	1.06	0.79	0	2.6	15.4	5	0	4.7	34	10.7	0
blue jay	0	0	0.04	0	0	0	0.2	0	0	0	2.5	0
bobolink	0.02	0.06	0	0	0.3	0.8	0	0	1.6	5.5	0	0
Brewer's blackbird	0	0	1.88	0	0	0	11.9	0	0	0	1.2	0
brown-headed cowbird	1.52	0.61	0.16	0	25.4	8.9	1	0	28.8	23.3	2.7	0
brown thrasher	0.02	0.01	0	0	0.3	0.2	0	0	1.6	1.4	0	0
chipping sparrow	0.02	0	0	0	0.3	0	0	0	1.6	0	0	0
cliff swallow	0	0.20	0	0	0	2.9	0	0	0	5	0	0
common grackle	0.35	0.10	0.18	0	5.8	1.4	1.1	0	12.6	8.3	3.8	0
common yellowthroat	0	0.03	0	0	0	0.4	0	0	0	2.7	0	0
dark-eyed junco	0	0	0	1.25	0	0	0	10.8	0	0	0	4.2
dickcissel	0	0.23	0	0	0	3.4	0	0	0	19.6	0	0
eastern bluebird	0.02	0	0.05	0	0.3	0	0.3	0	1.6	0	1.2	0
eastern kingbird	0	0.38	0	0	0	5.5	0	0	0	23.5	0	0
European starling	0.03	0.24	1.07	0	0.5	3.4	6.8	0	1.6	1.2	3.9	0
field sparrow	0	0	0	0.17	0	0	0	1.5	0	0	0	4.7
grasshopper sparrow	0.03	0	0	0	0.5	0	0	0	1.6	0	0	0
Harris' sparrow	0	0	0.01	0	0	0	<0.1	0	0	0	1.2	0
horned lark	0.22	0.03	0.87	7.15	3.7	0.4	5.5	62	14.2	1.3	5.4	27.5
house wren	0	0	0.01	0	0	0	<0.1	0	0	0	1.4	0
Lapland longspur	0	0	0	1.17	0	0	0	10.1	0	0	0	5.8
loggerhead shrike	0.03	0	0	0	0.6	0	0	0	1.7	0	0	0
northern rough-winged swallow	0	0.03	0	0	0	0.4	0	0	0	1.3	0	0
orchard oriole	0	0.03	0	0	0	0.4	0	0	0	1.4	0	0
red-winged blackbird	1.37	1.54	2.31	0	22.9	22.3	14.7	0	22.1	17.7	9.3	0
Savannah sparrow	0	0.12	0.06	0	0	1.7	0.4	0	0	9.5	2.7	0

Appendix A3. Mean small bird use (number of large birds/100-meter plot/20-minute survey), percent of total use, and frequency of occurrence for each small bird type and species by season during Year One of the fixed-point bird use surveys conducted at the Prairie Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from March 25, 2015 – February 21, 2016.

	Mean Use				Percent of Use (%)				Frequency of Occurrence (%)			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
snow bunting	0	0	0	0.88	0	0	0	7.7	0	0	0	5.8
song sparrow	0	0.01	0.16	0	0	0.2	1	0	0	1.2	3.9	0
tree swallow	0	0.06	0	0	0	0.9	0	0	0	3.8	0	0
unidentified blackbird	0	0.01	5.5	0	0	0.2	35	0	0	1.2	2.5	0
unidentified passerine	0.05	0.3	0.2	0	0.8	4.4	1.3	0	3.2	2.6	9.3	0
unidentified sparrow	0	0	0.17	0	0	0	1.1	0	0	0	6.6	0
unidentified swallow	0.02	0	0	0	0.3	0	0	0	1.7	0	0	0
vesper sparrow	0.05	0.01	0	0	0.8	0.2	0	0	3.1	1.4	0	0
western kingbird	0	0.04	0	0	0	0.6	0	0	0	2.6	0	0
western meadowlark	1.22	0.68	1	0.86	20.3	9.8	6.4	7.5	74.6	44.7	35	3.1
yellow-headed blackbird	0	0.68	0	0	0	9.9	0	0	0	2.8	0	0
yellow warbler	0	0	0.01	0	0	0	<0.1	0	0	0	1.4	0
Woodpeckers	**0.12**	**0.07**	**0.12**	**0.05**	**2.1**	**0.9**	**0.8**	**0.4**	**10.9**	**5.3**	**6.6**	**3.3**
hairy woodpecker	0.02	0	0	0	0.3	0	0	0	1.6	0	0	0
northern flicker	0.11	0.05	0.11	0.05	1.8	0.8	0.7	0.4	10.9	5.3	5.4	3.3
red-headed woodpecker	0	0.01	0.01	0	0	0.2	<0.1	0	0	1.2	1.2	0
Overall	**6.01**	**6.90**	**15.71**	**11.53**	**100**	**100**	**100**	**100**				

[a.] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

Avian Use Surveys for the Prevailing Winds Wind Project Bon Homme and Charles Mix Counties, South Dakota

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Year Two Final Draft Report

May 2016 – April 2017

Prepared for:

Prevailing Winds, LLC

Prepared by:

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February 16, 2018

EXECUTIVE SUMMARY

Prevailing Winds, LLC. (Prevailing Winds), has proposed a wind energy facility in Bon Homme and Charles Mix counties, South Dakota, referred to as the Prevailing Winds Wind Project (Project). Prevailing Winds contracted Western EcoSystems Technology, Inc. (WEST) to conduct field surveys developed in coordination with the US Fish and Wildlife Service (USFWS) and South Dakota Game Fish and Parks (SDGFP). Surveys were designed to assess wildlife resources in the Project area and assess risk to sensitive species by addressing the issues posed under Tier 3 of the USFWS Final Land-Based Wind Energy Guidelines. The following document contains results for the general fixed-point bird use surveys and incidental wildlife observations. A summary of all data collected is contained in the document, but the overall body of the report focuses on a smaller group of species – diurnal raptors, eagles, state/federally listed species, and South Dakota Sensitive Species (State Species of Concern [SSC] and State Species of Greatest Conservation Need [SGCN]).

The principal objectives of the fixed-point bird use surveys were to: 1) assess the relative abundance and spatial distribution of species in the Project area during all seasons, and 2) identify and assess the potential risk of adverse impacts to species or groups.

Fixed-point bird use surveys were conducted at 16 survey points from March 3, 2016 – April 19, 2017. This was the second year of surveys at the Project, but the survey area between Year One (March 25, 2015 – February 21, 2016) and Year Two changed significantly and thus the point count locations were modified in Year Two. Each survey plot was surveyed for 60 minutes (min). Every bird and/or unique bird species group observed during the first 20 min of each fixed-point bird use survey was recorded using two viewsheds: 800-meter (m; 2,625-feet [ft]) radius plot for large birds and 100-m (328-ft) radius plot for small birds, observations beyond the radius plots were excluded from analysis. Large birds included waterbirds, waterfowl, rails and coots, grebes and loons, gulls and terns, shorebirds, diurnal raptors, owls, vultures, upland game birds, doves/pigeons, large corvids (e.g., ravens, magpies, and crows), and goatsuckers. Passerines (excluding large corvids), kingfishers, swifts/hummingbirds, woodpeckers, and most cuckoos were considered small birds. During the next 40 min of the survey period, only eagles and state/federally listed species were recorded out to the 800-m radius.

A total of 205 fixed-point bird use surveys were conducted during 13 visits. During all surveys and incidental observations, no federally listed species were recorded but one state-listed species (peregrine falcon) was recorded. Thirteen bird species (great blue heron, bald eagle, Cooper's hawk, ferruginous hawk, sharp-shinned hawk, Swainson's hawk, American pelican, white-faced ibis, bufflehead, common merganser, golden eagle, merlin, and peregrine falcon]) listed as South Dakota SGCN and/or SSC were observed during fixed-point surveys and incidentally.

Diurnal raptor use at the Project during Year Two (0.33 raptors/800-m plot/20-min survey) was low compared to other US wind facilities and comparable to other wind energy facilities in the

Midwest with publicly available data and similar to Year One at the Project (0.31 raptors/800-m plot/20-min survey). Fatality monitoring data collected at wind projects in the Midwest suggest that some collision risk exists for individual raptors, but the level of impact is not likely to cause significant adverse impacts to overall species populations.

Significant adverse impacts to overall bird populations are not anticipated at the Project based on data collected at the site, review of available literature, and results of post-construction fatality monitoring at other wind energy facilities. Further post-construction survey effort should be determined in consultation with appropriate agencies to confirm the anticipated impacts.

STUDY PARTICIPANTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

In 2015, Prevailing Winds LLC originally contracted Western EcoSystems Technology, Inc. (WEST) to conduct field surveys in accordance with agency recommendations to quantify wildlife resources within the Prevailing Winds Wind Project (Project) in South Dakota. Year-round surveys were conducted by WEST in 2015 – 2016 within an initial assessment area of approximately 18,139.5 hectares (ha; 44,823.7 acres [ac]). A second year of biological surveys was conducted by WEST to address the issues posed under Tier 3, following guidance in the United States (US) Fish and Wildlife Service (FWS) *Final Land-Based Wind Energy Guidelines* (Guidelines; USFWS 2012) and *Eagle Conservation Plan Guidance* (Guidance; USFWS 2013), within a revised Project area being considered in 2016 (Figure 1). This report includes a summary for the Year Two survey efforts.

Fixed-point bird use surveys were conducted to achieve these principal objectives: 1) assess the relative abundance and spatial distribution of species in the Project area during an entire year, with emphasis on eagles, non-eagle raptors, and state/federally listed species, and 2) identify and assess the potential risk of adverse impacts to sensitive species or groups.

The following document contains results for the general fixed-point bird use surveys and incidental wildlife observations for the study period 2016 – 2017 (Year Two), with focus on eagles, non-eagle diurnal raptors, state/federally listed species, and State non-listed special-status species (i.e., State Species of Greatest Conservation Need [SGCN] and State Species of Concern [SSC]). A summary of the data collected during the 2015 – 2016 study period (Year One) is also included in this report.

STUDY AREA

The revised Project area used for surveys conducted in 2016 – 2017 encompassed approximately 14,981.40 ha (37,019.85 ac) in Bon Homme and Charles Mix counties, north of the town of Avon in southeastern South Dakota (Figure 1). The Project, located in a higher elevated area within the greater landscape, is characterized by a generally flat topography, with elevation ranging from 454.46 meters (m; 1,491.01 feet [ft]) – 573.72 m (1,882.28 ft; US Geological Survey [USGS] Digital Elevation Model 2017). The Project area, historically dominated by grasslands, has extensively been converted to agricultural use, with crop production and livestock grazing the primary practices (Bryce et al. 1998). Approximately half (47.5) % of the proposed Project area is cultivated crops followed by pasture/hay land (37.5%); grassland/herbaceous cover represent 6.7% of the Project area while all other land cover/land use types compose 4% or less of the Project area each (USGS National Land Cover Database 2011). As evidenced during the site visit conducted by WEST in 2015 of the general area, trees and woodlands are found mainly in planted shelter belts and within draws and on hillslopes; wetlands are scattered throughout the Project area (Figure 2), with the USFWS National Wetland Inventory (NWI) indicating approximately 528.08 ha (1,304.91 ac) of wetlands (USFWS NWI 2015).

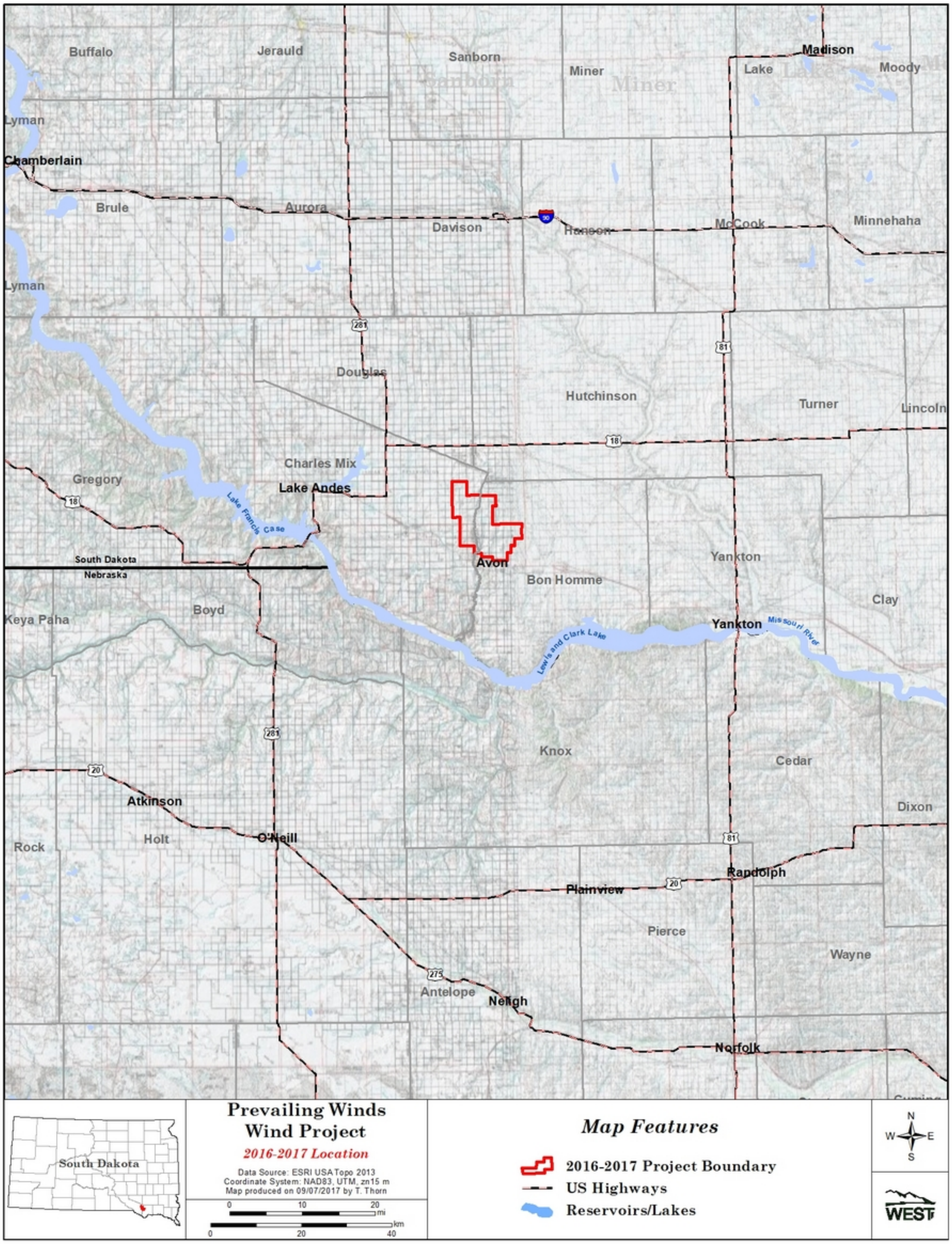

Figure 1. Location of the revised Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, for surveys conducted in 2016 – 2017.

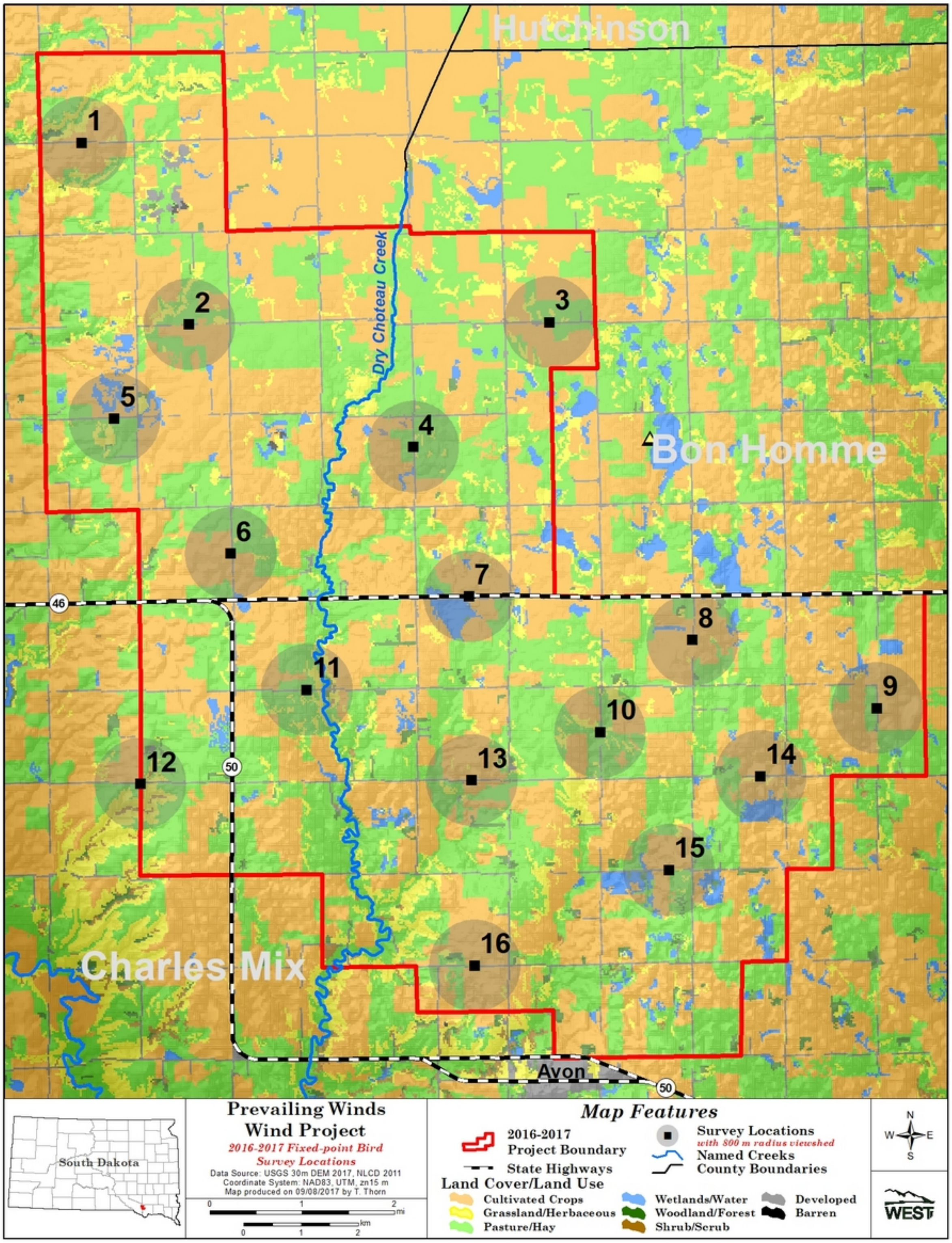

Figure 2. Land cover/Land use and location of the fixed-point plots selected for the Year Two bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017 (USFWS NLCD 2011, Homer et al. 2015).

METHODS

Fixed-Point Bird Use Surveys

Fixed-point bird use surveys (variable circular plots) were conducted using methods described by Reynolds et al. (1980), to estimate the seasonal and spatial use of the study area by birds, particularly diurnal raptors (defined here as kites, accipiters, buteos, harriers, eagles, falcons, and osprey [*Pandion haliaetus*]). Methodologies employed during avian use surveys conducted at the Project are generally comparable to those used at past wind energy facilities in South Dakota.

Survey Plots

Sixteen points were selected to survey representative habitats and topography of the Project, while achieving relatively even coverage of the study area (Figure 2). Each survey plot was an 800-m (2,625-ft) radius circle centered on the point; for analysis purposes, only birds within the 800-m radius were considered for analysis to allow comparison to other projects that used similar analyses.

Survey Methods

Each survey plot was surveyed for 60 minutes (min). Every bird and/or unique bird species group observed during the first 20 min of each fixed-point bird use survey was recorded by a unique observation number. During the next 40 min of the survey period, only eagles and state/federally listed species and state species of concern were recorded out to the 800-m radius. In some cases, the tally of observations may represent repeated sightings of the same individual. Observations of large birds beyond the 800-m radius were recorded but were not included in statistical analyses. For small birds, observations beyond the 100-m (328-ft) radius were excluded. Large birds included waterbirds, waterfowl, rails and coots, grebes and loons, gulls and terns, shorebirds, diurnal raptors, owls, vultures, upland game birds, doves/pigeons, large corvids (e.g., ravens, magpies, and crows), and goatsuckers. Passerines (excluding large corvids), kingfishers, swifts/hummingbirds, woodpeckers, and most cuckoos were considered small birds.

The date, start and end time of the survey period, and weather information (e.g., temperature, wind speed and direction, and cloud cover) were recorded for each survey. Species or best possible identification, number of individuals, sex and age class (if possible), distance from plot center when first observed, closest distance, altitude above ground, activity (behavior), and habitat(s) were recorded for each observation. Bird behavior and habitat type were recorded based on the point of first observation. Approximate flight height and distance from plot center at first observation were recorded to the nearest 5-m (16-ft) interval. Other information collected included whether the observation was auditory only and the 10-min interval of the survey in which the detection first occurred. Locations and flight paths, if applicable, of large birds were recorded during fixed-point bird use surveys on field maps by unique observation number. Data on eagle flight paths and habitat use (i.e., distance from observer, activity, and flight height) were recorded on a per min basis; comments were made when appropriate. Incidental wildlife observations were recorded while conducting all surveys, moving between fixed-point locations, and traveling within the Project. All raptors, listed species, and State sensitive bird species were documented.

Observation Schedule

Survey intensity (i.e., number of fixed-point circular plots and frequency of monitoring) was designed to document year-round use and behavior of birds in the Project area. Fixed-point bird use surveys were conducted approximately monthly for the year. The schedule was generally conducting even numbered points on one visit and then odd numbered points two week later. Surveys were carried out during daylight hours and survey periods varied to approximately cover all daylight hours during a season. To the extent practicable, each point was surveyed roughly the same number of times.

Statistical Analysis

For analysis purposes, a visit was defined as the required length of time, in days, to survey all of the plots once within the Project area. Under certain circumstances, such as extreme weather conditions, all plots may not have been surveyed during a visit. In these cases, a visit might not have constituted a survey of all plots.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures were implemented at all stages of the study, including in the field, during data entry and analysis, and report writing. Following field surveys, observers were responsible for inspecting data forms for completeness, accuracy, and legibility. Potentially erroneous data were identified using a series of database queries. Irregular codes or data suspected as questionable were discussed with the observer and/or project manager. Errors, omissions, and/or problems identified in later stages of analysis were traced back to the raw data forms, and appropriate changes in all steps were made.

Data Compilation and Storage

A Microsoft® MSSQL database was developed to store, organize, and retrieve survey data. Data were keyed into the electronic database using a pre-defined protocol to facilitate subsequent QA/QC and data analysis. All data forms and electronic data files were retained for reference.

Fixed-Point Bird Use Surveys

Bird Diversity and Species Richness

Bird diversity was illustrated by the total number of unique species observed. Species lists and counts, with the number of observations and the number of groups, were generated by season and included all observations of birds detected, regardless of their distance from the observer. In some cases, the tally of observations may represent repeated sightings of the same individual. Species richness was calculated for each season by first averaging the total number of species observed within each plot during a visit, then averaging across plots within each visit, followed by averaging across visits within each season. Overall species richness was calculated as a weighted average of seasonal values by the number of days in each season.

Mean Use, Percent of Use, and Frequency of Occurrence

Large birds detected within the 800-m radius plot and small birds recorded within the 100-m radius plot were used to calculate mean use and frequency of occurrence. The metric used for mean bird use was number of birds per plot (100-m radius plot for small birds, 800-m radius plot for large birds) per 20-min survey. Seasonal mean use was calculated by first averaging the total number of birds seen within each plot during a visit, then averaging across plots within each visit, followed by averaging across visits within each season. Overall mean use was calculated as a weighted average of seasonal values by the number of days in each season. Percent of use was calculated as the proportion of large or small bird use that was attributable to a particular bird type or species, and frequency of occurrence was calculated as the percent of surveys in which a particular bird type or species was observed. Frequency of occurrence, calculated as the percent of surveys in which a particular bird type or species was observed, provides a relative measure of species exposure to the proposed Project.

Bird Flight Height and Behavior

Bird flight heights are important metrics to assess potential exposure. Flight height information was used to calculate the percentage of birds observed flying within the rotor-swept heights (RSH; estimated to be between 25 – 200 m [82 –656 ft] above ground level). The flight height recorded when the bird was first observed was used to calculate the percentage of birds flying within the RSH and mean flight height. The percentage of birds flying within the RSH at any time (e.g., first 20-min for all birds, entire 60-min for eagles) was calculated using the lowest and highest flight heights recorded. Auditory only observations were excluded from flight height calculations.

Spatial Use

Spatial use of the Project area was evaluated using mean use by survey point. For each species and bird group, the number of individuals observed at each point during the 20-min survey was divided by the total number of surveys at that point.

RESULTS

Surveys were completed within the Project area from May 3, 2016 – April 19, 2017. Summary statistics for the full suite of species observed in the Project area are presented in Appendix A. Results related to eagles, non-eagle raptors, federally/state-listed species (Endangered Species Act [ESA] 1973, South Dakota Game, Fish and Parks [SDGFP] 2016, USFWS 2017), and State sensitive species (SGCN [SDGFP 2014] and SSC [SDGFP 2017]), are more thoroughly covered in the body of this report.

Fixed-Point Bird Use Surveys

Bird Diversity and Species Richness

A total of 205 fixed-point bird use surveys were conducted during 13 visits to the Project area during Year Two surveys: 47 surveys in spring, 63 in summer, 47 in fall, and 48 in winter (Table 1). Ninety unique bird species were observed during the entire duration (60 min) of the fixed-point bird use surveys (Table 1). Bird diversity (the number of unique species observed for entire 60-min survey) was highest during the summer (60 species), followed by spring and fall (46 and 43, respectively), and was lowest in winter (18). Overall species richness (mean number of species/plot/20-min survey) was higher for small birds (2.64) compared to large birds (1.49), being lowest in the winter compared to all other seasons, for both large and small birds (0.38 and 0.94 species/plot/20-min survey, respectively).

Table 1. Number of visits, surveys, bird diversity (number of unique species for entire 60-minute [min] survey), and bird species richness (species/plot[a]/20-min survey) by season and overall, observed during the Year Two fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Season	Number of Visits	Number of Surveys Conducted	Bird Diversity	Bird Species Richness	
				Large Birds	Small Birds
Spring	3	47	46	2.86	2.50
Summer	4	63	60	1.48	4.43
Fall	3	47	43	1.48	2.32
Winter	3	48	18	0.38	0.94
Overall	**13**	**205**	**90**	**1.49**	**2.64**

[a] 800-meter (m; 2,625-foot [ft]) radius plot for large birds; 100-m (328-ft) radius plot for small birds

A total of 9,276 observations in 1,090 separate groups (defined as one or more individuals) were recorded during the first 20 min of the Year Two fixed-point bird use surveys (Appendix A1). Regardless of bird size, two identified species (2.2% of all species) accounted for approximately one-third (29%) of all observations: common grackle (*Quiscalus quiscula*; 1,590 observations in 30 groups) and red-winged blackbird (*Agelaius phoeniceus*; 1,105 observations in 84 groups). All other species each accounted for less than 6% of the total observations.

Waterfowl accounted for the majority (2,095 observations within 79 groups) of large bird observations, with snow goose (*Chen caerulescens*) being the most abundant waterfowl species (499 observations within eight groups). Waterbirds composed 1.5% (140 observations) of the total bird observations, with sandhill cranes (111 observations in five groups) being the most abundant waterbird species recorded during bird use surveys. Passerines accounted for the majority (5,855 observations within 681 groups) of small bird observations, with common grackle accounting for the majority of those observations (Appendix A1).

Sixty-nine diurnal raptor observations within 61 groups were recorded during the first 20 min of the Year Two fixed-point bird use surveys conducted at the Project, representing five unique species (Table 2; Appendix A1). Red-tailed hawk (*Buteo jamaicensis*; 34 observations in 32 groups) and northern harrier (*Circus cyaneus*; 11 observations in 10 groups) were the most commonly observed raptor species, accounting for 49.3% and 15.9% of all raptor observations, respectively. One state-listed (SDGFP 2016) species (peregrine falcon [*Falco peregrinus*]) was recorded during Year Two of 60-min fixed-point bird use surveys conducted at the Project; no federally listed (ESA 1973) species were observed during the study period.

Table 2. Number of groups and individuals of diurnal raptors observed, regardless of distance from observer, during the first 20 minutes of the Year Two fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

		Spring		Summer		Fall		Winter		Total	
Raptor Subtype/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
Diurnal Raptors		**19**	**24**	**11**	**13**	**25**	**26**	**6**	**6**	**61**	**69**
Accipiters		*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*1*	*1*
Cooper's hawk[a]	*Accipiter cooperii*	0	0	1	1	0	0	0	0	1	1
Buteos		*13*	*13*	*10*	*12*	*13*	*13*	*3*	*3*	*39*	*41*
red-tailed hawk	*Buteo jamaicensis*	12	12	9	11	11	11	0	0	32	34
rough-legged hawk	*Buteo lagopus*	0	0	0	0	2	2	3	3	5	5
unidentified buteo	*Buteo spp*	1	1	1	1	0	0	0	0	2	2
Northern Harrier		*3*	*4*	*0*	*0*	*7*	*7*	*0*	*0*	*10*	*11*
northern harrier	*Circus cyaneus*	3	4	0	0	7	7	0	0	10	11
Eagles		*1*	*4*	*0*	*0*	*1*	*1*	*2*	*2*	*4*	*7*
bald eagle[a,b]	*Haliaeetus leucocephalus*	1	4	0	0	1	1	2	2	4	7
Other Raptors		*2*	*3*	*0*	*0*	*4*	*5*	*1*	*1*	*7*	*9*
unidentified raptor		2	3	0	0	4	5	1	1	7	9
Overall Diurnal Raptors		**19**	**24**	**11**	**13**	**25**	**26**	**6**	**6**	**61**	**69**

Grps = Number of groups, # Obs = Number of observations

[a] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b] State Species of Greatest Conservation Need (SDGFP 2014)

Mean Use, Percent of Use, and Frequency of Occurrence

Mean bird use, percent of use, and frequency of occurrence by season for all bird types and species observed during the first 20 min of surveys are shown in Appendix A2; Table 3 shows a summary of mean use and frequency of occurrence by major bird type and species of concern. The highest overall large bird use occurred during spring (36.38 birds/800-m plot/20-min survey), followed by fall (20.11), winter (9.12), and summer (3.65; Appendix A2). Seasonal large bird use was largely driven by waterfowl in the spring and winter, and by shorebirds and waterbirds in the fall and summer, respectively (Appendix A2). Small bird use was lowest in the winter (6.79 birds/100-m plot/20-min survey) compared to any other season, and was largely driven by passerine use across seasons (Appendix A3).

Waterbird use ranged from 0.42 – 1.23 birds/800-m plot/20-min survey in the fall, spring and summer, with no waterbirds being recorded in the winter (Table 3). Of the four waterbird species observed, sandhill cranes (*Antigone canadensis*) were observed only in spring and summer (0.85 and 1.17 birds/800-m plot/20-min survey, respectively) and composed the majority of observations during those seasons; use by great blue heron (*Ardea herodias*), a SSC, was recorded in all seasons but winter, ranging from 0.02 – 0.06 birds/800-m plot/20-min survey (Appendix A2). Waterbirds were observed more frequently during the spring (10.6%) compared to fall (6.4%) and summer (4.8%; Table 3).

Diurnal raptor use was highest in the fall and spring (0.55 and 0.51 raptors/800-m plot/20-min survey, respectively), followed by summer (0.21), and winter (0.12; Table 3). Higher raptor use during the fall and spring was primarily due to use of the Project area by red-tailed hawks (0.23 and 0.25, respectively). Diurnal raptor use in the winter consisted of rough legged hawks (*Buteo lagopus*), bald eagles (*Haliaeetus leucocephalus*; a SGCN), and one unidentified raptor (Table 3, Appendices A1 and A2). Diurnal raptors were observed during 38.2% of fall and 33.9% of spring surveys compared to 15.9% of summer and 8.3% of winter surveys (Table 3).

Use by Cooper's hawk (*Accipiter cooperii*; a SSC) was observed exclusively during the summer (0.02 birds/800-m plot/20-min survey) and use by northern harriers was observed exclusively during fall and spring migration (0.15 and 0.09 birds/800-m plot/20-min survey, respectively). Bald eagles were observed in all seasons but summer during the first 20 min of fixed-point bird use surveys, and were the only eagle species observed during fixed-point bird use surveys conducted at the Project (Appendix A1). Use by bald eagles ranged from 0.02 – 0.08 birds/800-m plot/20-min survey (Appendix A2) and they were observed during 2.1% of spring, fall, and winter surveys (Table 3).

Passerine use was lowest during the winter (6.58 birds/100-m plot/20-min survey), compared to any other season (Table 3), and was largely due to use by horned larks (*Eremophila alperstris*; 5.54 birds/100-m plot/20-min survey; Appendix A3). Red-winged blackbird (*Agelaius phoeniceus*) had the highest use (13.19 birds/100-m plot/20-min survey) of passerine species observed in spring, while common grackle (*Quiscalus quiscula*) had the highest passerine use during the summer and fall (16.14 and 12.00, respectively; Appendix A3). Passerines were observed during 97.9% of spring surveys, 96.9% of summer surveys, 75.0% of fall surveys, and 62.5% of winter surveys (Appendix A3).

Table 3. Seasonal bird mean use and frequency of occurrence for waterbirds, waterfowl, passerines, diurnal raptor species, and sensitive species observed during the first 20 minutes of Year Two fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

	Mean Use[1]				**Frequency of Occurrence (%)**			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Waterbirds	**0.96**	**1.23**	**0.42**	**0**	**10.6**	**4.8**	**6.4**	**0**
great blue heron[a]	0.02	0.02	0.06	0	2.1	1.6	6.4	0
Waterfowl	**29.2**	**0.48**	**5.12**	**8.71**	**44.7**	**7.8**	**6.2**	**8.3**
bufflehead	0	0	0.25	0	0	0	2.1	0
Common merganser	0	0	0	0.02	0	0	0	2.1
Diurnal Raptors	**0.51**	**0.21**	**0.55**	**0.12**	**33.9**	**15.9**	**38.2**	**8.3**
Accipiters	*0*	*0.02*	*0*	*0*	*0*	*1.7*	*0*	*0*
Cooper's hawk[a]	0	0.02	0	0	0	1.7	0	0
Buteos	*0.28*	*0.19*	*0.28*	*0.06*	*23.3*	*14.3*	*25.4*	*6.2*
red-tailed hawk	0.25	0.17	0.23	0	21.1	12.7	21.2	0
rough-legged hawk	0	0	0.04	0.06	0	0	4.2	6.2
unidentified buteo	0.02	0.02	0	0	2.2	1.6	0	0
Northern Harrier	*0.09*	*0*	*0.15*	*0*	*6.4*	*0*	*14.9*	*0*
northern harrier	0.09	0	0.15	0	6.4	0	14.9	0
Eagles	*0.08*	*0*	*0.02*	*0.04*	*2.1*	*0*	*2.1*	*2.1*
bald eagle[a,b]	0.08	0	0.02	0.04	2.1	0	2.1	2.1
Other Raptors	*0.06*	*0*	*0.10*	*0.02*	*4.2*	*0*	*8.3*	*2.1*
unidentified raptor	0.06	0	0.10	0.02	4.2	0	8.3	2.1
Passerines	**22.10**	**28.8**	**35.31**	**6.58**	**97.9**	**96.9**	**75.0**	**62.5**

Note: Totals by bird type and overall might not correspond to the sum of individual species due to rounding

[1] 800-meter (m; 2,625-foot [ft]) radius plot for large birds; 100-m (328-ft) radius plot for small birds

[a] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b] State Species of Greatest Conservation Need (SDGFP 2014)

State/Federally Listed Species and Sensitive Species Observations

No federally listed species (ESA 1973) were observed during Year Two of fixed-point bird use surveys conducted in the Project area from May 3, 2016 – April 19, 2017 (Table 4). One peregrine falcon, a state-listed species, was observed during the 60-min fixed-point bird use surveys (Table 4) conducted in the fall of the Year Two surveys. Twelve non-listed special-status species were recorded during fixed-point bird use surveys and incidentally, including 24 bald eagles (a SGCN) within 15 groups, and one golden eagle (*Aquila chrysaetos*; a SSC) observed incidentally in the winter of 2016 (Table 4); both eagle species are further protected under the Bald and Golden Eagle Protection Act (1940). Two additional South Dakota SGCN were recorded during the Year Two survey period: ferruginous hawk (*Buteo regalis*; three observations within three groups), and American white pelican (*Pelecanus erythrorhynchos*; 10 observations within one group). The other eight non-listed special-status species observed were: great blue heron, white-faced ibis (*Plegadis chihi*), bufflehead (*Bucephala albeola*), common merganser (*Mergus merganser*), Cooper's hawk, merlin (*Falco columbarius*), sharp-shinned hawk (*Accipiter striatus*), and Swainson's hawk (*Buteo swainsoni*); see Species Specific Summaries section for a detailed discussion of these species.

Table 4. Sensitive species observed during fixed-point bird use surveys (FP)[a] and Incidentally (Inc.) within the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

			FP		Inc.		Total	
Species	**Scientific Name**	**Status**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
American white pelican	*Pelecanus erythrorhynchos*	SGCN, SSC	1	10	0	0	1	10
great blue heron	*Ardea herodias*	SSC	5	5	0	0	5	5
white-faced ibis	*Plegadis chihi*	SSC	1	1	0	0	1	1
bufflehead	*Bucephala albeola*	SSC	1	12	0	0	1	12
common merganser	*Mergus merganser*	SSC	2	10	0	0	2	10
bald eagle	*Haliaeetus leucocephalus*	SGCN, SSC, BGEPA	12	20	3	4	15	24
golden eagle	*Aquila chrysaetos*	SSC, BGEPA	0	0	1	1	1	1
Cooper's hawk	*Accipiter cooperii*	SSC	1	1	0	0	1	1
ferruginous hawk	*Buteo regalis*	SGCN	3	3	0	0	3	3
merlin	*Falco columbarius*	SSC	1	1	0	0	1	1
peregrine falcon	*Falco peregrinus*	SE, SGCN, SSC	1	1	0	0	1	1
sharp-shinned hawk	*Accipiter striatus*	SSC	2	2	0	0	2	2
Swainson's hawk	*Buteo swainsoni*	SSC	2	2	0	0	2	2

Grps = Number of groups, # Obs = Number of observations

[a] Within 60-minute (min) survey for large birds and 20-min survey for small birds

BGEPA = Bald and Golden Eagle Protection Act (1940)

SE = State Endangered,

SGCN = State Species of Greatest conservation Need (SDGFP 2014)

SSC = State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

Bird Flight Height and Behavior

Flight height characteristics, based on initial flight height observations and estimated use, were estimated for both bird types and species (Tables 5 and 6). During the 60-min fixed-point bird use surveys, 240 groups of large birds were observed flying within the 800-m radius plot, totaling 2,682 individuals. Although the percentage of large birds observed flying was evenly spread across flight height categories, the majority of waterbirds (78.1%) and shorebirds (84.1%) were recorded flying within the RSH, while approximately half (47.1%) of the waterfowl observations were recorded flying within the RSH for collision with turbine blades of 25 -- 200 m (82 – 656 ft) above ground level (Table 5). Diurnal raptors tended to fly within (53.6%) and below (39.3%) the RSH, with some subtype differences. The majority (61.9%) of flying buteos was recorded within the RSH, while the majority (90.0%) of harriers were recorded flying below the RSH and the majority (71.4%) of eagles were recorded flying within the RSH (Table 5).

During the first 20 min of the fixed-point bird use surveys, 326 groups of small birds were observed flying within the 100-m radius plot, totaling 3,098 individuals, mostly passerines (Table 5). Overall, 91.1% of flying small birds were recorded below the RSH (Table 5).

Table 5. Flight height (meters [m] above ground level), based on initial observation, characteristics by bird types and raptor subtypes observed during Year Two of the fixed-point bird use surveys[a] conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Bird Type/Subtype	# Groups Flying	# Obs Flying	Mean Flight Height (m)	% Obs Flying	% Within Flight Height Categories		
					< 25 m	25 - 200 m[b]	> 200 m
Loons/Grebes	0	0	0	0	0	0	0
Waterbirds	10	96	83.40	63.6	11.5	78.1	10.4
Waterfowl	54	1,621	77.76	77.0	20.9	47.1	32
Shorebirds	34	477	12.94	90.3	15.9	84.1	0
Gulls/Terns	7	194	25.43	100	90.2	9.8	0
Rails/Coots	0	0	0	0	0	0	0
Diurnal Raptors	72	84	72.31	91.3	39.3	53.6	7.1
Accipiters	*3*	*3*	*31.33*	*100*	*66.7*	*33.3*	*0*
Buteos	*40*	*42*	*62.83*	*91.3*	*38.1*	*61.9*	*0*
Northern Harrier	*9*	*10*	*14.11*	*90.9*	*90.0*	*10.0*	*0*
Eagles	*13*	*21*	*143.08*	*100*	*4.8*	*71.4*	*23.8*
Falcons	*2*	*2*	*8.50*	*100*	*100*	*0*	*0*
Unidentified Raptors	*5*	*6*	*119.00*	*66.7*	*50.0*	*33.3*	*16.7*
Vultures	6	6	50.33	66.7	66.7	33.3	0
Upland Game Birds	2	3	1.00	4.2	100	0	0
Doves/Pigeons	45	110	6.33	72.4	99.1	0.9	0
Large Corvids	10	91	9.20	91.0	100	0	0
Goatsuckers	0	0	0	0	0	0	0
Large Birds Overall	240	2,682	48.08	78.7	31.3	48.7	19.9
Passerines	320	3,092	7.64	64.4	91.1	8.9	0
Woodpeckers	5	5	3.80	38.5	100	0	0
Kingfishers	0	0	0	0	0	0	0
Unidentified Birds	1	1	10.00	3.2	100	0	0
Small Birds Overall[c]	326	3,098	7.59	63.9	91.1	8.9	0

Obs = Observations

[a] 800-meter (m; 2,625-foot [ft]) radius plot and 60 min survey for large birds; 100-m (328-ft) radius plot and 20 min survey for small birds

[b] The likely rotor-swept height for potential collision with a turbine blade, or 25 – 200 m (82 – 656 ft) above ground level

[c] Excluding large corvids

One-hundred percent of Swainson's hawks and common merganser groups were observed flying within RSH based on initial observation (Table 6) while half (50.0%) of sharp-shinned hawk groups were observed flying within RSH; 75.0% of bald eagle and 33.3% of ferruginous hawk groups were also observed flying within RSH. No other special-status species were observed flying within the RSH at any time (Table 6).

Table 6. Flight characteristics for non-listed special-status species observed[a] during Year Two of the fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Species	# Groups Flying	Overall Mean Use	% Flying	% Flying within RSH[b] Based on Initial Observation	% Within RSH at Any time
American white pelican	1	0.04	100	0	0
great blue heron	3	0.02	60.0	0	0
white-faced ibis	1	<0.01	100	0	0
bufflehead	0	0.06	0	0	0
common merganser	1	0.05	10	100	100
bald eagle[c]	12	0.09	100	75.0[c]	95.0
Cooper's hawk	1	<0.01	100	0	0
ferruginous hawk	3	0.01	100	33.3	33.3
merlin	1	<0.01	100	0	0
peregrine falcon	1	<0.01	100	0	0
sharp-shinned hawk	2	<0.01	100	50.0	50.0
Swainson's hawk	2	<0.01	100	100	100

[a] 800-meter (m; 2,625-foot [ft]) radius plot and 60 min survey for large birds; 100-m (328-ft) radius plot and 20 min survey for small birds

[b] The likely rotor-swept height (RSH) for potential collision with a turbine blade, or 25 – 200 m (82-656 ft) above ground level

[c] Does not include the one unidentified eagle observed during fixed-point bird use surveys.

Spatial Use

For all large bird species combined, use (focused within 800 m) was highest at Point 9 (47.15 birds/20-min survey) largely due to high waterfowl use at this point (32.08 birds/20-min survey). Waterfowl were observed at all but two points, with use ranging from 0.08 – 32.42 birds/20-min survey (Table 7). Large bird use at other points ranged from 2.62 – 39.17 birds/20-min survey. Waterbird use was observed at seven of the 16 points, ranging from 0.08 (at Point 6) – 5.46 (at Point 9) birds/20-min survey and shorebird use was recorded at all points, ranging from 0.15 – 23.54 birds/20-min survey. Diurnal raptors were observed at all points but one, with use largely driven by buteos and harriers (Table 7). Diurnal raptor use was highest at Point 9 (0.62 birds/20-min survey), and ranged from 0.08 – 0.54 birds/20-min survey at other points. Eagle use (for the observations included in analysis) occurred at Points 4, 9, and 13 (0.08, 0.31, and 0.15 birds/20-min survey, respectively), while accipiters were only observed at Point 8 (0.08 birds/20-min). Small bird use (focused within 100 m), was highest at Point 8 (101.67 birds/20-min survey), and ranged from 4.08 – 84.15 birds/20-min surveys at all other points; small bird use at all points was mostly due to use by passerines (Table 7).

Eagle Use and Flight Paths

Overall, there were 205 hours (12,300 min) of eagle fixed-point use surveys (60-min surveys) conducted at the Project (Table 8) during Year Two. During this time, 20 bald eagles were visible for 135 min and one unidentified eagle for eight min. The majority of total eagle minutes as well as eagle risk minutes were accounted for during one 60-min survey on March 5, 2017 along the eastern edge of the Project at Point 9. During the survey one group of four and one group of five bald eagles were observed for a total of 72 total eagle minutes and 43 eagle risk minutes. The unidentified eagle was recorded at Point 12 after the initial 20-min survey period. Thirteen of the 20 bald eagle observations were observed after the initial 20-min survey period, including the individuals recorded at Points 7 and 15. Flight paths for bald eagles at the Project showed no apparent pattern (Figure 3).

Table 7. Mean use recorded at each survey point during the first 20 minutes of Year Two fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

	Mean Use (number of birds/20-minute survey)^{a} by Survey Point															
Bird Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Loons/Grebes	**0**	**0**	**0**	**0**	**0**	**0**	**0.38**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Waterbirds	**0**	**0**	**0**	**0**	**0.46**	**0.08**	**1.85**	**0**	**5.46**	**0.23**	**2.31**	**0**	**0.38**	**0**	**0**	**0**
Waterfowl	**17.85**	**16.67**	**3.46**	**5.62**	**4.62**	**0.92**	**12.31**	**32.42**	**32.08**	**15.46**	**0**	**7.69**	**0**	**1.23**	**15.75**	**0.08**
Shorebirds	**0.31**	**0.17**	**23.54**	**0.54**	**0.92**	**1.46**	**0.62**	**0.58**	**8.54**	**0.23**	**0.15**	**0.23**	**1.92**	**0.31**	**0.50**	**0.69**
Gulls/Terns	**0.77**	**3.33**	**0**	**0**	**2.54**	**0**	**7.85**	**0**	**0**	**0.69**	**0**	**0**	**0**	**0**	**0**	**0**
Rails/Coots	**0**	**0**	**0.08**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Diurnal Raptors	**0.46**	**0.42**	**0.08**	**0.54**	**0.23**	**0.23**	**0.23**	**0.17**	**0.62**	**0.46**	**0.46**	**0.54**	**0.54**	**0.15**	**0**	**0.23**
Accipiters	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.08*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Buteos	*0.31*	*0.25*	*0*	*0.38*	*0.08*	*0.15*	*0.15*	*0.08*	*0.08*	*0.31*	*0.38*	*0.46*	*0.31*	*0.15*	*0*	*0.08*
Northern Harrier	*0.08*	*0.17*	*0*	*0.08*	*0.15*	*0.08*	*0.08*	*0*	*0.08*	*0.08*	*0.08*	*0*	*0*	*0*	*0*	*0*
Eagles	*0*	*0*	*0*	*0.08*	*0*	*0*	*0*	*0*	*0.31*	*0*	*0*	*0*	*0.15*	*0*	*0*	*0*
Unidentified Raptors	*0.08*	*0*	*0.08*	*0*	*0*	*0*	*0*	*0*	*0.15*	*0.08*	*0*	*0.08*	*0.08*	*0*	*0*	*0.15*
Vultures	**0**	**0.08**	**0**	**0.15**	**0.08**	**0**	**0**	**0**	**0**	**0**	**0**	**0.23**	**0**	**0.08**	**0.08**	**0**
Upland Game Birds	**0.92**	**0.25**	**0.15**	**0.23**	**0.23**	**0.31**	**0.23**	**0.17**	**0.23**	**0.15**	**0.15**	**0.31**	**0.15**	**0.31**	**0.33**	**1.38**
Doves/Pigeons	**0.23**	**0.50**	**0.08**	**0.46**	**0.08**	**0.08**	**0.46**	**0.83**	**0.23**	**1.31**	**4**	**0.46**	**2.08**	**0.54**	**0.25**	**0.23**
Large Corvids	**0**	**0**	**0**	**0.15**	**0.15**	**0**	**0.08**	**5.00**	**0**	**0.08**	**0.08**	**0.38**	**0**	**0**	**2.17**	**0.15**
Goatsuckers	**0.08**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Overall large birds	**20.62**	**21.42**	**27.38**	**7.69**	**9.31**	**3.08**	**24.00**	**39.17**	**47.15**	**18.62**	**7.15**	**9.85**	**5.08**	**2.62**	**19.08**	**2.77**
Passerines	**8.77**	**18.50**	**6.08**	**7.00**	**10.62**	**12.85**	**18.77**	**101.42**	**10**	**37.62**	**23.92**	**11.00**	**4.00**	**15.15**	**9.83**	**83.92**
Woodpeckers	**0**	**0**	**0**	**0.08**	**0**	**0**	**0.08**	**0.17**	**0.08**	**0.08**	**0**	**0.23**	**0.08**	**0.15**	**0.08**	**0**
Kingfishers	**0**	**0**	**0**	**0**	**0**	**0**	**0.08**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Unidentified Birds	**0.23**	**0.17**	**0**	**0.15**	**0.15**	**0.23**	**0.15**	**0.08**	**0.15**	**0**	**0**	**0**	**0**	**0.08**	**0.83**	**0.23**
Overall small birds	**9.00**	**18.67**	**6.08**	**7.23**	**10.77**	**13.08**	**19.08**	**101.67**	**10.23**	**37.69**	**23.92**	**11.23**	**4.08**	**15.38**	**10.75**	**84.15**

800-m (m; 2,625-foot [ft]) radius plot for large birds; 100-m (328-ft) radius plot for small birds

Table 8. Survey effort, number of eagle observations and groups, total eagle minutes (min), risk minutes, and eagle use by season, observed during Year Two of the 60-min bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Season	Survey Effort (hours)	Number of Eagle Observations	Number of Groups	Total Eagle Minutes	Risk Minutes[a]	Eagle Use[b]
Bald Eagle						
Spring	47	14	6	75	45	0.29
Summer	63	2	2	25	6	0.03
Fall	47	1	1	8	5	0.02
Winter	48	3	3	27	14	0.06
Overall Bald Eagle	**205**	**20**	**12**	**135**	**70**	
Unidentified Eagle						
Spring	47	0	0	0	0	0
Summer	63	0	0	0	0	0
Fall	47	1	1	8	8	0.02
Winter	48	0	0	0	0	0
Overall Unidentified Eagle	**205**	**1**	**1**	**8**	**8**	**0**

[a] Where eagles flew below 200 meters (m) above ground level and within 800 m of the observer

[b] Eagles/800-m plot/60 minutes

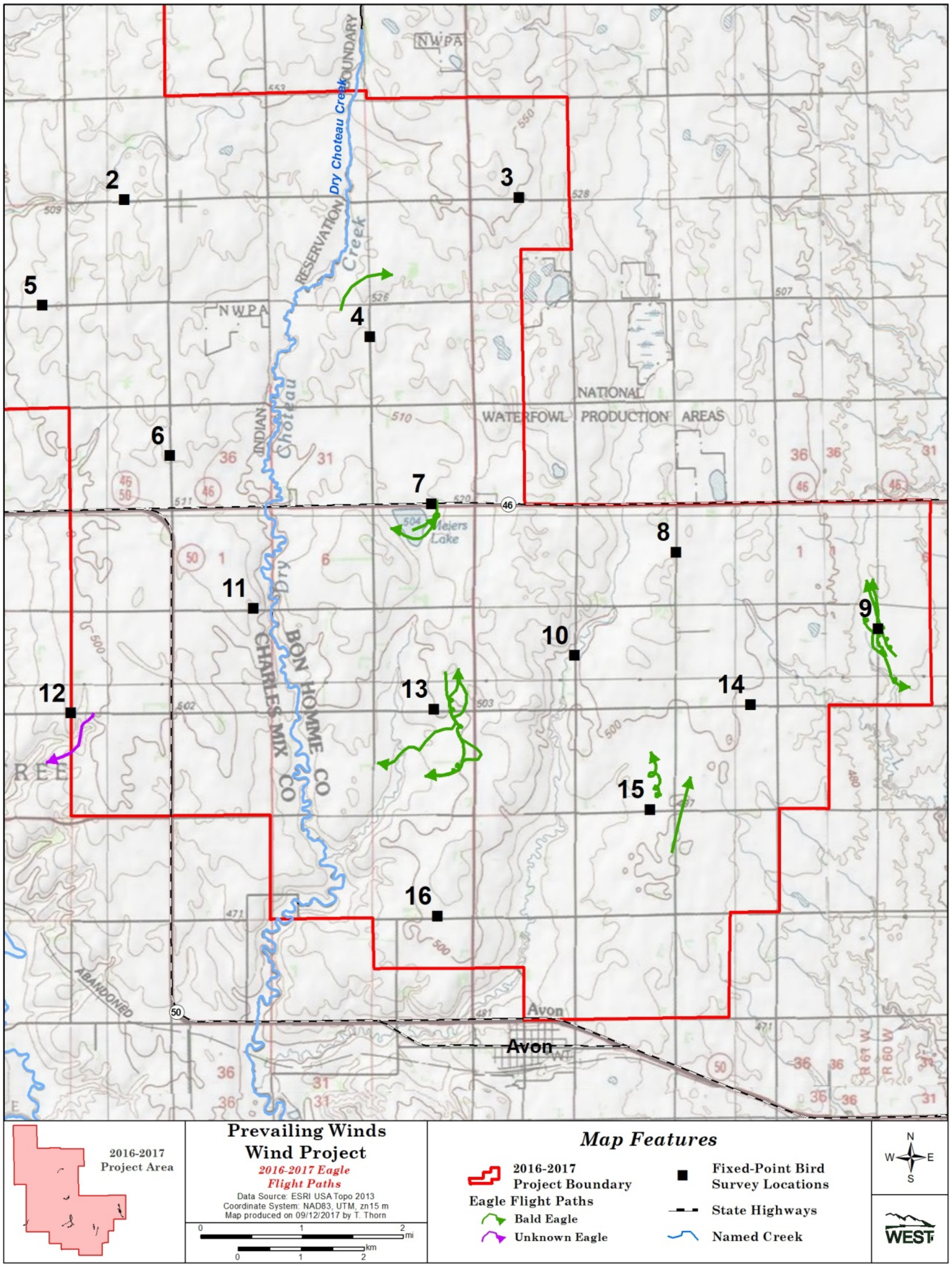

Figure 3. Eagle flight paths observed during the Year Two 60-minute fixed-point bird use surveys conducted at the at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Incidental Observations

Thirty-six unique bird species and 10 unidentified species were observed incidentally at the Project, totaling 4,029 birds within 379 separate groups (Table 9). Sandhill crane (763 birds within seven groups) and Canada goose (*Branta canadensis*; 400 birds within 19 groups) were the most abundant incidental species observed at the Project (Table 9). Six unique and four unidentified diurnal raptor species were recorded incidentally during the Year Two survey period, totaling 177 individuals within 164 groups. Red-tailed hawk was the most abundant (114 birds within 104 groups) diurnal raptor recorded incidentally; American kestrel (*Falco sparverius*) and golden eagle were only observed incidentally, with three and one observations, respectively (Table 9).

Table 9. Incidental wildlife observed while conducting all surveys at the at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Species	Scientific Name	# Groups	# Individuals
double-crested cormorant	*Phalacrocorax auritus*	2	2
sandhill crane	*Antigone canadensis*	7	763
blue-winged teal	*Anas discors*	3	13
cackling goose	*Branta hutchinsii*	14	289
Canada goose	*Branta canadensis*	19	400
Canvasback[a]	*Aythya valisineria*	2	33
greater white-fronted goose	*Anser albifrons*	5	87
Mallard	*Anas platyrhynchos*	8	30
northern pintail	*Anas acuta*	1	5
northern shoveler	*Anas clypeata*	1	1
redhead[a]	*Aythya americana*	1	50
ring-necked duck	*Aythya collaris*	1	20
Ross' goose[a]	*Chen rossii*	6	88
ruddy duck	*Oxyura jamaicensis*	2	12
snow goose	*Chen caerulescens*	6	332
unidentified duck		6	25
unidentified goose		3	1,196
unidentified waterfowl		4	54
Killdeer	*Charadrius vociferus*	26	40
upland sandpiper	*Bartramia longicauda*	7	7
Bonaparte's gull[a]	*Chroicocephalus philadelphia*	2	26
Franklin's gull	*Leucophaeus pipixcan*	2	60
ring-billed gull	*Larus delawarensis*	8	60
unidentified gull		2	22
American kestrel[a]	*Falco sparverius*	3	3
bald eagle	*Haliaeetus leucocephalus*	3	4
golden eagle[a]	*Aquila chrysaetos*	1	1
northern harrier	*Circus cyaneus*	17	18
rough-legged hawk	*Buteo lagopus*	9	9
red-tailed hawk	*Buteo jamaicensis*	104	114
unidentified accipiter	*Accipiter spp*	4	4
unidentified buteo	*Buteo spp*	6	7
unidentified eagle		2	2
unidentified raptor		15	15
turkey vulture	*Cathartes aura*	15	24
ring-necked pheasant	*Phasianus colchicus*	24	31

Table 9. Incidental wildlife observed while conducting all surveys at the at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Species	Scientific Name	# Groups	# Individuals
wild turkey	*Meleagris gallopavo*	2	12
Eurasian collared-dove	*Streptopelia decaocto*	2	2
rock pigeon	*Columba livia*	5	16
American crow	*Corvus brachyrhynchos*	22	94
American robin	*Turdus migratorius*	1	2
blue jay	*Cyanocitta cristata*	2	3
northern shrike	*Lanius excubitor*	1	1
unidentified blackbird		1	50
northern flicker	*Colaptes auratus*	1	1
unidentified large bird		1	1
Total		**379**	**4,029**

[a] Species that were only 0bserved incidentally.

DISCUSSION

The Guidelines use a tiered approach to assess impacts to species and their habitats, and avian use surveys are one of a suite of Tier 3 studies used to inform risk at the Project. Tier 3 studies were targeted to address questions regarding impact that could not be sufficiently addressed using available literature (i.e., Tiers 1 and 2 desktop analyses). These studies provide additional data that, when combined with available literature reviewed in previous Tiers, allow for a confident assessment of the risk of significant population-level adverse impacts to sensitive species; identify measures to mitigate significant adverse impacts, if necessary; and/or identify a need for more field studies, if the current survey effort did not provide sufficient data to adequately characterize the potential for significant adverse impacts to such species. While the avian use surveys reported herein were conducted across all species observed, the report focuses on a smaller group of species – diurnal raptors, eagles, listed species, and State sensitive species.

The impact of wind energy development on birds can be direct or indirect. Direct impacts include fatalities or injury associated with facility infrastructure and the loss of habitat where infrastructure is placed. Indirect impacts include the displacement of wildlife and rendering habitat unsuitable through fragmentation of the landscape.

The focus of this study was mainly to document large bird use with an emphasis on eagles and diurnal raptors. The majority (86%) of all bird observations during this study were waterfowl or passerine species. The most common waterfowl species were snow and greater-white fronted geese, while the most common passerine species were common grackle and red-winged blackbird. Waterbirds composed a small percentage of the total bird observations, with sandhill cranes being the most abundant waterbird species recorded during bird use surveys. Relatively few (69 observations) diurnal raptors were observed during standardized surveys and 177 were recorded incidentally. The most common diurnal raptor species was red-tailed hawk, documented both incidentally and during scheduled surveys; golden eagles were documented only incidentally within the Project area, while bald eagles were documented both incidentally and during fixed-point bird use surveys. One State-listed species (the State-endangered peregrine falcon) was documented during the Year Two survey period; no federally listed species were documented within the Project area during the survey period. Diurnal raptors and State sensitive species are discussed in more detail below;

Diurnal Raptors

Annual mean diurnal raptor use at the Project was 0.33 raptors/800-m plot/20-min survey, with highest use in the fall and spring, likely from an influx of migrating raptors. Mean raptor use was compared with other wind energy facilities that implemented similar protocols and had data covering similar seasons, ranking 33rd from the highest compared to the 47 other wind energy facilities in North America (Figure 4).

Publicly available data containing both mean raptor use and raptor fatality information in the Midwest is scarce, while data having this information for four seasons is even rarer (Table 10). The Beethoven Project, immediately adjacent to the Project, had a mean raptor use of 0.103 raptors/800-m plot/20-min survey (Derby and Thorn 2014) and a raptor fatality rate of 0.07 fatalities/MW/year (WEST 2016; Table 10). The Wessington Springs Project, approximately 80 miles north of the project, in South Dakota had a mean raptor use of 0.23 raptors/800-m plot/20-min survey and raptor fatality rates of 0.06 and 0.07 fatalities/MW/year during two separate years of fatality monitoring (Derby et al. 2010f, 2011d). Raptor fatality rates reported at other South Dakota wind energy facilities have ranged from 0 – 0.20 fatalities/MW/year (Table 10). Raptor fatality rates throughout the Midwest have ranged from zero at numerous facilities to 0.47 fatalities/MW/year at Buffalo Ridge, Phase I (Johnson et al. 2000a).

In the Midwest states, 55 diurnal raptor fatalities representing seven species have been documented at wind energy facilities in publicly available fatality studies. Red-tailed hawks represented most of the fatalities (38 fatalities; 69.1% of raptor fatalities), followed by American kestrel (five fatalities; 9.1% of raptor fatalities), sharp-shinned hawk (four fatalities; 7.3% of raptor fatalities), rough-legged hawk (three fatalities; 5.5% of raptor fatalities), and Cooper's hawk (two fatalities; 3.6% of raptor fatalities). Each of the remaining species (merlin, Swainson's hawk, and unidentified raptor) accounted for one fatality each. These are unadjusted, raw data. Cumulative fatalities and species are from data compiled by WEST from publicly available fatality studies (a list of facilities and references are available from WEST). Based on the currently available data, raptor fatality rates in the Project will likely be similar to other wind energy facilities in the Midwest that also have low raptor use and are likely to consist of the relatively common and widespread species documented in this survey.

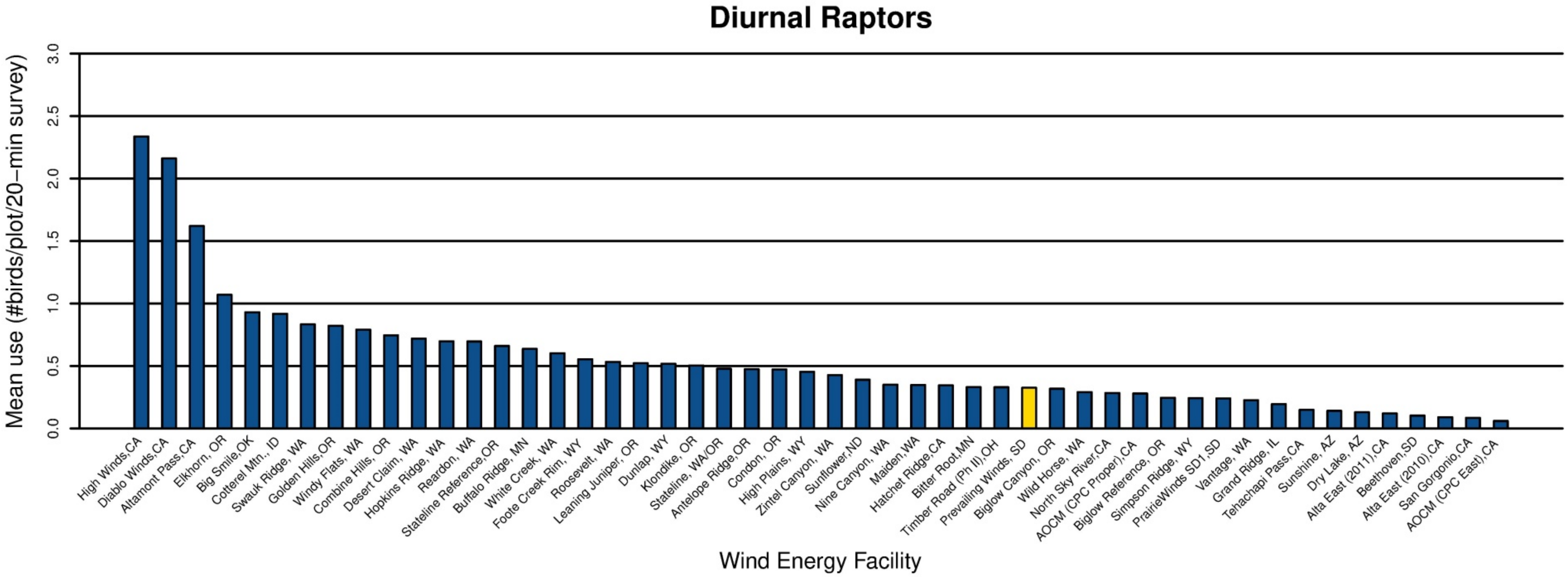

Figure 4. Comparison of estimated annual diurnal raptor use during the Year Two of the fixed-point bird use surveys conducted at the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017, and diurnal raptor use at other US wind resource areas with comparable raptor use data.

Data from the following sources:

Study and Location	Reference	Study and Location	Reference	Study and Location	Reference
Prevailing Winds, SD	This study.				
High Winds, CA	Kerlinger et al. 2005	Foote Creek Rim, WY	Johnson et al. 2000b	Wild Horse, WA	Erickson et al. 2003d
Diablo Winds, CA	WEST 2006	Roosevelt, WA	NWC and WEST 2004	North Sky River, CA	Erickson et al. 2011
Altamont Pass, CA	Orloff and Flannery 1992	Leaning Juniper, OR	Kronner et al. 2005	AOCM (CPC Proper), CA	Chatfield et al. 2010
Elkhorn, OR	WEST 2005a	Dunlap, WY	Johnson et al. 2009a	Biglow Reference, OR	WEST 2005c
Big Smile (Dempsey), OK	Derby et al. 2010a	Klondike, OR	Johnson et al. 2002	Simpson Ridge, WY	Johnson et al. 2000b
Cotterel Mtn., ID	BLM 2006	Stateline, WA/OR	Erickson et al. 2003a	Vantage, WA	Jeffrey et al. 2007
Swauk Ridge, WA	Erickson et al. 2003b	Antelope Ridge, OR	WEST 2009	Grand Ridge, IL	Derby et al. 2009
Golden Hills, OR	Jeffrey et al. 2008	Condon, OR	Erickson et al. 2002b	Tehachapi Pass, CA	Anderson et al. 2000, Erickson et al. 2002b
Windy Flats, WA	Johnson et al. 2007	High Plains, WY	Johnson et al. 2009b	Sunshine, AZ	WEST and the CPRS 2006
Combine Hills, OR	Young et al. 2003c	Zintel Canyon, WA	Erickson et al. 2002a, 2003c	Dry Lake, AZ	Young et al. 2007b
Desert Claim, WA	Young et al. 2003b	Nine Canyon, WA	Erickson et al. 2001	Alta East (2011), CA	Chatfield et al. 2011
Hopkins Ridge, WA	Young et al. 2003a	Maiden, WA	Young et al. 2002	Alta East (2010), CA	Chatfield et al. 2011
Reardon, WA	WEST 2005b	Hatchet Ridge, CA	Young et al. 2007a	San Gorgonio, CA	Anderson et al. 2000, Erickson et al. 2002b
Stateline Reference, OR	URS et al. 2001	Bitter Root. MN	Derby and Dahl 2009	AOCM (CPC East), CA	Chatfield et al. 2010
Buffalo Ridge, MN	Johnson et al. 2000a	Timber Road (Phase II), OH	Good et al. 2010	Beethoven, SD	Derby and Thorn 2014
White Creek, WA	NWC and WEST 2005	Biglow Canyon, OR	WEST 2005c		

Table 10. Raptor use (number of raptors/plot/20-minute survey) and fatality (number of bird fatalities/megawatt/year) estimates for wind-energy facilities in the Midwest with publicly available data.

Project Name	Raptor Use Estimate	Raptor Fatality Estimate	Total #of Turbines	Total MW	Use Reference	Fatality Reference
Barton I & II, IA (2010-2011)	NA	0	80	160.0		Derby et al. 2011a
Beethoven (2016-2016)	0.103	0.07	43	80.0	Derby and Thorn 2014	WEST 2016
Big Blue, MN (2013)	NA	0	18	36.0		Fagen Engineering 2014
Big Blue, MN (2014)	NA	0	18	36.0		Fagen Engineering 2015
Blue Sky Green Field, WI (2008; 2009)	NA	0	88	145.0		Gruver et al. 2009
Buffalo Ridge I, SD (2009-2010)	NA	0.20	24	50.4		Derby et al. 2010b
Buffalo Ridge II, SD (2011-2012)	NA	0	105	210.0		Derby et al. 2012a
Buffalo Ridge, MN (Phase I; 1996)	NA	0	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase I; 1997)	NA	0	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase I; 1998)	NA	0	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase I; 1999)	NA	0.47	73	25.0		Johnson et al. 2000a
Buffalo Ridge, MN (Phase II; 1998)	NA	0	143	107.3		Johnson et al. 2000a
Buffalo Ridge, MN (Phase II; 1999)	NA	0	143	107.3		Johnson et al. 2000a
Buffalo Ridge, MN (Phase III; 1999)	NA	0	138	103.5		Johnson et al. 2000a
Cedar Ridge, WI (2009)	NA	0.18	41	67.6		BHE Environmental 2010
Cedar Ridge, WI (2010)	NA	0.13	41	68.0		BHE Environmental 2011
Elm Creek II, MN (2009-2010)	NA	0	67	100.0		Derby et al. 2010c
Elm Creek, MN (20011-2012)	NA	0	62	148.8		Derby et al. 2012b
Fowler I, IN (2009)	NA	0	162	301.0		Johnson et al. 2010
Grand Ridge I, IL (2009-2010)	0.2	0	66	99.0	Derby et al. 2009	Derby et al. 2010g
Kewaunee County, WI (1999-2001)	NA	0	31	20.5		Howe et al. 2002
Moraine II, MN (2009)	NA	0.37	33	49.5		Derby et al. 2010d
NPPD Ainsworth, NE (2006)	NA	0.06	36	20.5		Derby et al. 2007
Pioneer Prairie II, IA (2011-2012)	NA	0	62	102.3		Chodachek et al. 2012
PrairieWinds ND1 (Minot), ND (2010)	NA	0.05	80	115.5		Derby et al. 2011c
PrairieWinds ND1 (Minot), ND (2011)	NA	0.05	80	115.5		Derby et al. 2012c
PrairieWinds SD1, SD (2011-2012)	NA	0	108	162.0		Derby et al. 2012d
PrairieWinds SD1, SD (2012-2013)	NA	0.03	108	162.0		Derby et al. 2013
PrairieWinds SD1, SD (2013-2014)	NA	0.17	108	162.0		Derby et al. 2014
Rail Splitter, IL (2012-2013)	NA	0	67	100.5		Good et al. 2013
Ripley, Ont (2008)	NA	0.10	38	76.0		Jacques Whitford 2009
Rugby, ND (2010-2011)	NA	0.06	71	149.0		Derby et al. 2011b
Top of Iowa, IA (2003)	NA	0	89	80.0		Jain 2005
Top of Iowa, IA (2004)	NA	0.17	89	80.0		Jain 2005
Wessington Springs, SD (2009)	0.23	0.06	34	51.0	Derby et al. 2008	Derby et al. 2010f

Table 10. Raptor use (number of raptors/plot/20-minute survey) and fatality (number of bird fatalities/megawatt/year) estimates for wind-energy facilities in the Midwest with publicly available data.

Project Name	Raptor Use Estimate	Raptor Fatality Estimate	Total #of Turbines	Total MW	Use Reference	Fatality Reference
Wessington Springs, SD (2010)	0.23	0.07	34	51.0	Derby et al. 2008	Derby et al. 2011d
Winnebago, IA (2009-2010)	NA	0.27	10	20.0		Derby et al. 2010e

This fixed-point bird use survey was designed to provide a relative index of use by raptors during all seasons at the Project. While mean diurnal raptor use was higher during the fall and spring (0.55 and 0.51 raptors/800-m plot/20-min survey), probably due to an influx of migrant birds, the Project is not located within a known raptor migration corridor, and there are no features unique to the Project area, as compared to adjacent areas, that would appear to attract large numbers of diurnal raptors. Furthermore, raptor fatality rates reported from studies in the Midwest are typically low. Site-specific and regional data suggest there is some potential for raptor mortality, but these potential impacts to individuals are unlikely to cause significant adverse impacts to raptor populations. Likewise, there is some potential for habitat loss and displacement of individuals, but the resources available within the Project area are widely available at the local landscape level; therefore, any diurnal raptor habitat loss and displacement attributable to the Project is unlikely to result in significant adverse population-level impacts to raptors.

While abundance is intuitively connected to raptor fatality risk to some degree, risk is likely influenced by other factors as well, such as species-specific flight behaviors. Diurnal raptors were observed flying within all three fleight height categories; although the majority (53.6%) of diurnal raptors were observed flying within RSH, some differences were observed among raptor suptypes. A higher proportion of buteos and eagles flew within the RSH compared to other raptor types, while most of the harriers were observed flying below RSH, potentially indicating that some species may have a higher risk for collision; however, many of these are based on a few individual observations.

Species-Specific Summaries

American white Pelican, white-faced ibis, bufflehead, and common merganser

A single flock of 10 American white pelicans was recorded flying over the Project area in the spring; one white-faced ibis was recorded flying over the Project area in the summer; one group of 12 bufflehead was recorded using open water habitats within the Project area in the fall; and two common merganser groups, totaling 10 individuals, were observed flying over or using open water habitats within the Project area in the winter and spring. The limited number of sightings suggests that the Project area is not a major stopover or breeding area for any of these non-listed special-status species. Furthermore, habitats within the Project area are not unique in the general region, thus development of the Project would likely have minimal population-level impacts.

Great blue heron

Five great blue herons, a common summer resident and migrant in South Dakota, were recorded during the surveys conducted at the Project. Site-specific data indicate that use of the Project area by this species is low and population-level effects from Project development are unlikely.

Bald and golden eagles

A total of 24 bald eagle observations (20 during 60-min surveys and regardless of distance from observer, and four incidentally) were recorded within the Project area during Year Two surveys conducted from May 3, 2016 – April 19, 2017 (Table 4). The majority of total eagle minutes were accounted for during one survey in spring 2017 when two groups, totaling nine individual bald eagles, were observed at Point 9 for 72 total minutes. The majority (71.4%) of flying bald eagles recorded during fixed-point bird use surveys were observed within the RSH (Table 5). Bald eagles are uncommon in migration, summer, and winter throughout South Dakota; however, they are locally common below the Missouri River dams in winter and nesting within the State is increasingly reported (South Dakota Birds, Birding, and Nature 2017).

One golden eagle was recorded incidentally in the winter of 2016; no golden eagle nests were recorded during raptor nest surveys conducted in April of 2016, with most golden eagle nesting habitat in South Dakota found in the western portion of the state. Golden eagles are generally found on wide open prairies in the western half of the US (All About Birds 2017). In South Dakota, golden eagles are very often found on the Fort Pierre National Grasslands, located approximately 289.7 km (180 mi) northwest of the Project area, especially in winter and migration (South Dakota Birds, Birding, and Nature 2017).

The number and timing of eagle observations recorded during Year Two of the fixed-point bird use surveys suggest that year-round eagle use is expected. The presence of active bald eagle nests in the vicinity of the Project (Derby 2016) indicates bald eagles are present in the general area for an extended period of time (breeding season). Thus, development of the Project may influence individuals moving through or using the Project area, but given low use and apparent relatively low susceptibility of bald eagles to turbine impacts, potential impact to bald eagle populations appears minimal.

Swainson's and Ferruginous Hawk

There were two observations of Swainson's and three observations of ferruginous hawks during the Year Two study period (Table 4). Both of the Swainson's hawk observations were of flying individuals within the RSH and one of the three ferruginous hawk observations were within the RSH (Table 6). Swainson's hawks are common in South Dakota and utilize a variety of habitats, including open grasslands with occasional trees and shrubs, wetland edges, and agriculture fields, nesting in trees, shrubs, or occasionally on the ground (South Dakota Birds, Birding, and Nature 2017). Ferruginous hawk, an uncommon migrant and summer resident, is rarely observed in winter, and inhabits grasslands and open areas (South Dakota Birds, Birding, and Nature 2017).

The potential for individual mortality does exist for both species; however, the low number of fatalities reported throughout projects in the Midwest (one Swainson's hawk and no ferruginous hawk fatalities out of 55 total reported fatalities) suggests that these species are not particularly susceptible to turbine collisions in the Midwest. Collision mortality may affect a few individuals, but are unlikely to cause significant adverse impacts to either populations of the species.

Sharp-shinned and Cooper's Hawk

Two sharp-shinned hawks and one Cooper's hawk were recorded during the study period (Table 4). Both are an uncommon migrant in South Dakota, generally preferring wooded areas (South Dakota Birds, Birding, and Nature 2017). Only two Cooper's hawks and no sharp-shinned hawks have been found as fatalities through projects in the Midwest. Collision mortality may affect a few individuals of these species, but significant population-level impacts are unlikely.

Peregrine Falcon

Peregrine falcons, listed as endangered in the state of South Dakota, can be found in a variety of habitats, including tundra, moorlands, steppe, and seacoasts, especially where there are suitable nesting cliffs, mountains, open forested regions, and human population centers (All About Birds 2017). When not breeding, they occur in areas where prey concentrate, including farmlands, marshes, lakeshores, river mouths, tidal flats, dunes and beaches, broad river valleys, cities, and airports. Still uncommon throughout most of its former range, reintroduction programs and natural reproduction are resulting in slowly increasing numbers and range (South Dakota Birds, Birding, and Nature 2017). In 2017, the SDGFP confirmed that two pairs of peregrine falcons successfully nested in the Black Hills of South Dakota, located approximately 300 miles west of the Project (Capital Journal 2017).

One juvenile peregrine falcon was recorded during the Year Two fixed-point bird use surveys, using grassland habitats within the Project area during the fall of 2016. Peregrine falcons have been reported in the general region where the Project is located, the closest one recorded on April of 2017 in Bon Homme County along the Missouri River, approximately 20 km (12.4 mi) to the southeast of the Project area (eBird 2017). Significant use of the Project area is unlikely due to the lack of nesting habitat and negative impacts from Project development are not expected.

YEAR ONE AND YEAR TWO SURVEYS COMPARISON SUMMARY

Ninety unique bird species were recorded during Year Two of bird use surveys compared to 72 unique bird species recorded in Year One of surveys conducted at the Project area, mainly due to a higher number of species recorded in the summer of 2016 – 2017 (60 unique species) compared to the summer of 2015 – 2016 (43 unique species). Temporal patterns of bird use were similar between years, with summer having the highest overall use, followed by migration seasons, and use being the lowest during winter. Species richness patterns were also similar between years, with overall species richness being higher for small birds compared to large birds; however, small bird species richness recorded in Year Two was almost twice as the small bird species richness recorded during Year One of surveys (2.64 and 1.64 mean number of species/plot/20-min survey, respectively).

Passerines were the most recorded bird type in both Year One and Year Two of surveys; two species composed approximately one-third (29%) of all observations in Year Two, compared to six species that composed approximately half (52%) of all observation in Year One, with red-winged blackbird being one of the most common species in both years. Waterfowl accounted for the majority of large bird observations in both years, with snow geese being the most recorded waterfowl species in Year Two and Canada geese being the most recorded waterfowl species in Year One. Waterbirds accounted for 1.5% of the total bird observations in Year Two with four species; they composed 9% of the total bird observations in Year One with only two species. Sandhill cranes were the most recorded waterbird species in both years.

Sixty-nine diurnal raptor observations within 61 groups were recorded in Year Two, compared to 89 within 83 groups Year One. Number of unique diurnal raptor species was similar between years (five in Year Two and eight in Year One); diurnal raptor species composition was similar between years, with red-tailed hawk and northern harrier being the most recorded diurnal raptor species. Diurnal raptor species composition varied between years, with American kestrel, Swainson's hawk, and northern goshawk recorded only in Year One. Peregrine falcon was recorded only during Year Two surveys and golden eagle was observed (incidentally) only during the Year Two survey period.

Patterns of bird use varied seasonally between years. Large Bird use was highest in the spring and lowest in the summer in both years; small bird use patterns were different between years, with winter bird use being the lowest compared to any other season during Year Two surveys and the second highest during Year One surveys. Frequency of occurrence of waterbirds was similar between years, but mean use patterns were different, with waterbird use being recorded in all seasons but winter during Year Two surveys and only migration seasons during Year One surveys; almost 10 times less waterbird use was recorded in spring of Year Two surveys compared to Year One.

Diurnal raptor use was highest in the fall during both years; spring use was the second highest during Year Two and the lowest during Year One surveys. Species-specific patterns of use were different between years, with use by Cooper's hawk being observed only in the summer of Year Two surveys, and both the fall and winter of Year One surveys. Bald eagle use was observed in all seasons but summer during Year Two surveys, and only in the winter during Year One surveys. Winter passerine use was lowest compared to any other season during Year Two surveys and was the second highest during Year One surveys.

Spatial patterns of bird use were similar between years. Although use by point varied annually and seasonally, large bird use by point was largely driven by waterfowl (generally high across points) and shorebirds (lower but consistent across points). Diurnal raptors were observed at all points but one, with use largely driven by buteos and harriers.

Diurnal raptor use at the Project was low during both years (0.33 and 0.31 raptors/800-m plot/20-min survey during Year Two and Year One, respectively), compared to other US wind facilities and comparable to other wind energy facilities in the Midwest with publicly available data. Eagle use was different between years, being higher in Year Two (20 bald eagles for a total of 135 min) compared to Year One (four bald eagles for a total of 15 min). It is unknown why eagle use was higher in Year Two compared to Year One, but most use was focused on just a one day during migration in Year Two at point 9. Based on current Project design, Point 9 is no longer part of the planned Project area.

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Appendix A. Descriptive Statistics for Bird Species Recorded during Year Two of Fixed-Point Bird Use Surveys Conducted at the Prevailing Winds Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year Two fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

		Spring		Summer		Fall		Winter		Total	
Type/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
Loons/Grebes		**0**	**0**	**0**	**0**	**1**	**5**	**0**	**0**	**1**	**5**
unidentified grebe		0	0	0	0	1	5	0	0	1	5
Waterbirds		**6**	**46**	**4**	**74**	**5**	**20**	**0**	**0**	**15**	**140**
double-crested cormorant	*Phalacrocorax auritus*	1	4	0	0	2	17	0	0	3	21
glossy ibis	*Plegadis falcinellus*	0	0	2	3	0	0	0	0	2	3
great blue heron[a]	*Ardea herodias*	1	1	1	1	3	3	0	0	5	5
sandhill crane	*Antigone canadensis*	4	41	1	70	0	0	0	0	5	111
Waterfowl		**45**	**1,400**	**16**	**31**	**8**	**246**	**10**	**418**	**79**	**2,095**
blue-winged teal	*Anas discors*	5	10	7	12	0	0	0	0	12	22
bufflehead[a]	*Bucephala albeola*	0	0	0	0	1	12	0	0	1	12
cackling goose	*Branta hutchinsii*	3	74	0	0	0	0	0	0	3	74
Canada goose	*Branta canadensis*	4	21	0	0	0	0	2	8	6	29
common merganser[a]	*Mergus merganser*	0	0	0	0	0	0	1	1	1	1
greater white-fronted goose	*Anser albifrons*	2	129	0	0	0	0	2	350	4	479
green-winged teal	*Anas crecca*	0	0	1	1	1	2	0	0	2	3
mallard	*Anas platyrhynchos*	9	12	5	12	2	201	3	17	19	242
northern pintail	*Anas acuta*	2	10	0	0	0	0	0	0	2	10
northern shoveler	*Anas clypeata*	0	0	2	3	0	0	0	0	2	3
ring-necked duck	*Aythya collaris*	2	28	0	0	0	0	0	0	2	28
ruddy duck	*Oxyura jamaicensis*	0	0	0	0	1	1	0	0	1	1
snow goose	*Chen caerulescens*	7	496	1	3	0	0	0	0	8	499
unidentified duck		4	95	0	0	0	0	0	0	4	95
unidentified goose		4	480	0	0	0	0	0	0	4	480
unidentified waterfowl		3	45	0	0	3	30	2	42	8	117
Shorebirds		**41**	**58**	**20**	**26**	**12**	**443**	**1**	**1**	**74**	**528**
killdeer	*Charadrius vociferus*	41	58	18	23	7	21	0	0	66	102
unidentified shorebird		0	0	0	0	5	422	1	1	6	423
upland sandpiper	*Bartramia longicauda*	0	0	2	3	0	0	0	0	2	3
Gulls/Terns		**4**	**83**	**1**	**1**	**2**	**110**	**0**	**0**	**7**	**194**
Franklin's gull	*Leucophaeus pipixcan*	3	82	0	0	1	10	0	0	4	92
Herring gull	*Larus argentatus*	0	0	1	1	0	0	0	0	1	1
ring-billed gull	*Larus delawarensis*	1	1	0	0	0	0	0	0	1	1
unidentified gull		0	0	0	0	1	100	0	0	1	100

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year Two fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

		Spring		Summer		Fall		Winter		Total	
Type/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
Rails/Coots		**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**
American coot	*Fulica americana*	0	0	1	1	0	0	0	0	1	1
Diurnal Raptors		**19**	**24**	**11**	**13**	**25**	**26**	**6**	**6**	**61**	**69**
Accipiters		*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*1*	*1*
Cooper's hawk[a]	*Accipiter cooperii*	0	0	1	1	0	0	0	0	1	1
Buteos		*13*	*13*	*10*	*12*	*13*	*13*	*3*	*3*	*39*	*41*
red-tailed hawk	*Buteo jamaicensis*	12	12	9	11	11	11	0	0	32	34
rough-legged hawk	*Buteo lagopus*	0	0	0	0	2	2	3	3	5	5
unidentified buteo	*Buteo spp*	1	1	1	1	0	0	0	0	2	2
Northern Harrier		*3*	*4*	*0*	*0*	*7*	*7*	*0*	*0*	*10*	*11*
northern harrier	*Circus cyaneus*	3	4	0	0	7	7	0	0	10	11
Eagles		*1*	*4*	*0*	*0*	*1*	*1*	*2*	*2*	*4*	*7*
bald eagle[a,b,c]	*Haliaeetus leucocephalus*	1	4	0	0	1	1	2	2	4	7
Other Raptors		*2*	*3*	*0*	*0*	*4*	*5*	*1*	*1*	*7*	*9*
unidentified raptor		2	3	0	0	4	5	1	1	7	9
Vultures		**1**	**1**	**5**	**7**	**1**	**1**	**0**	**0**	**7**	**9**
turkey vulture	*Cathartes aura*	1	1	5	7	1	1	0	0	7	9
Upland Game Birds		**29**	**44**	**9**	**10**	**9**	**16**	**1**	**1**	**48**	**71**
ring-necked pheasant	*Phasianus colchicus*	27	28	9	10	8	9	1	1	45	48
wild turkey	*Meleagris gallopavo*	2	16	0	0	1	7	0	0	3	23
Doves/Pigeons		**10**	**16**	**39**	**61**	**12**	**68**	**1**	**7**	**62**	**152**
Eurasian collared-dove	*Streptopelia decaocto*	0	0	6	8	1	1	0	0	7	9
mourning dove	*Zenaida macroura*	8	12	33	53	7	27	0	0	48	92
rock pigeon	*Columba livia*	2	4	0	0	4	40	1	7	7	51
Large Corvids		**8**	**68**	**1**	**1**	**4**	**26**	**5**	**5**	**18**	**100**
American crow	*Corvus brachyrhynchos*	8	68	1	1	4	26	5	5	18	100
Passerines		**166**	**1,054**	**321**	**1,829**	**137**	**2,655**	**57**	**317**	**681**	**5,855**
alder flycatcher	*Empidonax alnorum*	0	0	1	1	0	0	0	0	1	1
American goldfinch	*Spinus tristis*	0	0	13	13	10	19	4	15	27	47
American robin	*Turdus migratorius*	14	25	16	21	13	52	5	8	48	106
American tree sparrow	*Spizella arborea*	0	0	0	0	0	0	2	7	2	7
Baltimore oriole	*Icterus galbula*	0	0	2	2	0	0	0	0	2	2
barn swallow	*Hirundo rustica*	4	5	24	63	0	0	0	0	28	68

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year Two fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

Type/Species	Scientific Name	Spring		Summer		Fall		Winter		Total	
		# Grps	# Obs	# Grps	# Obs	# Grps	# Obs	# Grps	# Obs	# Grps	# Obs
blue jay	*Cyanocitta cristata*	0	0	4	4	6	8	0	0	10	12
bobolink	*Dolichonyx oryzivorus*	0	0	5	5	0	0	0	0	5	5
Brewer's blackbird	*Euphagus cyanocephalus*	0	0	1	4	2	3	0	0	3	7
brown-headed cowbird	*Molothrus ater*	10	16	29	64	8	293	0	0	47	373
brown thrasher	*Toxostoma rufum*	1	1	3	4	1	1	0	0	5	6
clay-colored sparrow	*Spizella pallida*	0	0	0	0	1	1	0	0	1	1
cliff swallow	*Petrochelidon pyrrhonota*	1	25	25	127	3	35	0	0	29	187
common grackle	*Quiscalus quiscula*	6	18	17	1,032	7	540	0	0	30	1,590
common yellowthroat	*Geothlypis trichas*	0	0	5	5	0	0	0	0	5	5
dickcissel	*Spiza americana*	0	0	13	15	0	0	0	0	13	15
eastern bluebird	*Sialia sialis*	1	1	2	2	0	0	1	5	4	8
eastern kingbird	*Tyrannus tyrannus*	1	2	26	45	0	0	0	0	27	47
European starling	*Sturnus vulgaris*	5	14	0	0	7	238	0	0	12	252
field sparrow	*Spizella pusilla*	1	1	3	3	0	0	0	0	4	4
horned lark	*Eremophila alpestris*	13	39	1	1	11	80	35	266	60	386
house finch	*Haemorhous mexicanus*	0	0	2	2	0	0	0	0	2	2
house sparrow	*Passer domesticus*	0	0	4	15	0	0	0	0	4	15
house wren	*Troglodytes aedon*	0	0	1	1	1	1	0	0	2	2
Lincoln's sparrow	*Melospiza lincolnii*	0	0	1	1	0	0	0	0	1	1
marsh wren	*Cistothorus palustris*	0	0	4	4	0	0	0	0	4	4
northern shrike	*Lanius excubitor*	0	0	0	0	1	1	2	2	3	3
orchard oriole	*Icterus spurius*	0	0	3	3	0	0	0	0	3	3
red-winged blackbird	*Agelaius phoeniceus*	23	631	45	235	16	239	0	0	84	1,105
Savannah sparrow	*Passerculus sandwichensis*	1	1	0	0	0	0	0	0	1	1
snow bunting	*Plectrophenax nivalis*	0	0	0	0	0	0	6	12	6	12
song sparrow	*Melospiza melodia*	2	2	7	7	3	53	0	0	12	62
spotted towhee	*Pipilo maculatus*	0	0	1	1	0	0	0	0	1	1
swamp sparrow	*Melospiza georgiana*	0	0	1	1	0	0	0	0	1	1
tree swallow	*Tachycineta bicolor*	2	3	0	0	0	0	0	0	2	3
unidentified blackbird		6	92	0	0	12	998	0	0	18	1,090
unidentified sparrow		3	9	1	1	10	36	1	1	15	47
vesper sparrow	*Pooecetes gramineus*	3	3	5	6	1	3	0	0	9	12
western bluebird	*Sialia mexicana*	0	0	2	2	0	0	0	0	2	2
western kingbird	*Tyrannus verticalis*	0	0	2	2	0	0	0	0	2	2

Appendix A1. Summary of individuals and group observations, regardless of distance from observer, by bird type and species recorded during the first 20 minutes of Year Two fixed-point bird use surveys conducted in the Prevailing Winds Wind Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

		Spring		Summer		Fall		Winter		Total	
Type/Species	**Scientific Name**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**	**# Grps**	**# Obs**
western meadowlark	*Sturnella neglecta*	67	150	42	49	24	54	1	1	134	254
yellow-headed blackbird	*Xanthocephalus xanthocephalus*	2	16	6	82	0	0	0	0	8	98
yellow warbler	*Setophaga petechia*	0	0	4	6	0	0	0	0	4	6
Goatsuckers		**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**1**
common nighthawk	*Chordeiles minor*	0	0	1	1	0	0	0	0	1	1
Woodpeckers		**1**	**1**	**6**	**6**	**7**	**8**	**0**	**0**	**14**	**15**
downy woodpecker	*Picoides pubescens*	0	0	0	0	1	1	0	0	1	1
northern flicker	*Colaptes auratus*	0	0	2	2	4	5	0	0	6	7
red-bellied woodpecker	*Melanerpes carolinus*	0	0	2	2	0	0	0	0	2	2
red-headed woodpecker	*Melanerpes erythrocephalus*	1	1	2	2	2	2	0	0	5	5
Kingfishers		**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**1**
belted kingfisher	*Megaceryle alcyon*	0	0	0	0	1	1	0	0	1	1
Unidentified Birds		**9**	**16**	**0**	**0**	**3**	**13**	**8**	**11**	**20**	**40**
unidentified bird (small)		9	16	0	0	3	13	8	11	20	40
Overall		**339**	**2,811**	**435**	**2,061**	**227**	**3,638**	**89**	**766**	**1,090**	**9,276**

Grps = Number of groups, # Obs = Number of observations

[a.] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b.] State Species of Greatest Conservation Need (SDGFP 2014)

[c.] Bald and Golden Eagle Protection Act (1940)

Appendix A2. Mean large bird use (number of large birds/800-meter radius plot/20-minute survey), percent of total use, and frequency of occurrence for each large bird type and species by season during Year Two of the fixed-point bird use surveys conducted at the Prevailing Winds Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

	Mean Use				Percent of Use (%)				Frequency of Occurrence (%)			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Loons/Grebes	**0**	**0**	**0.1**	**0**	**0**	**0**	**0.5**	**0**	**0**	**0**	**2.1**	**0**
unidentified grebe	0	0	0.1	0	0	0	0.5	0	0	0	2.1	0
Waterbirds	**0.96**	**1.23**	**0.42**	**0**	**2.6**	**33.7**	**2.1**	**0**	**10.6**	**4.8**	**6.4**	**0**
double-crested cormorant	0.09	0	0.35	0	0.2	0	1.8	0	2.2	0	4.2	0
glossy ibis	0	0.05	0	0	0	1.3	0	0	0	3.1	0	0
great blue heron[a]	0.02	0.02	0.06	0	<0.1	0.4	0.3	0	2.1	1.6	6.4	0
sandhill crane	0.85	1.17	0	0	2.3	32	0	0	6.2	1.7	0	0
Waterfowl	**29.2**	**0.48**	**5.12**	**8.71**	**80.3**	**13.3**	**25.5**	**95.4**	**44.7**	**7.8**	**6.2**	**8.3**
blue-winged teal	0.22	0.19	0	0	0.6	5.1	0	0	11.1	6.2	0	0
bufflehead[a]	0	0	0.25	0	0	0	1.2	0	0	0	2.1	0
cackling goose	1.54	0	0	0	4.2	0	0	0	6.2	0	0	0
Canada goose	0.44	0	0	0.17	1.2	0	0	1.8	8.5	0	0	2.1
common merganser[a]	0	0	0	0.02	0	0	0	0.2	0	0	0	2.1
greater white-fronted goose	2.69	0	0	7.29	7.4	0	0	79.9	4.2	0	0	2.1
green-winged teal	0	0.02	0.04	0	0	0.4	0.2	0	0	1.6	2.1	0
mallard	0.26	0.19	4.19	0.35	0.7	5.1	20.8	3.9	17.1	3.1	4.2	4.2
northern pintail	0.21	0	0	0	0.6	0	0	0	4.2	0	0	0
northern shoveler	0	0.05	0	0	0	1.3	0	0	0	3.1	0	0
ring-necked duck	0.58	0	0	0	1.6	0	0	0	4.2	0	0	0
ruddy duck	0	0	0.02	0	0	0	0.1	0	0	0	2.1	0
snow goose	10.34	0.05	0	0	28.4	1.3	0	0	10.6	1.6	0	0
unidentified duck	1.98	0	0	0	5.4	0	0	0	8.5	0	0	0
unidentified goose	10	0	0	0	27.5	0	0	0	8.3	0	0	0
unidentified waterfowl	0.94	0	0.62	0.88	2.6	0	3.1	9.6	6.2	0	2.1	4.2
Shorebirds	**1.21**	**0.41**	**9.26**	**0.02**	**3.3**	**11.3**	**46**	**0.2**	**52.2**	**30.2**	**25.8**	**2.1**
killdeer	1.21	0.37	0.47	0	3.3	10.1	2.3	0	52.2	28.6	15.4	0
unidentified shorebird	0	0	8.79	0.02	0	0	43.7	0.2	0	0	10.4	2.1
upland sandpiper	0	0.05	0	0	0	1.3	0	0	0	3.1	0	0
Gulls/Terns	**1.77**	**0.02**	**2.29**	**0**	**4.9**	**0.5**	**11.4**	**0**	**8.5**	**1.7**	**4.2**	**0**
Franklin's gull	1.75	0	0.21	0	4.8	0	1	0	6.4	0	2.1	0
Herring gull	0	0.02	0	0	0	0.5	0	0	0	1.7	0	0
ring-billed gull	0.02	0	0	0	<0.1	0	0	0	2.1	0	0	0
unidentified gull	0	0	2.08	0	0	0	10.4	0	0	0	2.1	0
Rails/Coots	**0**	**0.02**	**0**	**0**	**0**	**0.4**	**0**	**0**	**0**	**1.6**	**0**	**0**
American coot	0	0.02	0	0	0	0.4	0	0	0	1.6	0	0

Appendix A2. Mean large bird use (number of large birds/800-meter radius plot/20-minute survey), percent of total use, and frequency of occurrence for each large bird type and species by season during Year Two of the fixed-point bird use surveys conducted at the Prevailing Winds Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

	Mean Use				**Percent of Use (%)**				**Frequency of Occurrence (%)**			
Type/Species	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Diurnal Raptors	**0.51**	**0.21**	**0.55**	**0.12**	**1.4**	**5.7**	**2.7**	**1.4**	**33.9**	**15.9**	**38.2**	**8.3**
Accipiters	*0*	*0.02*	*0*	*0*	*0*	*0.5*	*0*	*0*	*0*	*1.7*	*0*	*0*
Cooper's hawk[a]	0	0.02	0	0	0	0.5	0	0	0	1.7	0	0
Buteos	*0.28*	*0.19*	*0.28*	*0.06*	*0.8*	*5.2*	*1.4*	*0.7*	*23.3*	*14.3*	*25.4*	*6.2*
red-tailed hawk	0.25	0.17	0.23	0	0.7	4.8	1.2	0	21.1	12.7	21.2	0
rough-legged hawk	0	0	0.04	0.06	0	0	0.2	0.7	0	0	4.2	6.2
unidentified buteo	0.02	0.02	0	0	<0.1	0.4	0	0	2.2	1.6	0	0
Northern Harrier	*0.09*	*0*	*0.15*	*0*	*0.2*	*0*	*0.7*	*0*	*6.4*	*0*	*14.9*	*0*
northern harrier	0.09	0	0.15	0	0.2	0	0.7	0	6.4	0	14.9	0
Eagles	*0.08*	*0*	*0.02*	*0.04*	*0.2*	*0*	*0.1*	*0.5*	*2.1*	*0*	*2.1*	*2.1*
bald eagle[a,b,c]	0.08	0	0.02	0.04	0.2	0	0.1	0.5	2.1	0	2.1	2.1
Other Raptors	*0.06*	*0*	*0.1*	*0.02*	*0.2*	*0*	*0.5*	*0.2*	*4.2*	*0*	*8.3*	*2.1*
unidentified raptor	0.06	0	0.1	0.02	0.2	0	0.5	0.2	4.2	0	8.3	2.1
Vultures	**0.02**	**0.11**	**0.02**	**0**	**<0.1**	**3.1**	**0.1**	**0**	**2.2**	**8**	**2.2**	**0**
turkey vulture	0.02	0.11	0.02	0	<0.1	3.1	0.1	0	2.2	8	2.2	0
Upland Game Birds	**0.93**	**0.16**	**0.34**	**0.02**	**2.6**	**4.4**	**1.7**	**0.2**	**53.8**	**12.7**	**19**	**2.1**
ring-necked pheasant	0.6	0.16	0.19	0.02	1.7	4.4	0.9	0.2	51.7	12.7	16.8	2.1
wild turkey	0.33	0	0.16	0	0.9	0	0.8	0	4.2	0	2.2	0
Doves/Pigeons	**0.34**	**0.98**	**1.45**	**0.15**	**0.9**	**26.8**	**7.2**	**1.6**	**17.2**	**49.5**	**15**	**2.1**
Eurasian collared-dove	0	0.13	0.02	0	0	3.5	0.1	0	0	8	2.2	0
mourning dove	0.26	0.85	0.6	0	0.7	23.2	3	0	13.1	43	10.8	0
rock pigeon	0.08	0	0.83	0.15	0.2	0	4.1	1.6	4.2	0	6.2	2.1
Large Corvids	**1.42**	**0.02**	**0.54**	**0.1**	**3.9**	**0.5**	**2.7**	**1.1**	**14.7**	**1.7**	**2.1**	**6.2**
American crow	1.42	0.02	0.54	0.1	3.9	0.5	2.7	1.1	14.7	1.7	2.1	6.2
Goatsuckers	**0**	**0.02**	**0**	**0**	**0**	**0.4**	**0**	**0**	**0**	**1.6**	**0**	**0**
common nighthawk	0	0.02	0	0	0	0.4	0	0	0	1.6	0	0
Overall	**36.38**	**3.65**	**20.11**	**9.12**	**100**	**100**	**100**	**100**				

Note: Totals by bird type and overall might not correspond to the sum of individual species due to rounding

[a] State Species of Concern tracked by the South Dakota Natural Heritage Program (SDGFP 2017)

[b] State Species of Greatest Conservation Need (SDGFP 2014)

[c] Bald and Golden Eagle Protection Act (1940)

Appendix A3. Mean small bird use (number of large birds/100-meter plot/20-minute survey), percent of total use, and frequency of occurrence for each small bird type and species by season during Year Two of the fixed-point bird use surveys conducted at the Prevaling Winds Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

	Mean Use				Percent of Use (%)				Frequency of Occurrence %)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Passerines	**22.10**	**28.8**	**35.31**	**6.58**	**99.2**	**99.7**	**98.8**	**96.9**	**97.9**	**96.9**	**75.0**	**62.5**
alder flycatcher	0	0.02	0	0	0	<0.1	0	0	0	1.6	0	0
American goldfinch	0	0.21	0.41	0.31	0	0.7	1.2	4.6	0	21.2	21.9	6.2
American robin	0.53	0.34	0.40	0.17	2.4	1.2	1.1	2.5	21.2	23.8	10.8	8.3
American tree sparrow	0	0	0	0.15	0	0	0	2.1	0	0	0	2.1
Baltimore oriole	0	0.03	0	0	0	0.1	0	0	0	3.1	0	0
barn swallow	0.11	1.00	0	0	0.5	3.4	0	0	8.8	31.7	0	0
blue jay	0	0.07	0.04	0	0	0.2	0.1	0	0	6.6	4.4	0
bobolink	0	0.08	0	0	0	0.3	0	0	0	6.2	0	0
Brewer's blackbird	0	0.07	0.07	0	0	0.2	0.2	0	0	1.7	4.4	0
brown-headed cowbird	0.36	1.00	6.51	0	1.6	3.5	18.2	0	15.6	36.1	15.6	0
brown thrasher	0.02	0.06	0.02	0	<0.1	0.2	<0.1	0	2.2	4.8	2.2	0
clay-colored sparrow	0	0	0.02	0	0	0	<0.1	0	0	0	2.2	0
cliff swallow	0.56	2.06	0.78	0	2.5	7.1	2.2	0	2.2	38.5	6.7	0
common grackle	0.38	16.14	12.00	0	1.7	55.9	33.6	0	8.3	22.4	11.1	0
common yellowthroat	0	0.08	0	0	0	0.3	0	0	0	7.9	0	0
dickcissel	0	0.23	0	0	0	0.8	0	0	0	17.2	0	0
eastern bluebird	0.02	0.03	0	0.10	<0.1	0.1	0	1.5	2.1	3.3	0	2.1
eastern kingbird	0.04	0.71	0	0	0.2	2.5	0	0	2.2	34.6	0	0
European starling	0.29	0	0.8	0	1.3	0	2.2	0	10.4	0	10.7	0
field sparrow	0.02	0.05	0	0	<0.1	0.2	0	0	2.1	4.7	0	0
horned lark	0.81	0.02	1.67	5.54	3.6	<0.1	4.7	81.6	22.9	1.6	14.6	45.8
house finch	0	0.03	0	0	0	0.1	0	0	0	3.2	0	0
house sparrow	0	0.25	0	0	0	0.9	0	0	0	6.4	0	0
house wren	0	0.02	0.02	0	0	<0.1	<0.1	0	0	1.7	2.2	0
Lincoln's sparrow	0	0.02	0	0	0	<0.1	0	0	0	1.6	0	0
marsh wren	0	0.06	0	0	0	0.2	0	0	0	6.2	0	0
northern shrike	0	0	0.02	0.02	0	0	<0.1	0.3	0	0	2.1	2.1
orchard oriole	0	0.05	0	0	0	0.2	0	0	0	4.8	0	0
red-winged blackbird	13.19	3.67	5.28	0	59.2	12.7	14.8	0	34.2	50.6	30.6	0
Savannah sparrow	0.02	0	0	0	<0.1	0	0	0	2.1	0	0	0
snow bunting	0	0	0	0.25	0	0	0	3.7	0	0	0	10.4
song sparrow	0.04	0.11	1.18	0	0.2	0.4	3.3	0	4.2	11.1	6.7	0
spotted towhee	0	0.02	0	0	0	<0.1	0	0	0	1.6	0	0

Appendix A3. Mean small bird use (number of large birds/100-meter plot/20-minute survey), percent of total use, and frequency of occurrence for each small bird type and species by season during Year Two of the fixed-point bird use surveys conducted at the Prevaling Winds Project in Bon Homme and Charles Mix counties, South Dakota, from May 3, 2016 – April 19, 2017.

	Mean Use				Percent of Use (%)				Frequency of Occurrence %)			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
swamp sparrow	0	0.02	0	0	0	<0.1	0	0	0	1.6	0	0
tree swallow	0.07	0	0	0	0.3	0	0	0	4.4	0	0	0
unidentified blackbird	1.92	0	4.19	0	8.6	0	11.7	0	10.4	0	4.2	0
unidentified sparrow	0.19	0.02	0.76	0.02	0.8	<0.1	2.1	0.3	4.2	1.6	21.1	2.1
vesper sparrow	0.07	0.09	0.07	0	0.3	0.3	0.2	0	4.4	6.2	2.2	0
western bluebird	0	0.03	0	0	0	0.1	0	0	0	3.1	0	0
western kingbird	0	0.02	0	0	0	<0.1	0	0	0	1.6	0	0
western meadowlark	3.14	0.78	1.07	0.02	14.1	2.7	3	0.3	71.7	52.1	39.3	2.1
yellow-headed blackbird	0.33	1.36	0	0	1.5	4.7	0	0	2.1	6.4	0	0
yellow warbler	0	0.10	0	0	0	0.3	0	0	0	6.4	0	0
Woodpeckers	0.02	0.10	0.13	0	<0.1	0.3	0.4	0	2.2	9.8	10.7	0
downy woodpecker	0	0	0.02	0	0	0	<0.1	0	0	0	2.1	0
northern flicker	0	0.03	0.06	0	0	0.1	0.2	0	0	3.3	4.2	0
red-bellied woodpecker	0	0.03	0	0	0	0.1	0	0	0	3.3	0	0
red-headed woodpecker	0.02	0.03	0.04	0	<0.1	0.1	0.1	0	2.2	3.1	4.4	0
Kingfishers	0	0	0.02	0	0	0	<0.1	0	0	0	2.1	0
belted kingfisher	0	0	0.02	0	0	0	<0.1	0	0	0	2.1	0
Unidentified Birds	0.17	0	0.27	0.21	0.7	0	0.8	3.1	12.5	0	6.2	12.5
unidentified bird (small)	0.17	0	0.27	0.21	0.7	0	0.8	3.1	12.5	0	6.2	12.5
Overall	22.29	28.9	35.73	6.79	100	100	100	100				

Note: Totals by bird type and overall might not correspond to the sum of individual species due to rounding

Active Bald Eagle Nest Monitoring Near the Prevailing Wind Park Bon Homme, Hutchinson and Charles Mix Counties, South Dakota

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Final Draft Report

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Prevailing Wind Park, LLC

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Prevailing Wind Park, LLC contracted with Western EcoSystems Technology, Inc. (WEST) to conduct field surveys in accordance with agency recommendations to quantify wildlife resources within the Prevailing Wind Park project (Project) in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota (Figure 1). Surveys were conducted by WEST in 2015 – 2016 and 2016 – 2017 to address the issues posed under Tier 3 within the Project area, following guidance in the United States Fish and Wildlife Service (USFWS) *Final Land-Based Wind Energy Guidelines* (USFWS 2012) and *Eagle Conservation Plan Guidance* (ECPG; USFWS 2013).

The focus of the eagle nest monitoring survey was to document flight paths and use within the vicinity of an active bald eagle (*Haliaeetus leucocephalus*) nest located during aerial raptor nest surveys conducted for the Project in 2015 and 2016 (Derby 2015, 2016). The nest was located east of the Project (Figure 1). A fixed point survey location was established to allow documentation of the activity of bald eagles utilizing the nest.

STUDY AREA

The Project is located near the town of Avon in southern South Dakota and is characterized by a generally flat topography that is primarily used for crop production and livestock grazing (US Environmental Protection Agency 2016). Trees and woodlands are found mainly in planted shelterbelts and within draws and on hillslopes.

The active bald eagle nest of interest was documented during aerial nest surveys in 2015 and 2016 (Derby 2015 and 2016). The nest was located within one mile (mi; 1.6 kilometer [km]) of the Project boundary (Figure 1). The nest tree was located at the western edge of a USFWS Waterfowl Production Area that contains freshwater emergent wetland (Figures 3 and 4; USFWS NWI 2017).

METHODS

Eagle Nest Monitoring

Eagle nest monitoring was conducted at a survey point overlooking a known bald eagle nest. The survey point was selected to allow good visibility of the eagle nest and was about 500 m (about 1,640 ft) from the nest on a public road (Figures 3 and 4). Surveys were conducted for 60 minutes (min) each time the biologist was onsite for eagle/avian use surveys during the nesting season (see Derby et al. 2018a and 2018b for description of eagle/avian use surveys). Each eagle observed during the survey was recorded by a unique observation number and flight path or perch location. The date, start, and end time of the survey period were recorded for each survey. Number of individuals, sex and age class (if possible), distance from plot center when first observed, closest distance, altitude above ground, activity (behavior), and habitat(s) were recorded for each observation. Bird behavior and habitat type used were recorded based on the point of first observation. Approximate flight height and distance from plot center at first observation were recorded to the nearest 5.0-m (16.4-ft) interval.

Observation Schedule

Surveys commenced when adult eagles were incubating eggs and ended when eaglets fledged from the nest or the nest failed or otherwise was determined to be no longer occupied. Dates of survey were March 31 – July 21, 2015 and May 4 – September 7, 2016.

RESULTS

Twelve 60-min surveys were completed from March 31 – July 21, 2015 and 10 60-min surveys were completed from May 4 – September 7, 2016.

In 2015, bald eagles were observed during all but one survey; the first bald eagle observation occurred on March 31, 2015 and the last bald eagle was observed on July 7, 2015. Twenty-seven eagle observations were made during the 12 hr of surveys (Table 1); individual eagles, both adults and young-of-year birds, were observed multiple times. Of the bald eagles observed, most were perched on or near the nest. Eagles were observed flying for only 11 min (Table 1). Flight paths were generally to the west of the nest, in a northern and northwesterly direction (Figure 3).

In 2016, bald eagle nest monitoring began May 4 when other eagle/avian use surveys were initiated, missing the initial eagle activity at the nest. Once surveys began, bald eagles were observed in six of the 10 surveys (Table 1); no eagles were observed at the nest on July 1, July 27, August 9, and August 25, 2016, although visibility was good during those survey times; the last bald eagle was observed on September 7, 2016. Eleven eagle observations were made during the 10 hr of surveys (Table 1). As in 2015, individual eagles, both adults and young of year birds, were observed multiple times. Eagles were observed flying for 10 min. Most eagles were observed perched on or near the nest. The few flight paths were generally to the southwest of the nest and showed no apparent pattern (Figure 4).

Table 1. Number of bald eagle observations and flight minutes observed at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota, from March 31 – July 21, 2015, and from May 4 – September 7, 2016.

Year	Eagle Age	Number of Eagle Observations	Total Minutes of Eagle Flight Observations
2015	Adults and Juveniles	27	11
2015	Adults Only	21	11
2016	Adults and Juveniles	11	10
2016	Adults Only	9	10

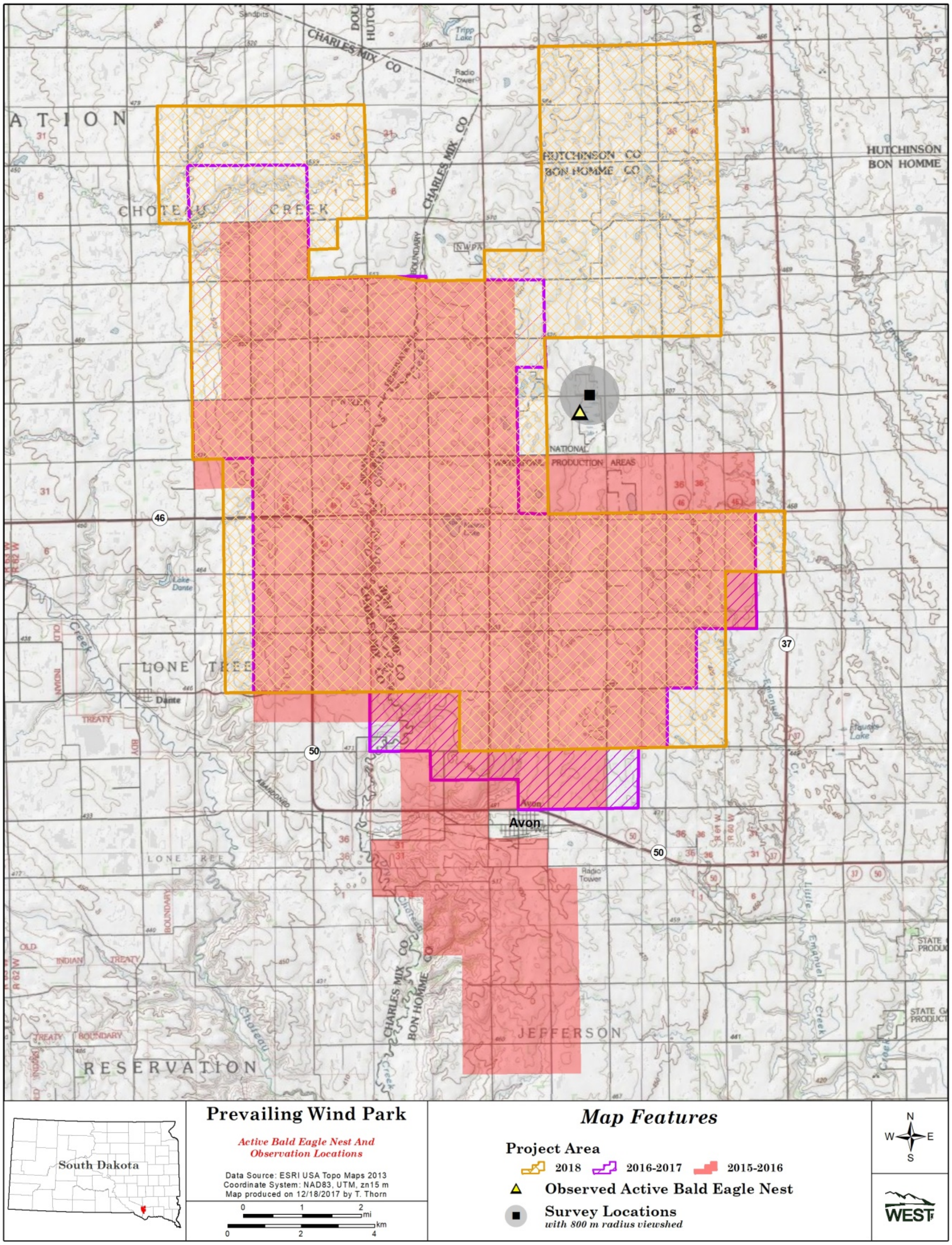

Figure 1. Location of the Prevailing Wind Park Project, eagle nest (PW-EN3), and the survey point used for eagle nest monitoring surveys in 2015 and 2016.

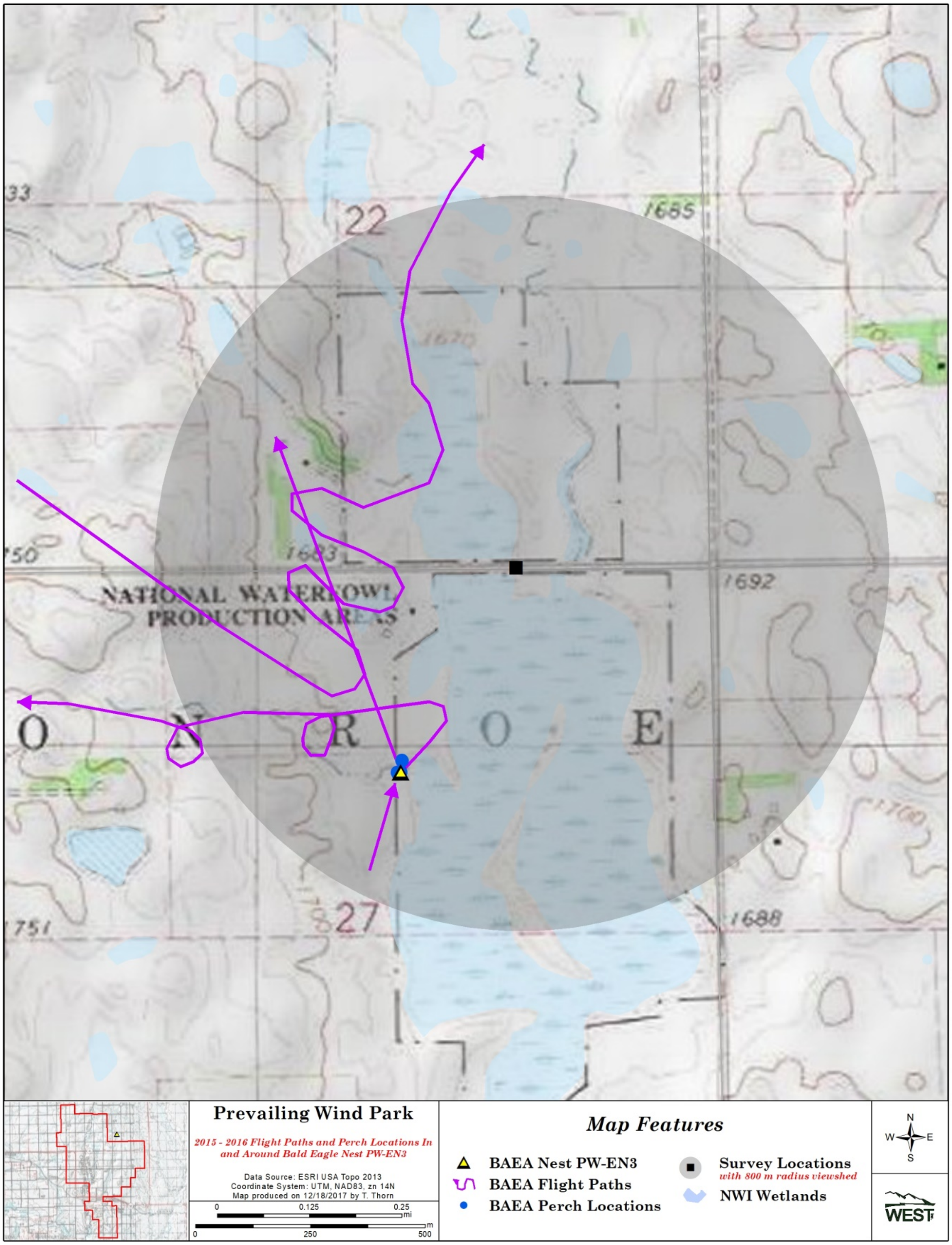

Figure 2. Bald eagle flight paths and perch locations observed during 2015 eagle nest monitoring surveys conducted at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.

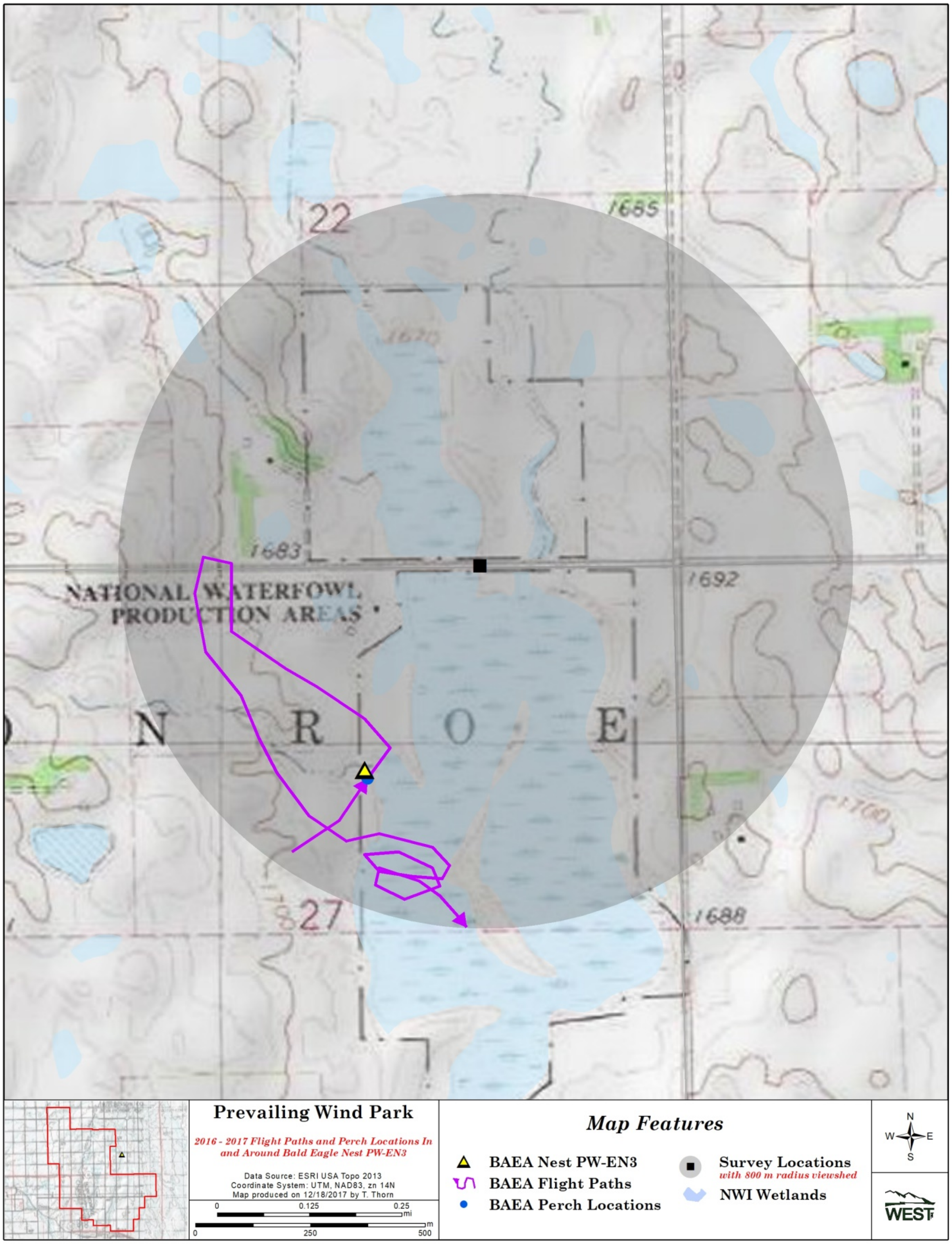

Figure 3. Bald eagle flight paths and perch locations observed during 2016 eagle nest monitoring surveys conducted at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.

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NORTHERN LONG-EARED BAT ACOUSTIC SURVEY REPORT FOR PROJECT FEASIBLITY AND LOCATION

Prevailing Winds Study Area in Bon Homme and Charles Mix Counties, South Dakota

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Prevailing Winds, LLC (Prevailing Winds), is considering the development of the Prevailing Winds Wind Farm (Project), located in Bon Homme and Charles Mix Counties, South Dakota. To help in siting the eventual Project, Prevailing Winds evaluated a large Study Area (see Figure 1 for depiction of the Study Area as defined for 2015 studies). Prevailing Winds requested that Western Ecosystems Technology, Inc. (WEST) evaluate the potential for the federally threatened northern long-eared bat (*Myotis septentrionalis*; [NLEB]) to occur within the 2015 Study Area during the summer months. This report describes the results of the NLEB presence or probable absence acoustical assessment completed for the Study Area by WEST. These surveys were conducted following the survey recommendations found in the U.S. Fish and Wildlife Service (USFWS) *Northern Long-eared Bat Interim Conference and Planning Guidance* (USFWS 2014a) and *2015 Range-Wide Indiana Bat Summer Survey Guidelines* (USFWS 2015).

NORTHERN LONG-EARED BAT SUMMER HABITAT REQUIREMENTS

NLEB are forest dependent species, generally relying on forest features for both foraging and roosting during the summer months (USFWS 2013; USFWS 2007). In particular, NLEB appear to be a forest interior species that require adequate canopy closure for both roost and foraging habitat (Lausen 2009). Additionally, riparian areas are considered critical resource areas for many species of bats because they support higher concentrations of prey, provide drinking areas, and act as unobstructed commuting corridors (Grindal et al. 1999). While NLEB are associated with forest habitats, they also occur in agricultural settings where forest habitats have been highly fragmented.

Wing morphology of the NLEB makes them ideally suited for the high maneuverability required for gleaning-type foraging within a cluttered forest interior (Henderson and Broders 2008). Abundance of NLEB prey items, particularly beetles and moths, are typically higher in more closed forest stands than in openings, which supports studies which have found that NLEB tend to avoid open habitats (Owen et al. 2003).

During the summer, NLEB roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees (USFWS 2007; USFWS 2013). Males and non-reproductive females may also roost in cooler places, like caves and mines. NLEB seem opportunistic in selecting roosts, using tree species based on suitability to retain bark or provide cavities or crevices. NLEB have also been found roosting in structures like barns and sheds.

During the summer months, NLEBs are unlikely to cross over large open lands (i.e., land lacking suitable habitat) to search for foraging and roosting habitats, but rather to use tree-lined linear features as travel corridors to and from roosting and foraging habitats (USFWS 2014a). These tree-lined corridors may be important for bats as navigational aids in agricultural landscapes, as protection from predators and wind, and may act to concentrate insect prey (Verboom and Huitema 1997). The NLEB is expected to be particularly tied to intact forested habitats; for example, Henderson and Broders (2008) found that NLEB did not travel more than 255 feet (78 meters) from the edge of intact forest structure. A study of nine female NLEBs using an intensively managed forest in West Virginia found this species forages in areas with forest patch sizes between 114 and 161 acres (46 and 65 hectares; Owen et al. 2003); however, studies in landscapes dominated by agricultural activities found NLEB can use woodlots and riparian zones with as little as 15 to 49 acres (6 to 20 hectares) of forest cover (Henderson and Broders 2008; Foster and Kurta 1999).

METHODS

Acoustic surveys followed the USFWS *2015 Range-Wide Indiana Bat Summer Survey Guidelines* (USFWS 2015), per the *Northern Long-Eared Bat Interim Conference and Planning Guidance* (USFWS 2014a). The USFWS guidelines require one survey site for every 123 acres of suitable habitat for a minimum of four detector nights (USFWS 2014a). Two sampling locations at each survey site should then be surveyed for a minimum of two detector/nights each.

Initial desktop assessment of potential habitat conducted by WEST, identified approximately 1,180 acres of forested habitat; as such, this equates to 20 survey locations (two detectors per site). Although the USFWS protocol calls for 20 survey locations (10 sites with two detectors per site) for two detector/nights (for a total of 40 detector/nights), WEST surveyed 20 locations/stations for a minimum of two nights each for a total of 104 detector nights. WEST biologists deployed up to eight detectors at suitable sites throughout the Study Area for a minimum of four detector nights.

Acoustic surveys were conducted from July 21 – August 10, 2015 following USFWS guidelines (USFWS 2015). Bats were surveyed using SD1 or SD2 AnaBat™ ultrasonic detectors (Titley Electronics Pty Ltd., NSW, Australia), or SM2 Song Meter detectors (Wildlife Acoustics, Inc., Concord, Maine). Acoustic monitoring began before sunset and continued for the entire night. Survey duration at each site was for a minimum of two nights. If weather conditions such as persistent rain (> 30 minutes), strong winds (> 9 mph for > 30 minutes), or persistent cold temperatures (below 10°C [50°F] for > 30 minutes) occurred during the first five hours of a survey night, then that site was surveyed for an additional night (USFWS 2014). To maximize the quality of recorded echolocation calls, detectors were positioned at least 1.5 meters off the ground, at ≥ 45° angle, and with PVC tube weatherproofing (Britzke et al. 2010, USFWS 2014a). Sensitivity was set to “6” on AnaBat detectors, and the amplifier gain was set to 36 decibels for the SM2 units.

Bat calls were identified to species using Bat Call Identification (BCID; Allen 2012). If the identification program identified calls as NLEB at a site with a high degree of probability ($P < 0.05$), then qualitative analysis was conducted to determine if NLEB were present or absent at the site. Qualitative echolocation call analysis was conducted by a biologist experienced with acoustic identification and who met required USFWS qualifications (Dr. Kevin Murray of WEST; USFWS 2014a). If probable NLEB echolocation call sequences identified by BCID were not characteristic of NLEB, contained distinct calls produced by species other than NLEB, or were of insufficient quality, they were reclassified. Per USFWS guidelines, NLEB were considered present at sites with probable calls verified by qualitative analysis. NLEB were considered absent from sites with no probable NLEB calls or from sites with probable NLEB calls that were not verified by qualitative analysis. The Study Area lies well outside of the accepted range of Indiana bats; therefore Indiana bats were not included in the BCID model.

RESULTS

AnaBat and SM2 detectors were used to survey 20 acoustic survey locations, consisting of two detector stations per site, from July 21 – August 10, 2015. UTM coordinates and brief site descriptions for each site are listed in Table 1. Pictures and datasheets with site descriptions are found in Appendices A and B. WEST checked weather at the Hajek Farms, Tyndall, SD (KSDTYNDA2) weather station, which can be found on Weather Underground's Wundermap (http://www.wunderground.com/wundermap/). Weather conditions at sites 1, 2, 3, 4, 5, 6a, and 8 did not meet the standards for acoustic monitoring set by USFWS (2014a) on July 25 and at sites 6, 9, 10, and 11 on July 27 due to wind speeds sustaining greater than 9 miles per hour during the first five hours of survey on both nights. However, data on these nights were still included in the analysis because, while not ideal, conditions could still be suitable during a portion of the night and NLEB and other bats might still be detected. Weather conditions at all 20 locations for all other survey nights met the criteria established by the USFWS (2014a), and each detector location had at least two detector nights with good weather conditions (Table 2).
Acoustic surveys were completed at 20 locations (two detector stations per site) for a total of 104 detector nights (Tables 1 and 2). BCID identified a total of 6,478 bat call files and identified 6,323 files (98%) to species, with an average of 62.3 bat calls per detector night (Table 2). Table 2 summarizes the number of detector nights, number of bat call files, and number of bat calls identified to species at each site. Table 3 provides information on species identifications for each site.

Based on the BCID analysis, nine stations (locations), recorded potential NLEB calls with a p-value less than 0.05 for the maximum-likelihood estimation (Table 4); therefore data from the nine stations were included in qualitative analysis (USFWS 2014a). Six stations (PW1, PW6a, PW8a, PW11, PW14, and PW16) recorded probable (i.e., p-value <0.05) NLEB calls on a single night only; stations PW9a and PW17 recorded probable NLEB calls on two and three nights, respectively; and station PW13 recorded probable NLEB calls on six nights (Table 4). Qualitative identification verified the presence of NLEB at stations PW9a (on a single night only) and PW13 (on six nights); however, qualitative analysis did not verify the presence of NLEB at the remaining seven stations with probable NLEB calls (Table 4).

DISCUSSIONS/CONCULSIONS

Limited information is available on NLEB migratory pathways and behaviors. While there is some information suggesting this species tends to follow forested areas and avoid open areas if possible, these bats may occasional move through non-forested areas.

The habitat assessment conducted by WEST at the Study Area provides information on potential NLEB habitat that might be found within the Study Area and nearby areas. If these bats occur in the area during the summer months, they will likely occur within or near (within

1,000 feet) of these habitat patches. Given its association with forest habitat (Henderson and Broders 2008; Foster and Kurta 1999), WEST anticipates that the larger and more contiguous blocks of forested areas would be more likely to be used by these species compared to the smaller forested blocks and/or tree lines and shelterbelts.

The NLEB was qualitatively verified as occurring at two acoustical stations surveyed within the Study Area (stations PW9a and PW13). Though not documented during this survey effort, there is potential for NLEB to be present within other suitable habitat within the Study Area during the summer months, particularly in the west/southwest portions of the Study Area, given the density and distribution of potential NLEB habitat; and the connectivity to larger forested and/or forested riparian habitats just outside of the Study Area boundary (i.e., forested/semi-forested corridors of Choteau Creek and Dry Choteau Creek and tributaries thereof).

Surveys are considered complete for all 20 stations at the Study Area and no further action is recommended to confirm NLEB presence within the current boundary (Table 5); however, acoustic data is probabilistic and presence determinations can be error prone. For a more detailed assessment of NLEB occurrence in the area, the USFWS guidelines (USFWS 2014a, 2015) recommend mist-netting in combination with radio-telemetry and emergence counts to confirm roost tree locations and roost size (Phase 3 and 4). Though the possibility exists for mist-netting results to contradict the acoustic results, it is unlikely for the USFWS to overturn acoustic evidence with mist-net evidence.

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Table 1. Location and site description of the 20 acoustic survey stations at the Prevailing Winds Study Area.

Station ID	Zone	Easting†	Northing†	Site Description
PW1	14	0569563	4776786	Edge of shelterbelts, adjacent to agricultural fields
PW2	14	0568133	4774899	Open woodlot adjacent to pasture
PW3	14	0568878	4775146	Edge of shrubby grove, adjacent to pond and pasture
PW4	14	0572800	4773535	Edge of shelterbelt and creek bed, adjacent to hay fields
PW5	14	0570321	4772303	Edge of small forest patch, adjacent to pasture
PW6	14	0579638	4770270	Edge of shelterbelt and grassy area, adjacent to pasture
PW6a	14	0574168	4770744	Grassy path adjacent to forest
PW7	14	0572985	4766554	Edge of forest in pasture
PW8	14	0575714	4766373	Edge of forest in grassy area, adjacent to pasture
PW8a	14	0575652	4768628	Grassy area adjacent to forest
PW9	14	0580064	4765600	Grassy path adjacent to forest edge and cornfield
PW9a	14	0569742	4766932	Pasture adjacent to forest edge
PW10	14	0578533	4763193	Grassy area adjacent to shelterbelt
PW11	14	0576700	4763072	Grassy area adjacent to forest edge and cropland
PW12	14	0575445	4762139	Grassy area adjacent to forest edge
PW13	14	0574443	4759581	Grassy/shrubby area adjacent to forest edges
PW14	14	0574925	4758670	Grassy/shrubby area adjacent to cedar/juniper
PW15	14	0575580	4758206	Grassy area adjacent to forest edge
PW16	14	0576680	4757714	Grassy area adjacent to forest edge
PW17	14	0578987	4756031	Grassy area adjacent to forest edge and cropland

Table 2. Number of bat calls recorded at each acoustic survey station determined by BCID for the Prevailing Winds Study Area.

Acoustic Survey Station	Total Bat Calls	Calls Identified	Detector Nights	Bat Calls/ Detector Night
PW1	248	241 (97%)	6	41.3
PW2	406	390 (96%)	6	67.7
PW3	104	100 (96%)	6	17.3
PW4	42	42 (100%)	6	7
PW5	137	135 (96%)	6	22.8
PW6a	1,309	1,296 (99%)	5	261.8
PW6	185	183 (99%)	9	20.6
PW7	379	372 (98%)	3	126.3
PW8	279	271 (97%)	5	55.8
PW8a	530	520 (98%)	4	132.5
PW9	325	320 (98%)	5	65
PW9a	203	194 (96%)	4	50.8
PW10	209	207 (99%)	5	41.8
PW11	458	450 (98%)	5	91.6
PW12	53	53 (100%)	3	17.7
PW13	699	674 (96%)	6	116.5
PW14	36	36 (100%)	6	6
PW15	29	28 (97%)	2	14.5
PW16	192	188 (98%)	6	32
PW17	655	623 (95%)	6	109.2
Total	**6,478**	**6,323 (98%)**	**104**	**62.3**

Table 3. Summary of BCID echolocation call identifications for the Prevailing Winds Study Area[1].

Station ID	EPFU	LABO	LACI	LANO	MYLU	MYSE	NYHU	PESU	UNK	Total
PW1	42	24	71	89	2	1	3	9	7	248
PW2	137	137	11	39	1	0	14	51	16	406
PW3	19	35	2	13	2	0	8	21	4	104
PW4	21	0	1	19	0	0	0	1	0	42
PW5	72	4	9	48	0	0	1	1	2	137
PW6	100	4	9	62	1	0	0	7	2	185
PW6a	626	176	22	425	1	1	29	16	13	1,309
PW7	234	36	6	60	25	0	4	7	7	379
PW8	40	181	0	2	5	0	36	7	8	279
PW8a	113	316	7	30	4	1	31	18	10	530
PW9	47	14	35	213	0	0	4	7	5	325
PW9a	51	55	9	32	4	5	5	33	9	203
PW10	97	10	16	76	2	0	0	6	2	209
PW11	115	59	48	182	2	1	3	40	8	458
PW12	24	7	0	16	0	0	1	5	0	53
PW13	123	223	8	56	15	195	28	26	25	699
PW14	14	3	1	16	0	2	0	0	0	36
PW15	16	0	1	8	0	0	2	1	1	29
PW16	45	63	2	32	9	1	14	22	4	192
PW17	138	218	3	62	8	3	17	174	32	655

[1] EPFU = Big Brown Bat; LABO = Eastern Red Bat; LACI = Hoary Bat; LANO = Silver-haired Bat; MYLU = Little Brown Bat; MYSE = Northern Long-eared Bat; NYHU = Evening Bat; PESU = Tri-colored bat; UNK = Unknown

Table 4. Summary of Myotis call identifications by BCID and qualitative analysis[1] for stations with potential Northern long-eared bat calls at the Prevailing Winds Study Area.

Station ID	Date	Identification Method	MYSE (NLEB)
PW1	July 24	BCID	1
		Qualitative	0
PW6a	July 31	BCID	1
		Qualitative	0
PW8a	July 30	BCID	1
		Qualitative	0
PW9a	August 9	BCID	1
		Qualitative	0

Table 4. Summary of Myotis call identifications by BCID and qualitative analysis[1] for stations with potential Northern long-eared bat calls at the Prevailing Winds Study Area.

Station ID	Date	Identification Method	MYSE (NLEB)
PW9a	August 10	BCID	4
		Qualitative	1
PW11	July 29	BCID	1
		Qualitative	0
PW13	August 1	BCID	39
		Qualitative	25
PW13	August 2	BCID	41
		Qualitative	21
PW13	August 3	BCID	33
		Qualitative	23
PW13	August 4	BCID	29
		Qualitative	19
PW13	August 5	BCID	19
		Qualitative	9
PW13	August 6	BCID	34
		Qualitative	16
PW14	August 1	BCID	2
		Qualitative	0
PW16	August 1	BCID	1
		Qualitative	0
PW17	August 1	BCID	1
		Qualitative	0
PW17	August 4	BCID	1
		Qualitative	0
PW17	August 5	BCID	1
		Qualitative	0

[1] Only calls with p-values < 0.05 for the maximum-likelihood estimation were included in qualitative analysis (USFWS 2014a).

Table 5. Summary of actions at each acoustic survey site for the Prevailing Winds Study Area.

Station ID	BCID NLEB Calls	Probable NLEB Calls (P < 0.05)	NLEB Qualitatively Verified	Presence/Absence Determination
PW1	Yes	Yes	No	NLEB absent
PW2	No	No	No	NLEB absent
PW3	No	No	No	NLEB absent
PW4	No	No	No	NLEB absent
PW5	No	No	No	NLEB absent
PW6	No	No	No	NLEB absent
PW6a	Yes	Yes	No	NLEB absent
PW7	No	No	No	NLEB absent
PW8	No	No	No	NLEB absent
PW8a	Yes	Yes	No	NLEB absent
PW9	No	No	No	NLEB absent
PW9a	Yes	Yes	Yes	NLEB present
PW10	No	No	No	NLEB absent
PW11	Yes	Yes	No	NLEB absent
PW12	No	No	No	NLEB absent
PW13	Yes	Yes	Yes	NLEB present
PW14	Yes	Yes	No	NLEB absent
PW15	No	No	No	NLEB absent
PW16	Yes	Yes	No	NLEB absent
PW17	Yes	Yes	No	NLEB absent

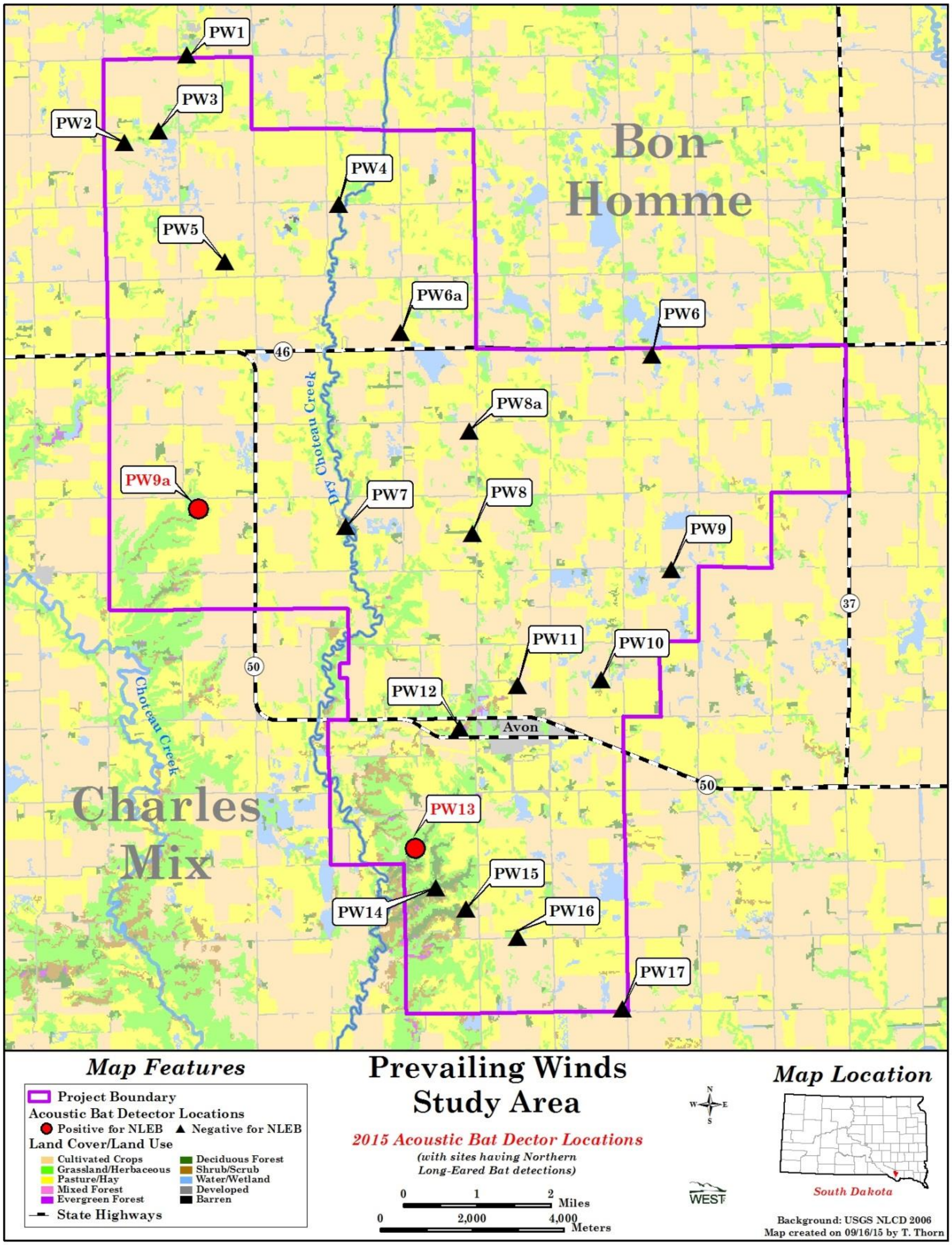


Figure 1. Locations of acoustic bat detectors and those confirmed positive for NLEB at the Prevailing Winds Study Area from July 21 through August 10, 2015.

Appendix A. Pictures of Acoustic Survey Sites

Photo 1. Bat habitat surveyed by AnaBat detector at station PW1.

Photo 2. Bat habitat surveyed by AnaBat detector at site PW2.

Photo 3. Bat habitat surveyed by AnaBat detector at station PW3.

Photo 4. Bat habitat surveyed by AnaBat detector at site PW4.

Photo 5. Bat habitat surveyed by AnaBat detector at station PW5.

Photo 6 . Bat habitat surveyed by AnaBat detector at site PW6.

Photo 7. Bat habitat surveyed by AnaBat detector at station PW6a.

Photo 8. Bat habitat surveyed by AnaBat detector at site PW7.

Photo 9. Bat habitat surveyed by AnaBat detector at station PW8.

Photo 10. Bat habitat surveyed by AnaBat detector at site PW8a.

Photo 11. Bat habitat surveyed by AnaBat detector at station PW9.

Photo 12. Bat habitat surveyed by AnaBat detector at site PW9a.

Photo 13. Bat habitat surveyed by AnaBat detector at station PW10.

Photo 14. Bat habitat surveyed by AnaBat detector at site PW11.

Photo 15. Bat habitat surveyed by AnaBat detector at station PW12.

Photo 16. Bat habitat surveyed by AnaBat detector at site PW13.

Photo 17. Bat habitat surveyed by AnaBat detector at station PW14.

Photo 18. Bat habitat surveyed by AnaBat detector at site PW15.

Photo 19. Bat habitat surveyed by AnaBat detector at station PW16.

Photo 20. Bat habitat surveyed by AnaBat detector at site PW17.

Appendix B. Datasheets from Acoustic Survey Sites

Acoustic Monitoring STATION 2011 Data Form Station #: PW-1

Observer: RS Date: 7-21-15 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 Easting: 0569503 Northing: 4776786

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80814 *(microphone)*

_______________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: [✓ N/A] Pulley Fixed

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 1.5
(Height from ground to detector/microphone)

Aspect: E
(Bearing or Cardinal Direction of mic)

Power Supply: 12V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest		Grassland		Other (describe)	
Crop/Agriculture	1	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

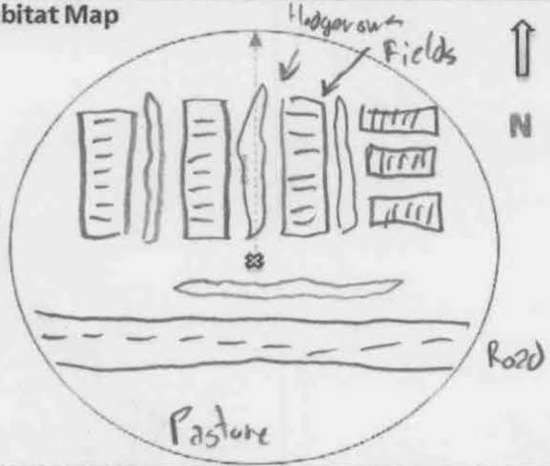
Topography: [✓ Flat] Slope High Point Low Point Other: _______________

Was this station chosen to sample a bat feature? [✓ Yes] No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.* N, E, S, W, Unit, Cone

General Remarks: _______________

Habitat Map



Codes Bat Features **Description**

AS=anthropogenic structure : _______________
CV=cave : _______________
MN=mine : _______________
RO=rocky outcrop : _______________
CF=coniferous forest stand : _______________
DF=deciduous forest stand : _______________
WA=water : _______________
Other=: _______________

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW-2

Observer: RS Date: 7-21-15 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 Easting: 0568133 Northing: 4774899

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80966 *(microphone)*

________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: [✓ N/A] Pulley Fixed

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2m *(Height from ground to detector/microphone)*

Aspect: S *(Bearing or Cardinal Direction of mic)*

Power Supply: 12V *(e.g., voltage and Amp-hours of battery, solar panel, etc.)*

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe	2	Deciduous Forest		Grassland		Other (describe)	3 - Pasture
Crop/Agriculture	1	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

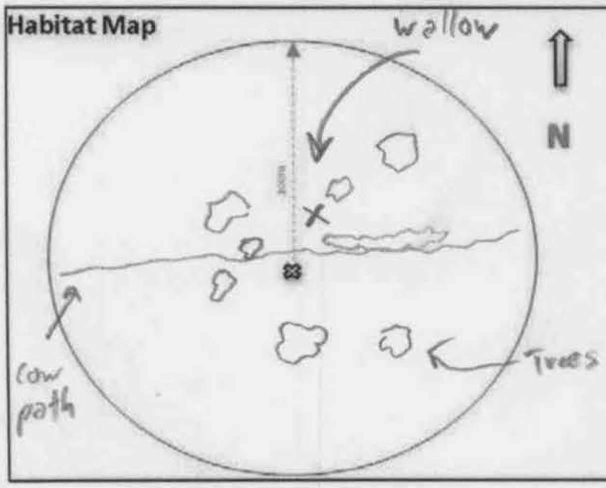
Topography: [✓ Flat] Slope High Point Low Point Other: ________

Was this station chosen to sample a bat feature? [✓ Yes] No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). __Label__ and mail to your bat liaison on your thumb drive.*

General Remarks: N, E, S, W, Unit, Cone

Habitat Map



Codes	Bat Features	Description
AS=	anthropogenic structure	:
CV=	cave	:
MN=	mine	:
RO=	rocky outcrop	:
CF=	coniferous forest stand	:
DF=	deciduous forest stand	:
WA=	water	:

Other=: ________

Map out bat __and__ habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: Pw-3

Observer: RS Date: 7-21-15 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 Easting: 0568878 Northing: 4775146

Detector Type: SD2 [✓ SD1] Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 03697 *(microphone)*

________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: [✓ N/A] Pulley Fixed

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2 m
(Height from ground to detector/microphone)

Aspect: NE
(Bearing or Cardinal Direction of mic)

Power Supply: 12V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe	2	Deciduous Forest		Grassland		Other (describe)	1
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland	3	Pinyon-Juniper		Water (lake, etc.)			

Pasture

Topography: Flat Slope High Point [✓ Low Point] Other: ________

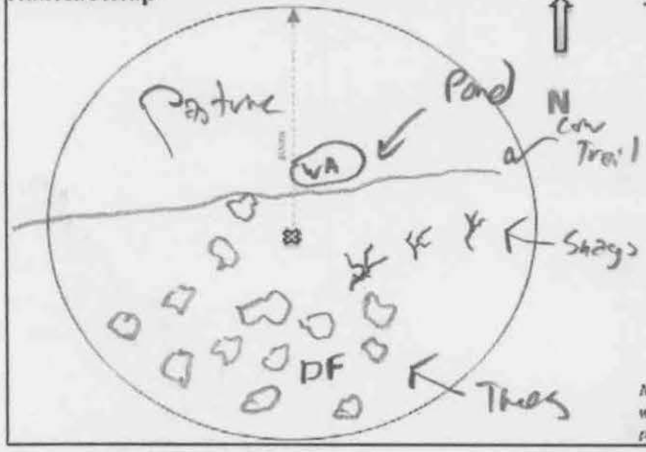
Was this station chosen to sample a bat feature? [✓ Yes] No

N, E, S, W, unit, Cone

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: ________

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	:
WA=water	:
Other=:	

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW-4

Observer: RS Date: 7-21-15 Project: Prevailing Winds

Station Information

Datum: NAD27 or NAD83 Zone: 14 Easting: 0572800 Northing: 4773535

Detector Type: SD2 [✓ SD1] Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 03483 *(microphone)*

________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: [✓ N/A] Pulley Fixed

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: E
(Bearing or Cardinal Direction of mic)

Power Supply: 12V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe	1	Deciduous Forest		Grassland		Other (describe)	3 hay field
Crop/Agriculture	2	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

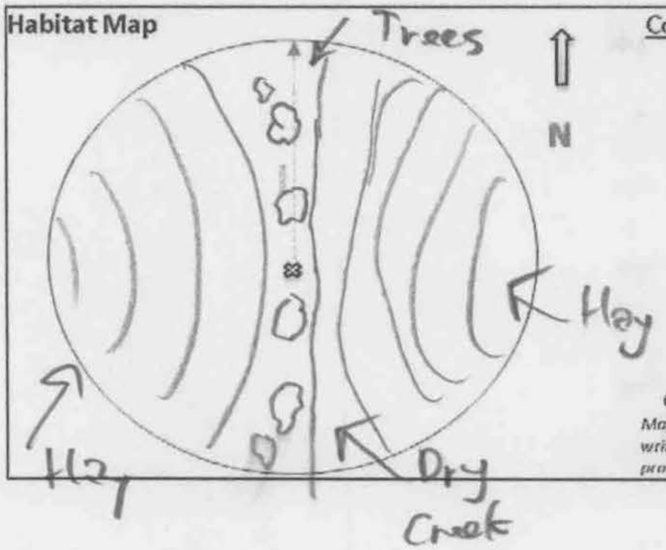
Topography: [✓ Flat] Slope High Point Low Point Other: ________

Was this station chosen to sample a bat feature? [✓ Yes] No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.* N, E, S, W, Unit, Cone

General Remarks: ________

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	:
WA=water	:
Other=:	

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW-5

Observer: RS Date: 7-21-15 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 Easting: 0570321 Northing: 4772303

Detector Type: SD2 [✓ SD1] Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80917 *(microphone)*

________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: [✓ N/A] Pulley Fixed

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: E
(Bearing or Cardinal Direction of mic)

Power Supply: 12V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe	1	Deciduous Forest	3	Grassland		Other (describe)	2
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

Pasture

Topography: [✓ Flat] Slope High Point Low Point Other: ________

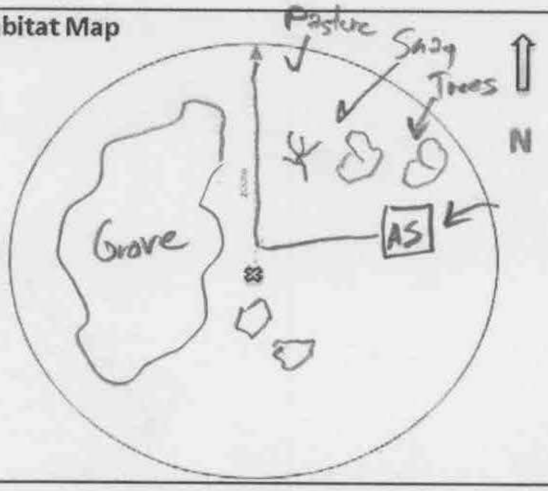
Was this station chosen to sample a bat feature? [✓ Yes] No

N, E, S, W, unit, cone

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). __Label__ and mail to your bat liaison on your thumb drive.*

General Remarks: ________

Habitat Map



Codes	Bat Features	Description
AS=anthropogenic structure		:
CV=cave		:
MN=mine		:
RO=rocky outcrop		:
CF=coniferous forest stand		:
DF=deciduous forest stand		:
WA=water		:

Other=: ________

Map out bat __and__ habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW-6

Observer: RS Date: 7-21-15 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 Easting: 0579638 Northing: 4770270

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80482 (microphone)

(recorder, if applicable)

Placement: [✓ Ground] Raised

Raised System: [✓ N/A] Pulley Fixed

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: NE
(Bearing or Cardinal Direction of mic)

Power Supply: 12V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe	1	Deciduous Forest		Grassland		Other (describe)	2
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

Pasture

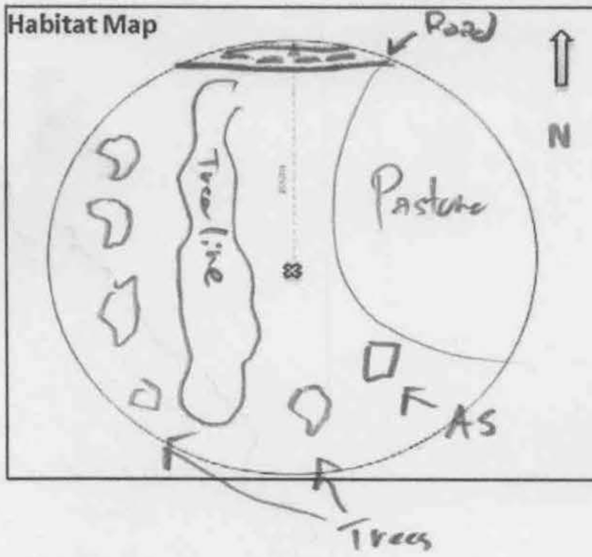
Topography: Flat [✓ Slope] High Point Low Point Other:

Was this station chosen to sample a bat feature? [✓ Yes] No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.* N, E, S, W, Unit, Cone

General Remarks:

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	:
WA=water	:
Other=:	

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION **2011 Data Form** **Station #:** PW-6A

Observer: Ryan McDonald **Date:** 7/28/2015 **Project:** Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] **Zone:** 14 T **Easting:** 574168 **Northing:** 4770744

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80966 *(microphone)*

_______ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: 350°
(Bearing or Cardinal Direction of mic)

Power Supply: 12V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest	1	Grassland	2	Other (describe)	4
Crop/Agriculture	3	Coniferous Forest		Desert		road	
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

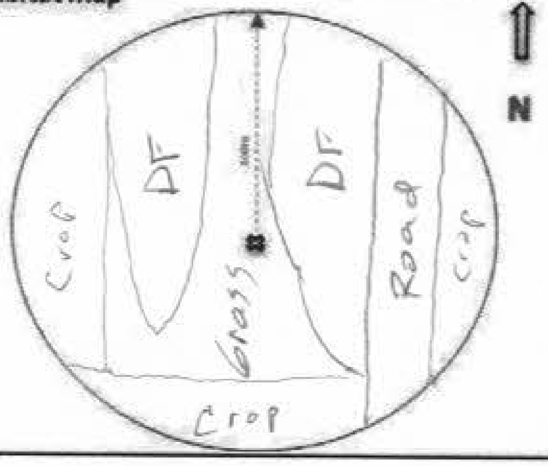
Topography: [✓ Flat] Slope High Point Low Point Other: _______

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: grassy road leads directly to point

Habitat Map



Codes	**Bat Features**	**Description**
AS=anthropogenic structure		:
CV=cave		:
MN=mine		:
RO=rocky outcrop		:
CF=coniferous forest stand		:
DF=deciduous forest stand		: mature
WA=water		:

Other: _______

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW-7

Observer: RS Date: 7-21-15 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 Easting: 0572985 Northing: 4766554

Detector Type: SD2 SD1 Anabat II [✓ SM2] Pettersson B.A.T.

Serial Number(s): 015567 (microphone)

__________ (recorder, if applicable)

Placement: [✓ Ground] Raised

Raised System: [✓ N/A] Pulley Fixed

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: PVC Elbow Reflector Plate [✓ None]

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: NE
(Bearing or Cardinal Direction of mic)

Power Supply: 6V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest	1	Grassland		Other (describe)	2 Pasture
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

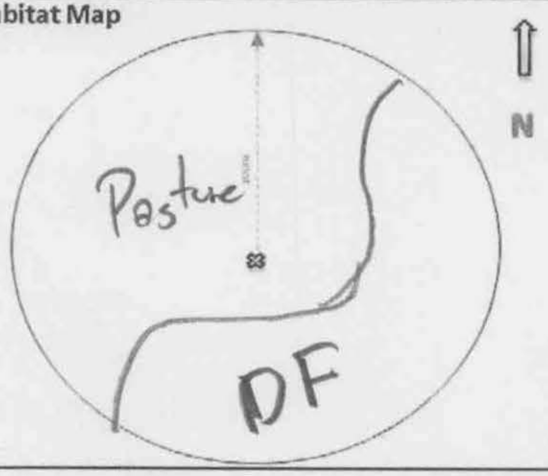
Topography: Flat Slope High Point [✓ Low Point] Other: ________

Was this station chosen to sample a bat feature? [✓ Yes] No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.* N, E, S, W, Unit, Core

General Remarks: ________

Habitat Map



Codes Bat Features — Description

AS=anthropogenic structure: ________

CV=cave: ________

MN=mine: ________

RO=rocky outcrop: ________

CF=coniferous forest stand: ________

DF=deciduous forest stand: ________

WA=water: ________

Other=: ________

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION   2011 Data Form   Station #: PW-8

Observer: RS   Date: 7-21-15   Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83]   Zone: 14   Easting: 0575714   Northing: 4266373

Detector Type: SD2   SD1   Anabat II   [✓ SM2]   Pettersson   B.A.T.

Serial Number(s): 015653 *(microphone)*

______ *(recorder, if applicable)*

Placement: [✓ Ground]   Raised

Raised System: [✓ N/A]   Pulley   Fixed

Station Type: Fixed   [✓ Temporary]

Microphone Protection: Plastic Bin   Bat Hat   [✓ None]

Met Tower Present? Yes   [✓ No]

Sound Reception: PVC Elbow   Reflector Plate   [✓ None]

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: E
(Bearing or Cardinal Direction of mic)

Power Supply: 6V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe	1	Deciduous Forest	2	Grassland	3	Other (describe)	
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

Topography: [✓ Flat]   Slope   High Point   Low Point   Other: ______

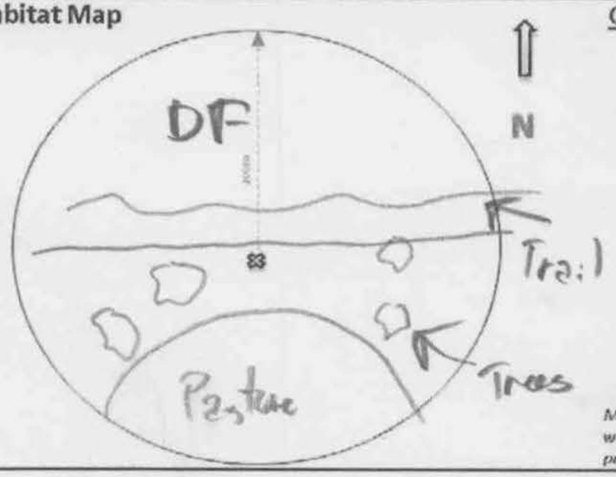
Was this station chosen to sample a bat feature? [✓ Yes]   No

N, E, S, W, Unit, Core

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). __Label__ and mail to your bat liaison on your thumb drive.*

General Remarks: ______

Habitat Map



<u>Codes</u> <u>Bat Features</u>	<u>Description</u>
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	:
WA=water	:
Other=:	

Map out bat __and__ habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION **2011 Data Form** **Station #:** PW 8 A

Observer: Ryan McDonald **Date:** 7/28/2015 **Project:** Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] **Zone:** 14 T **Easting:** 575652 **Northing:** 4768628

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80917 (microphone)

_____ (recorder, if applicable)

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: 120
(Bearing or Cardinal Direction of mic)

Power Supply: 12 V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest	1	Grassland	2	Other (describe)	
Crop/Agriculture	3	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

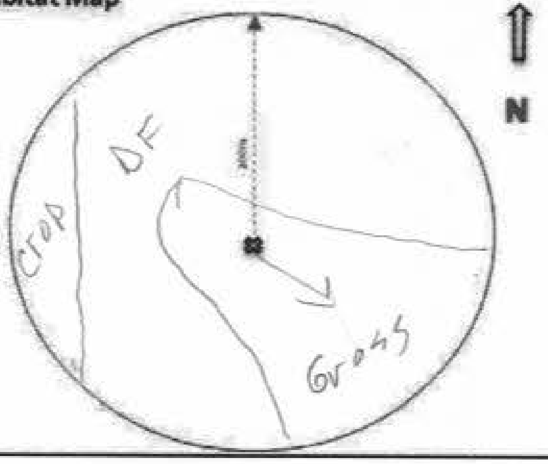
Topography: [✓ Flat] Slope High Point Low Point Other: _____

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: follow driveway to point

Habitat Map



Codes **Bat Features** **Description**

AS=anthropogenic structure : _____
CV=cave : _____
MN=mine : _____
RO=rocky outcrop : _____
CF=coniferous forest stand : _____
DF=deciduous forest stand : _____
WA=water : _____
Other=: _____

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW-9

Observer: Ryan McDonald Date: 7/27/2015 Project: Prevailing winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 T Easting: 580064 Northing: 4765600

Detector Type: SD2 [✓ SD1] Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 034835 *(microphone)*

_______________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: 270°
(Bearing or Cardinal Direction of mic)

Power Supply: 12 V battery
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest	2	Grassland	4	Other (describe)	
Crop/Agriculture	1	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper	3	Water (lake, etc.)			

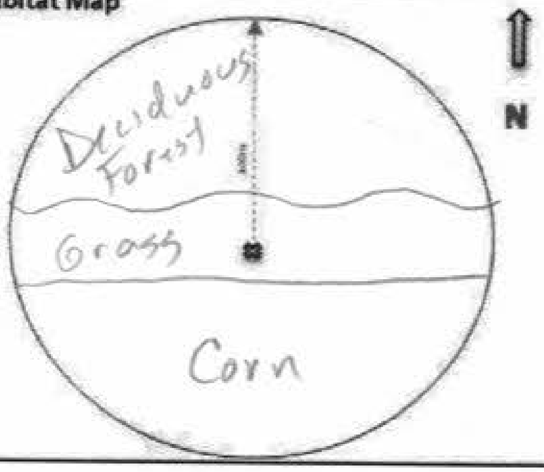
Topography: [✓ Flat] Slope High Point Low Point Other: ________

Was this station chosen to sample a bat feature? [✓ Yes] No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: ________

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	: mature
DF=deciduous forest stand	: mature
WA=water	:

Other=: ________

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form **Station #:** PW 9A

Observer: Ryan McDonald **Date:** 8/7/2015 **Project:** Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] **Zone:** 14T **Easting:** 569742 **Northing:** 4766932

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80917 *(microphone)*

________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 1.5 *(Height from ground to detector/microphone)*

Aspect: 80° *(Bearing or Cardinal Direction of mic)*

Power Supply: 12 V *(e.g., voltage and Amp-hours of battery, solar panel, etc.)*

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe		Deciduous Forest	2	Grassland	1	Other (describe)	
Crop/Agriculture		Coniferous Forest	3	Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)	4		

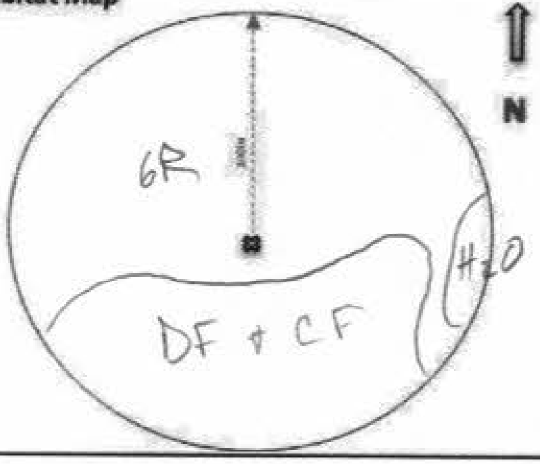
Topography: Flat [✓ Slope] High Point Low Point Other: ________

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: ________

Habitat Map



Codes Bat Features **Description**

AS=anthropogenic structure: ________

CV=cave: ________

MN=mine: ________

RO=rocky outcrop: ________

CF=coniferous forest stand: ________

DF=deciduous forest stand: ________

WA=water: ________

Other=: ________

Map out bat and habitat features within 100 m radius of detector (s). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION **2011 Data Form** **Station #:** PW10

Observer: Ryan McDonald **Date:** 7/27/2015 **Project:** Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] **Zone:** 14T **Easting:** 578533 **Northing:** 4763193

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T. **Serial Number(s):** 80814 *(microphone)*

_______________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised **Raised System:** N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary] **Microphone Protection:** [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No] **Sound Reception:** [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: 15°
(Bearing or Cardinal Direction of mic)

Power Supply: 12 V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe		Deciduous Forest	2	Grassland	1	Other (describe)	
Crop/Agriculture	3	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

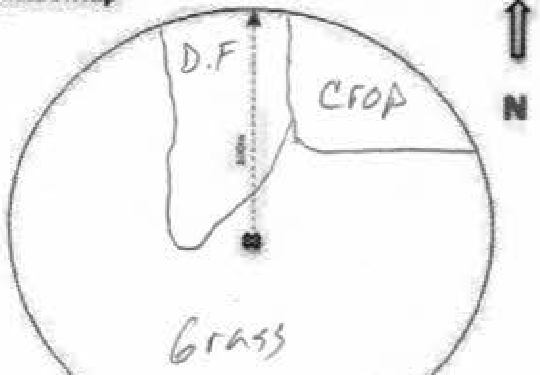
Topography: [✓ Flat] Slope High Point Low Point Other: _______________

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: _______________

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	: mature
WA=water	:

Other=: _______________

Map out bat and habitat features within 100 m radius of detector (s). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION **2011 Data Form** **Station #:** DW-11

Observer: Ryan McDonald **Date:** 7/27/2015 **Project:** Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] **Zone:** 14T **Easting:** 576700 **Northing:** 4763072

Detector Type: SD2 [✓ SD1] Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 03697 *(microphone)*

_____ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: 5°
(Bearing or Cardinal Direction of mic)

Power Supply: 12 V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest	1	Grassland	3	Other (describe)	
Crop/Agriculture	2	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

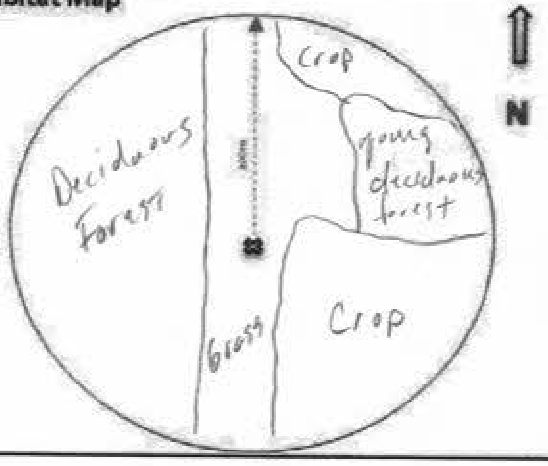
Topography: [✓ Flat] Slope High Point Low Point Other: _____

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: _____

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	:
WA=water	:
Other=:	

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW12

Observer: Ryan McDonald Date: 7/28/2015 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 T Easting: 575445 Northing: 4762139

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T. Serial Number(s): 80482 (microphone)

_______________ (recorder, if applicable)

Placement: [✓ Ground] Raised Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary] Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No] Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: 200°
(Bearing or Cardinal Direction of mic)

Power Supply: 12 ✓
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest	2	Grassland	1	Other (describe)	
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

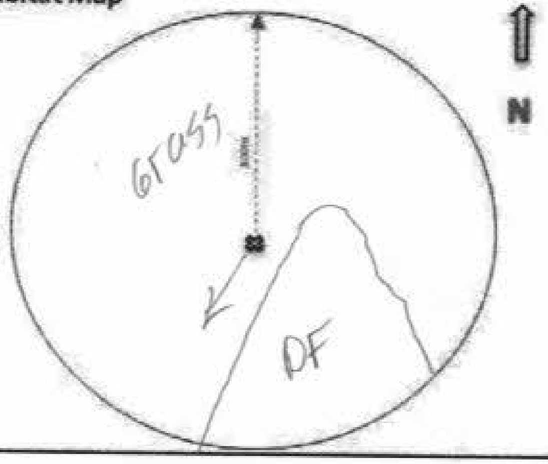
Topography: Flat Slope High Point [✓ Low Point] Other: _______________

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: _______________

Habitat Map



Codes	Bat Features	Description
AS	anthropogenic structure	:
CV	cave	:
MN	mine	:
RO	rocky outcrop	:
CF	coniferous forest stand	:
DF	deciduous forest stand	:
WA	water	:

Other: _______________

Map out bat and habitat features within 100 m radius of detector (s). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: Pw13

Observer: Ryan McDonald Date: 8/1/2015 Project: Prevailing Wind

Station Information

Datum: NAD27 or NAD83 Zone: 14T Easting: 574443 Northing: 4759581

Detector Type: SD2 [✓ SD1] Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 03483 *(microphone)*

_______________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 1.5 *(Height from ground to detector/microphone)*

Aspect: 90 *(Bearing or Cardinal Direction of mic)*

Power Supply: 12 V *(e.g., voltage and Amp-hours of battery, solar panel, etc.)*

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe		Deciduous Forest	1	Grassland	2	Other (describe)	
Crop/Agriculture		Coniferous Forest	3	Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

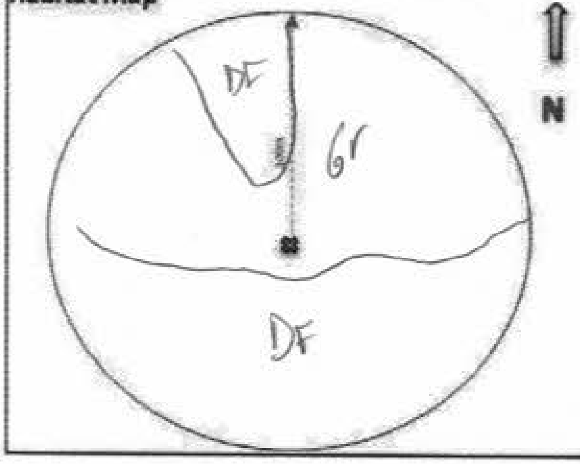
Topography: Flat Slope High Point [✓ Low Point] Other: _______________

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). **Label** and mail to your bat liaison on your thumb drive.*

General Remarks: _______________

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	:
WA=water	:
Other=:	

*Map out bat **and** habitat features within 100 m radius of detector (s). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.*

Acoustic Monitoring STATION 2011 Data Form Station #: PW-14

Observer: Ryan McDonald Date: 8/1/2015 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14T Easting: 574925 Northing: 4758670

Detector Type: SD2 [✓ SD1] Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 03697 *(microphone)*

________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2
(Height from ground to detector/microphone)

Aspect: 30
(Bearing or Cardinal Direction of mic)

Power Supply: 12 V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat:
Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe	3	Deciduous Forest	2	Grassland	4	Other (describe)	
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper	1	Water (lake, etc.)			

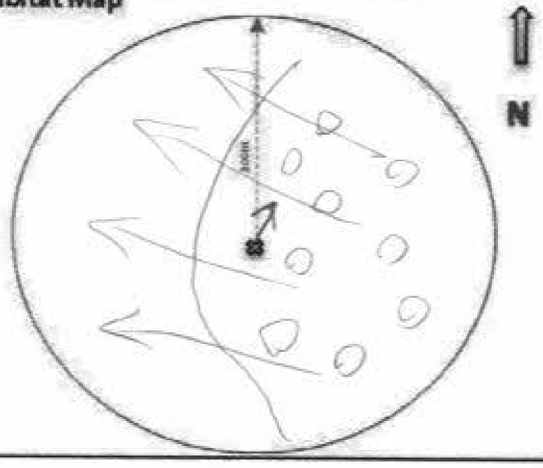
Topography: Flat [✓ Slope] High Point Low Point Other: ________

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: ________

Habitat Map



Codes Bat Features Description

AS=anthropogenic structure: ________

CV=cave: ________

MN=mine: ________

RO=rocky outcrop: ________

CF=coniferous forest stand: ________

DF=deciduous forest stand: ________

WA=water: ________

Other=: ________

Map out bat and habitat features within 100 m radius of detector (s). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION **2011 Data Form** **Station #:** PW-15

Observer: Ryan McDonald **Date:** 8/1/2015 **Project:** Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] **Zone:** 14T **Easting:** 575580 **Northing:** 4758206

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T. **Serial Number(s):** 80966 *(microphone)*

_____ *(recorder, if applicable)*

Placement: [✓ Ground] Raised **Raised System:** N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary] **Microphone Protection:** [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No] **Sound Reception:** [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 1,5 *(Height from ground to detector/microphone)* **Aspect:** 0° *(Bearing or Cardinal Direction of mic)* **Power Supply:** 12 V *(e.g., voltage and Amp-hours of battery, solar panel, etc.)*

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe		Deciduous Forest	2	Grassland	1	Other (describe)	
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)	3		

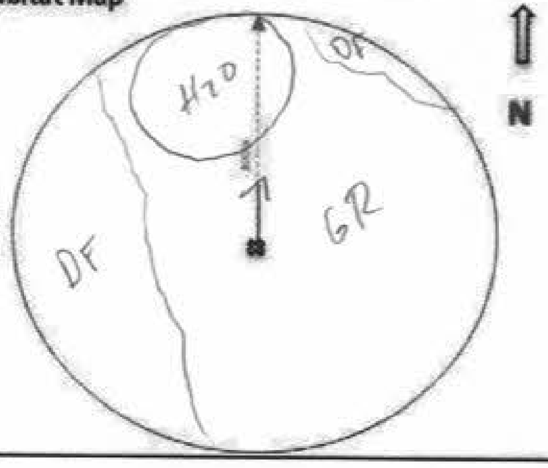
Topography: Flat Slope High Point [✓ Low Point] Other: _____

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: _____

Habitat Map



Codes	Bat Features	Description
AS=	anthropogenic structure	:
CV=	cave	:
MN=	mine	:
RO=	rocky outcrop	:
CF=	coniferous forest stand	:
DF=	deciduous forest stand	:
WA=	water	:
Other=	:	

Map out bat and habitat features within 100 m radius of detector (s). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW 16

Observer: Ryan McDonald Date: 8/1/2015 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 T Easting: 576680 Northing: 4757714

Detector Type: SD2 SD1 Anabat II SM2 Pettersson B.A.T. Serial Number(s): 80482 *(microphone)*

_______________ *(recorder, if applicable)*

Placement: [✓ Ground] Raised Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary] Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No] Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 2 *(Height from ground to detector/microphone)*

Aspect: 0 *(Bearing or Cardinal Direction of mic)*

Power Supply: 12 V *(e.g., voltage and Amp-hours of battery, solar panel, etc.)*

Habitat Information

Habitat: *Rank by abundance within 100 m of detector. 1 = most abundant, etc.*

Shrub/Steppe		Deciduous Forest	2	Grassland	1	Other (describe)	
Crop/Agriculture		Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

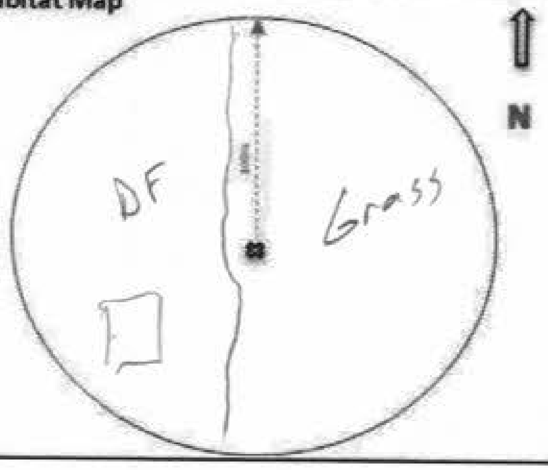
Topography: [✓ Flat] Slope High Point Low Point Other: _______________

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: _______________

Habitat Map



Codes Bat Features	Description
AS=anthropogenic structure	:
CV=cave	:
MN=mine	:
RO=rocky outcrop	:
CF=coniferous forest stand	:
DF=deciduous forest stand	:
WA=water	:
Other=	

Map out bat and habitat features within 100 m radius of detector (s). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

Acoustic Monitoring STATION 2011 Data Form Station #: PW-17

Observer: Ryan McDonald Date: 8/1/2015 Project: Prevailing Winds

Station Information

Datum: NAD27 or [✓ NAD83] Zone: 14 T Easting: 578987 Northing: 4756031

Detector Type: [✓ SD2] SD1 Anabat II SM2 Pettersson B.A.T.

Serial Number(s): 80917 (microphone)

__________ (recorder, if applicable)

Placement: [✓ Ground] Raised

Raised System: N/A Pulley [✓ Fixed]

Station Type: Fixed [✓ Temporary]

Microphone Protection: [✓ Plastic Bin] Bat Hat None

Met Tower Present? Yes [✓ No]

Sound Reception: [✓ PVC Elbow] Reflector Plate None

Microphone Ht (m): 1.5
(Height from ground to detector/microphone)

Aspect: 280°
(Bearing or Cardinal Direction of mic)

Power Supply: 12 V
(e.g., voltage and Amp-hours of battery, solar panel, etc.)

Habitat Information

Habitat: Rank by abundance within 100 m of detector. 1 = most abundant, etc.

Shrub/Steppe		Deciduous Forest	1	Grassland	2	Other (describe)	
Crop/Agriculture	3	Coniferous Forest		Desert			
Riparian/Wetland		Pinyon-Juniper		Water (lake, etc.)			

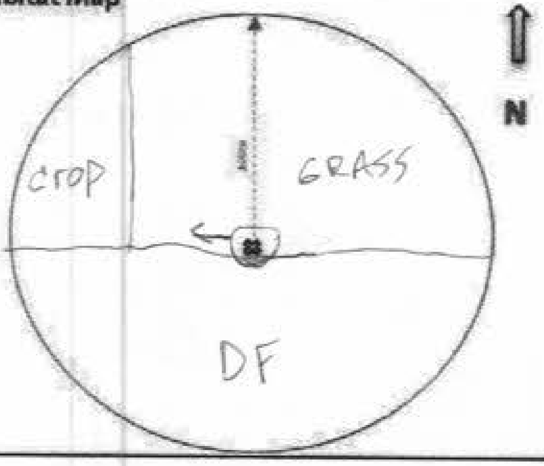
Topography: [✓ Flat] Slope High Point Low Point Other: ________

Was this station chosen to sample a bat feature? Yes No

Photos: *Take photos of the area from each cardinal direction (facing away from the detector), as well as from the direction the microphone is pointing, and one of the detector set-up itself. Also take photos of any bat features present and anything else of interest (e.g., sage grouse pellets, etc.). Label and mail to your bat liaison on your thumb drive.*

General Remarks: There

Habitat Map



Codes Bat Features Description

AS=anthropogenic structure :
CV=cave :
MN=mine :
RO=rocky outcrop :
CF=coniferous forest stand :
DF=deciduous forest stand :
WA=water :
Other=:

Map out bat and habitat features within 100 m radius of detector (x). Label using codes provided, and write in any other features of interest (cliff, road, etc.). Provide descriptions for bat features in spaces provided.

ENVIRONMENTAL & STATISTICAL CONSULTANTS
4007 State Street, Suite 109, Bismarck, ND 58503
Phone: 701-250-1756 ◆ www.west-inc.com ◆ Fax: 701-250-1761

February 12, 2018

Bridget Canty
Prevailing Winds, LLC.

RE: Prevailing Winds Project
Northern Long-eared Bat 2016 Summer Presence/Absence Survey

Dear Ms. Canty,

Prevailing Winds, LLC, (Prevailing Winds) requested that Western EcoSystems Technology, Inc. (WEST) implement the USFWS 2016 Northern Long-eared Bat Survey[1] guidance to determine the presence/absence of the proposed northern long-eared bat (*Myotis septentrionalis*) within the Prevailing Winds Wind Project (the Project). Based on the Project boundary, as provided by Prevailing Winds before the 2016 survey, there were approximately 440 acres of wooded habitat within the Project boundary. The USFWS 2016 guidelines call for a minimum of two sample locations each sampled for two nights (total of four acoustic detector nights) for each 123 acres of woodlands. Based on the amount of wooded habitat, the guidelines required that 8 locations (see attached figure) be surveyed for 2 nights each, for a total of 16 detector nights.

A combination eight Anabat SD1 and SD2 detectors, with microphones elevated to 10 feet, were placed in habitat that would likely attract bats commuting between roosting and foraging areas (e.g., along forest edges and along forest corridors) in adherence with the USFWS 2016 guidelines. Detectors were deployed from July 12 until August 4, during which adequate nighttime sample conditions of low wind (below 9 mph), mild temperatures (above 50^{o}F), and lack of sustained precipitation (less than 1 hour) occurred on a minimum of two nights based on local weather stations. Other nights had elevated winds or sustained periods of rain. Regardless, call data from all nights from all detectors were analyzed.

Echolocation call analysis followed the acoustic survey guidelines issued by the USFWS which involves a combination of automated species identification software and qualitative review by an acoustic expert. Echolocation call data were reviewed using Kaleidoscope version 4.0.0, one of the candidate acoustic identification programs recommended by USFWS[2]. We selected the

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[1] US Fish and Wildlife Service (USFWS). 2016. Range-wide Indiana Bat Summer Survey Guidelines (April 2016). Available: https://www.fws.gov/midwest/endangered/mammals/inba/inbasummersurveyguidance.html

[2] http://www.fws.gov/midwest/endangered/mammals/inba/surveys/inbaAcousticSoftware.html

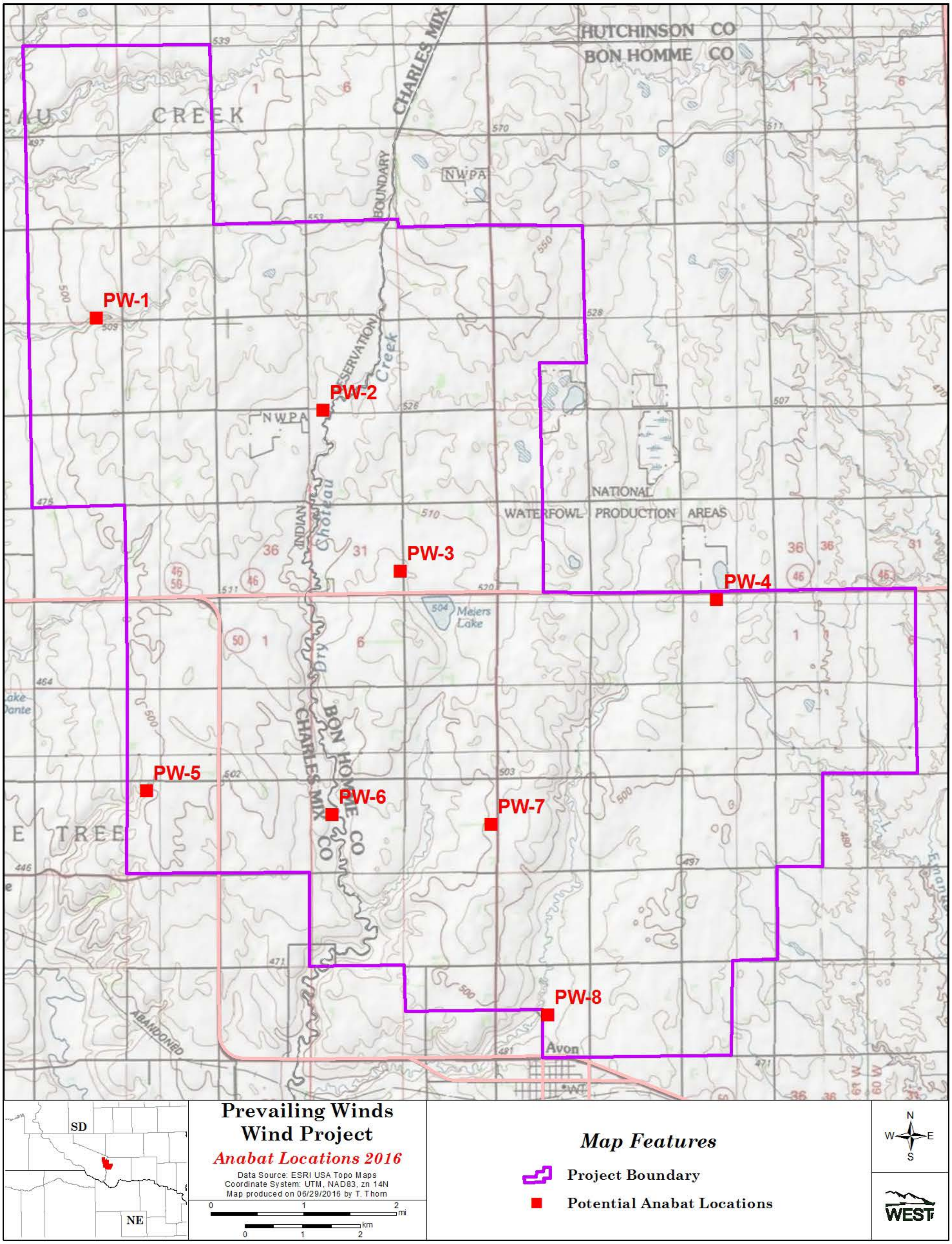
South Dakota subset of 7 species, as well as the northern long-eared bat, from the Bats of North America 3.1.0 classifier, and used the recommended sensitivity setting of -1 (Liberal). Kaleidoscope probabilistically identifies echolocation calls to species based on statistical comparison of the unknown calls to known calls. If the program identified potential northern long-eared bat calls, or identified a night that northern long-eared bats were likely present (Presence p-value > 0.05), then qualitative identification was performed to determine if calls were likely to have been produced by northern long-eared bats or other species. All calls that were identified as northern long-eared bat were reviewed by Jeff Gruver (WEST, Inc.), a recognized bat acoustic expert, per USFWS guidelines. Qualitative review was based on Mr. Gruver's extensive experience with bat acoustics, and relied primarily on comparison of calls recorded at the site to known calls from northern long-eared and other species (e.g., little brown bats) that can produce calls similar to northern long-eared bats.

No northern long-eared bat calls were recorded at any station during the sampling period, indicating probable absence within the area.

Please let me know if you have any questions or need further information.

Sincerely,

Clayton Derby
Senior Manager



Prevailing Winds Wind Project

Anabat Locations 2016

Data Source: ESRI USA Topo Maps
Coordinate System: UTM, NAD83, zn 14N
Map produced on 06/29/2016 by T. Thorn

Map Features

Project Boundary

🟥 Potential Anabat Locations

Whooping Crane Habitat Review
Prevailing Winds Wind Project
Bon Homme and Charles Mix Counties, South Dakota

Prepared for:

Prevailing Winds, LLC
101 Second Street West
P.O. Box 321
Chokio, Minnesota 56221

Prepared by:

Clayton Derby
Western EcoSystems Technology, Inc.
4007 State Street, Suite 109
Bismarck, ND 58503

August, 2016

NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Prevailing Winds Wind Project (PWWP) is proposed for development by Prevailing Winds Wind Project LLC (Prevailing Winds) in Bon Homme and Charles Mix Counties, South Dakota. Prevailing Winds requested that Western EcoSystems Technology, Inc. (WEST) implement a desktop review and analysis of potential whooping crane (*Grus americana*) habitat resources within the PWWP and to compare these resources to areas outside of the project boundary to the north, south, east, and west. The habitat review and analysis evaluates whether or not the proposed PWWP area represents the only unique whooping crane habitat compare to the surrounding landscape. From this analysis all parties can then discuss what impacts there may be to whooping cranes from development of the PWWP.

PROJECT AREA

The PWWP is located in the southeastern South Dakota counties of Bon Homme and Charles Mix, just north of the city of Avon (Figure 1). The PWWP is currently about 37,017 acres (ac; 150 square kilometers [km^2]; 58 square miles [mi^2]). Landscape within the project area is generally flat with some steeper hills. Elevations range from 454.5 to 573.7 meters (m; 1,491.2 to 1,882.3 feet [ft]) above sea level. Historically, the PWWP's landscape was dominated by grasslands but has since been converted largely to agricultural use with crop production and livestock grazing the primary practices. Trees and shrubs can be found around farmsteads, within planted shelter belts, and along/within drainages. Wetlands are scattered throughout the PWWP with some being man-made. Common agricultural crops include small grains, corn, soybeans, and alfalfa.

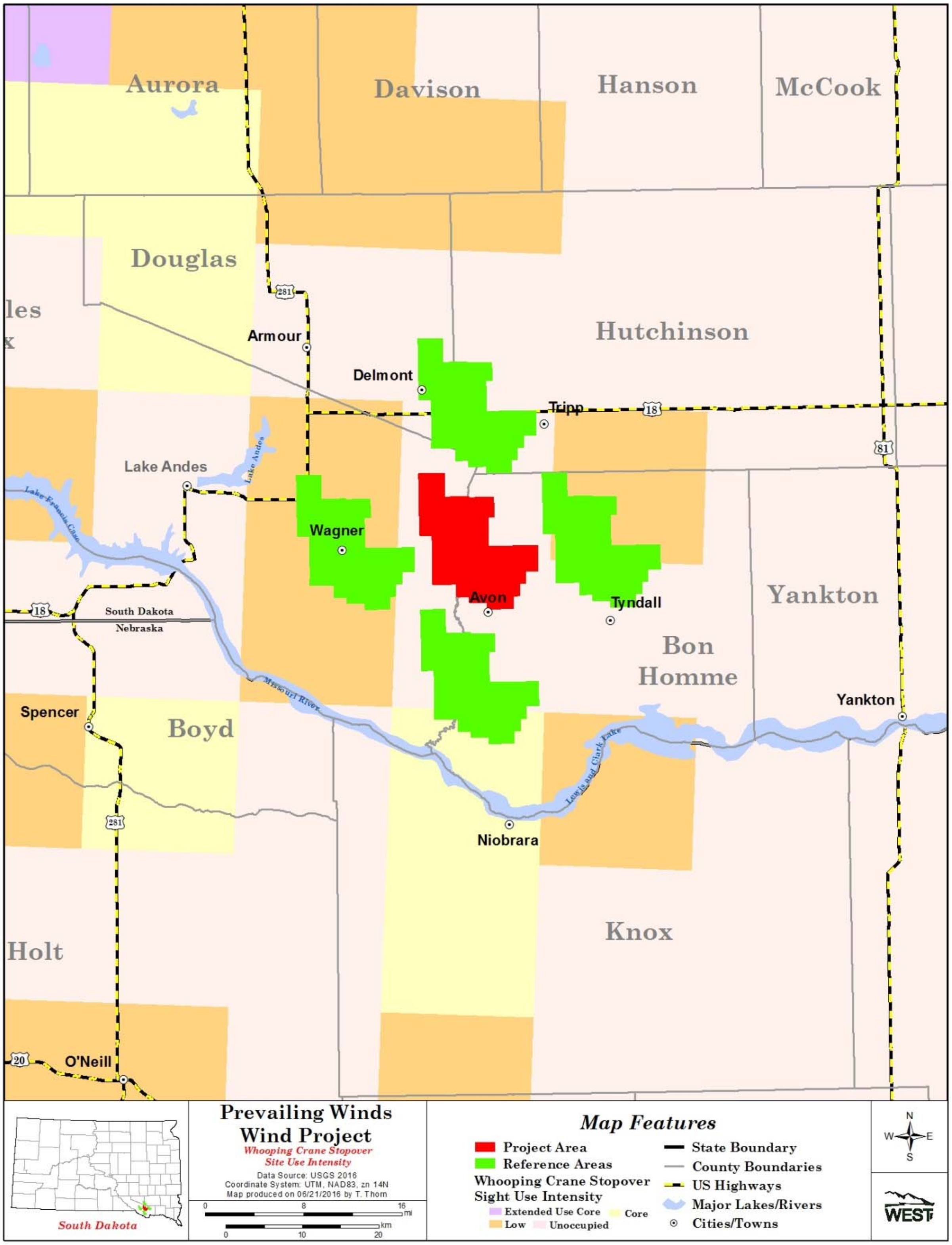


Figure 1. Location of the Prevailing Winds Wind Project, alternate areas, and whooping crane stopover site use intensity.

METHODS

A desktop review was completed using ArcGIS, ArcMap 10.3, land cover information from the National Land Cover Database (NLCD), wetland data from the National Wetland Inventory (NWI), 2014 National Agricultural Imagery Program (NAIP) aerial imagery, and the current project boundary as provided by Prevailing Winds. A site visit was not completed by WEST for this exercise specifically, but WEST has conducted other surveys at the PWWP and confirmed that the mapping generally agrees with current conditions.

The whooping crane habitat analysis included a comparison of land cover within the proposed PWWP boundary and four alternate areas of the same dimensions located adjacent (based on the PWWP's boundary extent) to the PWWP boundary in the four cardinal directions (Figure 1). A potentially suitable habitat assessment (Watershed Institute 2012) was also used to quantify and compare whooping crane habitat within the study areas. This assessment first screens all wetlands within the study areas for minimum size, visual obstructions, and disturbances. Those wetlands left are then quantified by their size, density of wetlands around them, distance to food, whether they are natural or man-made, and their water regime as a means to quantify suitability. This work was initially done in Kansas and the results were compared to Quivira National Wildlife Refuge, a traditional migratory stopover area. In Kansas, it was determined that a score of 12 or higher represented potentially suitable whooping crane habitat.

RESULTS

There is almost 17,588 ac of cropland within the proposed project area, or 47.5% of the total area. Pasture/hay lands make up approximately 38% of the project area while grass/herbaceous lands and developed areas occupy another 6.7% and 4.3% respectively. Water, forest, shrub/scrub, and barren habitats comprise the remaining 3.5% of the PWWP (Figure 2; Table 1).

Croplands, Grasslands, and Other Habitats

The percentage of cropland varied between the project area and comparison areas, with the PWWP containing the second lowest (47.5%) and the east comparison area the most (66.4%; Figure 2; Table 1). The south reference area had the least cropland (39.8%) with the north and west areas comprised of 54.1% and 55.4% cropland respectively (Table 1). All cropland has the potential as foraging areas for whooping cranes but crop type could influence the extent of use of a particular field during any one migration season.

Considering grassland/herbaceous and pasture/hay habitats as "grasslands", this habitat type also varied between analyzed areas (Figure 2; Table 1). The south (46.6%) had the most while the east reference area had the least (26.6%). Grassland percentages in the other three areas ranged from 44.2% (PWWP) to 34.8% (Table 1).

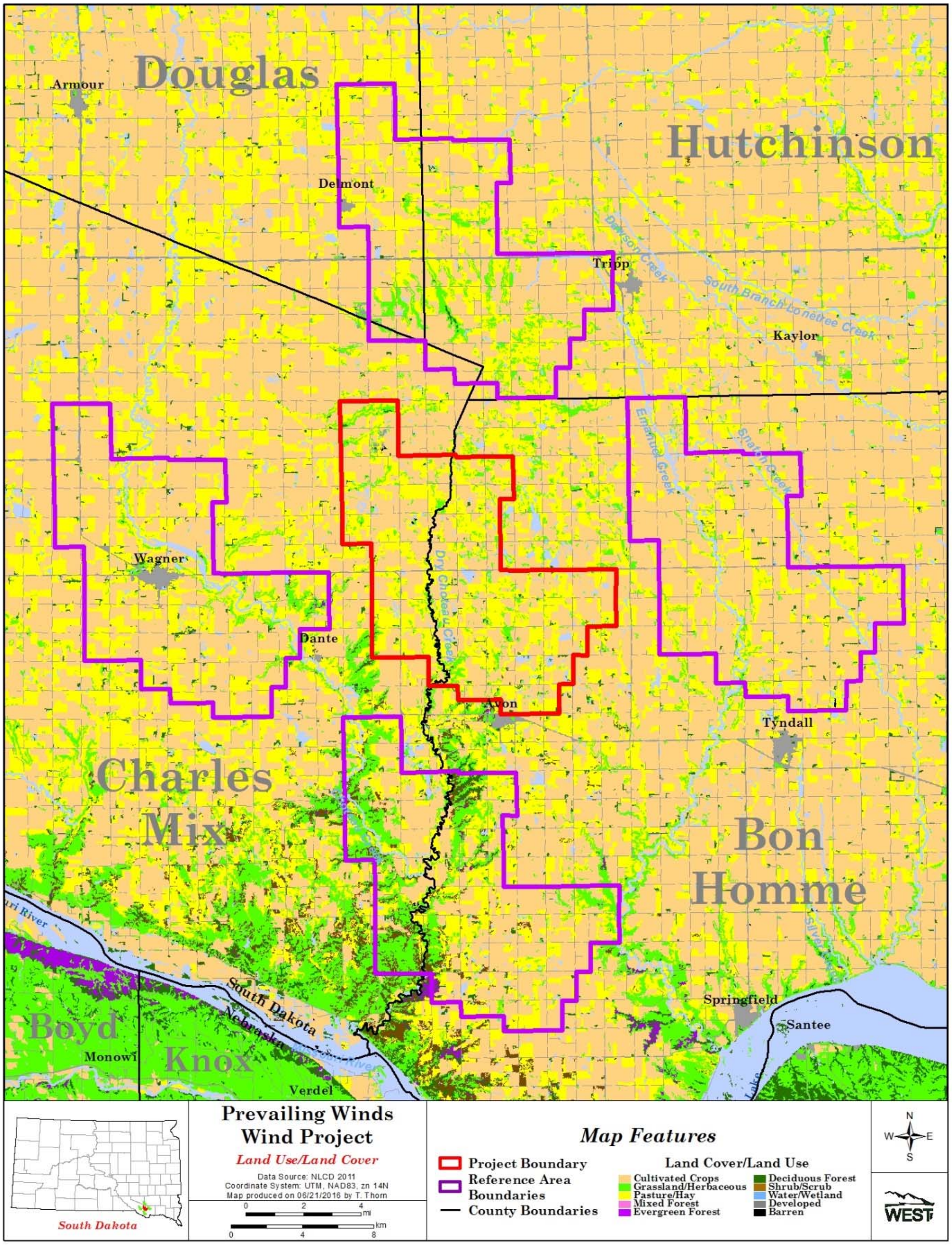


Figure 2. Land Use/Land Cover within and around the Prevailing Winds Wind Project.

The influence of grassland habitats on migrating whooping crane behavior is unknown; however, short grasslands (i.e. grazed pasture) adjacent to wetlands may provide loafing areas and cranes may utilize grasslands to some degree for foraging.

All other habitat types comprised approximately 8.3% of the PWWP's area. This is similar to the north, east, and west reference areas while in the south comparison area, other habitat types occupied 13.6% of the area. Shrub/scrub land made up almost half of the other habitats in this area (Figure 2; Table 1).

Table 1. Land Use/Land Cover within the Prevailing Winds Wind Project and adjacent areas.

	PWWP		North		East		South		West	
Habitat Type	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**cres**	**%**
Cultivated Crops	17,588.3	47.5	20,033.3	54.1	24,592.7	66.4	14,716.9	39.8	20,507.8	55.4
Grassland/Herbaceous	2,481.9	6.7	2,922.5	7.9	995.0	2.7	7,270.35	19.6	1,398.2	3.8
Pasture/Hay	13,897.5	37.5	11,676.7	31.5	8,853.2	23.9	9,985.0	27.0	1,1482.6	31.0
Developed	1,578.0	4.3	1,894.3	5.1	1,668.2	4.5	1,142.3	3.1	1,998.4	5.4
Water/Wetlands	1,016.5	2.8	327.6	0.9	562.2	1.5	682.0	1.8	1,086.7	2.9
Forests	372.1	1.0	152.5	0.4	307.5	0.8	958.8	2.6	441.8	1.2
Shrub/Scrub	67.5	0.2	9.7	<0.1	22.7	<0.1	2,251.6	6.1	93.3	0.3
Barren	14.7	<0.1			15.1	<0.1	9.7	<0.1	7.8	<0.1

National Land Cover Database - Fry et al. 2011.

Wetlands

NWI wetland data was used for this analysis because it represents wetland features to a higher degree than the NLCD. For this analysis, it is assumed that all wetlands are potential whooping crane roosting areas under one water regime or another (e.g., drought, normal, or flood). The PWWP had similar total acres, mean size and size range of wetland basins as the north and east reference areas (Table 2). Total number of wetland basins ranged from 792 in the PWWP to 924 in the east reference area. The south comparison area had the fewest basins (507) and the lowest total wetland acreage (688 ac). However, mean wetland size and wetland size range was similar to all other areas except the west comparison area (Table 2). The west reference area has by far the highest total wetland acreage (2,268.7 ac). However, almost 41% of the total acreage is made up of wetlands associated with Choteau Creek (Figure 3). This causes the size and acreage range of wetlands within this area to be somewhat misleading

Freshwater emergent (77.5%) made up the highest percentages of wetland types in the PWWP, with freshwater ponds accounting for another 14.7% (Table 3). Wetlands in all the comparison areas were 83% or greater freshwater emergent (Table 3). The west and south reference areas contained riverine wetlands with slightly more the 8% of wetlands in the west and 4% in the south classified as this wetland type (Table 3).

To summarize, the PWWP had similar wetland acreages and types as those for the north and east comparison areas and to a lesser extent the south area. The south reference area had the fewest wetland basins and smallest wetland total acreage but had similar mean wetland size and wetland size range to all other areas except the west. Wetland statistics (highest total wetland acreage, mean wetland size, and basin size range) for the west reference area were misleading due wetlands associated with Choteau Creek which intersects the area from north central to southeast (Figure 3).

Table 2. Comparison of the number of wetland basins and mean size within the Prevailing Winds Wind Project and adjacent areas.

Area	Basins	Total - acres	Mean Size - acres	Range - acres
PWWP	792	1,304.9	1.6	<0.1 – 63.4
North	913	1,158.0	1.3	<0.1 – 39.5
East	924	1,149.0	1.2	<0.1 – 34.6
South	507	687.8	1.4	<0.1 – 54.8
West	769	2,268.7	3.0	<0.1 – 919.8

Data Source: NWI data with wetland parts dissolved.

Table 3. Wetland types within the Prevailing Winds Wind Project and adjacent areas.

	PWWP		North		East		South		West	
Wetland Type	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Freshwater Emergent	1,011.0	77.5	962.8	83.1	987.9	85.9	610.9	88.8	1959.4	86.4
Freshwater Forested/Shrub	44.3	3.4	20.5	1.8	43.2	3.8	4.4	0.6	15.8	0.7
Freshwater Pond	192.2	14.7	122.6	10.6	95.0	8.3	43.4	6.3	79.4	3.5
Lake	57.4	4.4	52.0	4.5	23.9	2.1			24.7	1.1
Riverine							29.1	4.2	189.4	8.3

Data Source: NWI 2010.

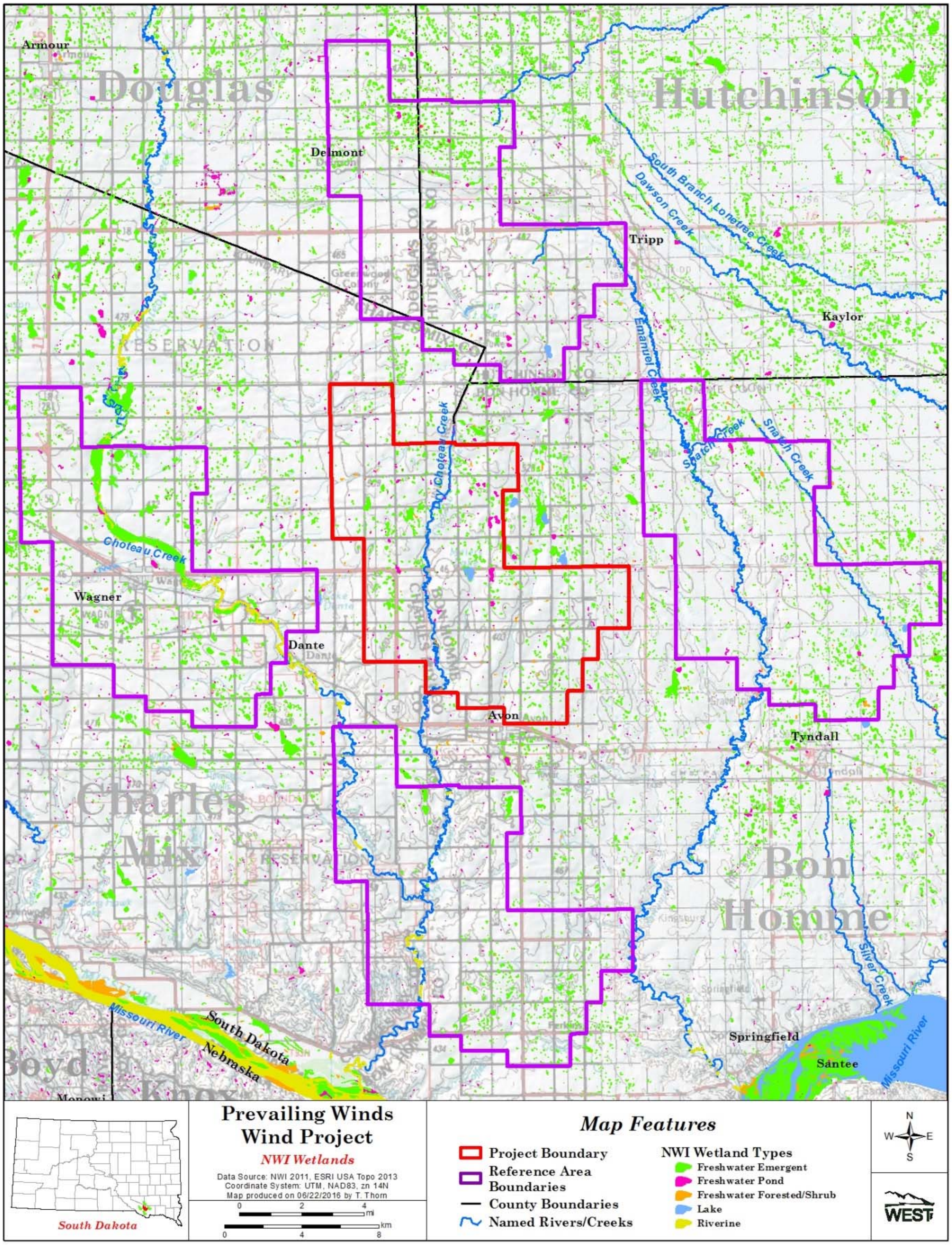


Figure 3. NWI wetlands within and around the Prevailing Winds Wind Project.

Whooping Crane Suitable Habitat Assessment

The habitat assessment model identified 262 wetland basins within the PWWP as potential whooping crane roosting habitat. The mean suitability score for these wetlands was 9.4 with the scores ranging from 6 to 16 (Table 4). This mean suitability score and range was similar to the score and range for three of the four reference areas. The exception being the southern comparison area which had the fewest potential whooping crane roosting wetlands, lowest total potential wetland acreage, lowest mean suitability score and lowest and narrowest score range (Table 4).

In Kansas, a wetland with a score of 12 or more was considered suitable potential whooping crane habitat (Watershed Institute 2012). If applied to the PWWP, there would be 41 wetlands (15.6% of identified potential whooping crane wetlands) considered as such. The south reference area would have only 13 and the north, east, and west comparison areas would have between 33 and 63 potentially suitable whooping crane wetlands

Table 4. Comparison of suitable whooping crane habitat within the Prevailing Winds Wind Project and adjacent areas.

Area	Basins	Total - acres	Mean Score	Score range
PWWP	262	490.1	9.4	6 – 16
North	270	517.2	9.8	6 – 18
South	157	285.9	8.4	5 – 14
East	244	395.6	9.7	6 – 16
West	284	1,239.8	9.8	6 – 17

Data Derived From: Potentially Suitable Habitat Assessment, Watershed Institute 2012.

Whooping Crane Stopover Site Use Intensity

USGS and its' partners recently determined whooping crane stopover sites and the intensity of use of these areas within the Great Plains using radio telemetry information from 2010 to 2014 of tagged whooping cranes (Pearse et al. 2015). Stopover sites and their use intensity were based on 20 km square grid cells.

The PWWP and the north review area fall within “unoccupied” 20 km cells while the east and west reference areas lie within “low intensity” cells and the south intersects a “core intensity” cell (Figure 1). USGS describes an “unoccupied” cell as “lacking evidence of use”, “low intensity” cell shows “evidence of use and low stopover site use intensity”, and a “core intensity” site “contains density of stopovers identified as high use intensity and crane days of lower intensity” (Pearse et al. 2015).

DISCUSSION

Whooping cranes are currently listed as endangered under the Endangered Species Act (32 FR 4001, 1967 March 11) except where nonessential experimental populations exist (66 FR 33903-33917, 2001 June 26; 62 FR 38932-38939, 1997 July 21; and 58 FR 5647-5658, 1993 January 22). In the US, the whooping crane was listed as threatened with extinction in 1967 and endangered in 1970 – both listings were "grandfathered" into the Endangered Species Act of 1973 (ESA 1973). The 2015 – 2016 winter population within the primary wintering grounds was estimated at 329 birds (291 – 371, 95% confidence interval.). There was another 10 whooping cranes thought to be outside of the primary wintering grounds when systematic surveys were conducted (USFWW 2016). Whooping cranes typically migrate from their breeding grounds in Wood Buffalo National Park, Canada to their wintering areas in Aransas National Wildlife Refuge, Texas. During the migration, most birds pass through central South Dakota.

The USGS has recently determined whooping crane stopover sites and their intensity of use within the Great Plains from radio telemetry information. This information shows whooping crane use directly to the south, east, and west of the project area. Although no whooping crane use was document within the 20 km grid cell the project falls within, at the least, it is possible that whooping cranes would fly over or through the project area during migration. Whooping cranes generally migrate at 1,000-6,000 ft (305-1830 m) altitude, well above turbine height (Stehn 2007), and thus for the most part are unlikely to collide with turbines. However, as whooping cranes ascend and descend during takeoff and landing, or migrate during inclement weather, they may fly at lower altitudes and may fly at altitudes corresponding to the rotor-swept areas. In summary, low altitude flight is generally of short duration in the morning and evenings with more time and distance covered at higher elevation during typical migration flight; reducing potential risk to whooping cranes.

No whooping cranes have been reported as being killed or injured by wind turbines (NWCC 2004), but one sandhill crane (*Grus canadensis*) was reported at the Altamont wind energy facility in California (Smallwood and Karas 2009), it is unclear if this was a result of turbine collision or collision with a power line. Two sandhill cranes were also apparently struck by turbines during a study of wintering cranes in Texas (Navarrete and Griffis 2011a). It appears that cranes are not overly susceptible to collision with turbines given that 100,000's sandhill cranes migrate twice annually through the Great Plains and none have been documented as wind turbine collision fatalities in this region during migration.

Besides direct mortality, concern has also been raised regarding potential displacement impacts that wind facilities may have on whooping cranes. For example, if whooping cranes avoid wind facilities, the likelihood of impacts with turbines is further decreased but the availability of habitat in the project area may be diminished, causing cranes to have to fly further to find suitable habitat to roost and forage. To date, very little quantitative data is available to help address displacement impacts on whooping cranes or sandhill cranes. A presentation by Navarrete and Griffis (2011b) suggested that the mean density of sandhill cranes wintering in the high plains of Texas increased the further away from studied wind facilities and this distribution was not a random event. There is an operating wind energy facility just north of the proposed project boundary. What, if any impact this facility has on crane use in and around the surrounding area is unknown.

Although developed for transmission line impacts on whooping crane habitat in Kansas, the Watershed Institute's (2012) potentially suitable habitat assessment for whooping cranes can help to quantify potential whooping crane habitat in and around a proposed wind energy project. This tool indicates that the range of scores and average score at the PWWP is similar to three of the four other study areas. The exception being the southern reference area which had fewer potential roost wetlands, with the average score for those basins one less than the other areas. Overall, the average score and the majority of the individual wetland scores were lower than the reference score of 12 developed for quality habitat at the Quivira National Wildlife Refuge.

SUMMARY

In analyzing the potential for significant impacts from wind development on whooping crane stopover habitat, Stehn (2007) suggests assessing whether there is "lots of suitable stopover habitat in the general area … or is the proposed wind farm site the only suitable whooping crane stopover habitat for miles around". This issue was investigated by comparing the potential whooping crane stopover habitat (using wetlands as this indicator) in the project area to surrounding (in the four cardinal directions) areas of the same dimensions, located adjacent (based on the PWWP's boundary extent) to the PWWP boundary. A Geographic Information System (GIS) was used to calculate the amount of the various habitats and in the case of wetlands, number of individual basins and their type, in each of the areas compared to the proposed PWWP (Tables 1, 2, and 3). This analysis shows that both roosting (i.e. wetlands) and foraging (i.e. croplands) habitats are available in the PWWP and alternate areas. Potential whooping crane habitat within the PWWP appears to be most similar to that in the north, east, and west reference areas and more suitable than that found in the south alternate area. Based on the USGS's recent determination of whooping crane stopover use sites adjacent to the proposed project area, whooping cranes will likely migrate over or through the PWWP during some migration period. There is potential whooping habitat within the PWWP but this habitat is not unique compared to adjacent areas.

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Bird and Bat Conservation Strategy
Prevailing Wind Park Project
Bon Homme, Charles Mix, and Hutchinson Counties, South Dakota

Prepared for:

Prevailing Wind Park, LLC

201 Mission Street, Suite 540
San Francisco, CA 94105

Prepared by:

Clayton Derby and Sofia Agudelo

4007 State Street, Suite 109
Bismarck, North Dakota 58503

May 3, 2018

EXECUTIVE SUMMARY

Prevailing Wind Park, LLC (Prevailing Wind) is developing the Prevailing Wind Park Project (Project) near Avon, South Dakota. As part of the wind energy development process, Prevailing Wind voluntarily implemented the tiered approach detailed in the final Land-Based Wind Energy Guidelines (WEG) and incorporated agency recommendations in Project survey efforts and development. The purpose of this Bird and Bat Conservation Strategy is to develop and implement a program to identify and minimize risks to avian and bat species that may result from construction and operation of the Project.

Information gathered during Tier 1, 2, and 3 studies was used during the development process to reduce potential impacts to birds and bats and their habitats. Tier 1 and 2 studies included a review of environmental characteristics and other aspects to help inform the Project in an overall sense. This analysis, as well as the Project's biological and environmental assessments, concluded that the Project area was suited for wind energy development and any significant impacts could be avoided, minimized, or mitigated with pre-construction design and siting.

Tier 3 studies included whooping crane habitat assessment, avian use surveys, raptor and eagle nest surveys, acoustic bat surveys, and northern long-eared bat presence/absence surveys, to help determine impacts to birds and bats and assist in avoiding and minimizing impacts. Results of these studies indicated that no direct or indirect impacts to whooping cranes were expected, but due to the location of the Project and the whooping crane migration corridor, whooping cranes could use the Project area. Direct impacts to migratory birds were anticipated to be similar to other wind projects in South Dakota and elsewhere in the Midwest. Direct impacts to bald and golden eagles were unlikely as a result of low eagle use within the Project area. No eagle nests were found in the Project; however, nests were observed in the surrounding areas. Impacts to bats were anticipated to be low and within the range of other wind energy projects in South Dakota and the Midwest region. Northern long-eared bats were detected within the Project area during bat acoustic surveys in 2015, but the Project was revised to be several miles away from the area of detection.

Tier 4 studies planned include post-construction studies to estimate the actual impacts the Project has on birds and bats. For this Project, the focus will be on the Tier 4a questions set forth in the WEG. Post-construction surveys will include fatality monitoring (i.e., standardized carcass searches and bias trials), operations personnel training, and adaptive management as deemed necessary. Given that the information collected during the pre-construction period indicated that the Project is not likely to cause significant adverse impacts, per the WEG, it is not anticipated that Tier 5 research will be necessary at this Project.

This document includes whooping crane migration use data from the Central Flyway stretching from Canada to Texas, collected, managed, and owned by the US Fish and Wildlife Service (USFWS). Data were provided to Western Ecosystems, Technology, Inc. (WEST), as a courtesy for their use. The USFWS has not directed, reviewed, or endorsed any aspect of the use of these data. Any and all data analysis, interpretation, and conclusions from these data are solely those of WEST.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

The Prevailing Wind Park Project (Project) is located in Bon Homme, Charles Mix, and Hutchinson counties, South Dakota (Figure 1). The Project area was changed over the course of Tier 1, 2, and 3 studies, with different but overlapping Project areas surveyed in 2015 and 2016. The current Project boundary continues to be overlapping with those studies in 2015 and 2016, but extends somewhat outside of both areas to the northwest and northeast. Overall landscape characteristics are similar throughout the region contained within the boundaries. As part of the wind energy development process, Prevailing Wind Park, LLC (Prevailing Wind) has been implementing the US Fish and Wildlife Service's (USFWS) *Land-Based Wind Energy Guidelines* (WEG; USFWS 2012)). This Bird and Bat Conservation Strategy (BBCS) describes Prevailing Wind's process to identify and avoid and/or minimize potential impacts to birds and bats that may result from the construction and operation of the Project.

Specifically, this BBCS document was developed to:

1) Respond to the recommendations in the WEG for completion of a BBCS and post-construction monitoring actions;
2) Consolidate documentation of steps already taken to avoid and minimize potential effects on birds and bats during Project planning and development;
3) Identify and implement steps to further reduce the potential for avian and bat fatality or other potential adverse effects on birds and bats at the Project; and
4) Continue the coordination between Prevailing Wind and state and federal wildlife agencies.

1.1 Project Description

The Project mostly falls within the Southern Missouri Coteau Slope Level IV Ecoregion, with only a small portion falling within the Southern Missouri Coteau Level IV Ecoregion (US Environmental Protection Agency 2013). Historically, this area was dominated by mixed-grass prairie with numerous wetlands scattered throughout; today, the majority of the Project area has been converted to agricultural use, with crop production and livestock grazing as the main agricultural practices (Table 1, Figure 2; US Geological Survey (USGS) National Land Cover Database [NLCD] 2011, Homer et al. 2015). Trees and shrubs can be found around farmsteads, within planted shelter belts, and along drainages (Hamilton and Derby 2016; Appendix A). The landscape within the Project area is generally flat with elevation ranging from 455–574 meters (m; 1,491–1,882 feet [ft]; USGS 2016).

The 2015 Project area included land south of Avon, South Dakota, but in 2016, the Project area was reduced (Figure 2); the 2015 Project boundary was 8.2 miles (mi; 13.2 kilometers [km]) from the Missouri River, while the adjusted 2016 boundary was 12.1 mi (19.5 km) from the River. Additionally, the current Project boundary extends somewhat further to the northwest and northeast (Figure 2). Land use/cover types were assessed using the current boundary.

Cultivated cropland (49.92%) and grasslands (42.22%; including herbaceous/pasture/hay lands) dominated the overall landscape (Table 1, Figure 2).

Table 1. Land use/cover types acreage and percent (%) cover within the current Prevailing Wind Park Project in Bon Homme, Charles Mix, and Hutchinson counties, South Dakota, based on the US Geological Service's (USGS) National Land Cover Database (NLCD).

Land Use/Cover	Project Acres	% Cover
Cultivated Crops	25,128.83	49.92
Pasture/Hay	17,731.32	35.23
Grassland/Herbaceous	3,520.49	6.99
Developed	2,158.00	4.29
Wetlands/Open Water	1,336.99	2.66
Forest	375.96	0.75
Shrub/Scrub	69.65	0.14
Barren Land	14.67	0.03
Total	**50,335.91**	**100.00**

Data Source: USGS NLCD 2011

Based on the USFWS's National Wetland Inventory (NWI; USFWS NWI 2009), there are approximately 1,826 acres (ac; 739 hectares [ha]) of wetlands within the Project area, with freshwater emergent wetlands making up the majority (77.1%) of wetlands (Table 2).

Table 2. Wetlands present within the Prevailing Wind Park Project, Bon Homme, Charles Mix, and Hutchinson counties, South Dakota, based on the US Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI).

Wetland Type	Project Acres	Percent Total
Freshwater Emergent Wetland	1,407.89	77.10
Freshwater Pond	245.70	13.46
Lake	128.75	7.05
Freshwater Forested/Shrub Wetland	43.7	2.39
Total	**1,826.04**	**100.00**

Data Source: USFWS MWI 2009

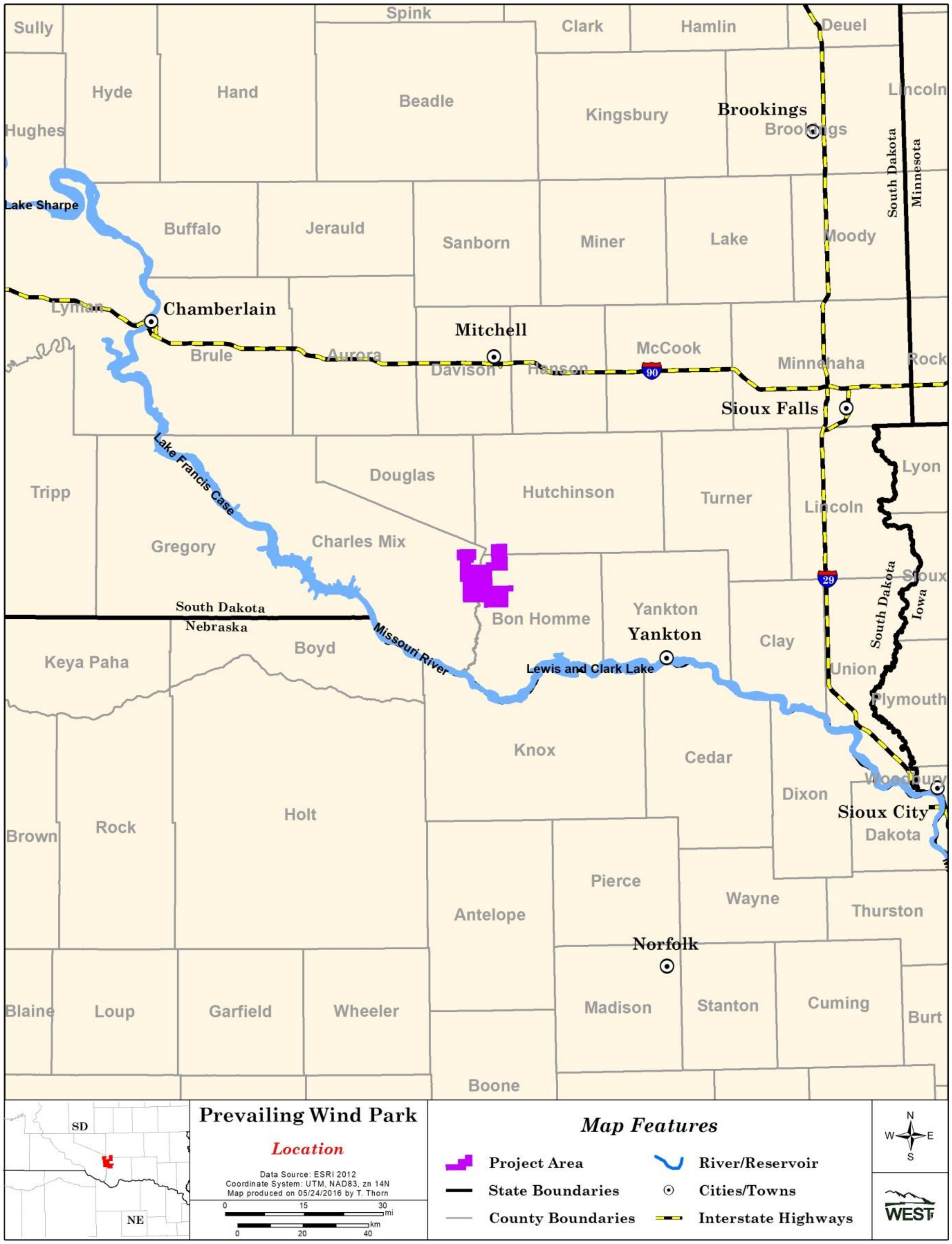

Figure 1. Location of the Prevailing Wind Park Project in Bon Homme, Charles Mix, and Hutchinson counties, South Dakota.

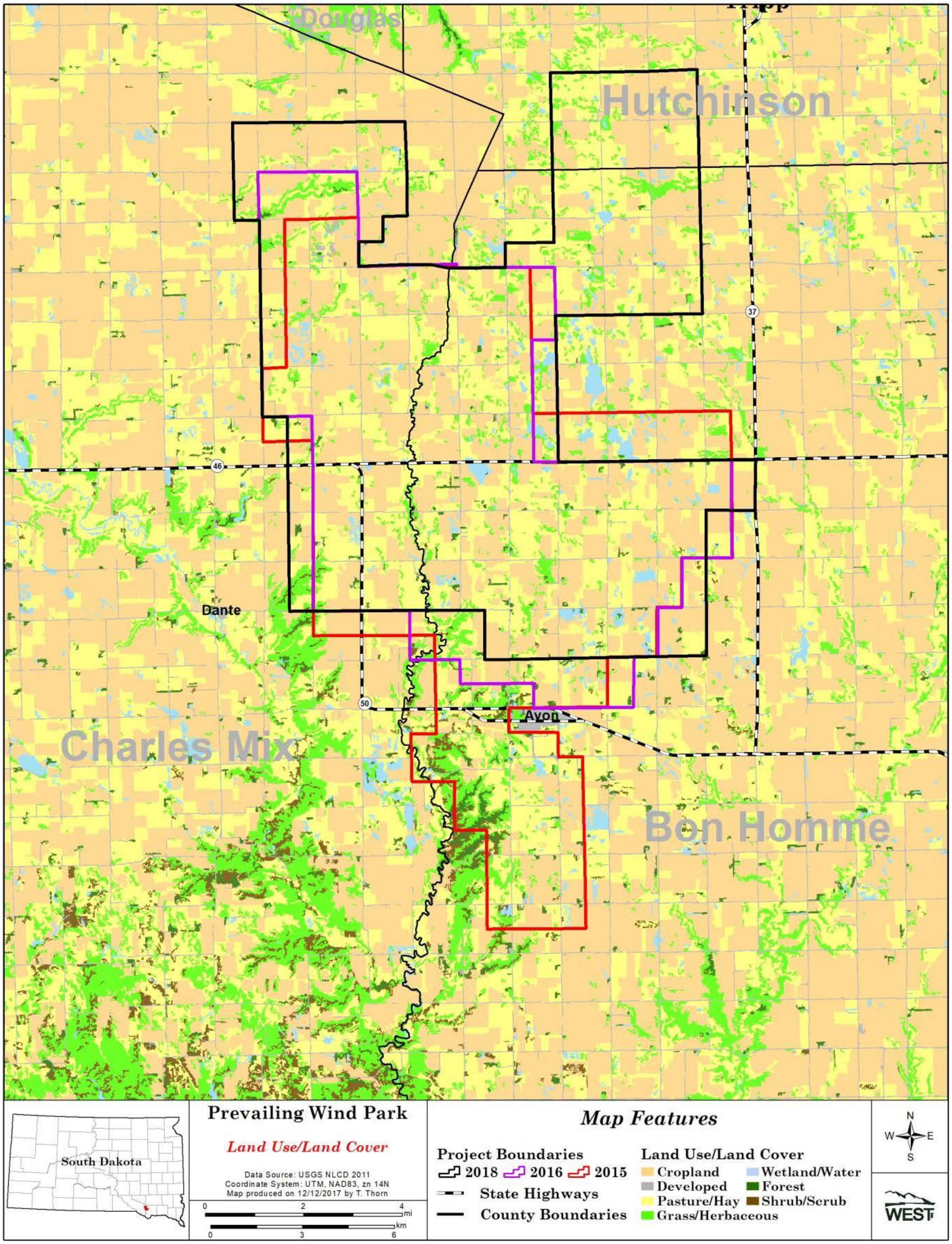

Figure 2. Land use/cover types within the 2015, 2016, and current Prevailing Wind Park Project boundaries in Bon Homme, Charles Mix, and Hutchinson counties, South Dakota (Sources: US Geological Survey (USGS) National Land Cover Data [NLCD] 2011, Homer et al. 2015).

The Project, planned for 200-megawatt (MW) output, will consist of either 57 3.6-MW turbines or 61 3.8 MW turbines. Turbines will have a hub height of 105 or 110 m (344.5 or 360.9 ft) with 136 or 137 m (446.2 or 449.5 ft) blades.

1.2 Project Siting, Construction, and Best Management Practices

The siting and development of the Project included a tiered-study review process that aligned closely with the tiered approach detailed in the final WEG (USFWS 2012). Information gathered during Tier 1–3 studies was used during the turbine and infrastructure siting process to minimize potential impacts to birds and bats and their habitats. Prior to designing the facility layout, Prevailing Wind incorporated setback and constraint information from expert sources, literature reviews, and siting standards suggested by the South Dakota Public Utilities Commission. This information was used to establish setbacks and inform site design.

1.2.1 Project Siting and Design Measures Used to Reduce Impacts

- The Project is attempting to avoid impacts to wildlife and habitat by siting turbines and roads mostly in cultivated fields.
- Standard, state-required, setbacks for non-participating landowners, residences, noise, airports, etc., will be implemented.
- Existing roads and field accesses will be used or improved for access roads when practicable.
- Electrical collection systems within the Project will be buried underground.
- Wind turbines designed with tubular towers and no external ladders or platforms on the towers or nacelles will be used so bird perching and nesting opportunities are minimized.
- The number of turbines with visibility lighting will be minimized, within Federal Aviation Administration (FAA) requirements.
- Implementation of FAA-approved lighting that uses the shortest allowable flash duration, the minimum allowed flashes per minute, and synchronized flashing, will reduce the potential for nocturnal migrating birds to be disoriented by lights.
- Lighting at the operations and maintenance facility, Project substation, and other installations will be minimized and designed such that light is directed downward (toward the access or work area), and is hooded to prevent light from shining into the sky and attracting or disorienting nocturnal migrants. Motion or heat-activated lighting will be used where practicable.
- Permanent meteorological towers without guy wires will be used, installing the minimum number needed within the Project area to minimize collision risk for birds.

1.2.2 Operational Procedures to Minimize Impacts

- Impacts to wetlands and water resources will be avoided or mitigated by following provisions of the Clean Water Act (1972).

- A Site Environmental Plan, specific to the operational activities of the Project, will be developed and implemented by the Site Supervisor or his/her designated Environmental Manager including, but not limited to:
    - Exhibits identifying sensitive resources and associated set-backs.
    - An employee orientation program to raise awareness of any wildlife issues on the site, as well as how to treat sensitive resource areas.
    - Instructions for employees and contractors to drive at an appropriate speed on all public and private roads within the Project area, in consideration of potential wildlife that may be present and to promote general site safety.
    - Instructions for employees to avoid harassing or disturbing wildlife, especially during the breeding seasons.
    - Federal and state measures for handling toxic substances to minimize contamination of water and wildlife resources.
    - Local policies for noxious weed control (e.g., cleaning vehicles and equipment arriving from areas with known invasive species issues, using locally sourced topsoil, identification and annual removal, etc.).
    - Parts and equipment that may be used as cover by prey will not be stored in the vicinity of wind turbines.
- During normal operational activities, if facility personnel discover carrion on or near Project facilities, reasonable measures will be taken to minimize attracting predators/scavengers such as raptors and vultures.
- A Wildlife Response and Reporting System or similar program will be implemented to establish protocols for identifying and communicating bird and bat fatalities.

1.3 Key Bird and Bat Regulations

1.3.1 Federal Endangered Species Act

Certain species at risk of extinction, including several birds and bats, are protected under the federal Endangered Species Act (ESA) of 1973, as amended (ESA 1973). The federal ESA provides a program for conservation and recovery of threatened and endangered species. Section 3 of the ESA defines and lists species as “endangered” and “threatened” and provides regulatory protection for the listed species (ESA Section [§] 3 1973). Section 9 of the federal ESA prohibits the “take” of species listed by USFWS as threatened or endangered (ESA Section [§] 9 1973). Take is defined in Section 3 as follows: “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in such conduct” (ESA § 3 1973). As of February 2017, there were 16 endangered and threatened animal species believed to or known to occur in South Dakota (USFWS 2017), five of which had the potential to occur within the Project area according to the Tier 1 and 2 studies (Hamilton and Derby 2016; Appendix A); Section 2.1 includes a description of these species.

1.3.2 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) makes it unlawful to pursue, capture, kill, or possess any migratory bird or part, nest, or egg of any such bird listed in wildlife protection treaties between the US, Great Britain, Mexico, Japan, and Russia (and other countries of the former Soviet Union; MBTA 1918). Most birds (except for introduced species and non-migratory game birds) within the US are protected under the MBTA. The birds, occupied nests, and the contents of the nests (eggs or chicks) within the Project area are afforded protection pursuant to the MBTA. Due to the potential for resident and migratory birds within the Project area, compliance with the MBTA has been considered in the development of this BBCS. Unlike the ESA and the Bald and Golden Eagle Protection Act (BGEPA), no permits are available to authorize incidental take of birds under the MBTA. However, on December 22, 2017, the U.S. Department of the Interior's Solicitor's Office issued a legal opinion in which it concluded that the MBTA ". . . is a law limited in relevant part to affirmative and purposeful actions . . ." and as such, any incidental takings would not constitute criminal violations (*See*, DOI Solicitor's Opinion, M-37050 [December 22, 2017]).

1.3.3 Bald and Golden Eagle Protection Act

The federal BGEPA (1940), administered by the USFWS, was enacted to protect bald (*Haliaeetus leucocephalus*) and golden (*Aquila chrysaetos*) eagles, their nests, eggs, and parts (e.g., feathers or talons). The BGEPA states that no person shall take, possess, sell, purchase, barter, offer for sale, transport, export, or import any bald or golden eagle alive or dead, or any body part, nest or egg without a valid permit to do so (BGEPA 1940). The BGEPA also prohibits the take of bald and golden eagles unless pursuant to regulations. Take is defined by the BGEPA as an action "to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb". Disturb is defined in the BGEPA as "to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available: 1) injury to an eagle; 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior; or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior" (USFWS 2007b). In addition to immediate impacts, this definition also covers impacts that result from human-caused alterations initiated around a previously used nest site during a time when eagles were not present.

In 2009, the USFWS issued a final rule on new permit regulations that would allow some disturbance of eagles "in the course of conducting lawful activities" (50 Code of Federal Regulations [CFR] § 22.26 2009). The USFWS's description of its 2009 rule suggests that recurring, incidental take of eagles, will only be authorized if every avoidance measure has been exhausted. Removal of nests will still generally be permitted only in cases where the nest poses a threat to human health, or where the removal would protect eagles. Take permits may be issued when "necessary for the protection of other interests in any particular locality" (USFWS 2009). The discussion expands the definition of such public and private interests to include utility infrastructure development and maintenance. The document states that due to concerns about population declines, permits for take of golden eagles are likely to be restricted throughout the eagle's range (USFWS 2009). Considerations for issuing take permits include the health of the local and regional eagle populations, availability of suitable nesting and foraging habitat for any displaced eagles, and whether the take and associated mitigation provides a net benefit to eagles (50 CFR § 22.26 2009). In April 2013, the USFWS issued the *Eagle Conservation Plan Guidance Module 1 – Land-based Wind Energy Version 2* to address these new regulatory matters (ECPG; USFWS 2013). In December 2016, the USFWS published notice of a final rule revising its eagle permitting regulations and extended the maximum permit duration to 30 years. The development of an Eagle Conservation Plan for this Project is underway following the 2016 eagle rule to meet USFWS's requirements for addressing take under the BGEPA.

1.3.4 Birds of Conservation Concern

The USFWS's list of Birds of Conservation Concern (BCC) includes migratory and non-migratory bird species of conservation priority across North America; concern for these BCC species results from naturally or human-caused small ranges or population sizes, threats to habitat and other factors (USFWS 2015b). The Project area falls within Bird Conservation Region 11, which lists 27 bird species (USFWS 2008).

1.3.5 South Dakota State Issues

The South Dakota Game, Fish, and Parks (SDGFP) manages a state-specific list of endangered and threatened species. As of April 2016, South Dakota listed 16 endangered and threatened species that did not appear on the federal list for a total of 22 state-listed species; the SDGFP is responsible for managing and conserving the state's endangered species. Seven of the 22 state-listed species are birds; no state-listed bat species were included in this list (SDGFP 2014a). Seventy-seven species listed by the South Dakota Wildlife Action Plan as species of greatest conservation need have records of occurrence in at least one of the counties in which the Project is located (SDGFP 2014a, SDGFP 2014b; USGS 2015; NatureServe 2017). Some of these species are only associated with the Missouri River and would not be expected to occur in the Project. Section 2.1 includes a description of the state-listed species potentially occurring in the Project area.

2.0 PRE-CONSTRUCTION: TIER 1-3 SUMMARIES

The WEG outlines a tiered approach to assessing suitability and risks to wildlife at a potential wind resource area. The tiered approach ensures that sufficient data are collected to enable project proponents to make informed decisions about continued development of a proposed project (USFWS 2012). At each tier, potential issues associated with the development or operations of the opposed project are identified and questions are formulated to guide the decision process. This process starts with a broad scope and provides more site-specific detail at each tier as more data are gathered and the potential for avian and bat issues are better understood. The sections below briefly describe the efforts completed as part of Tiers 1–3 studies (Appendices A–F).

2.1 Tiers 1 and 2: Desktop Evaluation Review

As recommended in the WEG, Tier 1 and 2 studies for the Project evaluated potential issues that needed to be addressed before further actions could be taken with the development or operations of the proposed Project. The objective of the Tiers 1 and 2 studies was to assist the developer in further identifying a potential Project site through a preliminary evaluation or screening of public data from federal, state, and tribal entities, and to offer early guidance about the sensitivity of the Project in regards to flora and fauna. Tier 1 and 2 studies provided a preliminary evaluation or screening of public data from federal, state, and tribal entities and offered early guidance about the sensitivity of the site, in regards to flora and fauna; these studies also included a more substantive review of existing information, including publicly available data on land use land cover, topography, wetland data, wildlife, habitat, and sensitive plant distribution, and a reconnaissance level site visit (Hamilton and Derby 2016; Appendix A)

The Tier 1 and 2 Report identified federally and state-listed wildlife species present in the Project area (Hamilton and Derby 2016; Appendix A). Five of the 16 animal species listed as federally listed species in South Dakota had the potential to occur within the Project area, including the federally endangered interior least tern (*Sterna antillarum athalassos*) and whooping crane (*Grus americana*), and the federally threatened piping plover (*Charadrius melodus*), red knot (*Calidris canutus rufa*), and northern long-eared bat (*Myotis septentrionalis*). The interior least tern, whooping crane, and piping plover are also listed as threatened or endangered in the state of South Dakota (SDGFP 2016); additionally, the state-threatened osprey (*Pandion haliaetus*) has the potential to occur within the Project area (Hamilton and Derby 2016; Appendix A).

According to the Tier 1 and 2 studies, no suitable nesting habitat for interior least tern was identified within the Project, but the interior least tern could potentially nest along the Missouri River or pass through the Project area during spring and fall migration (Hamilton and Derby 2016; Appendix A). No suitable habitat for piping plover was observed in the Project during the site visit conducted in 2016, and this species is unlikely to breed within the Project, but individuals could potentially migrate through the Project area; piping plover Critical Habitat has been designated along the Missouri River in both counties 19.5 km (12.1 mi) south of the Project area (Appendix A). No suitable habitat for rufa red knot was observed in the Project during the site visit conducted in 2016 and this species is unlikely to breed within the Project, but could potentially migrate through the Project area (Appendix A). The 2016 Project boundary occurred 3.5 km (2.2 mi) east of 95% of the confirmed whooping crane sightings within the 354-km (220-mi) whooping crane national migration corridor (Figure 3), but is within the South Dakota specific migration corridor; therefore, whooping cranes may occasionally migrate through the Project area (Appendix A).

The Tier 1 and 2 studies recommended coordinating with the USFWS and South Dakota Game, Fish, and Parks in regards to Project development. This coordination occurred during an in person site visit and was used for both the formal scoping process in the Tier 3 studies as well as to inform ongoing Project siting. In conclusion, the Tier 1 and 2 studies did not find any items that suggested abandonment of the Project area, and as such, the pre-construction efforts progressed to Tier 3 studies to further investigate issues in more detail.

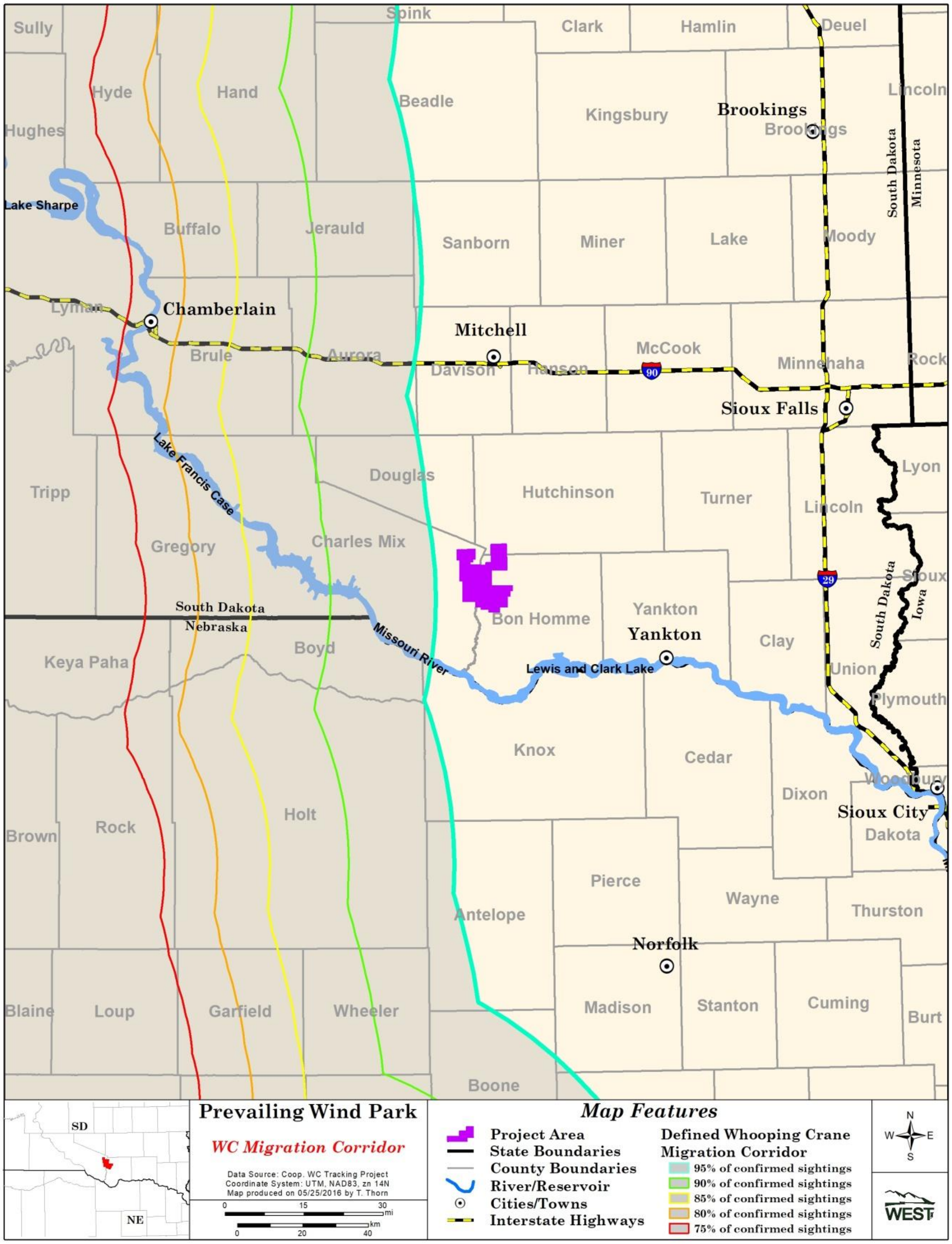

Figure 3. Location of the national whooping crane migration corridor in relation to the 2016 Prevailing Wind Park Project in Bon Homme, Charles Mix and Hutchinson counties, South Dakota.

2.2 Tier 3: Baseline Survey Results Review

A number of site-specific baseline avian and bat studies have been conducted within the Project area since 2015. A brief summary of each of these baseline studies is provided below and final reports are provided in Appendices B–F. The data collected and methods used to conduct the Tier 3 studies were consistent with other regional studies and followed the recommendations in the WEG. The results of Tier 3 studies indicated that significant adverse impacts are not anticipated from the Project.

2.2.1 Whooping Crane Habitat Review

Whooping crane habitat was assessed within the Project and surrounding area to determine if the Project area contained unique features to attract whooping cranes (Derby 2016b; Appendix B). This issue was investigated by comparing the potential whooping crane stopover habitat (using wetlands as this indicator) in the Project area to adjacent areas of the same dimensions in the four cardinal directions, located adjacent to the Project boundary, based on the Project's boundary extent (Figure 4). GIS was used to calculate the amount of the various habitats and in the case of wetlands, number of individual basins, their type, and suitability (score of 12 or higher according to the Watershed Institute 2012), in each of the adjacent areas compared to the proposed Project (Tables 3 and 4). This analysis showed that both roosting (i.e., wetlands) and foraging (i.e., croplands) habitats were available in the Project and alternate areas.

Potential whooping crane habitat within the Project appeared to be most similar to that in the north, east, and west reference areas and more suitable than that found in the south alternate area (Derby 2016), indicating that the potential whooping crane habitat found within the Project was not unique compared to adjacent areas. Based on the USGS's recent determination of whooping crane stopover use sites and their intensity of use within the Great Plains Region from radio telemetry information (Pearse et al. 2015), whooping crane use occurs adjacent to the proposed Project area, and it is possible that this species could fly over or through the Project area during the migration period (Appendix B).

Table 3. Comparison of land use/cover acreage and percent (%) cover for whooping crane habitat assessment within the 2016 Prevailing Wind Park Project in Bon Homme, Charles Mix and Hutchinson counties, South Dakota, and adjacent areas.

Habitat Type	Project Area		North		East		South		West	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Cultivated Crops	17,588.3	47.5	20,033.3	54.1	24,592.7	66.4	14,716.9	39.8	20,507.8	55.4
Grassland/ Herbaceous	2,481.9	6.7	2,922.5	7.9	995.0	2.7	7,270.3	19.6	1,398.2	3.8
Pasture/Hay	13,897.5	37.5	11,676.7	31.5	8,853.2	23.9	9,985.0	27.0	1,1482.6	31.0
Developed	1,578.0	4.3	1,894.3	5.1	1,668.2	4.5	1,142.3	3.1	1,998.4	5.4
Water/ Wetlands	1,016.5	2.8	327.6	0.9	562.2	1.5	682.0	1.8	1,086.7	2.9
Forests	372.1	1.0	152.5	0.4	307.5	0.8	958.8	2.6	441.8	1.2
Shrub/Scrub	67.5	0.2	9.7	<0.1	22.7	<0.1	2,251.6	6.1	93.3	0.3
Barren	14.7	<0.1	NA	NA	15.1	<0.1	9.7	<0.1	7.8	<0.1

National Land Cover Database 2011

Table 4. Comparison of suitable whooping crane habitat within the 2016 Prevailing Wind Park Project in Bon Homme, Charles Mix and Hutchinson counties, South Dakota, and adjacent t areas.

Area	Number of Basins	Total Acres	Mean Score[1]	Score Range
Project Area	262	490.1	9.4	6–16
North	270	517.2	9.8	6–18
South	157	285.9	8.4	5–14
East	244	395.6	9.7	6–16
West	284	1,239.8	9.8	6–17

[1]. A score of 12 or higher represents potentially suitable whooping crane habitat. Data Derived From: Potentially Suitable Habitat Assessment, Watershed Institute 2012.

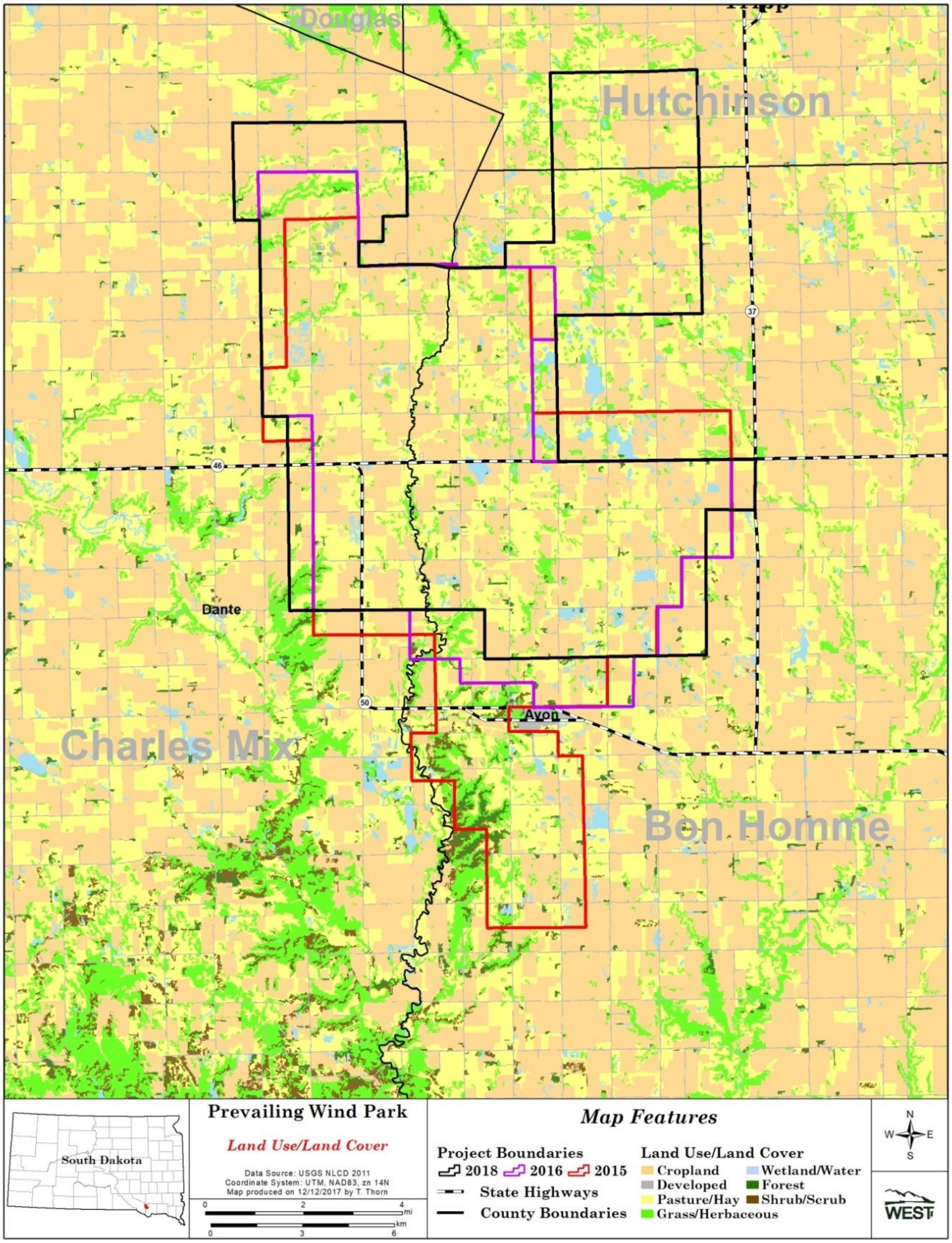

Figure 4. Land use/cover type comparisons for whooping crane habitat assessment within the 2016 Prevailing Wind Park Project in Bon Homme, Charles Mix, and Hutchinson counties, South Dakota, and adjacent areas.

2.2.2 Avian Use Surveys

Year-round avian-use surveys were conducted by WEST during 2015 – 2016 (Year 1) and 2016 – 2017 (Year 2) to address issues posed under Tier 3, following guidance in the WEG (USFWS 2012) and ECPG (USFWS 2013), within the Project area. The primary objectives of the avian use studies were to: 1) assess the relative abundance and spatial distribution of species in the Project area during an entire year, with emphasis on eagles, other raptors, and federally and state-listed species; and 2) identify and assess the potential risk of adverse impacts from the Project to sensitive species or groups (Derby et al. 2018a, 2018b; Appendices C1 and C2).

During Years 1 and 2, sixteen points were surveyed for 60 minutes (min; Figures 5 and 6) with all bird species observed in the first 20 min being recorded and only eagles and federally and state-listed species being recorded during the remaining 40 min (Appendices C1 and C2). The metric used for mean bird use was number of birds per plot (100-m [328-ft]) radius plot for small birds and 800-m [2,625-ft] radius plot for large birds) per 20-min survey. Surveys were conducted twice per month in the spring (March 4 – May 20) and fall (September 9 – November 28), and monthly during winter (November 29 – March 3) and summer (May 21 – September 8). Surveys were carried out during daylight hours and survey periods varied to approximately cover all daylight hours during a season. To the extent practical, each point was surveyed roughly the same number of times.

A total of 271 fixed-point avian use surveys were conducted during 18 visits during Year 1, while 205 surveys were conducted during 13 visits in Year 2 (Appendices C1 and C2). Bird diversity (the number of unique species observed for the entire 60-min survey) was lower in Year 1 (72) than Year 2 (90). No federally or state-listed species were observed during Year 1 surveys, and one state-listed species (peregrine falcon [*Falco peregrinus*]) was observed during Year 2 surveys. Additionally, seven and thirteen state sensitive species were observed during fixed-point surveys and incidentally during Years 1 and 2, respectively.

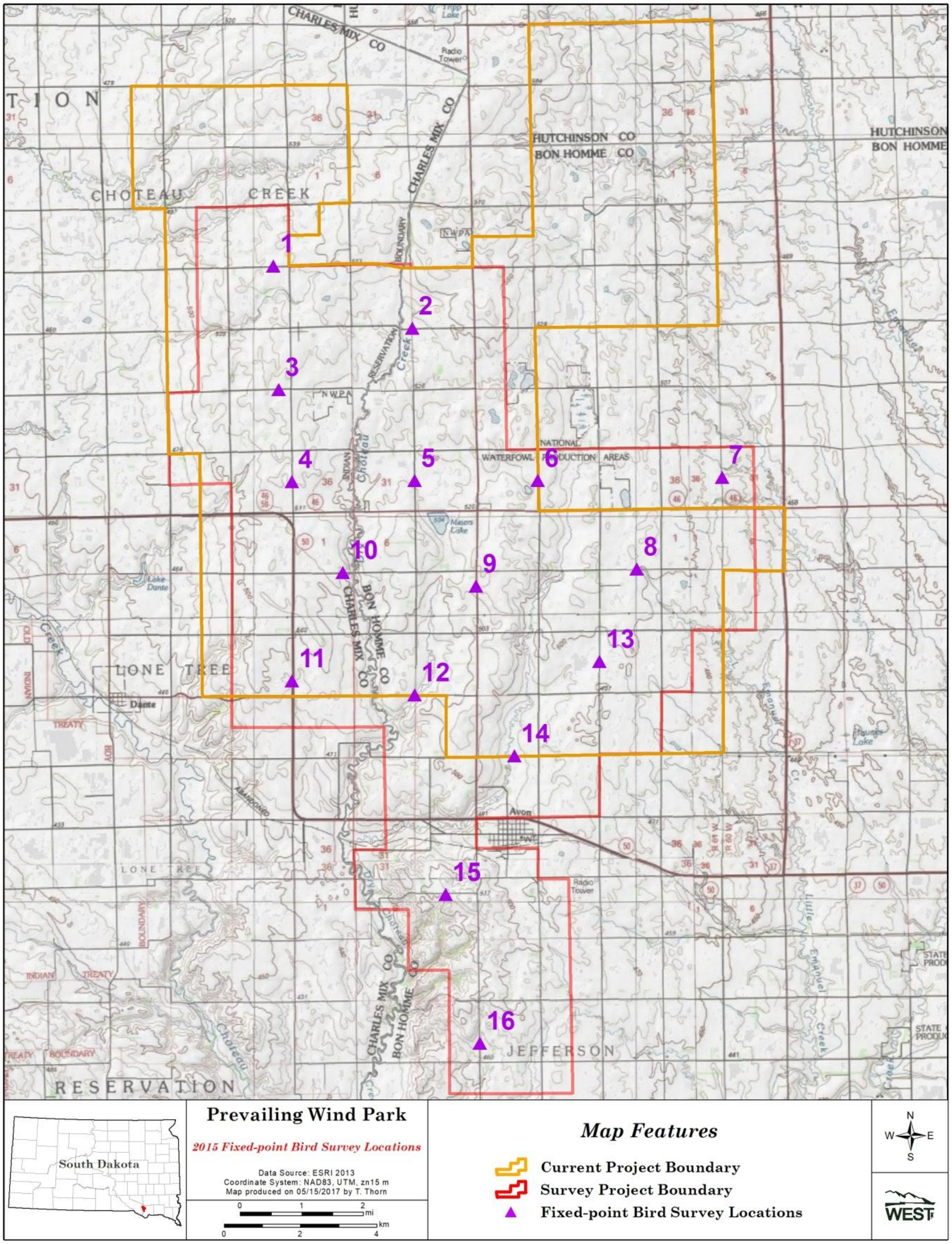

Figure 5. Location of the fixed-points selected for the Year 1 fixed-point avian use surveys conducted from 2015 – 2016 at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.

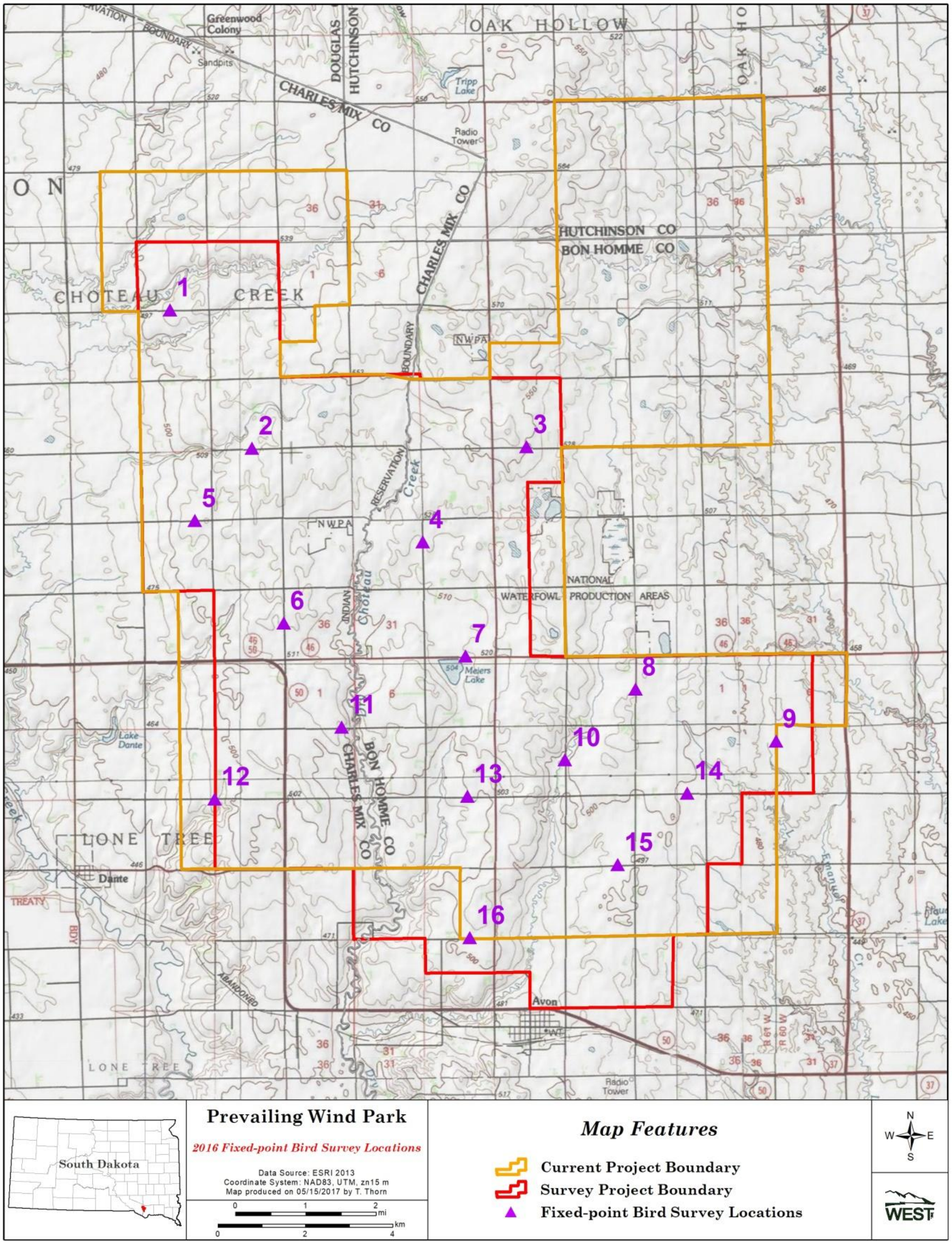

Figure 6. Location of the fixed-points selected for the Year 2 fixed-point avian use surveys conducted from 2016 – 2017 at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.

During Year 1, large bird use was highest during spring (30.43 birds800-m plot/20-min survey), whereas small bird use was highest during fall (15.71 birds/100-m plot/20-min survey; Appendix C1). Annual mean diurnal raptor use during Year 1 was 0.31 raptors/800-m plot/20-min survey with the highest mean use during the fall (0.52; Appendix C1). Four bald eagles were observed during the Year 1 fixed-point avian use surveys (Appendix C1). Eagles were observed for 15 min of which 11 min were risk minutes (eagles flew below 200 m above ground level and within 800 m of the observer; Appendix C1). Three other bald eagles were observed incidentally.

Year 2 avian use was similar to Year 1 for large and small birds; however, more eagles were observed during Year 2. Large bird use was highest during spring (36.38 birds/800-m plot/20-min survey), whereas small bird use was highest during fall (35.73 birds/100-m plot/20-min survey; Appendix C2). Annual mean diurnal raptor use was 0.33 raptors/800-m plot/20-min survey during Year 2 with the highest mean diurnal raptor use during fall (0.55; Appendix C2). Twenty bald eagles and one unidentified eagle were observed during Year 2 fixed-point avian use surveys. Bald eagles were observed for 135 min of which 70 min were risk minutes; the unidentified eagle was observed for eight minutes, all of which were risk minutes (Appendix C2). Most of the observations (nine) and minutes (72 total and 43 risk minutes) came from survey point nine during the spring migration on March 9, 2017. One golden eagle was observed incidentally during Year 2. Further detailed information pertaining specifically to eagles is discussed in the Eagle Conservation Plan developed for the Project.

Mean raptor use during Year 1 was compared with other wind energy facilities that implemented similar protocols and had data covering similar seasons, ranking 34th from the highest use compared to 47 other wind energy facilities in North America (Appendix C1). Mean raptor use during Year 2 ranked 33rd from the highest use compared to the other 47 wind energy facilities in North America (Appendix C2). Publicly available data containing both mean raptor use and raptor fatality information in the Midwest are scarce, while data having this information for four seasons is even rarer. Annual raptor use at the adjacent Beethoven Wind Energy Project (Beethoven; an operating wind energy facility immediately north of the Project area) was 0.10 raptors/plot/20-min survey (WEST 2015). Raptor fatality rates reported at other South Dakota wind energy facilities have ranged from 0–0.20 fatalities/MW/year. At the Grand Ridge I Project in Illinois, mean raptor use was 0.20 raptors/800-m plot/20-min survey, and no raptor fatalities were recorded (Derby et al. 2010a). Raptor fatality rates throughout the Midwest have ranged from zero at numerous facilities to 0.47 fatalities/MW/year at Buffalo Ridge, Phase I (Johnson et al. 2000a).

2.2.3 Raptor Nest Surveys

The objective of the raptor nest surveys was to locate and record raptor nests that may be subject to disturbance and displacement effects by wind energy facility construction and operation. As part of agency-approved baseline survey efforts, aerial surveys for raptor nests were completed in 2015 and 2016 by a qualified biologist before leaf out when raptors would be actively tending to a nest or incubating eggs (Derby 2015, 2016a); Appendices D1 and D2). Aerial surveys were conducted in accordance with the guidance provided in the USFWS Inventory and Monitoring Protocols (Pagel et al. 2010) and focused on locating large, stick nest structures in suitable raptor nesting substrate (trees, transmission lines, cliff faces, etc.) within the proposed Project and a 1.6-km (1-mi) buffer. Additionally, a second buffer was surveyed out to 16.1 km (10 mi) beyond the Project boundary to document any eagle nests.

Nests were classified as “occupied” if any of the following were observed at the nest structure: 1) an adult in an incubating position; 2) eggs; 3) nestlings or fledglings; 4) occurrence of a pair of adults (or, sometimes sub-adults); 5) a newly constructed or refurbished stick nest in the area where territorial behavior of a raptor was observed or had been observed early in the breeding season; or 6) a recently repaired nest with fresh sticks (clean breaks) or fresh boughs on top, and/or droppings and/or molted feathers on its rim or underneath. A nest that did not meet the above criteria for “occupied” was classified as “unoccupied”.

During April 11, 12, and 15, 2015, 71 raptor nests representing three species were documented within the Project area and 16.1 km (10.0 mi) buffer (Figure 7; Derby 2015; Appendix D1). No bald eagle nests were located within the Project area, but eight bald eagle nests (seven occupied and one unoccupied) were documented during the survey (Figure 7). The closest bald eagle nest was observed approximately 0.8 km (0.5 mi) north of the 2015 Project boundary. Three of the seven active bald eagle nests observed in 2015 corresponded to known historic nest locations (PW-EN2, PW-EN3, PW-EN6; Figure 7). Additionally, three occupied great horned owl (*Bubo virginianus*) and five red-tailed hawk (*Buteo jamaicensis*) nests were recorded during raptor nest surveys conducted in 2015.

During the April 21, 2016, aerial raptor nest survey, 50 occupied and/or unoccupied raptor nests representing three species were documented within the Project area and associated 16.1- km (10-mi) buffer (Figure 7 and 8; Appendix D2). No eagle nests were documented within the Project area, but six eagle nests (three unoccupied and three occupied) were located during the 2016 survey (Figure 8); three of these were known historic bald eagle nests (PW-EN1, PW-EN2, PW-EN6). The closest active bald eagle nest was observed approximately 0.8 km (0.5 mi) from the 2016 Project boundary (Figure 8). Other raptor species identified during aerial raptor nest surveys conducted in 2016 included three occupied great horned owl nests and ten occupied red-tailed hawk nests (Figure 8); additionally, 31 unknown raptor nests (two occupied; 29 unoccupied) were documented during the 2016 survey (Derby 2016a; Appendix D2).

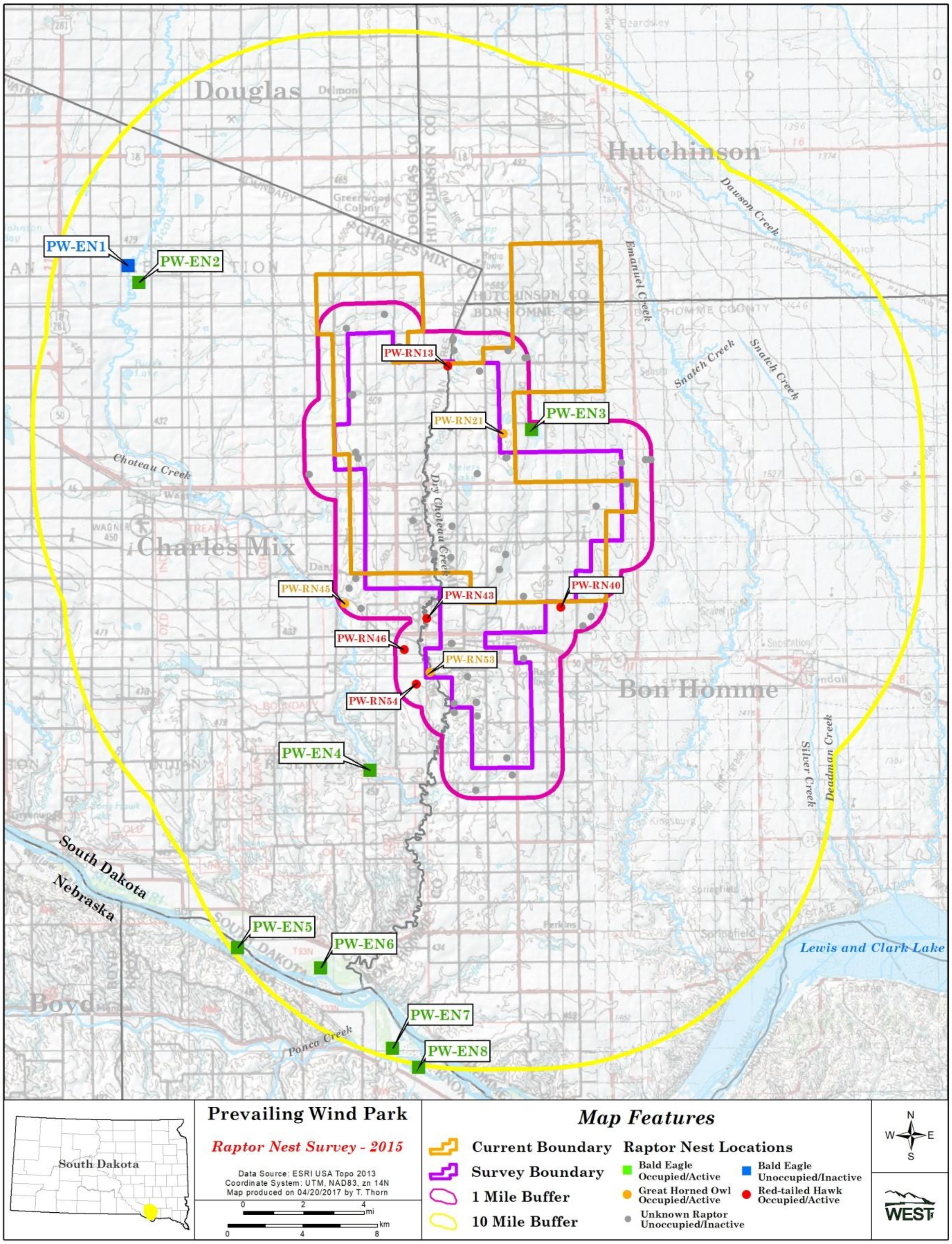

Figure 7. Raptor and eagle nest locations documented during the aerial survey conducted in April 2015 at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.

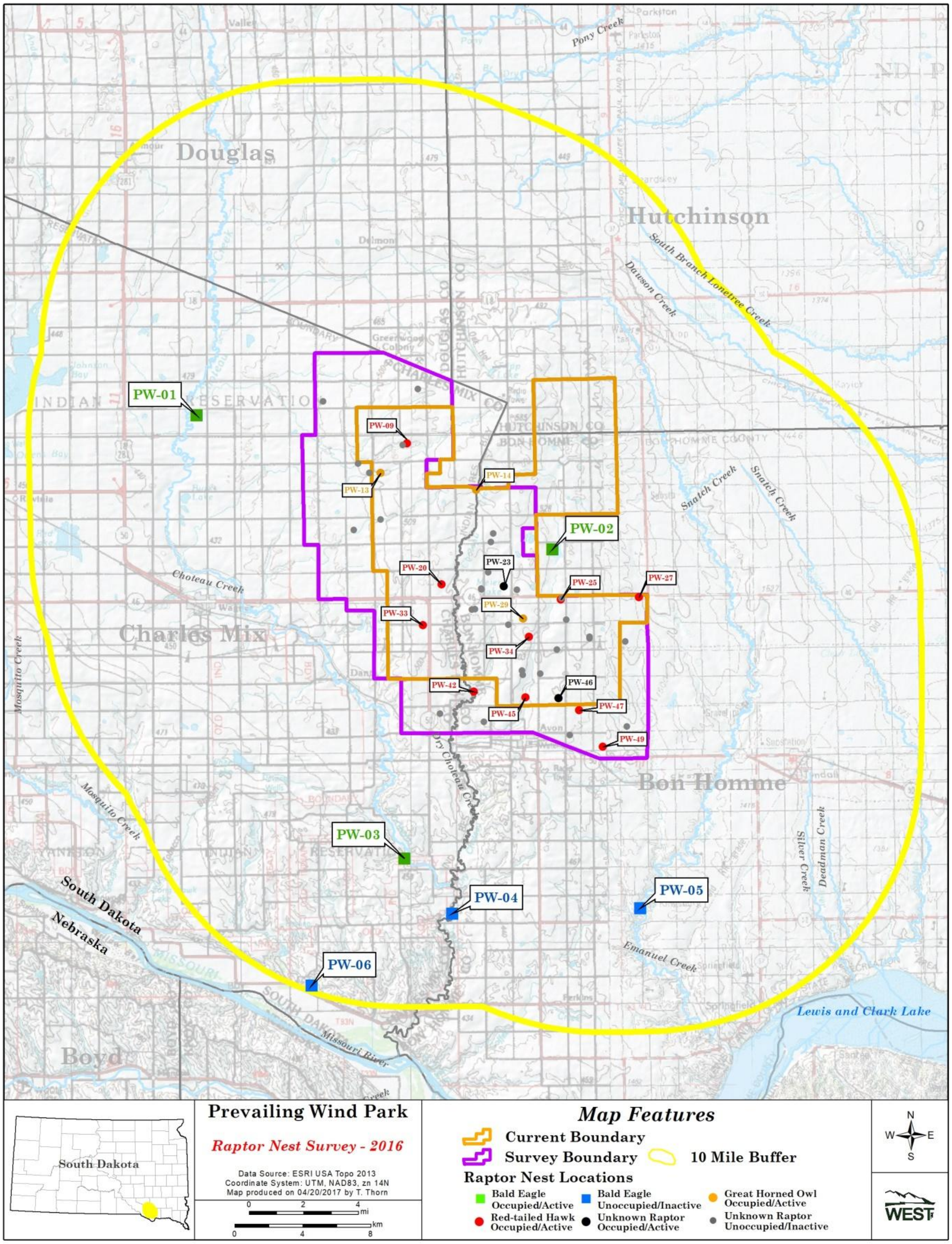

Figure 8. Raptor and eagle nest locations documented during the aerial survey conducted in April 2016 at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.

2.2.4 Acoustic Bat Surveys

No general bat survey was conducted within the Project area during Tier 3 surveys; however, an acoustic bat survey was completed by WEST at Beethoven, located north and adjacent to the Project area, in 2014. Bat surveys at Beethoven recorded an average of 11.49±5.36 bat passes per detector-night (WEST 2015). For all detector locations, 85.4% of bat passes were classified as low-frequency (e.g., big brown bats [*Eptesicus fuscus*], hoary bats [*Lasiurus cinereus*], and silver-haired bats [*Lasionycteris noctivagans*]), while only 14.6% were classified as high frequency (e.g., eastern red bats [*Lasiurus borealis*] and *Myotis* species); summer bat activity at Beethoven was higher than fall bat activity with peak activity the week of July 7 – July 14, 2014 (WEST 2015).

As a means to compare bat activity rates across projects with different sampling periods as well as to compare rates during what historically has been the period of higher fatality rates, WEST uses a standardized “fall migration period” in reviewing bat activity rates. The pre-construction bat activity rate recorded by ground detectors at Beethoven during the fall migration period (2.04±0.99 bat passes per detector-night; WEST 2015) was very low compared to activity rates at other facilities in the Midwest (Table 5), and throughout North America, from studies conducted with similarly-collected data. Bat activity rates are not available for other wind energy projects in North and South Dakota (Table 5). Reported bat fatality rates at Beethoven (2.69 bats/MW/year; WEST 2016) were within the range of other regional projects in the Midwest region of North America, where reported bat fatalities have ranged from 0.16–2.81 bat fatalities/MW/year (Table 5). Based on the location of the Project, habitats present, activity rates recorded during studies at nearby Beethoven, and bat fatality rates at Beethoven and other Midwest wind energy facilities, estimated direct impacts to bats at the Project is expected to be similar to Beethoven and low compared to bat fatality rates at other projects across the country.

Table 5. Wind energy facilities in the Midwest with comparable activity and fatality data for bats.

Wind Energy Facility	Bat Activity Estimate[A]	Bat Activity Dates	Fatality Estimate[B]	Number of Turbines	Total Megawatts
Cedar Ridge, WI (2009)	9.97[C,D,E,F]	7/16/07-9/30/07	30.61	41	67.60
Blue Sky Green Field, WI (2008; 2009)	7.70[d]	7/24/07-10/29/07	24.57	88	145.00
Cedar Ridge, WI (2010)	9.97[C,D,E,F]	7/16/07-9/30/07	24.12	41	68.00
Fowler I, II, III, IN (2011)			20.19	355	600.00
Fowler I, II, III, IN (2010)			18.96	355	600.00
Forward Energy Center, WI (2008-2010)	6.97	8/5/08-11/08/08	18.17	86	129.00
Harrow, Ont (2010)			11.13	24 (four 6-turb facilities)	39.60
Top of Iowa, IA (2004)	35.70	5/26/04-9/24/04	10.27	89	80.00
Pioneer Prairie I, IA (Phase II; 2011-2012)			10.06	62	102.30
Fowler I, IN (2009)			8.09	162	301.00
Crystal Lake II, IA (2009)			7.42	80	200.00
Top of Iowa, IA (2003)			7.16	89	80.00
Kewaunee County, WI (1999-2001)			6.45	31	20.46
Ripley, Ont (2008)			4.67	38	76.00
Winnebago, IA (2009-2010)			4.54	10	20.00
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	2.20[c]	6/15/01-9/15/01	4.35	143	107.25
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	2.20[c]	6/15/01-9/15/01	3.71	138	103.50
Crescent Ridge, IL (2005-2006)			3.27	33	49.50
Fowler I, II, III, IN (2012)			2.96	355	600.00
Elm Creek II, MN (2011-2012)			2.81	62	148.80
Buffalo Ridge II, SD (2011-2012)			2.81	105	210.00
Buffalo Ridge, MN (Phase III; 1999)			2.72	138	103.50
Buffalo Ridge, MN (Phase II; 1999)			2.59	143	107.25
Moraine II, MN (2009)			2.42	33	49.50
Buffalo Ridge, MN (Phase II; 1998)			2.16	143	107.25
PrairieWinds ND1 (Minot), ND (2010)			2.13	80	115.50
Grand Ridge I, IL (2009-2010)			2.1	66	99.00
Barton I & II, IA (2010-2011)			1.85	80	160.00
Fowler III, IN (2009)			1.84	60	99.00
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.90[C]	6/15/02-9/15/02	1.81	138	103.50
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.90[C]	6/15/02-9/15/02	1.64	143	107.25
Rugby, ND (2010-2011)			1.60	71	149.00
Elm Creek, MN (2009-2010)			1.49	67	100.00
Wessington Springs, SD (2009)			1.48	34	51.00
PrairieWinds ND1 (Minot), ND (2011)			1.39	80	115.50

Table 5. Wind energy facilities in the Midwest with comparable activity and fatality data for bats.

Wind Energy Facility	Bat Activity Estimate[A]	Bat Activity Dates	Fatality Estimate[B]	Number of Turbines	Total Megawatts
PrairieWinds SD1, SD (2011-2012)			1.23	108	162.00
NPPD Ainsworth, NE (2006)			1.16	36	20.50
PrairieWinds SD1, SD (2012-2013)			1.05	108	162.00
Buffalo Ridge, MN (Phase I; 1999)			0.74	73	25.00
Wessington Springs, SD (2010)			0.41	34	51.00
Buffalo Ridge I, SD (2009-2010)			0.16	24	50.40

A. = Bat passes per detector-night.

B. = Number of fatalities per megawatt per year.

C. = Activity rate was averaged across phases and/or years.

D. = Activity rate based on pre-construction monitoring; data for all other activity and fatality rates were collected concurrently.

E. = Activity rate calculated by WEST from data presented in referenced report.

F. = Activity rate based on data collected at various heights all other activity rates are from ground-based units only.

Data from the following sources:

Wind Energy Facility	Activity Reference	Fatality Reference	Wind Energy Facility	Activity Reference	Fatality Reference
Barton I & II, IA (10-11)		Derby et al. 2011b	Fowler I, II, III, IN (10)		Good et al. 2011
Blue Sky Green Field, WI (08; 09)	Gruver 2008	Gruver et al. 2009	Fowler I, II, III, IN (11)		Good et al. 2012
Buffalo Ridge, MN (Phase I; 99)		Johnson et al. 2000b	Fowler I, II, III, IN (12)		Good et al. 2013
Buffalo Ridge, MN (Phase II; 98)		Johnson et al. 2000b	Grand Ridge I, IL (09-10)		Derby et al. 2010a
Buffalo Ridge, MN (Phase II; 99)		Johnson et al. 2000b	Harrow, Ont (10)		NRSI 2011
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Kewaunee County, WI (99-01)		Howe et al. 2002
Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Moraine II, MN (09)		Derby et al. 2010e
Buffalo Ridge, MN (Phase III; 99)		Johnson et al. 2000b	NPPD Ainsworth, NE (06)		Derby et al. 2007
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Pioneer Prairie I, IA (Phase II; 11-12)		Chodachek et al. 2012
Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	PrairieWinds ND1 (Minot), ND (10)		Derby et al. 2011d
Buffalo Ridge I, SD (09-10)		Derby et al. 2010c	PrairieWinds ND1 (Minot), ND (11)		Derby et al. 2012e
Buffalo Ridge II, SD (11-12)		Derby et al. 2012a	PrairieWinds SD1 (Crow Lake), SD (11-12)		Derby et al. 2012c
Cedar Ridge, WI (09)	BHE Environmental 2008	BHE Environmental 2010	PrairieWinds SD1 (Crow Lake), SD (12-13)		Derby et al. 2013
Cedar Ridge, WI (10)	BHE Environmental 2008	BHE Environmental 2011	Ripley, Ont (08)		Jacques Whitford 2009
Crescent Ridge, IL (05-06)		Kerlinger et al. 2007	Rugby, ND (10-11)		Derby et al. 2011c
Elm Creek, MN (09-10)		Derby et al. 2010d	Top of Iowa, IA (03)		Jain 2005
Elm Creek II, MN (11-12)		Derby et al. 2012b	Top of Iowa, IA (04)	Jain 2005	Jain 2005
Forward Energy Center, WI (08-10)	Watt and Drake 2011	Grodsky and Drake 2011	Wessington Springs, SD (09)		Derby et al. 2010b
Fowler I, IN (09)		Johnson et al. 2010a	Wessington Springs, SD (10)		Derby et al. 2011a
Fowler III, IN (09)		Johnson et al. 2010b	Winnebago, IA (09-10)		Derby et al. 2010g

2.2.5 Northern Long-Eared Bat Presence/Absence Surveys

In 2015, the northern long-eared bat was listed as federally threatened. During the summers of 2015 and 2016, acoustic surveys were implemented at the Project to determine the probable presence/absence of the species within the Project area (Derby et al. 2016, Derby 2017; Appendices E1 and E2). Surveys were conducted following the survey recommendations found in the USFWS's *Northern Long-eared Bat Interim Conference and Planning Guidance* and *2015 Range-Wide Indiana Bat Summer Survey Guidelines* (USFWS (USFWS 2014, 2015a, 2016). Consistent with survey guidelines and based on total wooded acres within the Project area as defined in 2015 (total of 477.5 ha [1,180 ac] of woodland), acoustic surveys were completed at 20 locations (two detector stations per site) for a total of 104 detector nights (Derby et al. 2016; Appendix E1) from July 21 – August 10, 2015 (Figure 10). Presence/absence surveys conducted in the summer of 2016 were based on the Project boundary as provided by Prevailing Winds, LLC in 2016. Based on this redefined boundary, there were approximately 178 ha (440 ac) of wooded habitat within the Project boundary (Table 1); therefore, eight locations were surveyed for two nights each, for a total of 16 detector-nights, from July 12 – August 4 (Figure 10; Derby 2017).

Based on the Bat Call Identification (Allen 2012) analysis, in 2015, nine locations recorded potential northern long-eared bat calls with a p-value less than 0.05 for the maximum-likelihood estimation; therefore, data from these nine stations were included in qualitative analysis (USFWS 2014, Derby et al. 2016). Qualitative identification verified the presence of northern long-eared bats at one station on six nights and at another station on one night; however, qualitative analysis did not verify the presence of this bat species at the remaining seven stations with probable northern long-eared bat calls (Appendix E1). Based on echolocation call analysis, using Kaleidoscope version 4.0.0 (Wildlife Acoustics 2017) and qualitative identification, following the acoustic survey guidelines issued by the USFWS (2016), no northern long-eared bat calls were recorded during the 2016 survey (Derby 2017; Appendix E2).

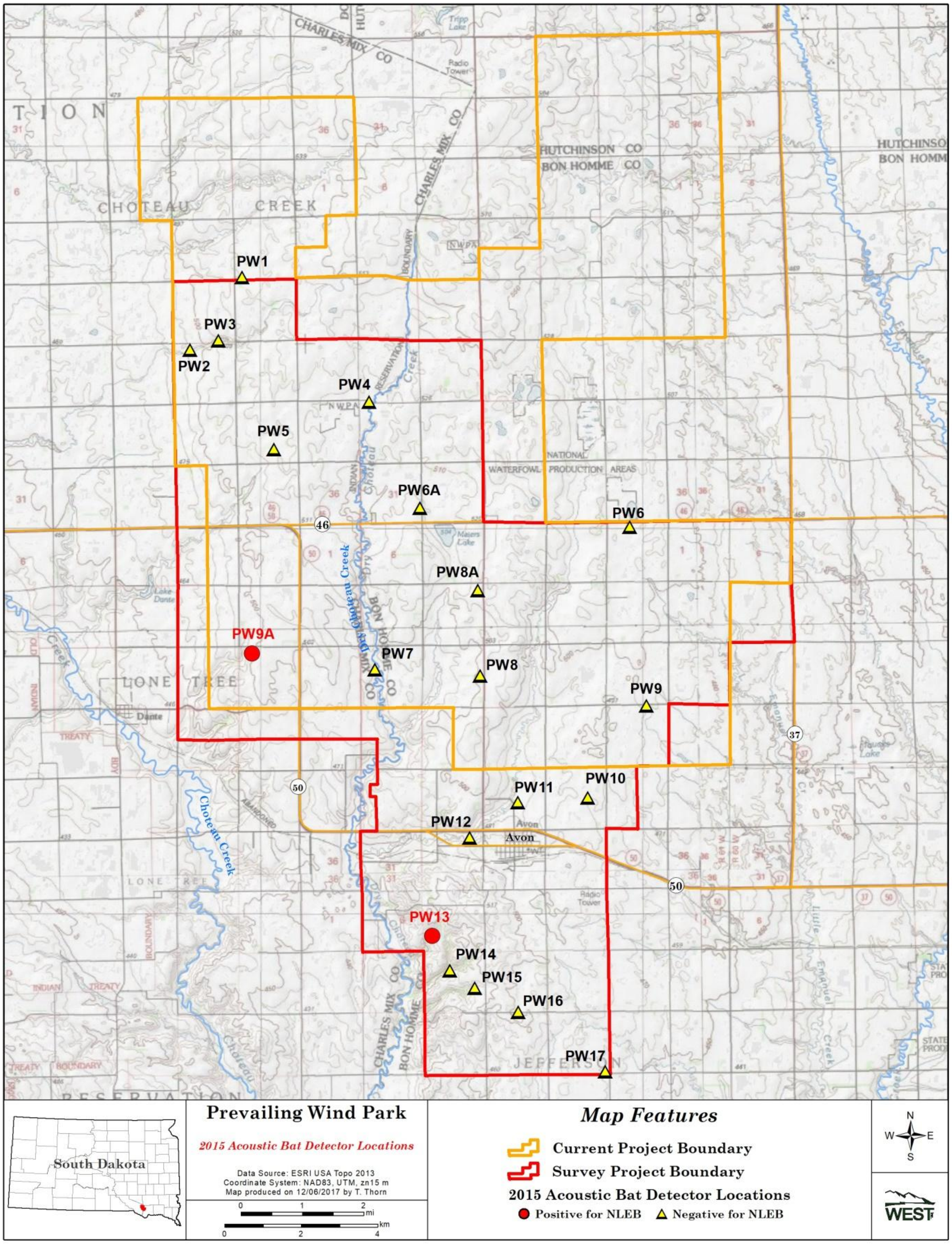

Figure 9. Locations of acoustic bat detectors and those confirmed positive for northern long-eared bats during acoustic surveys conducted in 2015 at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.

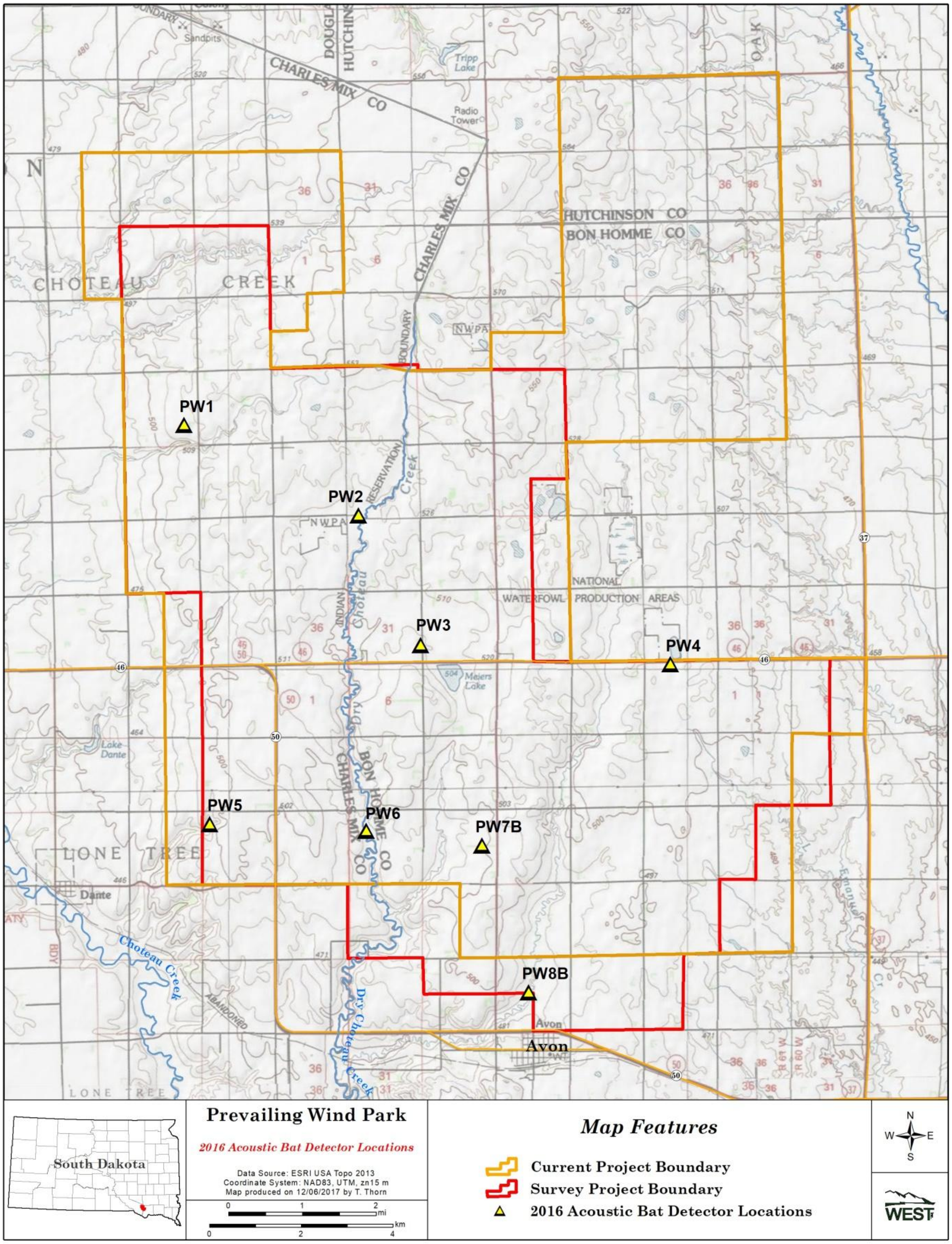

Figure 10. **Locations of acoustic bat detectors during acoustic surveys conducted in 2016 at the Prevailing Wind Park Project in Bon Homme, Hutchinson, and Charles Mix counties, South Dakota.**

2.2.6 Summary of Tier 3 Questions

1. *Do field studies indicate that species of concern are present on or likely to use the proposed site?*

While there is whooping crane habitat available within the Project area, the Project area does not have unique features compared to the surrounding landscape. Due to the close proximity of the Project to the whooping crane corridor, whooping cranes could potentially migrate through the Project area. Bald eagles nests were observed during spring surveys and individuals were observed during fixed-point counts in spring, fall, and winter, indicating eagles may utilize the Project area year-round; additionally, one golden eagle was observed incidentally during Year 2 surveys. One state-listed bird species (peregrine falcon) was observed during avian use surveys conducted at the Project and several special status bird species, including ferruginous hawk (*Buteo regalis*) and Swainson's hawk (*Buteo swainsoni*) were observed during these surveys. The federally threatened northern long-eared bat was recorded in two locations during the 2015 acoustic survey, but none were found during surveys in 2016, including at one point where one call was classified as a NLEB in 2015.

2. *Do field studies indicate potential for significant adverse impacts on the affected populations of species of habitat fragmentation concern?*

Approximately 42% of the Project area is composed of grassland/pasture land that may contain native grasses. If construction takes place in grassland areas, it is possible that some grassland and/or shrub-dependent species could be displaced. Grassland dependent species observed during fixed-point avian use surveys and incidentally included ferruginous hawk, golden eagle, and bobolink (*Dolichonys oryzivorous*). Project development is being planned to minimize impacts and disturbances to grasslands by siting in cropland to the greatest extent practicable.

3. *What is the distribution, relative abundance, behavior, and site use of species of concern identified in Tiers 1 or 2, and to what extent do these factors expose these species to risk from the proposed Project?*

No whooping cranes have been observed in the Project area. Site-specific data indicate whooping cranes may migrate over the Project, but site characteristics are similar to the surrounding area. Although large groups of sandhill cranes (*Antigone canadensis*) were observed incidentally during both years of fixed-point avian use surveys at the Project; no whooping cranes were observed during baseline studies. No sandhill or whooping cranes have been reported as fatalities from wind energy centers within the migration corridor; therefore impacts to whooping cranes are expected to be low (Derby et al. 2012d). One juvenile peregrine falcon, a state-listed species, was observed using grassland habitats within the Project area. Peregrine falcons have been reported in the general region where the Project is located and negative impacts from Project development are not expected due to the lack of suitable nesting habitat for this species.

The Canada goose (*Branta canadensis*), European starling (*Sturnus vulgaris*), sandhill crane, Franklin's gull (*Leucophaeus pipixcan*), snow goose (*Chen caerulescens*), common grackle (*Quiscalus quiscula*), and red-winged blackbird (*Agelaius phoeniceus*) were observed most often during Years 1 and 2 fixed-point avian use surveys. None of the above species are listed as federal or state-threatened or endangered. However, bald and golden eagles, both protected by the BGEPA, were observed during surveys and incidentally. Impacts are expected to be low for migratory bird species and population-level impacts are not expected.

While eagles are known to nest in the immediate area, no eagle nests were observed within the Project area. One eagle nest is within 1.6 km (1 mile) of the current Project boundary and approximately 3.2 km (2 mile) from the nearest turbine. Due to the proximity of the eagle nest, eagle use of the Project area is possible. Other eagle nests have been documented south of the Project along the Missouri River, and those individuals may utilize resources in the Project. Bald eagles were observed in spring, fall, and winter; however, eagle use of the Project was low.

As described in previous sections, northern long-eared bats were detected in two locations during acoustic surveys conducted in 2015, but were not detected during 2016 surveys.

4. *What are the potential risks of adverse impacts of the proposed Project to individuals and local populations of species of concern and their habitats?*

Where practicable, Project siting has avoided grasslands to limit impacts to wildlife species. Non-cropland vegetation may need to be cleared for construction of facilities, but habitat impacts are not expected to be significant. Most turbines will be located in cropland, which is of low habitat value for most wildlife species. The most likely impacts would be to individual birds and bats that may collide with wind turbines or other Project facilities; however, significant adverse impacts are not anticipated.

5. *How can developers mitigate identified significant adverse impacts?*

No significant impacts to species of concern are expected. Placement of turbines in cultivated crop fields and away from forested and native grassland areas will minimize impacts to sensitive bird and bat species. Project design alterations and best management practices have been developed based on the results from Tier 3 studies, information available in the WEG, and other studies at wind energy facilities. These steps to avoid and reduce impacts are described in Section 3 below.

6. *Are there studies that should be initiated at this stage that would be continued in either Tier 4 or Tier 5?*

Prevailing Wind plans to conduct Tier 4 post-construction monitoring studies for the Project as detailed in Section 4.

2.2.7 Summary of Potential Adverse Impacts

Overall impacts to bird species are expected to be low. The Project is located within a mix of grass/pasture land and cropland. Placement of turbines in grasslands or pasture lands could displace grassland-dependent species and other bird species that can occur in large blocks of grassland. Placement of turbines within mostly cultivated crop fields will limit impacts on birds and displacement of nesting birds.

Whooping cranes may utilize the Project area; however, no whooping or sandhill crane fatalities have been recorded at wind energy facilities in the migratory corridor and no impacts to whooping cranes are expected (Derby et al. 2012d). Overall diurnal raptor use was relatively low throughout the Project area during Years 1 and 2 (0.31 and 0.33 raptors/800-m plot/20-min survey, respectively) and pre-construction raptor use data is shown to generally correlate with post-construction raptor fatality rates at other wind energy projects. Post-construction monitoring at existing wind energy facilities in South Dakota has indicated that impacts to raptors in the region are low; therefore, impacts to raptors are likely to be low at the Project. Bald eagles were observed within the Project area during both years; however more eagles were observed during Year 2. One active bald eagle nest was located 1.6 km (1 mi) east of the Project boundary or 3.2 km (2 mi) from nearest turbine and other bald eagle nests were located within 16.1 km (10 mi) of the Project. Observed eagle use was low within the Project area which suggests minimal potential impacts to eagles.

Based on the Project's location in an agricultural setting, any impacts to bat species will likely be low and fall within the range of other wind energy projects in North and South Dakota and the Midwest region. However, it is difficult to predict what the actual level of bat mortality may be. Based on the location of the Project, limited bat roosting habitat, low bat activity recorded during acoustic surveys, and fatality data from other facilities close to the Project area, low levels of bat mortality could occur from the Project, and significant adverse impacts are not anticipated. The post-construction fatality monitoring surveys planned for the Project (see Section 4) are designed to provide empirical data on actual bat fatalities that can be compared to the pre-construction survey data.

3.0 POST-CONSTRUCTION: TIER 4

According to the WEG, "during post-construction tiers (including Tier 4), developers are assessing whether actions taken in earlier tiers to avoid and minimize impacts are successfully achieving the goals and, when necessary, taking additional steps to compensate for impacts" (USFWS 2012). The specific questions to be investigated in Tier 4 are:

- What are the bird and bat fatality rates within the Project area?
- What are the fatality rates of species of concern?
- How do the estimated fatality rates compare to the predicted fatality rates?
- Do bird and bat fatalities vary within the Project area in relation to site characteristics?

- How do the bird and bat fatality rates compare to the fatality rates from existing projects in similar landscapes with similar species composition and use?
- What is the composition of fatalities in relation to migrating and resident birds and bats at the Project?
- Do fatality data suggest the need for measures to reduce Project impacts?

After the field surveys and analysis are completed in accordance with the protocol described below, Prevailing Wind will review the efforts and make a determination pursuant to the WEG "Decision Framework for Tier 4a Fatality Monitoring" (USFWS 2012) to determine the need for further monitoring or if any measures are needed to reduce impacts.

3.1 Formal Avian and Bat Fatality Monitoring

Prevailing Wind has developed a post-construction monitoring plan with the intent to focus on the WEG Tier 4a questions for the Project. Fatality monitoring will provide information on the impact of the Project on birds and bats and give an indication of whether any specific turbines or Project facilities are responsible for a significant proportion of fatalities. As pre-construction surveys did not indicate significant potential impacts for birds or bats, current plans for the post-construction fatality monitoring are to conduct one year of general bird and bat fatality monitoring.

Fatality monitoring will begin after all the turbines have been commissioned and are fully operational, and will be conducted by a third party biologist. The duration and intensity of carcass searches, the number of selected turbines, and the levels of searcher efficiency and carcass removal trials will be consistent with general wind industry standard practices as described in the WEG. Impacts to avian and bat species are anticipated to be within the overall range of other Midwestern facilities, particularly those within North and South Dakota. The objective of the monitoring will be to determine if the avian or bat fatality rates are lower, similar to, or higher than other regional and national studies.

Fatality monitoring procedures will consist of the following components: 1) standardized carcass searches of selected turbines and/or turbine pads and roads, 2) searcher efficiency trials to estimate the percentage of carcasses found by searchers, and 3) carcass removal trials to estimate the length of time that a carcass remains in the field for possible detection. Fatality estimates for the monitoring period will be provided for a minimum of three categories: 1) bats, 2) all birds, and 3) raptors. The primary purpose of the proposed fatality monitoring is to document bat fatalities and large bird (e.g., raptor) fatalities.

Estimates of facility-related fatalities will be based on:

- Observed number of carcasses found during standardized searches during the monitoring year, for which the cause of death is either unknown or is probably facility-related.

- Non-removal rates, expressed as the estimated average probability a carcass is expected to remain in the study area and be available for detection by the searchers during removal trials.
- Searcher efficiency, expressed as the proportion of planted carcasses found by searchers during searcher efficiency trials.
- Percent of area searched at each turbine (i.e., takes into consideration road and pad sampling) and percentage of carcasses found at varying distances from turbine.

3.2 Incidental Monitoring

3.2.1 On-Site Staff Training

All operations personnel will be trained to identify potential wildlife interactions and the proper response. An incidental reporting process will be developed for operations personnel ensuring they can document bird or bat casualties within the Project area during routine maintenance work and at other times. In addition to incidental fatality reporting, operations personnel will be trained to identify bald and golden eagles, to be sensitive to relative use rates of eagles, and to look for eagle casualties while driving between turbines and conducting turbine maintenance.

3.2.2 Injured Wildlife Handling and Reporting Protocol

Any injured wildlife observed during operations of the Project will be left in place until Prevailing Wind's primary biological/ecological representative has been contacted. Prevailing Wind will then decide the most appropriate course of action depending on the condition and species of injured animal discovered. All injured native birds, including federally or state-listed species, will be promptly delivered to the appropriate rehabilitation center or other approved facility as specified in state and federal permits; or as directed by necessary law enforcement personnel.

3.3 Post-Construction Results and Recommendations Reporting Protocol

Prevailing Wind will prepare a report summarizing the results of the monitoring and assessment completed, as described in Sections 3.1 and 3.2.

Specific to the formal avian and bat fatality monitoring, this report will include turbine-specific information on found carcasses, along with estimated fatality rates for birds and bats. Fatality estimates will be calculated for bats, all birds, and raptors, at a minimum. Seasonal estimates for both birds and bats will also be reported. Estimated fatality rates will be calculated using the total number of carcasses found, along with data from searcher efficiency and carcass removal trials. The report will include an analysis that provides a comparison of fatality estimates, searcher efficiency, and scavenger removal rates between the cleared plots and road and pad searches. All species found as fatalities will be reported and if any federally listed or state-listed species are found they will be reported immediately to the proper agency personnel.

4.0 RESEARCH: TIER 5

In addition to the Tiers 1–4 described above, the WEG contain a Tier 5 *"Other Post-Construction Studies*" section. In general, the studies identified in Tier 5 are research-related and "will not be necessary for most wind energy projects" (USFWS 2012). Given that the Project's pre-construction studies indicate that the Project is not likely to cause significant adverse impacts, no Tier 5 studies are planned.

5.0 ADAPTIVE MANAGEMENT AND OPERATIONS MEASURES

Within the WEG, the Department of the Interior defines adaptive management as "an iterative decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Comprehensively applying the tiered approach embodies the adaptive management process" (USFWS 2012). The WEG further note that adaptive management at most wind energy facilities is unlikely to be needed if they are sited in accordance with the tiered approach. Nevertheless, Prevailing Wind recognizes the value of applying this approach to its Project activities that include some uncertainty. As such, Prevailing Wind has incorporated an adaptive approach for the conservation of wildlife potentially impacted by the Project.

Section 2.0 of this BBCS describes the tiered approach used to study wildlife conditions and predict Project impacts. Based on Project siting, response to pre-construction monitoring actions (turbines sited mostly in cultivated areas), and results to date of overall biological monitoring, the anticipated bat and bird mortality is expected to be within the overall range for other projects in the region and no significant adverse impacts on birds and bats are anticipated from the Project. Estimated avian and bat fatality rates reported at the nearby Beethoven were 2.69 bat fatalities/MW/study period, 1.43 bird fatalities, and 0.07 raptor fatalities. Additional available studies from Midwestern projects have reported estimated fatality rates ranging from 0.16–2.81 bats/MW/year (Table 5), 0.27–8.25 birds/MW/year (Table 6), and 0–0.47 raptors/MW/year (Table 7). To confirm the anticipated impacts, post-construction fatality surveys will be conducted after the facility is fully functioning, using a third party biologist according to the methods set forth in Section 3.

Table 6. Wind energy facilities in the Midwest with fatality data for all bird species.

Wind Energy Facility	Fatality Estimate[A]	Number of Turbines	Total Megawatts
Wessington Springs, SD (2009)	8.25	34	51.00
Blue Sky Green Field, WI (2008; 2009)	7.17	88	145.00
Cedar Ridge, WI (2009)	6.55	41	67.60
Buffalo Ridge, MN (Phase III; 1999)	5.93	138	103.50
Moraine II, MN (2009)	5.59	33	49.50
Barton I & II, IA (2010-2011)	5.5	80	160.00
Buffalo Ridge I, SD (2009-2010)	5.06	24	50.40
Buffalo Ridge, MN (Phase I; 1996)	4.14	73	25.00

Table 6. Wind energy facilities in the Midwest with fatality data for all bird species.

Wind Energy Facility	Fatality Estimate^{A}	Number of Turbines	Total Megawatts
Winnebago, IA (2009-2010)	3.88	10	20.00
Rugby, ND (2010-2011)	3.82	71	149.00
Cedar Ridge, WI (2010)	3.72	41	68.00
Elm Creek II, MN (2011-2012)	3.64	62	148.80
Buffalo Ridge, MN (Phase II; 1999)	3.57	143	107.25
Buffalo Ridge, MN (Phase I; 1998)	3.14	73	25.00
Ripley, Ont (2008)	3.09	38	76.00
Fowler I, IN (2009)	2.83	162	301.00
Buffalo Ridge, MN (Phase I; 1997)	2.51	73	25.00
Buffalo Ridge, MN (Phase II; 1998)	2.47	143	107.25
PrairieWinds SD1, SD (2012-2013)	2.01	108	162.00
Buffalo Ridge II, SD (2011-2012)	1.99	105	210.00
Kewaunee County, WI (1999-2001)	1.95	31	20.46
NPPD Ainsworth, NE (2006)	1.63	36	20.50
PrairieWinds ND1 (Minot), ND (2011)	1.56	80	115.50
Elm Creek, MN (2009-2010)	1.55	67	100.00
PrairieWinds ND1 (Minot), ND (2010)	1.48	80	115.50
Buffalo Ridge, MN (Phase I; 1999)	1.43	73	25.00
PrairieWinds SD1, SD (2011-2012)	1.41	108	162.00
Wessington Springs, SD (2010)	0.89	34	51.00
Top of Iowa, IA (2004)	0.81	89	80.00
Grand Ridge I, IL (2009-2010)	0.48	66	99.00
Top of Iowa, IA (2003)	0.42	89	80.00
Pioneer Prairie I, IA (Phase II; 2011-2012)	0.27	62	102.30

^{A}. = Number of bird fatalities per megawatt per year.

Data from the following sources:

Wind Energy Facility	Fatality Reference	Wind Energy Facility	Fatality Reference
Barton I & II, IA (10-11)	Derby et al. 2011b	Grand Ridge, IL (09-10)	Derby et al. 2010a
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Kewaunee County, WI (99-01)	Howe et al. 2002
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000b	Moraine II, MN (09)	Derby et al. 2010e
Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000b	NPPD Ainsworth, NE (06)	Derby et al. 2007
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000b	Pioneer Prairie I, IA (Phase II; 11-12)	Chodachek et al. 2012
Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000b	PrairieWinds ND1 (Minot), ND (10)	Derby et al. 2011d
Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000b	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012e
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000b	PrairieWinds SD1 (Crow Lake), SD (11-12)	Derby et al. 2012c
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000b	PrairieWinds SD1 (Crow Lake), SD (12-13)	Derby et al. 2013
Buffalo Ridge I, SD (09-10)	Derby et al. 2010c	Ripley, Ont (08)	Jacques Whitford 2009
Buffalo Ridge II, SD (11-12)	Derby et al. 2012a	Rugby, ND (10-11)	Derby et al. 2011c
Cedar Ridge, WI (09)	BHE Environmental 2010	Top of Iowa, IA (03)	Jain 2005
Cedar Ridge, WI (10)	BHE Environmental 2011	Top of Iowa, IA (04)	Jain 2005
Elm Creek, MN (09-10)	Derby et al. 2010d	Wessington Springs, SD (09)	Derby et al. 2010b
Elm Creek II, MN (11-12)	Derby et al. 2012b	Wessington Springs, SD (10)	Derby et al. 2011a
Fowler I, IN (09)	Johnson et al. 2010a	Winnebago, IA (09-10)	Derby et al. 2010f

Table 7. Wind energy facilities in the Midwest with fatality data for raptors.

Wind Energy Facility	Raptor Fatality Estimate^A	Number of Turbines	Total Megawatts
Buffalo Ridge, MN (Phase I; 1999)	0.47	73	25.00
Moraine II, MN (2009)	0.37	33	49.50
Winnebago, IA (2009-2010)	0.27	10	20.00
Buffalo Ridge I, SD (2009-2010)	0.2	24	50.40
Cedar Ridge, WI (2009)	0.18	41	67.60
Top of Iowa, IA (2004)	0.17	89	80.00
Cedar Ridge, WI (2010)	0.13	41	68.00
Ripley, Ont (2008)	0.10	38	76.00
Wessington Springs, SD (2010)	0.07	34	51.00
NPPD Ainsworth, NE (2006)	0.06	36	20.50
Wessington Springs, SD (2009)	0.06	34	51.00
Rugby, ND (2010-2011)	0.06	71	149.00
PrairieWinds ND1 (Minot), ND (2011)	0.05	80	115.50
PrairieWinds ND1 (Minot), ND (2010)	0.05	80	115.50
PrairieWinds SD1, SD (2012-2013)	0.03	108	162.00
Kewaunee County, WI (1999-2001)	0	31	20.46
Buffalo Ridge, MN (Phase I; 1996)	0	73	25.00
Buffalo Ridge, MN (Phase I; 1997)	0	73	25.00
Buffalo Ridge, MN (Phase I; 1998)	0	73	25.00
Top of Iowa, IA (2003)	0	89	80.00
Grand Ridge I, IL (2009-2010)	0	66	99.00
Elm Creek, MN (2009-2010)	0	67	100.00
Pioneer Prairie I, IA (Phase II; 2011-2012)	0	62	102.30
Buffalo Ridge, MN (Phase III; 1999)	0	138	103.50
Buffalo Ridge, MN (Phase II; 1998)	0	143	107.25
Buffalo Ridge, MN (Phase II; 1999)	0	143	107.25
Blue Sky Green Field, WI (2008; 2009)	0	88	145.00
Elm Creek II, MN (2011-2012)	0	62	148.80
Barton I & II, IA (2010-2011)	0	80	160.00
PrairieWinds SD1, SD (2011-2012)	0	108	162.00
Buffalo Ridge II, SD (2011-2012)	0	105	210.00
Fowler I, IN (2009)	0	162	301.00

^{A} = Number of raptor fatalities per megawatt per year

Data from the following sources:

Wind Energy Facility	Fatality Reference	Wind Energy Facility	Fatality Reference
Barton I & II, IA (10-11)	Derby et al. 2011b	Grand Ridge, IL (09-10)	Derby et al. 2010a
Blue Sky Green Field, WI (08; 09)	Gruver et al. 2009	Kewaunee County, WI (99-01)	Howe et al. 2002
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000b	Moraine II, MN (09)	Derby et al. 2010e
Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000b	NPPD Ainsworth, NE (06)	Derby et al. 2007
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000b	Pioneer Prairie I, IA (Phase II; 11-12)	Chodachek et al. 2012
Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000b	PrairieWinds ND1 (Minot), ND (10)	Derby et al. 2011d
Buffalo Ridge, MN (Phase II; 98)	Johnson et al. 2000b	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012e
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000b	PrairieWinds SD1 (Crow Lake), SD (11-12)	Derby et al. 2012c
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000b	PrairieWinds SD1 (Crow Lake), SD (12-13)	Derby et al. 2013
Buffalo Ridge I, SD (09-10)	Derby et al. 2010c	Ripley, Ont (08)	Jacques Whitford 2009
Buffalo Ridge II, SD (11-12)	Derby et al. 2012a	Rugby, ND (10-11)	Derby et al. 2011c
Cedar Ridge, WI (09)	BHE Environmental 2010	Top of Iowa, IA (03)	Jain 2005
Cedar Ridge, WI (10)	BHE Environmental 2011	Top of Iowa, IA (04)	Jain 2005
Elm Creek, MN (09-10)	Derby et al. 2010d	Wessington Springs, SD (09)	Derby et al. 2010b
Elm Creek II, MN (11-12)	Derby et al. 2012b	Wessington Springs, SD (10)	Derby et al. 2011a
Fowler I, IN (09)	Johnson et al. 2010a	Winnebago, IA (09-10)	Derby et al. 2010f

5.1 Unexpected Avian, Bat, and/or Habitat Impacts

Based on the results of the Tier 4 monitoring program described in the sections above, adaptive management measures could be considered to further avoid, minimize, or compensate for unanticipated and significant Project impacts to wildlife. Examples for considering an adaptive response may include:

- Mortality of a bald or golden eagle (to be addressed via the Eagle Conservation Plan), northern long-eared bat, whooping crane or species listed as endangered/threatened under the federal ESA;
- Significant levels of mortality of non-listed species of birds or bats above those outlined in the tables above; or
- New occurrence of an eagle nest or listed species occupancy during operations.

Prevailing Wind would also consider adaptive management responses if additional species become listed under federal or state-protected species regulations.

6.0 IMPLEMENTATION OF THE BBCS

6.1 Document Availability

This BBCS will be maintained by Prevailing Wind's appropriate management staff member and a copy of the BBCS will be kept on-site throughout operations of the Project.

6.2 Reporting

In accordance with the BBCS, annual reports for post-construction Tier 4 efforts will be developed and submitted to appropriate agency representatives for review. Reporting of finding any listed species fatality will be done immediately to the USFWS for the life of the Project. Prevailing Wind will also coordinate any adaptive management changes needed with agency personnel.

7.0 REFERENCES

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Sound Study

Prevailing Wind Park, LLC

Prevailing Wind Park
Project No. 105644

Revision 5
05/30/2018

Sound Study

prepared for

Prevailing Wind Park, LLC
Prevailing Wind Park
Bon Homme/Charles Mix/Hutchinson Counties, SD

Project No. 105644

Revision 5
05/30/2018

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
ANSI	American National Standards Institute
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
CadnaA	Computer Aided Design for Noise Abatement
dB	Decibel
dBA	A-weighted decibels
DEM	Digital Elevation Model
Developer	Prevailing Wind Park, LLC
GE	General Electric
Hz	Hertz
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
L_{90}	the sound level exceeded 90 percent of the time period
L_{eq}	equivalent-continuous sound level
LWES	Large Wind Energy System
L_x	exceedance sound level
MP	measurement point
Project	Prevailing Wind Park
The Act	The Noise Control Act of 1972
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WES	Wind Energy System

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REVISION HISTORY

Rev	Issue Date	Release Notes
0	03-Apr-2018	Original release
1	09-Apr-2018	Revised wind turbine layout, incorporated client comments
2	11-Apr-2018	Added REC-138
3	16-Apr-2018	Revised wind turbine layout
4	27-Apr-2018	Revised wind turbine layout
5	14-May-2018	Incorporated client comments

1.0 EXECUTIVE SUMMARY

Prevailing Wind Park, LLC (Developer) is proposing to construct the Prevailing Wind Park near Avon, South Dakota, in Bon Homme, Hutchinson, and Charles Mix Counties (Project). The Project will consist of 57 to 61 wind turbines with a maximum nameplate capacity of up to 219.6 megawatts (MW), although output at the point of interconnection will be limited to a maximum of 200 MW. A total of 63 wind turbine sites were analyzed for two turbine models: General Electric (GE) 3.8-137 and Vestas V136-3.6. This sound assessment was completed to determine if the Project can operate in compliance with the applicable sound regulations.

Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell) conducted an ambient sound survey and sound modeling study for the proposed Project. There were several objectives in this study, which included:

- Identification of any applicable county, city, state, or federal noise ordinances and other applicable sound guidelines;
- Measure ambient sound levels at noise-sensitive receivers;
- Estimation of the operational sound levels from the hypothetical Project layout using the three-dimensional sound modeling program Computer Aided Design for Noise Abatement (CadnaA); and
- Determination if the wind farm can operate in compliance with the identified applicable regulatory standards.

There are no federal or state noise regulations that apply to this Project. Therefore, only local regulations would apply. Bon Homme County has adopted a zoning ordinance that pertains to wind energy systems. The ordinance limits sound levels of WES to 45 dBA at occupied receptors, unless a signed waiver or easement is obtained from the owner of the residence. Neither Charles Mix nor Hutchinson County has a numerical noise limit. Therefore, the Bon Homme County ordinance sound level limit was used as the design goal for all areas of the Project.

The wind turbines were modeled using manufacturer-specified sound power levels. Sound pressure levels were predicted at all receivers within and surrounding the Project area. There are no expected exceedances of the identified regulations due to operation of any of the proposed wind turbine locations of the Project.

2.0 ACOUSTICAL TERMINOLOGY

The term “sound level” is often used to describe two different sound characteristics: sound power and sound pressure. Every source that produces sound has a sound power level. The sound power level is the acoustical energy emitted by a sound source and is an absolute number that is not affected by the surrounding environment. The acoustical energy produced by a source propagates through media as pressure fluctuations. These pressure fluctuations, also called sound pressure, are what human ears hear and microphones measure.

Sound is physically characterized by amplitude and frequency. The amplitude of sound is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure (20 microPascals). The reference sound pressure corresponds to the typical threshold of human hearing. To the average listener, a 3-dB change in a continuous broadband sound is generally considered “just barely perceptible”; a 5-dB change is generally considered “clearly noticeable”; and a 10-dB change is generally considered a doubling (or halving, if the sound is decreasing) of the apparent loudness.

Sound waves can occur at many different wavelengths, also known as the frequency. Frequency is measured in hertz (Hz) and is the number of wave cycles per second that occur. The typical human ear can hear frequencies ranging from approximately 20 to 20,000 Hz. Normally, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the lower and higher frequencies. As such, the A-weighting scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels, or dBA. For reference, the A-weighted sound pressure level and subjective loudness associated with some common sound sources are listed in Table 2-1.

Table 2-1: Typical Sound Pressure Levels Associated with Common Noise Sources

Sound Pressure Level (dBA)[a]	Subjective Evaluation	Environment	
		Outdoor	Indoor
140	Deafening	Jet aircraft at 75 feet	--
130	Threshold of pain	Jet aircraft during takeoff at a distance of 300 feet	--
120	Threshold of feeling	Elevated train	Hard rock band
110		Jet flyover at 1,000 feet	Inside propeller plane
100	Very loud	Power mower, motorcycle at 25 feet, auto horn at 10 feet, crowd noise at football game	--
90	--	Propeller plane flyover at 1,000 feet, noisy urban street	Full symphony or band, food blender, noisy factory
80	Moderately loud	Diesel truck (40 mph)[a] at 50 feet	Inside auto at high speed, garbage disposal
70	Loud	B-757 cabin during flight	Close conversation, vacuum cleaner
60	Moderate	Air-conditioner condenser at 15 feet, near highway traffic	General office
50	Quiet	--	Private office
40	--	Farm field with light breeze, birdcalls	Soft stereo music in residence
30	Very quiet	Quiet residential neighborhood	Bedroom, average residence (without TV and stereo)
20	--	Rustling leaves	Quiet theater, whisper
10	Just audible	--	Human breathing
0	Threshold of hearing	--	--

Source: Adapted from *Architectural Acoustics*, M. David Egan, 1988 and *Architectural Graphic Standards*, Ramsey and Sleeper, 1994.
(a) dBA = A-weighted decibels; mph = miles per hour

Sound metrics have been developed to quantify fluctuating environmental sound levels. These metrics include the exceedance sound level. The exceedance sound level, L_x, is the sound level exceeded during “x” percent of the sampling period and is also referred to as a statistical sound level. L_{90} levels are presented throughout this study. The L_{90} is a common L_x value and represents the sound level with minimal influence from short-term, loud transient sound sources. The L_{90} represents the sound level exceeded for 90 percent of the time period during which sound levels are measured. The L_{90} value is regarded as the most accurate tool for measuring relatively constant background noise and for minimizing the influence of isolated spikes in sound levels (i.e., barking dog, door slamming).

3.0 REGULATIONS

Federal, state, and county regulations were reviewed to determine the applicable overall sound level limits for the Project.

The Noise Control Act of 1972 (the Act) (U.S.C. 4901) mandated a national policy “to promote an environment for all Americans free from noise that jeopardizes their health or welfare, to establish a means for effective coordination of Federal research activities in noise control, to authorize the establishment of Federal noise emission standards for products distributed in commerce, and to provide information to the public respecting the noise emission and noise reduction characteristics of such products.”

As required by the Act, the EPA established criteria for protecting the public health and wellbeing. However, these criteria do not constitute enforceable federal regulations or standards. The EPA has since delegated regulatory authority to local entities. Therefore, there are no federal noise regulations that apply to this Project.

Bon Homme County has adopted a zoning ordinance that pertains to wind energy systems. The ordinance limits sound levels of WES to 45 dBA at occupied receptors, unless a signed waiver or easement is obtained from the owner of the residence. Charles Mix County is only zoned in the townships, and because there are no turbines proposed for the townships, there are no zoning requirements for the Project within Charles Mix County (i.e., no zoning noise limits). Hutchinson County does not have a numerical noise ordinance.

Because there are no limits in Charles Mix and Hutchinson counties, the Bon Homme County ordinance sound level limit was used as the design goal for all areas of the Project. Therefore, the design criteria for the Project is 45 dBA at occupied receptors, unless a signed waiver or easement is obtained from the owner of the residence.

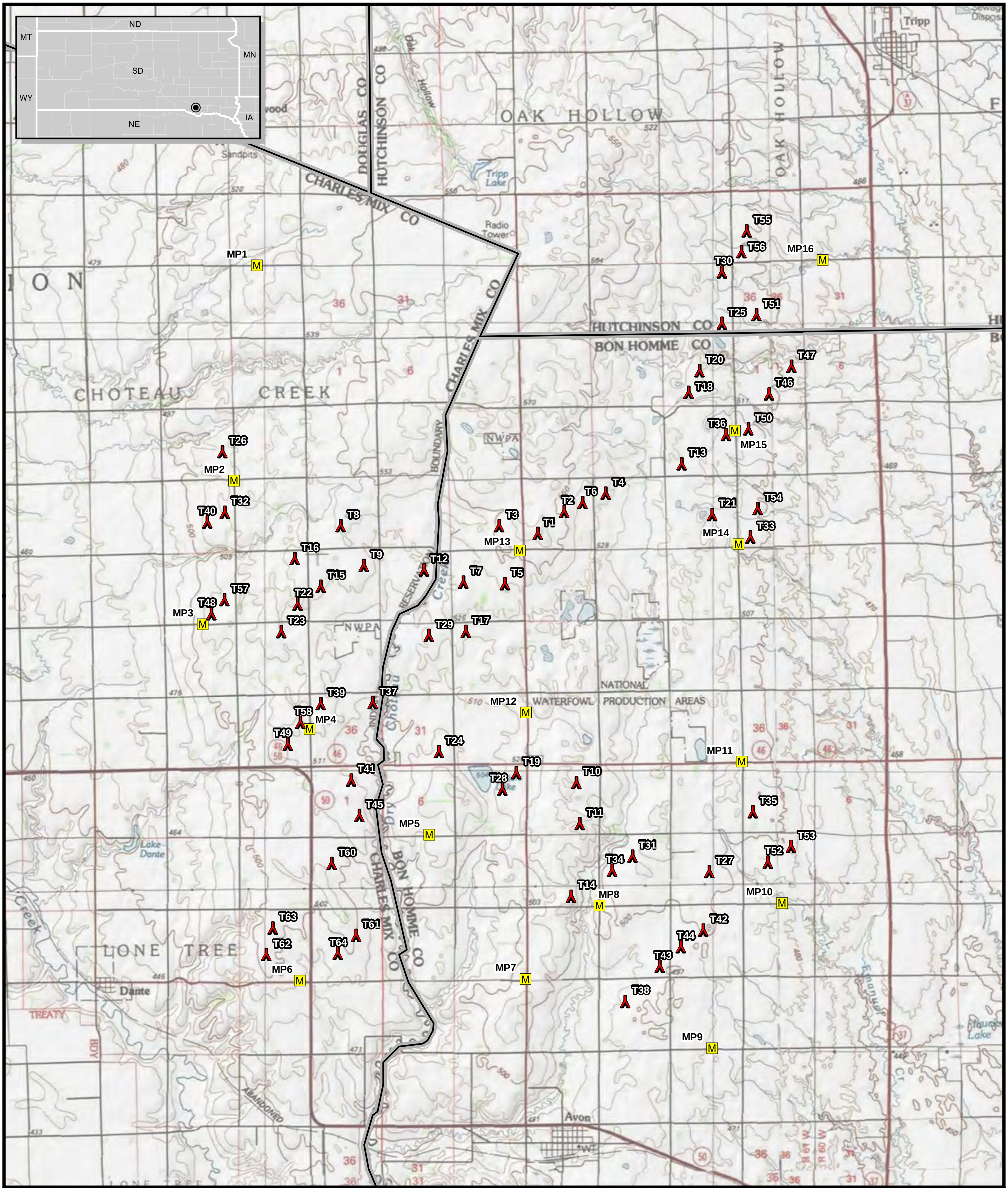
4.0 AMBIENT SOUND SURVEY

Burns & McDonnell personnel conducted an ambient sound survey of surrounding Project areas on March 12 and 13, 2018.

Measurements were taken using an American National Standards Institute (ANSI) S1.4 type 1 sound level meter (Larson David Model 831). The sound level meter was calibrated at the beginning and end of each set of measurements. None of the calibration level changes exceeded ± 0.5 dB. A windscreen was used at all times on the microphone, and the meter was mounted on a tripod. Certificates of calibration for the equipment used are available upon request. The microphone was located approximately 5 feet above ground level with the microphone directed towards the closest proposed wind turbine location and angled per the manufacturer’s recommendation. All measurements were taken when meteorological conditions were favorable for conducting ambient sound measurements, per ANSI standards (low wind, moderate temperatures, humidity, and no precipitation).

Ambient far-field measurements were made at 16 locations, labeled measurement point (MP) MP1 through MP16, as shown in Figure 4-1. The measurement points were selected because they were accessible and representative of existing ambient sound levels in the vicinity of noise-sensitive receivers.

The far-field sound level measurements were 5 minutes in duration, and measured values were logged by the sound meter at each measurement point. The sound levels varied at each measurement point due to the extraneous sounds that occurred during each measurement. The overall A-weighted L_{eq} and L_{90} sound levels collected during the ambient far-field measurements are shown below in Table 4-1. Sound levels measured were in the range of 21.5 dBA to 45.0 dBA L_{90}.



LEGEND

▭ County Boundary

⅄ Wind Turbine

M Measurement Points

REFERENCE

0 1 2

MILES

0 1 2

KILOMETERS

N

PREVAILING WIND PARK
Measurement Points

LOCATION:	Charles Mix/Bonne Homme/Hutchinson Cty, SD
CLIENT:	Prevailing Wind Park, LLC
PROJ. NO.:	105644
CREATED:	04/25/2018

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Path: \\bmcd\dfs\Clients\BTS\SPowerDC\105644_PrvWindStudies\Studies\Geospatial\DataFiles\ArcDocs\105644_PrevailingWinds_85x11P.mxd • Coordinate System: NAD 1983 UTM Zone 14N • Units: Meter

Table 4-1: Ambient Measurements Data

Measurement Location	Sound Pressure Level (dBA)					
	Ambient (5:00 PM on 03/12/18)		Ambient (12:00 AM on 03/13/18)		Ambient (10:00 AM on 03/13/18)	
	L_{eq}	L_{90}	L_{eq}	L_{90}	L_{eq}	L_{90}
MP1	34.6	26.0	40.4	30.0	35.2	25.1
MP2	36.5	29.6	35.7	28.6	39.0	30.2
MP3	37.7	29.2	32.6	22.3	41.0	28.0
MP4	39.6	29.1	33.7	24.3	35.0	28.9
MP5	36.9	28.0	34.6	22.6	35.4	25.4
MP6	47.9	33.4	34.7	26.3	40.0	31.8
MP7	38.3	31.0	30.2	24.0	42.6	37.7
MP8	34.8	28.4	28.6	22.7	47.7	27.9
MP9	35.7	27.0	35.3	29.5	33.2	24.4
MP10	37.4	30.6	39.4	35.2	35.0	27.1
MP11	62.7	45.0	35.6	31.6	69.1	28.1
MP12	39.5	32.6	37.1	21.5	40.6	29.4
MP13	36.3	27.1	38.9	32.1	59.5	28.4
MP14	35.7	28.8	34.1	27.4	35.1	28.9
MP15	33.8	28.4	35.7	28.7	35.0	29.3
MP16	49.8	36.9	39.0	29.8	35.0	28.8

Extraneous sounds during the measurement periods included high speed traffic, birds, wind noise, and farm equipment. The measured sound levels and noise sources are presented in Appendix A.

5.0 SOUND MODELING

5.1 Wind Turbine and Transformer Sound Characteristics

The sound commonly associated with a wind turbine is described as a rhythmic “whoosh” caused by aerodynamic processes. This sound is created as air flow interacts with the surface of rotor blades. As air flows over the rotor blade, turbulent eddies form in the surface boundary layer and wake of the blade. These eddies are where most of the “whooshing” sound is formed. Additional sound is generated from vortex shedding produced by the tip of the rotor blade. Air flowing past the rotor tip creates alternating low-pressure vortices on the downstream side of the tip, causing sound generation to occur. Older wind turbines, built with rotors which operate downwind of the tower (downwind turbines), often have higher aerodynamic impulse sound levels. This is caused by the interaction between the aerodynamic lift created on the rotor blades and the turbulent wake vortices produced by the tower. Modern wind turbine rotors are mostly built to operate upwind of the tower (upwind turbines). Upwind wind turbines are not impacted by wake vortices generated by the tower and, therefore, overall sound levels can be as much as 10 dBA less. The rhythmic fluctuations of the overall sound level are less perceivable the farther one gets from the turbine. Additionally, multiple turbines operating at the same time will create the whooshing sound at different times. These non-synchronized sounds will blend together to create a more constant sound to an observer at most distances from the turbines. Another phenomenon that reduces perceivable noise from turbines is the wind itself. Higher wind speed produces noise in itself that tends to mask (or drown out) the sounds created by wind turbines.

Advancement in wind turbine technology has reduced pure tonal emissions of modern wind turbines. Manufacturers have reduced distinct tonal sounds by reshaping turbine blades and adjusting the angle at which air contacts the blade. Pitching technology allows the angle of the blade to adjust when the maximum rotational speed is achieved, which allows the turbine to maintain a constant rotational velocity. Therefore, sound emission levels remain constant as the velocity remains the same.

Wind turbines can create noise in other ways as well. Wind turbines have a nacelle where the mechanical portions of the turbine are housed. The current generation of wind turbines uses multiple techniques to reduce the noise from this portion of the turbine: vibration isolating mounts, special gears, and acoustic insulation. In general, all moving parts and the housing of the current generation wind turbines have been designed to minimize the noise they generate.

5.2 Model Inputs and Settings

Predicted sound levels were modeled using industry-accepted sound modeling software. The program used to model the turbines was the CadnaA, Version 2017, published by DataKustik, Ltd., Munich, Germany. The CadnaA program is a scaled, three-dimensional program that accounts for air absorption, terrain, ground absorption, and ground reflection for each piece of noise-emitting equipment and predicts downwind sound pressure levels. The model calculates sound propagation based on International Organization for Standardization (ISO) 9613-2:1996, General Method of Calculation. ISO 9613, and therefore CadnaA, assesses the sound pressure levels based on the Octave Band Center Frequency range from 31.5 to 8,000 Hz. Compliance with the regulations for all turbines operating should equate to compliance for any combination of the turbines operating.

5.2.1 Project Layout

Prevailing Wind's hypothetical layout contains 63 wind turbine sites, including alternatives. Predictive modeling was conducted to determine the impacts at the occupied residences shown in Appendix B.

5.2.2 Terrain and Vegetation

Terrain and attenuation from ground absorption can have a significant impact on sound transmission. U.S. Geological Survey (USGS) Digital Elevation Model (DEM) contours were imported into the model to account for topographic variations around the Project. The contours were overlaid onto high resolution, digital orthoimagery obtained from the U.S. Department of Agriculture (USDA) to visually check proper contour positioning. The terrain around the proposed Project is mostly rural with few minor changes in elevation. The land is primarily used for agricultural purposes. As such, vegetation is mostly low-lying with some small areas of trees. Therefore, vegetation was excluded from the analysis to maintain conservativeness in the model. Ground attenuation is expected to be fairly high, due to the "soft ground" of the surrounding areas; however, a conservative value was used in the model.

5.2.3 Sound Propagation and Directivity

CadnaA calculates downwind sound propagation using ISO 9613 standards, which use omnidirectional downwind sound propagation and worst-case directivity factors. In other words, the model assumes that each turbine propagates its maximum sound level in all directions at all times. While this may seem to over-predict upwind sound levels, this approach has been validated by field measurements. Under most normal circumstances, wind turbine noise is not significantly directional, but tends to radiate uniformly in all directions.

5.2.4 Atmospheric Conditions

Atmospheric conditions were based on program defaults. Layers in the atmosphere often form where temperature increases with height (temperature inversions). Sound waves can reflect off of the temperature inversion layer and return to the surface of the earth. This process can increase sound levels at the surface, especially if the height of the inversion begins near the surface of the earth. Temperature inversions tend to occur mainly at night when winds are light or calm, usually when wind turbines are not operating. CadnaA calculates the downwind sound in a manner which is favorable for propagation (worst-case scenario) by assuming a well-developed moderate ground-based temperature inversion such as can occur at night. Therefore, predicted sound level results tend to be higher than would actually occur.

The atmosphere does not flow smoothly and tends to have swirls and eddies, also known as turbulence. Turbulence is basically formed by two processes: thermal turbulence and mechanical turbulence. Thermal turbulence is caused by the interaction of heated air rapidly rising from the heated earth’s surface, with cooler air descending from the atmosphere. Mechanical turbulence is caused as moving air interacts with objects such as trees, buildings, and wind turbines. Turbulent eddies generated by wind turbines and other objects can cause sound waves to scatter, which in turn, provides sound attenuation between the wind turbine and the receiver. The acoustical model assumes laminar air flow, which minimizes sound attenuation that would occur in a realistic inhomogeneous atmosphere. This assumption also causes the predicted sound levels to be higher than would actually occur.

5.2.5 Sound Emission Data

Acoustical modeling was conducted for the entire Project. Wind turbine heights and acoustical emissions were input into the model. The expected worst-case sound power levels for the GE 3.8-137 and Vestas V136-3.6 turbines were contained in documents provided by GE and Vestas based on various wind speeds. The sound emissions data supplied was developed using the International Electrotechnical Commission (IEC) 61400-11 acoustic measurement standards. The expected sound power level and modeled height for each turbine is displayed in Table 5-1.

Table 5-1: Wind Turbine Sound Power Levels

Turbine	Height	Sound Power Level (dBA)									
		31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**A-wt.[a]**
GE 3.8-137	110 m	78.5	86.8	92.6	96.4	99.4	102.1	102.0	93.7	79.2	**107.0**
Vestas V136-3.6	105 m	81.3	86.5	94.5	97.2	101.0	104.0	102.4	92.7	77.3	**108.2**

(a) A-wt. = A-weighted decibels

A point source at the hub was used to model sound emissions from the wind turbines. This approach is appropriate for simulating wind turbine noise emissions due to the large distances between the turbines and the receivers as compared to the dimensions of the wind turbines. The corresponding sound levels from the table above were applied to every point source.

Figure 4-1 shows the entire wind farm layout. Locations of receivers and wind turbines around the Project area were provided by the developer and are listed in Appendix B. Each receiver was assumed to have a height of 1.52 meters (5.0 feet) above ground level. Compliance with the regulation was assessed at the physical residence (each receiver).

The following assumptions were made to maintain the inherent conservativeness of the model and to estimate the worst case modeled sound levels:

- Attenuation was not included for sound propagation through wooded areas, existing barriers, and shielding
- All turbines were assumed to be operating at maximum power output (and therefore, maximum sound levels) at all times to represent worst-case noise impacts from the wind farm as a whole

5.3 Acoustical Modeling Results

Sound pressure levels were predicted for the identified receivers in the CadnaA noise modeling software using the manufacturer-specified sound power levels at each frequency and the assumptions listed above. CadnaA modeling results have been demonstrated in previous studies to conservatively approximate real-life measured noise from a source when extraneous noises are not present.

As previously mentioned, decibels are a logarithmic ratio of a sound pressure to a reference sound pressure. Therefore, they must be logarithmically added to determine a cumulative impact (i.e., logarithmically adding 50 dBA and 50 dBA results in 53 dBA). Logarithmically adding each of the individual turbine’s impacts together at each receiver provides an overall Project impact at each receiver.

The maximum model-predicted L_{eq} sound pressure levels at each receiver (the logarithmic addition of sound levels from each frequency from every turbine) are included in Appendix C. These values represent only the noise emitted by the wind turbines and do not include any extraneous noises (traffic, etc.) that could be present during physical noise measurements. There are no expected exceedances of the identified regulations due to operation of any of the proposed wind turbine locations of the Project. Extraneous sounds (grain dryers, traffic, etc.) may make the overall sound level higher than 45.0 dBA in some circumstances, but the turbines alone are not expected to cause that to happen.

Appendix D contains graphical representation of the Project's impact on the surrounding area for both GE and Vestas turbines. The figure depicts the maximum sound levels attributable to the new turbines.

6.0 CONCLUSION

Burns & McDonnell conducted a predictive sound assessment study for the proposed Prevailing Wind Park. The study included identification of applicable sound regulations and predictive modeling to estimate Project-related sound levels in the surrounding community.

Sound pressure levels were predicted at occupied receivers within and surrounding the Project area using manufacturer-specified sound power levels for each wind turbine. A number of conservative assumptions were applied to provide worst-case predicted sound pressure levels. Those results were then compared to the identified applicable regulations. There are no expected exceedances of the identified regulations due to operation of any of the proposed wind turbine locations of the Project.

APPENDIX A - AMBIENT MEASUREMENT DATA

Appendix A - Ambient Measurement Data

Prevailing Winds

Point Number	*LAeq*	*LA90*	*Notes*	
03/12/18 - 5:00PM to 7:00PM			**Meter1 Calibration before: 114.11**	**Meter2 Calibration before: 114.05**
36°F, 60% hm, 31°F dp, 4-9mph , clear skies			**Meter1 Calibration after: 113.91**	**Meter2 Calibration after: 113.91**
MP1	34.6 dBA	26.0 dBA	Distant traffic, light wind, existing wind farm not audible	
MP2	36.5 dBA	29.6 dBA	Distant traffic, birds, light wind, fan noise from nearby business	
MP3	37.7 dBA	29.2 dBA	Birds, light wind, distant traffic including large trucks, very distant airplane	
MP4	39.6 dBA	29.1 dBA	Birds, light wind, distant traffic	
MP5	36.9 dBA	28.0 dBA	Highway traffic, birds	
MP6	47.9 dBA	33.4 dBA	Highway traffic dominant, paused for local traffic	
MP7	38.3 dBA	31.0 dBA	Highway traffic, birds	
MP8	34.8 dBA	28.4 dBA	Birds, distant high speed traffic	
MP9	35.7 dBA	27.0 dBA	Nearby high speed traffic (409th Street), birds	
MP10	37.4 dBA	30.6 dBA	Distant high speed traffic, birds, horns	
MP11	62.7 dBA	45.0 dBA	Birds dominant, two high speed car passbys	
MP12	39.5 dBA	32.6 dBA	Birds, farm equipment, slight wind	
MP13	36.3 dBA	27.1 dBA	Slight wind	
MP14	35.7 dBA	28.8 dBA	Slight wind, distant high speed traffic	
MP15	33.8 dBA	28.4 dBA	Slight wind, distant birds, distant high speed traffic, backup alarm	
MP16	49.8 dBA	36.9 dBA	Birds dominant, slight wind	

Appendix A - Ambient Measurement Data

Prevailing Winds

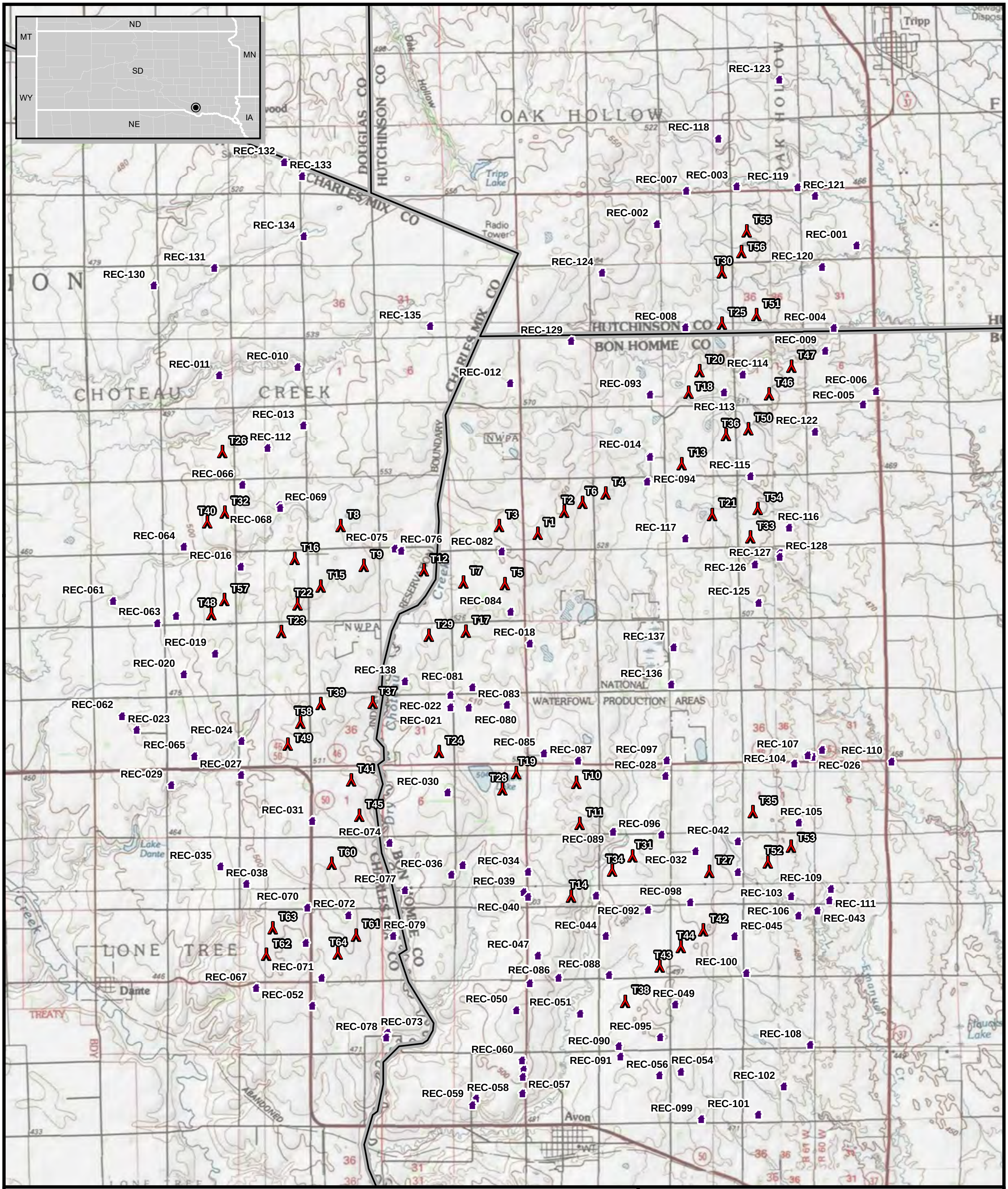
Point Number	***LAeq***	***LA90***	***Notes***	
03/13/18 - 12:00AM to 2:00AM			**Meter1 Calibration before: 114.19**	**Meter2 Calibration before: 113.87**
29°F, 74% hm, 21°F dp, 6-9 mph , clear skies			**Meter1 Calibration after: 113.83**	**Meter2 Calibration after: 114.20**
MP1	40.4 dBA	30.0 dBA	Wind turbines audible, light winds	
MP2	35.7 dBA	28.6 dBA	Wind turbines audible, light winds, sheep noise	
MP3	32.6 dBA	22.3 dBA	Very quiet, faint traffic	
MP4	33.7 dBA	24.3 dBA	Very quiet, faint traffic	
MP5	34.6 dBA	22.6 dBA	Distant traffic, large trucks, bull snort	
MP6	34.7 dBA	26.3 dBA	Traffic	
MP7	30.2 dBA	24.0 dBA	Traffic	
MP8	28.6 dBA	22.7 dBA	Distant high speed traffic	
MP9	35.3 dBA	29.5 dBA	Distant high speed traffic	
MP10	39.4 dBA	35.2 dBA	Slight wind	
MP11	35.6 dBA	31.6 dBA	Slight wind	
MP12	37.1 dBA	21.5 dBA	Distant high speed traffic	
MP13	38.9 dBA	32.1 dBA	Slight wind	
MP14	34.1 dBA	27.4 dBA	Slight wind	
MP15	35.7 dBA	28.7 dBA	Slight wind, distant high speed traffic	
MP16	39.0 dBA	29.8 dBA	Distant high speed traffic	

Appendix A - Ambient Measurement Data

Prevailing Winds

Point Number	*LAeq*	*LA90*	*Notes*
03/13/18 - 10:00AM to 12:00PM			**Meter1 Calibration before: 114.24** **Meter2 Calibration before: 114.04**
30°F, 62% hm, 19°F dp, 3-4 mph , clear skies			**Meter1 Calibration after: 113.82** **Meter2 Calibration after: 113.97**
MP1	35.2 dBA	25.1 dBA	Distant traffic, distant plane, wind turbines barely audible
MP2	39.0 dBA	30.2 dBA	Birds, wind turbines barely audible, tractor distant loading/unloading Birds,
MP3	41.0 dBA	28.0 dBA	distant traffic, wind
MP4	35.0 dBA	28.9 dBA	Birds, distant traffic, wind, distant airplane
MP5	35.4 dBA	25.4 dBA	Birds, wind, distant traffic
MP6	40.0 dBA	31.8 dBA	Birds, highway traffic
MP7	42.6 dBA	37.7 dBA	Birds, distant traffic, paused for local traffic
MP8	47.7 dBA	27.9 dBA	Owl, birds, distant high speed traffic, woman speaking (very end) Birds
MP9	33.2 dBA	24.4 dBA	Birds, dog barking, distant high speed traffic
MP10	35.0 dBA	27.1 dBA	High speed car passing
MP11	69.1 dBA	28.1 dBA	Farm equipment, cows
MP12	40.6 dBA	29.4 dBA	Birds, one car passing
MP13	59.5 dBA	28.4 dBA	Distant constant high speed traffic, birds
MP14	35.1 dBA	28.9 dBA	Birds, distant high speed traffic
MP15	35.0 dBA	29.3 dBA	Distant birds, distant high speed traffic
MP16	35.0 dBA	28.8 dBA	

APPENDIX B - SITE LAYOUT AND RECEIVER LOCATIONS



LEGEND

▭ County Boundary

⅄ Wind Turbine

● Receptor

REFERENCE

0 1 2

MILES

0 1 2

KILOMETERS

N

PREVAILING WIND PARK

Project Site Layout

LOCATION: Charles Mix/Bonne Homme/Hutchinson Cty, SD

CLIENT: Prevailing Wind Park, LLC

PROJ. NO.: 105644

CREATED: 04/25/2018

BURNS & McDONNELL
www.burnsmcd.com

Path: \\bmcd\dfs\Clients\BTS\SPowerDC\105644_PrvWindStudies\Studies\Geospatial\DataFiles\ArcDocs\105644_PrevailingWinds_85x11P.mxd • Coordinate System: NAD 1983 UTM Zone 14N • Units: Meter

APPENDIX C - MODELING RESULTS

Appendix C - Modeling Results

GE 3.8-137, 110 m

	Coordinates			Modeled		Exceed?
Receiver	*Easting (m)*	*Northing (m)*	*Base Elevation (m)*	*LAeq*	*Limit Value*	*(Y/N)*
REC-001	583178.93	4781949.36	473.94	24.7	45	N
REC-002	578731.00	4782428.97	540.99	29.1	45	N
REC-003	580506.89	4783273.92	505.27	33.7	45	N
REC-004	582678.66	4780104.52	480.03	32.4	45	N
REC-005	583326.78	4778396.84	476.81	27.5	45	N
REC-006	583615.28	4778695.43	471.94	26.2	45	N
REC-007	579386.45	4783171.84	519.65	29.7	45	N
REC-008	579364.54	4780122.78	515.18	38.2	45	N
REC-009	582485.70	4779597.03	481.47	34.3	45	N
REC-010	570706.40	4779232.69	531.85	20.3	45	N
REC-011	568954.92	4779049.93	516.88	23.0	45	N
REC-012	575450.96	4778869.67	571.47	-	45	N
REC-013	570834.43	4777923.92	539.22	27.4	45	N
REC-014	578568.31	4777265.47	526.35	38.1	45	N
REC-015	578578.94	4777228.45	526.13	38.3	45	N
REC-016	569437.95	4774776.35	523.53	38.9	45	N
REC-017	567999.72	4773683.50	489.60	36.8	45	N
REC-018	575893.85	4773069.05	525.25	32.5	45	N
REC-019	568870.35	4772837.61	510.51	36.3	45	N
REC-020	568170.58	4772373.09	491.63	30.5	45	N
REC-021	574122.73	4771641.66	507.46	35.0	45	N
REC-022	574117.98	4771913.43	508.31	34.7	45	N
REC-023	567115.19	4771132.04	470.89	-	45	N
REC-024	569455.79	4770885.60	499.55	34.2	45	N
REC-025	582409.59	4770691.28	486.10	26.3	45	N
REC-026	582205.90	4770538.43	489.18	27.7	45	N
REC-027	569450.78	4770122.57	499.25	32.0	45	N
REC-028	578915.96	4770106.59	519.65	30.5	45	N
REC-029	567890.47	4769896.98	472.42	19.1	45	N
REC-030	574057.84	4769738.20	530.58	35.9	45	N
REC-031	571038.40	4769099.63	510.51	36.6	45	N
REC-032	579594.58	4768433.69	507.46	40.2	45	N
REC-033	574388.42	4768112.11	502.26	29.5	45	N
REC-034	575856.91	4767968.51	509.35	34.3	45	N
REC-035	568988.11	4768088.17	487.50	27.6	45	N
REC-036	574139.54	4767903.27	507.06	28.6	45	N
REC-037	580534.75	4767955.77	497.42	40.6	45	N
REC-038	569570.52	4767693.73	493.87	33.1	45	N
REC-039	575753.59	4767511.52	511.25	33.5	45	N
REC-040	575853.92	4767408.85	513.56	34.3	45	N
REC-041	577365.54	4767429.45	496.85	41.4	45	N
REC-042	580534.93	4768649.62	501.93	40.0	45	N
REC-043	582314.18	4767105.01	476.98	30.8	45	N
REC-044	577581.91	4766535.38	501.37	35.6	45	N
REC-045	580459.53	4766528.35	495.27	37.9	45	N
REC-046	570892.00	4766384.10	500.34	39.9	45	N
REC-047	576071.91	4766099.10	511.58	28.5	45	N
REC-048	575888.47	4765484.03	507.46	26.2	45	N
REC-049	579136.06	4765003.57	501.37	36.3	45	N
REC-050	575594.26	4764877.78	513.56	22.9	45	N
REC-051	577014.96	4764806.12	483.08	32.6	45	N
REC-052	571034.71	4764976.49	483.08	32.4	45	N
REC-053	575751.76	4763553.72	504.89	18.1	45	N
REC-054	579261.02	4763508.83	493.92	26.2	45	N
REC-055	575738.19	4763383.18	501.37	18.7	45	N

Appendix C - Modeling Results

GE 3.8-137, 110 m

Receiver	*Coordinates* *Easting (m)*	*Northing (m)*	*Base Elevation (m)*	*Modeled LAeq*	*Limit Value*	*Exceed? (Y/N)*
REC-056	578784.40	4763423.45	495.27	26.8	45	N
REC-057	575728.70	4763020.56	496.19	-	45	N
REC-058	574689.98	4762905.51	489.18	-	45	N
REC-059	574608.88	4762765.31	484.23	-	45	N
REC-060	575719.36	4763758.78	507.46	19.6	45	N
REC-061	566590.17	4774005.26	470.89	25.5	45	N
REC-062	566794.52	4771446.01	467.84	-	45	N
REC-063	567575.59	4773523.26	480.49	32.1	45	N
REC-064	568169.85	4775221.75	493.83	37.5	45	N
REC-065	568402.45	4770548.21	483.08	24.8	45	N
REC-066	569474.73	4776605.15	525.75	39.0	45	N
REC-067	569782.41	4765373.88	493.98	36.1	45	N
REC-068	570301.18	4776152.11	533.82	35.8	45	N
REC-069	570320.63	4776086.07	530.62	36.0	45	N
REC-070	570930.65	4767169.47	502.79	37.7	45	N
REC-071	571246.87	4765598.42	488.81	38.5	45	N
REC-072	571847.73	4767001.23	507.46	41.7	45	N
REC-073	572712.41	4764371.30	476.98	25.2	45	N
REC-074	572760.45	4768609.65	494.96	35.3	45	N
REC-075	572875.14	4775183.93	528.80	39.1	45	N
REC-076	573023.77	4775137.74	528.80	39.6	45	N
REC-077	573104.39	4767558.79	488.61	31.1	45	N
REC-078	572689.83	4764269.58	472.84	24.7	45	N
REC-079	572840.24	4766532.05	483.08	35.8	45	N
REC-080	574527.24	4771635.20	508.86	34.0	45	N
REC-081	574606.23	4772084.46	513.56	34.0	45	N
REC-082	575265.41	4775117.32	552.59	41.9	45	N
REC-083	575384.42	4771695.61	513.56	32.3	45	N
REC-084	575459.57	4773771.95	533.47	39.2	45	N
REC-085	576210.31	4770611.18	524.57	38.1	45	N
REC-086	576537.52	4765598.06	498.89	30.2	45	N
REC-087	576971.43	4770447.24	531.85	40.8	45	N
REC-088	577659.69	4765661.22	489.18	38.1	45	N
REC-089	577747.37	4768859.92	513.80	40.5	45	N
REC-090	577878.24	4764078.53	490.80	32.8	45	N
REC-091	577915.85	4763844.06	489.18	30.5	45	N
REC-092	578531.67	4767119.28	501.56	37.6	45	N
REC-093	578575.67	4778618.52	525.75	36.7	45	N
REC-094	578514.65	4776677.36	519.65	37.9	45	N
REC-095	578804.05	4764274.93	501.37	32.8	45	N
REC-096	578827.98	4768793.31	520.74	37.4	45	N
REC-097	578943.49	4770454.51	519.65	29.0	45	N
REC-098	579475.34	4767289.07	507.32	40.3	45	N
REC-099	579720.64	4762441.83	480.38	-	45	N
REC-100	580720.17	4765706.10	489.18	32.2	45	N
REC-101	580991.94	4762540.89	476.98	-	45	N
REC-102	581560.41	4763175.20	470.14	-	45	N
REC-103	581721.12	4767420.32	484.05	35.9	45	N
REC-104	581794.35	4770381.50	494.21	30.1	45	N
REC-105	581890.50	4769063.10	495.27	40.1	45	N
REC-106	581882.94	4766984.50	478.66	32.1	45	N
REC-107	582089.90	4770568.08	488.75	27.9	45	N
REC-108	582148.44	4764102.27	470.89	-	45	N
REC-109	582609.65	4767582.94	483.08	31.6	45	N
REC-110	583963.39	4770430.23	460.42	18.2	45	N

Appendix C - Modeling Results

GE 3.8-137, 110 m

	Coordinates			Modeled		Exceed?
Receiver	***Easting (m)***	***Northing (m)***	***Base Elevation (m)***	***LAeq***	***Limit Value***	***(Y/N)***
REC-111	582577.80	4767332.36	480.99	30.7	45	N
REC-112	570034.28	4777428.88	531.85	33.7	45	N
REC-113	580225.65	4778670.25	516.61	41.3	45	N
REC-114	580643.69	4779065.86	510.51	40.5	45	N
REC-115	580812.98	4776797.89	507.54	39.5	45	N
REC-116	581676.22	4775653.66	495.49	37.4	45	N
REC-117	579367.75	4775404.23	525.75	36.8	45	N
REC-118	580095.28	4784336.60	507.46	25.3	45	N
REC-119	581867.73	4783246.46	489.52	29.7	45	N
REC-120	582410.57	4781467.20	486.13	30.9	45	N
REC-121	582256.16	4783054.99	483.20	28.4	45	N
REC-122	582261.38	4777793.15	487.45	33.8	45	N
REC-123	581460.71	4785645.95	483.97	-	45	N
REC-124	577505.30	4781336.06	557.16	19.3	45	N
REC-125	580995.88	4773976.31	501.99	29.4	45	N
REC-126	580915.69	4774830.29	502.29	38.6	45	N
REC-127	581473.61	4775075.61	495.27	37.0	45	N
REC-128	581468.21	4774997.26	495.27	36.4	45	N
REC-129	576815.58	4779814.18	556.23	21.4	45	N
REC-130	567502.00	4781060.00	502.37	-	45	N
REC-131	568850.00	4781446.00	523.04	-	45	N
REC-132	570408.00	4783811.00	527.44	-	45	N
REC-133	570806.00	4783497.00	538.25	-	45	N
REC-134	570845.00	4782153.00	543.29	-	45	N
REC-135	573665.00	4780153.00	564.37	-	45	N
REC-136	579049.00	4772150.00	519.65	-	45	N
REC-137	579104.00	4772978.00	519.65	17.9	45	N
REC-138	573105.45	4772224.12	513.56	37.1	45	N

"-" represents no expected impacts at the receiver location

Appendix C - Modeling Results

Vestas V136-3.6, 105 m

	Coordinates					
Receiver	*Easting (m)*	*Northing (m)*	*Base Elevation (m)*	*Modeled LAeq*	*Limit Value*	*Exceed? (Y/N)*
REC-001	583178.93	4781949.36	473.94	26.2	45	N
REC-002	578731.00	4782428.97	540.99	30.6	45	N
REC-003	580506.89	4783273.92	505.27	35.3	45	N
REC-004	582678.66	4780104.52	480.03	33.9	45	N
REC-005	583326.78	4778396.84	476.81	29.0	45	N
REC-006	583615.28	4778695.43	471.94	27.6	45	N
REC-007	579386.45	4783171.84	519.65	31.2	45	N
REC-008	579364.54	4780122.78	515.18	39.7	45	N
REC-009	582485.70	4779597.03	481.47	35.8	45	N
REC-010	570706.40	4779232.69	531.85	21.7	45	N
REC-011	568954.92	4779049.93	516.88	24.2	45	N
REC-012	575450.96	4778869.67	571.47	-	45	N
REC-013	570834.43	4777923.92	539.22	28.8	45	N
REC-014	578568.31	4777265.47	526.35	39.5	45	N
REC-015	578578.94	4777228.45	526.13	39.7	45	N
REC-016	569437.95	4774776.35	523.53	40.4	45	N
REC-017	567999.72	4773683.50	489.60	38.3	45	N
REC-018	575893.85	4773069.05	525.25	34.0	45	N
REC-019	568870.35	4772837.61	510.51	37.8	45	N
REC-020	568170.58	4772373.09	491.63	32.0	45	N
REC-021	574122.73	4771641.66	507.46	36.5	45	N
REC-022	574117.98	4771913.43	508.31	36.2	45	N
REC-023	567115.19	4771132.04	470.89	-	45	N
REC-024	569455.79	4770885.60	499.55	35.7	45	N
REC-025	582409.59	4770691.28	486.10	27.7	45	N
REC-026	582205.90	4770538.43	489.18	29.2	45	N
REC-027	569450.78	4770122.57	499.25	33.5	45	N
REC-028	578915.96	4770106.59	519.65	32.0	45	N
REC-029	567890.47	4769896.98	472.42	20.5	45	N
REC-030	574057.84	4769738.20	530.58	37.4	45	N
REC-031	571038.40	4769099.63	510.51	38.1	45	N
REC-032	579594.58	4768433.69	507.46	41.7	45	N
REC-033	574388.42	4768112.11	502.26	31.0	45	N
REC-034	575856.91	4767968.51	509.35	35.8	45	N
REC-035	568988.11	4768088.17	487.50	29.1	45	N
REC-036	574139.54	4767903.27	507.06	30.0	45	N
REC-037	580534.75	4767955.77	497.42	42.1	45	N
REC-038	569570.52	4767693.73	493.87	34.6	45	N
REC-039	575753.59	4767511.52	511.25	35.0	45	N
REC-040	575853.92	4767408.85	513.56	35.8	45	N
REC-041	577365.54	4767429.45	496.85	42.9	45	N
REC-042	580534.93	4768649.62	501.93	41.5	45	N
REC-043	582314.18	4767105.01	476.98	32.3	45	N
REC-044	577581.91	4766535.38	501.37	37.2	45	N
REC-045	580459.53	4766528.35	495.27	39.4	45	N
REC-046	570892.00	4766384.10	500.34	41.4	45	N
REC-047	576071.91	4766099.10	511.58	30.0	45	N
REC-048	575888.47	4765484.03	507.46	27.6	45	N
REC-049	579136.06	4765003.57	501.37	37.8	45	N
REC-050	575594.26	4764877.78	513.56	24.3	45	N
REC-051	577014.96	4764806.12	483.08	34.1	45	N
REC-052	571034.71	4764976.49	483.08	33.9	45	N
REC-053	575751.76	4763553.72	504.89	19.6	45	N
REC-054	579261.02	4763508.83	493.92	27.7	45	N
REC-055	575738.19	4763383.18	501.37	20.1	45	N

Appendix C - Modeling Results

Vestas V136-3.6, 105 m

	Coordinates					
Receiver	*Easting (m)*	*Northing (m)*	*Base Elevation (m)*	*Modeled LAeq*	*Limit Value*	*Exceed? (Y/N)*
REC-056	578784.40	4763423.45	495.27	28.2	45	N
REC-057	575728.70	4763020.56	496.19	-	45	N
REC-058	574689.98	4762905.51	489.18	-	45	N
REC-059	574608.88	4762765.31	484.23	-	45	N
REC-060	575719.36	4763758.78	507.46	21.1	45	N
REC-061	566590.17	4774005.26	470.89	26.9	45	N
REC-062	566794.52	4771446.01	467.84	-	45	N
REC-063	567575.59	4773523.26	480.49	33.6	45	N
REC-064	568169.85	4775221.75	493.83	39.0	45	N
REC-065	568402.45	4770548.21	483.08	26.2	45	N
REC-066	569474.73	4776605.15	525.75	40.5	45	N
REC-067	569782.41	4765373.88	493.98	37.5	45	N
REC-068	570301.18	4776152.11	533.82	37.4	45	N
REC-069	570320.63	4776086.07	530.62	37.5	45	N
REC-070	570930.65	4767169.47	502.79	39.2	45	N
REC-071	571246.87	4765598.42	488.81	40.0	45	N
REC-072	571847.73	4767001.23	507.46	43.2	45	N
REC-073	572712.41	4764371.30	476.98	26.7	45	N
REC-074	572760.45	4768609.65	494.96	36.8	45	N
REC-075	572875.14	4775183.93	528.80	40.6	45	N
REC-076	573023.77	4775137.74	528.80	41.1	45	N
REC-077	573104.39	4767558.79	488.61	32.6	45	N
REC-078	572689.83	4764269.58	472.84	26.2	45	N
REC-079	572840.24	4766532.05	483.08	37.3	45	N
REC-080	574527.24	4771635.20	508.86	35.6	45	N
REC-081	574606.23	4772084.46	513.56	35.5	45	N
REC-082	575265.41	4775117.32	552.59	43.3	45	N
REC-083	575384.42	4771695.61	513.56	33.8	45	N
REC-084	575459.57	4773771.95	533.47	40.7	45	N
REC-085	576210.31	4770611.18	524.57	39.6	45	N
REC-086	576537.52	4765598.06	498.89	31.7	45	N
REC-087	576971.43	4770447.24	531.85	42.3	45	N
REC-088	577659.69	4765661.22	489.18	39.6	45	N
REC-089	577747.37	4768859.92	513.80	42.0	45	N
REC-090	577878.24	4764078.53	490.80	34.3	45	N
REC-091	577915.85	4763844.06	489.18	32.0	45	N
REC-092	578531.67	4767119.28	501.56	39.1	45	N
REC-093	578575.67	4778618.52	525.75	38.2	45	N
REC-094	578514.65	4776677.36	519.65	39.4	45	N
REC-095	578804.05	4764274.93	501.37	34.3	45	N
REC-096	578827.98	4768793.31	520.74	38.9	45	N
REC-097	578943.49	4770454.51	519.65	30.5	45	N
REC-098	579475.34	4767289.07	507.32	41.8	45	N
REC-099	579720.64	4762441.83	480.38	-	45	N
REC-100	580720.17	4765706.10	489.18	33.7	45	N
REC-101	580991.94	4762540.89	476.98	-	45	N
REC-102	581560.41	4763175.20	470.14	-	45	N
REC-103	581721.12	4767420.32	484.05	37.4	45	N
REC-104	581794.35	4770381.50	494.21	31.6	45	N
REC-105	581890.50	4769063.10	495.27	41.6	45	N
REC-106	581882.94	4766984.50	478.66	33.6	45	N
REC-107	582089.90	4770568.08	488.75	29.4	45	N
REC-108	582148.44	4764102.27	470.89	-	45	N
REC-109	582609.65	4767582.94	483.08	33.1	45	N
REC-110	583963.39	4770430.23	460.42	19.6	45	N

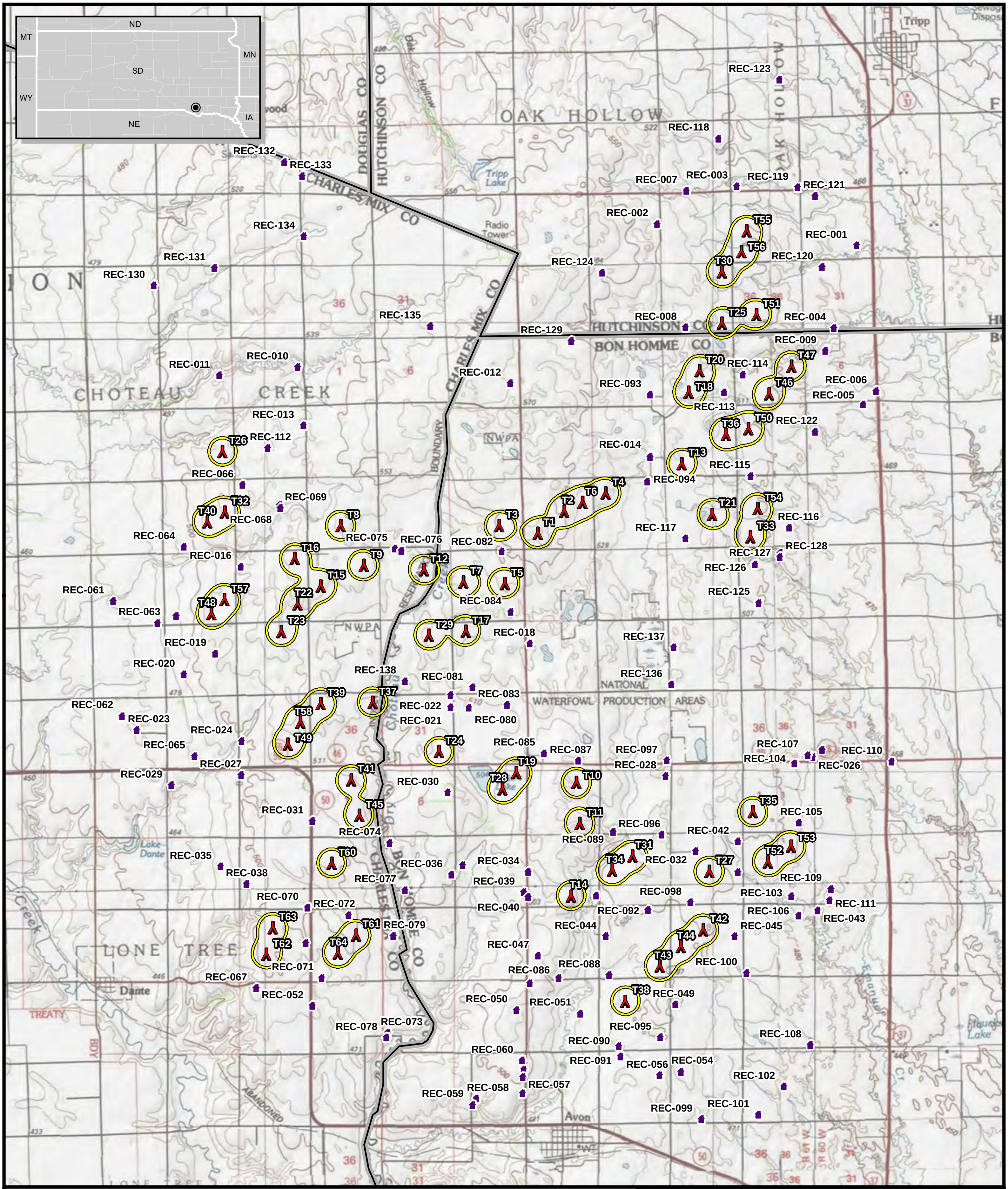
Appendix C - Modeling Results

Vestas V136-3.6, 105 m

Receiver	Coordinates Easting (m)	Northing (m)	Base Elevation (m)	Modeled LAeq	Limit Value	Exceed? (Y/N)
REC-111	582577.80	4767332.36	480.99	32.2	45	N
REC-112	570034.28	4777428.88	531.85	35.2	45	N
REC-113	580225.65	4778670.25	516.61	42.8	45	N
REC-114	580643.69	4779065.86	510.51	42.0	45	N
REC-115	580812.98	4776797.89	507.54	41.0	45	N
REC-116	581676.22	4775653.66	495.49	38.9	45	N
REC-117	579367.75	4775404.23	525.75	38.3	45	N
REC-118	580095.28	4784336.60	507.46	26.7	45	N
REC-119	581867.73	4783246.46	489.52	31.2	45	N
REC-120	582410.57	4781467.20	486.13	32.4	45	N
REC-121	582256.16	4783054.99	483.20	29.9	45	N
REC-122	582261.38	4777793.15	487.45	35.3	45	N
REC-123	581460.71	4785645.95	483.97	-	45	N
REC-124	577505.30	4781336.06	557.16	20.8	45	N
REC-125	580995.88	4773976.31	501.99	30.9	45	N
REC-126	580915.69	4774830.29	502.29	40.0	45	N
REC-127	581473.61	4775075.61	495.27	38.5	45	N
REC-128	581468.21	4774997.26	495.27	37.9	45	N
REC-129	576815.58	4779814.18	556.23	22.8	45	N
REC-130	567502.00	4781060.00	502.37	-	45	N
REC-131	568850.00	4781446.00	523.04	-	45	N
REC-132	570408.00	4783811.00	527.44	-	45	N
REC-133	570806.00	4783497.00	538.25	-	45	N
REC-134	570845.00	4782153.00	543.29	-	45	N
REC-135	573665.00	4780153.00	564.37	-	45	N
REC-136	579049.00	4772150.00	519.65	-	45	N
REC-137	579104.00	4772978.00	519.65	19.3	45	N
REC-138	573105.45	4772224.12	513.56	38.6	45	N

"-" represents no expected impacts at the receiver location

APPENDIX D - SOUND LEVEL CONTOURS



LEGEND

- County Boundary
- Wind Turbine
- Receptor
- 45 dBA Limit, GE 3.8-137

REFERENCE

0 1 2
MILES

0 1 2
KILOMETERS

N

PREVAILING WIND PARK
45 dBA Contours - GE 3.8-137 Layout

LOCATION:	Charles Mix/Bonne Homme/Hutchinson Cty, SD
CLIENT:	Prevailing Wind Park, LLC
PROJ. NO.:	105644
CREATED:	04/26/2018

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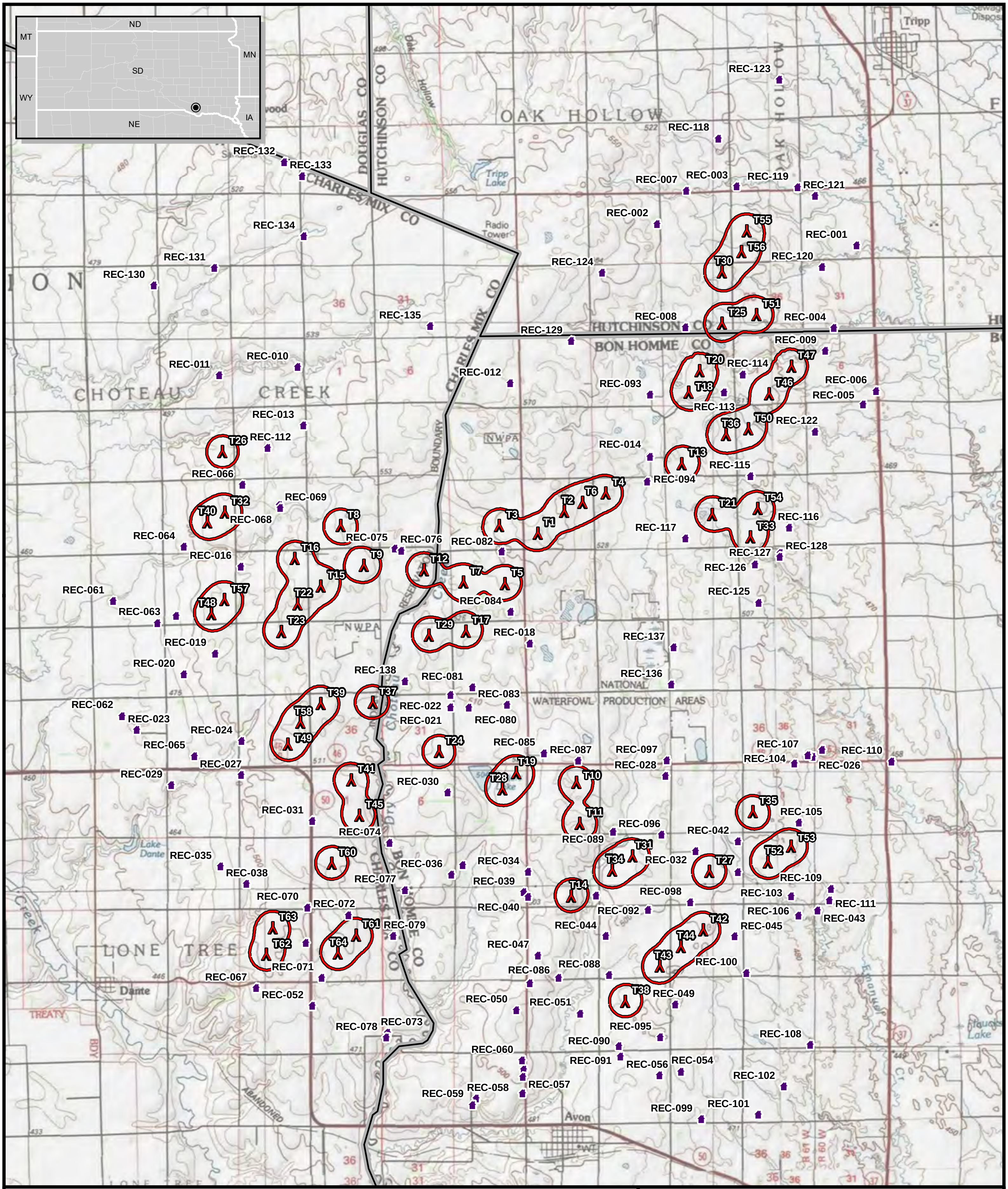
Path: \\bmcd\dfs\Clients\BTS\SPowerDC\105644_PrvWindStudies\Studies\Geospatial\DataFiles\ArcDocs\105644_PrevailingWinds_85x11P.mxd • Coordinate System: NAD 1983 UTM Zone 14N • Units: Meter



Path: \\bmcd\dfs\Clients\BTS\SPowerDC\105644_PrvWindStudies\Studies\Geospatial\DataFiles\ArcDocs\105644_PrevailingWinds_85x11P.mxd • Coordinate System: NAD 1983 UTM Zone 14N • Units: Meter

LEGEND

▭	County Boundary
⅄	Wind Turbine
●	Receptor
—	45 dBA Limit, Vestas V136-3.6

REFERENCE

0 1 2
MILES

0 1 2
KILOMETERS

N

PREVAILING WIND PARK
45 dBA Contours - Vestas V136-3.6 Layout

LOCATION: Charles Mix/Bonne Homme/Hutchinson Cty, SD
CLIENT: Prevailing Wind Park, LLC
PROJ. NO.: 105644
CREATED: 04/26/2018

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Shadow Flicker Analysis

Prevailing Wind Park, LLC

Prevailing Wind Park
Project No. 105644

Revision 5c
05/29/2018

Shadow Flicker Analysis

prepared for

Prevailing Wind Park, LLC
Prevailing Wind Park
Bon Homme/Charles Mix/Hutchinson Counties, SD

Project No. 105644

Revision 5c
05/29/2018

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page No.

LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
Developer	Prevailing Wind Park, LLC
GE	General Electric
kg/m^3	Kilograms per cubic meter
m/s	Meters per second
MW	Megawatt
Project	Prevailing Wind Park
Project Site	Location of Prevailing Wind Park in South Dakota
Study	Shadow Flicker Analysis

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REVISION HISTORY

Rev	Issue Date	Release Notes
0	03-Apr-2018	Original release
1	09-Apr-2018	Revised wind turbine layout, incorporated client comments
2	11-Apr-2018	Added REC-138
3	16-Apr-2018	Revised wind turbine layout
4	27-Apr-2018	Revised wind turbine layout
5	25-May-2018	Included obstacles at select locations; added participant status to receptors
5a	27-May-2018	Revised Table 3-1, added Table 3-2
5b	28-May-2018	Incorporated client comments
5c	29-May-2018	Incorporated client comments

1.0 INTRODUCTION

1.1 Study Overview

Burns & McDonnell Engineering Company, Inc. ("Burns & McDonnell") was retained by Prevailing Wind Park, LLC ("Developer") to conduct a shadow flicker analysis (the "Study") for the proposed Prevailing Wind Park (the "Project"). The objective of the Study was to estimate the annual frequency of shadow flicker on occupied residences caused by Project wind turbines. No attempt was made in this Study to examine or opine on health effects related to shadow flicker.

1.2 Project Overview

The proposed Prevailing Wind Park will be located in Bon Homme, Charles Mix, and Hutchinson Counties in South Dakota, approximately 10 miles east of the town of Wagner and approximately 75 miles southwest of the city of Sioux Falls, South Dakota (the "Project Site"). The Project will consist of 57 to 61 wind turbines with a maximum nameplate capacity of up to 219.6 megawatts ("MW"), although output at the point of interconnection will be limited to a maximum of 200 MW. A final turbine model had not been selected by Developer at the time of this report, so the following General Electric ("GE") and Vestas turbine models were considered as part of this Study:

- GE 3.8-137 with a 110-meter hub height
- Vestas V136-3.6 with a 105-meter hub height

A map showing the general location and configuration of the Project Site is included as Appendix A. For purposes of this Study, each turbine model noted above was evaluated at each potential turbine location shown in Appendix A (i.e., only one turbine configuration is being proposed, but the GE 3.8-137 turbines were evaluated at each potential turbine location and the Vestas V136-3.6 turbines were separately evaluated at each potential turbine location; all turbine coordinates in the proposed configuration are the same for each turbine model). A total of 63 turbine positions were evaluated, although only 57 to 61 turbines are expected to be installed.

1.3 Shadow Flicker Overview

Shadow flicker occurs when wind turbine blades pass in front of the sun to create recurring shadows on an object. Such shadows occur only under very specific conditions, including sun position, wind direction, time of day, and other similar factors.

The intensity of shadow flicker varies significantly with distance, and as separation between a turbine and receptor increases, shadow flicker intensity correspondingly diminishes. Shadow flicker intensity for distances greater than 10 rotor diameters (i.e., 1370 meters for the GE 3.8-137 layout and 1360 meters for the V136-3.6 layout) is generally low and considered imperceptible. At such distances, shadow flicker is typically only caused at sunrise or sunset, when cast shadows are sufficiently long.

Shadow flicker impacts are not currently regulated in applicable state or federal law, nor are there requirements in the current Charles Mix County (SD) or Hutchinson County (SD) ordinances. Section 1741 of the Bon Homme County (SD) zoning ordinance states the following:

> *When determined appropriate by the County, a Shadow Flicker Control System shall be installed upon all turbines which will cause a perceived shadow effect upon a habitable residential dwelling. Such system shall limit blade rotation at those times when shadow flicker exceeds thirty (30) minutes per day or thirty (30) hours per year at perceivable shadow flicker intensity as confirmed by the Zoning Administrator are probable.*

Thus, although the Project turbines fall within all three counties (Bon Homme, Charles Mix, and Hutchinson), the existing Bon Homme County requirements of 30 hours per year and 30 minutes per day were used as a baseline for this Study.

1.4 Site Visit

Burns & McDonnell did not visit the Project Site as part of this Study. The contents of this evaluation are based exclusively upon desktop analysis by Burns & McDonnell.

2.0 MODELING PARAMETERS AND INPUTS

2.1 Modeling Overview

Shadow flicker was modeled at the Project Site using WindPRO, an industry-leading software package for the design and planning of wind energy projects. This package models the sun's path with respect to every turbine location during every minute over a complete year. Any shadow flicker caused by each turbine is then aggregated for each receptor for the entire year.

The following sections are summaries of the inputs utilized in the WindPRO model for this Study.

2.2 Turbine Coordinates

Shadow flicker intensity is partially dependent upon the distance from a receptor to the turbine causing the shadow. The Developer-provided coordinates of each turbine are presented in Appendix B, and the location of each turbine is presented graphically in Appendix A. For purposes of this Study, each turbine model was evaluated at each potential turbine location shown in Appendix A (i.e., only one turbine configuration is being proposed, but the GE 3.8-137 turbines were evaluated at each potential turbine location and the Vestas V136-3.6 turbines were separately evaluated at each potential turbine location; all turbine coordinates in the proposed configuration are the same for each turbine model). A total of 63 turbine positions were evaluated, although only 57 to 61 turbines are expected to be installed.

2.3 Turbine Dimensions

The size of a wind turbine, including both hub height and rotor diameter, contributes to the length and width of the shadows that may be cast by that turbine. The GE 3.8-137 wind turbine generators were each modeled with a rotor diameter of 137 meters and a hub height of 110 meters. The Vestas V136-3.6 wind turbine generators were each modeled with a rotor diameter of 136 meters and a hub height of 105 meters.

2.4 Receptors

A quantity of 138 residences were modeled at the Project Site. The Developer-provided coordinates of each receptor are presented in Appendix B and the location of each receptor is presented graphically in Appendix A. Burns & McDonnell did not provide an independent verification of whether these receptors were occupied, although the physical location of each receptor was verified by Burns & McDonnell using publicly-available aerial imagery.

Each receptor was modeled in "green house" mode within the WindPRO model. This approach provides a conservative estimate of the amount of time when shadow flicker could occur by modeling each receptor as having windows on all sides and effectively causing the home to be susceptible to flicker effects in all directions.

2.5 Terrain

The WindPRO model utilizes topography data to place turbines and receptors at the proper elevations. This information is also used by the model to consider any natural land features between a turbine and a receptor that may block shadows from being seen at a receptor.

Publicly-available terrain data was downloaded from the National Elevation Dataset, a product of the United States Geological Survey. The 10-meter resolution digital elevation model DEM was exported at 10-foot intervals for use in the WindPRO model. Elevations were assigned by Burns & McDonnell to each turbine and each receptor using this data.

2.6 Obstacles

Obstacles located between a receptor and a turbine, such as trees or buildings, may significantly reduce or eliminate the duration and/or intensity of shadow flicker. Burns & McDonnell included obstacles in the WindPRO model, including trees and outbuildings, for only those receptors that exceeded the maximum number of flicker hours per year and/or minutes per day. Such receptors are indicated by an asterisk (*) in Appendix B and Appendix F, respectively. No obstacles were considered or modeled for any other receptors.

WindPRO models obstacles utilizing a cubic volume, where each obstacle is assigned a height, width, depth, and porosity level. The obstacles near the applicable receptors were reviewed by Burns & McDonnell and the type and characteristics of each obstacle were visually estimated using publicly-available desktop aerial imagery. Trees and groups of trees were assumed to be 12 meters tall, barns and other outbuildings were assumed to be 4 meters tall, and grain bins were assumed to be 6 meters tall. Only obstacles in reasonable close proximity to a receptor were considered (i.e., those that might be expected to influence flicker durations).

Burns & McDonnell did not make any in-person verifications regarding the existence, size, or influence of obstacles. The obstacles were modeled exclusively through desktop analysis of aerial imagery.

2.7 Turbine Operation

Shadow flicker is contingent upon the movement of the turbine blades. Shadow flicker can only occur when the turbine is in operation (i.e., when the turbine blades are rotating). Moreover, shadow flicker is generally most notable when a turbine is facing a receptor, as this results in the widest-possible shadow being cast. To more accurately reflect the periods of operation of each Project wind turbine, on-site hub-height wind data was provided by Developer and used to indicate the periods when the turbines are inactive due to wind speeds below the turbine cut-in speed or above the turbine cut-out speed, at which time the turbine rotor is not in motion and no shadow flicker will occur.

Project Site-specific wind data was also utilized to model the actual orientation of the turbines relative to each receptor. The Developer-provided wind data includes data collected by an on-site meteorological mast between July 2009 and January 2018. The provided data is shown in Appendix C.

Power curves for the proposed turbines were provided by Developer. These power curves were added to the WindPRO model to more accurately reflect the turbine's operational characteristics. The Developer-provided power curves are shown in Appendix E.

2.8 Flicker Relevance

At distances beyond 10 rotor diameters, shadow flicker effects are generally considered low, as shadows diffuse and become imperceptible. Thus, a distance equal to 10 times the rotor diameter of each turbine (i.e., 1370 meters for the GE 3.8-137 layout and 1360 meters for the V136-3.6 layout) was modeled as the maximum distance at which shadow flicker was considered relevant; receptors greater than this distance from a given turbine were not evaluated. The proximity of this buffer relative to each receptor is presented graphically in Appendix A.

2.9 Sun Angle

The sun's path with respect to each turbine location is calculated by the WindPRO model to determine the cast shadow paths during every minute over a complete year. However, at very low sun angles, the light must pass through more atmosphere and becomes too diffused to form a coherent shadow. Thus, a value of three (3) degrees was utilized for the height at which the sun would not cause noticeable flicker.

2.10 Sun Obstruction

The percentage of the turbine blade covering the sun disc is calculated by the WindPRO model to determine the size of shadow cast during every minute over a complete year. By default, the WindPRO model calculates shadow flicker only when at least 20 percent of the sun disc is covered by the turbine blades. When less than 20 percent of the sun disc is masked by the blades, the shadow will be too diffuse to cause a coherent shadow.

2.11 Environment

Shadow flicker is only caused when the sun is shining. Sunshine probability data (see Appendix D) was obtained by Burns & McDonnell from www.city-data.com. This data represents the percentage of hours each month that the sun is expected to be shining during daylight hours, with consideration given for cloud cover, rainy days, fog, or other similar occurrences that may diminish the potential occurrence or severity of shadow flicker.

3.0 RESULTS

Using the inputs and parameters defined in Section 2.0, the WindPRO model was used to calculate shadow flicker for the receptors at the Project Site. Table 3-1 presents a summary of these results for the GE 3.8-137 layout and Table 3-2 presents a summary of these results for the V136-3.6 layout; results in each table are presented by landowner status for the applicable receptor. Detailed tables are included within Appendix F that present shadow flicker durations by receptor, including estimated hours per year and maximum minutes per day. Additionally, maps are provided in Appendix G which illustrate the shadow flicker vectors (in hours per year) caused by each Project turbine.

Table 3-1: Summary of Results, GE 3.8-137 Layout

Landowner Status	No. of Turbines	No. of Receptors	No. of Receptors, Flicker ≥ 30 hr/yr	No. of Receptors, Flicker ≥ 30 min/day
Participating	63	46	2	12
Non-participating		92	1	13

Table 3-2: Summary of Results, Vestas V136-3.6 Layout

Landowner Status	No. of Turbines	No. of Receptors	No. of Receptors, Flicker ≥ 30 hr/yr	No. of Receptors, Flicker ≥ 30 min/day
Participating	63	46	2	11
Non-participating		92	1	12

The following is a set of key observations from the results of the Study:

- Using the GE 3.8-137 layout, 3 of the 138 known receptors exceed 30 hours per year of shadow flicker. Additionally, 25 of the 138 known receptors exceed 30 minutes per day of shadow flicker using the GE 3.8-137 layout, although approximately one quarter (7 of 25) exceed this daily threshold by only 5 or fewer minutes and more than half (13 of 25) exceed this daily threshold by only 10 or fewer minutes. Refer to Table F-1 in Appendix F for a complete listing of results.
- Using the V136-3.6 layout, 3 of the 138 known receptors exceed 30 hours per year of shadow flicker. Additionally, 23 of the 138 known receptors exceed 30 minutes per day of shadow flicker using the V136-3.6 layout, although approximately one quarter (6 of 23) exceed this daily threshold by only 5 or fewer minutes and more than half (13 of 23) exceed this daily threshold by only 10 or fewer minutes. Refer to Table F-2 in Appendix F for a complete listing of results.
- The majority of observed shadow flicker on each receptor occurs during early morning and/or late afternoon and evening hours (see Appendix H).

- A total of 63 turbine positions were evaluated, although Burns & McDonnell understands that only 57 to 61 turbines are expected to be installed. Depending on the 2 to 6 alternate turbine locations that are eliminated, flicker durations at impacted receptors are likely to decrease from those presented herein.
- The Study was performed using a conservative modeling approach with Project Site-specific conditions. For example, the Study modeled each receptor as a "green house", meaning each receptor was modeled as having windows on all sides and effectively causing the home to be susceptible to flicker effects in all directions. Further, the majority of the receptor locations were modeled as if no obstacles were present, including trees or buildings, which may significantly reduce or eliminate the duration and/or intensity of shadow flicker at a receptor. Due to the conservative approach of the Study, the actual duration and intensity of shadow flicker experienced at each receptor is expected to be less than those reported in the Study.
- Notwithstanding any shadow flicker which may occur at the Project Site, mitigation techniques may be utilized to reduce these effects. Common techniques include planting vegetation, awning installation, reduced turbine operation, and/or adjustments to the turbine layout.

At receptor locations where obstacles were considered, several receptors continued to indicate potential shadow flicker impacts over 30 hours per year and/or 30 minutes per day. The following is an overview of the shadow flicker characteristics at each of those receptors where obstacles were considered.

- REC-008 is receiving shadow flicker from T25 to the east. While there are a few buildings in the vicinity, the area to the east is largely exposed to this source. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-009 is receiving shadow flicker from T47 to the southwest. The area to the west-southwest is generally exposed, with insufficient geometry to fully mitigate shadow flicker. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-014 is receiving shadow flicker from T13 to the southeast. While obstacles exist to the east of the receptor it is largely exposed to shadow flicker to the southeast. Thus, a reduction in flicker duration of approximately 5 hours/year was observed when considering obstacles at this receptor.
- REC-015 is receiving shadow flicker from T13 to the southeast. This receptor is largely exposed to shadow flicker to the east and southeast. Thus, a reduction in flicker duration of approximately 7 hours/year was observed when considering obstacles at this receptor.
- REC-017 is receiving shadow flicker from T48 to the east and T57 to the northeast. Some trees and buildings reduce shadow impact, but the greatest exposure to shadow flicker is from the east

where the receptor is partially exposed. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.

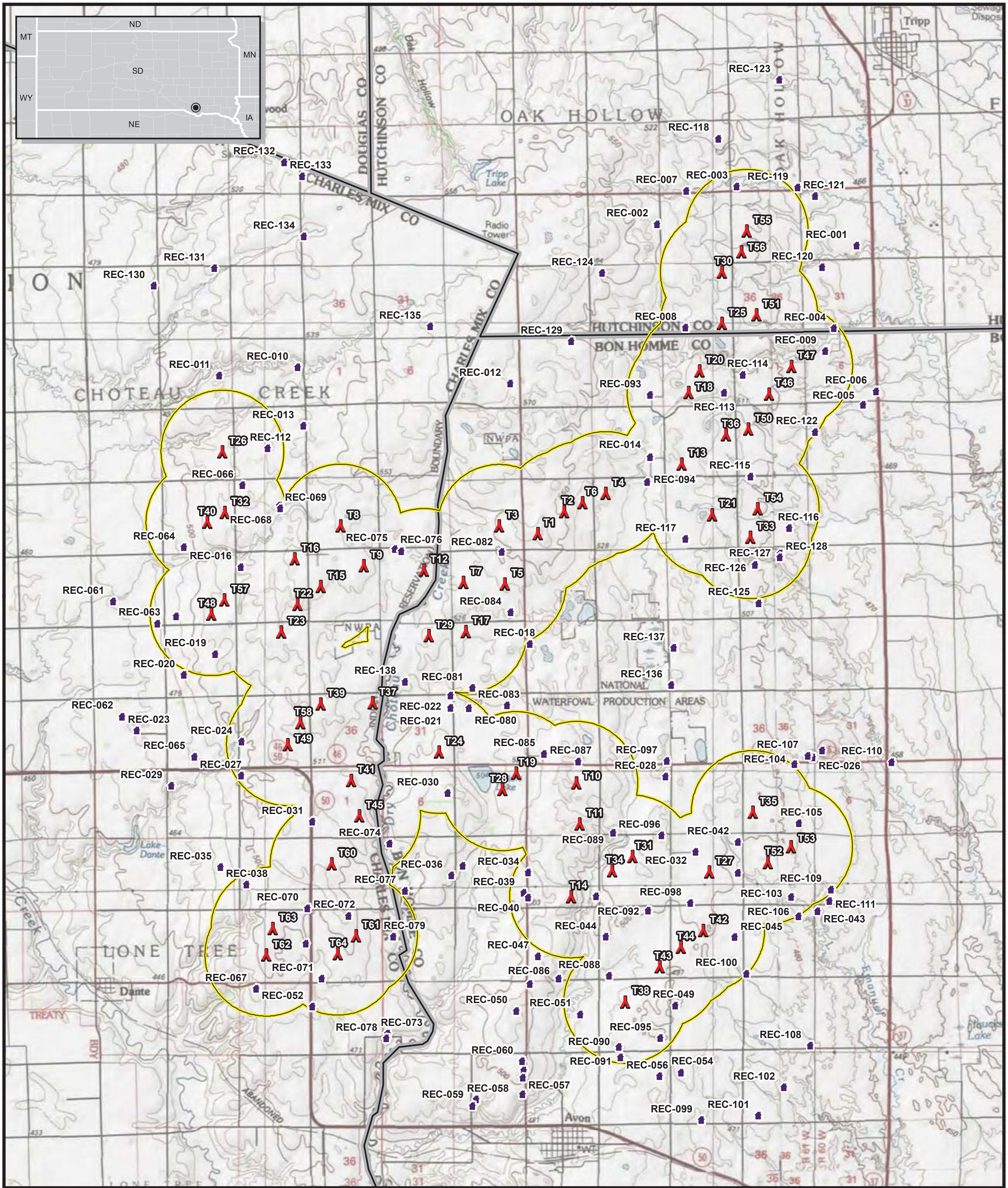
- REC-024 is receiving shadow flicker from T49 to the east. The receptor is largely exposed to the south and partially to the southeast. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-031 receiving shadow flicker from T45 to the east. The receptor is largely exposed to the east. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-032 is receiving shadow flicker from T27 to the southeast. Some buildings to the south reduce flicker, however the receptor is largely exposed to the south. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-040 is receiving shadow flicker from T14 to the east. Some obstacles are in line of flicker impact, but the area to the east-southeast is largely exposed. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-041 is receiving shadow flicker from T14 to the west. While several obstacles are within close proximity to this receptor, there is direct exposure to the west. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-042 is receiving shadow flicker from T27 to the southwest, from T52 to the southeast, and from T53 to the east-southeast. This receptor has several obstacles nearby to the north but is largely exposed to the east, west, and south. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-045 exceeded the limits of maximum minutes per day in the GE layout only. This receptor is receiving shadow flicker from T42 to the west-northwest. While several obstacles are in the vicinity, the geometry of the obstacles is insufficient to fully reduce flicker impact to the GE layout. Thus, a reduction in flicker duration of approximately 3 hours/year was observed when considering obstacles at this receptor.
- REC-046 exceeded shadow flicker duration for both maximum hours per year and maximum minutes per day. This receptor is receiving shadow flicker from T61 and T64 to the east and from T62 and T63 to the west. Several obstacles are in the vicinity; however, the receptor is largely exposed to the south and east. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-051 is receiving shadow flicker from T38 to the northeast. This receptor is largely exposed to the east. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.

- REC-070 is receiving shadow flicker form T63 to the southwest. While some obstacles are in the vicinity, the geometry is insufficient to fully reduce flicker impacts to the west and southwest. Thus, a reduction in flicker duration of approximately 5.5 hours/year and 24 minutes/day was observed when considering obstacles at this receptor.
- REC-075 is receiving shadow flicker from T12 to the southeast. While there are several obstacles in the vicinity, the receptor is largely exposed to the southeast. Thus, a reduction in flicker duration of approximately 22 hours/year and 23 minutes/day was observed when considering obstacles at this receptor.
- REC-076 exceeded shadow flicker duration for both maximum hours per year and maximum minutes per day. This receptor is receiving shadow flicker from T12 to the southeast and T9 to the southwest and is largely exposed to the east and south, with some exposure to the west. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-082 is receiving shadow from T7 to the southwest. This receptor has several obstacles in the vicinity but is partially exposed to the southwest. Thus, a reduction in flicker duration of approximately 12 hours/year and 6 minutes/day was observed when considering obstacles at this receptor.
- REC-089 is receiving shadow flicker from T11 to the northwest and T31 to the southeast. While there are several obstacles in the vicinity, the geometry is insufficient to fully mitigate shadow flicker impacts. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-093 is receiving shadow flicker from T18 to the east and T20 to the northeast. This receptor is largely exposed to the east and south. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-094 is receiving shadow flicker from T4 to the southwest and T13 to the northeast. While there are some obstacles in the vicinity, there remains sparse coverage to the east, south, and southeast. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.
- REC-096 is receiving shadow flicker from T27 to the southeast, and T31 and T34 to the southwest. Several obstacles are in the vicinity, but there remains some exposure to the east and southeast. Thus, a reduction in flicker duration of approximately 6 hours/year and 11 minutes/day was observed only in the Vestas layout when considering obstacles at this receptor.
- REC-112 exceeded the limits of maximum minutes per day in the GE layout only. This receptor is receiving shadow flicker from T26 to the east where there are some obstacles present; however,

the geometry is insufficient to fully mitigate shadow flicker impact. Thus, no reduction in flicker duration was observed when considering obstacles at this receptor.

- REC-113 is receiving shadow flicker from T46 to the east. This receptor is largely exposed to the east and south. Thus, a reduction in flicker duration of approximately 10 hours/year and 32 minutes/day was observed when considering obstacles at this receptor.
- REC 114 exceeded shadow flicker duration for both maximum hours per year and maximum minutes per day. This receptor is receiving shadow flicker from T18 to the southwest, T46 to the southeast, and T47 to the east-northeast and is largely exposed to the east, with some exposure to the west and partial exposure to the south. Thus, a reduction in flicker duration of approximately 8 hours/year and 10 minutes/day was observed when considering obstacles at this receptor.

APPENDIX A - PROJECT SITE LAYOUT



Path: \\bmcd\dfs\Clients\BTS\SPowerDC\105644_PrvWindStudies\Studies\Geospatial\DataFiles\ArcDocs\105644_PrevailingWinds_85x11P.mxd • Coordinate System: NAD 1983 UTM Zone 14N • Units: Meter

LEGEND

▭	County Boundary
⅄	Wind Turbine
●	Receptor
▭	Wind Turbine Buffer (1370m)

REFERENCE

0 1 2
MILES

0 1 2
KILOMETERS

N

PREVAILING WIND PARK
Project Site Layout - GE 3.8-137 Flicker Buffer

LOCATION: Charles Mix/Bonne Homme/Hutchinson Cty, SD
CLIENT: Prevailing Wind Park, LLC
PROJ. NO.: 105644
CREATED: 04/25/2018

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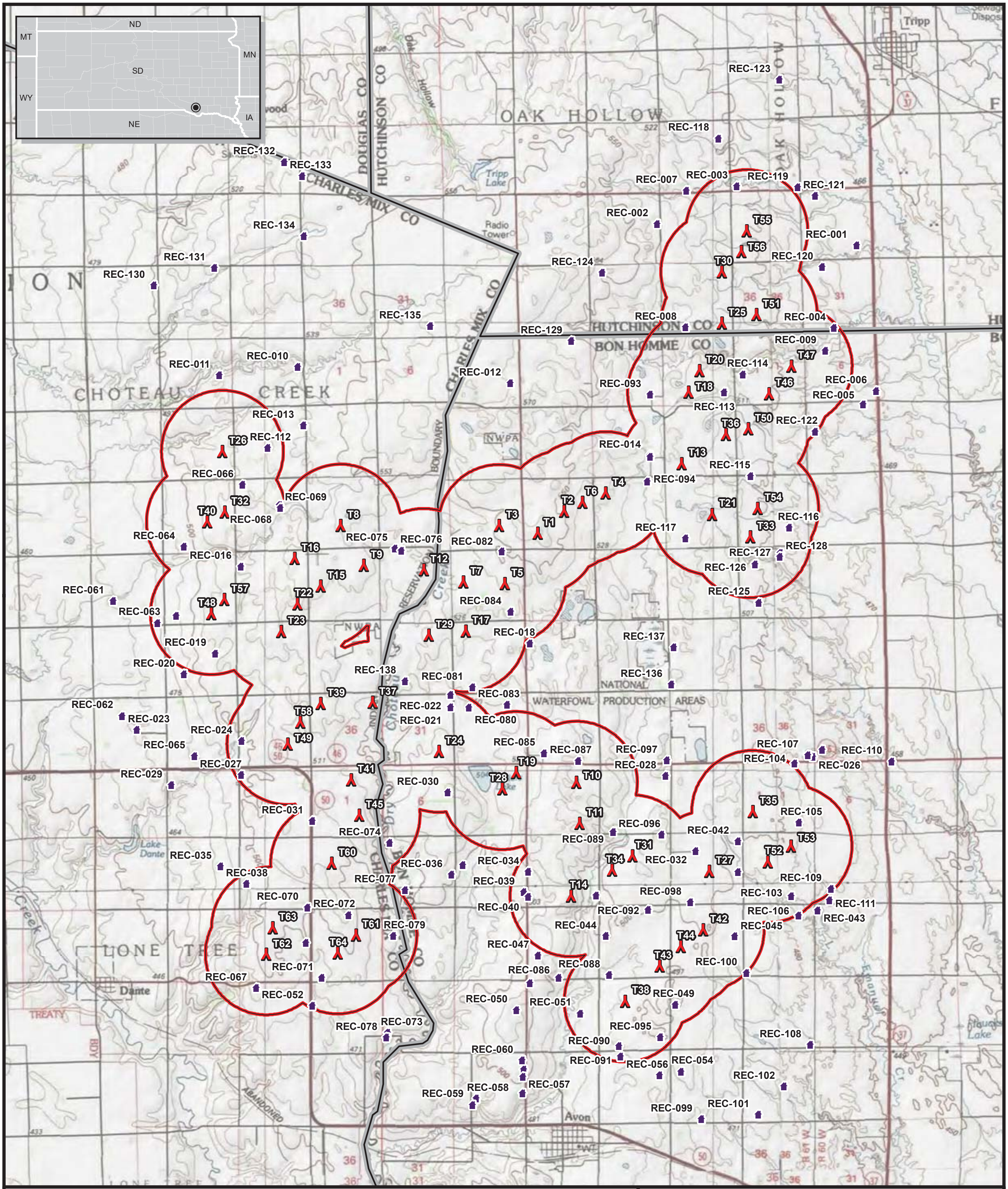

LEGEND

▭ County Boundary

⅄ Wind Turbine

● Receptor

▭ Wind Turbine Buffer (1360m)

REFERENCE

0 1 2
MILES

0 1 2
KILOMETERS

N

PREVAILING WIND PARK

Project Site Layout - Vestas V136-3.6 Flicker Buffer

LOCATION: Charles Mix/Bonne Homme/Hutchinson Cty, SD

CLIENT: Prevailing Wind Park, LLC

PROJ. NO.: 105644

CREATED: 04/25/2018

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Path: \\bmcd\dfs\Clients\BTS\SPowerDC\105644_PrvWindStudies\Studies\Geospatial\DataFiles\ArcDocs\105644_PrevailingWinds_85x11P.mxd • Coordinate System: NAD 1983 UTM Zone 14N • Units: Meter

APPENDIX B - INFRASTRUCTURE COORDINATES

Table B-1: Turbine Coordinates

Turbine Number	Easting [m]	Northing [m]
T1	576,064	4,775,521
T2	576,650	4,776,014
T3	575,201	4,775,693
T4	577,580	4,776,426
T5	575,324	4,774,400
T6	577,060	4,776,210
T7	574,404	4,774,436
T8	571,662	4,775,700
T9	572,180	4,774,804
T10	576,925	4,769,963
T11	576,997	4,769,043
T12	573,519	4,774,712
T13	579,275	4,777,080
T14	576,805	4,767,428
T15	571,219	4,774,346
T16	570,639	4,774,958
T17	574,452	4,773,337
T18	579,428	4,778,668
T19	575,579	4,770,180
T20	579,671	4,779,153
T21	579,956	4,775,946
T22	570,700	4,773,949
T23	570,336	4,773,327
T24	573,856	4,770,651
T25	580,170	4,780,211
T26	569,026	4,777,349
T27	579,886	4,767,974
T28	575,275	4,769,819
T29	573,634	4,773,249
T30	580,170	4,781,359
T31	578,173	4,768,318
T32	569,074	4,775,995
T33	580,807	4,775,442
T34	577,718	4,768,001
T35	580,860	4,769,311

Turbine Number	Easting [m]	Northing [m]
T36	580,259	4,777,725
T37	572,381	4,771,753
T38	578,014	4,765,078
T39	571,220	4,771,720
T40	568,691	4,775,777
T41	571,896	4,770,015
T42	579,755	4,766,668
T43	578,787	4,765,862
T44	579,255	4,766,296
T45	572,076	4,769,232
T46	581,221	4,778,640
T47	581,719	4,779,256
T48	568,780	4,773,724
T49	570,487	4,770,821
T50	580,759	4,777,856
T51	580,939	4,780,407
T52	581,200	4,768,190
T53	581,715	4,768,536
T54	580,970	4,776,074
T55	580,727	4,782,274
T56	580,604	4,781,811
T57	569,071	4,774,046
T58	570,763	4,771,308
T59	Not used	
T60	571,464	4,768,160
T61	572,005	4,766,554
T62	570,006	4,766,129
T63	570,143	4,766,716
T64	571,597	4,766,151

Notes:

[1] All coordinates presented in UTM NAD83 Zone 14N (meters)

[2] All coordinates provided by Developer in “PW_64x_Turbine_Locations_v180412_02.kmz”

[3] All coordinates apply to each turbine model studied

Table B-2: Receptor Coordinates

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status
REC-001	583,179	4,781,949	Hutchinson	Non-participating
REC-002	578,731	4,782,429	Hutchinson	Participating
REC-003	580,507	4,783,274	Hutchinson	Non-participating
REC-004	582,679	4,780,105	Hutchinson	Non-participating
REC-005	583,327	4,778,397	Bon Homme	Non-participating
REC-006	583,615	4,778,695	Bon Homme	Non-participating
REC-007	579,386	4,783,172	Hutchinson	Non-participating
REC-008*	579,365	4,780,123	Hutchinson	Non-participating
REC-009*	582,486	4,779,597	Bon Homme	Non-participating
REC-010	570,706	4,779,233	Charles Mix	Non-participating
REC-011	568,955	4,779,050	Charles Mix	Non-participating
REC-012	575,451	4,778,870	Bon Homme	Non-participating
REC-013	570,834	4,777,924	Charles Mix	Non-participating
REC-014*	578,568	4,777,265	Bon Homme	Non-participating
REC-015*	578,579	4,777,228	Bon Homme	Non-participating
REC-016	569,438	4,774,776	Charles Mix	Participating
REC-017*	568,000	4,773,684	Charles Mix	Non-participating
REC-018	575,894	4,773,069	Bon Homme	Participating
REC-019	568,870	4,772,838	Charles Mix	Participating
REC-020	568,171	4,772,373	Charles Mix	Non-participating
REC-021	574,123	4,771,642	Bon Homme	Participating
REC-022	574,118	4,771,913	Bon Homme	Non-participating
REC-023	567,115	4,771,132	Charles Mix	Non-participating
REC-024*	569,456	4,770,886	Charles Mix	Non-participating
REC-025	582,410	4,770,691	Bon Homme	Participating
REC-026	582,206	4,770,538	Bon Homme	Non-participating
REC-027	569,451	4,770,123	Charles Mix	Non-participating
REC-028	578,916	4,770,107	Bon Homme	Participating
REC-029	567,890	4,769,897	Charles Mix	Non-participating
REC-030	574,058	4,769,738	Bon Homme	Non-participating
REC-031*	571,038	4,769,100	Charles Mix	Non-participating
REC-032*	579,595	4,768,434	Bon Homme	Participating
REC-033	574,388	4,768,112	Bon Homme	Non-participating
REC-034*	575,857	4,767,969	Bon Homme	Non-participating
REC-035	568,988	4,768,088	Charles Mix	Non-participating

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status
REC-036	574,140	4,767,903	Bon Homme	Non-participating
REC-037*	580,535	4,767,956	Bon Homme	Participating
REC-038	569,571	4,767,694	Charles Mix	Non-participating
REC-039*	575,754	4,767,512	Bon Homme	Non-participating
REC-040*	575,854	4,767,409	Bon Homme	Non-participating
REC-041*	577,366	4,767,429	Bon Homme	Participating
REC-042*	580,535	4,768,650	Bon Homme	Non-participating
REC-043	582,314	4,767,105	Bon Homme	Non-participating
REC-044	577,582	4,766,535	Bon Homme	Participating
REC-045*	580,460	4,766,528	Bon Homme	Participating
REC-046*	570,892	4,766,384	Charles Mix	Participating
REC-047	576,072	4,766,099	Bon Homme	Non-participating
REC-048	575,888	4,765,484	Bon Homme	Non-participating
REC-049	579,136	4,765,004	Bon Homme	Non-participating
REC-050	575,594	4,764,878	Bon Homme	Participating
REC-051*	577,015	4,764,806	Bon Homme	Participating
REC-052	571,035	4,764,976	Charles Mix	Non-participating
REC-053	575,752	4,763,554	Bon Homme	Non-participating
REC-054	579,261	4,763,509	Bon Homme	Non-participating
REC-055	575,738	4,763,383	Bon Homme	Non-participating
REC-056	578,784	4,763,423	Bon Homme	Non-participating
REC-057	575,729	4,763,021	Bon Homme	Non-participating
REC-058	574,690	4,762,906	Bon Homme	Non-participating
REC-059	574,609	4,762,765	Bon Homme	Non-participating
REC-060	575,719	4,763,759	Bon Homme	Non-participating
REC-061	566,590	4,774,005	Charles Mix	Non-participating
REC-062	566,795	4,771,446	Charles Mix	Non-participating
REC-063	567,576	4,773,523	Charles Mix	Non-participating
REC-064	568,170	4,775,222	Charles Mix	Non-participating
REC-065	568,402	4,770,548	Charles Mix	Non-participating
REC-066	569,475	4,776,605	Charles Mix	Participating
REC-067	569,782	4,765,374	Charles Mix	Non-participating
REC-068	570,301	4,776,152	Charles Mix	Non-participating
REC-069	570,321	4,776,086	Charles Mix	Non-participating
REC-070*	570,931	4,767,169	Charles Mix	Non-participating
REC-071	571,247	4,765,598	Charles Mix	Non-participating

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status
REC-072	571,848	4,767,001	Charles Mix	Participating
REC-073	572,712	4,764,371	Charles Mix	Non-participating
REC-074	572,760	4,768,610	Bon Homme	Non-participating
REC-075*	572,875	4,775,184	Charles Mix	Participating
REC-076*	573,024	4,775,138	Charles Mix	Non-participating
REC-077	573,104	4,767,559	Bon Homme	Non-participating
REC-078	572,690	4,764,270	Charles Mix	Non-participating
REC-079*	572,840	4,766,532	Charles Mix	Participating
REC-080	574,527	4,771,635	Bon Homme	Participating
REC-081	574,606	4,772,084	Bon Homme	Participating
REC-082*	575,265	4,775,117	Bon Homme	Participating
REC-083	575,384	4,771,696	Bon Homme	Participating
REC-084	575,460	4,773,772	Bon Homme	Participating
REC-085*	576,210	4,770,611	Bon Homme	Participating
REC-086	576,538	4,765,598	Bon Homme	Participating
REC-087	576,971	4,770,447	Bon Homme	Participating
REC-088	577,660	4,765,661	Bon Homme	Participating
REC-089*	577,747	4,768,860	Bon Homme	Participating
REC-090	577,878	4,764,079	Bon Homme	Non-participating
REC-091	577,916	4,763,844	Bon Homme	Non-participating
REC-092	578,532	4,767,119	Bon Homme	Participating
REC-093*	578,576	4,778,619	Bon Homme	Participating
REC-094*	578,515	4,776,677	Bon Homme	Participating
REC-095	578,804	4,764,275	Bon Homme	Non-participating
REC-096*	578,828	4,768,793	Bon Homme	Non-participating
REC-097	578,943	4,770,455	Bon Homme	Non-participating
REC-098	579,475	4,767,289	Bon Homme	Non-participating
REC-099	579,721	4,762,442	Bon Homme	Participating
REC-100	580,720	4,765,706	Bon Homme	Non-participating
REC-101	580,992	4,762,541	Bon Homme	Non-participating
REC-102	581,560	4,763,175	Bon Homme	Non-participating
REC-103	581,721	4,767,420	Bon Homme	Participating
REC-104	581,794	4,770,381	Bon Homme	Non-participating
REC-105*	581,891	4,769,063	Bon Homme	Non-participating
REC-106	581,883	4,766,985	Bon Homme	Participating
REC-107	582,090	4,770,568	Bon Homme	Non-participating

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status
REC-108	582,148	4,764,102	Bon Homme	Participating
REC-109	582,610	4,767,583	Bon Homme	Non-participating
REC-110	583,963	4,770,430	Bon Homme	Non-participating
REC-111	582,578	4,767,332	Bon Homme	Non-participating
REC-112*	570,034	4,777,429	Charles Mix	Non-participating
REC-113*	580,226	4,778,670	Bon Homme	Participating
REC-114*	580,644	4,779,066	Bon Homme	Participating
REC-115	580,813	4,776,798	Bon Homme	Participating
REC-116*	581,676	4,775,654	Bon Homme	Participating
REC-117	579,368	4,775,404	Bon Homme	Participating
REC-118	580,095	4,784,337	Hutchinson	Non-participating
REC-119	581,868	4,783,246	Hutchinson	Non-participating
REC-120	582,411	4,781,467	Hutchinson	Non-participating
REC-121	582,256	4,783,055	Hutchinson	Non-participating
REC-122	582,261	4,777,793	Bon Homme	Participating
REC-123	581,461	4,785,646	Hutchinson	Non-participating
REC-124	577,505	4,781,336	Hutchinson	Non-participating
REC-125	580,996	4,773,976	Bon Homme	Non-participating
REC-126	580,916	4,774,830	Bon Homme	Participating
REC-127*	581,474	4,775,076	Bon Homme	Participating
REC-128	581,468	4,774,997	Bon Homme	Participating
REC-129	576,816	4,779,814	Bon Homme	Non-participating
REC-130	567,502	4,781,060	Charles Mix	Non-participating
REC-131	568,850	4,781,446	Charles Mix	Non-participating
REC-132	570,408	4,783,811	Charles Mix	Non-participating
REC-133	570,806	4,783,497	Charles Mix	Non-participating
REC-134	570,845	4,782,153	Charles Mix	Non-participating
REC-135	573,665	4,780,153	Charles Mix	Non-participating
REC-136	579,049	4,772,150	Bon Homme	Non-participating
REC-137	579,104	4,772,978	Bon Homme	Non-participating
REC-138*	573,105	4,772,224	Bon Homme	Participating

Notes:

[1] All coordinates presented in UTM NAD83 Zone 14N (meters)
[2] All coordinates provided by Developer in "RECEPTORS-OCCUPIED.KMZ"
[3] Participating status provided by Developer in "Prevailing Winds - Homes on Leased Land" dated 20180516
[4] * Indicates receptor that was analyzed with obstacles.

APPENDIX C - ON-SITE FREQUENCY DISTRIBUTION

Table C-1: Onsite Frequency Distribution, 105 magl

Bin	Wind Direction [degrees]											
[m/s]	**0**	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**
0	65.41	38.88	18.63	13.95	8.41	8.27	4.61	6.61	9.86	12.93	9.19	13.30
1	15.05	31.04	47.30	28.69	18.35	10.65	9.95	14.88	21.64	33.19	12.52	9.58
2	25.86	41.07	65.92	59.40	37.22	22.44	17.17	28.25	41.13	54.46	24.54	18.28
3	37.80	61.64	90.87	88.73	64.77	38.69	28.04	46.18	59.72	73.48	35.57	27.42
4	56.52	78.61	101.15	113.80	86.83	56.49	40.02	56.10	71.72	82.77	43.79	43.43
5	75.49	92.65	101.44	116.19	103.48	76.77	50.52	65.80	88.84	93.86	57.52	60.35
6	90.32	100.33	110.42	117.42	118.16	92.68	63.14	75.41	99.30	97.77	72.55	72.83
7	103.75	100.26	105.84	109.27	119.86	100.82	81.53	87.32	104.59	103.26	84.83	85.82
8	108.67	100.82	93.87	102.03	120.44	113.08	100.50	100.35	116.87	106.39	94.99	97.20
9	102.30	95.43	85.52	84.26	109.17	119.74	116.66	113.69	116.37	100.96	105.59	107.67
10	91.42	78.05	71.18	64.46	81.86	114.16	131.58	115.99	104.50	82.89	99.14	104.34
11	73.42	57.37	47.01	43.43	53.77	90.26	119.74	107.78	80.49	58.48	85.63	91.66
12	55.57	42.96	26.88	26.51	29.63	63.59	95.89	86.51	48.44	36.77	72.27	72.47
13	38.52	28.52	13.42	15.97	17.54	40.73	64.16	52.77	22.33	24.01	57.61	51.04
14	24.71	19.20	8.59	7.03	10.35	24.50	35.18	24.66	8.13	15.28	40.59	38.33
15	15.43	12.74	4.83	3.57	6.74	12.58	18.94	10.20	3.52	8.79	29.06	29.39
16	8.16	8.21	2.41	2.40	4.80	7.20	10.15	4.04	1.10	5.09	22.96	22.09
17	5.29	4.75	2.27	1.07	3.75	3.83	5.19	1.79	0.78	3.47	15.66	16.35
18	3.25	4.16	0.97	0.64	2.08	1.84	3.16	0.65	0.14	1.46	10.99	12.70
19	1.40	2.04	0.53	0.53	1.70	0.96	1.64	0.50	0.27	0.78	8.43	9.55
20	0.72	0.74	0.68	0.16	0.65	0.40	0.81	0.22	0.05	0.39	5.88	6.72
21	0.33	0.37	0.15	0.37	0.24	0.09	0.76	0.11	0.18	0.39	3.85	4.45
22	0.18	0.11	0.05	0.05	0.14	0.02	0.31	0.08	0.05	0.78	2.79	2.30
23	0.15	0.00	0.05	0.05	0.07	0.05	0.22	0.06	0.00	0.56	1.75	1.37
24	0.10	0.00	0.00	0.00	0.00	0.09	0.02	0.00	0.00	0.73	1.15	0.63
25	0.13	0.00	0.00	0.00	0.00	0.07	0.02	0.00	0.00	0.34	0.61	0.34
26	0.05	0.04	0.05	0.00	0.00	0.00	0.03	0.03	0.00	0.50	0.28	0.27
27	0.03	0.00	0.00	0.00	0.00	0.02	0.02	0.03	0.00	0.17	0.20	0.06
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.05
29	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
30	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**

Notes:

[1] All data presented in milles (sum = 1000)
[2] All data provided by Developer via "Roth 0005 03-14-2018 filtered-gapfilled.windog"
[3] All data presented at 105 magl

Table C-2: Onsite Frequency Distribution, 110 magl

Bin	Wind Direction [degrees]											
[m/s]	0	30	60	90	120	150	180	210	240	270	300	330
0	68.06	33.22	19.39	13.61	8.69	7.84	4.42	6.84	9.91	11.35	10.02	13.29
1	14.33	30.12	48.24	28.25	18.70	10.85	9.48	14.61	20.99	32.51	12.87	9.19
2	24.39	42.29	63.38	59.72	36.43	22.62	16.79	28.04	40.06	53.27	25.08	17.92
3	36.19	60.97	88.60	88.29	65.45	38.52	27.50	44.89	57.73	73.58	35.57	26.81
4	55.60	77.47	98.58	112.99	86.82	55.23	39.62	54.74	69.40	81.52	43.58	41.98
5	74.02	91.56	98.87	115.14	101.47	76.54	49.53	63.85	85.77	92.19	56.83	58.49
6	88.18	98.69	108.85	116.86	116.81	91.48	61.18	72.98	96.49	95.99	69.68	70.68
7	100.49	98.17	104.36	108.74	118.71	99.36	80.25	84.66	103.27	101.89	81.77	83.08
8	107.57	101.12	93.57	99.97	119.33	110.12	98.13	97.03	110.58	105.24	91.01	96.29
9	102.12	94.89	86.02	84.10	106.73	116.01	112.94	110.59	112.19	102.97	102.23	105.78
10	92.39	80.93	73.27	65.32	84.91	114.45	127.77	115.35	106.72	88.56	97.64	105.83
11	74.42	59.82	50.72	45.41	54.68	90.62	121.12	108.07	85.91	59.06	88.18	91.71
12	57.73	45.25	28.23	27.87	31.48	66.67	98.93	92.55	55.54	38.52	73.70	76.00
13	41.39	29.86	14.66	16.95	17.77	43.61	68.01	56.18	27.81	24.17	59.82	53.03
14	25.75	20.00	10.08	7.48	11.19	25.27	38.65	29.59	10.68	14.81	44.16	39.55
15	16.61	13.91	4.87	4.09	6.86	14.42	21.59	11.18	3.81	9.53	30.41	30.36
16	8.67	8.53	2.96	2.31	4.74	7.88	10.95	4.93	1.53	5.73	23.79	22.66
17	5.25	4.98	2.53	0.92	3.84	4.62	5.63	2.08	0.94	3.01	16.56	17.04
18	3.64	4.32	1.10	0.70	2.25	2.22	3.27	0.72	0.18	1.42	11.33	12.96
19	1.49	2.47	0.67	0.59	1.66	0.93	1.80	0.53	0.22	0.74	8.48	9.74
20	0.74	0.78	0.76	0.11	0.97	0.41	0.87	0.28	0.05	0.40	6.45	7.18
21	0.37	0.44	0.14	0.43	0.28	0.09	0.74	0.11	0.18	0.34	3.75	4.80
22	0.17	0.19	0.05	0.05	0.17	0.05	0.41	0.11	0.05	0.62	3.03	2.45
23	0.12	0.00	0.00	0.05	0.07	0.02	0.20	0.06	0.00	0.62	1.74	1.50
24	0.12	0.00	0.05	0.00	0.00	0.11	0.08	0.00	0.00	0.79	1.16	0.81
25	0.12	0.00	0.00	0.00	0.00	0.05	0.03	0.00	0.00	0.34	0.58	0.40
26	0.05	0.04	0.05	0.00	0.00	0.00	0.02	0.03	0.00	0.34	0.38	0.25
27	0.03	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.45	0.11	0.14
28	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.06	0.07	0.08
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.02
30	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**

Notes:

[1] All data presented in milles (sum = 1000)
[2] All data provided by Developer via "Roth 0005 03-14-2018 filtered-gapfilled.windog"
[3] All data presented at 110 magl

APPENDIX D - SUNSHINE PROBABILITY DATA

Figure D-1: Monthly Sunshine Probability for Wagner, South Dakota

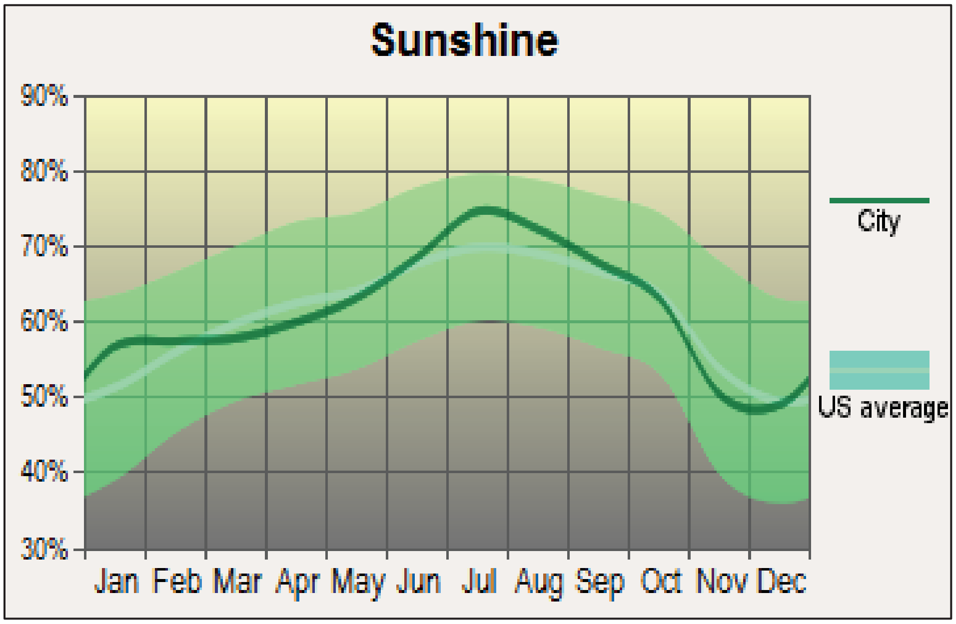


Table D-1: Monthly Sunshine Probability for Wagner, South Dakota

Month	Avg Sunshine Probability
January	58%
February	58%
March	59%
April	60%
May	63%
June	69%
July	74%
August	72%
September	68%
October	65%
November	50%
December	50%

Notes:
[1] Data source: http://www.city-data.com/city/Wagner-South-Dakota.html
[2] Data location: Wagner, South Dakota
[3] Data in Table D-1 estimated from source data in Figure D-1

APPENDIX E - POWER CURVES

Table E-1: GE 3.8-137 Power Curve Values

Wind Speed [m/s]	Power [kW]
0.0	0
1.0	0
2.0	0
3.0	44
4.0	213
5.0	467
6.0	831
7.0	1,333
8.0	1,973
9.0	2,666
10.0	3,271
11.0	3,661
12.0	3,818
13.0	3,830
14.0	3,830
15.0	3,830
16.0	3,830
17.0	3,830
18.0	3,830
19.0	3,830
20.0	3,830
21.0	3,830
22.0	3,830
23.0	3,830
24.0	3,830
25.0	3,830

Notes:
[1] Power curve for air density of 1.16 kg/m^3 and normal turbulence intensity
[2] Provided by Developer via "Power_Curve-NO_3.8-DFIG-137-xxHz_3MW_EN_r01.pdf"

Table E-2: V136-3.6 Power Curve Values

Wind Speed [m/s]	Power [kW]
0.0	0
1.0	0
2.0	0
3.0	43
4.0	207
5.0	448
6.0	801
7.0	1,296
8.0	1,943
9.0	2,706
10.0	3,333
11.0	3,581
12.0	3,600
13.0	3,600
14.0	3,600
15.0	3,600
16.0	3,600
17.0	3,600
18.0	3,600
19.0	3,600
20.0	3,600
21.0	3,600
22.0	3,600
23.0	0
24.0	0
25.0	0

Notes:

[1] Power curve for air density of 1.15 kg/m^3 and normal turbulence intensity

[2] Provided by Developer via " 0056-6306_V01_V136-3.60_PC_105m.pdf"

[3] Vestas V136-3.6 modeled with cut-out speed of 22.5 m/s (Table E-2 limited to 1 m/s increments)

APPENDIX F - FLICKER RESULTS BY RECEPTOR

Table F-1: Flicker Duration by Receptor, GE 3.8-137 Layout

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max. mins/day]
REC-001	583,179	4,781,949	Hutchinson	Non-participating	0.00	0
REC-002	578,731	4,782,429	Hutchinson	Participating	0.00	0
REC-003	580,507	4,783,274	Hutchinson	Non-participating	0.00	0
REC-004	582,679	4,780,105	Hutchinson	Non-participating	4.98	27
REC-005	583,327	4,778,397	Bon Homme	Non-participating	0.00	0
REC-006	583,615	4,778,695	Bon Homme	Non-participating	0.00	0
REC-007	579,386	4,783,172	Hutchinson	Non-participating	0.00	0
REC-008*	579,365	4,780,123	Hutchinson	Non-participating	10.27	39
REC-009*	582,486	4,779,597	Bon Homme	Non-participating	8.32	38
REC-010	570,706	4,779,233	Charles Mix	Non-participating	0.00	0
REC-011	568,955	4,779,050	Charles Mix	Non-participating	0.00	0
REC-012	575,451	4,778,870	Bon Homme	Non-participating	0.00	0
REC-013	570,834	4,777,924	Charles Mix	Non-participating	0.00	0
REC-014*	578,568	4,777,265	Bon Homme	Non-participating	12.15	43
REC-015*	578,579	4,777,228	Bon Homme	Non-participating	12.67	44
REC-016	569,438	4,774,776	Charles Mix	Participating	4.40	27
REC-017*	568,000	4,773,684	Charles Mix	Non-participating	18.48	40
REC-018	575,894	4,773,069	Bon Homme	Participating	0.00	0
REC-019	568,870	4,772,838	Charles Mix	Participating	0.00	0
REC-020	568,171	4,772,373	Charles Mix	Non-participating	0.00	0
REC-021	574,123	4,771,642	Bon Homme	Participating	0.00	0
REC-022	574,118	4,771,913	Bon Homme	Non-participating	0.00	0
REC-023	567,115	4,771,132	Charles Mix	Non-participating	0.00	0
REC-024*	569,456	4,770,886	Charles Mix	Non-participating	5.98	31
REC-025	582,410	4,770,691	Bon Homme	Participating	0.00	0
REC-026	582,206	4,770,538	Bon Homme	Non-participating	0.00	0
REC-027	569,451	4,770,123	Charles Mix	Non-participating	0.00	0
REC-028	578,916	4,770,107	Bon Homme	Participating	0.00	0
REC-029	567,890	4,769,897	Charles Mix	Non-participating	0.00	0
REC-030	574,058	4,769,738	Bon Homme	Non-participating	3.28	24
REC-031*	571,038	4,769,100	Charles Mix	Non-participating	5.90	31
REC-032*	579,595	4,768,434	Bon Homme	Participating	9.73	44
REC-033	574,388	4,768,112	Bon Homme	Non-participating	0.00	0
REC-034*	575,857	4,767,969	Bon Homme	Non-participating	0.00	0
REC-035	568,988	4,768,088	Charles Mix	Non-participating	0.00	0
REC-036	574,140	4,767,903	Bon Homme	Non-participating	0.00	0
REC-037*	580,535	4,767,956	Bon Homme	Participating	0.00	0
REC-038	569,571	4,767,694	Charles Mix	Non-participating	0.00	0
REC-039*	575,754	4,767,512	Bon Homme	Non-participating	0.00	0
REC-040*	575,854	4,767,409	Bon Homme	Non-participating	7.02	33
REC-041*	577,366	4,767,429	Bon Homme	Participating	21.53	55
REC-042*	580,535	4,768,650	Bon Homme	Non-participating	27.90	53
REC-043	582,314	4,767,105	Bon Homme	Non-participating	0.00	0
REC-044	577,582	4,766,535	Bon Homme	Participating	0.00	0

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max. mins/day]
REC-045*	580,460	4,766,528	Bon Homme	Participating	17.97	45
REC-046*	570,892	4,766,384	Charles Mix	Participating	45.67	76
REC-047	576,072	4,766,099	Bon Homme	Non-participating	0.00	0
REC-048	575,888	4,765,484	Bon Homme	Non-participating	0.00	0
REC-049	579,136	4,765,004	Bon Homme	Non-participating	4.68	28
REC-050	575,594	4,764,878	Bon Homme	Participating	0.00	0
REC-051*	577,015	4,764,806	Bon Homme	Participating	7.32	32
REC-052	571,035	4,764,976	Charles Mix	Non-participating	0.00	0
REC-053	575,752	4,763,554	Bon Homme	Non-participating	0.00	0
REC-054	579,261	4,763,509	Bon Homme	Non-participating	0.00	0
REC-055	575,738	4,763,383	Bon Homme	Non-participating	0.00	0
REC-056	578,784	4,763,423	Bon Homme	Non-participating	0.00	0
REC-057	575,729	4,763,021	Bon Homme	Non-participating	0.00	0
REC-058	574,690	4,762,906	Bon Homme	Non-participating	0.00	0
REC-059	574,609	4,762,765	Bon Homme	Non-participating	0.00	0
REC-060	575,719	4,763,759	Bon Homme	Non-participating	0.00	0
REC-061	566,590	4,774,005	Charles Mix	Non-participating	0.00	0
REC-062	566,795	4,771,446	Charles Mix	Non-participating	0.00	0
REC-063	567,576	4,773,523	Charles Mix	Non-participating	4.62	26
REC-064	568,170	4,775,222	Charles Mix	Non-participating	0.00	0
REC-065	568,402	4,770,548	Charles Mix	Non-participating	0.00	0
REC-066	569,475	4,776,605	Charles Mix	Participating	0.00	0
REC-067	569,782	4,765,374	Charles Mix	Non-participating	0.00	0
REC-068	570,301	4,776,152	Charles Mix	Non-participating	2.87	23
REC-069	570,321	4,776,086	Charles Mix	Non-participating	2.98	24
REC-070*	570,931	4,767,169	Charles Mix	Non-participating	7.95	36
REC-071	571,247	4,765,598	Charles Mix	Non-participating	11.75	25
REC-072	571,848	4,767,001	Charles Mix	Participating	0.00	0
REC-073	572,712	4,764,371	Charles Mix	Non-participating	0.00	0
REC-074	572,760	4,768,610	Bon Homme	Non-participating	0.00	0
REC-075*	572,875	4,775,184	Charles Mix	Participating	21.17	42
REC-076*	573,024	4,775,138	Charles Mix	Non-participating	34.73	52
REC-077	573,104	4,767,559	Bon Homme	Non-participating	0.00	0
REC-078	572,690	4,764,270	Charles Mix	Non-participating	0.00	0
REC-079*	572,840	4,766,532	Charles Mix	Participating	0.00	0
REC-080	574,527	4,771,635	Bon Homme	Participating	0.00	0
REC-081	574,606	4,772,084	Bon Homme	Participating	0.00	0
REC-082*	575,265	4,775,117	Bon Homme	Participating	7.82	31
REC-083	575,384	4,771,696	Bon Homme	Participating	0.00	0
REC-084	575,460	4,773,772	Bon Homme	Participating	4.33	29
REC-085*	576,210	4,770,611	Bon Homme	Participating	0.00	0
REC-086	576,538	4,765,598	Bon Homme	Participating	0.00	0
REC-087	576,971	4,770,447	Bon Homme	Participating	0.00	0
REC-088	577,660	4,765,661	Bon Homme	Participating	5.10	28
REC-089*	577,747	4,768,860	Bon Homme	Participating	24.60	42

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max. mins/day]
REC-090	577,878	4,764,079	Bon Homme	Non-participating	0.00	0
REC-091	577,916	4,763,844	Bon Homme	Non-participating	0.00	0
REC-092	578,532	4,767,119	Bon Homme	Participating	3.77	24
REC-093*	578,576	4,778,619	Bon Homme	Participating	19.17	37
REC-094*	578,515	4,776,677	Bon Homme	Participating	16.98	37
REC-095	578,804	4,764,275	Bon Homme	Non-participating	0.00	0
REC-096*	578,828	4,768,793	Bon Homme	Non-participating	21.07	53
REC-097	578,943	4,770,455	Bon Homme	Non-participating	0.00	0
REC-098	579,475	4,767,289	Bon Homme	Non-participating	0.00	0
REC-099	579,721	4,762,442	Bon Homme	Participating	0.00	0
REC-100	580,720	4,765,706	Bon Homme	Non-participating	0.00	0
REC-101	580,992	4,762,541	Bon Homme	Non-participating	0.00	0
REC-102	581,560	4,763,175	Bon Homme	Non-participating	0.00	0
REC-103	581,721	4,767,420	Bon Homme	Participating	0.00	0
REC-104	581,794	4,770,381	Bon Homme	Non-participating	0.00	0
REC-105*	581,891	4,769,063	Bon Homme	Non-participating	0.00	0
REC-106	581,883	4,766,985	Bon Homme	Participating	0.00	0
REC-107	582,090	4,770,568	Bon Homme	Non-participating	0.00	0
REC-108	582,148	4,764,102	Bon Homme	Participating	0.00	0
REC-109	582,610	4,767,583	Bon Homme	Non-participating	0.00	0
REC-110	583,963	4,770,430	Bon Homme	Non-participating	0.00	0
REC-111	582,578	4,767,332	Bon Homme	Non-participating	0.00	0
REC-112*	570,034	4,777,429	Charles Mix	Non-participating	4.98	30
REC-113*	580,226	4,778,670	Bon Homme	Participating	5.62	32
REC-114*	580,644	4,779,066	Bon Homme	Participating	33.18	47
REC-115	580,813	4,776,798	Bon Homme	Participating	1.48	17
REC-116*	581,676	4,775,654	Bon Homme	Participating	0.00	0
REC-117	579,368	4,775,404	Bon Homme	Participating	0.00	0
REC-118	580,095	4,784,337	Hutchinson	Non-participating	0.00	0
REC-119	581,868	4,783,246	Hutchinson	Non-participating	0.00	0
REC-120	582,411	4,781,467	Hutchinson	Non-participating	0.00	0
REC-121	582,256	4,783,055	Hutchinson	Non-participating	0.00	0
REC-122	582,261	4,777,793	Bon Homme	Participating	0.00	0
REC-123	581,461	4,785,646	Hutchinson	Non-participating	0.00	0
REC-124	577,505	4,781,336	Hutchinson	Non-participating	0.00	0
REC-125	580,996	4,773,976	Bon Homme	Non-participating	0.00	0
REC-126	580,916	4,774,830	Bon Homme	Participating	0.00	0
REC-127*	581,474	4,775,076	Bon Homme	Participating	0.00	0
REC-128	581,468	4,774,997	Bon Homme	Participating	0.00	0
REC-129	576,816	4,779,814	Bon Homme	Non-participating	0.00	0
REC-130	567,502	4,781,060	Charles Mix	Non-participating	0.00	0
REC-131	568,850	4,781,446	Charles Mix	Non-participating	0.00	0
REC-132	570,408	4,783,811	Charles Mix	Non-participating	0.00	0
REC-133	570,806	4,783,497	Charles Mix	Non-participating	0.00	0
REC-134	570,845	4,782,153	Charles Mix	Non-participating	0.00	0

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max. mins/day]
REC-135	573,665	4,780,153	Charles Mix	Non-participating	0.00	0
REC-136	579,049	4,772,150	Bon Homme	Non-participating	0.00	0
REC-137	579,104	4,772,978	Bon Homme	Non-participating	0.00	0
REC-138*	573,105	4,772,224	Bon Homme	Participating	0.00	0

Notes:

[1] All coordinates presented in UTM NAD83 Zone 14N (meters)

[2] All results based on turbine layout in Table A-1 using GE 3.8-137 wind turbines

Table F-2: Flicker Duration by Receptor, Vestas V136-3.6 Layout

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max min/day]
REC-001	583,179	4,781,949	Hutchinson	Non-participating	0.00	0
REC-002	578,731	4,782,429	Hutchinson	Participating	0.00	0
REC-003	580,507	4,783,274	Hutchinson	Non-participating	0.00	0
REC-004	582,679	4,780,105	Hutchinson	Non-participating	4.63	26
REC-005	583,327	4,778,397	Bon Homme	Non-participating	0.00	0
REC-006	583,615	4,778,695	Bon Homme	Non-participating	0.00	0
REC-007	579,386	4,783,172	Hutchinson	Non-participating	0.00	0
REC-008*	579,365	4,780,123	Hutchinson	Non-participating	10.07	39
REC-009*	582,486	4,779,597	Bon Homme	Non-participating	8.28	38
REC-010	570,706	4,779,233	Charles Mix	Non-participating	0.00	0
REC-011	568,955	4,779,050	Charles Mix	Non-participating	0.00	0
REC-012	575,451	4,778,870	Bon Homme	Non-participating	0.00	0
REC-013	570,834	4,777,924	Charles Mix	Non-participating	0.00	0
REC-014*	578,568	4,777,265	Bon Homme	Non-participating	12.03	43
REC-015*	578,579	4,777,228	Bon Homme	Non-participating	12.53	44
REC-016	569,438	4,774,776	Charles Mix	Participating	4.28	27
REC-017*	568,000	4,773,684	Charles Mix	Non-participating	18.02	40
REC-018	575,894	4,773,069	Bon Homme	Participating	0.00	0
REC-019	568,870	4,772,838	Charles Mix	Participating	0.00	0
REC-020	568,171	4,772,373	Charles Mix	Non-participating	0.00	0
REC-021	574,123	4,771,642	Bon Homme	Participating	0.00	0
REC-022	574,118	4,771,913	Bon Homme	Non-participating	0.00	0
REC-023	567,115	4,771,132	Charles Mix	Non-participating	0.00	0
REC-024*	569,456	4,770,886	Charles Mix	Non-participating	5.83	31
REC-025	582,410	4,770,691	Bon Homme	Participating	0.00	0
REC-026	582,206	4,770,538	Bon Homme	Non-participating	0.00	0
REC-027	569,451	4,770,123	Charles Mix	Non-participating	0.00	0
REC-028	578,916	4,770,107	Bon Homme	Participating	0.00	0
REC-029	567,890	4,769,897	Charles Mix	Non-participating	0.00	0
REC-030	574,058	4,769,738	Bon Homme	Non-participating	3.12	23
REC-031*	571,038	4,769,100	Charles Mix	Non-participating	5.72	31
REC-032*	579,595	4,768,434	Bon Homme	Participating	7.28	38
REC-033	574,388	4,768,112	Bon Homme	Non-participating	0.00	0
REC-034*	575,857	4,767,969	Bon Homme	Non-participating	0.00	0
REC-035	568,988	4,768,088	Charles Mix	Non-participating	0.00	0
REC-036	574,140	4,767,903	Bon Homme	Non-participating	0.00	0
REC-037*	580,535	4,767,956	Bon Homme	Participating	0.00	0
REC-038	569,571	4,767,694	Charles Mix	Non-participating	0.00	0
REC-039*	575,754	4,767,512	Bon Homme	Non-participating	0.00	0
REC-040*	575,854	4,767,409	Bon Homme	Non-participating	6.78	33
REC-041*	577,366	4,767,429	Bon Homme	Participating	21.18	55
REC-042*	580,535	4,768,650	Bon Homme	Non-participating	26.50	51
REC-043	582,314	4,767,105	Bon Homme	Non-participating	0.00	0
REC-044	577,582	4,766,535	Bon Homme	Participating	0.00	0

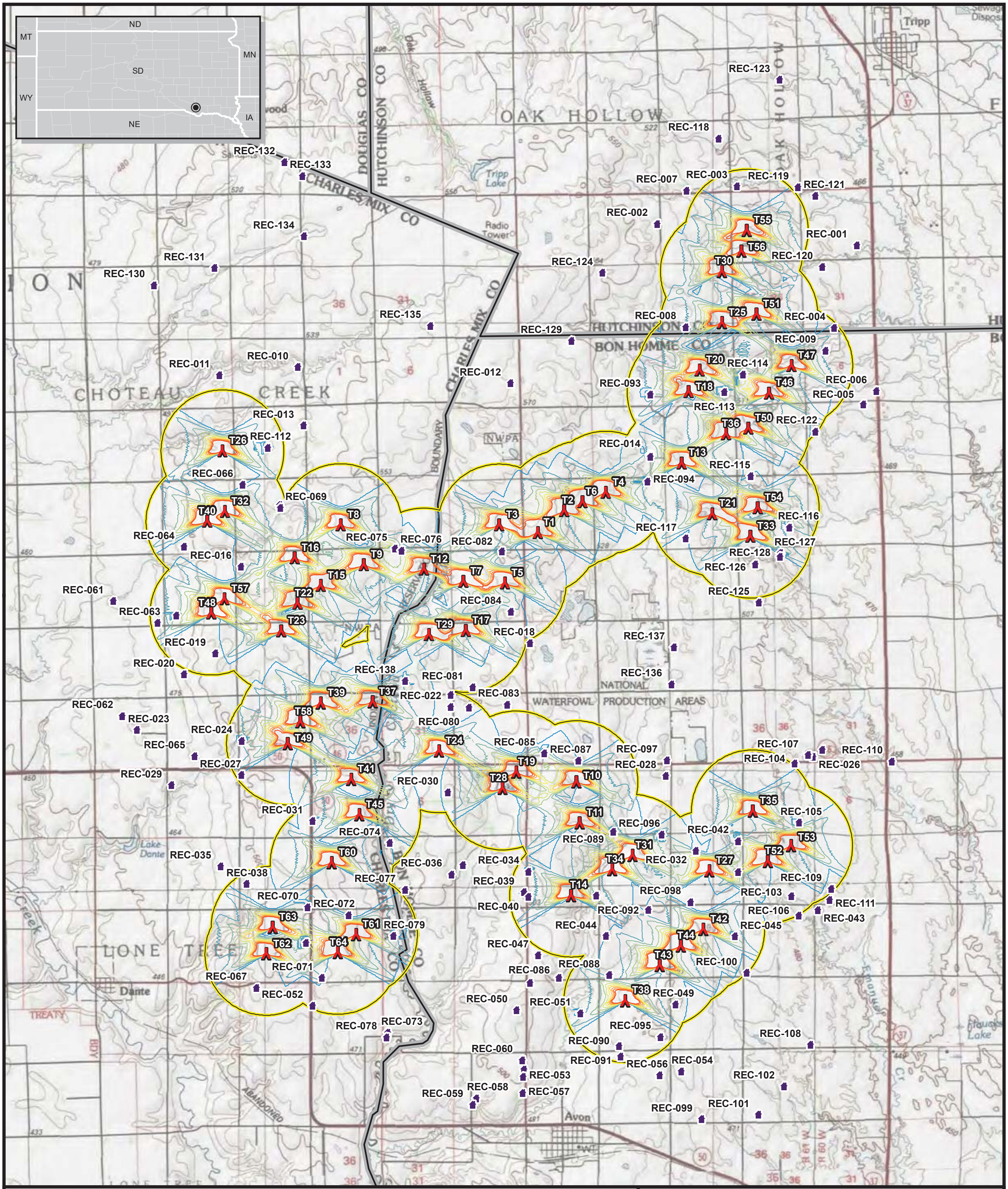
Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max min/day]
REC-045*	580,460	4,766,528	Bon Homme	Participating	0.00	0
REC-046*	570,892	4,766,384	Charles Mix	Participating	45.38	75
REC-047	576,072	4,766,099	Bon Homme	Non-participating	0.00	0
REC-048	575,888	4,765,484	Bon Homme	Non-participating	0.00	0
REC-049	579,136	4,765,004	Bon Homme	Non-participating	4.43	27
REC-050	575,594	4,764,878	Bon Homme	Participating	0.00	0
REC-051*	577,015	4,764,806	Bon Homme	Participating	7.08	32
REC-052	571,035	4,764,976	Charles Mix	Non-participating	0.00	0
REC-053	575,752	4,763,554	Bon Homme	Non-participating	0.00	0
REC-054	579,261	4,763,509	Bon Homme	Non-participating	0.00	0
REC-055	575,738	4,763,383	Bon Homme	Non-participating	0.00	0
REC-056	578,784	4,763,423	Bon Homme	Non-participating	0.00	0
REC-057	575,729	4,763,021	Bon Homme	Non-participating	0.00	0
REC-058	574,690	4,762,906	Bon Homme	Non-participating	0.00	0
REC-059	574,609	4,762,765	Bon Homme	Non-participating	0.00	0
REC-060	575,719	4,763,759	Bon Homme	Non-participating	0.00	0
REC-061	566,590	4,774,005	Charles Mix	Non-participating	0.00	0
REC-062	566,795	4,771,446	Charles Mix	Non-participating	0.00	0
REC-063	567,576	4,773,523	Charles Mix	Non-participating	4.53	26
REC-064	568,170	4,775,222	Charles Mix	Non-participating	0.00	0
REC-065	568,402	4,770,548	Charles Mix	Non-participating	0.00	0
REC-066	569,475	4,776,605	Charles Mix	Participating	0.00	0
REC-067	569,782	4,765,374	Charles Mix	Non-participating	0.00	0
REC-068	570,301	4,776,152	Charles Mix	Non-participating	2.68	22
REC-069	570,321	4,776,086	Charles Mix	Non-participating	2.80	23
REC-070*	570,931	4,767,169	Charles Mix	Non-participating	7.73	36
REC-071	571,247	4,765,598	Charles Mix	Non-participating	11.07	25
REC-072	571,848	4,767,001	Charles Mix	Participating	0.00	0
REC-073	572,712	4,764,371	Charles Mix	Non-participating	0.00	0
REC-074	572,760	4,768,610	Bon Homme	Non-participating	0.00	0
REC-075*	572,875	4,775,184	Charles Mix	Participating	20.85	41
REC-076*	573,024	4,775,138	Charles Mix	Non-participating	33.93	51
REC-077	573,104	4,767,559	Bon Homme	Non-participating	0.00	0
REC-078	572,690	4,764,270	Charles Mix	Non-participating	0.00	0
REC-079*	572,840	4,766,532	Charles Mix	Participating	0.00	0
REC-080	574,527	4,771,635	Bon Homme	Participating	0.00	0
REC-081	574,606	4,772,084	Bon Homme	Participating	0.00	0
REC-082*	575,265	4,775,117	Bon Homme	Participating	7.38	30
REC-083	575,384	4,771,696	Bon Homme	Participating	0.00	0
REC-084	575,460	4,773,772	Bon Homme	Participating	4.08	28
REC-085*	576,210	4,770,611	Bon Homme	Participating	0.00	0
REC-086	576,538	4,765,598	Bon Homme	Participating	0.00	0
REC-087	576,971	4,770,447	Bon Homme	Participating	0.00	0
REC-088	577,660	4,765,661	Bon Homme	Participating	4.95	28
REC-089*	577,747	4,768,860	Bon Homme	Participating	22.35	42

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max min/day]
REC-090	577,878	4,764,079	Bon Homme	Non-participating	0.00	0
REC-091	577,916	4,763,844	Bon Homme	Non-participating	0.00	0
REC-092	578,532	4,767,119	Bon Homme	Participating	3.57	23
REC-093*	578,576	4,778,619	Bon Homme	Participating	18.52	37
REC-094*	578,515	4,776,677	Bon Homme	Participating	17.48	38
REC-095	578,804	4,764,275	Bon Homme	Non-participating	0.00	0
REC-096*	578,828	4,768,793	Bon Homme	Non-participating	13.85	41
REC-097	578,943	4,770,455	Bon Homme	Non-participating	0.00	0
REC-098	579,475	4,767,289	Bon Homme	Non-participating	0.00	0
REC-099	579,721	4,762,442	Bon Homme	Participating	0.00	0
REC-100	580,720	4,765,706	Bon Homme	Non-participating	0.00	0
REC-101	580,992	4,762,541	Bon Homme	Non-participating	0.00	0
REC-102	581,560	4,763,175	Bon Homme	Non-participating	0.00	0
REC-103	581,721	4,767,420	Bon Homme	Participating	0.00	0
REC-104	581,794	4,770,381	Bon Homme	Non-participating	0.00	0
REC-105*	581,891	4,769,063	Bon Homme	Non-participating	0.00	0
REC-106	581,883	4,766,985	Bon Homme	Participating	0.00	0
REC-107	582,090	4,770,568	Bon Homme	Non-participating	0.00	0
REC-108	582,148	4,764,102	Bon Homme	Participating	0.00	0
REC-109	582,610	4,767,583	Bon Homme	Non-participating	0.00	0
REC-110	583,963	4,770,430	Bon Homme	Non-participating	0.00	0
REC-111	582,578	4,767,332	Bon Homme	Non-participating	0.00	0
REC-112*	570,034	4,777,429	Charles Mix	Non-participating	4.68	29
REC-113*	580,226	4,778,670	Bon Homme	Participating	5.35	31
REC-114*	580,644	4,779,066	Bon Homme	Participating	32.07	46
REC-115	580,813	4,776,798	Bon Homme	Participating	1.02	15
REC-116*	581,676	4,775,654	Bon Homme	Participating	0.00	0
REC-117	579,368	4,775,404	Bon Homme	Participating	0.00	0
REC-118	580,095	4,784,337	Hutchinson	Non-participating	0.00	0
REC-119	581,868	4,783,246	Hutchinson	Non-participating	0.00	0
REC-120	582,411	4,781,467	Hutchinson	Non-participating	0.00	0
REC-121	582,256	4,783,055	Hutchinson	Non-participating	0.00	0
REC-122	582,261	4,777,793	Bon Homme	Participating	0.00	0
REC-123	581,461	4,785,646	Hutchinson	Non-participating	0.00	0
REC-124	577,505	4,781,336	Hutchinson	Non-participating	0.00	0
REC-125	580,996	4,773,976	Bon Homme	Non-participating	0.00	0
REC-126	580,916	4,774,830	Bon Homme	Participating	0.00	0
REC-127*	581,474	4,775,076	Bon Homme	Participating	0.00	0
REC-128	581,468	4,774,997	Bon Homme	Participating	0.00	0
REC-129	576,816	4,779,814	Bon Homme	Non-participating	0.00	0
REC-130	567,502	4,781,060	Charles Mix	Non-participating	0.00	0
REC-131	568,850	4,781,446	Charles Mix	Non-participating	0.00	0
REC-132	570,408	4,783,811	Charles Mix	Non-participating	0.00	0
REC-133	570,806	4,783,497	Charles Mix	Non-participating	0.00	0
REC-134	570,845	4,782,153	Charles Mix	Non-participating	0.00	0

Receptor Name	Easting [m]	Northing [m]	County Name	Participating Status	Flicker Duration [hour/year]	Flicker Duration [max min/day]
REC-135	573,665	4,780,153	Charles Mix	Non-participating	0.00	0
REC-136	579,049	4,772,150	Bon Homme	Non-participating	0.00	0
REC-137	579,104	4,772,978	Bon Homme	Non-participating	0.00	0
REC-138*	573,105	4,772,224	Bon Homme	Participating	0.00	0

Notes:
[1] All coordinates presented in UTM NAD83 Zone 14N (meters)
[2] All results based on turbine layout in Table A-1 using Vestas V136-3.6 wind turbines
[3] * Indicates receptor that was analyzed with obstacles.

APPENDIX G - SHADOW FLICKER DURATION MAP



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LEGEND

▭ County Boundary

Wind Turbine

Receptor

▭ Wind Turbine Buffer (1370m)

Shadow Flicker Vectors [hours per year]

0 10 20 30 40 50 60 70 80 90 100

REFERENCE

0 1 2
MILES

0 1 2
KILOMETERS

N

PREVAILING WIND PARK
Shadow Flicker Duration [Hr/Yr] - GE 3.8-137 Layout

LOCATION:	Charles Mix/Bonne Homme/Hutchinson Cty, SD
CLIENT:	Prevailing Wind Park, LLC
PROJ. NO.:	105644
CREATED:	05/25/2018

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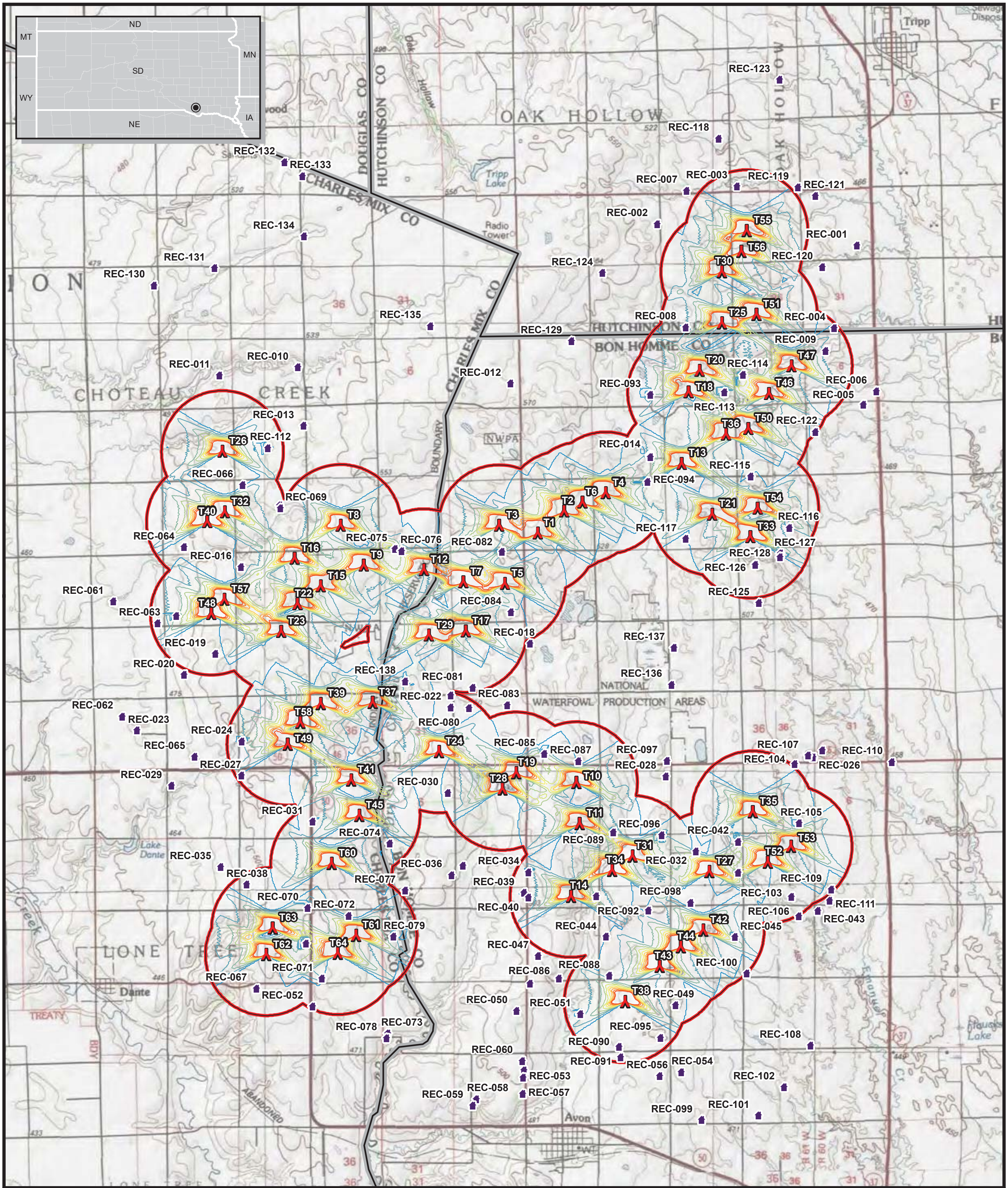

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LEGEND

▭ County Boundary

Wind Turbine

Receptor

▭ Wind Turbine Buffer (1360m)

Shadow Flicker Vectors [hours per year]

0 10 20 30 40 50 60 70 80 90 100

REFERENCE

0 1 2
MILES

0 1 2
KILOMETERS

N

PREVAILING WIND PARK

Shadow Flicker Duration [Hr/Yr] - V136-3.6 Layout

LOCATION: Charles Mix/Bonne Homme/Hutchinson Cty, SD

CLIENT: Prevailing Wind Park, LLC

PROJ. NO.: 105644

CREATED: 05/25/2018

BURNS McDONNELL
www.burnsmcd.com

APPENDIX H - SHADOW FLICKER CALENDAR

Project:

Prevailing Wind Park

Description:

Burns & McDonnell has relied upon information provided by third-party sources to complete this study. While there is no reason to believe that the information provided is inaccurate or incomplete in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee or warranty its accuracy or completeness.

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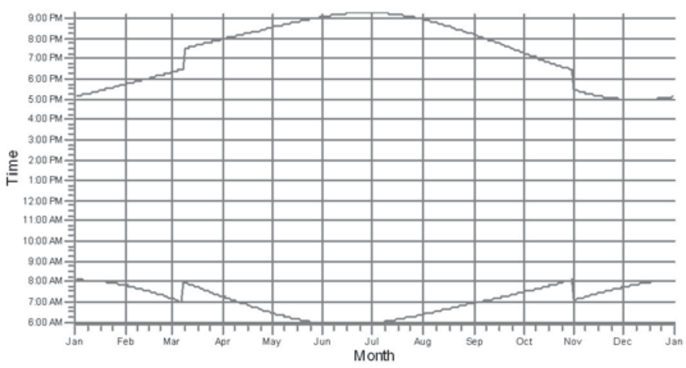
Burns & McDonnell Engineering Company Inc.
9400 Ward Parkway
US-KANSAS CITY, MO 64114
(816) 333 9400
Ella D. Rose / edrose@burnsmcd.com

Calculated:
5/25/2018 10:53 AM/3.0.654

SHADOW - Calendar, graphical

Calculation: FlickerGE.v5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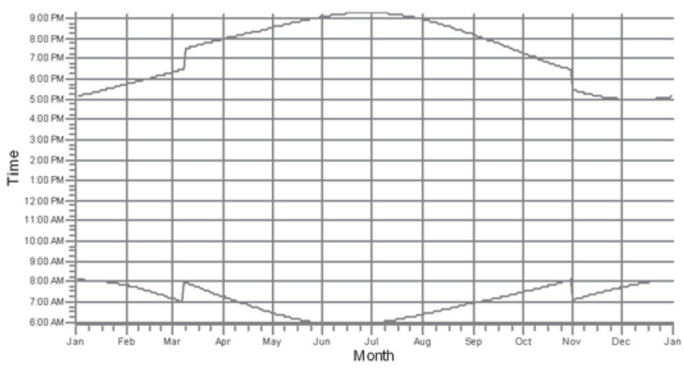
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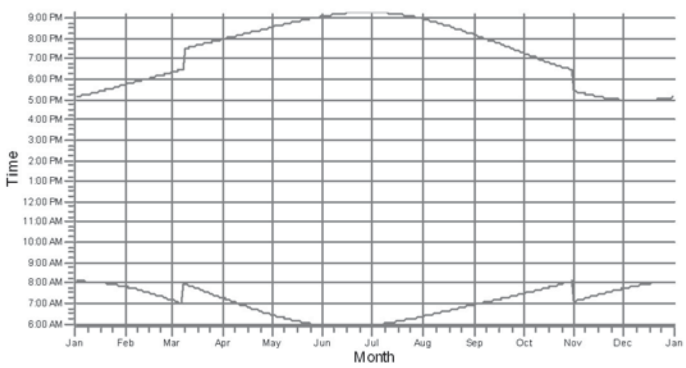
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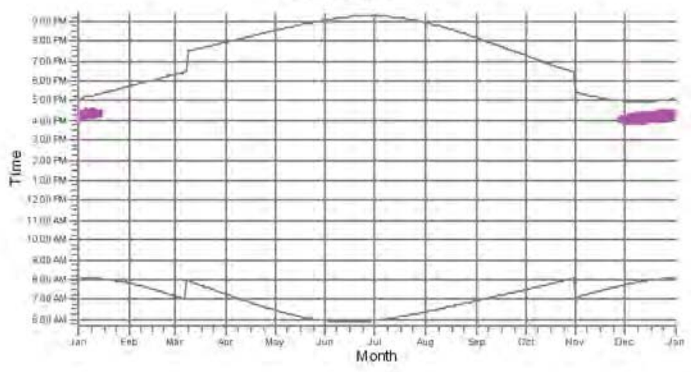
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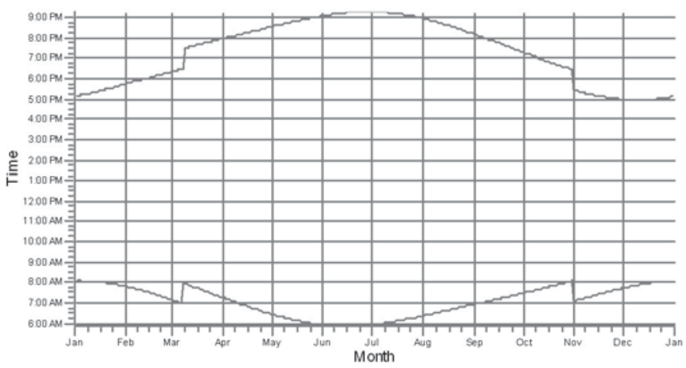
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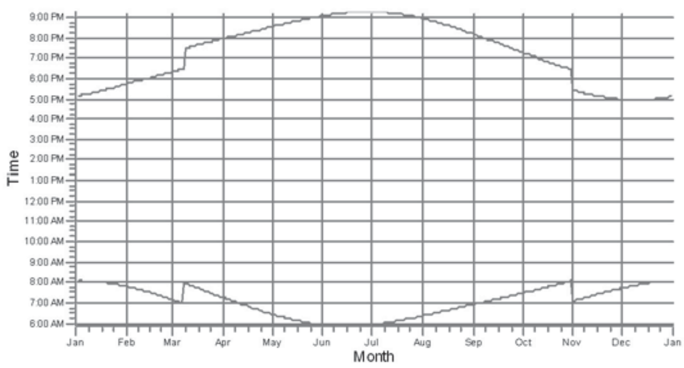
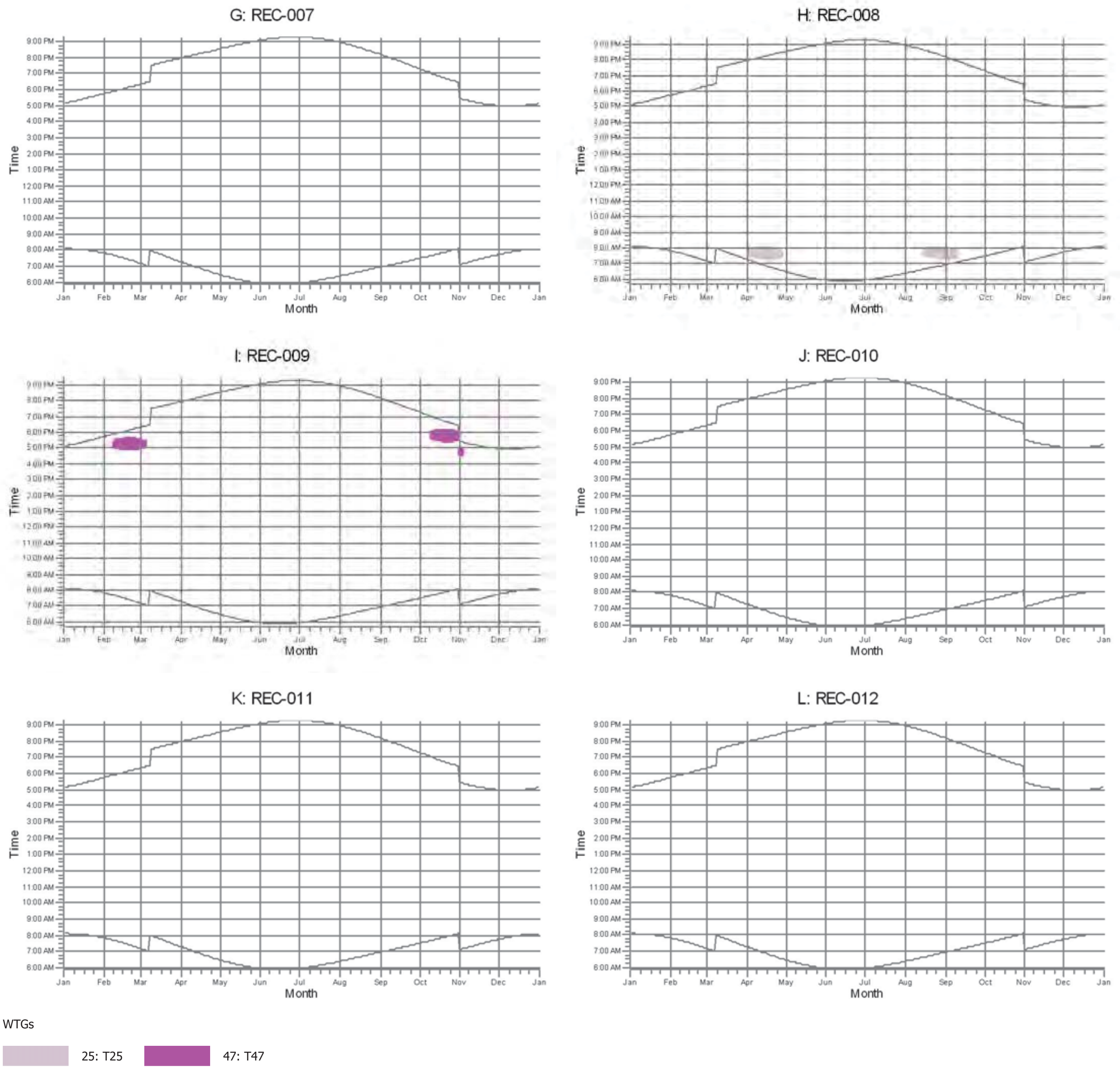

F: REC-006

WTGs

🟪 47: T47

SHADOW - Calendar, graphical

Calculation: FlickerGE.v5



Project:

Prevailing Wind Park

Description:
Burns & McDonnell has relied upon information provided by third-party sources to complete this study. While there is no reason to believe that the information provided is inaccurate or incomplete in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee or warranty its accuracy or completeness.

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Licensed user:

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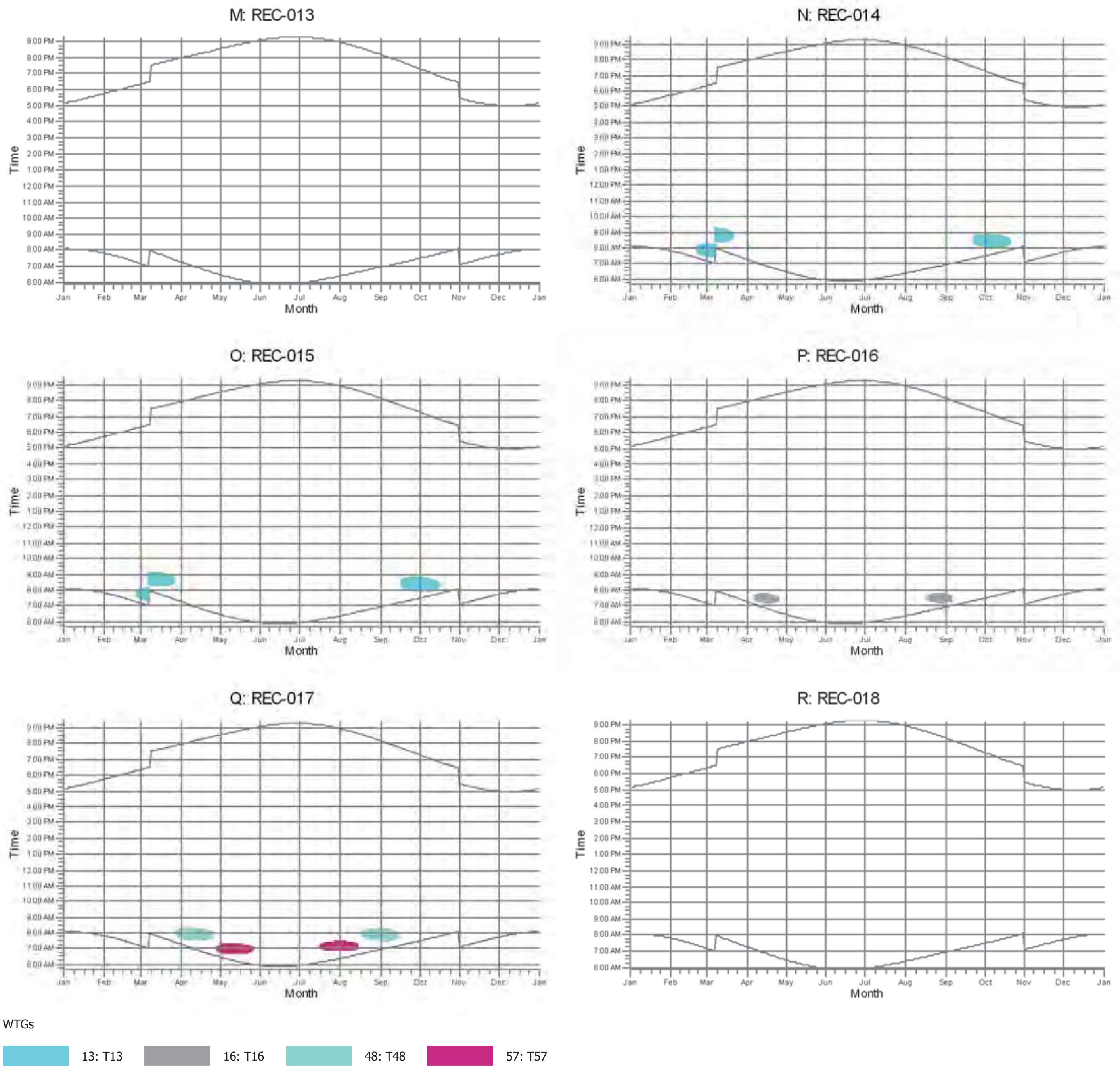
9400 Ward Parkway
US-KANSAS CITY, MO 64114
(816) 333 9400
Ella D. Rose / edrose@burnsmcd.com

Calculated:
5/25/2018 10:53 AM/3.0.654

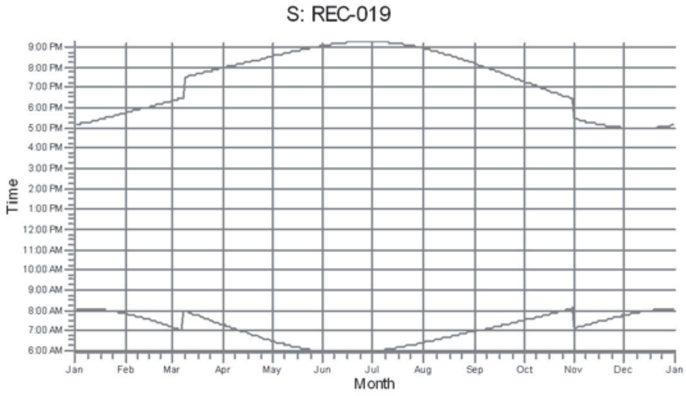
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5



SHADOW - Calendar, graphical

Calculation: FlickerGE.v5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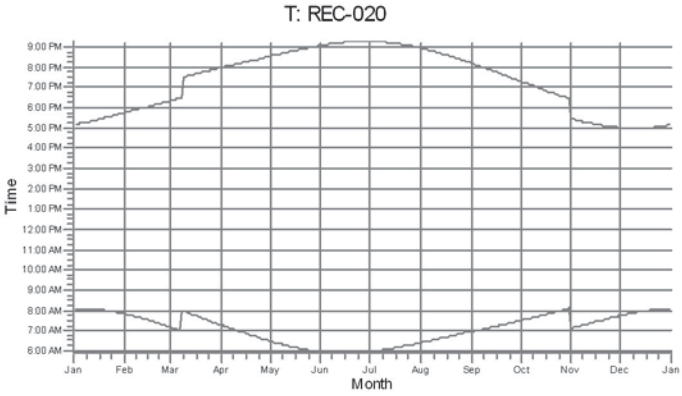
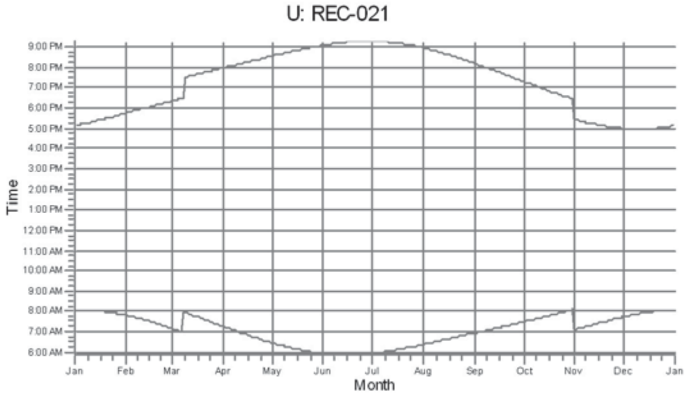
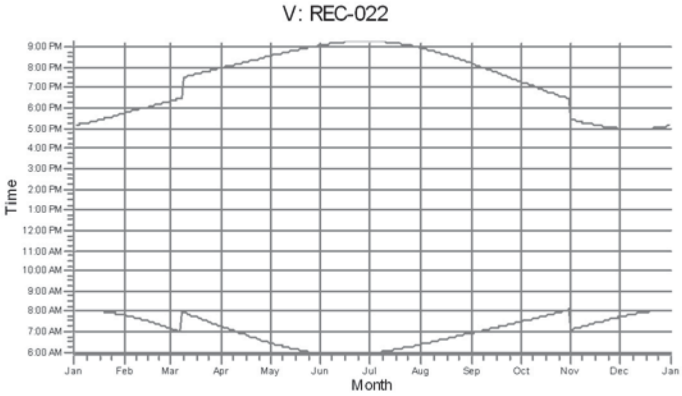
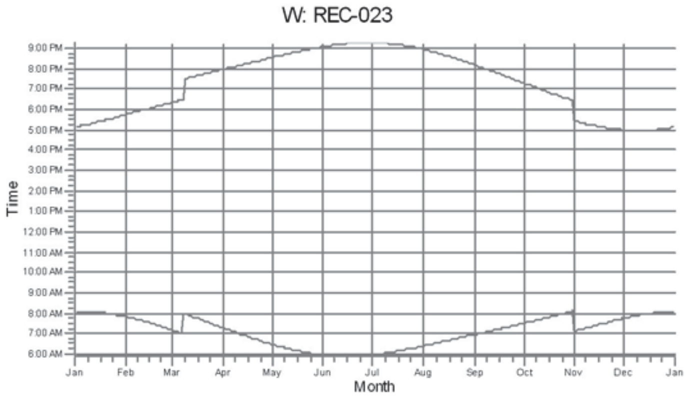
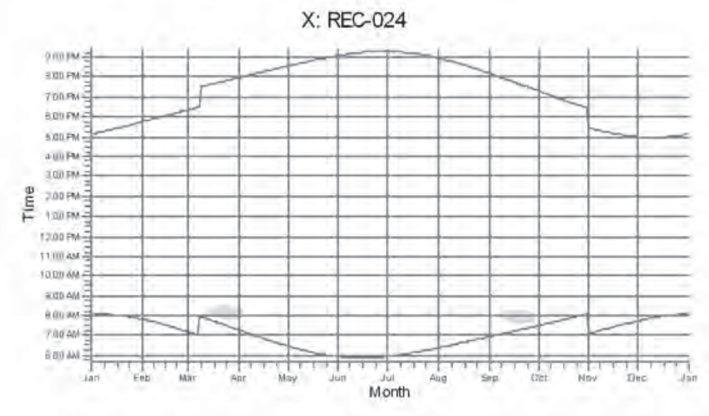

T: REC-020


U: REC-021


V: REC-022


W: REC-023


X: REC-024

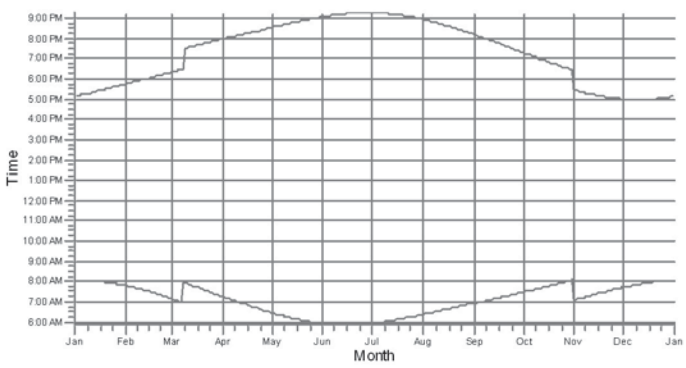
WTGs

▨ 49: T49

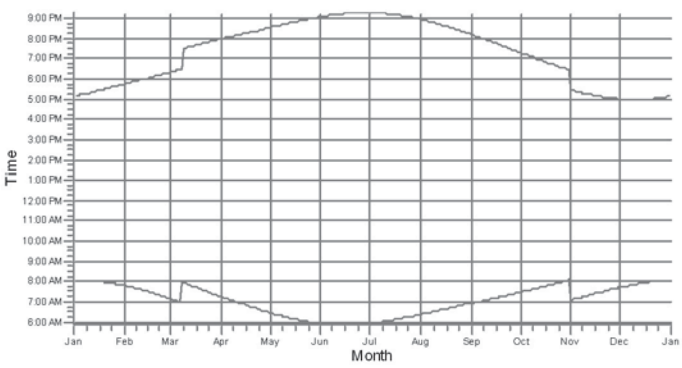
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5

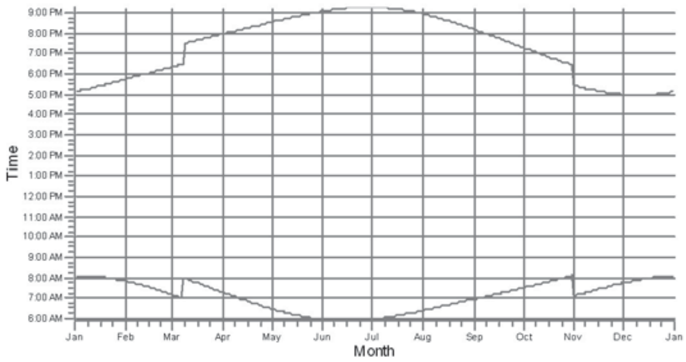
Y: REC-025



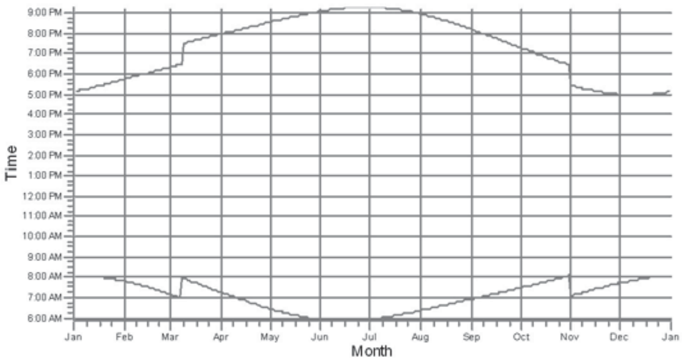
Z: REC-026



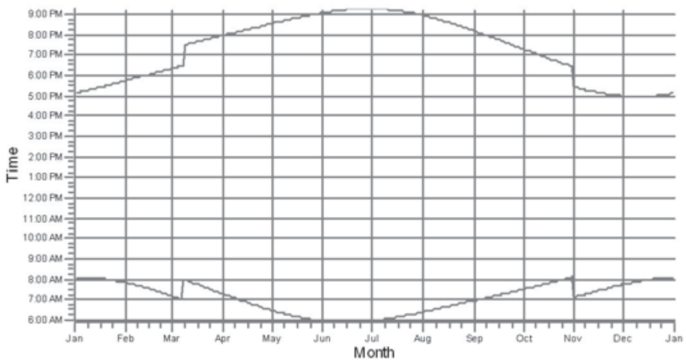
AA: REC-027



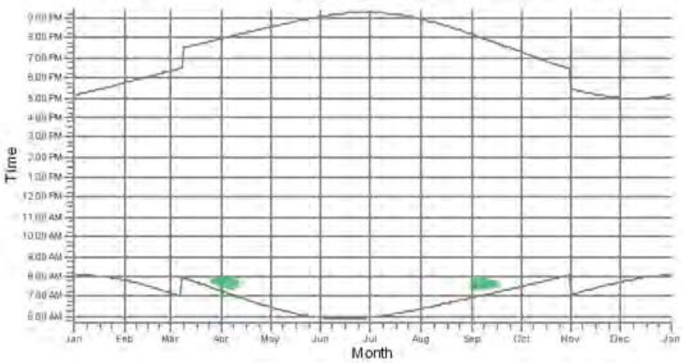
AB: REC-028



AC: REC-029



AD: REC-030

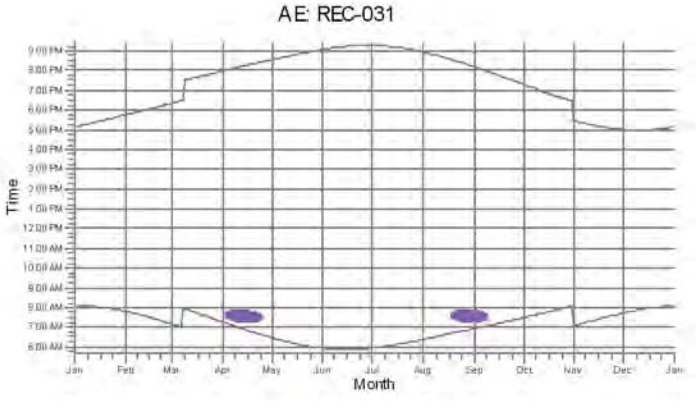


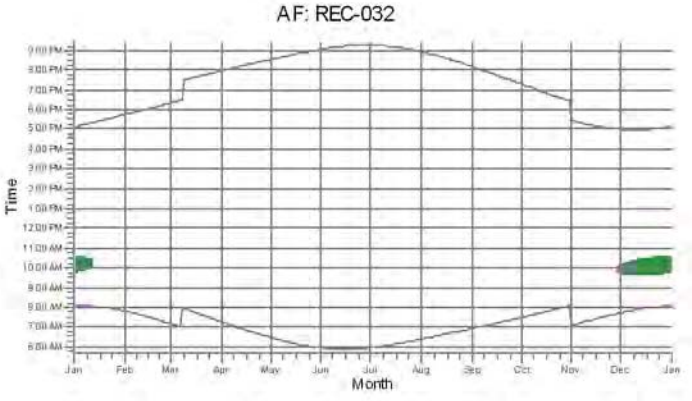
WTGs

🟩 28: T28

SHADOW - Calendar, graphical

Calculation: FlickerGE.v5


AE: REC-031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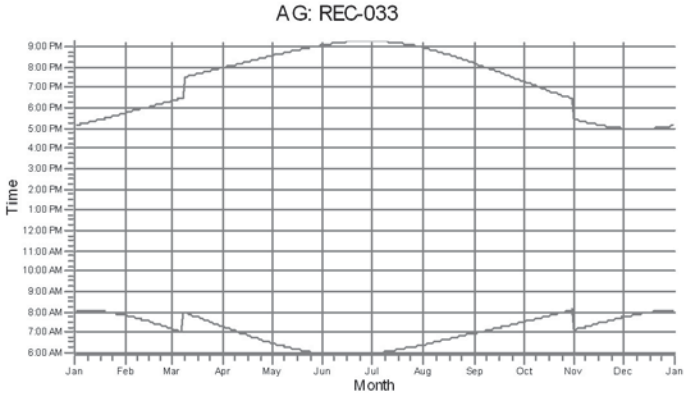
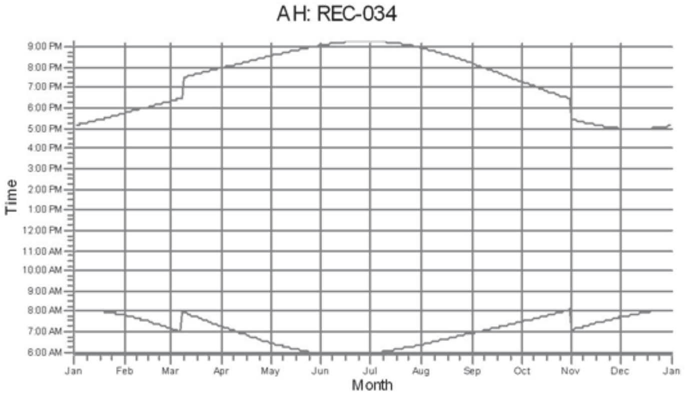
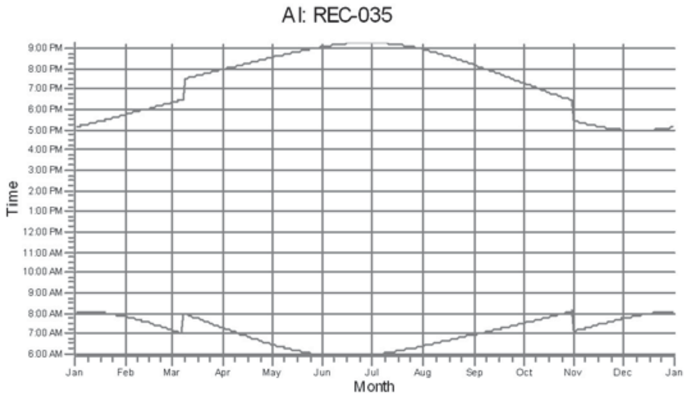
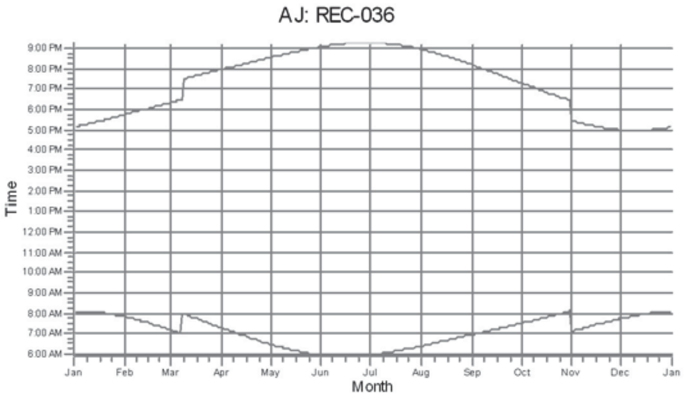

AG: REC-033


AH: REC-034


AI: REC-035


AJ: REC-036

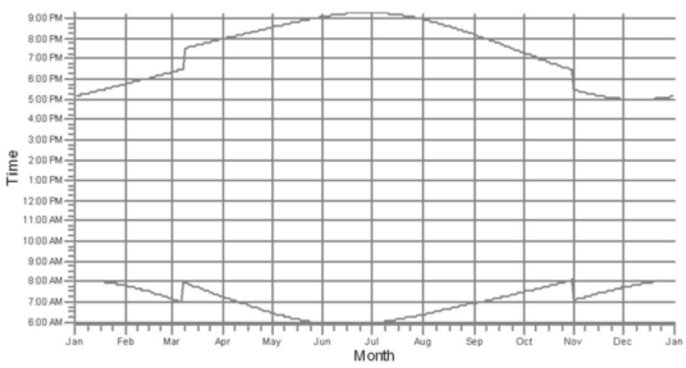
WTGs

🟩 27: T27 🟪 45: T45

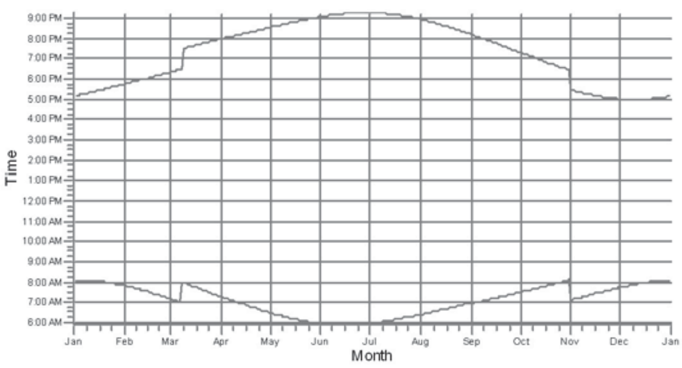
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5

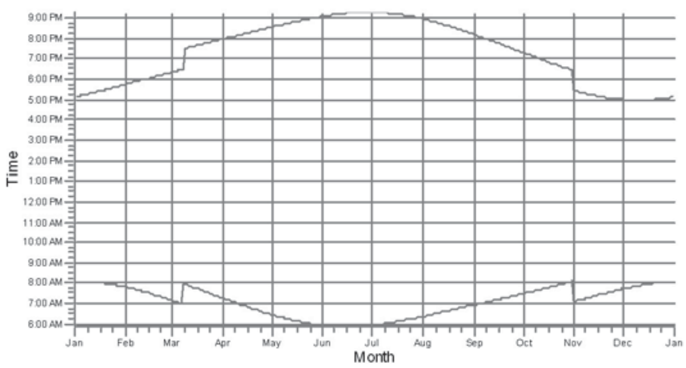
AK: REC-037



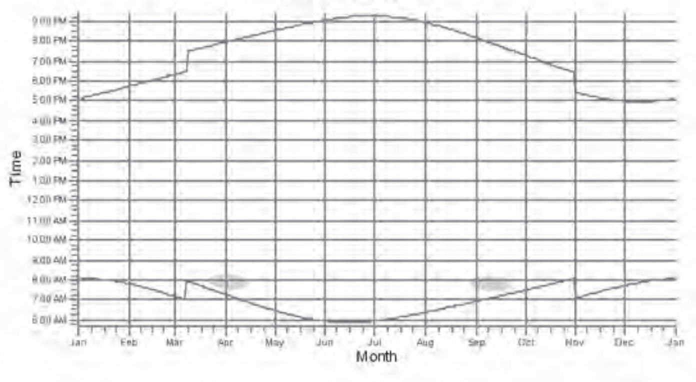
AL: REC-038



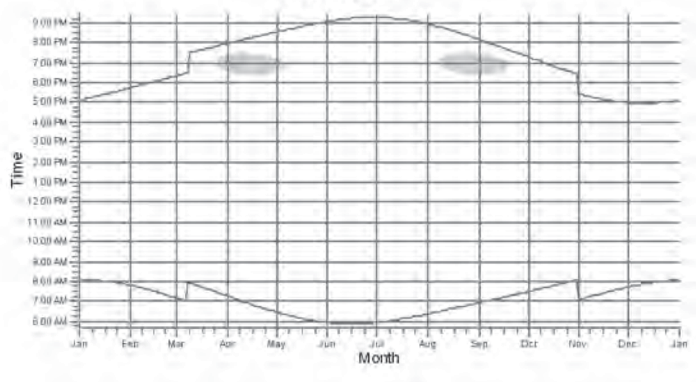
AM: REC-039



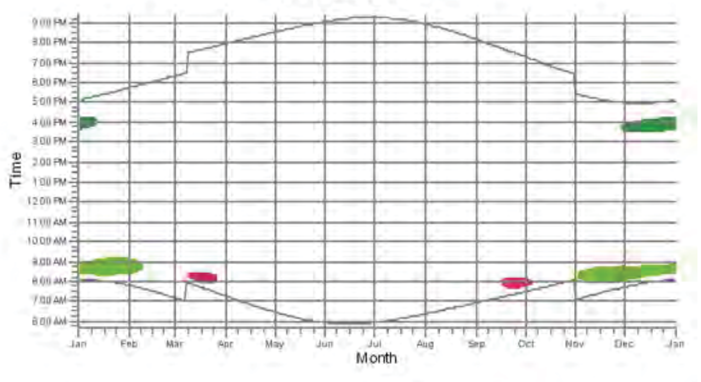
AN: REC-040



AO: REC-041



AP: REC-042



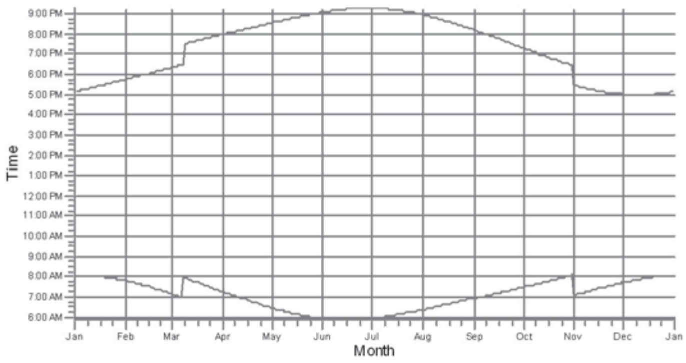
WTGs

🟩 14: T14
🟩 27: T27
🟩 52: T52
🟥 53: T53

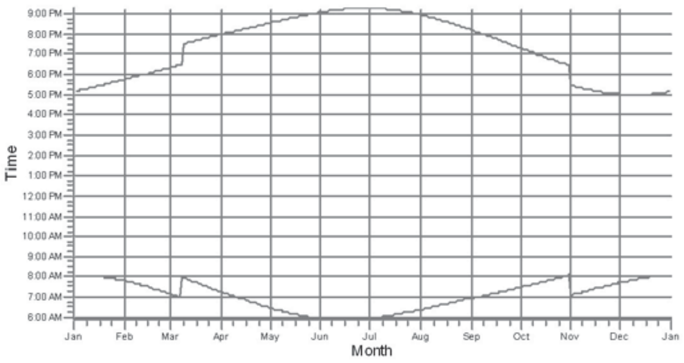
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5

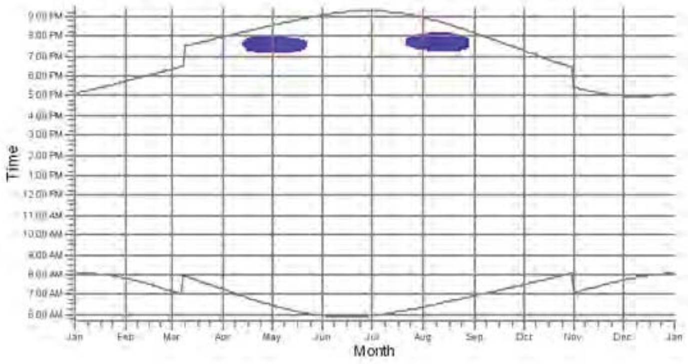
AQ: REC-043



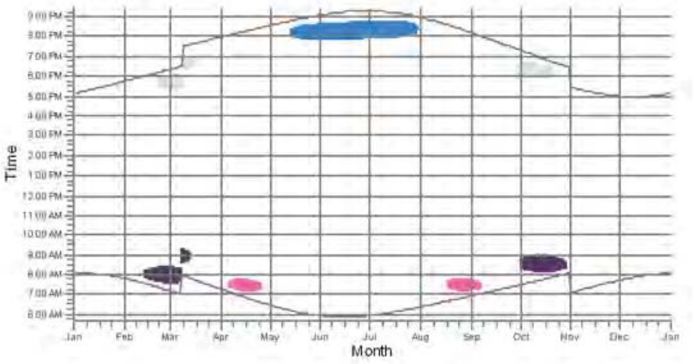
AR: REC-044



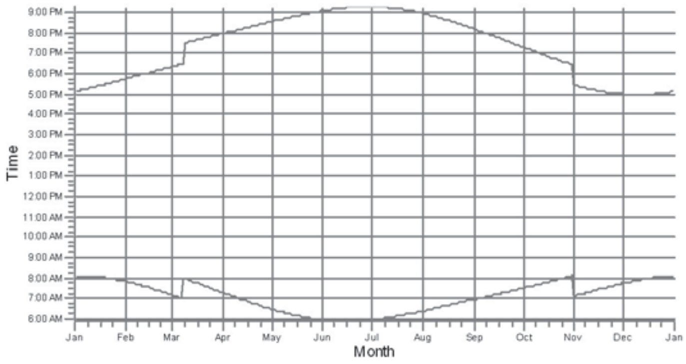
AS: REC-045



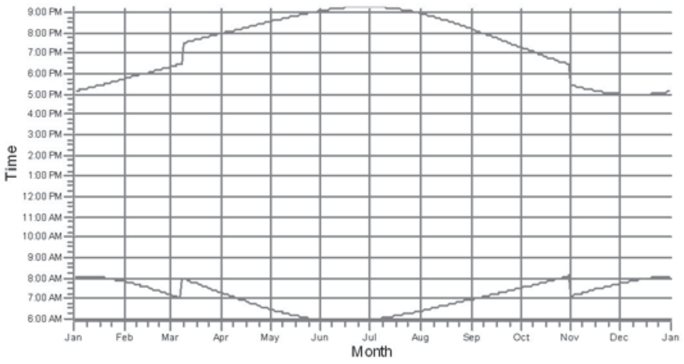
AT: REC-046



AU: REC-047



AV: REC-048



WTGs

■ 42: T42 ■ 60: T61 ■ 61: T62 ■ 62: T63 ■ 63: T64

Project:

Prevailing Wind Park

Description:

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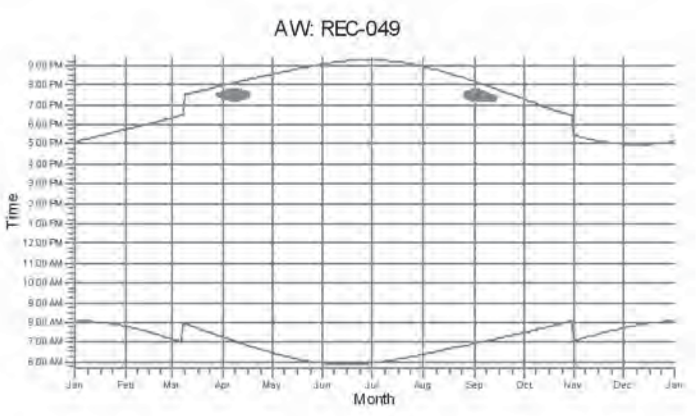
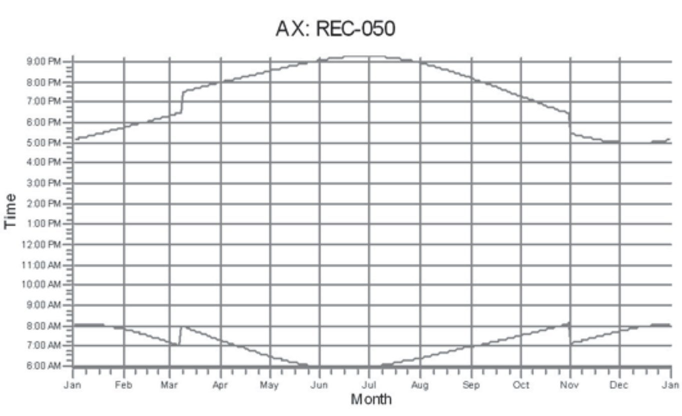
Calculated:

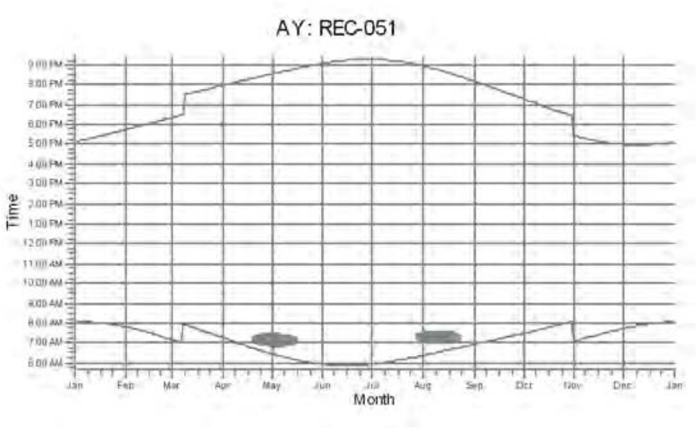
5/25/2018 10:53 AM/3.0.654

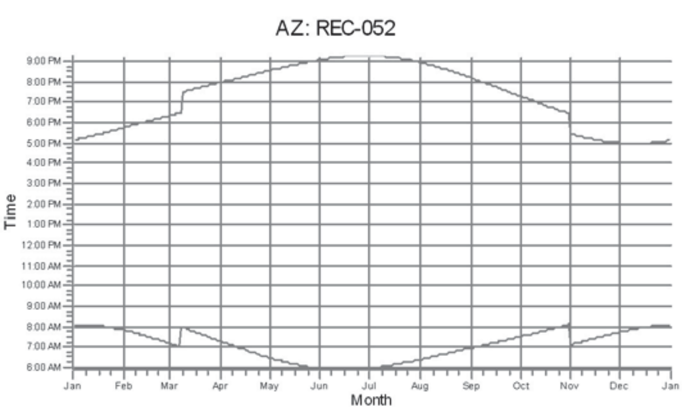
SHADOW - Calendar, graphical

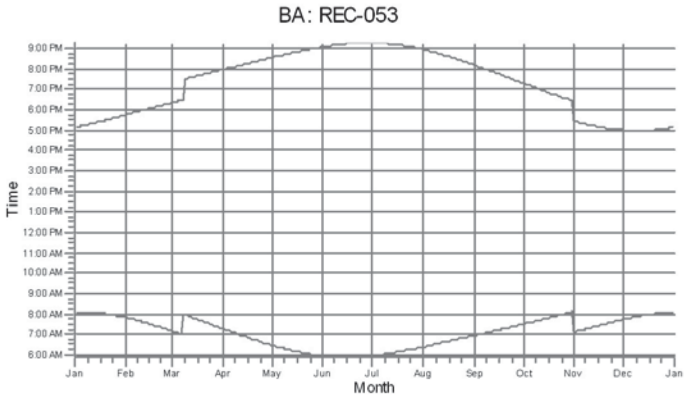
Calculation: FlickerGE.v5

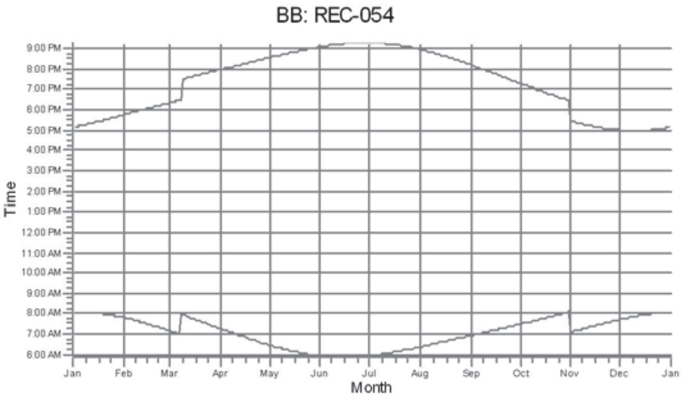












WTGs

▨ 38: T38

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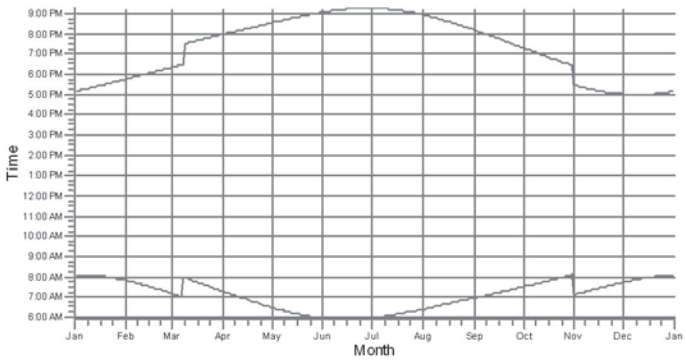
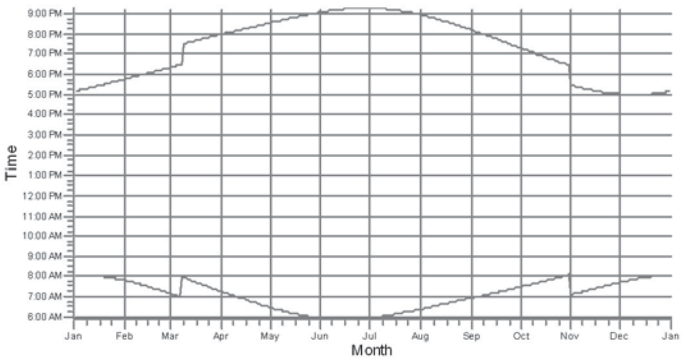
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5


BC: REC-055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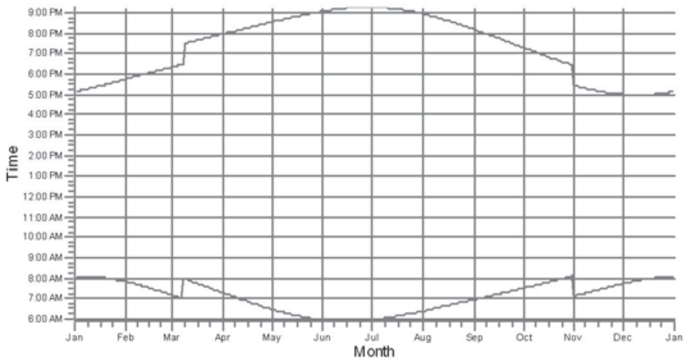
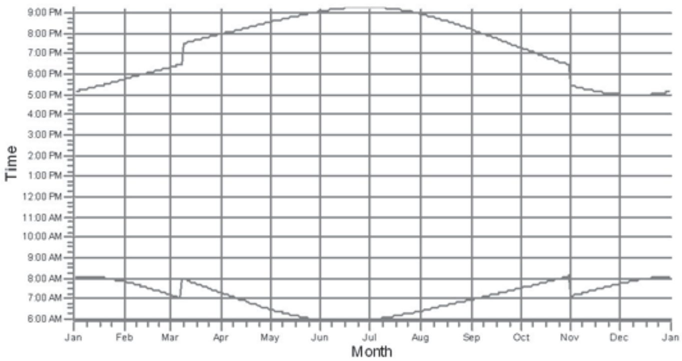
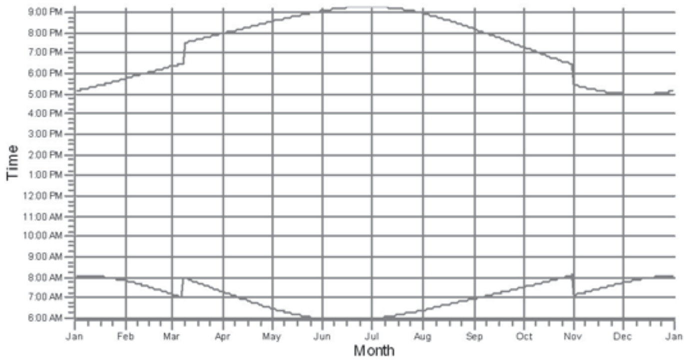
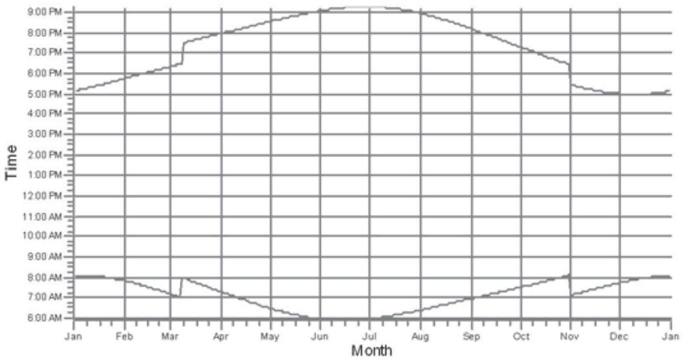

BE: REC-057


BF: REC-058

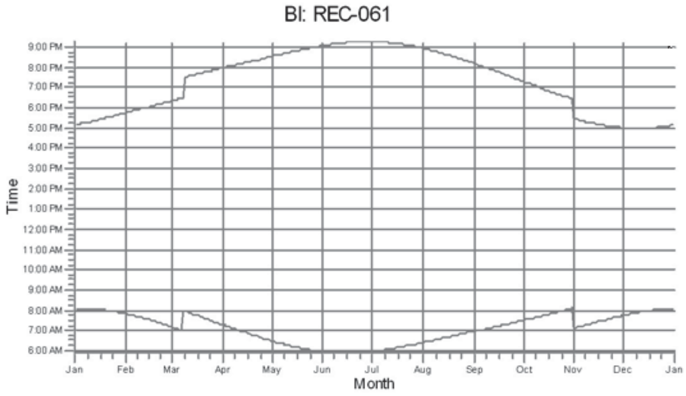

BG: REC-059

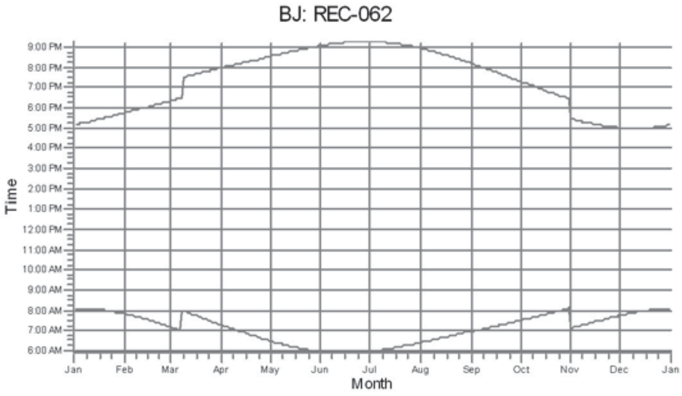

BH: REC-060

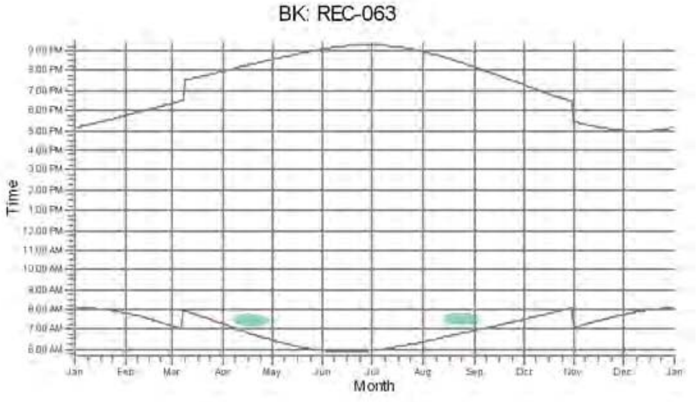
WTGs

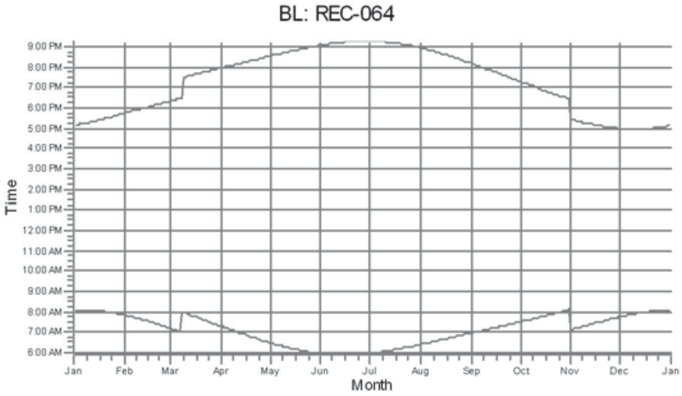
SHADOW - Calendar, graphical

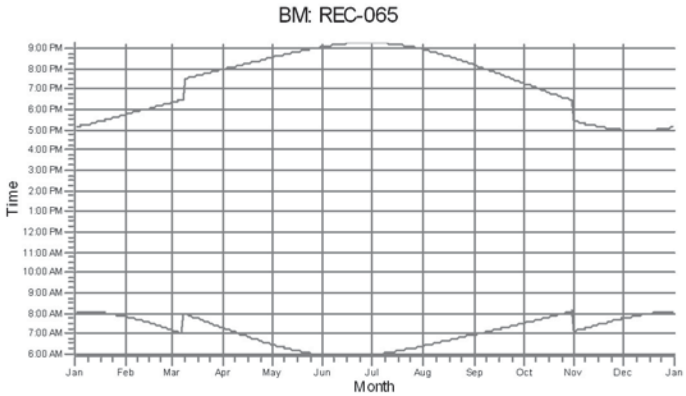
Calculation: FlickerGE.v5

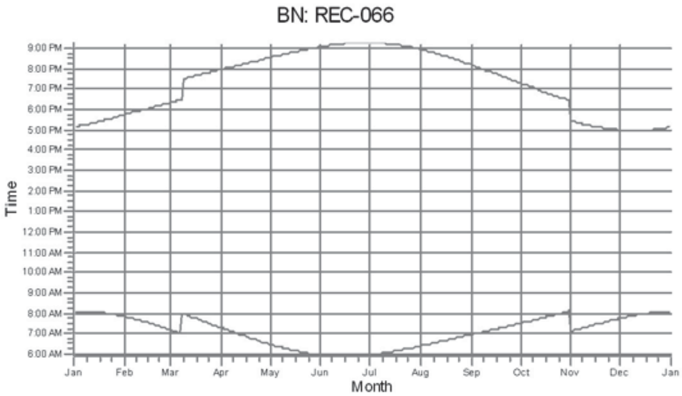










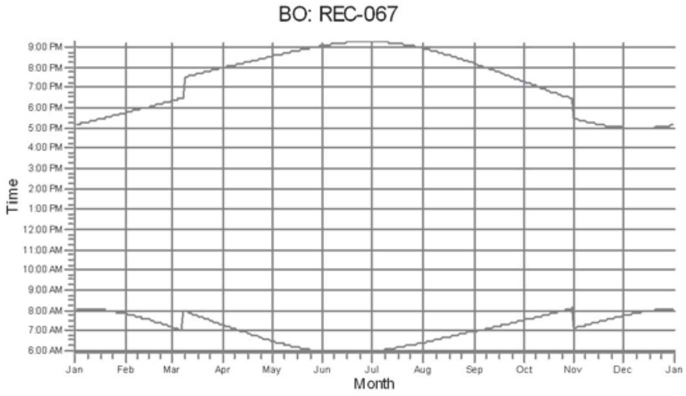


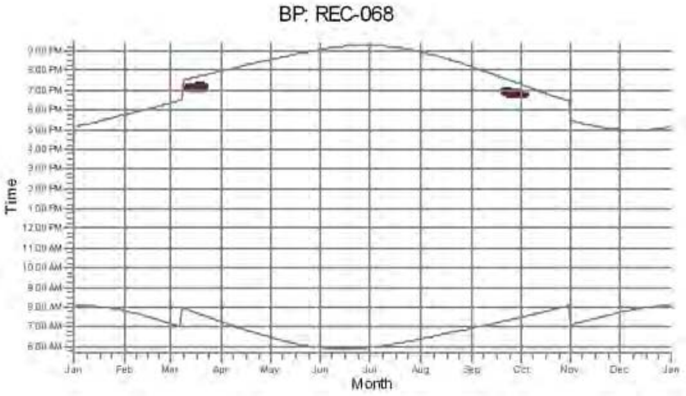
WTGs

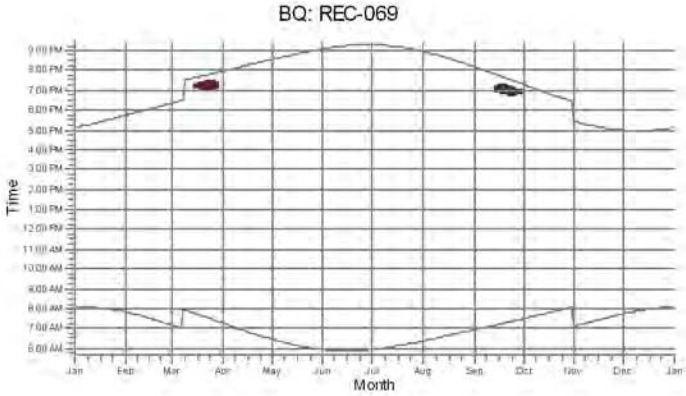
🟩 48: T48

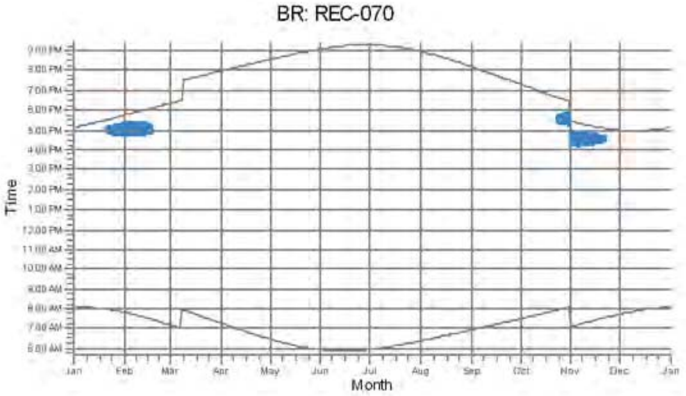
SHADOW - Calendar, graphical

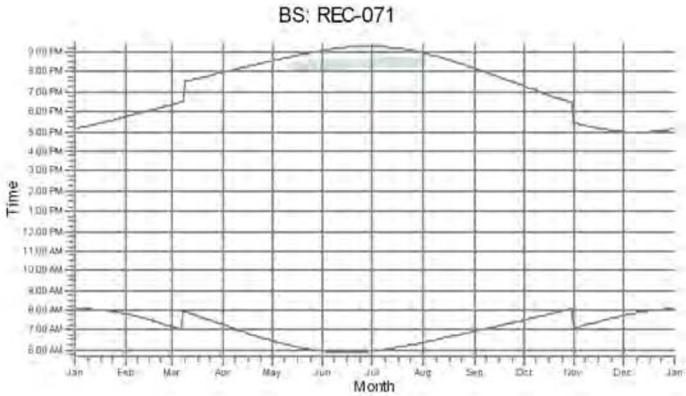
Calculation: FlickerGE.v5

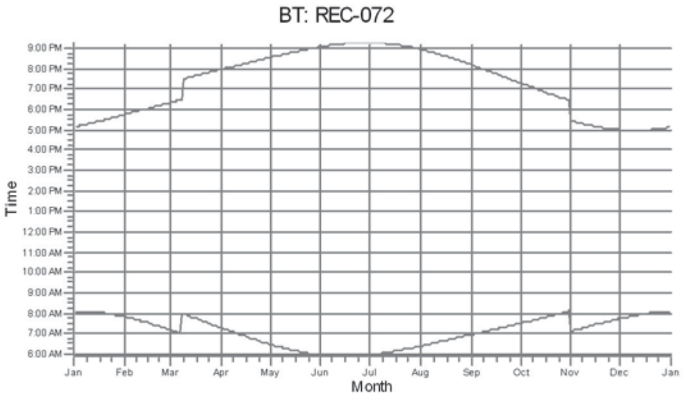

BO: REC-067


BP: REC-068


BQ: REC-069


BR: REC-070


BS: REC-071


BT: REC-072

WTGs

🟥 32: T32 🟩 61: T62 🟦 62: T63

Project:

Prevailing Wind Park

Description:

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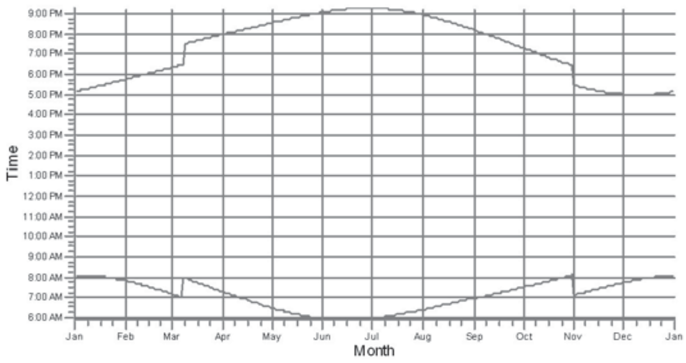
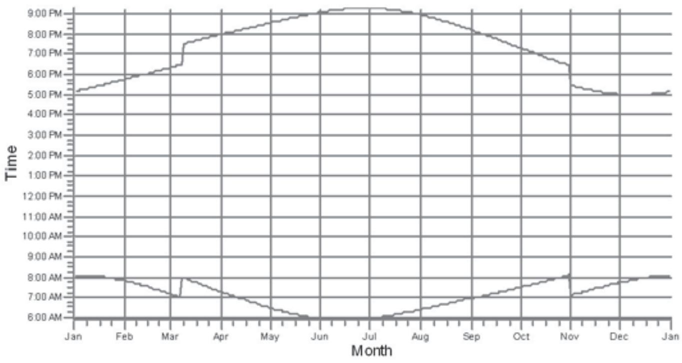
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5

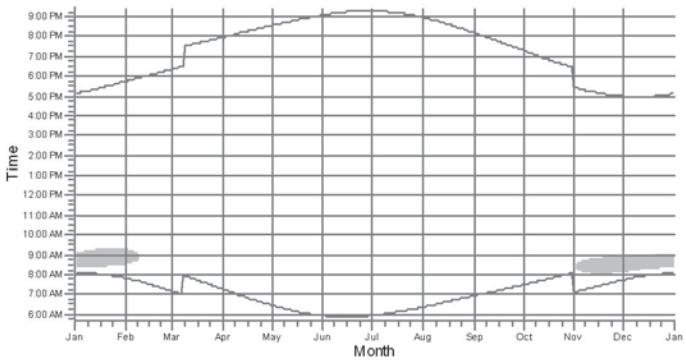
BU: REC-073



BV: REC-074



BW: REC-075



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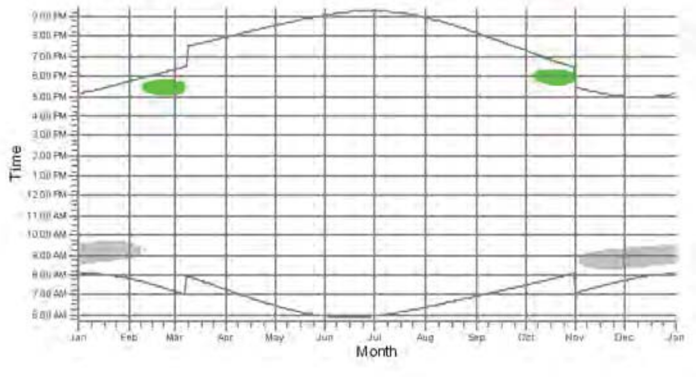
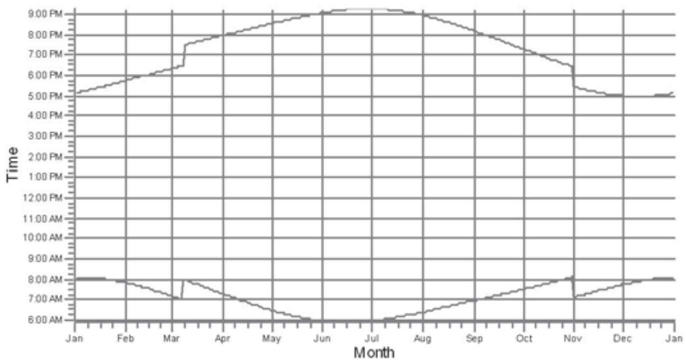
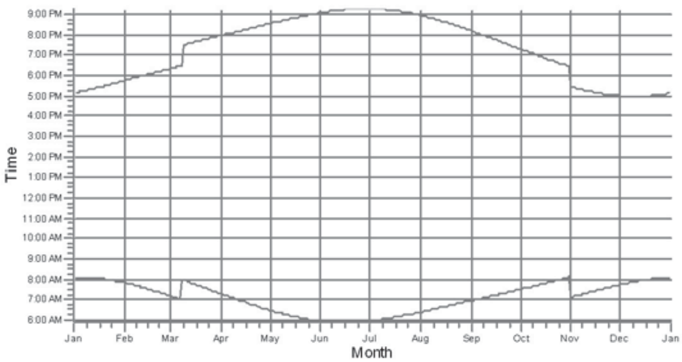


BY: REC-077



BZ: REC-078



WTGs

🟩 9: T9 ▨ 12: T12

Project:
Prevailing Wind Park

Description:
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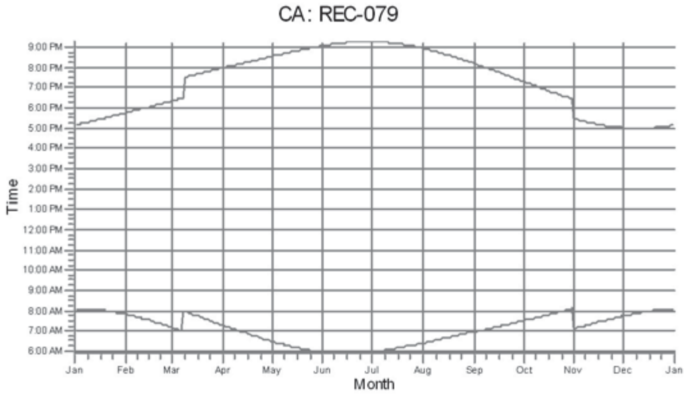
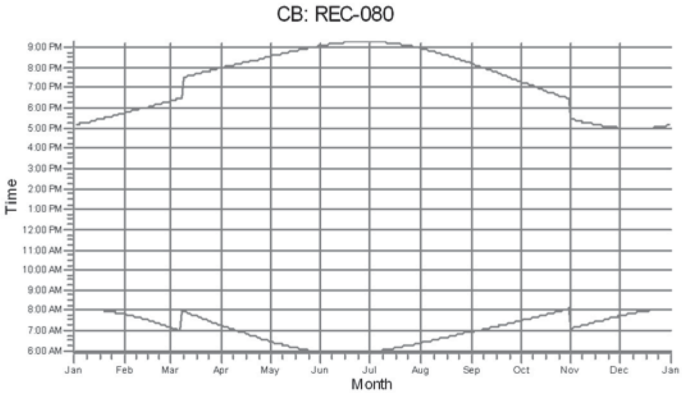
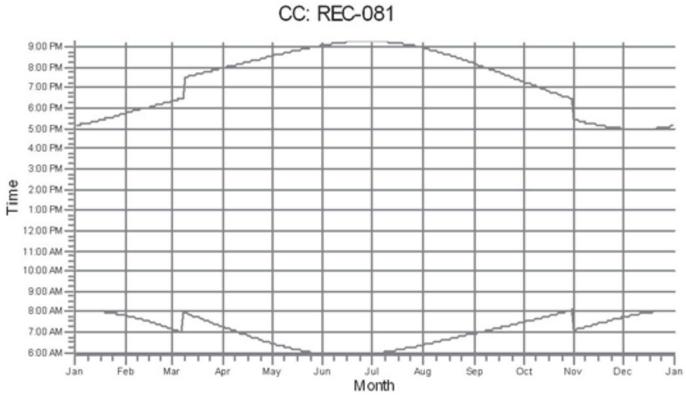
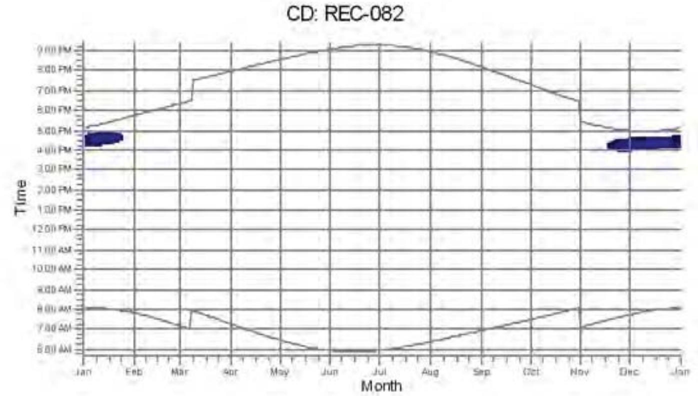
SHADOW - Calendar, graphical

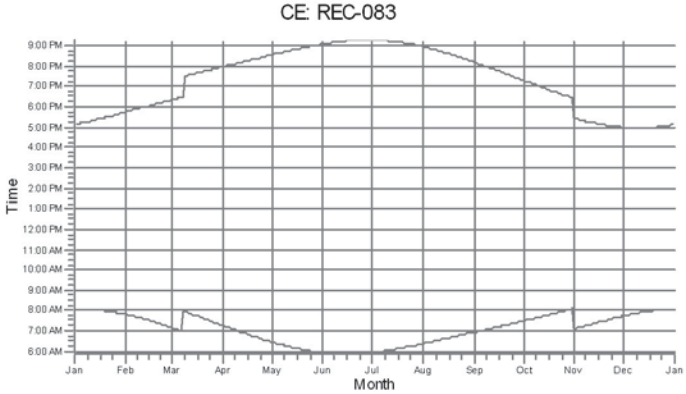
Calculation: FlickerGE.v5

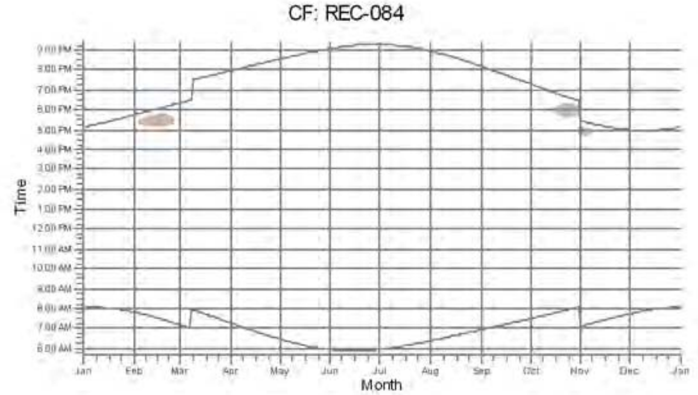












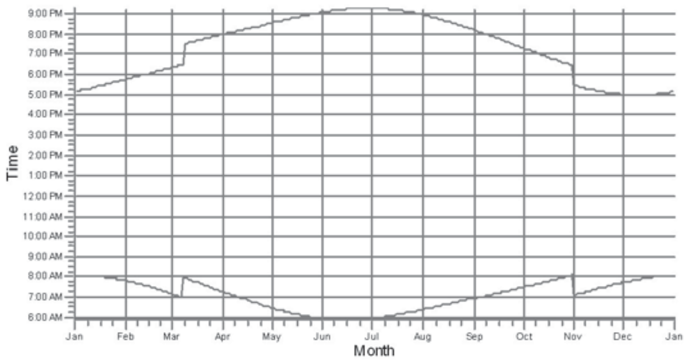
WTGs

🟦 7: T7 🟫 17: T17

SHADOW - Calendar, graphical

Calculation: FlickerGE.v5

CG: REC-085



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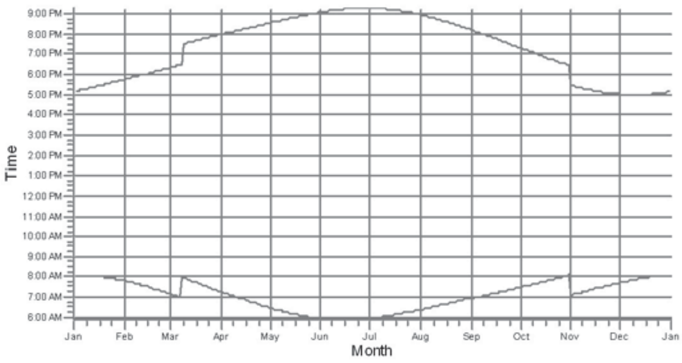

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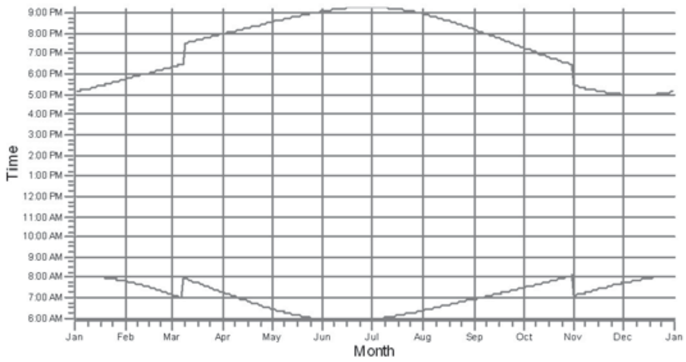

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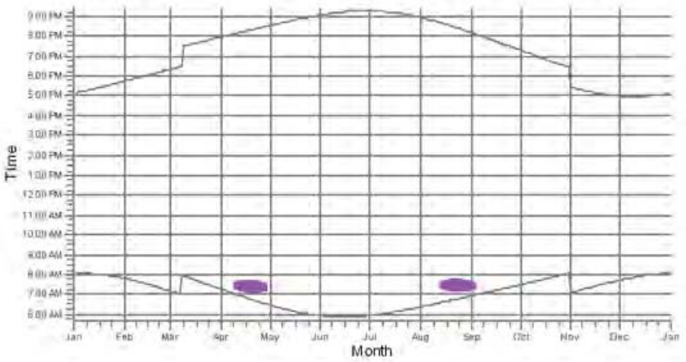

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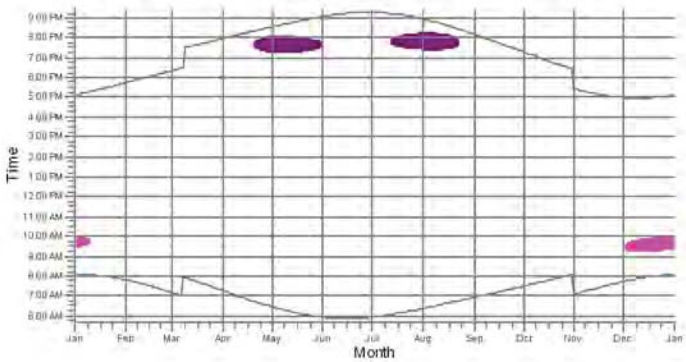

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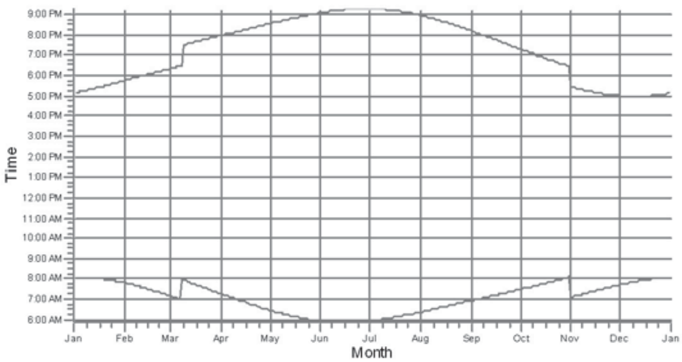
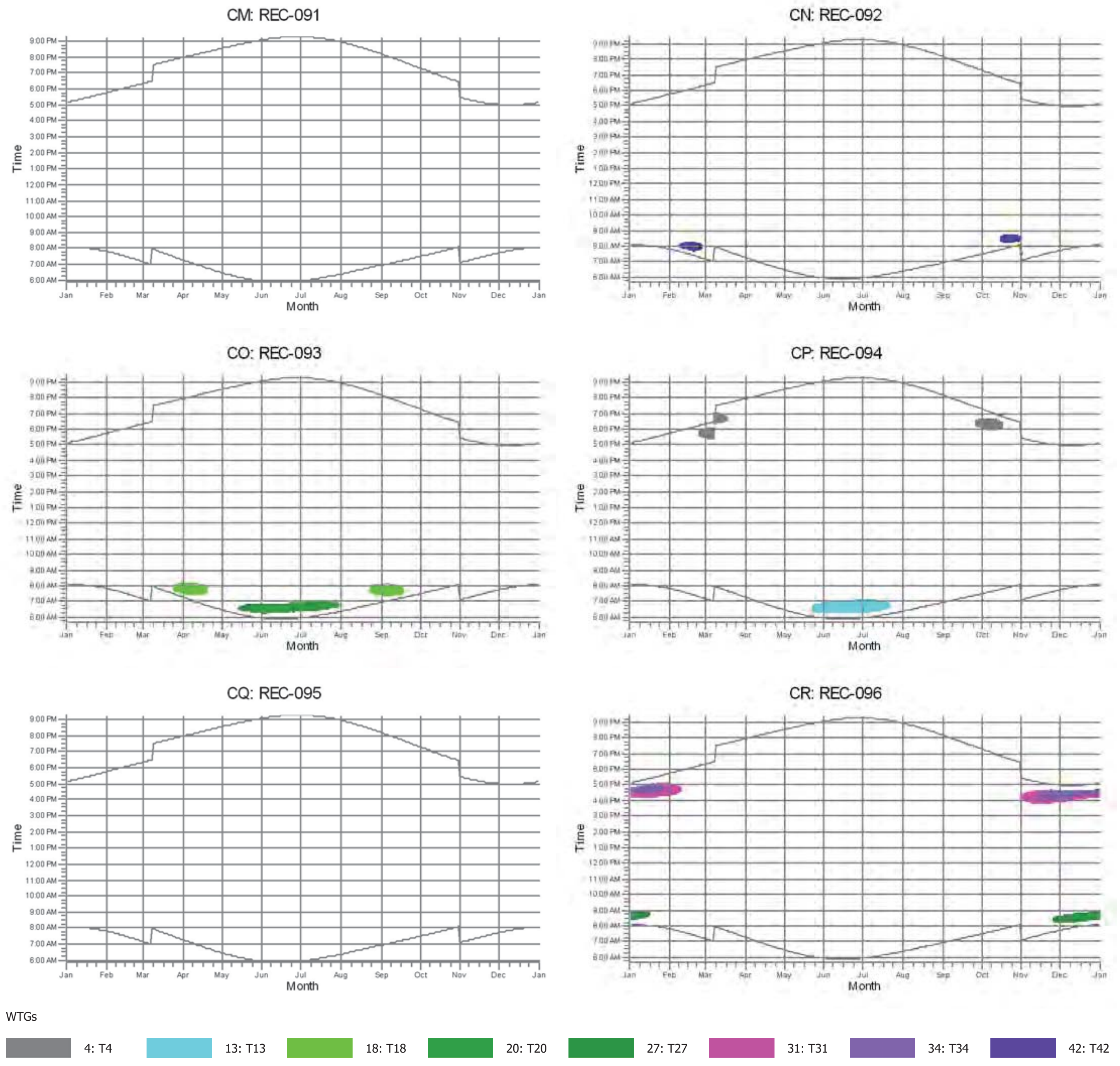


WTGs

■ 11: T11 ■ 31: T31 ■ 43: T43

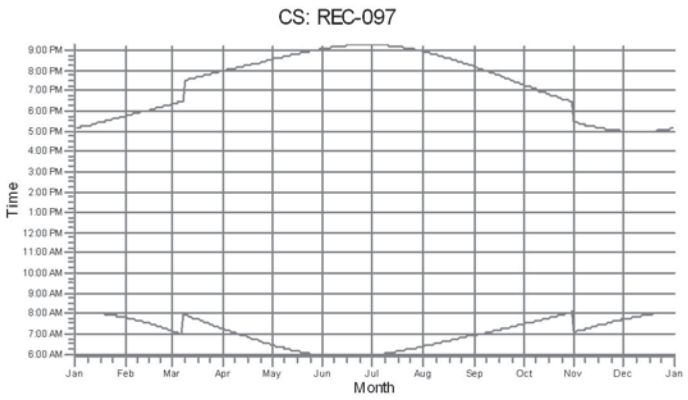
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5



SHADOW - Calendar, graphical

Calculation: FlickerGE.v5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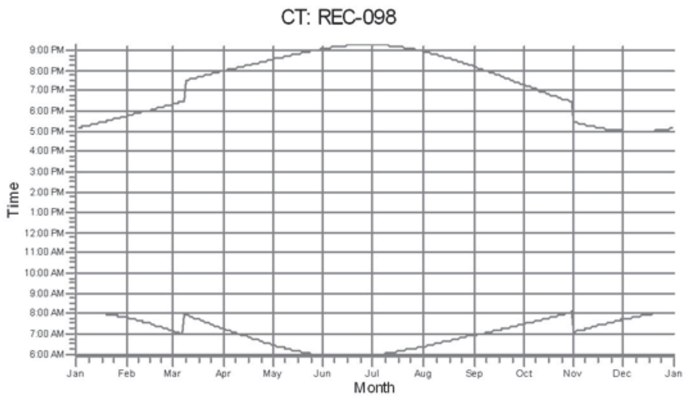
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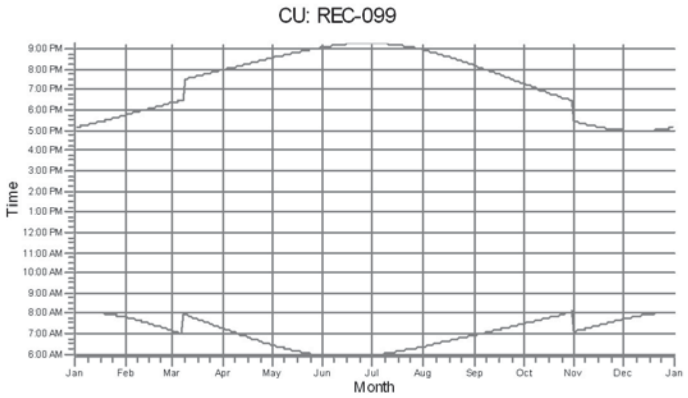
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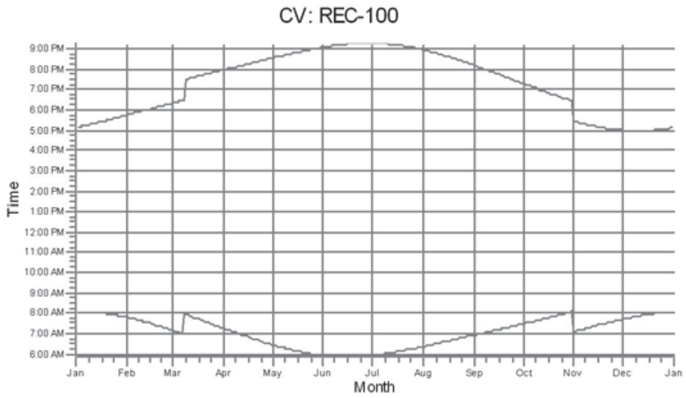
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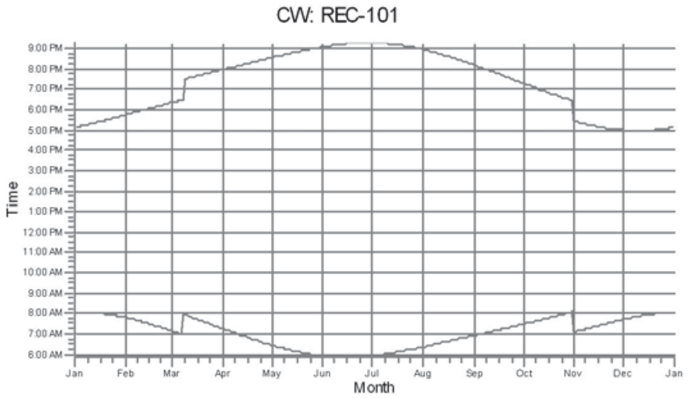
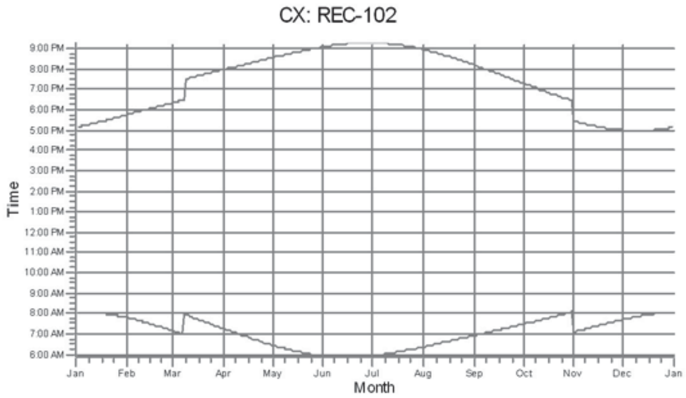

CW: REC-101

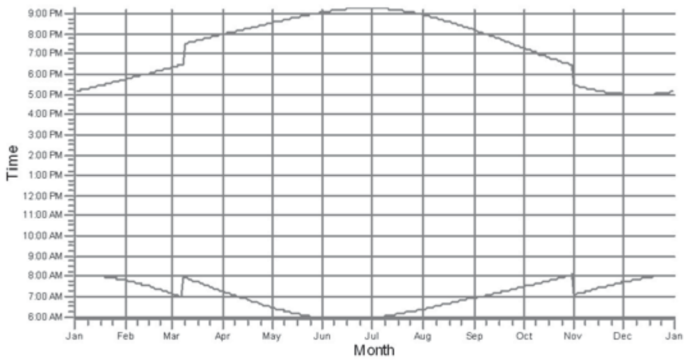

CX: REC-102

WTGs

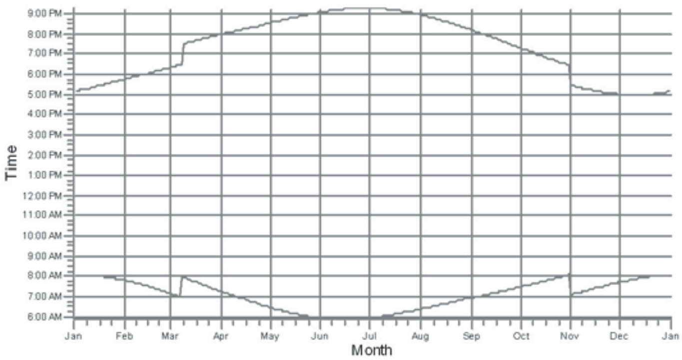
SHADOW - Calendar, graphical

Calculation: FlickerGE.v5

CY: REC-103



CZ: REC-104



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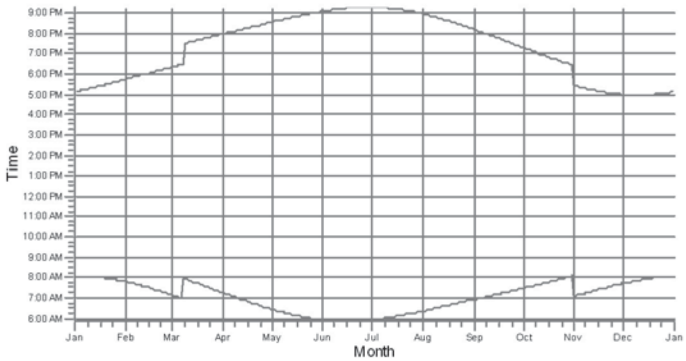

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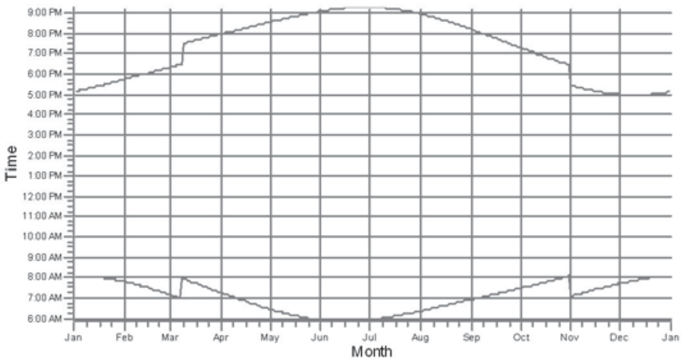

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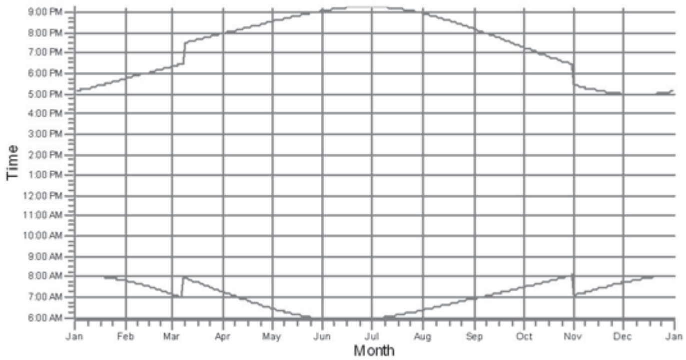

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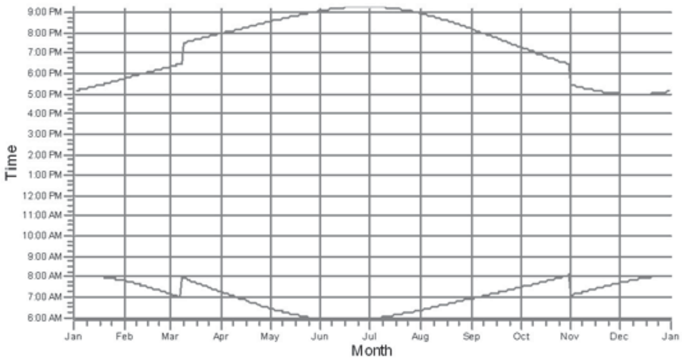

WTGs

Project:
Prevailing Wind Park

Description:
Burns & McDonnell has relied upon information provided by third-party sources to complete this study. While there is no reason to believe that the information provided is inaccurate or incomplete in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee or warranty its accuracy or completeness.
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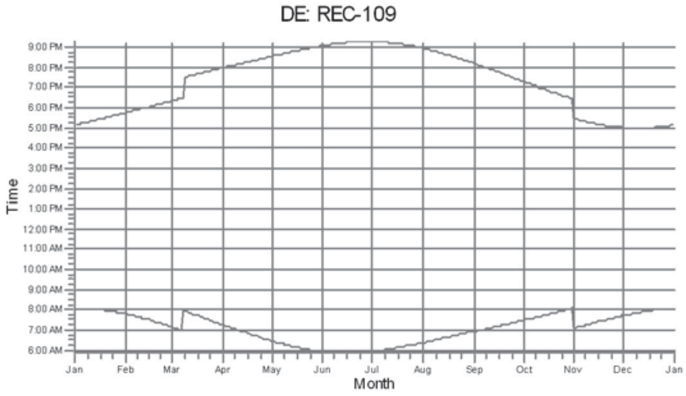
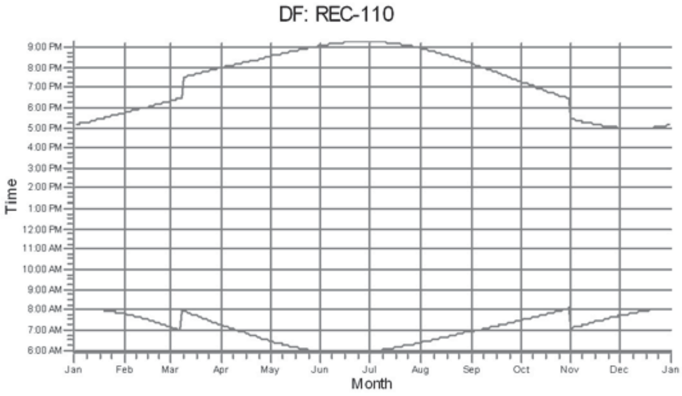
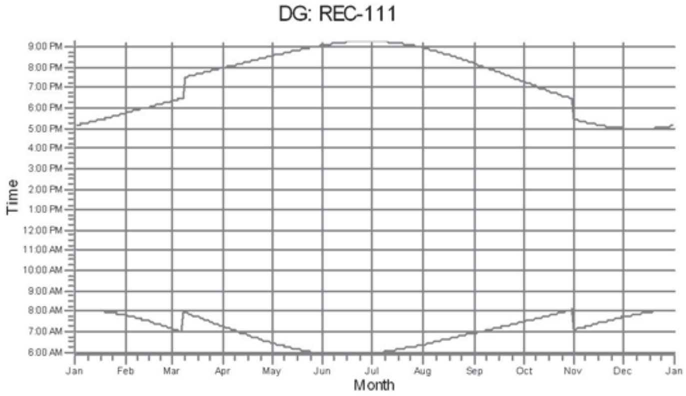
Calculated:
5/25/2018 10:53 AM/3.0.654

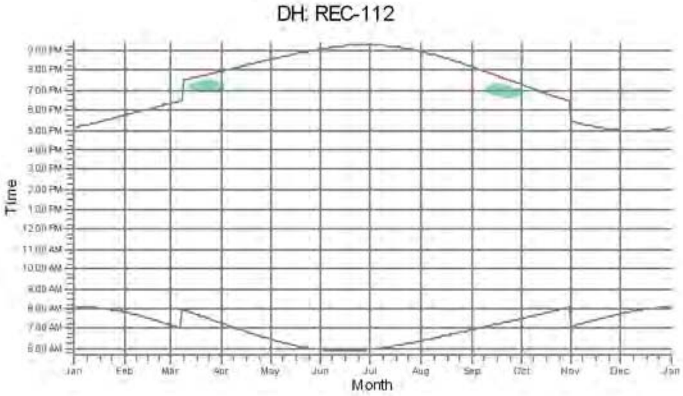
SHADOW - Calendar, graphical

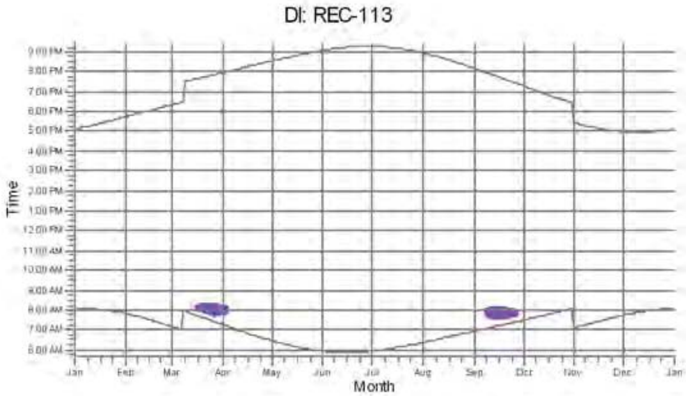
Calculation: FlickerGE.v5

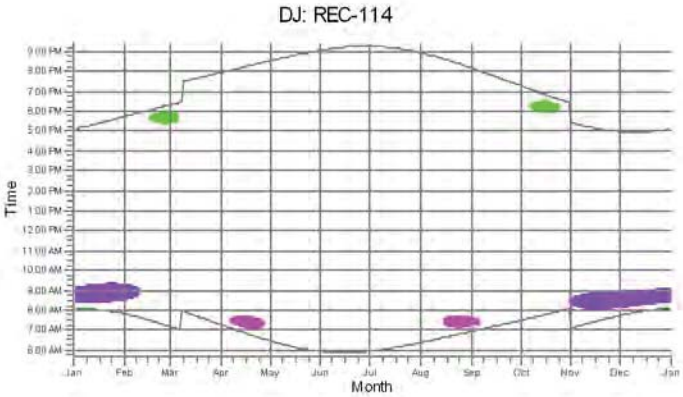










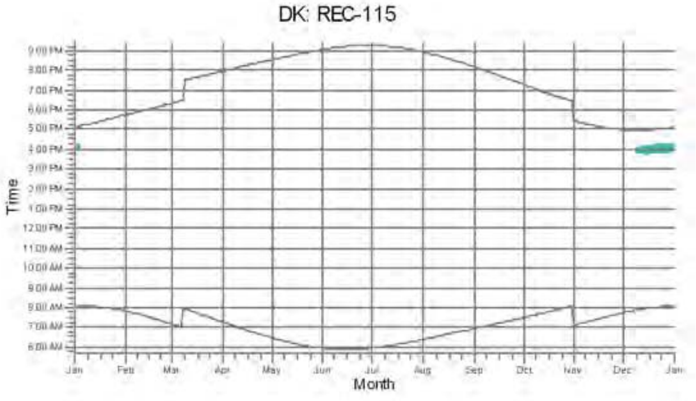


WTGs

🟩 18: T18 🟩 26: T26 🟪 46: T46 🟪 47: T47

SHADOW - Calendar, graphical

Calculation: FlickerGE.v5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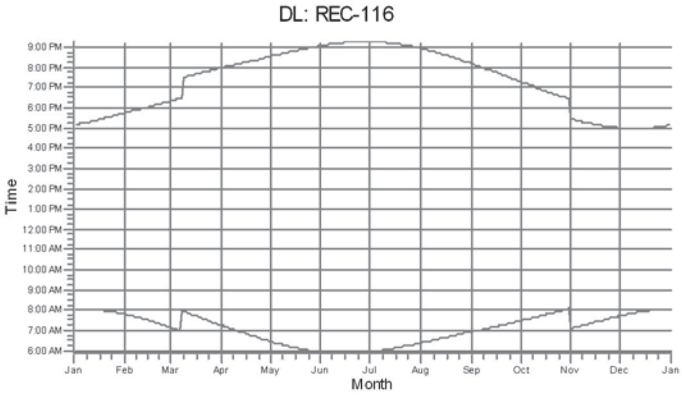
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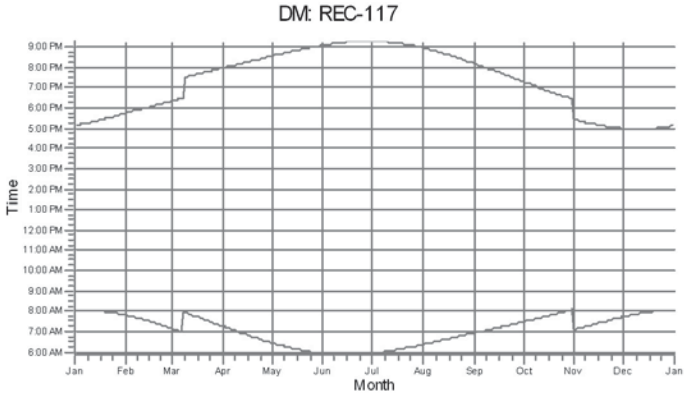
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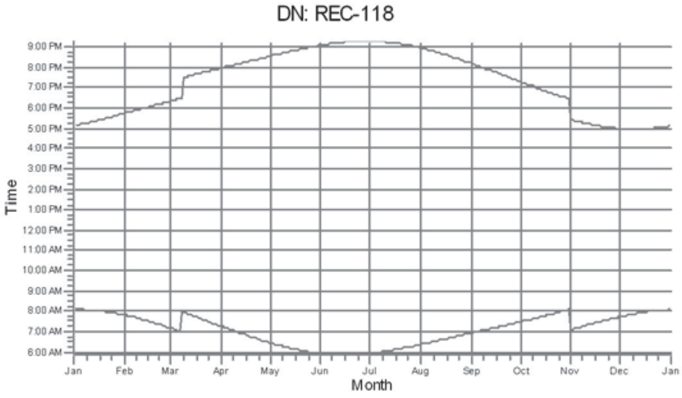
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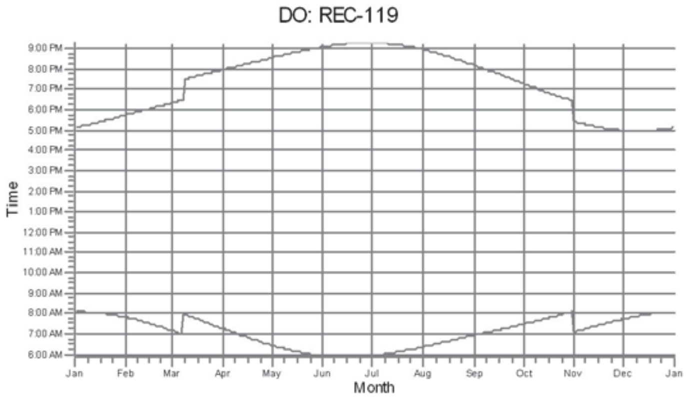
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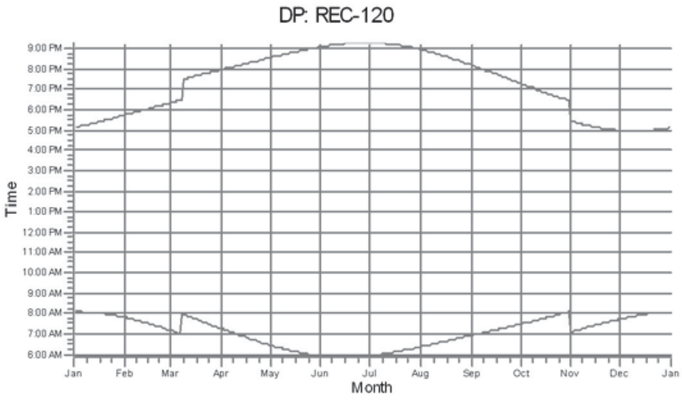

DP: REC-120

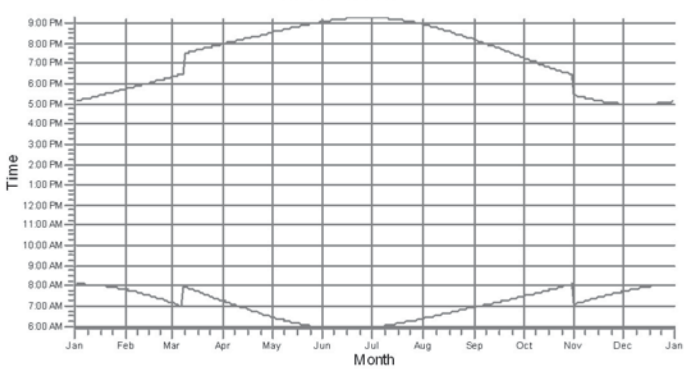
WTGs

🟩 21: T21

SHADOW - Calendar, graphical

Calculation: FlickerGE.v5

DQ: REC-121



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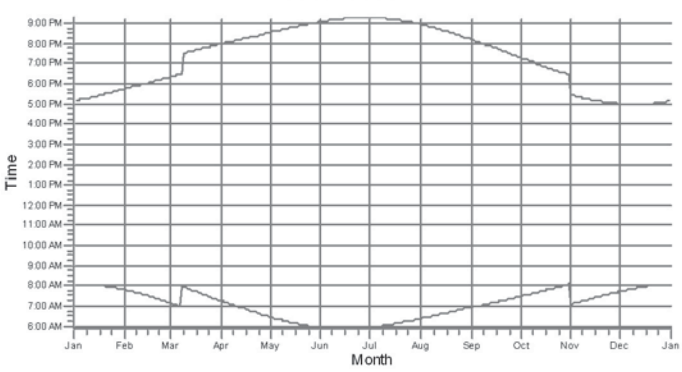

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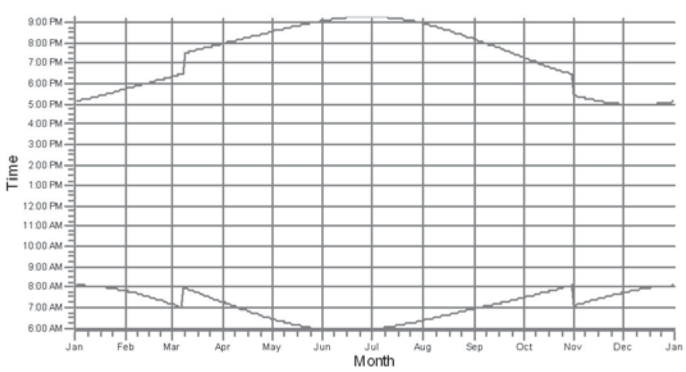

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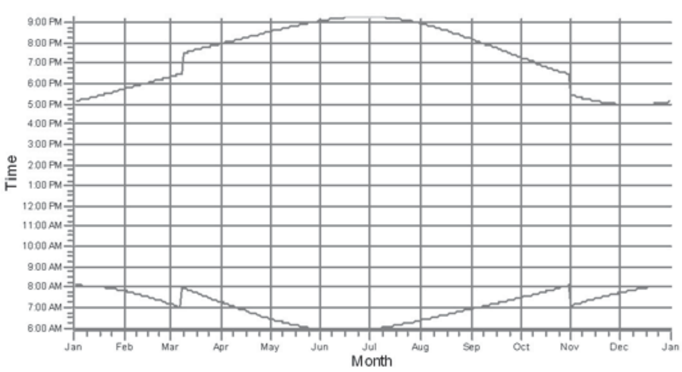
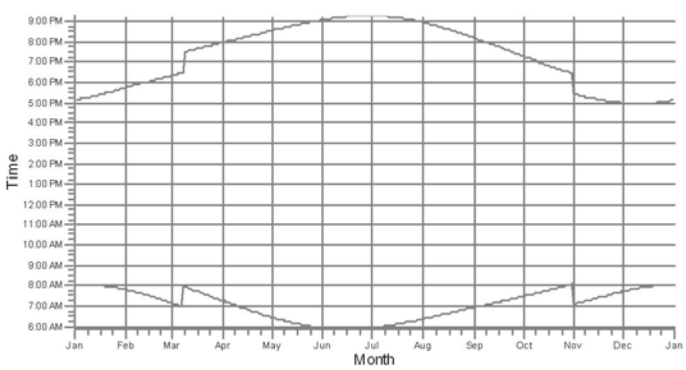


DU: REC-125



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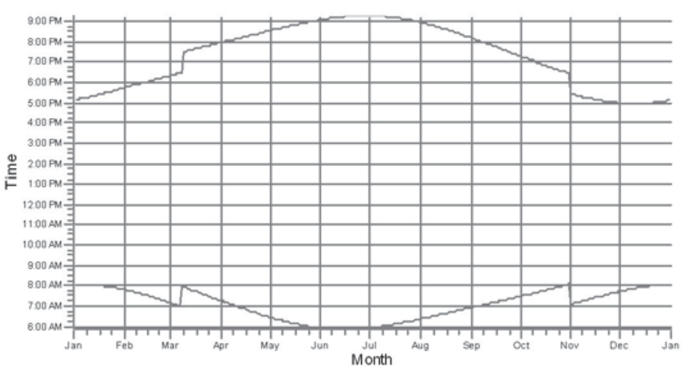
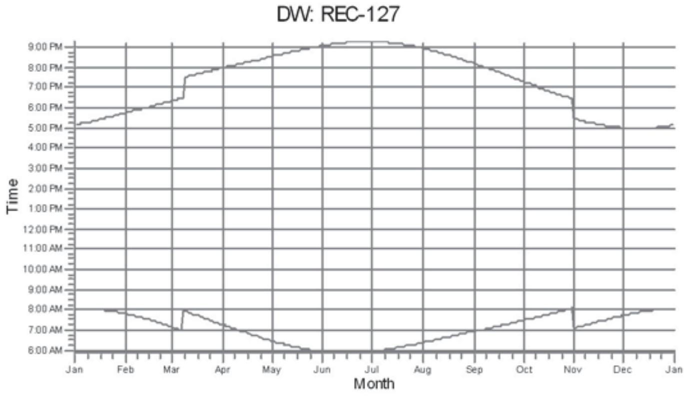


WTGs

SHADOW - Calendar, graphical

Calculation: FlickerGE.v5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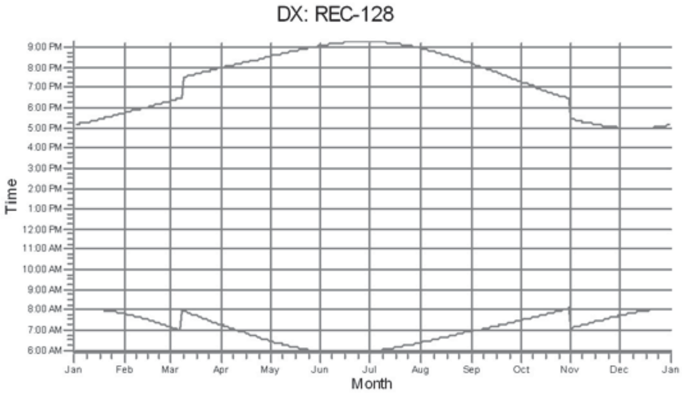
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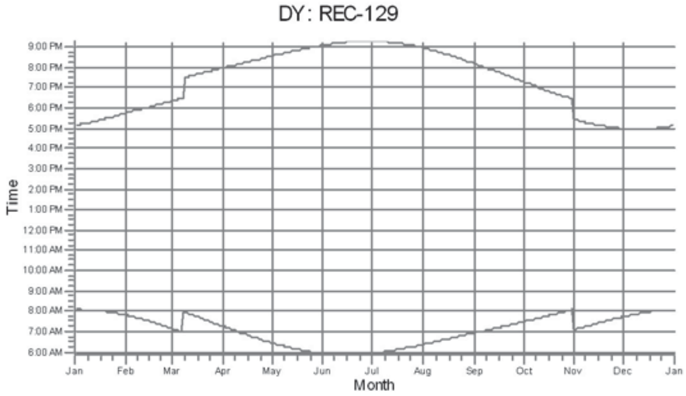
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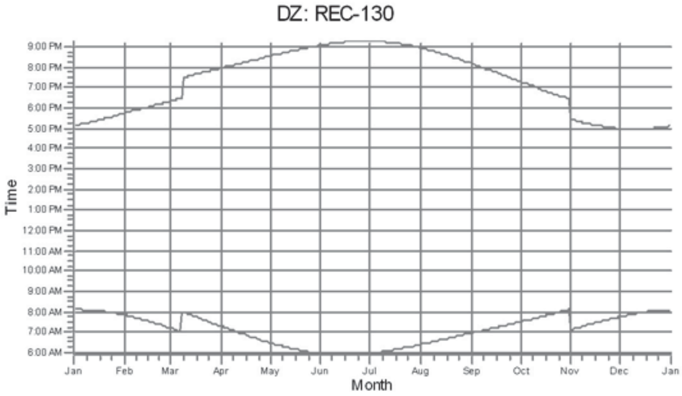
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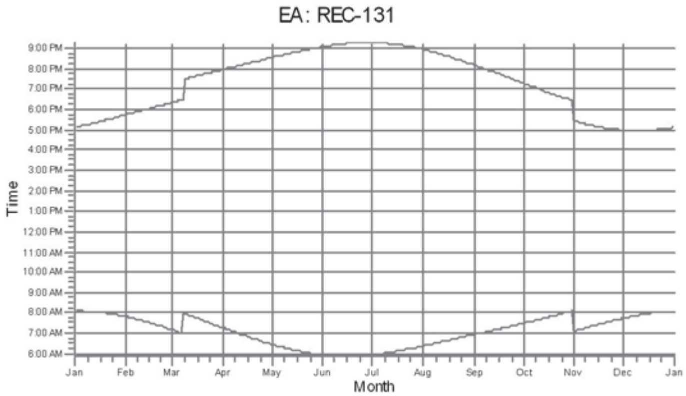
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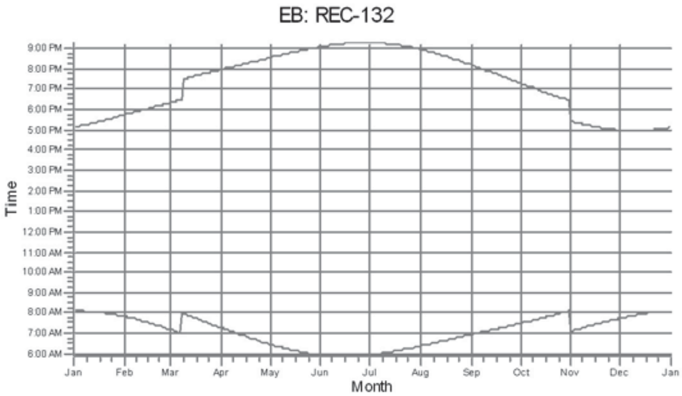
EB: REC-132

WTGs

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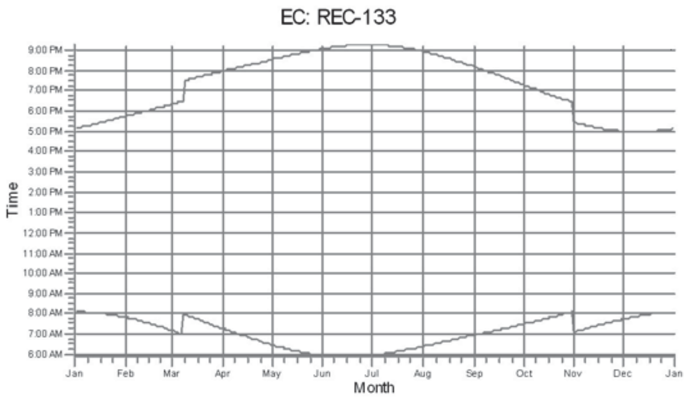
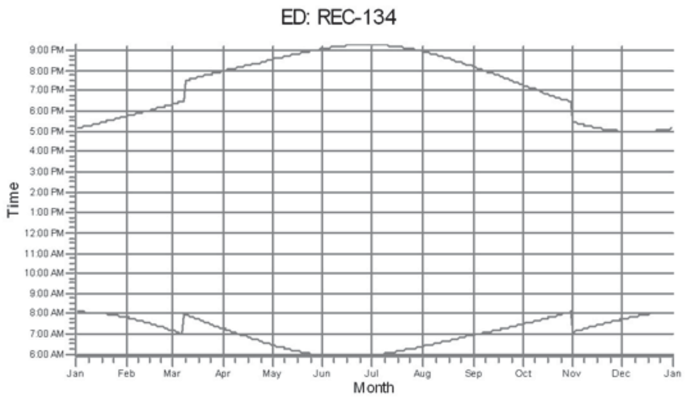
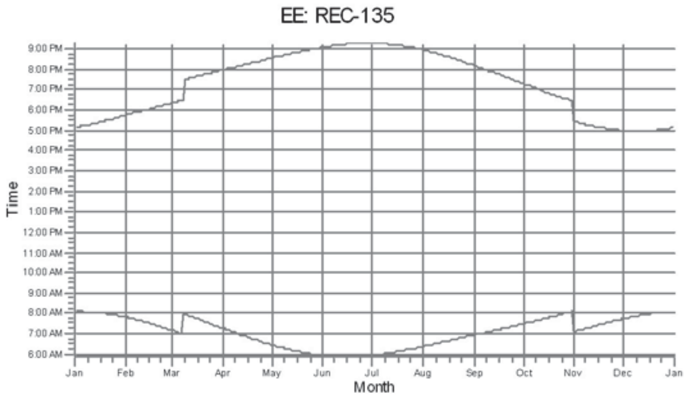
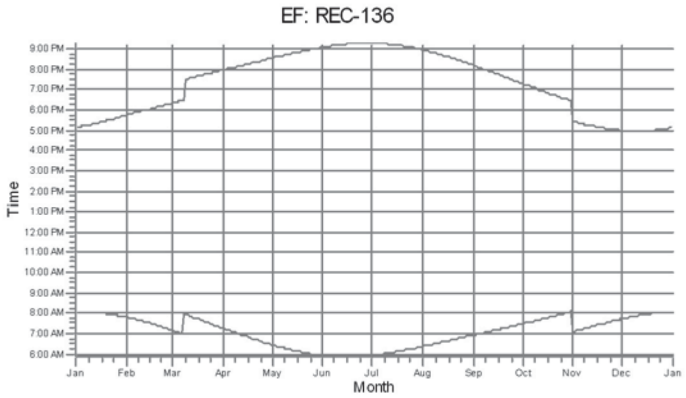
SHADOW - Calendar, graphical

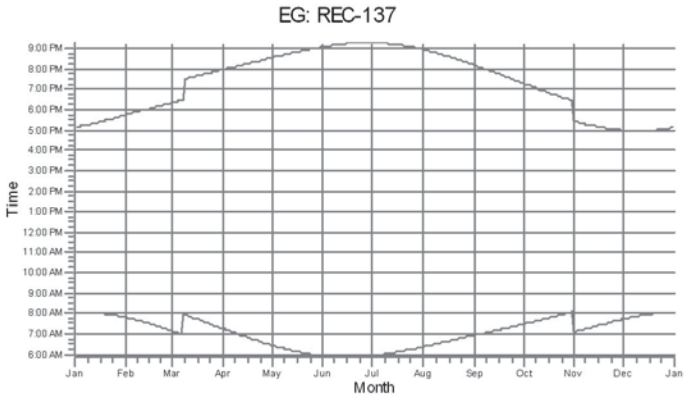
Calculation: FlickerGE.v5

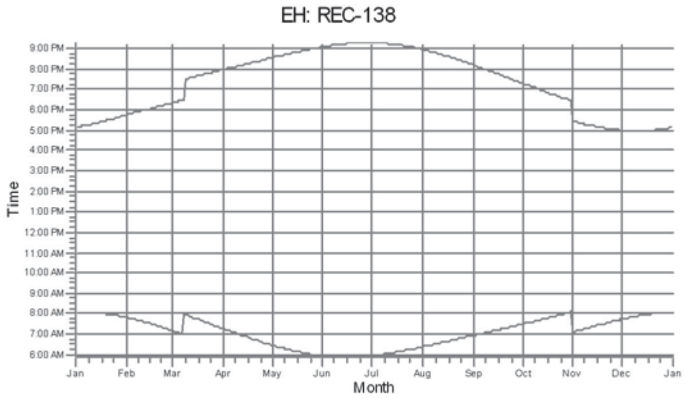












WTGs

Project:

Prevailing Wind Park

Description:

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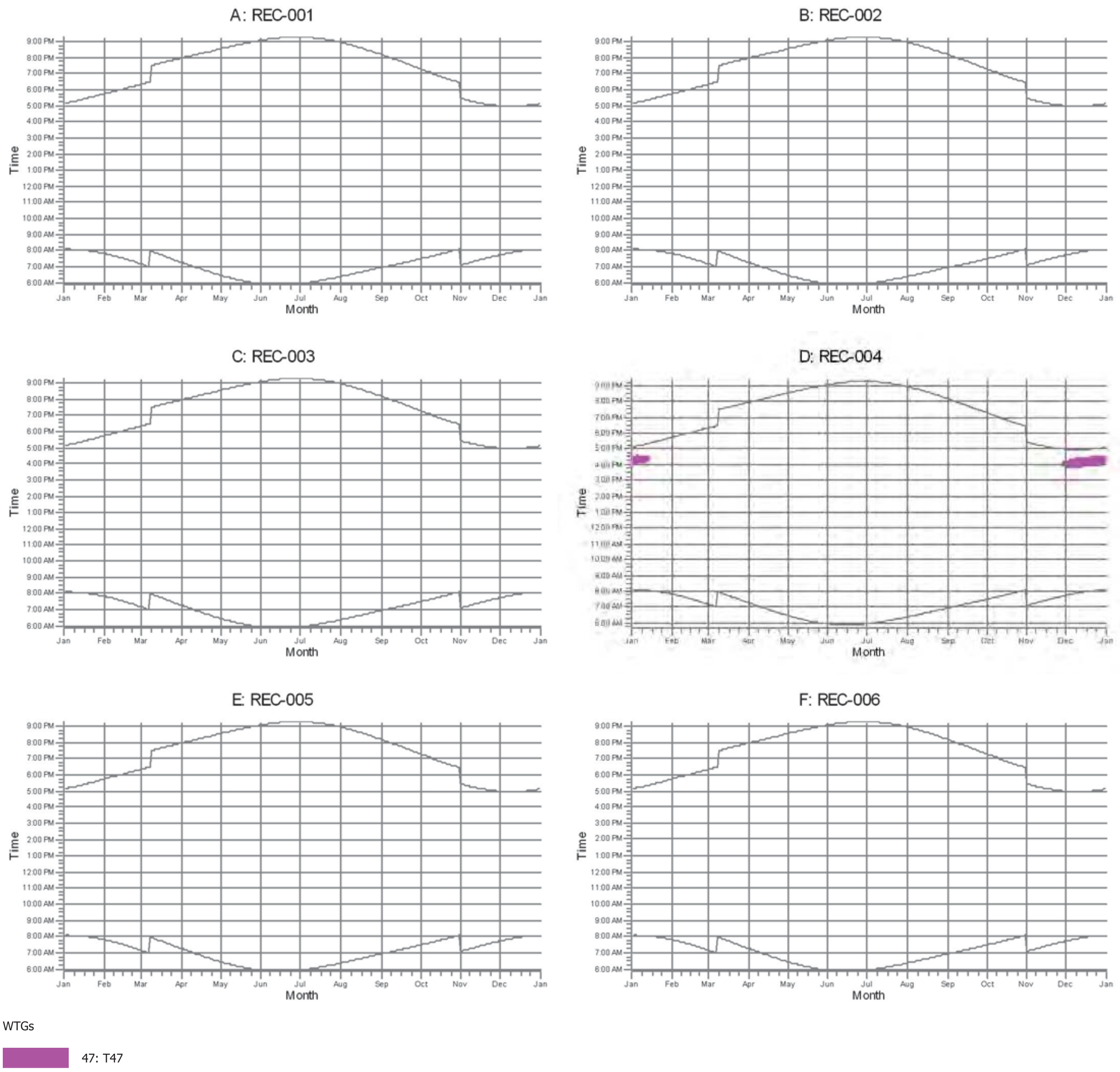
(816) 333 9400
Ella D. Rose / edrose@burnsmcd.com

Calculated:
5/25/2018 12:06 PM/3.0.654

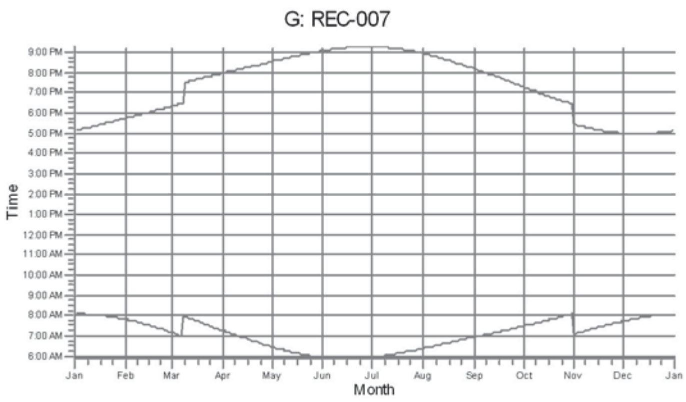
SHADOW - Calendar, graphical

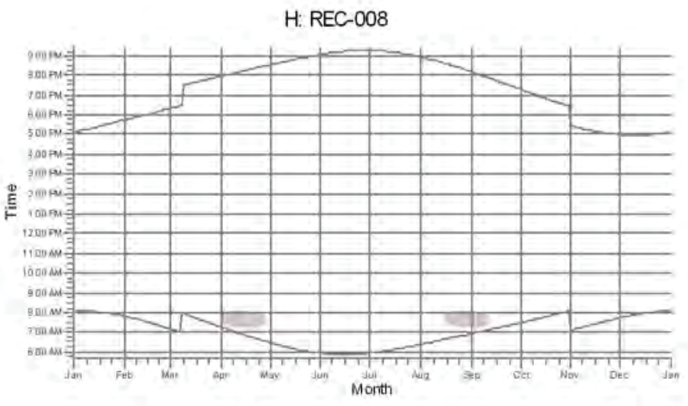
Calculation: FlickerVestas.v5

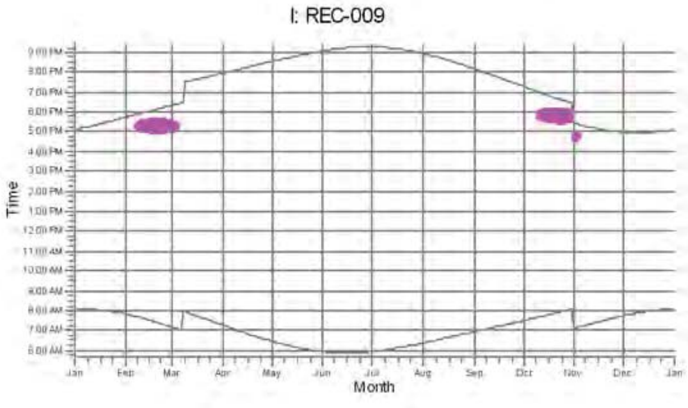


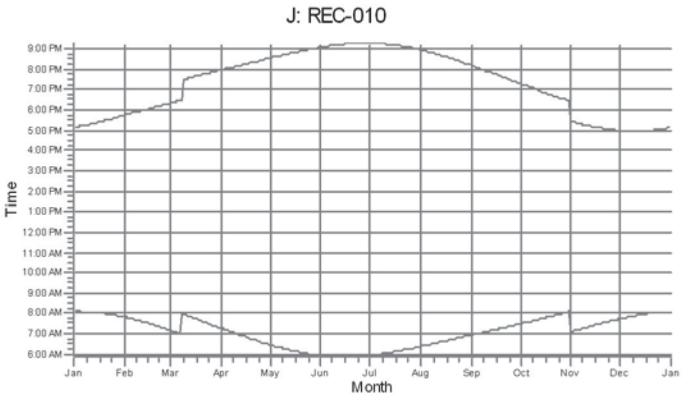
SHADOW - Calendar, graphical

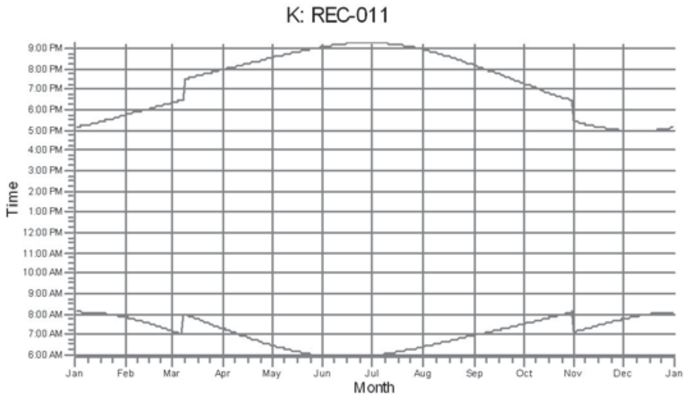
Calculation: FlickerVestas.v5

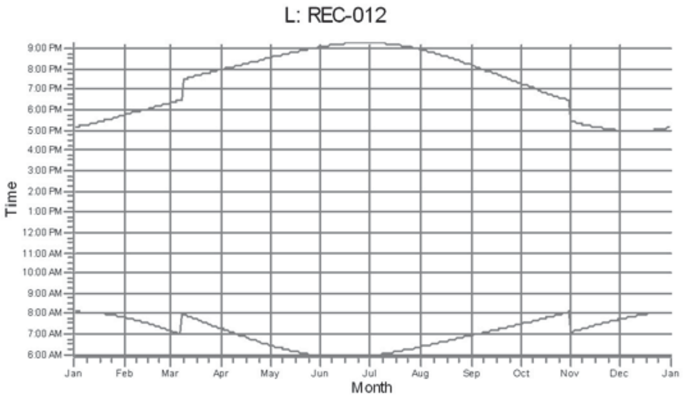










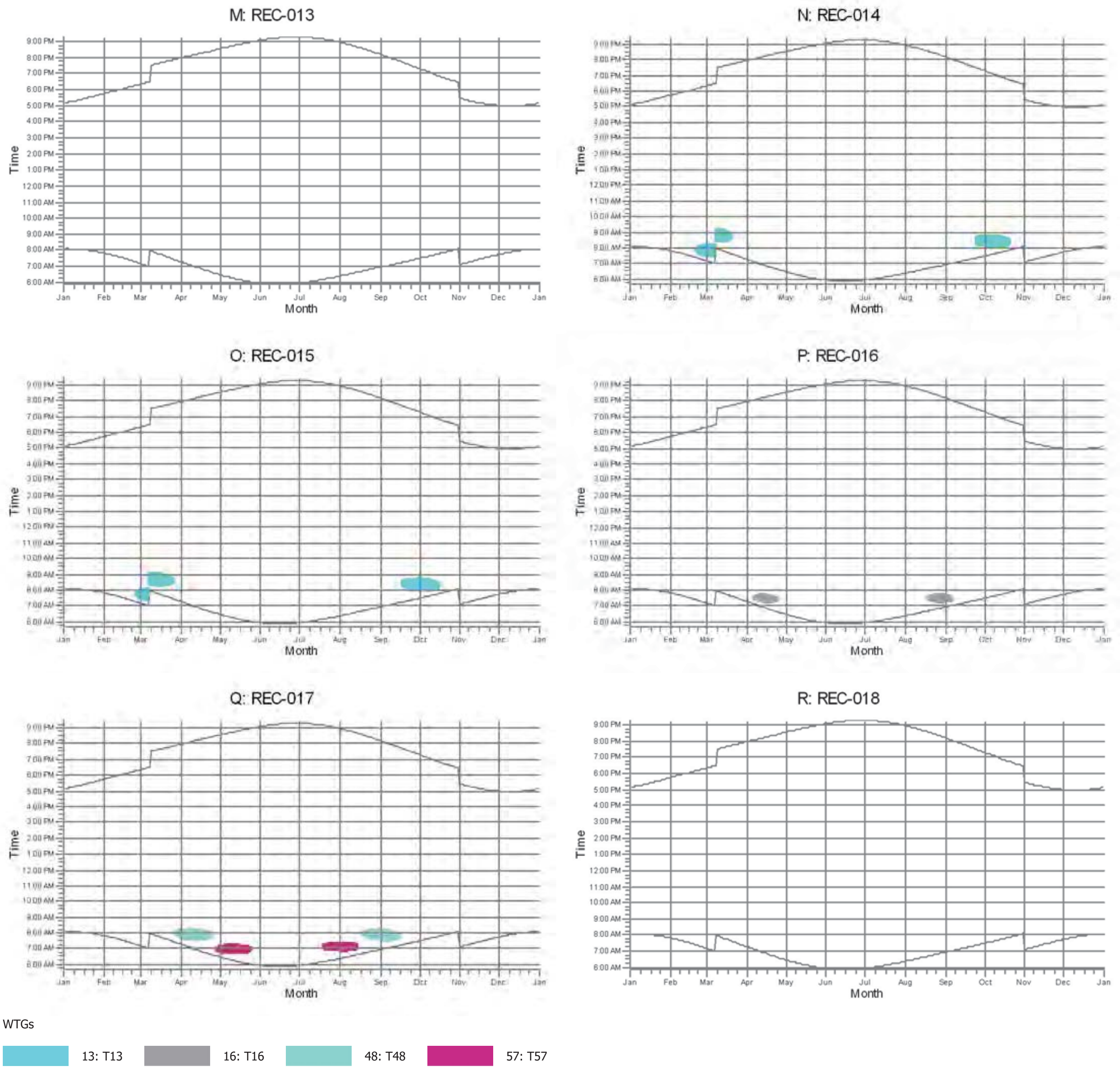


WTGs

▨ 25: T25 ■ 47: T47

SHADOW - Calendar, graphical

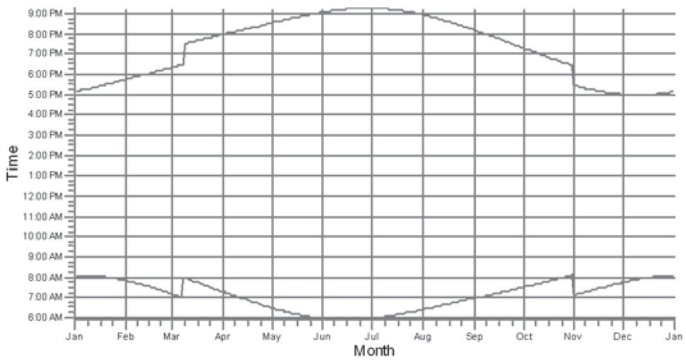
Calculation: FlickerVestas.v5



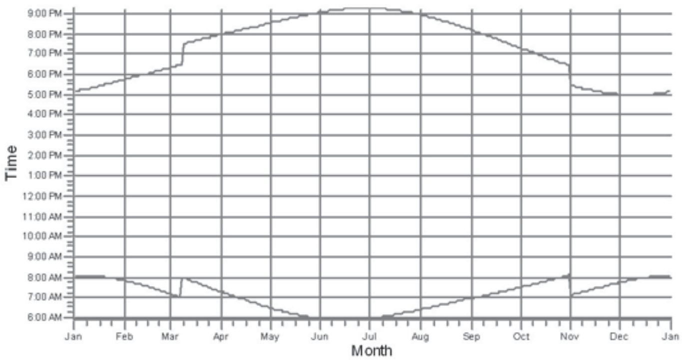
SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

S: REC-019



T: REC-020



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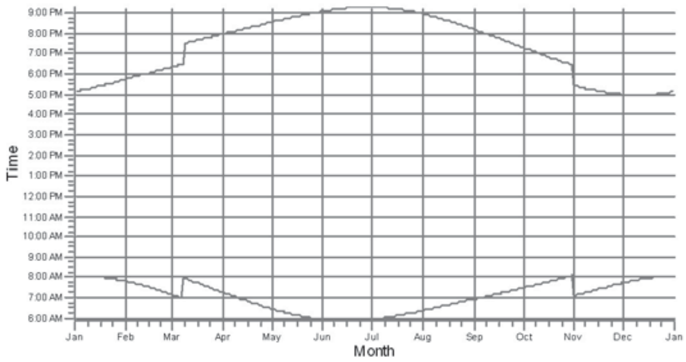

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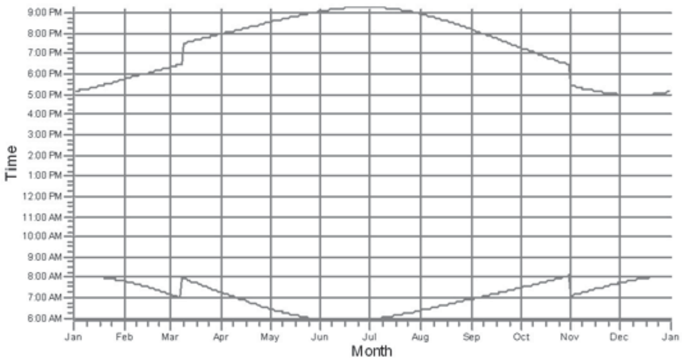

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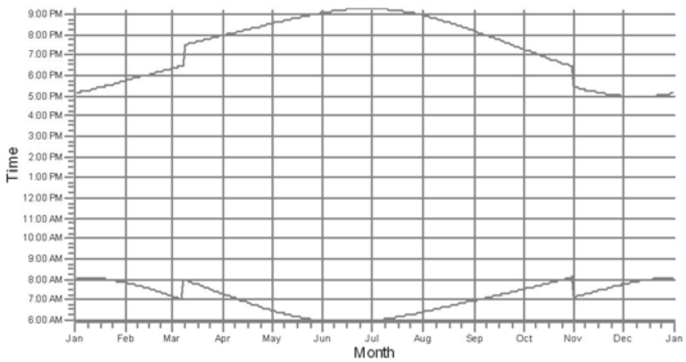
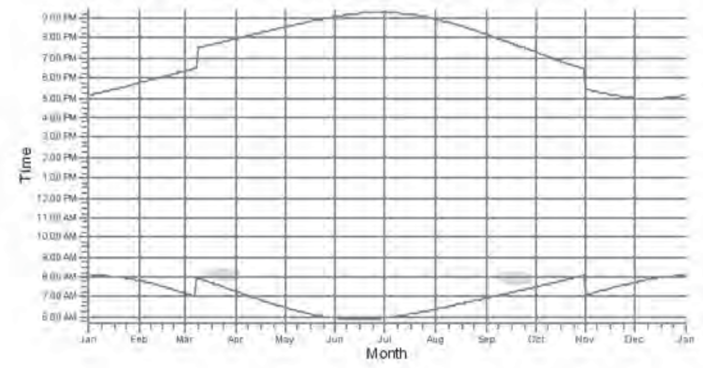


X: REC-024

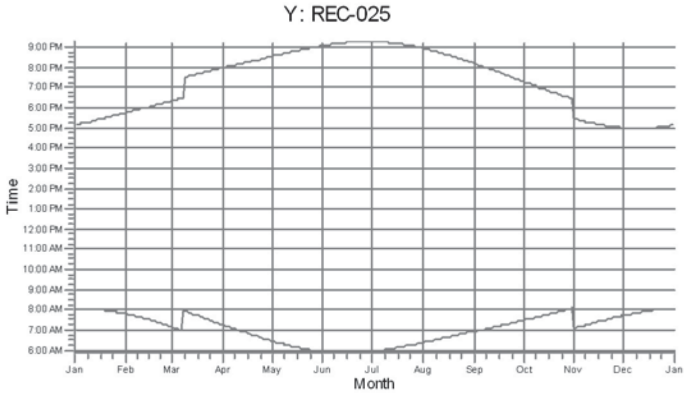


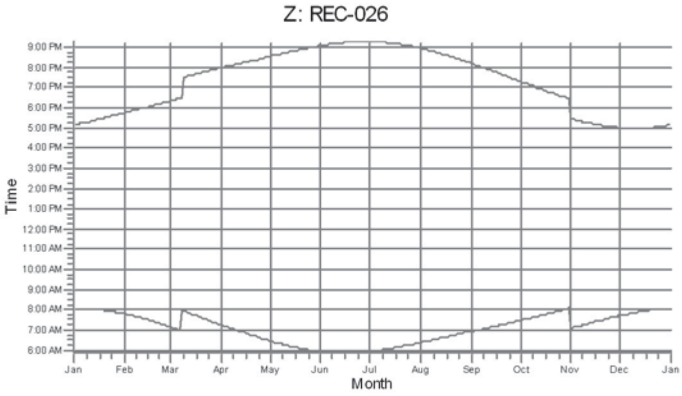
WTGs

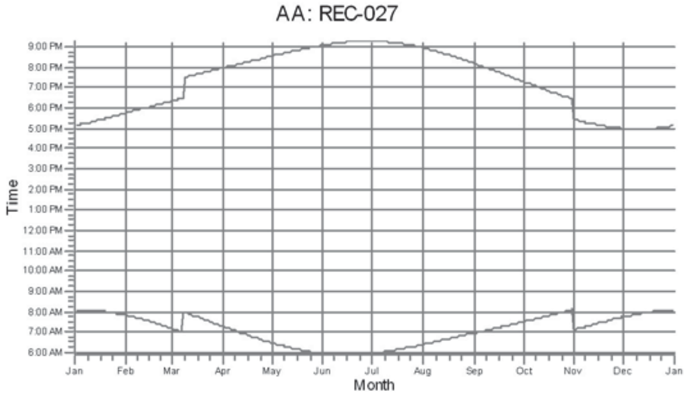
▨ 49: T49

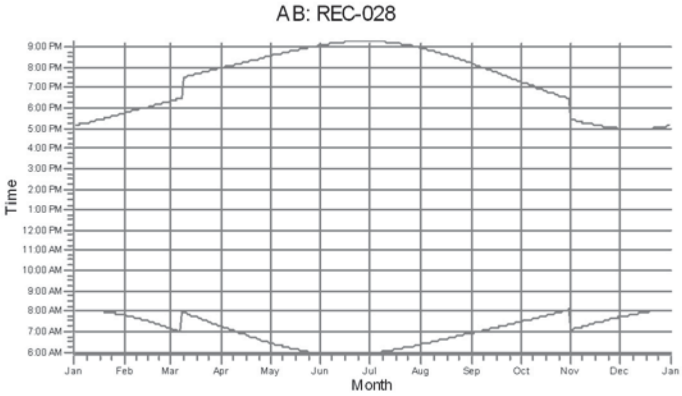
SHADOW - Calendar, graphical

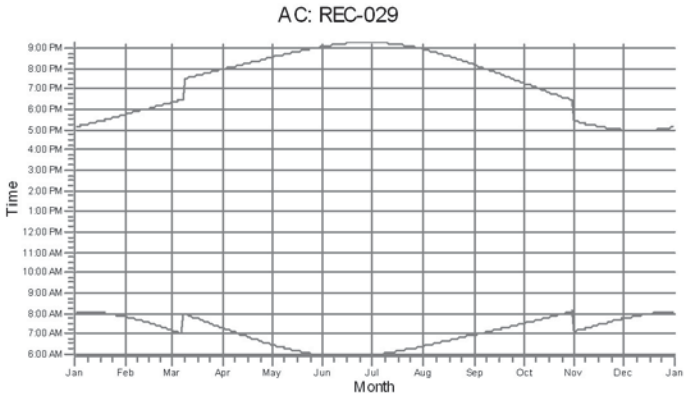
Calculation: FlickerVestas.v5

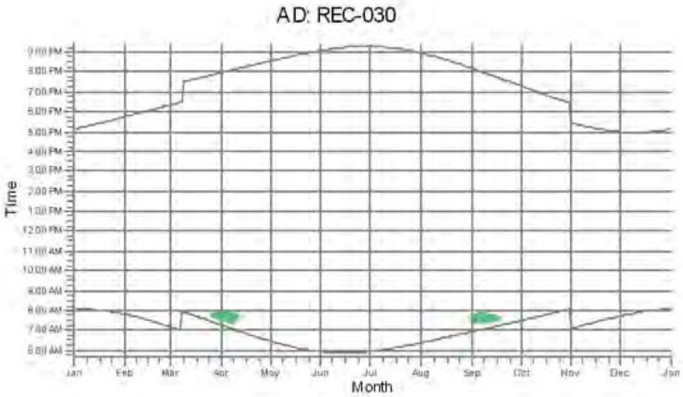

Y: REC-025


Z: REC-026


AA: REC-027


AB: REC-028


AC: REC-029


AD: REC-030

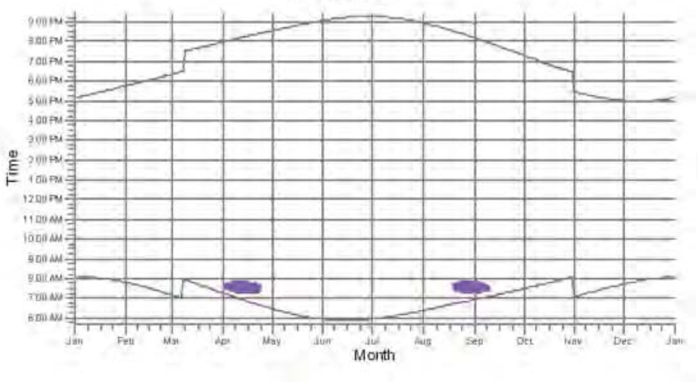
WTGs

🟩 28: T28

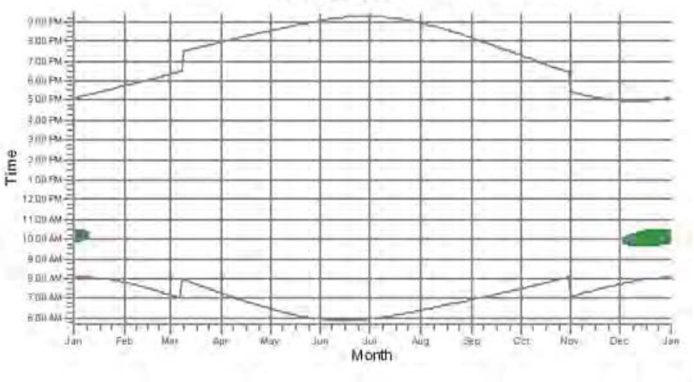
SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

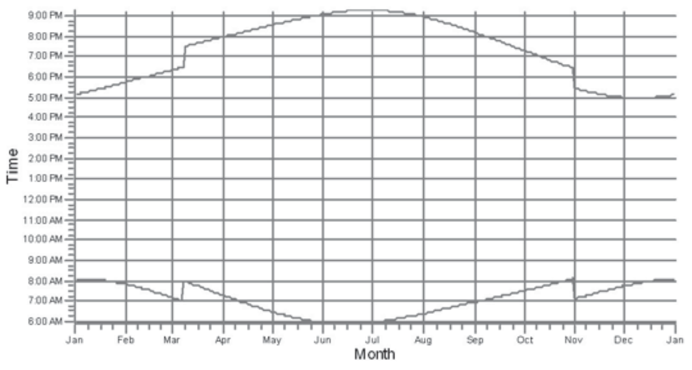
AE: REC-031



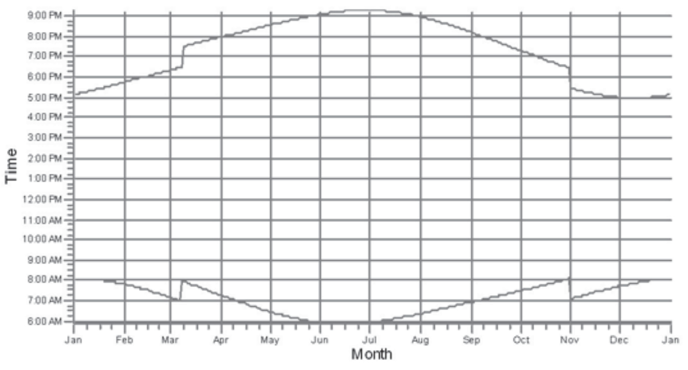
AF: REC-032



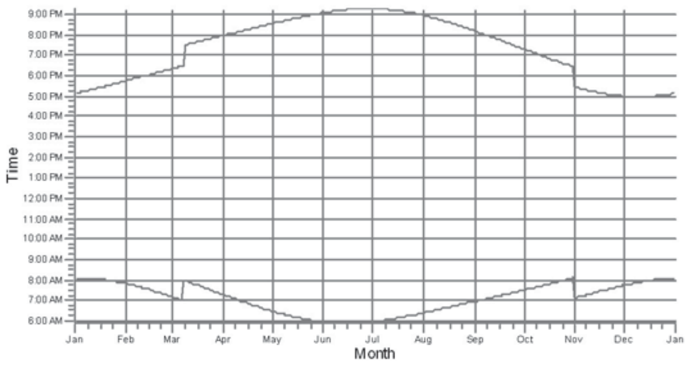
AG: REC-033



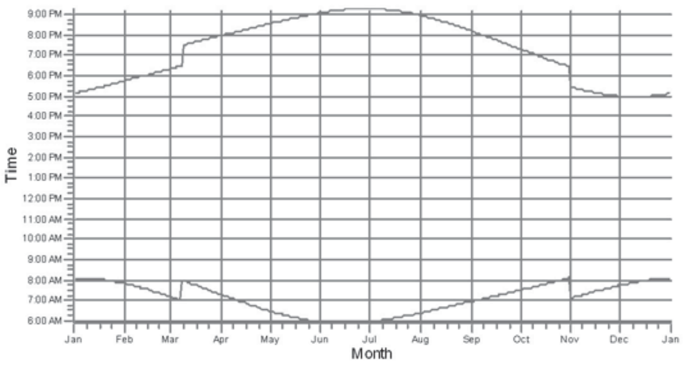
AH: REC-034



AI: REC-035



AJ: REC-036



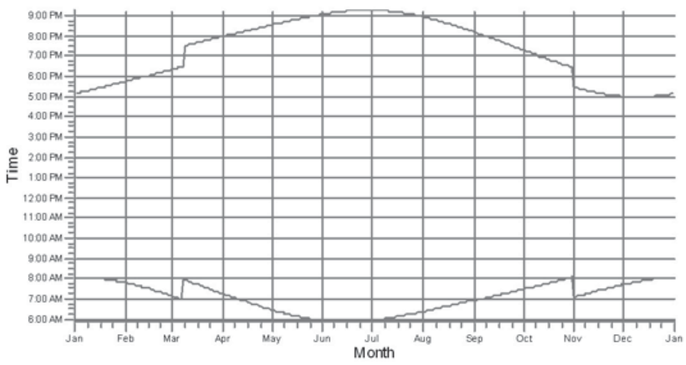
WTGs

🟩 27: T27 🟪 45: T45

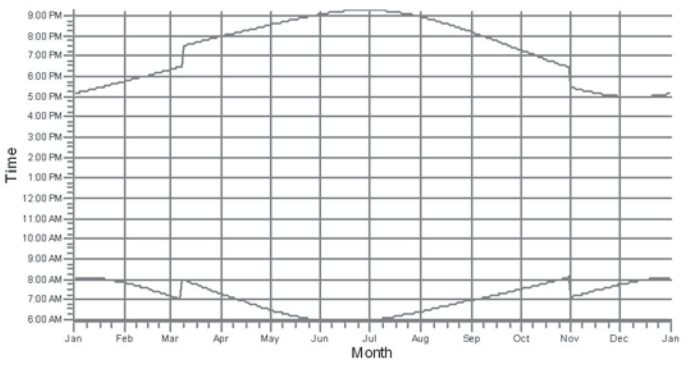
SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

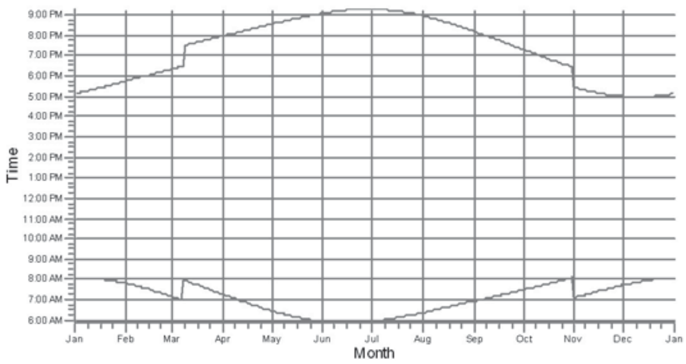
AK: REC-037



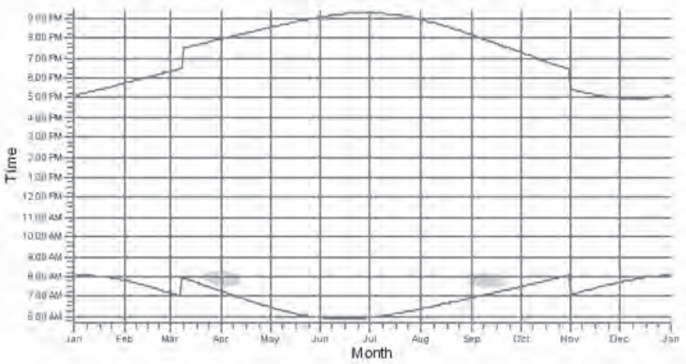
AL: REC-038



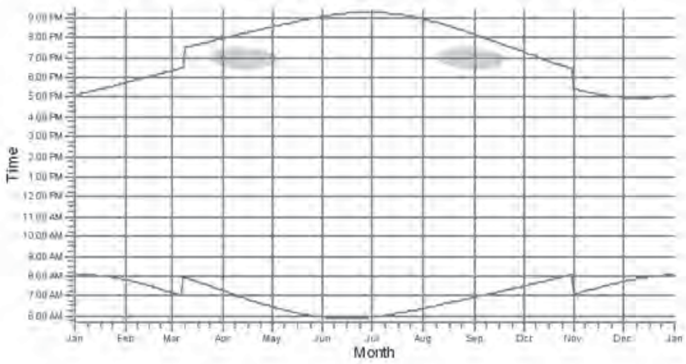
AM: REC-039



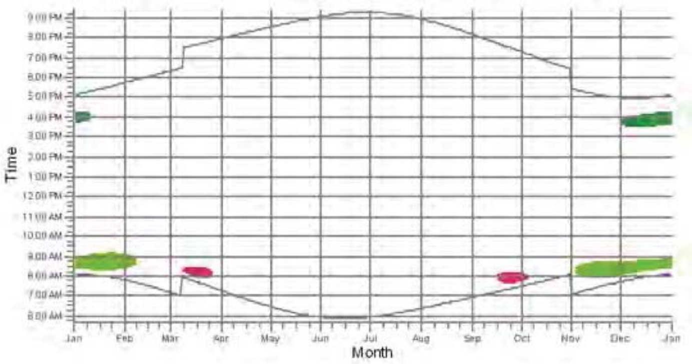
AN: REC-040



AO: REC-041



AP: REC-042



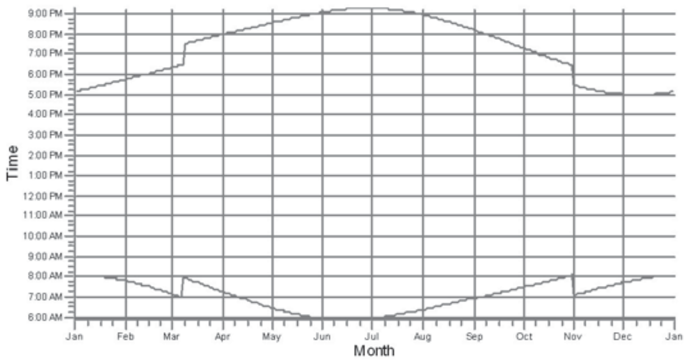
WTGs

🟩 14: T14
🟩 27: T27
🟩 52: T52
🟥 53: T53

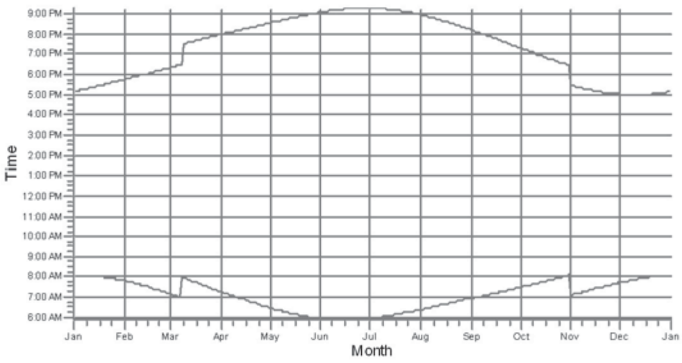
SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

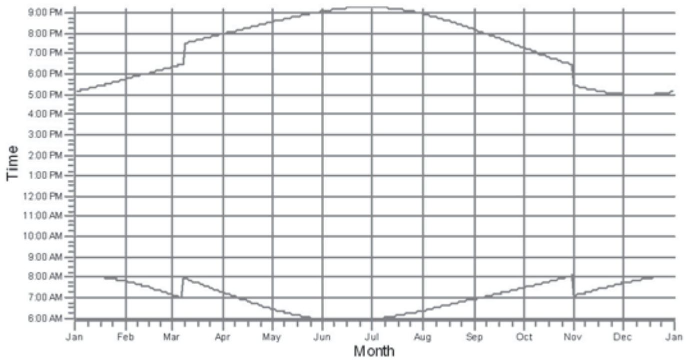
AQ: REC-043



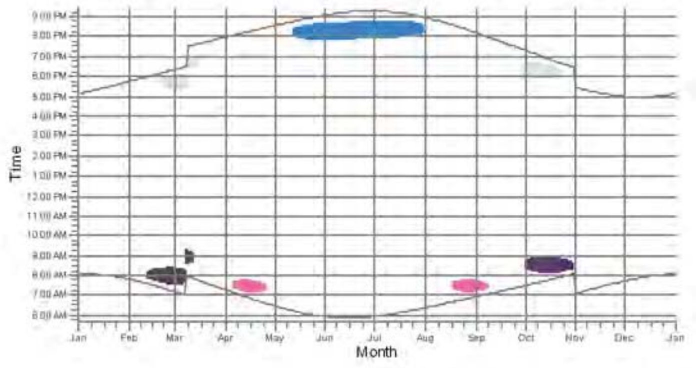
AR: REC-044



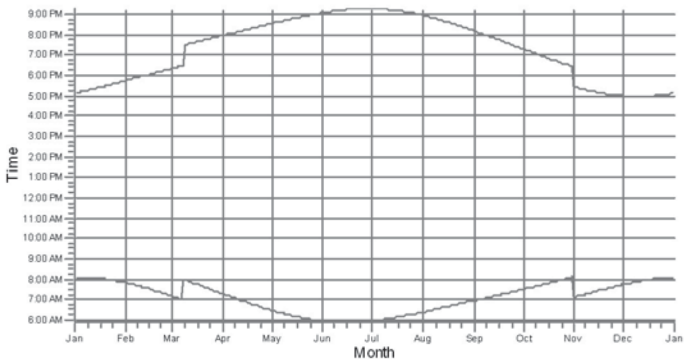
AS: REC-045



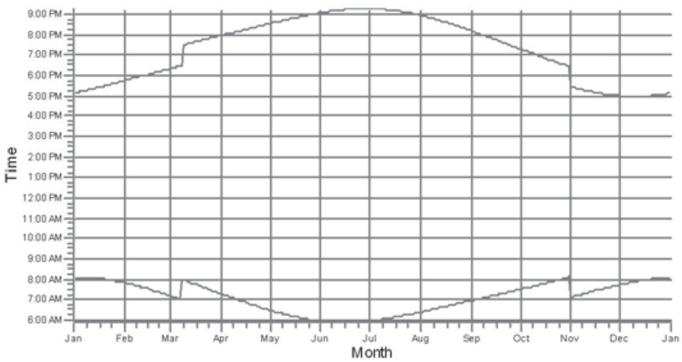
AT: REC-046



AU: REC-047



AV: REC-048

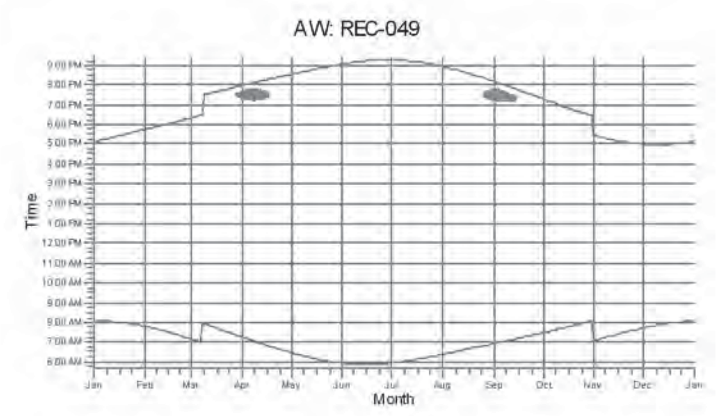


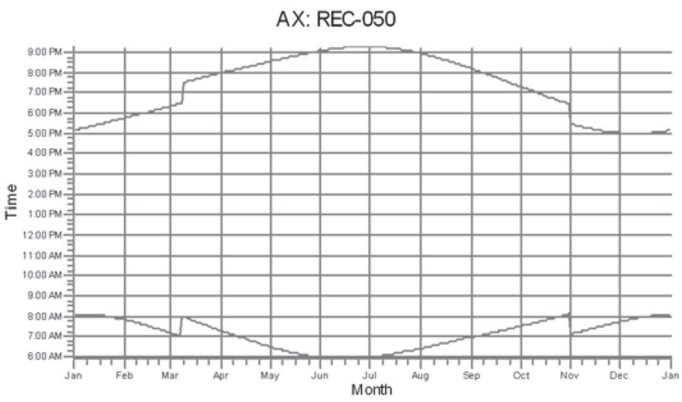
WTGs

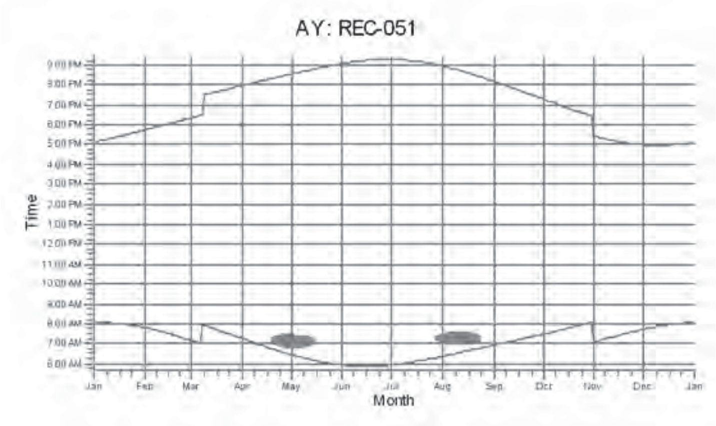
■ 60: T61 ■ 61: T62 ■ 62: T63 ■ 63: T64

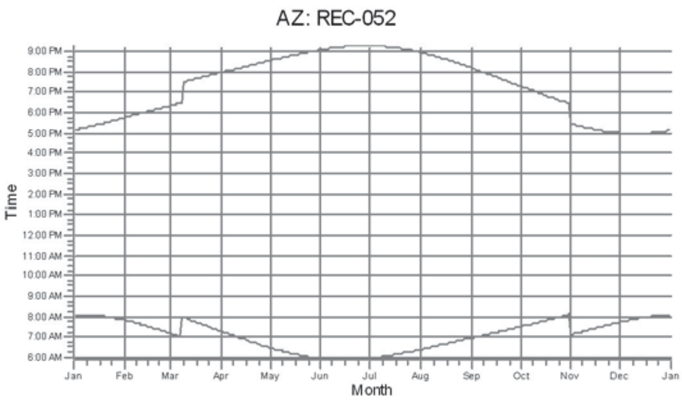
SHADOW - Calendar, graphical

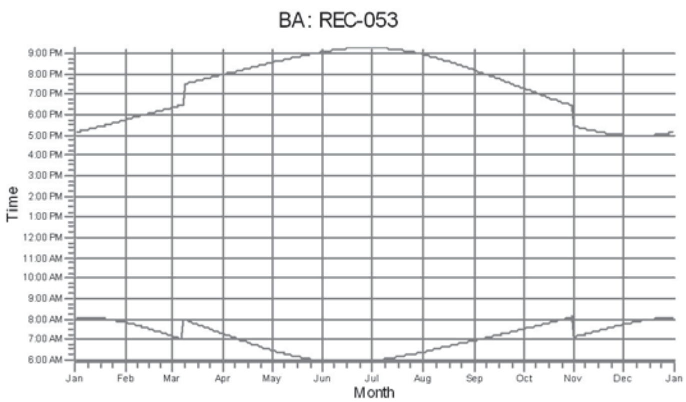
Calculation: FlickerVestas.v5

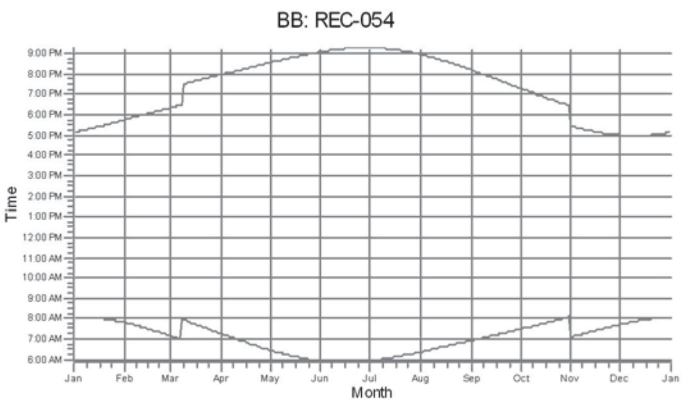

AW: REC-049


AX: REC-050


AY: REC-051


AZ: REC-052


BA: REC-053


BB: REC-054

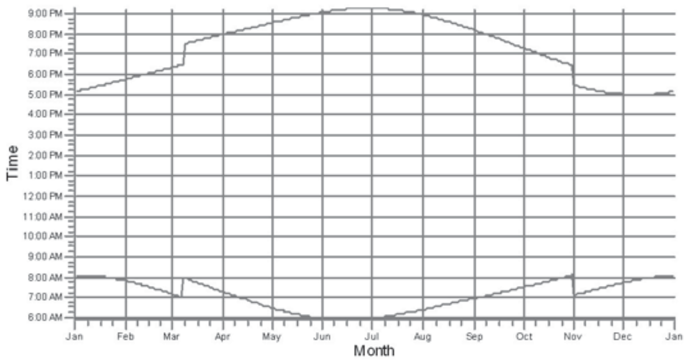
WTGs

▨ 38: T38

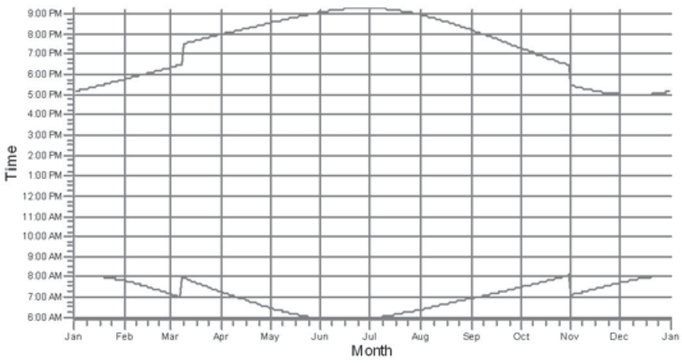
SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

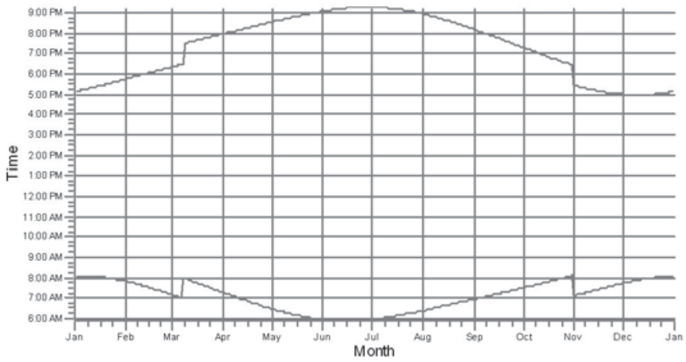
BC: REC-055



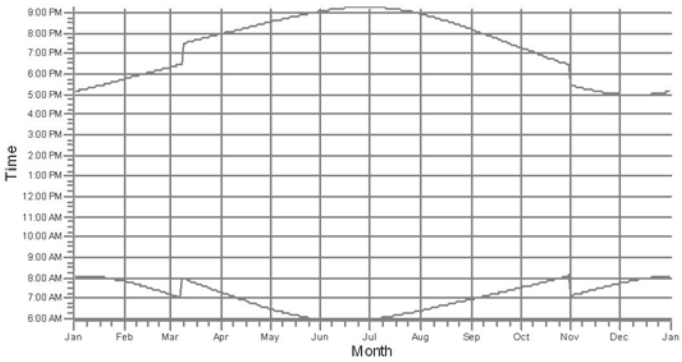
BD: REC-056



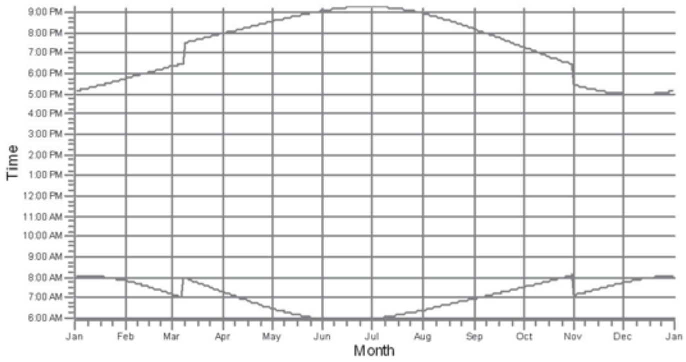
BE: REC-057



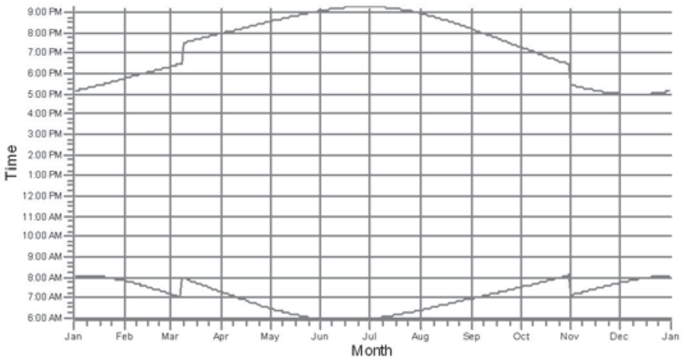
BF: REC-058



BG: REC-059



BH: REC-060

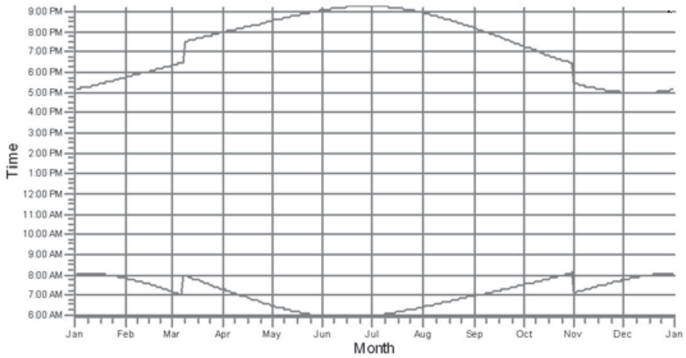


WTGs

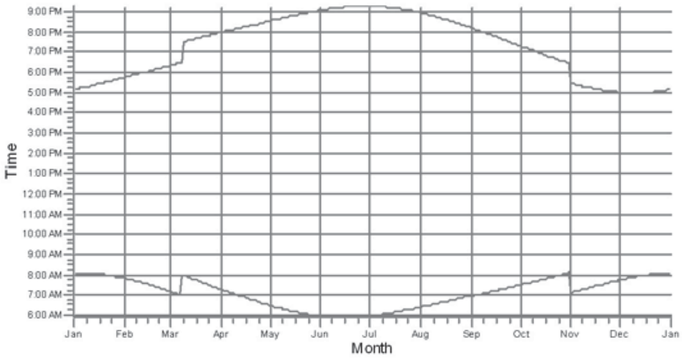
SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

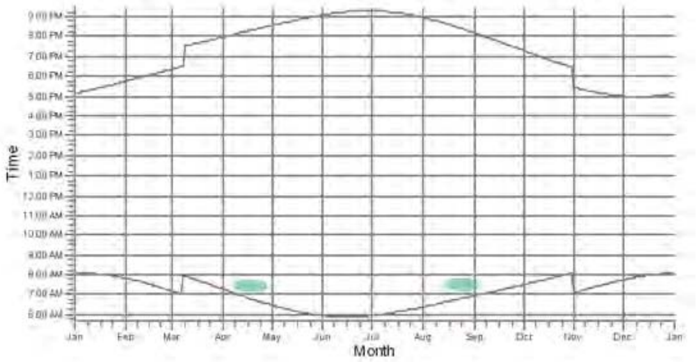
BI: REC-061



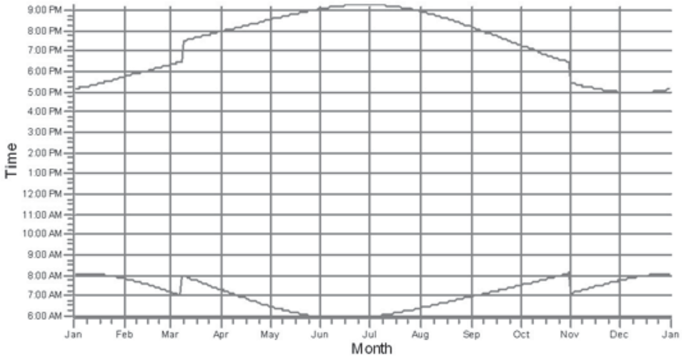
BJ: REC-062



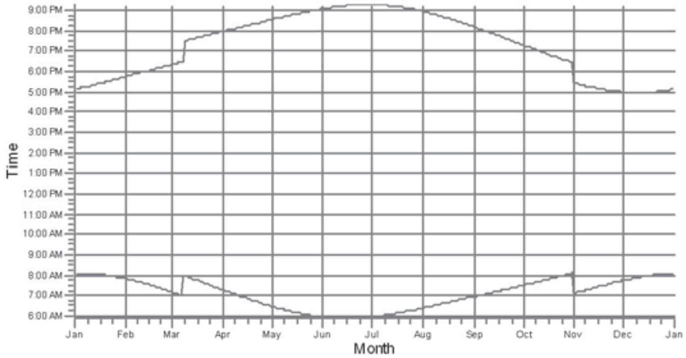
BK: REC-063



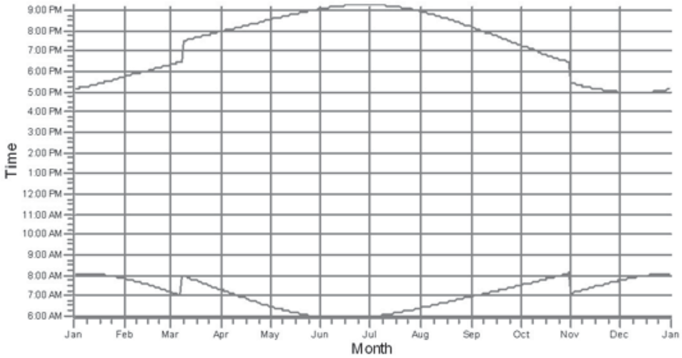
BL: REC-064



BM: REC-065



BN: REC-066

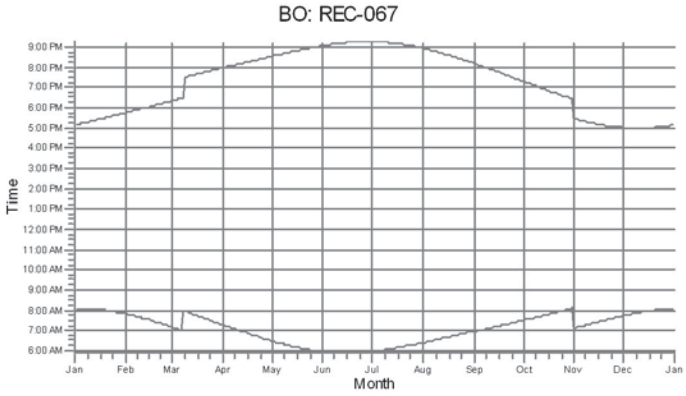


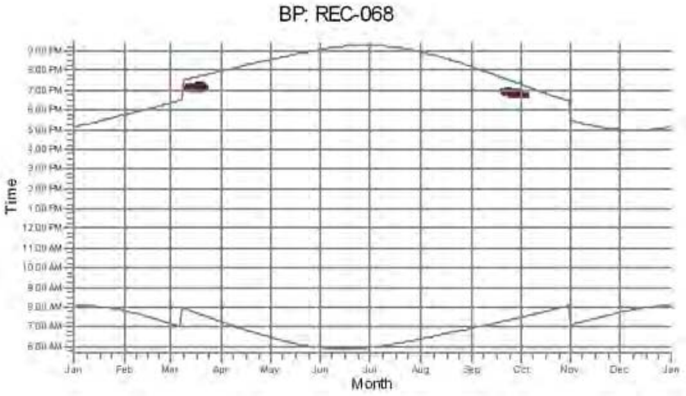
WTGs

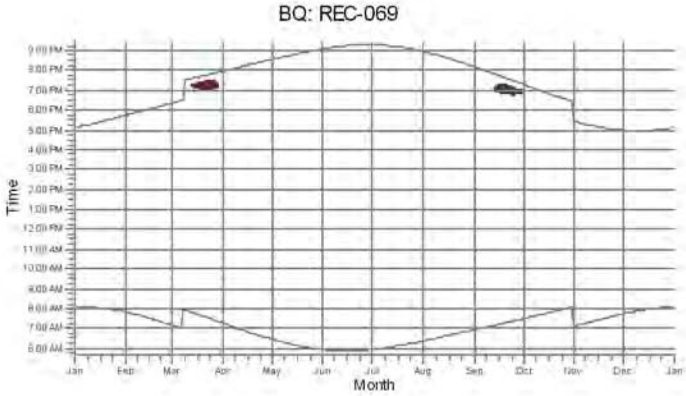
🟩 48: T48

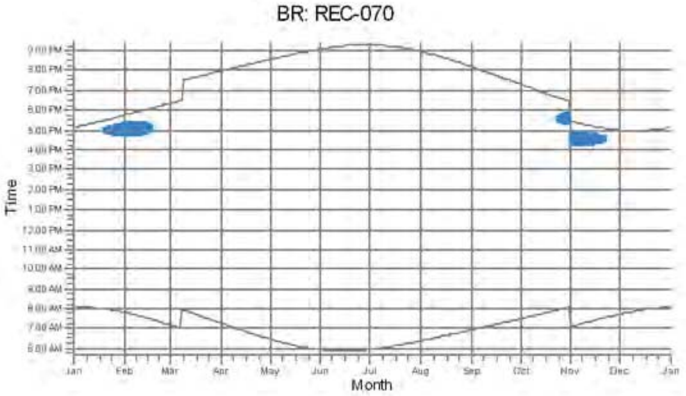
SHADOW - Calendar, graphical

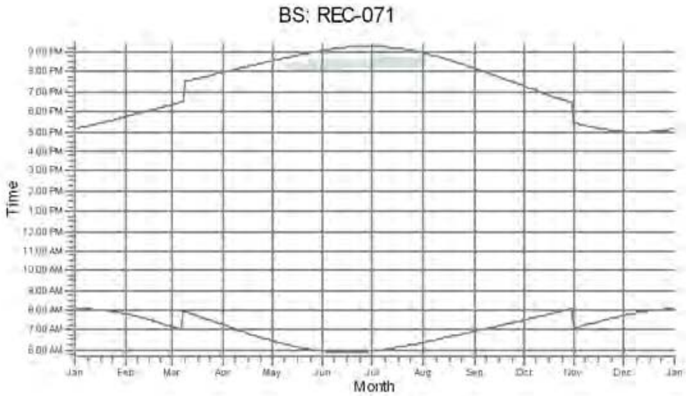
Calculation: FlickerVestas.v5

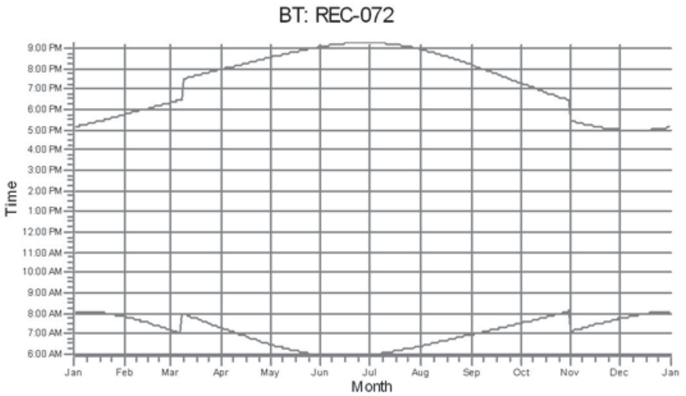

BO: REC-067


BP: REC-068


BQ: REC-069


BR: REC-070


BS: REC-071


BT: REC-072

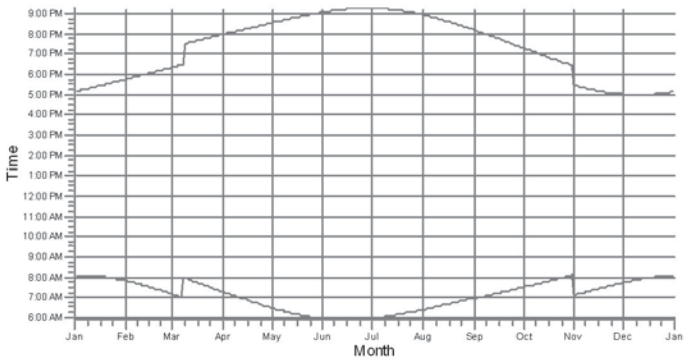
WTGs

🟥 32: T32 🟩 61: T62 🟦 62: T63

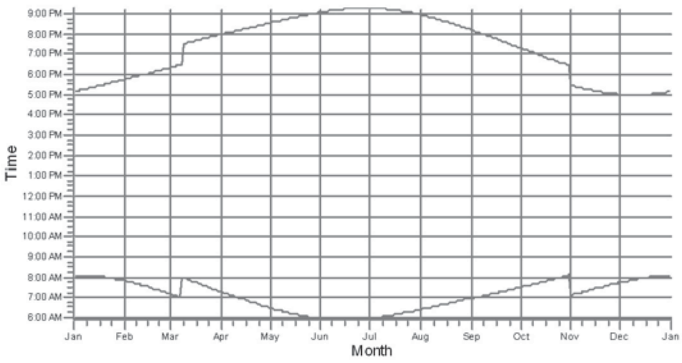
SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

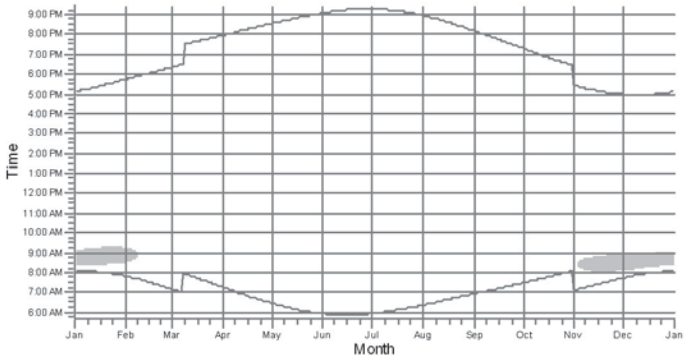
BU: REC-073



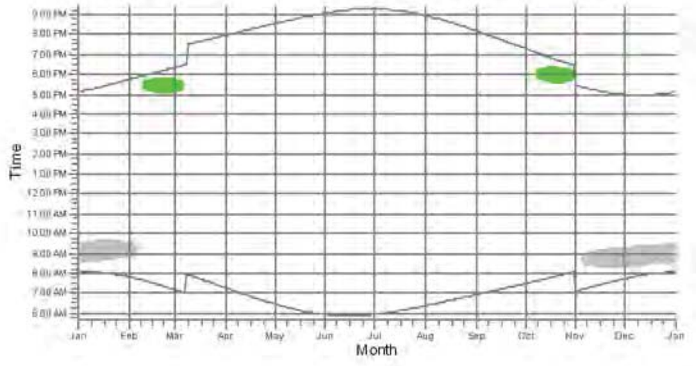
BV: REC-074



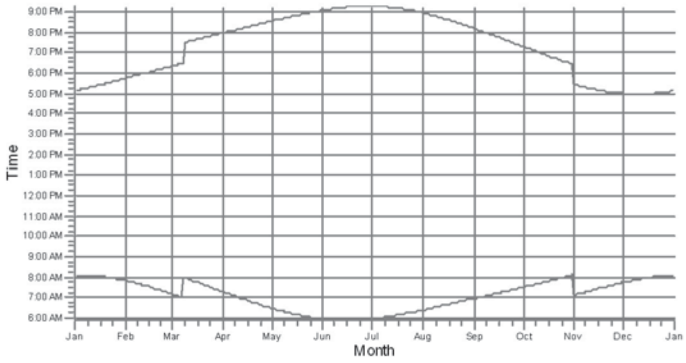
BW: REC-075



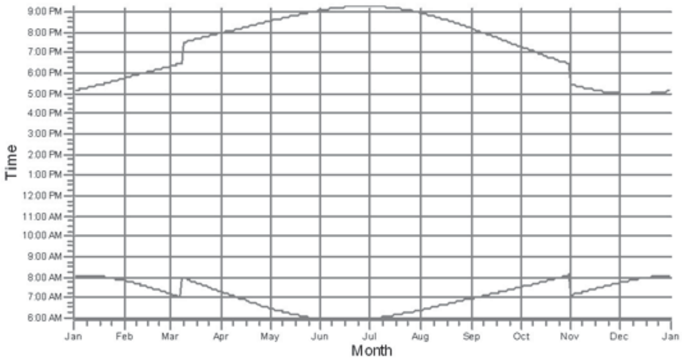
BX: REC-076



BY: REC-077



BZ: REC-078

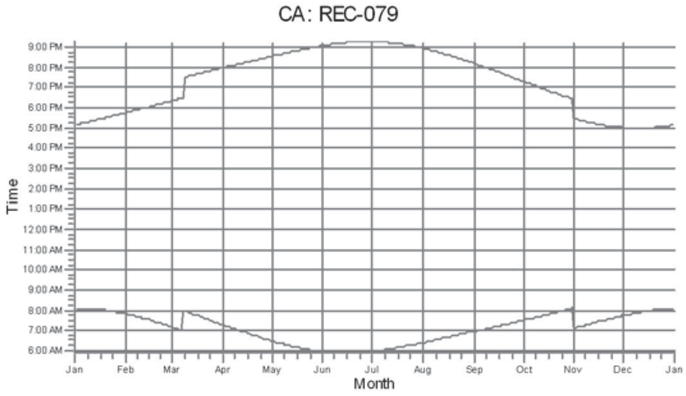


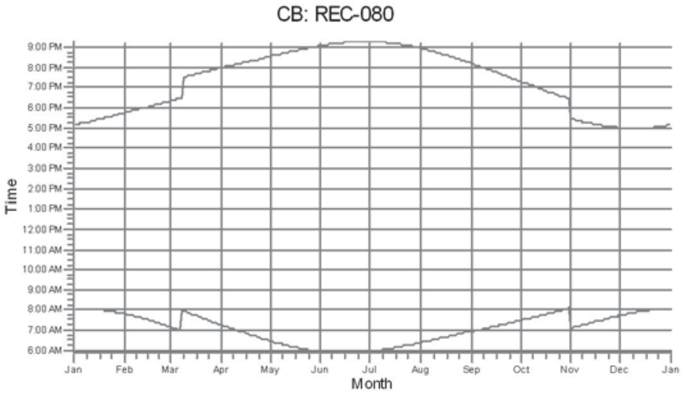
WTGs

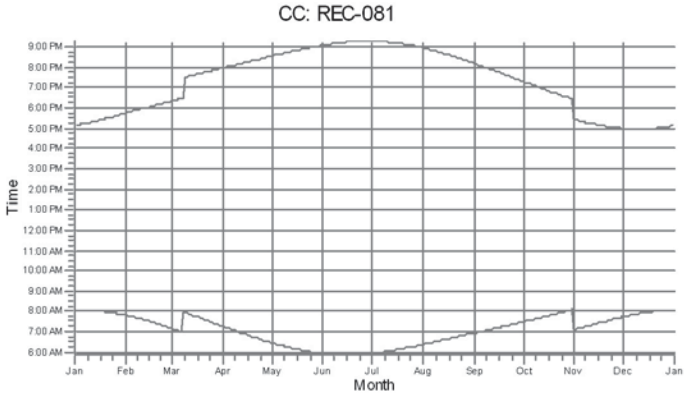
🟩 9: T9 ▨ 12: T12

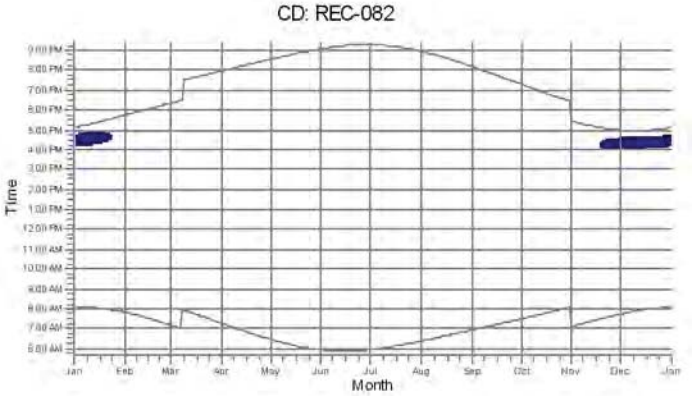
SHADOW - Calendar, graphical

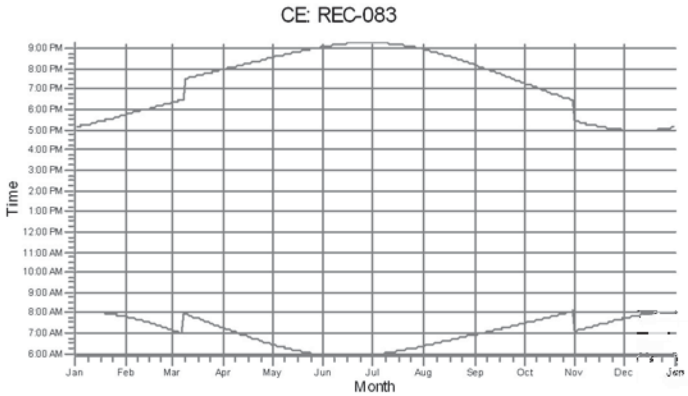
Calculation: FlickerVestas.v5

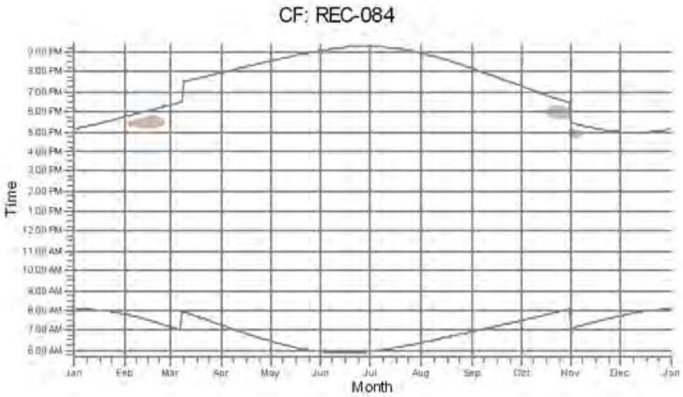












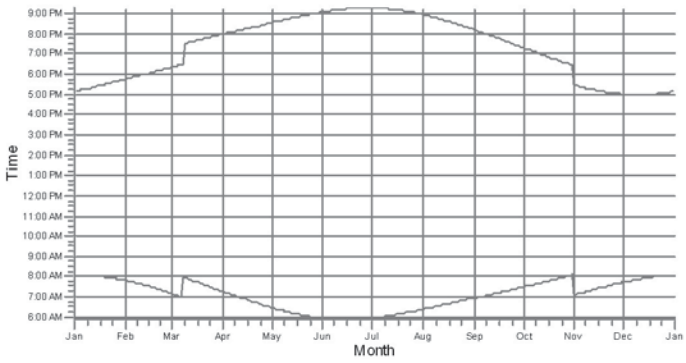
WTGs

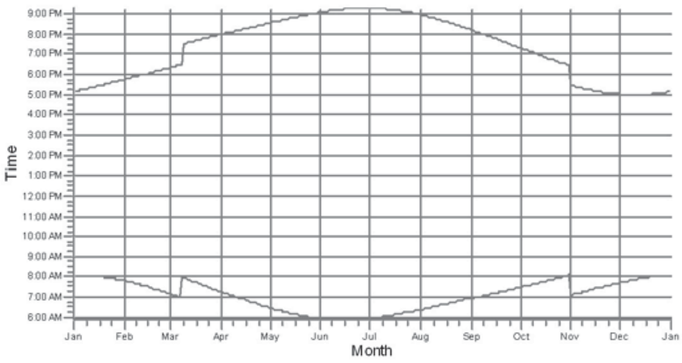
■ 7: T7 ■ 17: T17

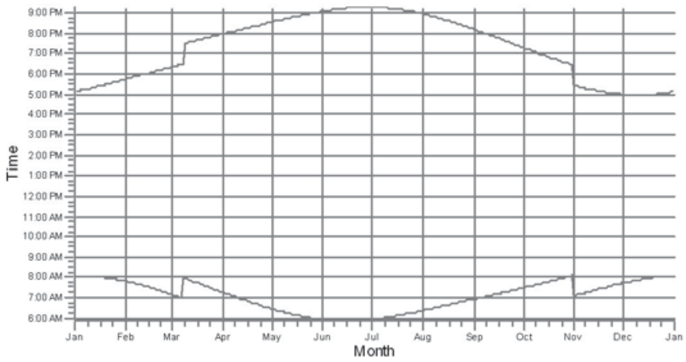
Burns & McDonnell has relied upon information provided by third-party sources to complete this study. While there is no reason to believe that the information provided is inaccurate or incomplete in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee or warranty its accuracy or completeness.

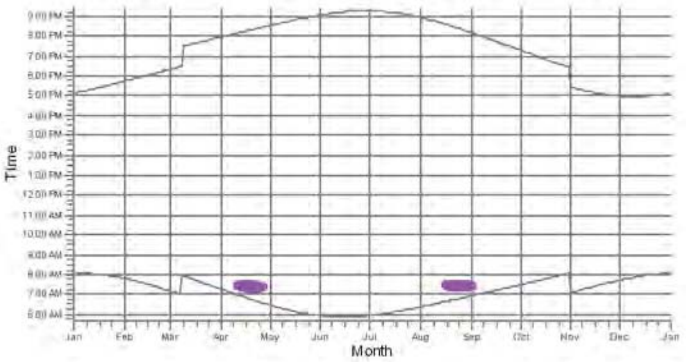
SHADOW - Calendar, graphical

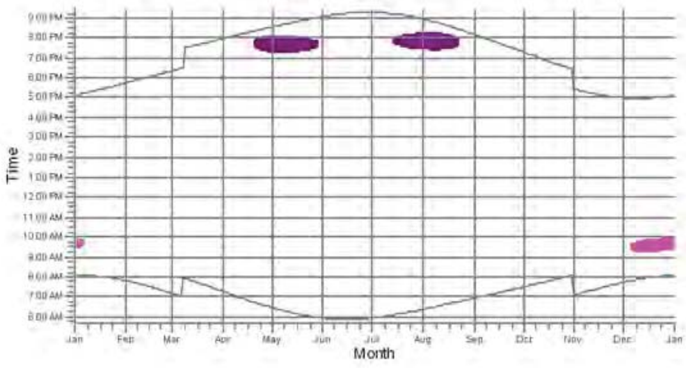
Calculation: FlickerVestas.v5

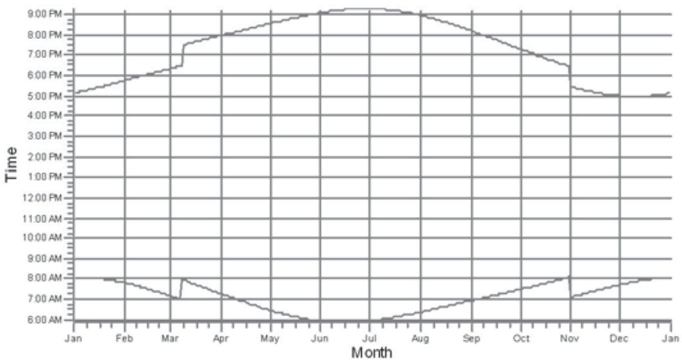

CG: REC-085


CH: REC-086


CI: REC-087


CJ: REC-088


CK: REC-089

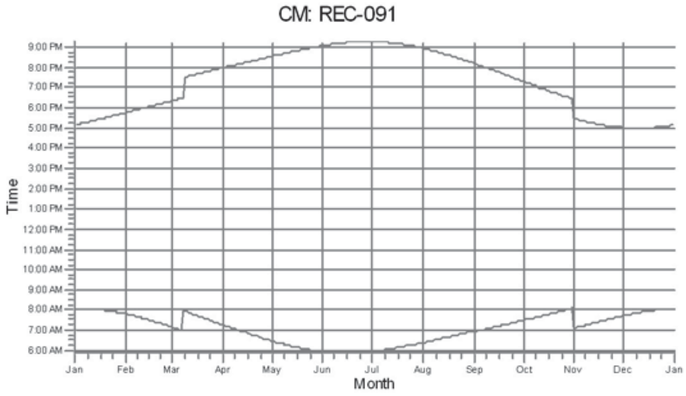

CL: REC-090

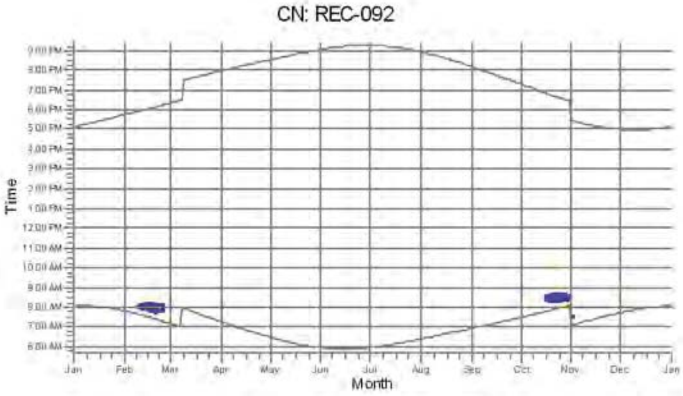
WTGs

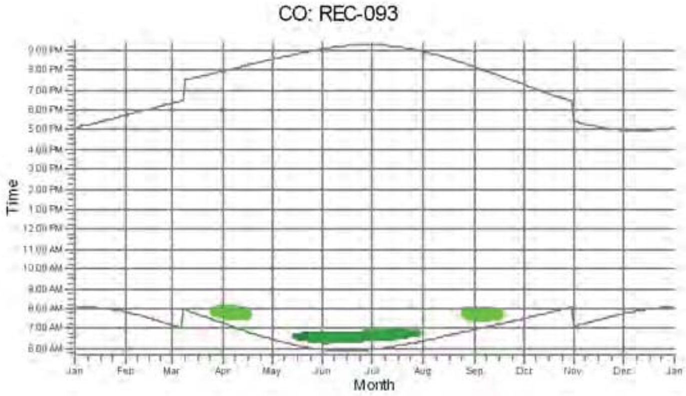
🟪 11: T11 🟪 31: T31 🟪 43: T43

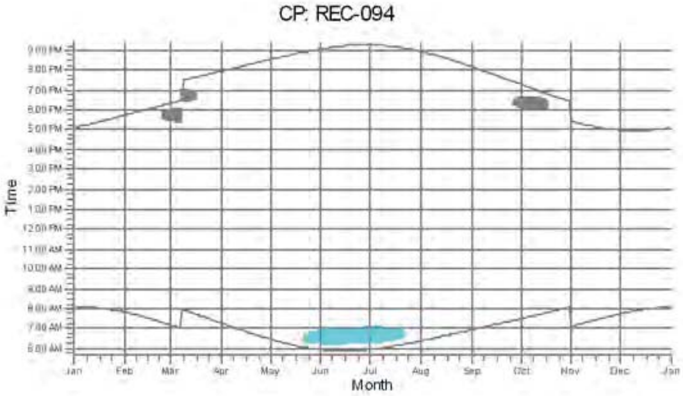
SHADOW - Calendar, graphical

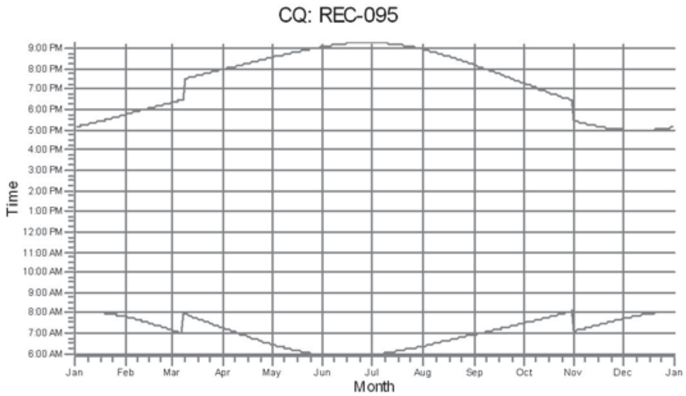
Calculation: FlickerVestas.v5

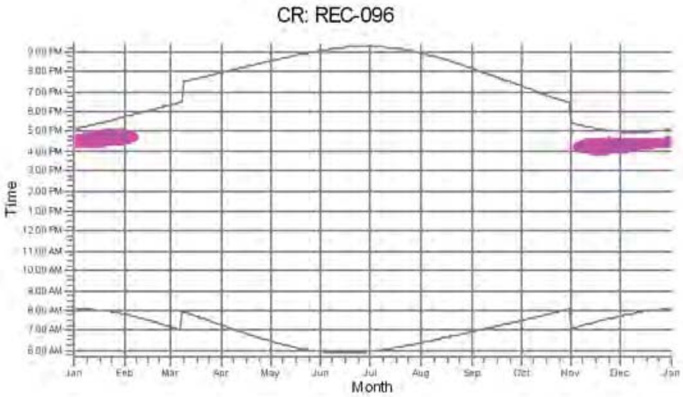












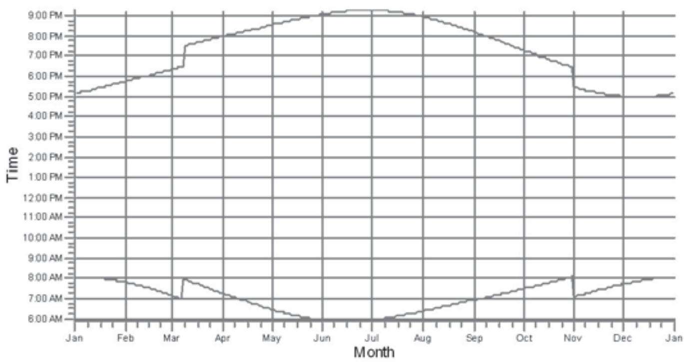
WTGs

⬛ 4: T4 🟦 13: T13 🟩 18: T18 🟩 20: T20 🟪 31: T31 🟪 42: T42

SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

CS: REC-097



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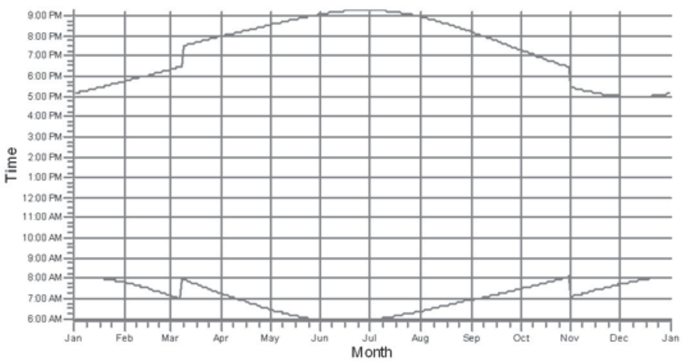

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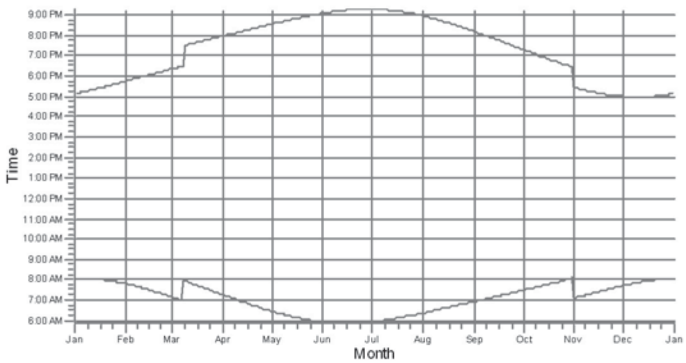

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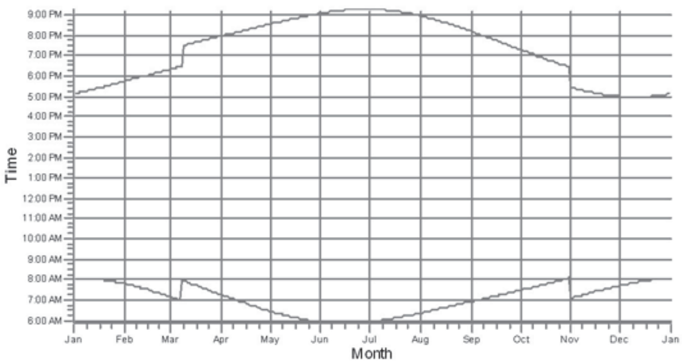

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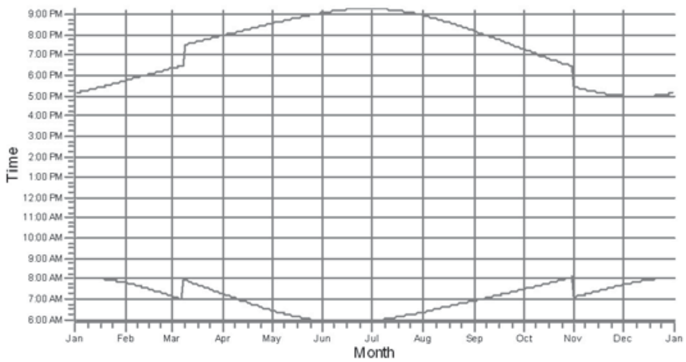

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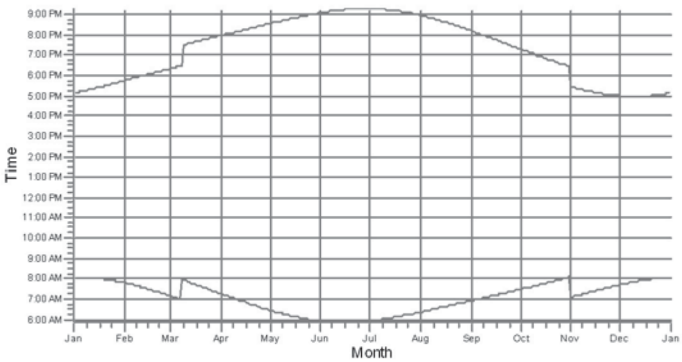
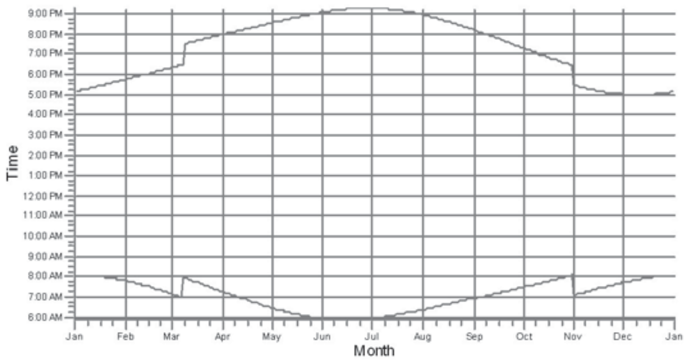


WTGs

SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5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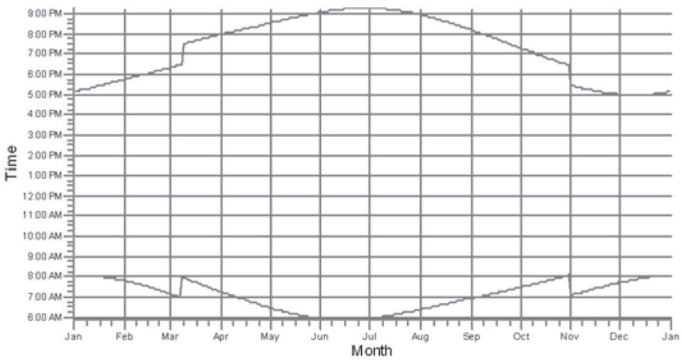
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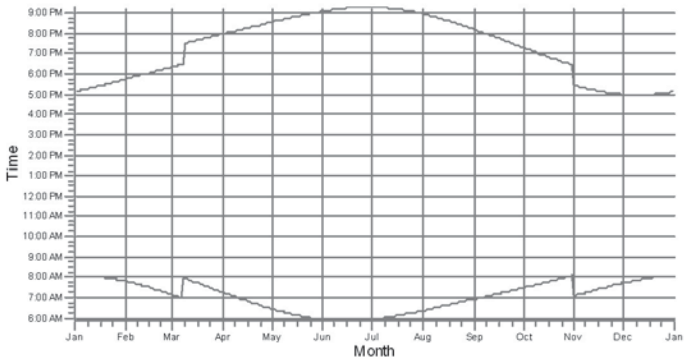
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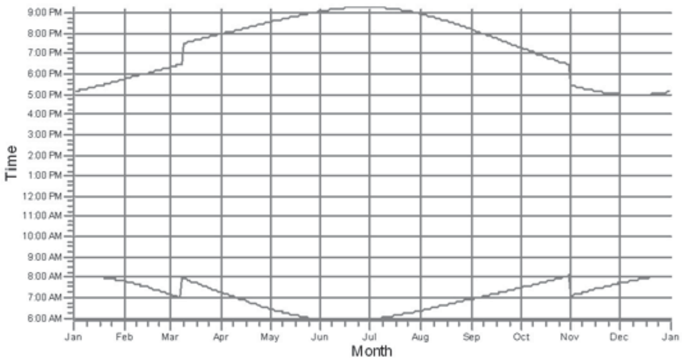
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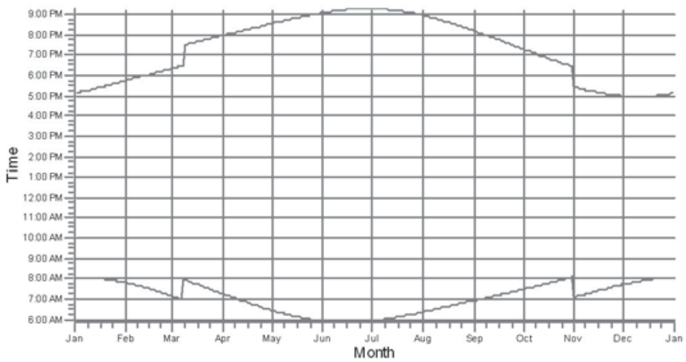
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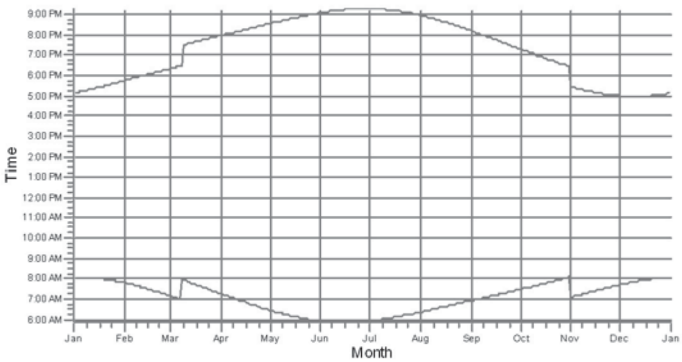
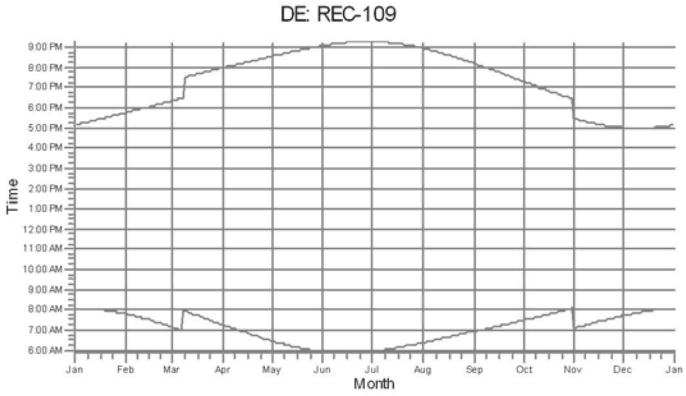
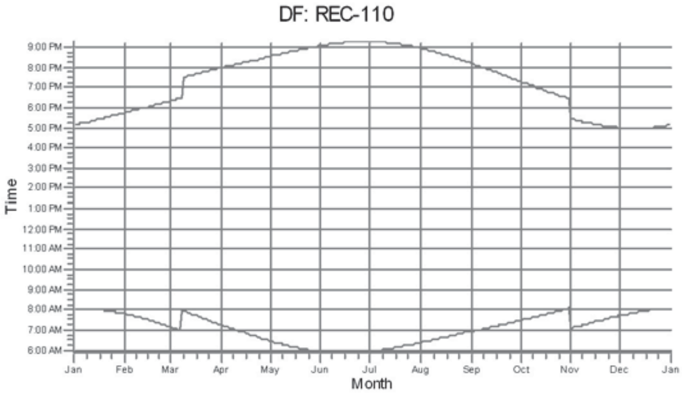

DD: REC-108

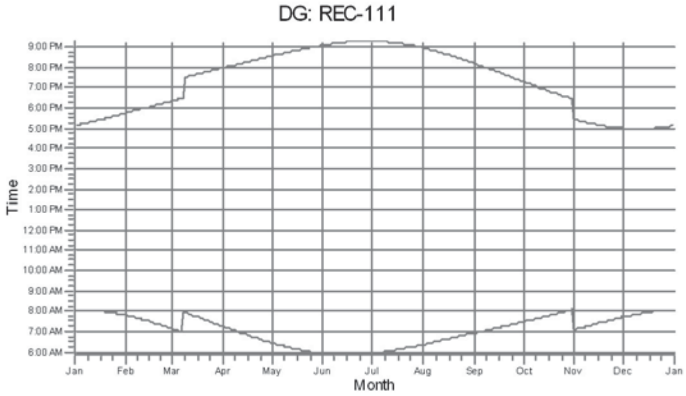
WTGs

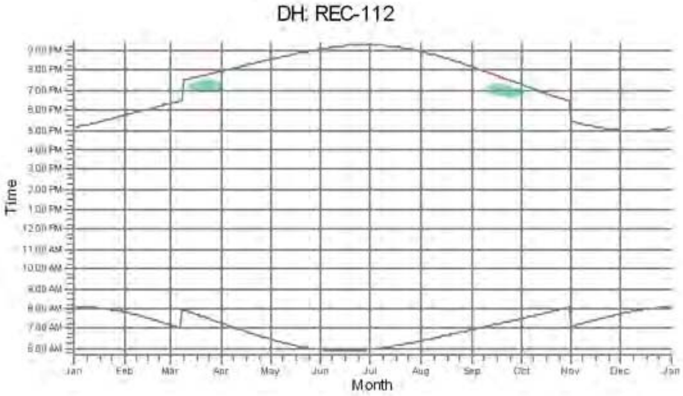
SHADOW - Calendar, graphical

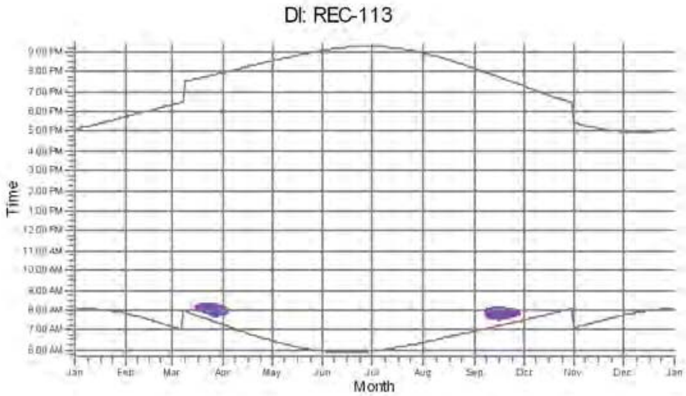
Calculation: FlickerVestas.v5

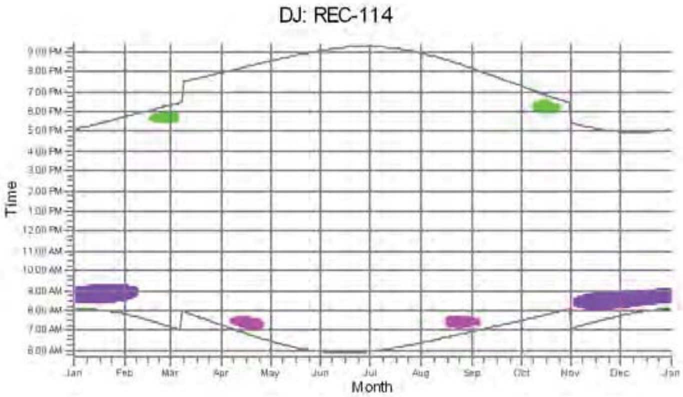












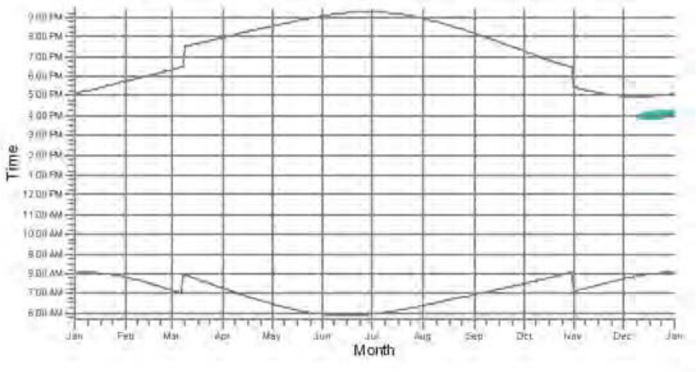
WTGs

🟩 18: T18 🟩 26: T26 🟪 46: T46 🟪 47: T47

SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

DK: REC-115



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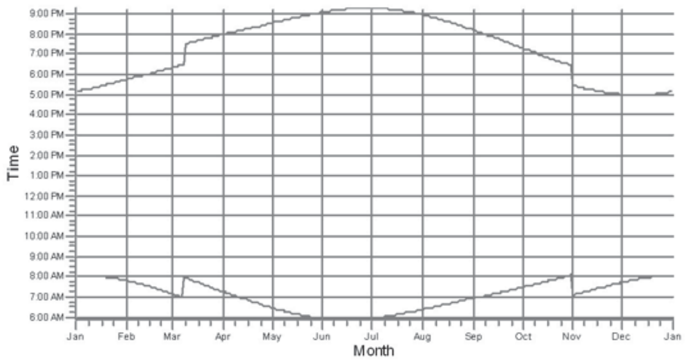

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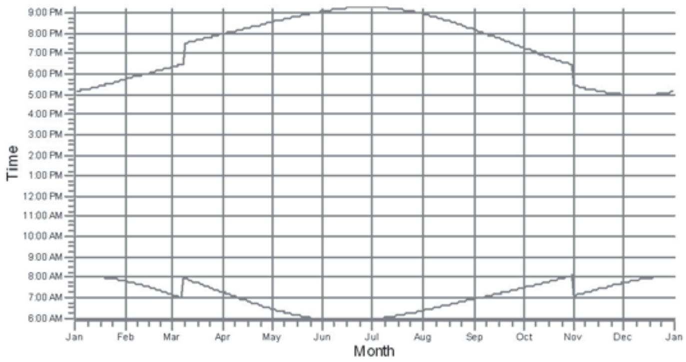

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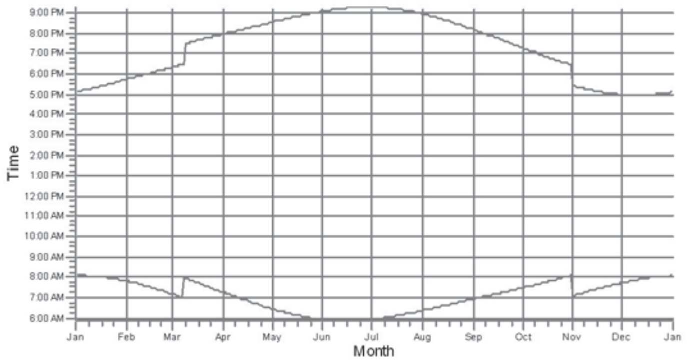

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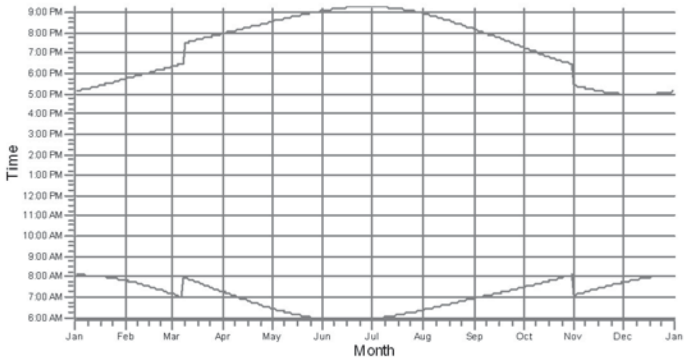

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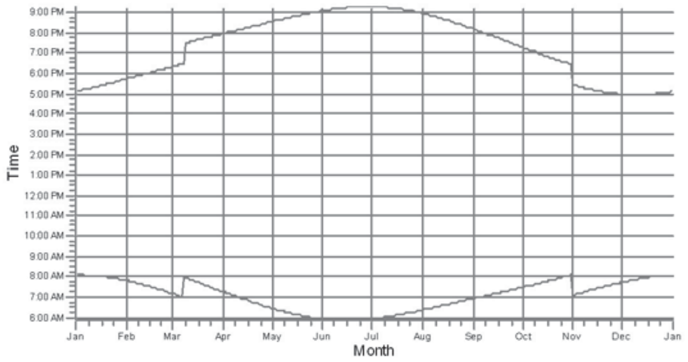


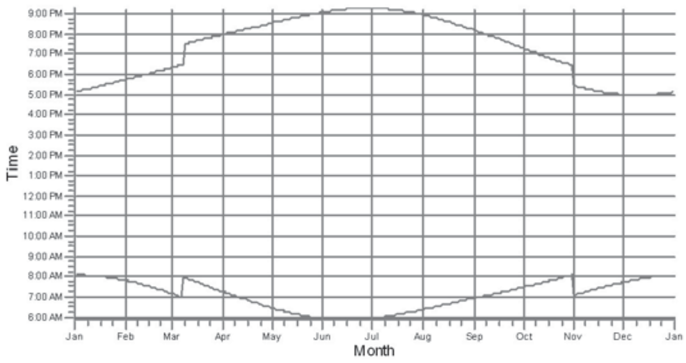
WTGs

🟩 21: T21

SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

DQ: REC-121



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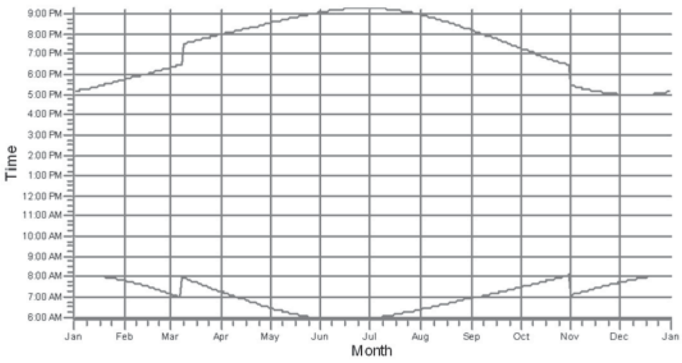

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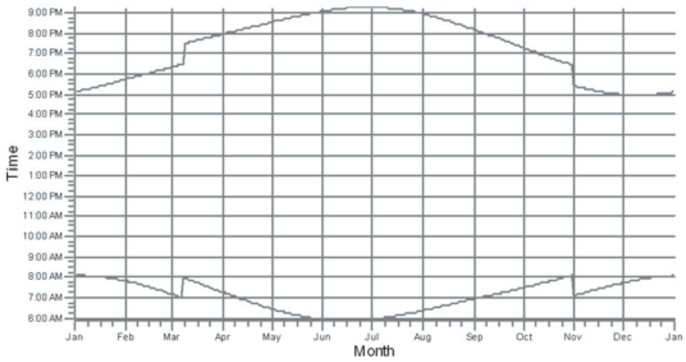

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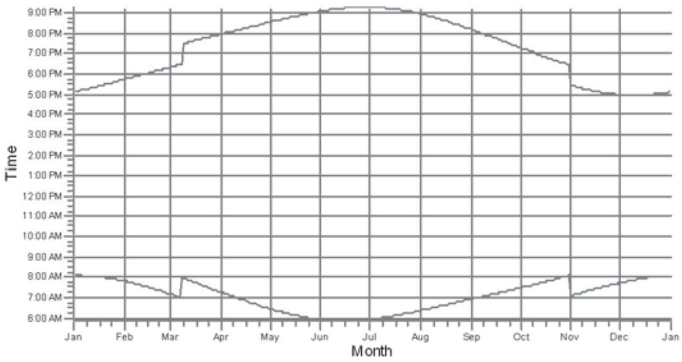

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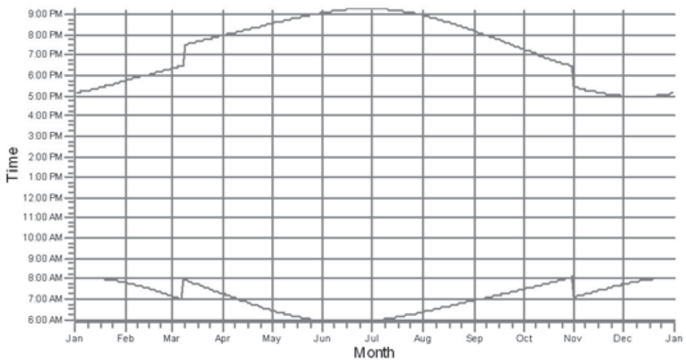

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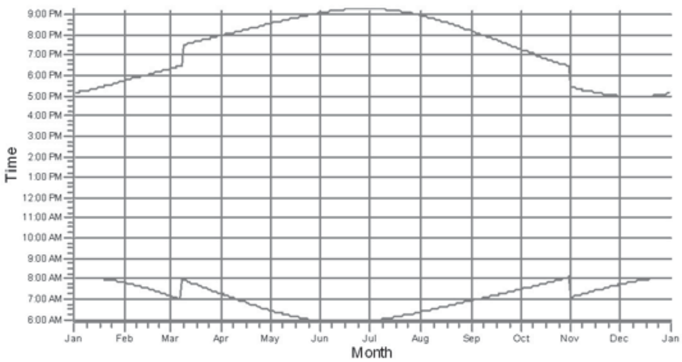


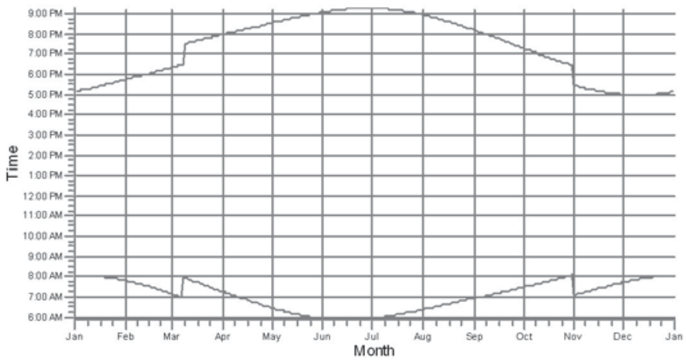
WTGs

Burns & McDonnell has relied upon information provided by third-party sources to complete this study. While there is no reason to believe that the information provided is inaccurate or incomplete in any material respect, Burns & McDonnell has not independently verified such information and cannot guarantee or warranty its accuracy or completeness.

SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5

DW: REC-127



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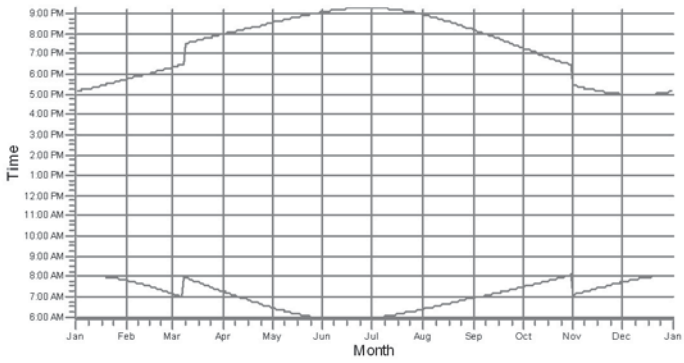

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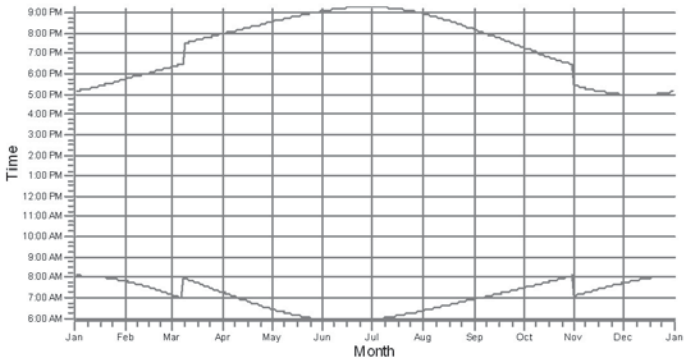

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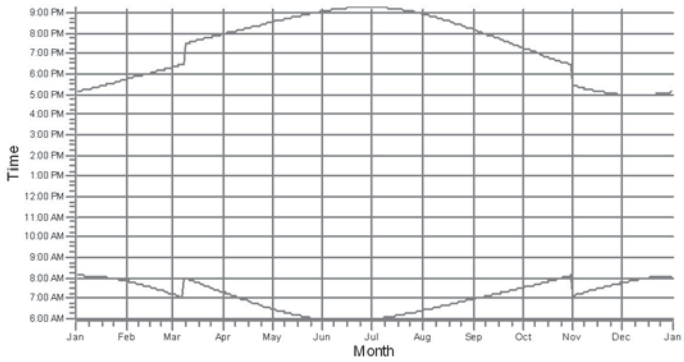

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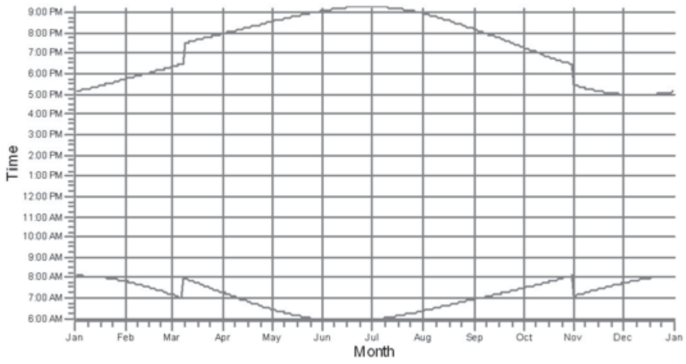
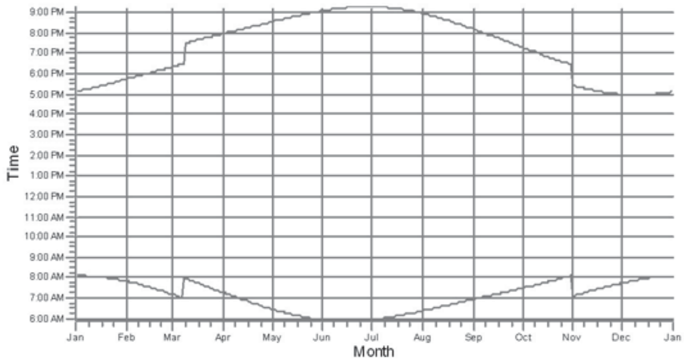


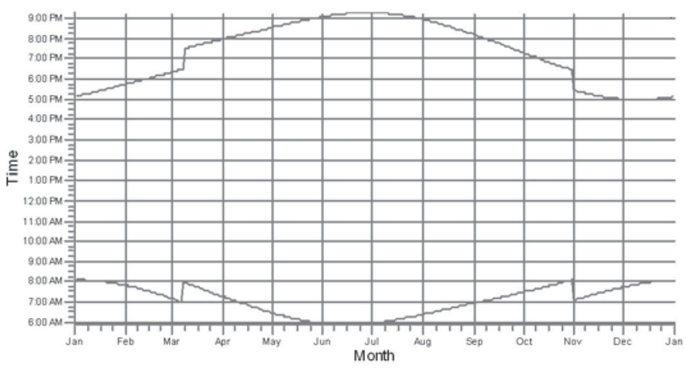
EB: REC-132



WTGs

SHADOW - Calendar, graphical

Calculation: FlickerVestas.v5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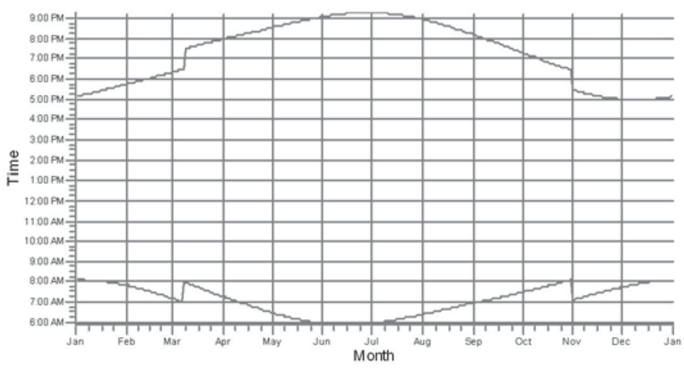
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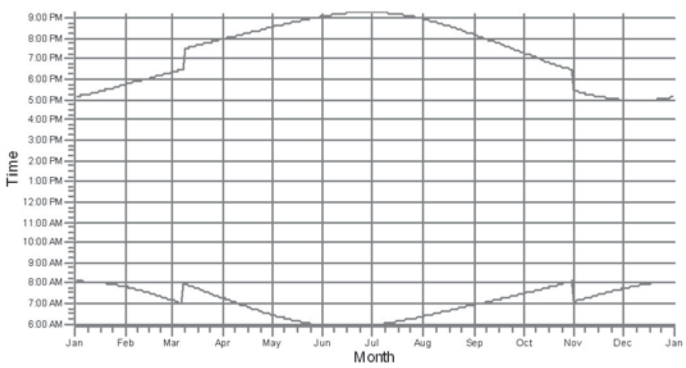
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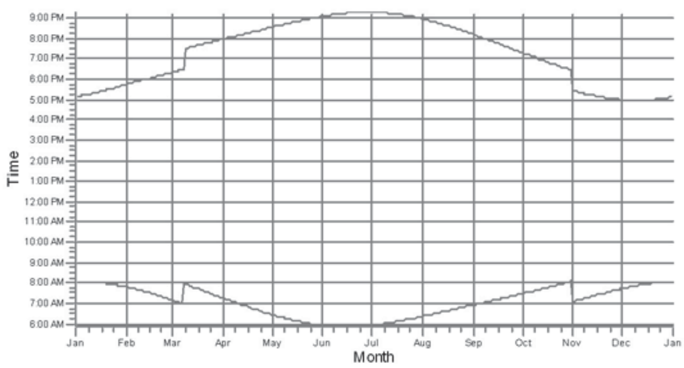
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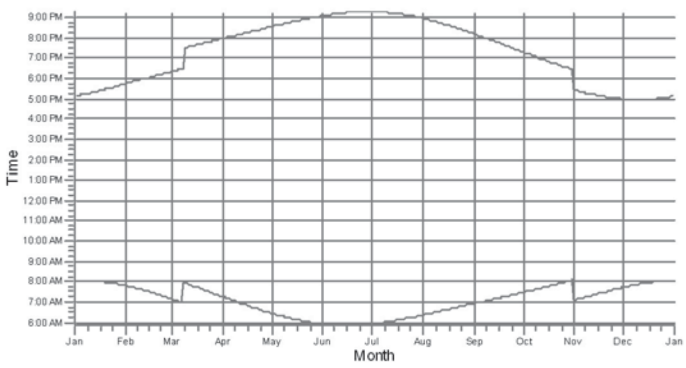
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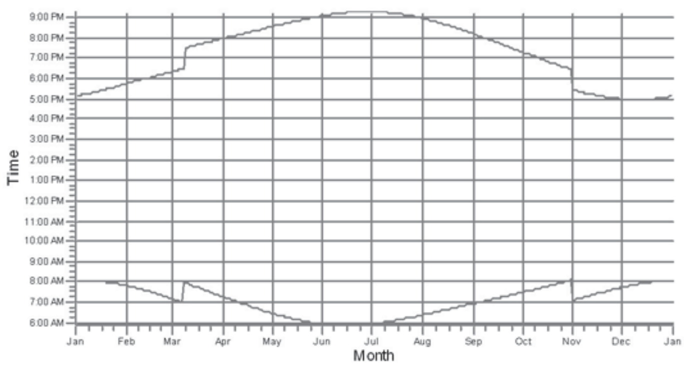
EH: REC-138

WTGs

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ENGINEERING REPORT
CONCERNING THE EFFECTS UPON
FCC LICENSED RF FACILITIES
DUE TO CONSTRUCTION OF
PREVAILING WIND PARK
In
BON HOMME, CHARLES MIX & HUTCHINSON COUNTIES, SOUTH DAKOTA

Prepared for
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201 Mission Street, Suite 540
San Francisco, CA 94105

April 16, 2018

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I. INTRODUCTION

This engineering report describes the results of a study and analysis to determine the locations of federally-licensed (FCC) microwave and other fixed station radio frequency (RF) facilities that may be adversely impacted as a result of the construction of the Prevailing Wind Park in Bon Homme, Charles Mix and Hutchinson Counties, South Dakota. This document describes impact zones and any necessary mitigation procedures, along with recommendations concerning individual wind turbine siting. All illustrations, calculations and conclusions contained in this document are based on FCC database records[1].

Frequently, wind turbines located on land parcels near RF facilities can cause more than one mode of RF impact, and may require an iterative procedure to minimize adverse effects. This procedure is necessary in order to ensure that disruption of RF facilities either does not occur or, in the alternative, that mitigation procedures will be effective. The purpose of this study is to facilitate the siting of turbines to avoid such unacceptable impact.

The Prevailing Wind Park as currently planned involves the construction of up to 61 turbines and up to 3 alternate winter turbine sites. A maximum of 61 turbines would be built. The geographic center of the project area is about 9.6 miles southwest of the City of Tripp, South Dakota. The wind turbines proposed to be erected will have a hub height of up to 110 meters and a rotor radius of about 137 meters. The maximum blade tip height therefore would be up to 178.5 meters AGL.

---

[1] The databases used in creating the attached tables and maps are generally accurate, but anomalies have been known to occur. Generally, for wind turbine siting, an on-site verification survey is often suggested as part of the due diligence process.

Using industry standard procedures and FCC databases, a search was conducted to determine the presence of any existing microwave paths crossing or near the subject property. A specific turbine layout has been submitted for analysis. Accordingly, this report will address the potential conflicts that may be caused by the proposed turbines.

The following tabulation and analysis consists of three sections:

1. Microwave point-to-point path analysis[2]
2. Airports, Radar Stations and Military Aircraft Operations
3. NTIA Notification

The attached figures were generated based upon the operating parameters of the FCC-licensed stations as contained in the FCC station database, with corrections of the antenna locations as needed.

The following analysis examines the pertinent FCC licensed services in the area for impact. This analysis assumes that all licensed services have been designed and constructed according to FCC requirements and good engineering practice. If this is not the case, the impacted facility must share responsibility with the Wind Park developer for the costs of any mitigation measures[3].

Each of the RF analyses is described separately in the sections that follow.

II. ANALYSIS OF MICROWAVE LINKS

An extensive analysis was undertaken to determine the likely effect of the new wind turbine farm upon the existing microwave paths, consisting of a Fresnel x/y/z axis study. The microwave paths have been overlaid on Google Earth™ maps, and the images of the microwave paths and the proposed turbines are also available in a KMZ file.

Important Note: Microwave path studies are based upon third party and FCC databases that normally exhibit a high degree of accuracy and reliability. Although Evans performs due diligence to ensure that all existing microwave facilities are represented, we cannot be responsible for errors in FCC databases that may lead to incomplete results. However, should such situations occur, Evans would perform an engineering analysis to determine how the

---

[2] Only point-to point microwave facilities were considered (for instance, a study of earth station facilities is not included).

[3] For instance, some microwave paths may have insufficient ground clearances as they are presently configured.

additional facilities can be accommodated or, if wind turbine structures are already built, determine a method to re-direct an impacted beam path.

For this microwave study, *Worst Case Fresnel Zones* (WCFZ) were calculated for each microwave path. The mid-point of a microwave path is the location where the widest (or worst case) Fresnel zone occurs. Possible geographic coordinate errors must be taken into account[4]. The radius R of the Worst Case Fresnel Zone, in meters, is calculated for each path using the following formula:

$$R \cong 8.65\sqrt{\frac{D}{F_{GHz}}}$$

where D is the microwave path length in kilometers and F_{GHz} is the frequency in gigahertz.

In general, the WCFZ is defined by the cylindrical area whose axis is the direct line between the microwave link endpoints and whose radius is R as calculated above. This is the zone where the siting of obstructions should be avoided. Evans Engineering Solutions has identified 15 unique point-to-point microwave paths and three point-to-multipoint microwave links from the FCC database that are within 0.5 mile of the project area. These microwave facilities are listed in Table 1 and mapped in Figures 1 and 2.

---

[4] Many microwave facilities were built before accurate methods were available to establish exact geographic coordinates (such as GPS). It is not unusual for database errors of up to 4 or 5 seconds to occur, which can affect the positioning of critical turbines located near Fresnel paths.

Call Sign 1	Site 1 Name	Call Sign 2	Site 2 Name	Freq. (MHz)	WCFZ (m)	Licensee
WBL30	Turkey Ridge (W)	WQDV593	Tripp (E)	6900/7100	24.8	South Dakota Board of Directors for Educational Telecommunic
WBL31	Tripp (W)	WQDV612	Stickney (E)	6900/7075	24.4	South Dakota Board of Directors for Educational Telecommunic
WIA867	Tripp	WNEG799	3370	6550.625 6730.625	19.9	East River Electric Power Coop
WIA867	Tripp	WNEG798	0484	6540.625 6718.125	18.2	East River Electric Power Coop
WIA867	Tripp	WPNL979	Lake Andes	5945.2/6197.24	24.0	East River Electric Power Coop
WIA867	Tripp	WPNL977	Turkey Ridge	6123.1/6375.14	26.4	East River Electric Power Coop
WMQ687	Mitchell	WPNB607	Tripp	5974.85 6226.89	26.5	New Cingular Wireless PCS, LLC
WNEO968	Mitchell	WNER900	Tripp	6152.75 6404.79	28.0	NorthWestern Corporation
WNER900	Tripp	*Receive only*	3024	953.15	46.0	NorthWestern Corporation
WNER900	Tripp	WQMH799	Yankton	6004.5/6256.54	24.7	NorthWestern Corporation
WNER900	Tripp	WQRU421	Tripp Jct	10775/11265	7.3	NorthWestern Corporation
WNER900	Tripp	WQRU420	Tripp City	10815/11305	9.6	NorthWestern Corporation
WNER900	Tripp	WQYY683	Avon Office	10875/11365	9.4	NorthWestern Corporation
WNEY412*	Tripp	--	*None documented*	928.38125 952.38125	--	NorthWestern Corporation
WPNB606	Pickstown	WPNB607	Tripp	6063.8-6815	21.4	New Cingular Wireless PCS, LLC
WPND588*	Tripp	--	*None documented*	928.68125 952.68125	--	East River Electric Power Coop
WQON219*	Avon	--	*None documented*	928.24375 952.24375	--	NorthWestern Corporation
WQST254	Avon Brandt	WQST255	Wagner	5974.85-6256.54	17.2	New Cingular Wireless PCS, LLC

Table 1 – Licensed Microwave Links in and near Prevailing Wind Park Area

Eleven point-to-point microwave paths, highlighted in orange in Table 1, cross the turbine project area. Three point-to-multipoint microwave link stations, highlighted in yellow, are inside the project area. As seen in Figures 3 through 7, several of the planned turbines would be located within 250 meters of the microwave paths (as measured from the turbine tower to the center of the path); however, as Figures 7 through 11 will show, it appears that these turbines would not penetrate the microwave worst-case Fresnel zones.

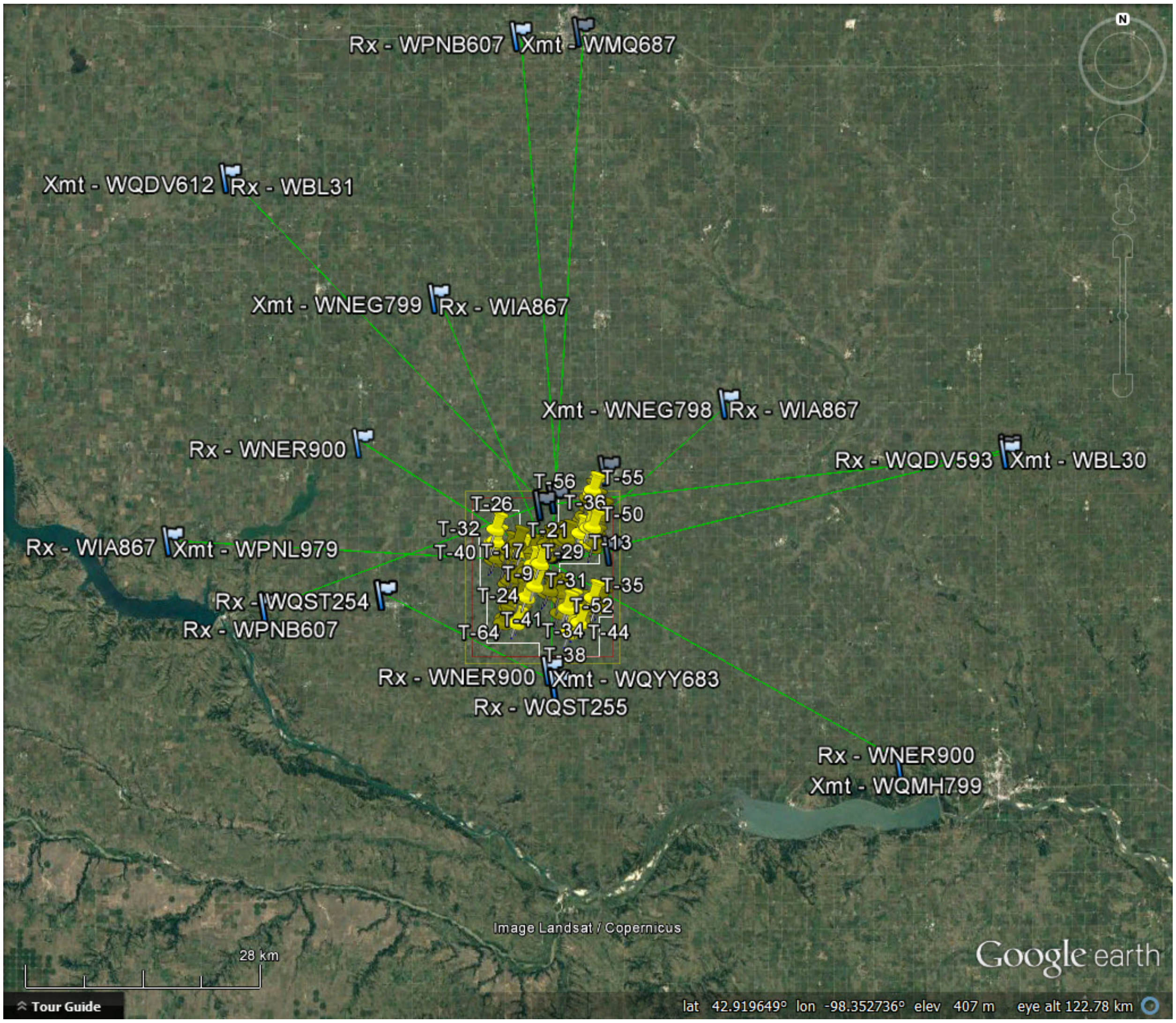


Figure 1 – Licensed Microwave Paths in or near Prevailing Wind Park Area

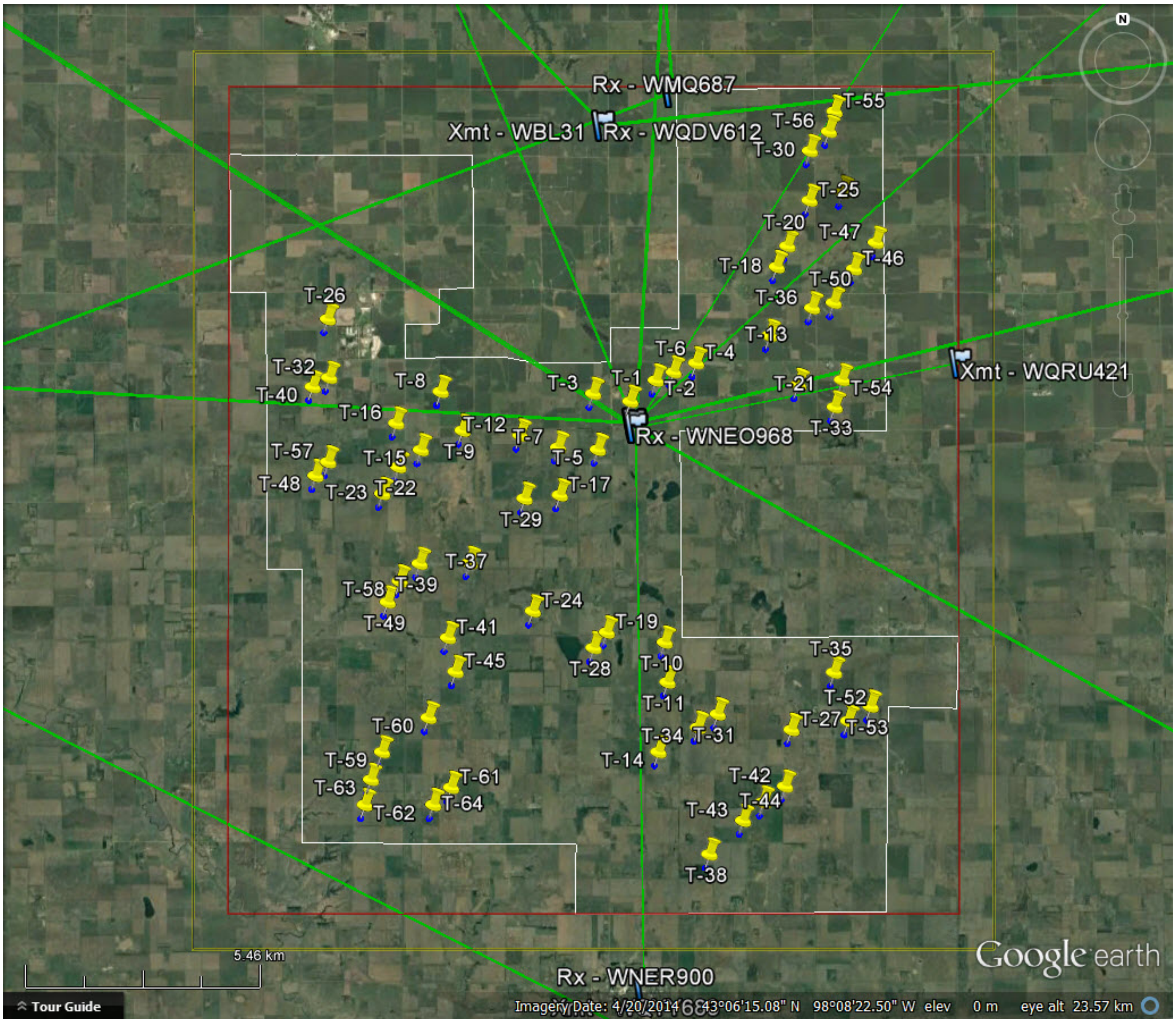


Figure 2 – Close-Up of Licensed Microwave Paths in or near Wind Park Area

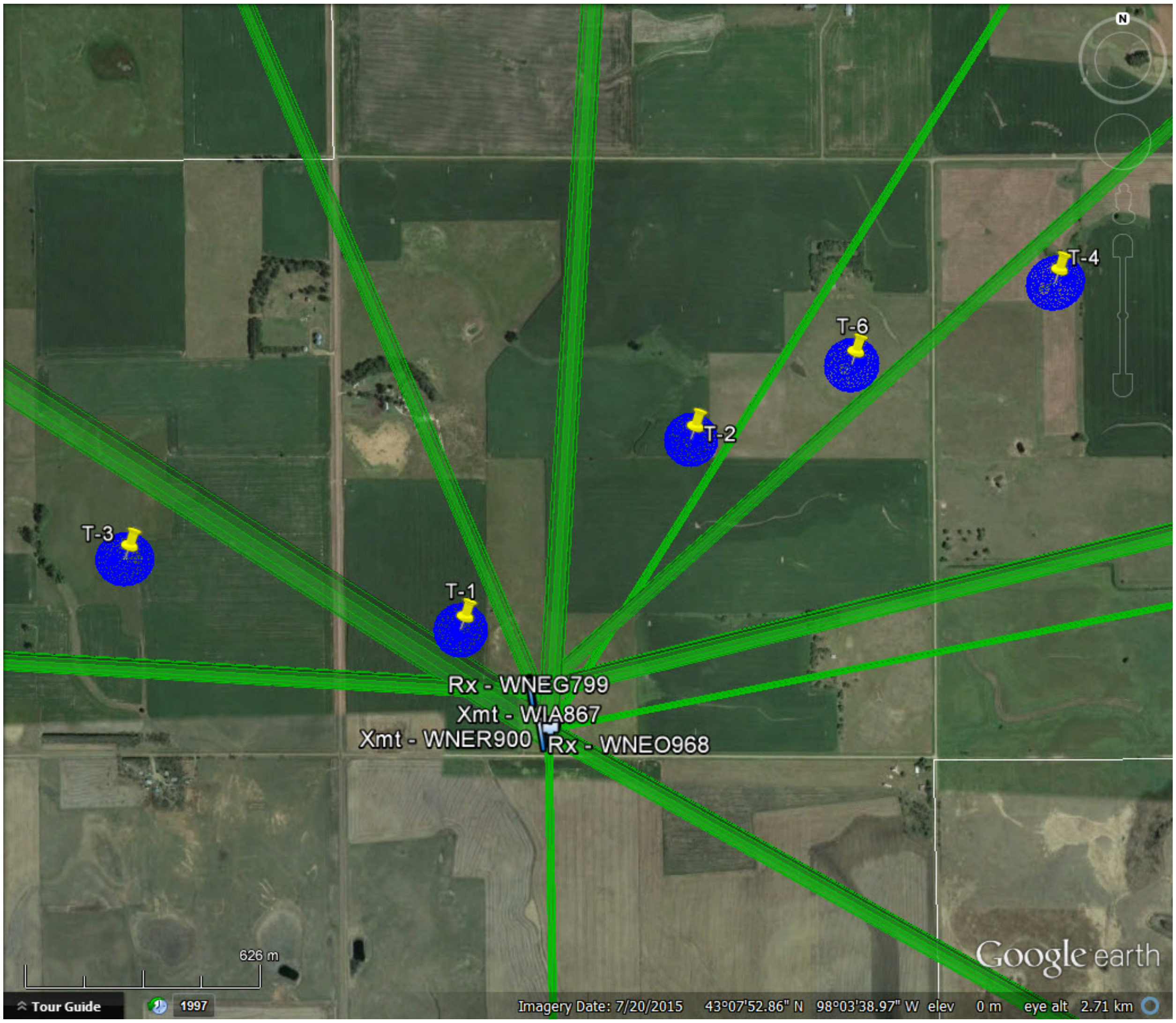


Figure 3 – Turbines 1, 2, 3, 4 and 6 Close to Microwave Paths

As seen in the above figure, Turbine 3 would be clear of any microwave paths, but Turbines 1, 2, 4 and 6 would be very close to paths. Closer views of these turbines are shown in Figures 7 and 8.

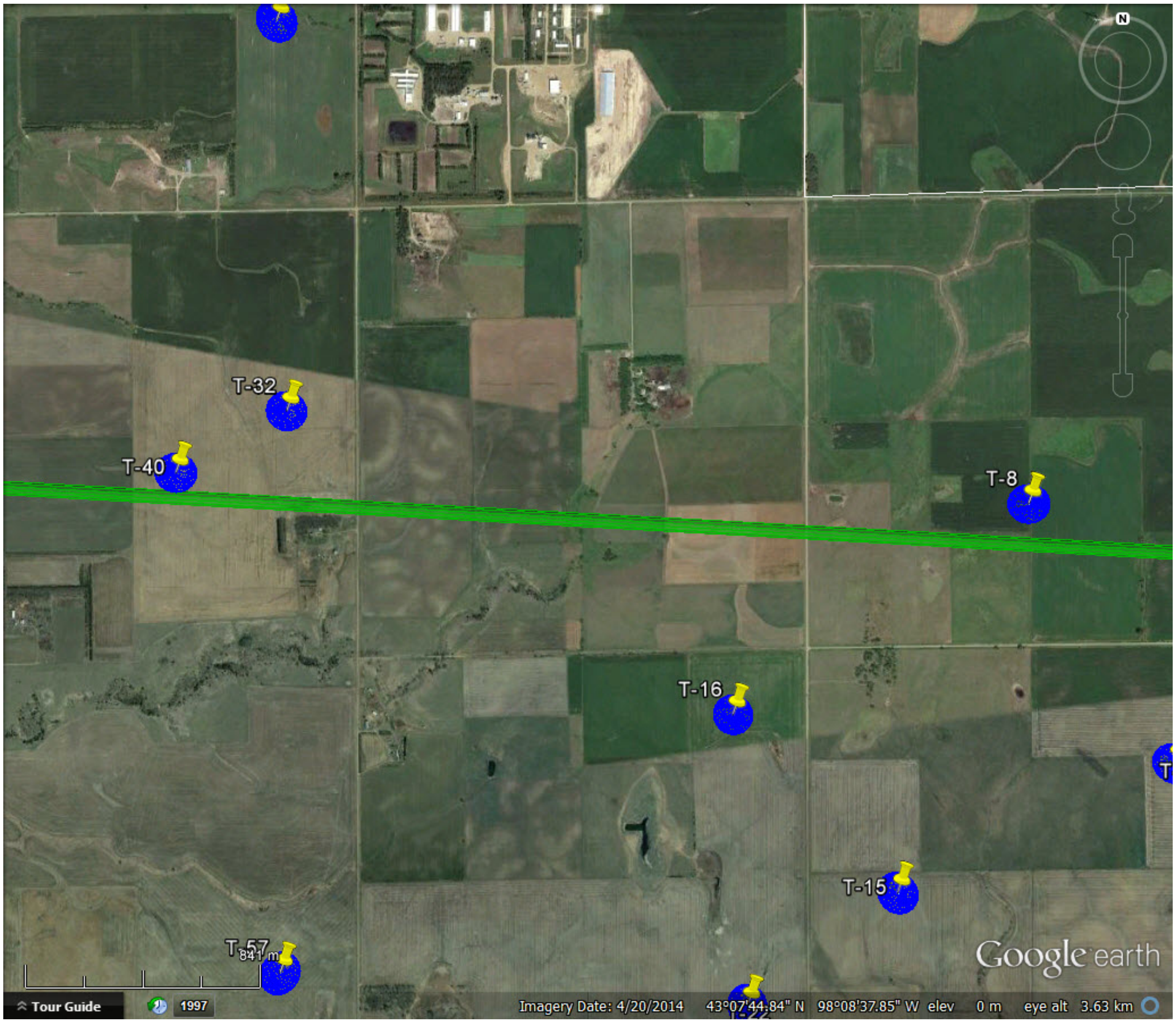


Figure 4 – Turbines 8 and 40 Close to Microwave Path WIA867/WPNL979

As seen in the above figure, Turbine 8 appears to clear the microwave beam, but Turbine 40 is very close to it. A closer view of Turbine 40 is shown in Figure 11.

Figure 5 – Turbines 21 and 54 Close to Microwave Path WNER900/WQRU421

As seen in the above figure, Turbine 54 appears to clear the microwave beam, but Turbine 21 is very close to it. A closer view of Turbine 21 is shown in Figure 9.

Figure 6 – Turbines 30, 55 and 56 Close to Microwave Path WNER900/WQRU420

As seen in the above figure, Turbine 56 appears to clear the microwave beam, but Turbines 30 and 55 are very close to it. A closer view of Turbines 30 and 55 is shown in Figure 10.

The following turbine sites are within 250 meters of a microwave path. The approximate clearances **in the horizontal plane** between the rotor and the edge of the Worst-Case Fresnel Zone (WCFZ) of the microwave path were calculated and were based on the proposed maximum rotor radius of 68.5 meters.

Turbine	Approx. Dist. to Path (m)*	WCFZ Radius (m)	Approx. Horiz. Rotor Clearance (m)
1	113	46.0	-1.5
2	93	9.6	14.9
3	198	46.0	83.5
4	94	18.2	7.3
6	96	18.2	9.3
8	141	24.0	48.5
21	73	7.3	-2.8
30	98	9.6	19.9
40	87	24.0	-5.5
54	156	7.3	80.2
55	93	9.6	14.9
56	231	9.6	152.9

* As measured from the turbine tower to the center of the microwave path.

A negative clearance number, as is derived for Turbines 1, 21 and 40, indicates possible rotor penetration but does not take into account the difference in vertical elevation between the rotor and the microwave Fresnel Zone. If the elevation of the rotor is higher than that of the microwave beam at the point of the path where the turbine is located, then the rotor is clear of the microwave beam. The figures on the following pages examine the potential turbine-to-microwave conflicts in all three dimensions.

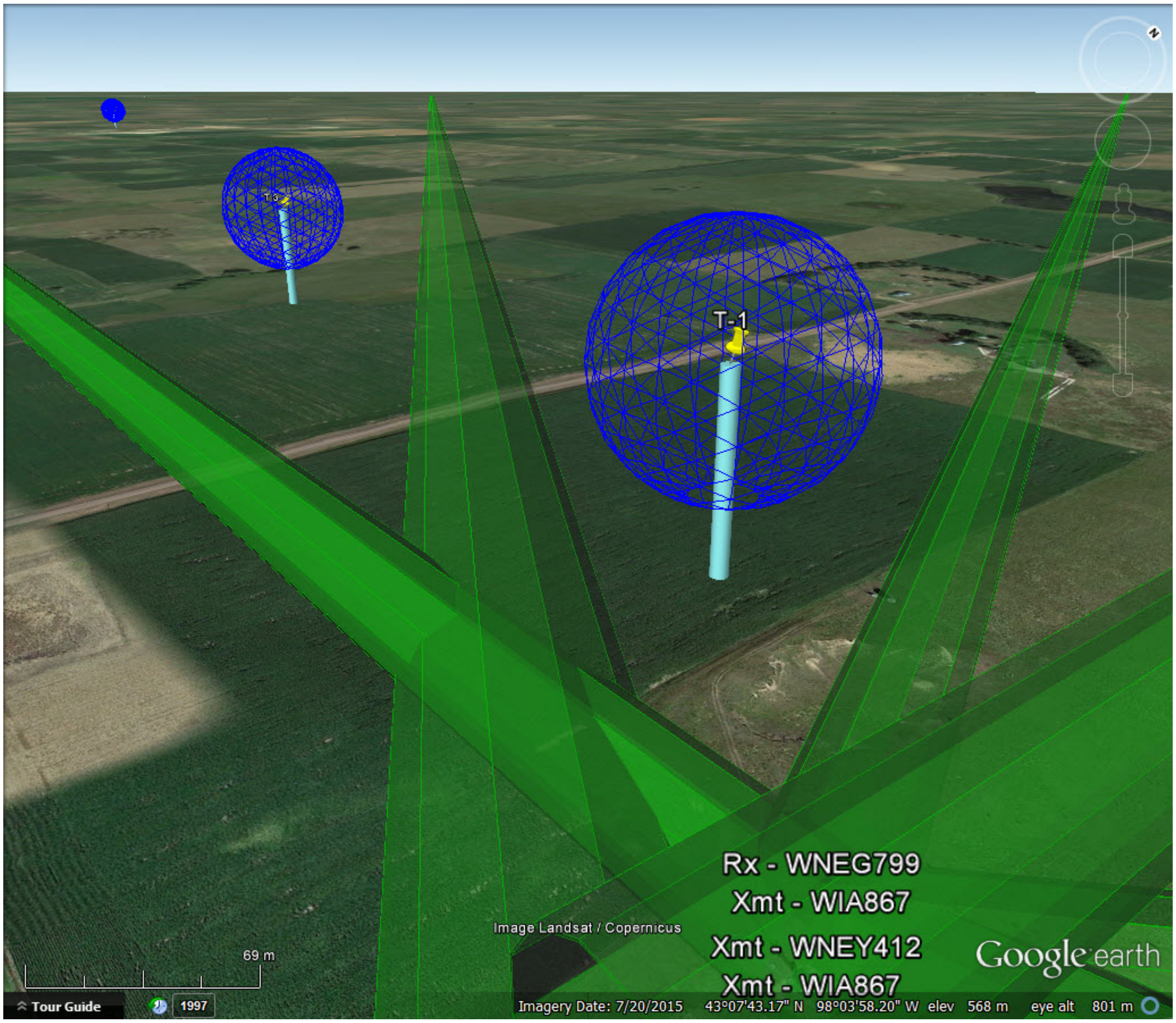


Figure 7 – Turbine 1 Close to Microwave Paths WNER900/Receive-Only & WIA867/WNEG799

As seen in the above figure, Turbine 1 appears to clear the microwave beams.

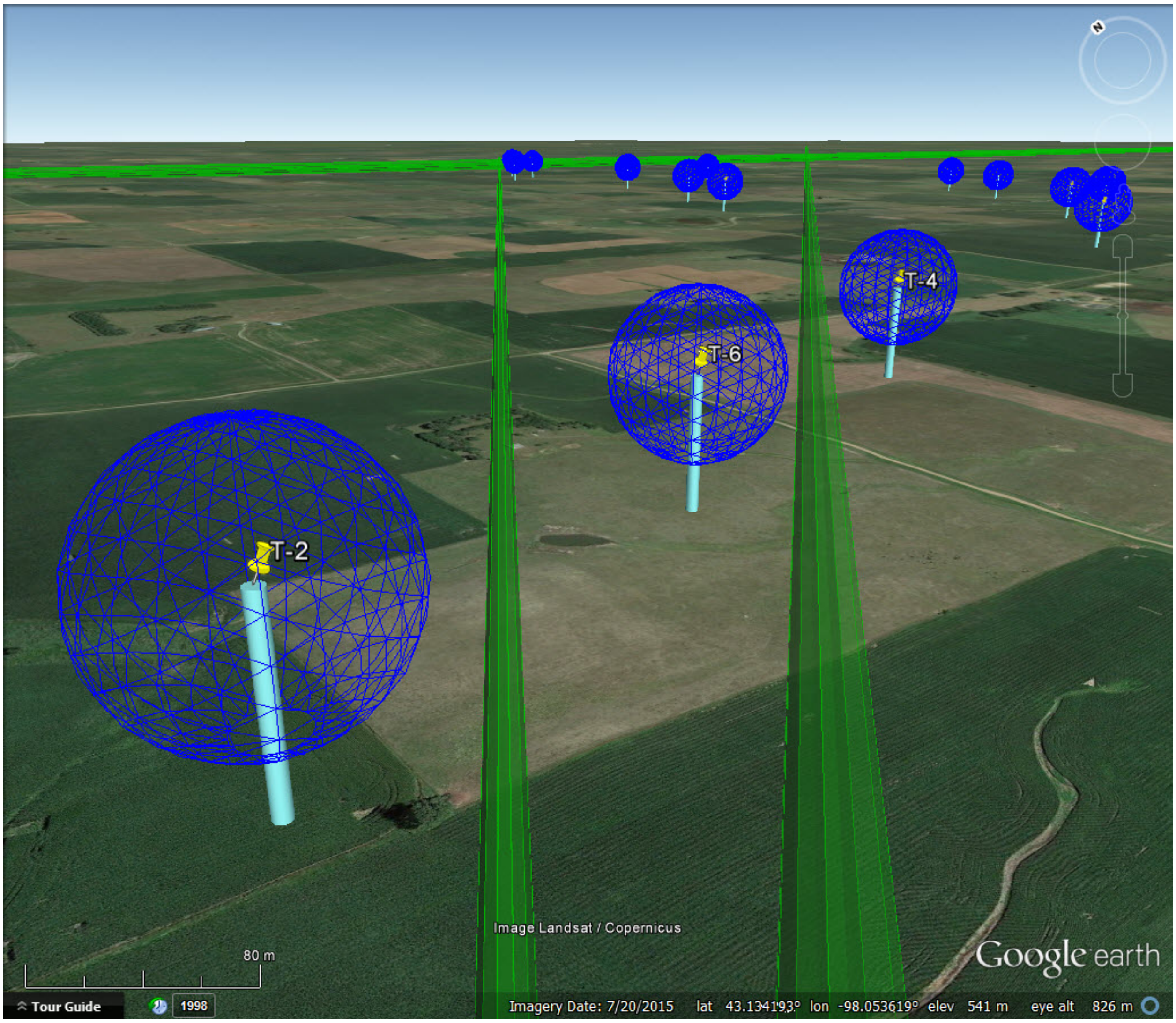


Figure 8 – Turbines 2, 4 and 6 Close to Microwave Paths WNER900/WQRU420 & WIA867/WNEG798

As seen in the above figure, Turbines 2, 4 and 6 appear to clear the microwave beams.

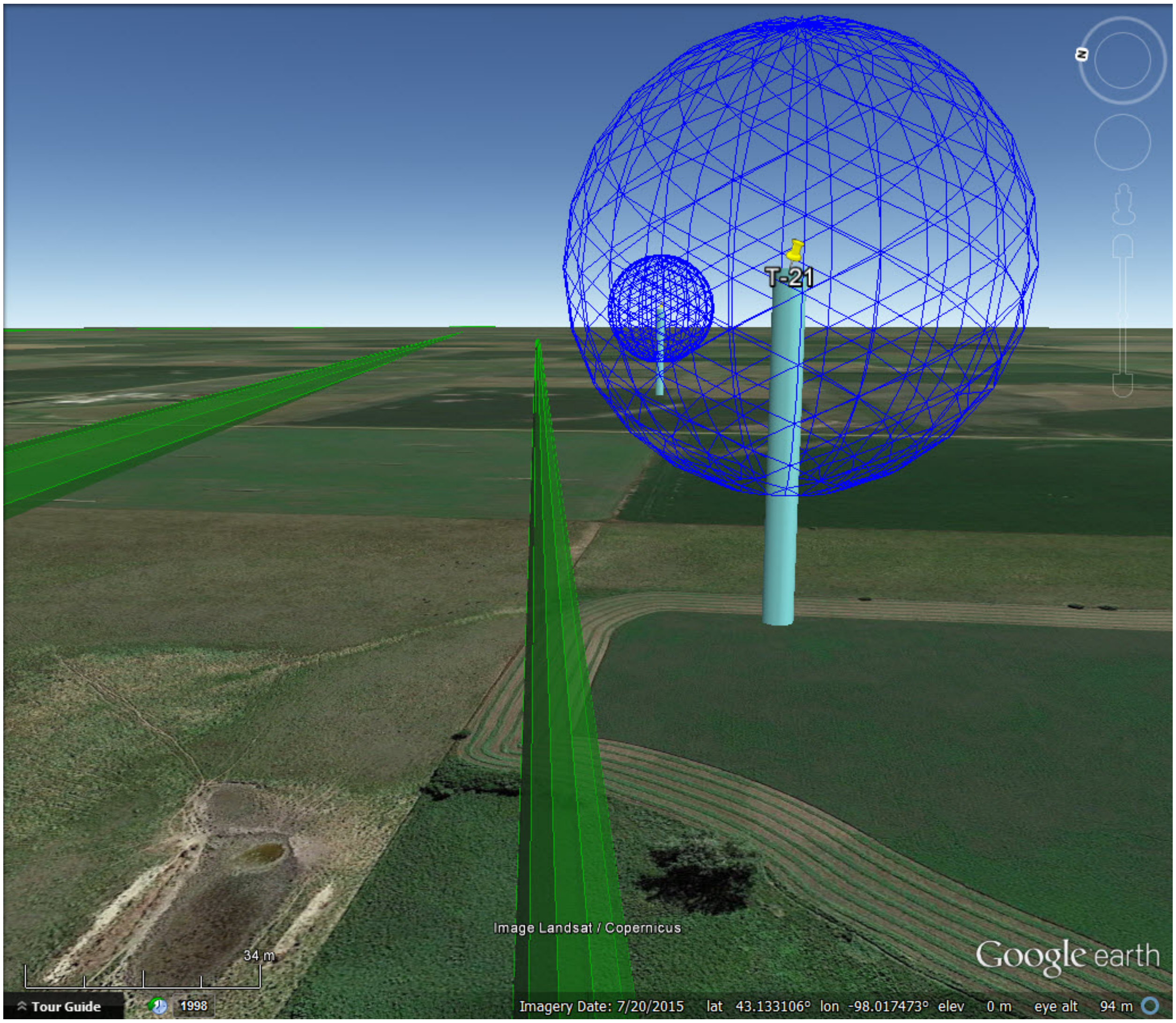


Figure 9 – Turbine 21 Close to Microwave Path WNER900/WQRU421

As seen in the above figure, Turbine 21 appears to clear the microwave beam.

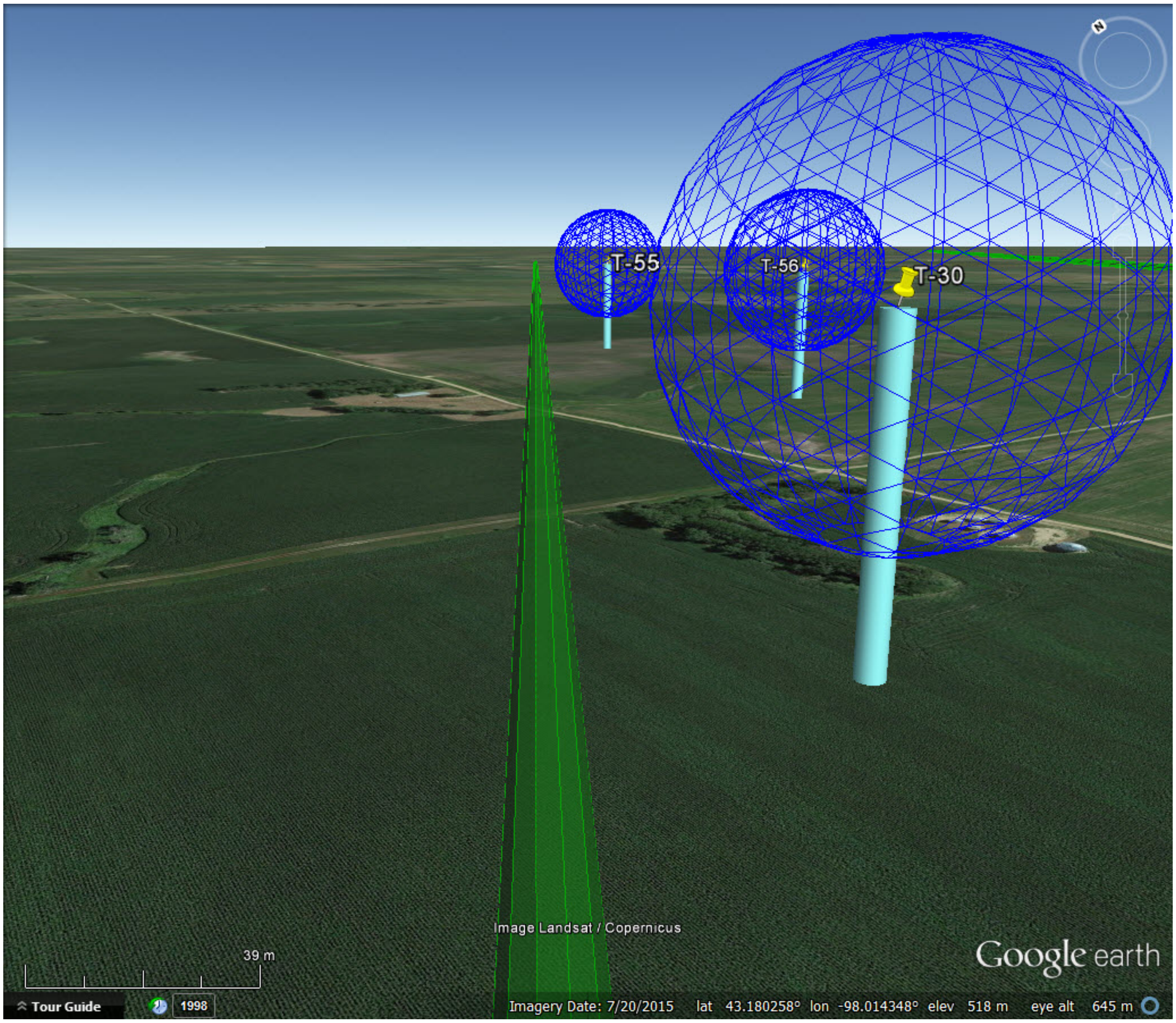


Figure 10 – Turbines 30 and 55 Close to Microwave Path WNER900/WQRU420

As seen in the above figure, Turbines 30 and 55 appear to clear the microwave beam.

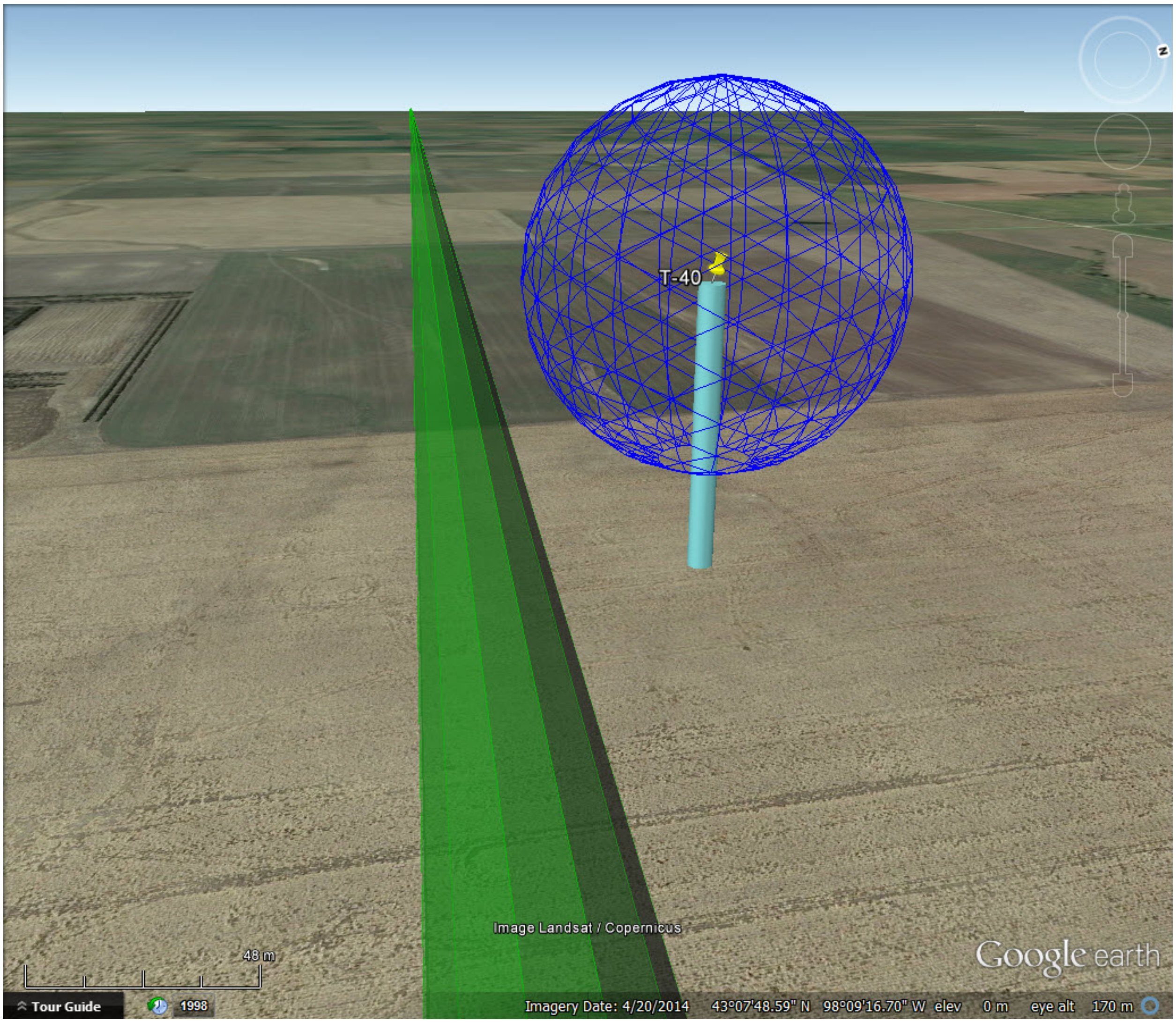


Figure 11 – Turbine 40 Close to Microwave Path WIA867/WPNL979

As seen in the above figure, Turbine 40 appears to clear the microwave beam.

Point-to-Multipoint Microwave Facilities in Project Area

As shown in Table 1, the main transmitter sites of Multiple Address System (MAS) microwave point-to-multipoint stations WNEY412, WPND588 and WQON219 are located inside the Wind Park area, less than 350 meters southeast of the Turbine 1 site. The remote sites for these facilities are not listed in the FCC licenses, so they are known only to their operators. It is the opinion of this engineering firm that adverse impact to any of these stations by the proposed wind turbines is unlikely. However, since the locations of the remote sites are undocumented, the licensees of these stations cannot reasonably expect its microwave links to be protected from the possible effects of new vertical construction.

However, if further due diligence regarding these point-to-multipoint microwave facilities is desired, or required by permitting agencies, additional investigation (beyond the scope of the analyses described in this report), should be conducted, which would include notification of the proposed windfarm construction to the station operators and, if proven to be necessary, performance of studies to determine the possible impact to these microwave facilities.

III. AIRPORTS, RADAR FACILITIES AND MILITARY AIRSPACE

3.1 Airports

The airports and air fields found to be within 20 nautical miles from the center of the Wind Park area are listed in the following Table 2.

FAA ID	Name	Type	City/State	Coordinates	Dist. (nm)	Azimth(°T)
AGZ	Wagner Munic.	Public AP	Wagner SD	43-03-51.0N 98-17-47.0W	10.18	253.8
SD61	Plihal Farms	Private AP	Tyndall SD	43-01-00.0N 97-52-01.3W	10.69	121.9
1SD1	Burke Field	Private AP	Scotland SD	43-09-55.5N 97-43-51.2W	15.36	77.6
Y03	Springfield Munic.	Public AP	Springfield SD	42-52-52.0N 97-54-05.9W	15.73	151.4
8V3	Parkston Munic.	Public AP	Parkston SD	43-22-38.7N 97-59-23.0W	16.39	13.0

Distance and azimuth are referenced to the center of the project area, determined to be 43-06-39N, 98-04-22W.

Table 2 – Airports within 20 Nautical Miles of Wind Park

A determination as to whether the Prevailing Wind Park as proposed would not be a hazard to airspace navigation can only be made by the Federal Aviation Administration. Prior to construction, sPower has sent or will send FAA 7460-1 notification forms for all of the proposed wind turbines to the FAA to begin the aeronautical study process.

3.2 DoD Radar Concerns

The Department of Defense (DoD) and the Department of Homeland Security *Long Range Radar Joint Program Office* “JPO” has adopted a “pre-screening tool” to evaluate the impact of wind turbines on air defense long-range radar. This tool was applied to the Prevailing Wind Park area, and it returned a result of “no anticipated impact” (green) to Air Defense and Homeland Security radars, as seen in Figure 12. However, a definitive determination is obtained only after formal study by the DoD, which is triggered by the FAA 7460-1 notification process.

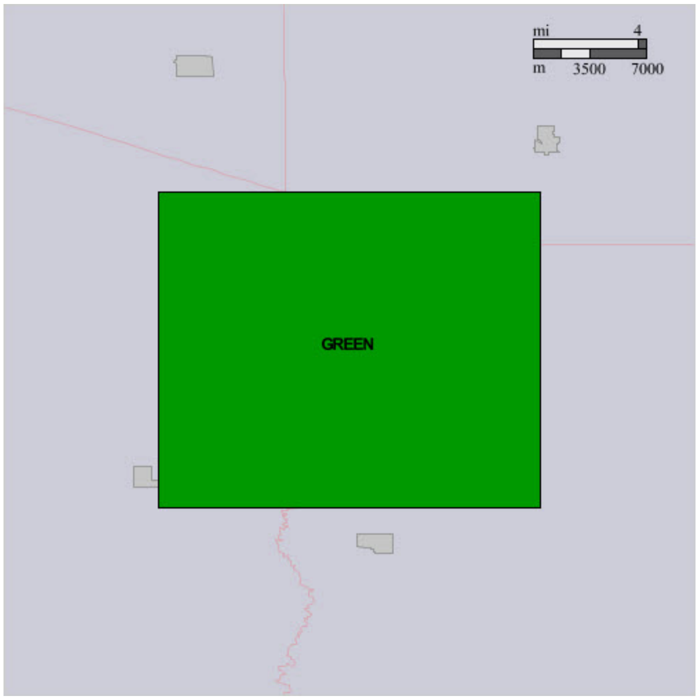
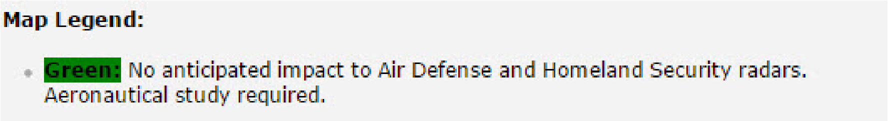


Figure 12 – DoD Long-Range Radar Screening



Map Legend:

- **Green:** No anticipated impact to Air Defense and Homeland Security radars. Aeronautical study required.

3.3 NEXRAD

A pre-screening tool has been developed to evaluate the potential impact of obstructions to the NEXRAD Weather Surveillance Doppler Radar Stations. This tool was applied to the Prevailing Wind Park area, and it returned a result, shown in Figure 13, of "impacts not likely" to weather radar operations. However, a definitive determination is obtained only after the NTIA review process.

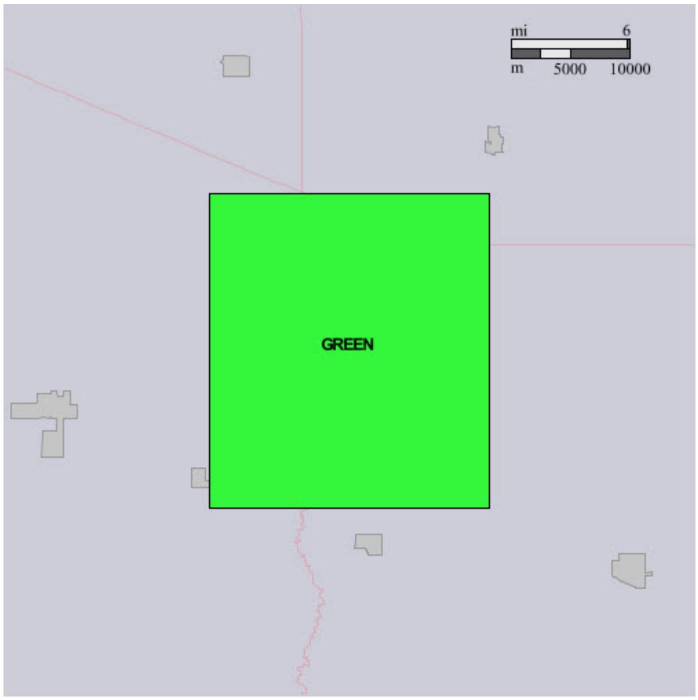
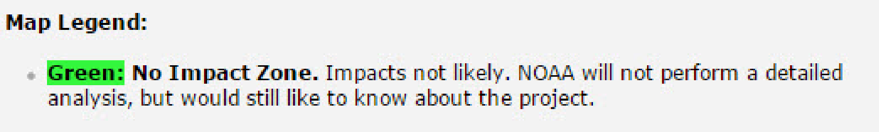


Figure 13 – NEXRAD Weather Radar Screening



Map Legend:

- **Green:** **No Impact Zone.** Impacts not likely. NOAA will not perform a detailed analysis, but would still like to know about the project.

3.4 MILITARY AIRSPACE

A preliminary review of the Wind Park proposal does not return any likely impacts to military airspace. Confirmation and documentation from the USAF Regional Environmental Coordination Office can be obtained if requested.

IV. NTIA NOTIFICATION

Operation of RF frequencies for federal government use is managed by the National Telecommunication Information Agency (NTIA), which is part of the U.S. Department of Commerce. The technical specifications for most government facilities are unavailable to the public. In order to avoid the derailment of the wind energy project due to late objections from a government agency, the NTIA should be notified of the proposed project during pre-construction planning. The NTIA has set in place a review process, wherein the Interdepartmental Radio Advisory Committee (IRAC), consisting of representatives from various government agencies, reviews new proposals for wind turbine projects for impact on government frequencies. In almost all cases, no adverse impact is found, and IRAC usually issues a determination in about 60 days.

On April 6, 2018, this office sent a notification of the Prevailing Wind Park to the NTIA, and a determination is expected around the beginning of June 2018.

V. CONCLUSIONS AND RECOMMENDATIONS

1. There are 11 FCC-licensed microwave paths crossing the project area. There appear to be no conflicts between the proposed turbines and the paths.

2. The main sites of three point-to-multipoint microwave MAS facilities are inside the Wind Park area. The locations of the remote sites are undocumented. While it is the belief of this firm that the turbines would not adversely impact these facilities, a follow-up investigation of these microwave links is suggested if further due diligence is desired.

3. If an excessive amount of time goes by before the turbines are to be constructed (six months or more), it is recommended that the microwave study be updated in case new paths have been added to the FCC's database.

Respectfully Submitted,

B. Benjamin Evans
RF Impact Consultant

April 16, 2018

LBNL-2829E

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BERKELEY NATIONAL LABORATORY

The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis

**Ben Hoen, Ryan Wiser, Peter Cappers,
Mark Thayer, and Gautam Sethi**

**Environmental Energy
Technologies Division**

December 2009

The work described in this report was funded by the Office of Energy Efficiency and Renewable Energy (Wind & Hydropower Technologies Program) of the U.S. Department of Energy under Contract No. DE-AC02-05CH1123.

Disclaimer

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The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis

Prepared for the

Office of Energy Efficiency and Renewable Energy
Wind & Hydropower Technologies Program
U.S. Department of Energy
Washington, D.C.

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Abstract

With wind energy expanding rapidly in the U.S. and abroad, and with an increasing number of communities considering wind power development nearby, there is an urgent need to empirically investigate common community concerns about wind project development. The concern that property values will be adversely affected by wind energy facilities is commonly put forth by stakeholders. Although this concern is not unreasonable, given property value impacts that have been found near high voltage transmission lines and other electric generation facilities, the impacts of wind energy facilities on residential property values had not previously been investigated thoroughly. The present research collected data on almost 7,500 sales of single-family homes situated within 10 miles of 24 existing wind facilities in nine different U.S. states. The conclusions of the study are drawn from eight different hedonic pricing models, as well as both repeat sales and sales volume models. The various analyses are strongly consistent in that none of the models uncovers conclusive evidence of the existence of any widespread property value impacts that might be present in communities surrounding wind energy facilities. Specifically, neither the view of the wind facilities nor the distance of the home to those facilities is found to have any consistent, measurable, and statistically significant effect on home sales prices. Although the analysis cannot dismiss the possibility that individual homes or small numbers of homes have been or could be negatively impacted, it finds that if these impacts do exist, they are either too small and/or too infrequent to result in any widespread, statistically observable impact.

Table of Contents

List of Tables

List of Figures

Acknowledgements

The work described in this report was funded by the Office of Energy Efficiency and Renewable Energy (Wind & Hydropower Technologies Program) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231. The authors would particularly like to thank Megan McCluer, Patrick Gilman, Jim Ahlgrimm, Michele Desautels, and Steve Lindenberg, all of the U.S. Department of Energy, for their long-term support of this work. For reviewing drafts of this report and/or for providing comments that helped shape the early thinking on this project, the authors thank Mark Bolinger, Galen Barbose, and Larry Dale (Berkeley Lab), Alejandro Moreno (US DOE), Larry Flowers and Eric Lantz (NREL), Peter Dent and Sally Sims (Oxford Brookes University), Sandy Bond (Curtin Business School), Randy Winter, Dave Loomis, and Jennifer Hinman (Illinois State University), Thomas Priestley (CH2M Hill), Barton DeLacy (Cushman & Wakefield), Dave Maturen (Maturen Appraisal), Mike McCann (McCann Appraisal), Tom Hewson (Energy Ventures Analysis), Kimberly Centera (AES), Jeff Peterson (NYSERDA), Charles Kubert (Clean Energy Group), Lisa Linowes (Industrial Wind Action), Chris Taylor (Element Power), Sam Enfield (MAP Royalty, Inc.), and Laurie Jodziewicz (AWEA). Of course, any remaining omissions or inaccuracies are those of the authors.

Executive Summary

Overview

Wind power development in the United States has expanded dramatically in recent years. If that growth is to continue it will require an ever-increasing number of wind power projects to be sited, permitted, and constructed. Most permitting processes in the U.S. require some form of environmental impact assessment as well as public involvement in the siting process. Though public opinion surveys generally show that acceptance towards wind energy is high, a variety of concerns with wind power development are often expressed on the local level during the siting and permitting process. One such concern is the potential impact of wind energy projects on the property values of nearby residences.

Concerns about the possible impact of wind power facilities on residential property values can take many forms, but can be divided into the following non-mutually exclusive categories:

- Area Stigma: A concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines.
- Scenic Vista Stigma: A concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Nuisance Stigma: A concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values.

Although concerns about the possible impact of wind energy facilities on the property values of nearby homes are reasonably well established, the available literature[1] that has sought to quantify the impacts of wind projects on residential property values has a number of shortcomings:

1) Many studies have relied on surveys of homeowners or real estate professionals, rather than trying to quantify real price impacts based on market data;
2) Most studies have relied on simple statistical techniques that have limitations and that can be dramatically influenced by small numbers of sales transactions or survey respondents;
3) Most studies have used small datasets that are concentrated in only one wind project study area, making it difficult to reliably identify impacts that might apply in a variety of areas;
4) Many studies have not reported measurements of the statistical significance of their results, making it difficult to determine if those results are meaningful;
5) Many studies have concentrated on an investigation of the existence of Area Stigma, and have ignored Scenic Vista and/or Nuisance Stigmas;
6) Only a few studies included field visits to homes to determine wind turbine visibility and collect other important information about the home (e.g., the quality of the scenic vista); and
7) Only two studies have been published in peer-reviewed academic journals.

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[1] This literature is briefly reviewed in Section 2 of the full report, and includes: Jordal-Jorgensen (1996); Jerabek (2001); Grover (2002); Jerabek (2002); Sterzinger et al. (2003); Beck (2004); Haughton et al. (2004); Khatri (2004); DeLacy (2005); Poletti (2005); Goldman (2006); Hoen (2006); Firestone et al. (2007); Poletti (2007); Sims and Dent (2007); Bond (2008); McCann (2008); Sims et al. (2008); and Kielisch (2009).

This report builds on the previous literature that has investigated the potential impact of wind projects on residential property values by using a hedonic pricing model and by avoiding many of the shortcomings enumerated above. The hedonic pricing model is one of the most prominent and reliable methods for identifying the marginal impacts of different housing and community characteristics on residential property values (see side bar). This approach dates to the seminal work of Rosen (1974) and Freeman (1979), and much of the available literature that has investigated the impacts of potential disamenities on property values has relied on this method.[2]

What Is a Hedonic Pricing Model?
Hedonic pricing models are frequently used by economists and real estate professionals to assess the impacts of house and community characteristics on property values by investigating the sales prices of homes. A house can be thought of as a bundle of characteristics (e.g., number of square feet, number of bathrooms). When a price is agreed upon by a buyer and seller there is an implicit understanding that those characteristics have value. When data from a large number of residential transactions are available, the individual marginal contribution to the sales price of each characteristic for an average home can be estimated with a hedonic regression model. Such a model can statistically estimate, for example, how much an additional bathroom adds to the sale price of an average home. A particularly useful application of the hedonic model is to value non-market goods – goods that do not have transparent and observable market prices. For this reason, the hedonic model is often used to derive value estimates of amenities such as wetlands or lake views, and disamenities such as proximity to and/or views of high-voltage transmission lines, roads, cell phone towers, and landfills. It should be emphasized that the hedonic model is not typically designed to appraise properties (i.e., to establish an estimate of the market value of a home at a specified point in time), as would be done with an automated valuation model. Instead, the typical goal of a hedonic model is to estimate the marginal contribution of individual house or community characteristics to sales prices.

To seed the hedonic model with appropriate market data, this analysis collects information on a large quantity of residential home sales (i.e., transactions) (*n* = 7,459) from ten communities surrounding 24 existing wind power facilities spread across multiple parts of the U.S. (e.g., nine states). Homes included in this sample are located from 800 ft to over five miles from the nearest wind energy facility, and were sold at any point from before wind facility announcement to over four years after the construction of the nearby wind project. Each of the homes that sold was visited to determine the degree to which the wind facility was likely to have been visible at the time of sale and to collect other essential data.

To assess the potential impacts of all three of the property value stigmas described earlier, a base hedonic model is applied as well as seven alternative hedonic models each designed to investigate the reliability of the results and to explore other aspects of the data (see Table ES - 1 below). In addition, a repeat sales model is analyzed, and an investigation of possible impacts on sales volumes is

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[2] Many of these studies are summarized in the following reviews: Kroll and Priestley (1992); McCann (1999); Bateman et al. (2001); Boyle and Kiel (2001); Jackson (2001); Simons and Saginor (2006); and Leonard et al. (2008). For further discussion of the hedonic model and its application to the quantification of environmental stigmas see Jackson (2005) and Simons (2006a).

conducted. Though some limitations to the analysis approach and available data are acknowledged, the resulting product is the most comprehensive and data-rich analysis to date in the U.S. or abroad on the impacts of wind projects on nearby property values.

Analysis Findings

Table ES - 1 describes the ten resulting statistical models that are employed to investigate the effects of wind facilities on residential sales prices, and the specific stigmas that those models investigate. Though all models test some combination of the three possible stigmas, they do so in different ways. For instance, the Base Model asks the question, “All else being equal, do homes near wind facilities sell for prices different than for homes located farther away?”, while the All Sales Model asks, “All else being equal, do homes near wind facilities that sell after the construction of the wind facility sell for prices different from similar homes that sold before the announcement and construction of the facility?” Each model is therefore designed to not only test for the reliability of the overall results, but also to explore the myriad of potential effects from a variety of perspectives. Table ES-2 summarizes the results from these models.

Table ES - 1: Description of Statistical Models

Statistical Model	Description
Base Hedonic Model	Using only "post-construction" transactions (those that occurred after the wind facility was built), this model investigates all three stigmas in a straightforward manner
Alternative Hedonic Models	
View Stability	Using only post-construction transactions, this model investigates whether the Scenic Vista Stigma results from the Base Model are independent of the Nuisance and Area Stigma results
Distance Stability	Using only post-construction transactions, this model investigates whether the Nuisance and Area Stigma results from the Base Model are independent of the Scenic Vista Stigma results
Continuous Distance	Using only post-construction transactions, this model investigates Area and Nuisance Stigmas by applying a continuous distance parameter as opposed to the categorical variables for distance used in the previous models
All Sales	Using all transactions, this model investigates whether the results for the three stigmas change if transactions that occurred before the announcement and construction of the wind facility are included in the sample
Temporal Aspects	Using all transactions, this model further investigates Area and Nuisance Stigmas and how they change for homes that sold more than two years pre-announcement through the period more than four years post-construction
Orientation	Using only post-construction transactions, this model investigates the degree to which a home’s orientation to the view of wind turbines affects sales prices
Overlap	Using only post-construction transactions, this model investigates the degree to which the overlap between the view of a wind facility and a home’s primary scenic vista affects sales prices
Repeat Sales Model	Using paired transactions of homes that sold once pre-announcement and again post-construction, this model investigates the three stigmas, using as a reference transactions of homes located outside of five miles of the nearest wind turbine and that have no view of the turbines
Sales Volume Model	Using both pre-announcement and post-construction transactions, this model investigates whether the rate of home sales (not the price of those sales) is affected by the presence of nearby wind facilities

Table ES-2: Impact of Wind Projects on Property Values: Summary of Key Results

	Is there statistical evidence of:			
Statistical Model	**Area Stigma?**	**Scenic Vista Stigma?**	**Nuisance Stigma?**	**Section Reference**
Base Model	No	No	No	*Section 4*
View Stability	Not tested	No	Not tested	*Section 5.1*
Distance Stability	No	Not tested	No	*Section 5.1*
Continuous Distance	No	No	No	*Section 5.2*
All Sales	No	No	Limited	*Section 5.3*
Temporal Aspects	No	No	No	*Section 5.4*
Orientation	No	No	No	*Section 5.5*
Overlap	No	Limited	No	*Section 5.6*
Repeat Sales	No	Limited	No	*Section 6*
Sales Volume	No	Not tested	No	*Section 7*

"No"…………………	*No statistical evidence of a negative impact*
"Yes"…………………	*Strong statistical evidence of a negative impact*
"Limited"……………	*Limited and inconsistent statistical evidence of a negative impact*
"Not tested"…………	*This model did not test for this stigma*

Base Model Results

The Base Model serves as the primary model and allows all three stigmas to be explored. In sum, this model finds no persuasive evidence of any of the three potential stigmas: neither the view of the wind facilities nor the distance of the home to those facilities is found to have any consistent, measurable, and statistically significant effect on home sales prices.

- Area Stigma: To investigate Area Stigma, the model tests whether the sales prices of homes situated anywhere outside of one mile and inside of five miles of the nearest wind facility are measurably different from the sales price of those homes located outside of five miles. No statistically significant differences in sales prices between these homes are found (see Figure ES-1).
- Scenic Vista Stigma: For Scenic Vista Stigma, the model is first used to investigate whether the sales prices of homes with varying scenic vistas - absent the presence of the wind facility - are measurably different. The model results show dramatic and statistically significant differences in this instance (see Figure ES-2); not surprisingly, home buyers and sellers consider the scenic vista of a home when establishing the appropriate sales price. Nonetheless, when the model tests for whether homes with minor, moderate, substantial, or extreme views of wind turbines have measurably different sales prices, no statistically significant differences are apparent (see Figure ES-3).
- Nuisance Stigma: Finally, for Nuisance Stigma, the model is used to test whether the sales prices of homes situated inside of one mile of the nearest wind energy facility are measurably different from those homes located outside of five miles. Although sample size is somewhat limited in this case,[3] the model again finds no persuasive statistical evidence that wind

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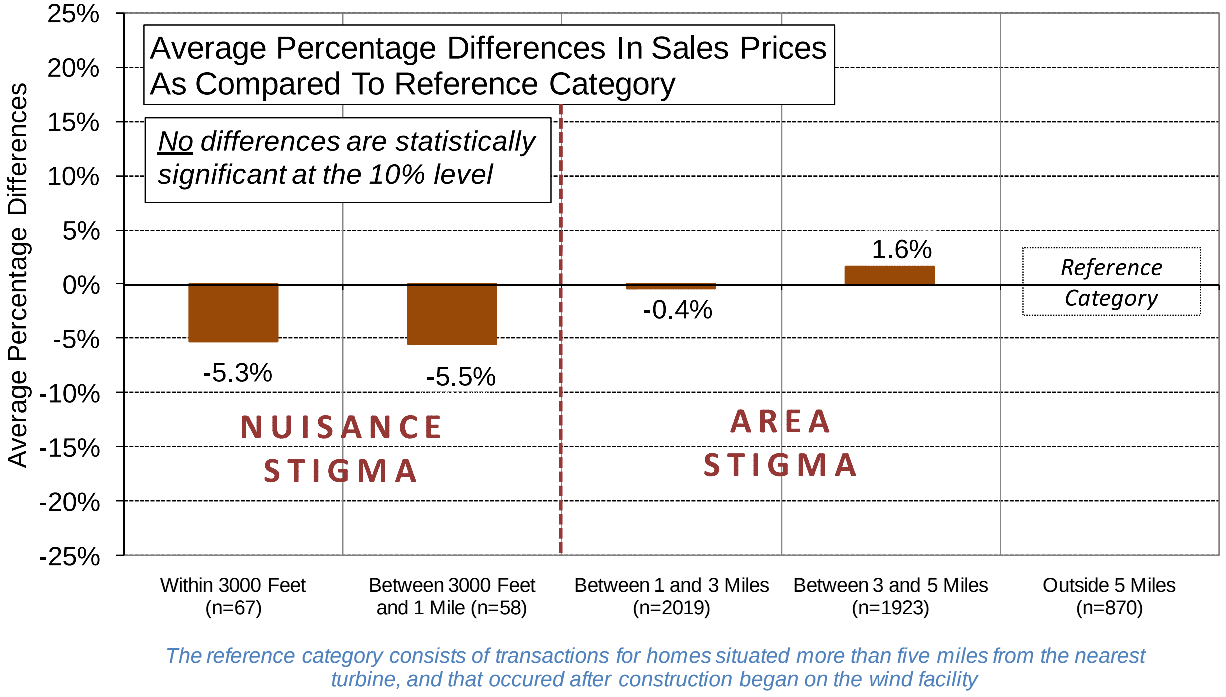
[3] 125 homes were located inside of one mile of the nearest wind facility and sold post-construction.

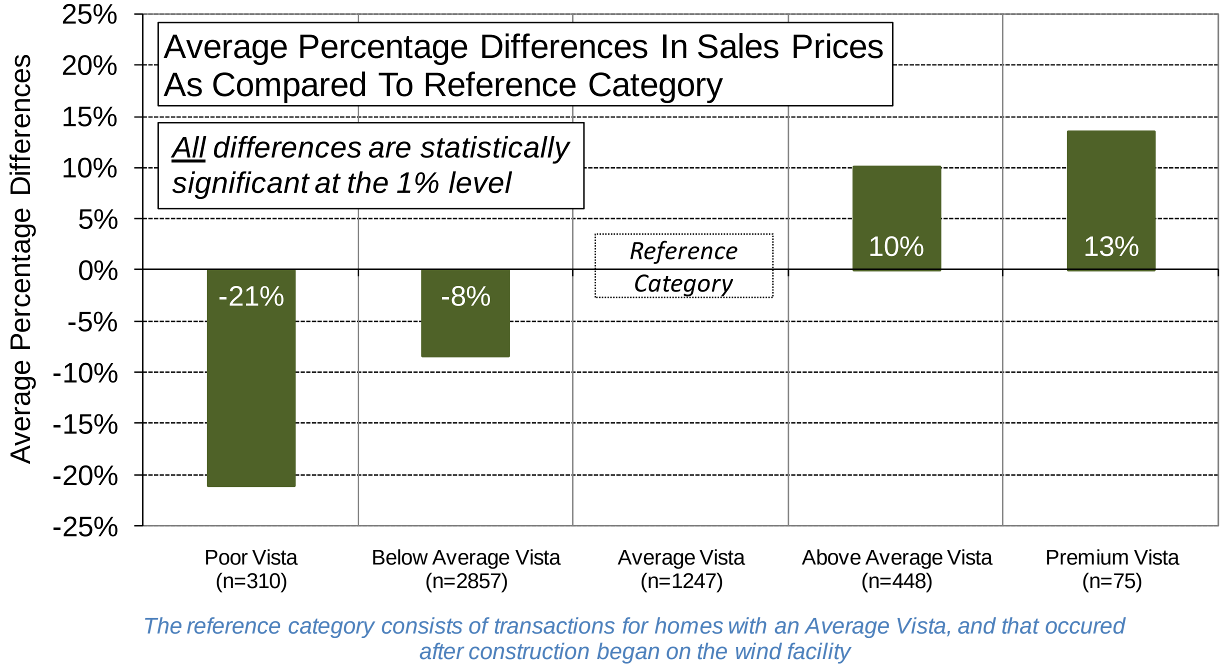
facilities measurably and broadly impact residential sales prices (see Figure ES-1 and later results).

Figure ES-1: Base Model Results: Area and Nuisance Stigma



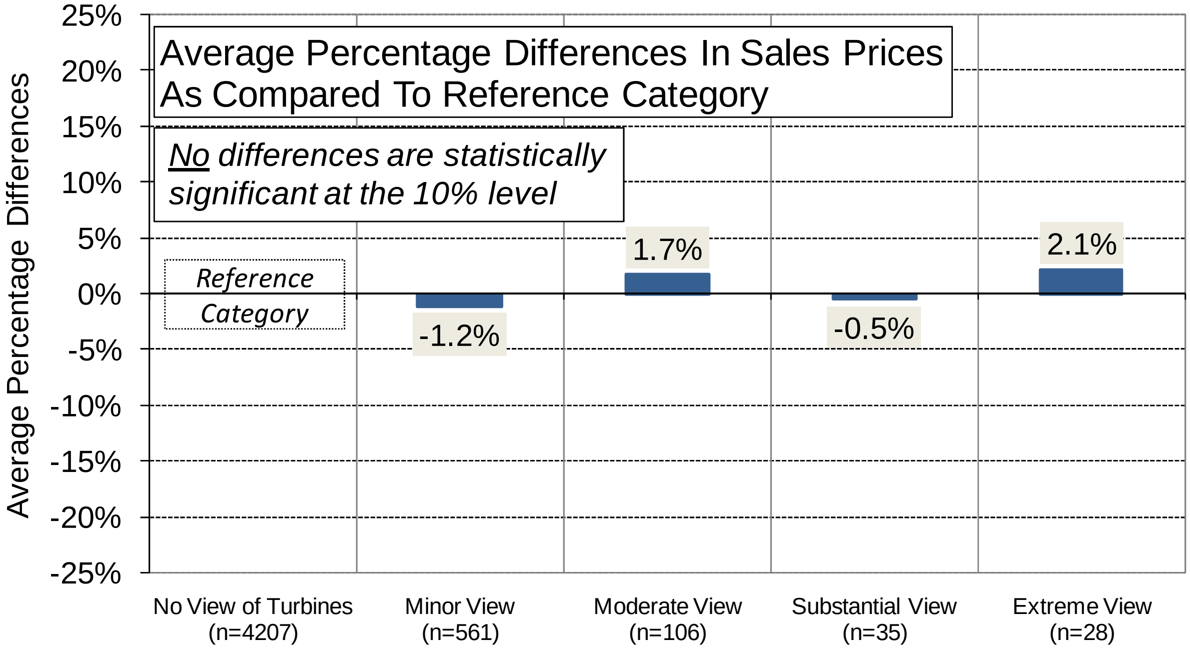
The reference category consists of transactions for homes situated more than five miles from the nearest turbine, and that occured after construction began on the wind facility

Figure ES-2: Base Model Results: Scenic Vista



The reference category consists of transactions for homes with an Average Vista, and that occured after construction began on the wind facility

Figure ES-3: Base Model Results: Scenic Vista Stigma



The reference category consists of transactions for homes without a view of the turbines, and that occured after construction began on the wind facility

The seven alternative hedonic models and the additional analysis contained in the Repeat Sales and Sales Volume Models (see Table ES-2) provide a fuller picture of the three stigmas and the robustness of the Base Model results.

Area Stigma: Other Model Results

Concentrating first on Area Stigma, the results from all of the models are similar: there is no statistical evidence of a widespread Area Stigma among the homes in this sample. Homes in the study areas analyzed here do not appear to be measurably stigmatized by the arrival of a wind facility, regardless of when those homes sold in the wind project development process and regardless of whether the homes are located one mile or five miles away from the nearest facility.

In the All Sales Model, for example, after adjusting for inflation,[4] homes that sold after wind facility construction and that had no view of the turbines are found to have transacted for higher prices - not lower - than those homes that sold prior to wind facility construction. Moreover, in the Temporal Aspects Model, homes that sold more than two years prior to the announcement of the wind facility and that were located more than five miles from where the turbines were eventually located are found to have transacted for lower prices - not higher - than homes situated closer to the turbines and that sold at any time after the announcement and construction of the wind facility (see Figure ES - 4). Further, in the Repeat Sales Model, homes located near the wind facilities that transacted more than once were found to have appreciated between those sales by an amount that was no different from that experienced by homes located in an area

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[4] All sales prices in all models are adjusted for inflation, but because this model (and the Temporal Aspects Model) deals with time explicitly, it is mentioned specifically here.

many miles away from the wind facilities. Finally, as shown in Table ES-2, none of the other models identified evidence of a broadly negative and statistically significant Area Stigma.

Scenic Vista Stigma: Other Model Results

With respect to Scenic Vista Stigma, the seven alternative hedonic models and the additional analysis contained in the Repeat Sales Model find little consistent evidence of a broadly negative and statistically significant impact. Although there are 730 residential transactions in the sample that involve homes that had views of a wind facility at the time of sale, 160 of which had relatively significant views (i.e., a rating higher than Minor), none of the various models finds strong statistical evidence that the view of a nearby wind facility impacts sales prices in a significant and consistent manner.

When concentrating only on the view of the wind facilities from a home (and not testing for Area and Nuisance Stigmas simultaneously), for example, the results from the View Stability Model are very similar to those derived from the Base Model, with no evidence of a Scenic Vista Stigma. Similarly, the All Sales Model finds that homes that sold after wind facility construction and that had a view of the facility transacted for prices that are statistically indistinguishable from those homes that sold at any time prior to wind facility construction. The Orientation Model, meanwhile, fails to detect any difference between the sales prices of homes that had either a front, back, or side orientation to the view of the wind facility. As shown in Table ES-2, the Continuous Distance and Temporal Aspects models also do not uncover any evidence of a broadly negative and statistically significant Scenic Vista Stigma.

In the Repeat Sales Model, some limited evidence is found that a Scenic Vista Stigma may exist, but those effects are weak, fairly small, somewhat counter-intuitive, and are at odds with the results of other models. This finding is likely driven by the small number of sales pairs that are located within one mile of the wind turbines and that experience a dramatic view of those turbines. Finally, in the Overlap Model, where the degree to which a view of the wind facility overlaps the primary scenic vista from the home is accounted for, no statistically significant differences in sales prices are detected between homes with somewhat or strongly overlapping views when compared to those homes with wind turbine views that did not overlap the primary scenic vista. Though this model produces some weak evidence of a Scenic Vista Stigma among homes with Minor views of wind facilities, the same model finds that the sales prices of those homes with views that barely overlap the primary scenic vista are positively impacted by the presence of the wind facility. When these two results are combined, the overall impact is negligible, again demonstrating no persuasive evidence of a Scenic Vista Stigma.

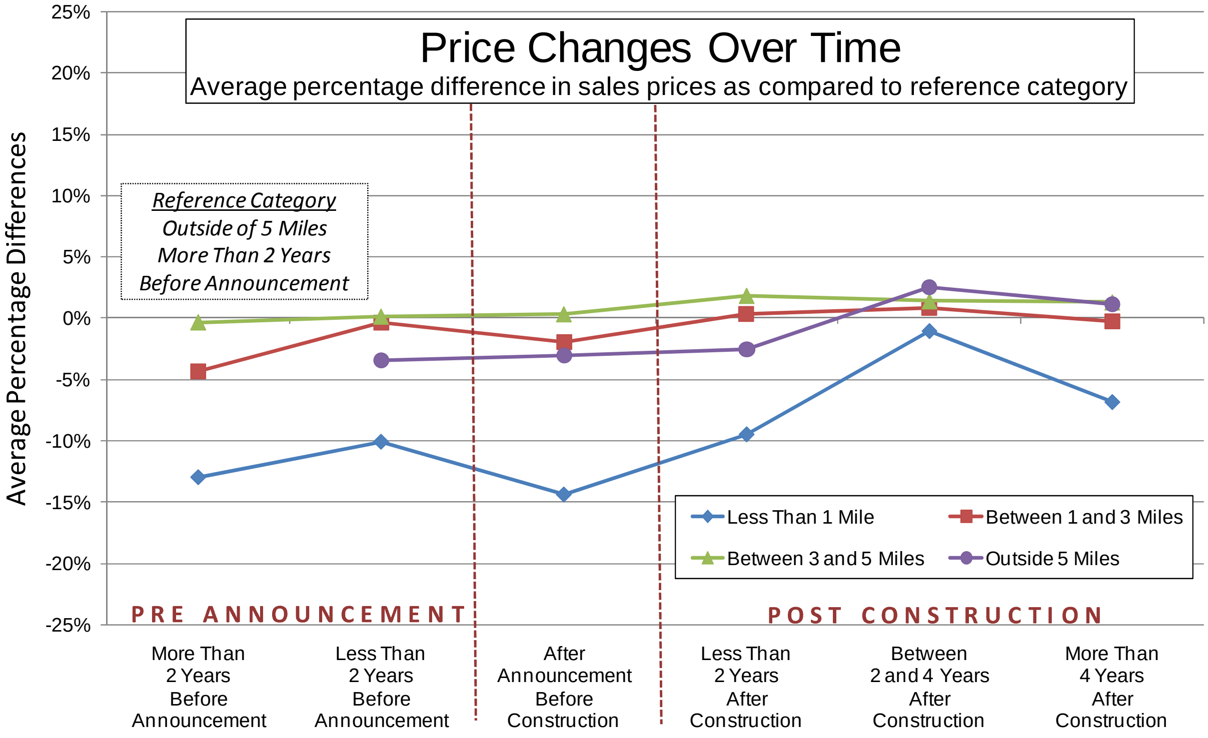
Nuisance Stigma: Other Model Results

Results for Nuisance Stigma from the seven alternative hedonic models and the additional analysis contained in the Repeat Sales and Sales Volume Models support the Base Model results. Taken together, these models present a consistent set of results: homes in this sample that are within a mile of the nearest wind facility, where various nuisance effects have been posited, have not been broadly and measurably affected by the presence of those wind facilities. These results imply that Nuisance Stigma effects are either not present in this sample, or are too small and/or infrequent to be statistically distinguished.

In the Distance Stability Model, for example, when concentrating only on the distance from homes to the nearest wind turbine (and not testing for Scenic Vista Stigma simultaneously), the results are very similar to those derived from the Base Model, with no statistical evidence of a Nuisance Stigma. These results are corroborated by the Continuous Distance, Orientation, Overlap, and Repeat Sales Models, none of which find a statistically significant relationship between distance and either sales prices or appreciation rates. Relatedly, the Sales Volume analysis finds no evidence that homes located within one mile of the nearest wind turbine are sold any more or less frequently than homes located farther away from the wind facilities.

In the All Sales Model, a weakly significant difference is found between the sales prices of homes located between 3000 feet and one mile of the nearest wind facility and the homes that sold before the announcement of the wind facility. This effect, however, is largely explained by the results of the Temporal Aspects Model, shown in Figure ES - 4. The Temporal Aspects Model finds that homes located within one mile of where the wind turbines would eventually be located sold for depressed prices well before the wind facility was even announced or constructed. In all time periods following the commencement of wind facility construction, however, inflation-adjusted sales prices increased - not decreased - relative to pre-announcement levels, demonstrating no statistical evidence of a Nuisance Stigma. The results from the All Sales Model (and, for that matter, the negative, albeit statistically insignificant coefficients inside of one mile in the Base Model, see Figure ES-1) are therefore an indication of sales price levels that preceded wind facility announcement construction, and that are not sustained after construction.

Figure ES - 4: Temporal Aspects Model Results: Area and Nuisance Stigma



The reference category consists of transactions of homes situated more than five miles from where the nearest turbine would eventually be located and that occurred more than two years before announcement of the facility

Conclusions and Further Research Needs

Though each of the analysis techniques used in this report has strengths and weaknesses, the results as a whole are strongly consistent in that none of the models uncovers conclusive evidence of the presence of any of the three property value stigmas that might be present in communities surrounding wind power facilities. Therefore, based on the data sample and analysis presented here, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual homes or small numbers of homes have been or could be negatively impacted, it finds that if these impacts do exist, they are either too small and/or too infrequent to result in any widespread, statistically observable impact. Moreover, to the degree that homes and wind facilities in this sample are similar to homes and facilities in other areas of the United States, the results presented here are expected to be transferable to other areas.

This work builds on the existing literature in a number of respects, but there remain a number of areas for further research. The primary goal of subsequent research should be to concentrate on those homes located closest to wind facilities, where the data sample herein was the most limited. Additional research of the nature reported in this paper could be pursued, but with a greater number of transactions, especially for homes particularly close to wind facilities. A more detailed analysis of sales volume impacts may also be fruitful, as would an assessment of the potential impact of wind facilities on the length of time homes are on the market in advance of an eventual sale. Finally, it would be useful to conduct a survey of those homeowners living close to existing wind facilities, and especially those residents who have bought and sold homes in proximity to wind facilities after facility construction, to assess their opinions on the impacts of wind project development on their home purchase and sales decisions.

1. Introduction

Wind power development has expanded dramatically in recent years (GWEC, 2009). Although the percent of electricity supplied to the U.S. and globally from wind power projects installed through 2008 remains relatively low (1.9% and 1.5%, respectively) (Wiser and Bolinger, 2009), there are expectations that those percentages will rise and that wind energy could contribute a significant percentage of future electricity supply (GWEC, 2008; Wiser and Hand, 2010). Most recently, President Obama, in his 2009 State of the Union address, called for a doubling of renewable energy in three years (by 2012), and in 2008 the U.S. Department of Energy produced a report that analyzed the feasibility of meeting 20% of U.S. electricity demand with wind energy by 2030 (US DOE, 2008).

To meet these goals, a significant amount of wind project development activity would be required. The average size of wind power projects built in the U.S. in 2007 and 2008 was approximately 100 MW (Wiser and Bolinger, 2009) and the total amount of capacity required to reach 20% wind electricity is roughly 300,000 MW (US DOE, 2008). Therefore, to achieve 20% wind electricity by 2030, a total of 3,000 wind facilities may need to be sited and permitted. Most permitting processes in the U.S. require some form of environmental impact assessment, and some form of public involvement in the siting process. Though surveys show that public acceptance is high in general for wind energy (e.g., Wolsink, 2000; Firestone and Kempton, 2006), a variety of concerns are often expressed on the local level that can impact the length and outcome of the siting and permitting process. These concerns range from the potential impacts of wind projects on wildlife habitat and mortality, radar and communications systems, ground transportation and historic and cultural resources, to aesthetic and property value concerns as well as potential nuisance and health impacts. As a result, a variety of siting and permitting guidelines (AWEA, 2008) and impact assessments (NAS, 2007) have been completed.

Surveys of local communities considering wind facilities have consistently ranked adverse impacts on aesthetics and property values in the top tier of concerns (e.g., BBC R&C, 2005; Firestone and Kempton, 2006). Developers of wind energy echo this assessment: they ranked aesthetics and property values as two of the top concerns (first and third respectively) for individuals or communities opposed to wind power development (Paul, 2006). Local residents have even brought suit against a developer over property values (Dale Rankin v. FPL, 2008), and some developers have responded to these concerns by offering “neighbor agreements” that compensate nearby homeowners for the potential impacts of wind projects.

The two concerns of aesthetics and property values are intrinsically linked. It is well established that a home’s value will be increased if a high-quality scenic vista is enjoyed from the property (e.g., Seiler et al., 2001). Alternatively, it is reasonable to assume that if a home’s scenic vista overlaps with a view of a disamenity, the home might be devalued, as has been found for high-voltage transmission lines (HVTL) (Kroll and Priestley, 1992; Des-Rosiers, 2002). Whether a view of wind turbines similarly impacts home values is a key topic of debate in local siting decisions. Aesthetics alone, however, is not the only pathway through which wind projects might impact residential property values. Distance to the nearest wind turbine, for example, might also have an impact if various nuisance effects are prominent, such as turbine noise, shadow flicker,[5] health or safety concerns, or other impacts, real or perceived. In this way, property values near wind turbines might be impacted in the same way as homes near roads might be devalued (Bateman et al., 2001). Additionally, there is evidence that proximity to a disamenity, even if that disamenity is not visible and is not so close as to have obvious nuisance effects, may still decrease a home's sales price, as has been found to be the case for landfills (Thayer et al., 1992).

Taken together, these general concerns about the possible impacts of wind projects on residential property values can be loosely categorized into three potential stigmas:

- Area Stigma: A concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines.
- Scenic Vista Stigma: A concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Nuisance Stigma: A concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values.

These three potential stigmas are not mutually exclusive and could, in theory, be present in part or in combination for any single home. Consequently, all three potential impacts must be considered when analyzing the effects of wind facilities on residential sales prices.

Although concerns about the potential impact of wind projects on residential property values are often mentioned in siting cases, the state of the existing literature on this topic leaves much to be desired. To some extent, the growing body of research investigating this topic has come to opposing conclusions. The most recent and comprehensive of these studies have often concluded that no widespread impacts of wind projects on residential property values are apparent (Hoen, 2006; Sims and Dent, 2007; Sims et al., 2008). At the same time, pre-construction surveys of both homeowners and real estate experts have sometimes found an expectation of negative impacts (e.g. Haughton et al., 2004), and post-construction appraisals have sometimes come to similar conclusions (McCann, 2008; Kielisch, 2009). Given the state of the literature, it is not uncommon for local siting and permitting processes to involve contradicting testimony from experts, as occurred in 2004 when the Public Service Commission of Wisconsin heard opposing conclusions from two studies conducted by experienced home valuation experts (Poletti, 2005; Zarem, 2005).

This report contains the most comprehensive and data-rich analysis to date on the potential impacts of wind projects on nearby residential sales prices. Data from 7,459 residential transactions were collected from the surrounding communities of 24 individual wind projects in nine states and 14 counties in the United States.[6] Because of the large sample size, the diversity of wind projects included in the analysis, and the depth of information collected, a number of different analyses were possible. Specifically, this report relies heavily on a hedonic regression

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[5] Shadow flicker occurs when the sun shines through the wind turbine blades when at a low angle to the horizon and shadows are cast on a window or interior wall of a residence (NAS, 2007).

[6] The majority of the analysis only includes homes that sold after wind facility construction began, totaling 4,937 transactions.

model[7] and uses various forms of that model to investigate potential effects and to confirm the robustness of the resulting findings. To further investigate the robustness of the results, a repeat sales model[8] and a sales volume model[9] are also utilized. In sum, this work builds and improves on the previous literature, and provides an in-depth assessment of the question of whether residential property values in the United States have been affected, in a statistically measurable way, by views of and proximity to wind power facilities.

The remainder of this report is structured as follows. The next section discusses the hedonic model in general, its application to environmental disamenities research, and some potentially analogous results drawn from these studies. This is followed by a summary of the existing literature that has investigated the effects of wind energy on residential property values. The report then turns to the data used in the analysis, a discussion of the primary (or "base") hedonic model, and an analysis of the results from that statistical model. Following that, a set of alternative hedonic models are estimated, as well as a repeat sales model and sales volume model, to test for the robustness of the "base" model results and to explore other aspects of the data. Taking into account the full set of results presented earlier, the report then discusses the three stigmas that may lead to wind projects impacting residential property values, and summarizes how the analysis informs the existence and magnitude of these potential effects. The report ends with a brief conclusion, and a discussion of future research possibilities. A number of appendices follow the conclusion, and contain detailed information on each wind project study area, the data collection instrument and qualitative rating systems used in the field research, the investigation of the best "base" model, the hedonic model assumptions and related tests, and full results from all of the additional statistical models estimated in the report.

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[7] The hedonic regression model, which was briefly described in a sidebar in the Executive Summary, is described in detail in Section 2.1.

[8] A repeat sales model uses, as its dataset, only those homes that have sold more than once. By comparing annual appreciation rates of homes that sold once before facility announcement, and again after construction, it can be tested, in an alternative fashion, if home values are affected by the distance to or view of nearby wind turbines.

[9] Sales volume can be defined as the percentage of homes that fit a certain criteria (e.g. single family, on less than 25 acres, zoned residential, assessed for more than $10,000) that actually did sell. By comparing sales volumes at various distances to wind facilities, before and after the facility was built, a further robustness test is possible.

2. Previous Research

Hedonic pricing models are frequently used to assess the marginal impacts of house and community characteristics on sales prices and by extension on property values in general. Because the hedonic model is the primary statistical method used in this report, this section begins by describing the model in more detail and providing some relevant examples of its use. The section then reviews the existing literature on the effects of wind energy facilities on surrounding property values, highlights the shortcomings of that literature, and outlines how the present research addresses those shortcomings.

2.1. Hedonic Models and Environmental Disamenities

A house can be thought of as a bundle of characteristics (e.g., number of square feet, number of bathrooms, number of fireplaces, and amount of acreage). When a price is agreed upon between a buyer and seller there is an implicit understanding that those characteristics have value. When data from a number of sales transactions are available, the individual marginal contribution to the sales price of each characteristic can be estimated with a hedonic regression model (Rosen, 1974; Freeman, 1979). This relationship takes the basic form:

Sales price = *f* (house structural characteristics, other factors)

where "house structural characteristics" might include, but are not limited to, the number of square feet of living area, bathrooms, and fireplaces, the presence of central AC and the condition of the home, and "other factors" might include, but are not limited to, home site characteristics (e.g., number of acres), neighborhood characteristics (e.g., school district), market conditions at the time of sale (e.g., prevailing mortgage interest rates), and surrounding environmental conditions (e.g., proximity to a disamenity or amenity).

The relationship between the sales price of homes and the house characteristics and other factors can take various forms. The most common functional form is the semi-log construction where the dependent variable is the natural log of the inflation adjusted sales price, and the independent variables are unadjusted (not transformed) home characteristics and other factors. The usefulness of this form of hedonic model is well established (Malpezzi, 2003; Sirmans et al., 2005b; Simons and Saginor, 2006) assuming that certain threshold assumptions are met.[10] The model is used commonly by academics, real estate assessors, appraisers, and realtors when large datasets are available on past residential sales transactions, and when estimates of the marginal impact of certain house characteristics and other factors on sales prices are desired.[11]

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[10] These assumptions, which are discussed in greater detail in Section 4.2 and Appendix G, include absence of outliers and/or influencers, presence of homoskedastic variances, absence of spatial and temporal autocorrelation, and absence of collinearity between the variables of interest and other independent variables.

[11] It should be emphasized that a hedonic model is not designed to appraise properties (i.e., to establish an estimate of the market value of a home at a specified point in time), as would be done with an automated valuation model (AVM). Rather, hedonic models are designed to estimate the marginal contribution of individual house or community characteristics to sales prices, which requires hedonic models to rely upon large data sets with a sizable number of explanatory variables. Appraisal models, on the other hand, are generally based on small, localized data sets (i.e., "comps") and a limited number of explanatory variables that pertain to nearby properties. Due to their higher level of accuracy through the use of significantly more information (e.g., diverse spatial, temporal, and

A particularly useful application of the hedonic regression model is to value non-market goods – goods that do not have transparent and observable market prices. For this reason, the hedonic model is often used to derive value estimates of amenities such as wetlands (e.g., Mahan et al., 2000) or lake views (e.g., Seiler et al., 2001), and disamenities, such as proximity to and/or views of high-voltage transmission lines (HVTLs) (e.g. Des-Rosiers, 2002), fossil fuel power plants (Davis, 2008), roads (e.g. Bateman et al., 2001), cell phone towers (e.g. Bond and Wang, 2007), and landfills (e.g., Thayer et al., 1992; Ready and Abdalla, 2005).

There are a number of useful reviews that describe the application of hedonic models in these circumstances (Kroll and Priestley, 1992; Farber, 1998; McCann, 1999; Bateman et al., 2001; Boyle and Kiel, 2001; Jackson, 2001; Ready and Abdalla, 2005; Simons and Saginor, 2006; Simons, 2006b; Leonard et al., 2008).[12] The large number of studies covered in these reviews demonstrate that hedonic models are regularly used to investigate the interplay between home values and distance to potential disamenities, teasing out if and how sales prices are adversely affected depending on the distance of a typical home from a disamenity. For example, Carroll et al. (1996) use a hedonic model to estimate a devaluation of 16% for homes "close to" a chemical plant, with a 6.5% increase in sales price per mile away out to 2.5 miles, at which point effects fade entirely. Dale et al. (1999) find a maximum effect of -4% near a lead smelter, with sales prices increasing 2% for each mile away out to two miles, where effects again fade. Ready and Abdalla (2005) find maximum effects near landfills of -12.4%, which fade entirely outside 2,400 feet, and maximum effects near confined animal feeding operations of -6.4%, which fade entirely outside of 1,600 feet. Meanwhile, studies of other energy infrastructure, such as HVTLs, find maximum effects of -5.7% for homes adjacent to a HVTL tower, and an increase in prices of 0.018% per foot away from the tower out to 300 feet (Hamilton and Schwann, 1995), and maximum effects of -14% for homes within 50 feet of a HVTL, but no effect for similar homes at 150 feet (Des-Rosiers, 2002). Further, for fossil fuel power plants, Davis (2008) finds average adverse effects of between 3 and 5% inside of two miles but that those effects fade entirely outside of that distance range.

In addition to investigating how sales prices change with distance to a disamenity, hedonic models have been used to investigate how prices have changed over time. For instance, sales prices have sometimes been found to rebound after the removal of a disamenity, such as a lead smelter (Dale et al., 1999), or to fade over time, as with HVTLs (Kroll and Priestley, 1992) or spent fuel storage facilities (Clark and Allison, 1999). Finally, hedonic models have been used to estimate how views of a disamenity affect sales prices. Des-Rosiers (2002), for example, finds that homes adjacent to a power line and facing a HVTL tower sell for as much as 20% less than similar homes that are not facing a HVTL tower.

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characteristic information) and rigorous methodology, hedonic models can also be used as appraisal models. Automated valuation models cannot, however, be reliably used to measure marginal effects because they do not employ sufficient information to do so, and, more importantly, AVMs do not hold controlling characteristics constant, which could bias any resulting estimates of marginal effects.

[12] For further discussion of the hedonic model and its application to the quantification of environmental stigmas in comparison to other methods see Jackson (2005).

It is unclear how well the existing hedonic literature on other disamenities applies to wind turbines, but there are likely some similarities. For instance, in general, the existing literature seems to suggest that concerns about lasting health effects provide the largest diminution in sales prices, followed by concerns for one's enjoyment of the property, such as auditory and visual nuisances, and that all effects tend to fade with distance to the disamenity - as the perturbation becomes less annoying. This might indicate that property value effects from wind turbines are likely to be the most pronounced quite close to them, but fade quickly as their auditory and visual impacts fade. The existing hedonic literature also, in general, finds that effects fade with time as self-selecting buyers without prejudice towards the disamenity move into the area, or as the real or perceived risks of the disamenity are lessoned (Jackson, 2001). This implies that any stigmas related to wind turbines might also fade over time as local communities come to accept their presence.

2.2. Impacts of Wind Projects on Property Values

Turning to the literature that has investigated the potential property value effects from wind facilities directly, it deserves note that few studies have been academically peer-reviewed and published; in some cases, the work has been performed for a party on one side or the other of the permitting process (e.g., the wind developer or an opposition group). Nonetheless, at a minimum, a brief review of this existing literature will set the stage for and motivate the later discussion of the methods and results of the present work. The literature described below is summarized in Table 1. To frame this discussion, where possible, the three potential stigmas discussed earlier are used:

- Area Stigma: A concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines.
- Scenic Vista Stigma: A concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista.
- Nuisance Stigma: A concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values.

In one of the most recent studies, Sims et al. (2008) used a hedonic model to investigate Scenic Vista Stigma using 199 residential transactions within ¼ of a mile of the 16-turbine Bears Down wind facility in Cornwall, UK. They found both large positive and smaller negative significant relationships between views of the turbines and sales prices depending on whether the view is seen from the front or rear of the home, respectively, but found no relationship between the number of wind turbines visible and sales prices. Previously, Sims and Dent (2007) used a hedonic model to investigate Nuisance and Scenic Vista Stigma with 919 transactions for homes within five miles of two wind facilities in the UK, finding only limited evidence of a relationship between proximity to and views of turbines and sales prices, which local real estate experts attributed to other causes. Hoen (2006) investigated Scenic Vista Stigma using a hedonic model to analyze 280 residential transactions occurring near a wind facility in Madison County, NY, and found no evidence that views of turbines significantly affects prices. Jordal-Jorgensen (1996) investigated Nuisance Stigma in Denmark, and found an adverse effect for homes located "close" to the turbines, but no statistical significance was reported.[13]

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[13] A copy of this report could not be obtained and therefore its findings are reported based on other citations.

Using different statistical methods, Poletti (2005; 2007) used a *t*-Test to investigate Nuisance and Area Stigma by comparing the mean sales prices of 187 and 256 homes in Illinois and Wisconsin, respectively, located near wind facilities (target group) to those further away (control group).[14, 15] He split these target and control groups into respective smaller and more-homogenous sub-groups, such as large and small tracts, with and without homes, finding no statistical evidence that homes near the wind facilities sold for different prices than those farther away. Sterzinger et al. (2003) analyzed roughly 24,000 residential transactions, which were divided between those within five miles of a wind facility and those outside of five miles in an effort to assess Area Stigma. They compared residential appreciation rates over time, and found no apparent difference between those homes within and outside of five miles from a wind facility, but the statistical significance of this comparison was not reported.

Other authors have used smaller samples of residential transactions and a variety of simple statistical techniques, without reporting statistical significance, and have found a lack of evidence of effects from Nuisance Stigma (Jerabek, 2001; Jerabek, 2002; Beck, 2004) and Area Stigma (DeLacy, 2005; Goldman, 2006). These results, however, are somewhat contrary to what one appraiser has found. In his investigation of Nuisance Stigma around a wind facility in Lee County, IL, McCann (2008) found that two homes nearby a wind facility had lengthy selling periods that, he believes, also adversely affected transaction prices. Additionally, Kielisch (2009) investigated Nuisance Stigma by comparing twelve transactions of undeveloped land near two wind facilities in Wisconsin (Blue Sky Green Field and Forward) to undeveloped land transactions farther away. He found that land tracts near the wind facilities sold for dramatically lower prices ($/acre) than the comparable group, but the statistical significance of the comparison was not reported.

In addition to these revealed preference studies, a number of stated preference surveys (e.g., contingent valuation) and general opinion surveys have investigated the existence of potential effects.[16] A survey of <u>local residents</u>, conducted after the wind facilities were erected, found no evidence of Area Stigma (Goldman, 2006), while another found limited evidence of these stigmas (Bond, 2008).[17] Similarly, some surveys of <u>real estate experts</u> conducted after facility

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[14] A *t*-Test is used to compare two sample means by discerning if one is significantly different from the other.

[15] The 2007 study used the data contained in the 2005 study in combination with new data consisting of transactions that occurred in the interim period.

[16] Contingent valuation is a survey based technique to value non-market goods (e.g., an environmental disamenity) that asks respondents what their “willingness to pay” (or “willingness to accept”) is to have, for instance, a disamenity removed from (or to have it remain in) their neighborhood. This technique is distinct from a general opinion survey, which might ask whether respondents believe property values have been impacted by an environmental disamenity and, if so, “by how much.” Although there are important distinctions between the two techniques, with the contingent valuation method often preferred by economic practitioners, for simplicity no distinction is made here between these two approaches. Finally, another subset of the survey literature focuses on public acceptance (i.e., opinion). Though these public acceptance surveys sometimes cover possible impacts on property values, those impacts are not quantified in economic terms. As a result, public acceptance survey results are not reported here.

[17] Bond (2008) asked respondents to declare if the wind facility, which is located roughly 7 miles away, would effect what they would be willing to pay for their house and 75% said either they would pay the same or more for their house, while the remainder would pay less. When those latter respondents were asked to estimate the percentage difference in value, their estimates averaged roughly 5%.

construction have found no evidence of Area or Nuisance Stigmas (Grover, 2002; Goldman, 2006). These results, however, are contrary to the expectations for Area, Scenic Vista, and Nuisance Stigma effects predicted by local residents (Haughton et al., 2004; Firestone et al., 2007) and real estate experts (Haughton et al., 2004; Khatri, 2004; Kielisch, 2009) prior to construction found elsewhere.[18] The difference between predicted and actual effects might be attributable, at least in part, to the fear of the unknown. For instance, Wolsink (1989) found that public attitudes toward wind power, on average, are at their lowest for local residents during the wind project planning stage, but return almost to pre-announcement levels after the facilities are built. This result is echoed by Exeter-Enterprises-Ltd. (1993) and Palmer (1997), whose post-construction surveys found higher approval than those conducted pre-construction. Others, however, have found that perceptions do not always improve, attributing the lack of improvement to the perceived "success" or lack therefore of the project, with strong disapproval forming if turbines sit idle (Thayer and Freeman, 1987) or are perceived as a waste of taxpayer dollars (Devine-Wright, 2004).

When this literature is looked at as a whole, it appears as if wind projects have been predicted to negatively impact residential property values when pre-construction surveys are conducted, but that sizable, widespread, and statistically significant negative impacts have largely failed to materialize post-construction when actual transaction data become available for analysis. The studies that have investigated Area Stigma with market data have failed to uncover any pervasive effect. Of the studies focused on Scenic Vista and Nuisance Stigmas, only one is known to have found statistically significant adverse effects, yet the authors contend that those effects are likely driven by variables omitted from their analysis (Sims and Dent, 2007). Other studies that have relied on market data have sometimes found the possibility of negative effects, but the statistical significance of those results have rarely been reported.

Despite these findings, the existing literature leaves much to be desired. First, many studies have relied on surveys of homeowners or real estate professionals, rather than trying to quantify real price impacts based on market data. Second, a number of studies conducted rather simplified analyses of the underlying data, potentially not controlling for the many drivers of residential sales prices. Third, many of the studies have relied upon a very limited number of residential sales transactions, and therefore may not have had an adequate sample to statistically discern any property value effects, even if effects did exist. Fourth, and perhaps as a result, many of the studies did not conduct, or at least have not published, the statistical significance of their results. Fifth, when analyzed, there has been some emphasis on Area Stigma, and none of the studies have investigated all three possible stigmas simultaneously. Sixth, only a few of the studies (Hoen, 2006; Sims and Dent, 2007; Sims et al., 2008; Kielisch, 2009) conducted field visits to the homes to assess the quality of the scenic vista from the home, and the degree to which the wind facility might impact that scenic vista. Finally, with two exceptions (Sims and Dent, 2007; Sims et al., 2008), none of the studies have been academically peer-reviewed and published.

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[18] It should be noted that the samples used by both Khatri and Kielisch contained a subset of respondents who did have some familiarity with valuing homes near wind facilities.

Table 1: Summary of Existing Literature on Impacts of Wind Projects on Property Values

Document Type Author(s)	Year	Number of Transactions or Respondents	Before or After Wind Facility Construction Commenced	Area Stigma	Scenic Vista Stigma	Nuisance Stigma
Homeowner Survey						
Haughton et al.	2004	501	Before	- *	- *	
Goldman	2006	50	After	**none**		
Firestone et al.	2007	504	Before	- *	- *	
Bond	2008	~300	After		- ?	- ?
Expert Survey						
Grover	2002	13	After	**none**		**none**
Haughton et al.	2004	45	Before	- *	- *	
Khatri	2004	405	Before[‡]	- ?		- ?
Goldman	2006	50	After	**none**		**none**
Kielisch	2009	57	Before[‡]			- ?
Transaction Analysis - Simple Statistics						
Jerabek	2001	25	After			**none**
Jerabek	2002	7	After			**none**
Sterzinger et al.	2003	24,000	After	**none**		
Beck	2004	2	After			**none**
Poletti	2005	187	After	**none**		**none**
DeLacy	2005	21	Before[†]	**none**		
Goldman	2006	4	After	**none**		
Poletti	2007	256	After	**none**		**none**
McCann	2008	2	After			- ?
Kielisch	2009	103	After			- ?
Transaction Analysis - Hedonic Model						
Jordal-Jorgensen	1996	?	After			- ?
Hoen	2006	280	After		**none**	
Sims & Dent	2007	919	After			- *
Sims et al.	2008	199	After		-/+ *	

" none " indicates the majority of the respondents do not believe properties have been affected (for surveys) or that no effect was detected at 10% significance level (for transaction analysis)

"- ?" *indicates a negative effect without statistical significance provided*

"- *" *indicates statistically significant negative effect at 10% significance level*

"-/+ *" *indicates positive and negative statistically significant effects at 10% significance level*

† *Sales were collected after facility announcement but before construction*

‡ *Some respondents had experience with valuations near facilities while others did not*

3. Data Overview

The methods applied in the present work are intended to overcome many of the limitations of the existing literature. First, a large amount of data is collected from residential transactions within 10 miles of 24 different wind projects in the U.S., allowing for a robust statistical analysis across a pooled dataset that includes a diverse group of wind project sites. Second, all three potential stigmas are investigated by exploring the potential impact of wind projects on home values based both on the distance to and view of the projects from the homes. Third, field visits are made to every home in the sample, allowing for a solid assessment of the scenic vista enjoyed by each home and the degree to which the wind facility can be seen from the home, and to collect other value-influencing data from the field (e.g., if the home is situated on a cul-de-sac). Finally, a number of hedonic regression models are applied to the resulting dataset, as are repeat sales and sales volume analyses, in order to assess the robustness of the results.

Testing for the three potential stigmas requires a significant sample of residential transactions within close proximity to existing wind facilities. Unfortunately for the study, most wind power projects are not located near densely populated areas. As a result, finding a single wind project site with enough transaction data to rigorously analyze was not possible. Instead, the approach was to collect data from multiple wind project sites, with the resulting data then pooled together to allow for robust statistical analyses.[19] The remainder of this section describes the site selection process that is used, and provides a brief overview of both the selected study areas and the data that were collected from these areas. Also provided is a description of how scenic vista, views of turbines, and distances from turbines were quantified for use in the hedonic analysis, and a summary of the field data collection effort. The section ends with a brief summary of the resulting dataset.

3.1. Site Selection

For the purpose of this study, an ideal wind project area would:

1) Have a large number of residential transactions both before and, more importantly, after wind facility construction, and especially in close proximity (e.g., within 2 miles) of the facility;
2) Have comprehensive data on home characteristics, sales prices, and locations that are readily available in electronic form; and
3) Be reasonably representative of the types of wind power projects being installed in the United States.

To identify appropriate sites that met these criteria, and that also provided a diversity of locations, the authors obtained from Energy Velocity, LLC a set of Geographic Information System (GIS) coordinates representing 241 wind projects in the U.S. that each had a total nameplate capacity greater than 0.6 megawatts (MW) and had gone online before 2006.[20] Also provided were facility capacity, number of turbines, and announcement, construction, and operational dates. These data were cross-checked with a similar dataset provided by the American Wind Energy Association (AWEA), which also included some turbine hub-height information.

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[19] A thorough discussion of this "pooled" approach is contained in Section 4.2 and in Appendix F.

[20] Energy Velocity, LLC was owned at the time by Global Energy Decisions, which was later purchased by Ventyx. The dataset is available as Velocity Suite 2008 from Ventyx.

By using a variety of different GIS sorting techniques involving nearby towns with populations greater than, for example, 2,500 people, using census tract population densities, and having discussions with wind energy stakeholders, a prospective list of 56 possible study areas was generated, which were then ranked using two scales: “highly desirable” to “least desirable,” and “feasible” to “potentially unfeasible.”[21] Then, through an iterative process that combined calls to county officials to discuss the number of residential transactions and data availability, with investigations using mapping software to find the location of individual wind turbines, and, in some cases, preliminary visits, a list of 17 prospective study areas were chosen as both “highly desirable” and “feasible.” Ultimately, three of these proved to be “unfeasible” because of data availability issues and four “undesirable” because the study area was considered not representative. This effort ultimately resulted in a final set of ten study areas that encompass a total of 24 distinct wind facilities (see Figure 1 and Table 2).[22] A full description of each study area is provided in Appendix A.

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[21] “Desirability” was a combination of a number of factors: the wind facility having more than one turbine; the study area having greater than 350 sales within 5 miles and within 10 years, 250 of which transacted following construction of the facility; having some transaction data old enough to pre-date facility announcement; having data on the core home and site characteristics (e.g., square feet, acres); and, where possible, having a concentration of sales within 1 mile of the facility. “Feasibility” was also a combination of factors: having home characteristic and sales data in electronic form; having GIS shapefiles of the parcel locations; and being granted ready access to this information.

[22] The “unfeasible” study areas were Cerro Gordo County, IA, Bennington County, VT, and Atlantic County, NJ. Cerro Gordo County, IA contained multiple wind projects totaling 140 MW. Although the data at this site were available in electronic form, the county only agreed to share data in paper form, which would have created an enormous data entry burden. Because another site in the sample was considered similar to the Cerro Gordo site (IABV), Cerro Gordo County was dropped from the prospective sites. Bennington County, VT contained the 11 turbine Searsburg Wind Project (6 MW) but had no electronic records. Atlantic County, NJ contained the five turbine Jersey Atlantic Wind Farm (7.5 MW), but had data in paper records only and the county was unresponsive to inquiries regarding the study. The “undesirable” study areas were Plymouth County, MA, Wood County, OH, Cascade County, MT, and Riverside County, CA. Although the data in Plymouth County, MA were more than adequate, this small, on-land, yet coastal Hull Wind facility (2 turbines, 2.5 MW) was not considered to be particularly representative of wind development across the US. Wood County’s four turbine Bowling Green facility (7 MW) met the appropriate data requirements, but ultimately it was decided that this facility was too small and remote to be representative. Cascade County’s six turbine Horseshoe Bend Wind Park (9 MW) did not have enough transactions to justify study. Riverside, CA, where roughly 2500 turbines are located, had less-than-desired home characteristic data, had transactions that came more than 10 years after large scale development began, and despite having homes that were within 1 mile of the turbines, those homes typically had limited views because of high subdivision walls.

Figure 1: Map of Study Areas and Potential Study Areas

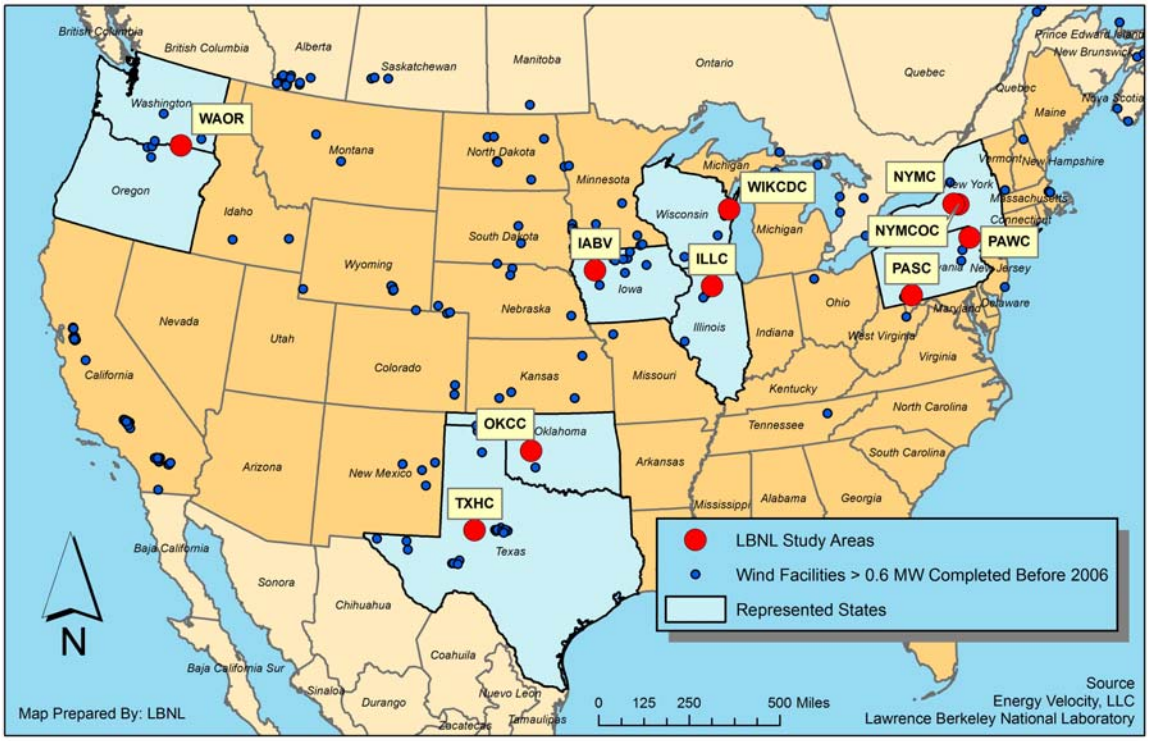

Table 2: Summary of Study Areas

Study Area Code	Study Area Counties, States	Facility Names	Number of Turbines	Number of MW	Max Hub Height (meters)	Max Hub Height (feet)
WAOR	Benton and Walla Walla Counties, WA and Umatilla County, OR	Vansycle Ridge, Stateline, Nine Canyon I & II, Combine Hills	582	429	60	197
TXHC	Howard County, TX	Big Spring I & II	46	34	80	262
OKCC	Custer County, OK	Weatherford I & II	98	147	80	262
IABV	Buena Vista County, IA	Storm Lake I & II, Waverly, Intrepid I & II	381	370	65	213
ILLC	Lee County, IL	Mendota Hills, GSG Wind	103	130	78	256
WIKCDC	Kewaunee and Door Counties, WI	Red River, Lincoln	31	20	65	213
PASC	Somerset County, PA	Green Mountain, Somerset, Meyersdale	34	49	80	262
PAWC	Wayne County, PA	Waymart	43	65	65	213
NYMCOC	Madison and Oneida Counties, NY	Madison	7	12	67	220
NYMC	Madison County, NY	Fenner	20	30	66	218
		TOTAL	**1345**	**1286**		

These 10 study areas and 24 projects are located in nine separate states, and include projects in the Pacific Northwest, upper Midwest, the Northeast, and the South Central region. The wind projects included in the sample total 1,286 MW, or roughly 13% of total U.S. wind power capacity installed at the time (the end of 2005). Turbine hub heights in the sample range from a minimum of 164 feet (50 meters) in the Washington/Oregon (WAOR) study area, to a maximum of 262 (80 meters) (TXHC, OKCC and PASC), with nine of the ten study areas having hub heights of at least 213 feet (65 meters). The sites include a diverse variety of land types, including combinations of ridgeline (WAOR, PASC, and PAWC), rolling hills (ILLC, WIKCDC, NYMCOC, and NYMC), mesa (TXHC), and windswept plains (OKCC, IABV).[23]

3.2. Data Collection

In general, for each study area, residential transaction data in as close proximity to the wind turbines as possible was sought, from both before and after wind facility construction. To balance the cost and quantity of data collection in each study area with the desire to cover as many study areas as possible, the research effort sought to collect data on 400 to 1,250 transactions in each study area.[24] In some instances, this meant including all residential transactions within ten miles of the wind turbines. In others, only transactions within five miles were included. In some extreme instances, when the number of transactions inside of five miles far exceeded the 1,250 limit, all transactions in close proximity to the wind turbines (e.g., inside three miles) were included in combination with a random sample of transactions outside of that distance band (e.g., between three and five miles).[25] The data selection processes for each Study Area are contained in Appendix A.

Three primary sets of data are used in the analysis: tabular data, GIS data, and field data, each of which is discussed below. Following that, this subsection highlights the two qualitative variables that are essential to this analysis and that therefore require special attention, scenic vista and views of turbines, and then discusses the field data collection process.

3.2.1. Tabular Data

Berkeley Lab obtained tabular transaction data from participating counties[26] containing 7,459 "valid" [27] transactions of single family residential homes, on less than 25 acres,[28] which were

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[23] Some areas, such as PASC, had both a ridgeline and rolling hills on which wind facilities were located.

[24] This range was chosen to ensure that a minimum of data were present in each study area to allow for a robust analysis, and yet not too much so as to make data collection (e.g., the visiting of each home) inordinately time and resource consuming in any individual study area.

[25] An alternative method would have been to collect data on every sale that occurred. Although in most cases this would be preferred, in ours it would not have added one additional transaction within close proximity or with dramatic views of wind turbine, the focus of the study. Rather, it would have added an overwhelming majority of transactions of homes without views and at distances outside of three miles from the turbines, all of which would have come at considerably cost and, more importantly, would not likely have influenced the results significantly while perhaps necessitating a reduction in the total number of study areas that could be included in the sample.

[26] In some cases, the county officials, themselves, extracted data from their database, and in some cases a company engaged to manage a county's data provided the necessary information. In either case the provider is referred to as "county." Detailed descriptions of the providers are presented in Appendix A.

[27] Validity was determined by each individual county data provider. A sale that is considered "valid" for county purposes would normally meet the minimum requirements of being arm's length; being a transfer of all rights and warrants associated with the real estate; containing an insignificant amount of personal property so as not to affect the price; demonstrating that neither party in the sale acting under duress or coercion; not being the result of a liquidation of assets or any other auction, a mortgage foreclosure, a tax sale, or a quit claim; and being appropriate for use in calculating the sales price to assessed value ratios that are reported to the state. Due to the formal requirements associated with this calculation, "validity" is often defined by a state's Department of Revenue, as shown, for example, here: http://www.orps.state.ny.us/assessor/manuals/vol6/rfv/index.htm. In addition, though the

sold for a price of more than $10,000,[29] which occurred after January 1, 1996,[30] and which had fully populated "core" home characteristics. These core characteristics are: number of square feet of the living area (not including finished basement), acres of land, bathrooms, and fireplaces, the year the home was built,[31] if the home had exterior wallsthatwere stone, a central air conditioning unit, and/or a finished basement, and the exterior condition of the home. The 7,459 residential transactions in the sample consist of 6,194 homes (a number of the homes in the sample sold more than once in the selected study period). Because each transaction had a corresponding set of the core home characteristic data, they could all be pooled into a single model. In addition to the home characteristic data, each county provided, at a minimum, the home's physical address and sales price. The counties often also provided data on homes in the study area that did not sell in the study period.[32] Finally, market-specific quarterly housing inflation indexes were obtained from Freddie Mac, which allowed nominal sales prices to be adjusted to 1996 dollars.[33]

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sample originally contained 7,498 sales, 34 homes sold twice in a 6 month period and, after discussions with local officials, these transactions were considered likely to have been "invalid" despite the county coding them to the contrary. Additionally, five transactions produced standardized residuals that were more than six standard deviations away from the mean, indicating that these sales were abnormal and likely not valid. Both of these sets of transactions, totaling 39, were removed from the final dataset. Of the 39 sales, 32 sold following construction, 10 were concentrated in IABV and nine in TXHC with the others spread between seven of the remaining eight study areas. One of the homes was inside of one mile from the turbines at the time of sale, and two had views of the turbines (both of which were MINOR). The home that was located within one mile was surrounded by a number of other homes – at similar distances from the turbines - that transacted both before and after the wind facilities were built and were included in the sample. A more thorough discussion of the screening techniques used to ensure the appropriateness of the final data set are presented in detail in Appendix G under "Outliers/Influencers." Finally, it should be noted that the authors are aware of four instances in the study areas when homes were sold to wind developers. In two cases the developer did not resell the home; in the other two, the developer resold the home at a lower price than which it was purchased. But, because the sales were to a related party, these transactions were not considered "valid' and are therefore not included here. One might, however, reasonably expect that the property values of these homes were impacted by the presence of the wind turbines.

[28] Single family residences on more than 25 acres were considered to be likely candidates for alternative uses, such as agricultural and recreational, which could have an influence on sales price that was outside of the capabilities of the model to estimate. Because all records were for parcels that contained a residence, the model did not contain any "land-only" transactions. Further, none of the transactions provided for this research were for parcels on which a turbine was located.

[29] A sales price of $10,000 was considered the absolute minimum amount an improved parcel (one containing a residential structure) would sell for in any of the study areas and study periods. This provided an additional screen over and above the "valid" screen that the counties performed.

[30] This provided a maximum of 12 years of data. Some counties did not have accessible data back to 1996 but in all cases these countries had data on transactions that occurred before the wind facilities were erected.

[31] "Year Built" was used to construct a variable for the age of the home at the time of the sale.

[32] These data were used to calculate the "Sales Volume" percentages referred to in Section 7.

[33] Freddie Mac Conventional Mortgage Home Price Index: municipal statistical area (MSA) series data are available from the following site: http://www.freddiemac.com/finance/cmhpi/. Because most of the study areas do not fall within the MSAs, a collection of local experts was relied upon, including real estate agents, assessors, and appraisers, to decide which MSA most-closely matched that of the local market. In all cases the experts had consensus as to the best MSA to use. In one case (NYMCOC) the sample was split between two MSAs. These indexes are adjusted quarterly, and span the entire sample period. Therefore, during the housing boom, insofar as a boom occurred in the sample areas, the indexes increased in value. Subsequently when the market began falling, the index retracted.

3.2.2. GIS Data

GIS data on parcel location and shape were also required, and were obtained from the counties. The counties also often provided GIS layers for roads, water courses, water bodies, wind turbines (in some cases), house locations, and school district and township/town/village delineations. GIS data on census tract and school district delineations were obtained from the U.S. Census Bureau, if not provided by the county.[34] GIS data were obtained on water courses, water bodies, land elevations, and satellite imagery, as was necessary, from the U.S. Department of Agriculture.[35] Combined, these data allowed each home to be identified in the field, the construction of a GIS layer of wind turbine locations for each facility, and the calculation of the distance from each home to the nearest wind turbine.[36] Determining the distance from each home to the nearest wind turbine was a somewhat involved process, and is discussed in detail in Appendix B. Suffice it to say that each transaction had a unique distance ("DISTANCE")[37] that was determined as the distance between the home and nearest wind turbine at the time of sale, and that these distances are grouped into five categories: inside of 3000 feet (0.57 miles), between 3000 feet and one mile, between one and three miles, between three and five miles, and outside of five miles.[38] Finally, the GIS data were used to discern if the home was situated on a cul-de-sac and had water frontage, both of which were corroborated in the field.

3.2.3. Field Data

Additional data had to be collected through field visits to all homes in the sample. Two qualitative measures in particular – for scenic vista and for view of the wind turbines – are worth discussing in detail because each is essential to the analysis and each required some amount of professional judgment in its creation.

The impact or severity of the view of wind turbines ("VIEW") [39] may be related to some combination of the number of turbines that are visible, the amount of each turbine that is visible (e.g., just the tips of the blades or all of the blades and the tower), the distance to the nearest turbines, the direction that the turbines are arrayed in relation to the viewer (e.g., parallel or perpendicular), the contrast of the turbines to their background, and the degree to which the turbine arrays are harmoniously placed into the landscape (Gipe, 2002). Recent efforts have made some progress in developing quantitative measures of the aesthetic impacts of wind turbines (Torres-Sibillea et al., 2009),[40] but, at the time this project began, few measures had

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[34] These data were sourced from the U.S. Census Bureau's Cartographic Boundary Files Webpage: http://www.census.gov/geo/www/cob/bdy_files.html.

[35] These data were sourced from the USDA Geospatial Data Gateway: http://datagateway.nrcs.usda.gov/GatewayHome.html.

[36] Although in some cases the county provided a GIS layer containing wind turbine points, often this was not available. A description of the turbine mapping process is provided in Appendix B.

[37] Distance measures are collectively and individually referred to as "DISTANCE" from this point forward.

[38] The minimum distance of "inside 3000 feet" was chosen because it was the closest cutoff that still provided an ample supply of data for analysis.

[39] View of turbines ratings are collectively and individually referred to as "VIEW" from this point forward.

[40] In addition to these possible field techniques, previous studies have attempted to use GIS to estimate wind turbine visibility using "line-of-sight" algorithms. For example, Hoen (2006) used these algorithms after adding ground cover to the underlying elevation layer. He found that the GIS method differed substantially from the data collected in the field. Seemingly, small inaccuracies in the underlying elevation model, errors in the software's algorithm, and the existence of ground cover not fully accounted for in the GIS, substantially biased GIS-based assessments of

been developed, and what had been developed was difficult to apply in the field (e.g., Bishop, 2002). As a result, the authors opted to develop an ordered qualitative VIEW rating system that consisted of placing the view of turbines into one of five possible categories: NO VIEW, MINOR, MODERATE, SUBSTANTIAL, and EXTREME. These ratings were developed to encompass considerations of distance, number of turbines visible, and viewing angle into one ordered categorical scale, and each rating is defined in Table 3:[41]

Table 3: Definition of VIEW Categories

NO VIEW	The turbines are not visible at all from this home.
MINOR VIEW	The turbines are visible, but the scope (viewing angle) is narrow, there are many obstructions, or the distance between the home and the facility is large.
MODERATE VIEW	The turbines are visible, but the scope is either narrow or medium, there might be some obstructions, and the distance between the home and the facility is most likely a few miles.
SUBSTANTIAL VIEW	The turbines are dramatically visible from the home. The turbines are likely visible in a wide scope and most likely the distance between the home and the facility is short.
EXTREME VIEW	This rating is reserved for sites that are unmistakably dominated by the presence of the wind facility. The turbines are dramatically visible from the home and there is a looming quality to their placement. The turbines are often visible in a wide scope or the distance to the facility is very small.

Photographic examples of each of the categories are contained in Appendix E.

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visibility. This was corroborated elsewhere by Maloy and Dean (2001) and Riggs and Dean (2007). As a result of these findings, it was determined that field collection of VIEW data was essential.

[41] In addition to the qualitative rating system that was ultimately used in this study, a variety of quantitative data were collected that might describe the nature of the view of wind turbines, including the total number of turbines visible, the distance of the home to the nearest wind turbine, and the view scope/viewing angle (i.e., the degree to which the turbines spread out in front of the home: narrow, medium, or wide). To explore the validity of the qualitative rating scale two tests were conducted. First, a pre-study survey was conducted by showing 10 different off-site respondents 15 randomly selected photographs from the field representing the various rated VIEW categories. The higher VIEW ratings were oversampled to create a roughly equal distribution among the categories. The respondents rated the views into one of the qualitative categories. The on-site / field collected ratings matched the off-site responses 65% of the time, with 97% of the rankings differing by no more than one category. Ninety-eight percent of the on-site-ranked MINOR VIEWs and 89% of the EXTREME VIEWs were similarly ranked by off-site respondents. The on-site rankings were less than the off-site rankings 97% of the time; it is assumed that this is because on-site ratings took into account a greater portion of the panorama than were captured in the photos, which translated into a lower ranking. Secondly, a post hoc Multinomial Logistic Regression model was created that used the qualitative on-site VIEW ratings as the dependent variable and the quantitative measures of distance to nearest turbine, number of turbines visible, and view scope as the independent variables. This model produced high Pseudo R^2 statistics (Cox and Snell 0.88, Nagelkerke 0.95, and McFadden 0.79) and predicted values that were highly correlated with the actual qualitative rating (Pearson's 0.88). Therefore, both tests corroborated the appropriateness of the simpler qualitative VIEW rankings used herein.

In addition to the qualitative VIEW measurements, a rating for the quality of the scenic vista ("VISTA")[42] from each home, absent the existence of the wind facilities, was also collected in the field. An assessment of the quality of the VISTA from each home was needed because VIEW and VISTA are expected to be correlated; for example, homes with a PREMIUM VISTA are more likely to have a wide viewing angle in which wind turbines might also be seen. Therefore, to accurately measure the impacts of the VIEW of wind turbines on property values a concurrent control for VISTA (independent of any views of turbines) is required. Drawing heavily on the landscape-quality rating system developed by Buhyoff et al. (1994) and to a lesser degree on the systems described by others (Daniel and Boster, 1976; USDA, 1995), an ordered VISTA rating system consisting of five categories was developed: POOR, BELOW AVERAGE, AVERAGE, ABOVE AVERAGE, and PREMIUM, with each rating defined in Table 4:[43]

Table 4: Definition of VISTA Categories

POOR VISTA	These vistas are often dominated by visually discordant man-made alterations (not considering turbines), or are uncomfortable spaces for people, lack interest, or have virtually no recreational potential.
BELOW AVERAGE VISTA	These scenic vistas contain visually discordant man-made alterations (not considering turbines) but are not dominated by them. They are not inviting spaces for people, but are not uncomfortable. They have little interest or mystery and have minor recreational potential.
AVERAGE VISTA	These scenic vistas include interesting views that can be enjoyed often only in a narrow scope. These vistas may contain some visually discordant man-made alterations (not considering turbines), are moderately comfortable spaces for people, have some interest, and have minor recreational potential.
ABOVE AVERAGE VISTA	These scenic vistas include interesting views that often can be enjoyed in a medium to wide scope. They might contain some man-made alterations (not considering turbines), yet still possess significant interest and mystery, are moderately balanced and have some potential for recreation.
PREMIUM VISTA	These scenic vistas would include "picture postcard" views that can be enjoyed in a wide scope. They are often free or largely free of any discordant man made alterations (not considering turbines), possess significant interest, memorable qualities, and mystery and are well balanced and likely have a high potential for recreation.

Photographic examples of each of the categories are contained in Appendix D.

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[42] Scenic vista ratings are individually and collectively referred to as "VISTA" from this point forward.

[43] The appropriateness of these rankings were tested in two ways. First, a set of 34 pictures taken on-site and representing various categories of VISTA were shown to 10 off-site respondents who were asked to rank them using the same categories, and then explain why they rated them as such. Although the off-site ratings matched the on-site ratings only 51% of the time, 94% of on- and off-site rankings differed by no more than one category, with 17% of the off-site rankings below the on-site and 26% ranked above. The descriptions of why the rankings where chosen by the off-site respondents illuminated the fact that off-site ratings did not take into account a number of aspects that were not adequately captured in the photos, but that were apparent in the field. This finding was borne out by a second test that had five individuals visit seven homes in the field to rank their scenic vistas. When all respondents were on-site, they similarly ranked the vista 72% of the time, with a rankingthat differed by no more than one category occurring one hundred percent of the time.

In addition to the VIEW and VISTA ratings, it was assumed that the orientation of the home to the view of turbines (e.g., front, back, or side) ("ORIENTATION"), and the degree to which the view of the turbines overlapped the primary scenic vista (e.g., not at all, barely, somewhat or strongly) ("OVERLAP"), might influence residential property values. As such, information on ORIENTATION and OVERLAP were also collected in the field.

3.2.4. Field Data Collection

Field data collection was conducted on a house-by-house basis. Each of the 6,194 homes was visited by the same individual to remove bias among field ratings. Data collection was conducted in the fall of 2006, and the spring, summer, and fall of 2007 and 2008. Each house was photographed and, when appropriate, so too were views of turbines and the prominent scenic vista.[44] Data on VIEW were collected only for those homes that sold after at least one wind power facility had been erected in the study area. When multiple wind facilities, with different construction dates, were visible from a home, field ratings for VIEW were made by taking into account which turbines had been erected at the time of sale. Additionally, if the season at the time of sale differed from that of data collection and, for example, if leaves were off the trees for one but on for the other, an effort was made to modulate the VIEW rating accordingly if necessary.[45]

Both VIEW and VISTA field ratings were arrived at through a Q-Sort method (Pitt and Zube, 1979), which is used to distinguish relatively similar rankings. For views of turbines, the rater first determined if the ranking was MINOR or EXTREME. If neither of these two rankings was appropriate, then only a choice between MODERATE and SUBSTANTIAL was required. Similarly, for VISTA rankings, first POOR and PREMIUM were distinguished from the others; if neither applied then BELOW AVERAGE or ABOVE AVERAGE could be selected. If neither of those were appropriate the VISTA, by default, was considered AVERAGE. In all cases, if wind turbines were visible from the home, the VISTA rankings were made as if those turbines did not exist.

3.3. Data Summary

The final dataset consists of 7,459 valid and screened residential transactions occurring between January 2, 1996 and June 30, 2007. Those transactions are arrayed across time and the ten wind project study areas as shown in Table 5. The sample of valid residential transactions ranges from 412 in Lee County, Illinois (ILLC) to 1,311 in Howard County, Texas (TXHC).[46] Of the total 7,459 transactions, 4,937 occurred after construction commenced on the relevant wind facilities. More specifically, 23% of the transactions (*n*=1,755) took place before any wind facility was announced and 10% occurred after announcement but before construction commenced (*n*=767),

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[44] In many cases the prominent VISTA was homogenous across groups of home, for instance urban homes on the same road. In those cases a picture of the VISTA of one home was applied to all of the homes. All pictures were taken with a Canon EOS Rebel XTi Single Lens Reflex Camera with a 18-55mm lens. VIEW and VISTA pictures were taken with the lens set to 18mm, with the camera at head height, and with the center of the camera pointed at the center of the prominent VISTA or VIEW. Examples of the various VISTA and VIEW categories are contained in Appendices D and E respectively.

[45] This "modulation" occurred only for trees in the foreground, where, for instance, a single tree could obscure the view of turbines; this would not be the case for trees nearer the horizon.

[46] See description of "valid" in footnote 27 on page 13.

with the rest of the transactions occurring after construction commenced (66%, *n*=4,937).[47] Of that latter group, 17% (*n*=824, 11% of total) sold in the first year following the commencement of construction, 16% in the second year (*n*=811, 11% of total), and the remainder (67%) sold more than two years after construction commenced (*n*=3,302, 44% of total).

Table 5: Summary of Transactions across Study Areas and Development Periods

	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	226	45	76	59	384	**790**
Howard, TX (TXHC)	169	71	113	131	827	**1311**
Custer, OK (OKCC)	484	153	193	187	96	**1113**
Buena Vista, IA (IABV)	152	65	80	70	455	**822**
Lee, IL (ILLC)	115	84	62	71	80	**412**
Kewaunee/Door, WI (WIKCDC)	44	41	68	62	595	**810**
Somerset, PA (PASC)	175	28	46	60	185	**494**
Wayne, PA (PAWC)	223	106	64	71	87	**551**
Madison/Oneida, NY (MYMCOC)	108	9	48	30	268	**463**
Madison, NY (NYMC)	59	165	74	70	325	**693**
TOTAL	**1755**	**767**	**824**	**811**	**3302**	**7459**

A basic summary of the resulting dataset, including the many independent variables used in the hedonic models described later, is contained in Table 6 and Table 7. These tables present summary information for the full dataset (7,459 transactions) as well as the post-construction subset of that dataset (4,937 transactions); the latter is provided because much of the analysis that follows focuses on those homes that sold after wind facility construction. The mean nominal residential transaction price in the sample is $102,968, or $79,114 in 1996 dollars. The average house in the sample can be described as follows: it is 46 years old, has 1,620 square feet of finished living area above ground, is situated on 1.13 acres, has 1.74 bathrooms, and has a

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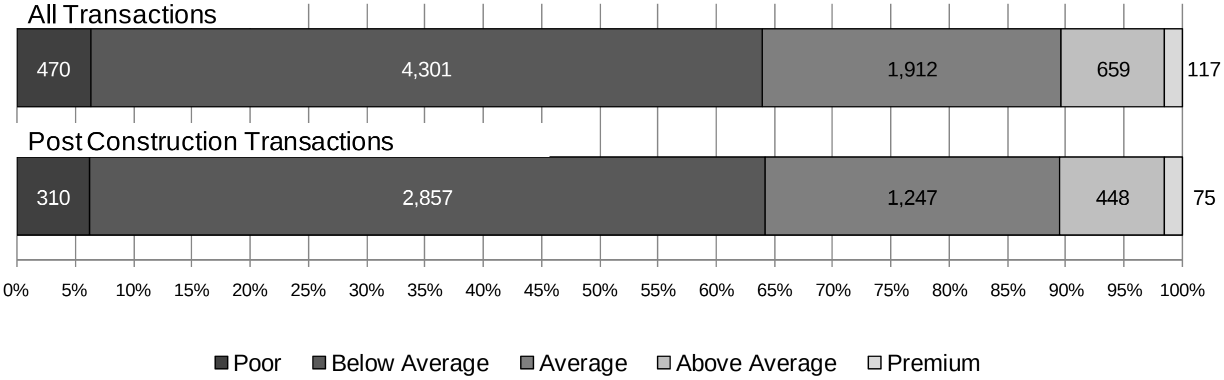
[47] The announcement date (as well as construction and online dates) was provided by Energy Velocity with the GIS files as described in footnote 20 on page 10. The date corresponds to the first time the facility appears in the public record, which was often the permit application date. This constitutes the first well established date when the existing wind facility would have been likely known by the public, and therefore is appropriate to use for this analysis, but there remain a number of areas for potential bias in this date. First, the permit application date might be preceded by news reports of the impending application; alternatively, if the public record was not published online (that Energy Velocity used to establish their date), the "announcement" date – as used here - could, in fact, follow the permit application date. To address this, when possible, the authors had discussions with the developer of the facility. In most cases, the Energy Velocity dates were found to be accurate, and when they were not they were adjusted to reflect the dates provided by the developer. A second potential source of bias is the possibility that a different project was proposed but never built, but that influenced the residential market in the study area prior to the "announcement" date. Although this is likely rarer, we are aware of at least a few projects that fit that description in the study areas. A final source of bias might revolve around the likelihood that awareness of a project could occur even before the facility is formally announced. For example, a community member might know that a wind facility is being considered because they had been approached by the wind development company well ahead of a public announcement. In turn, they might have had private discussions regarding the facility with other members of the community. Taken together, it is appropriate to assume that there is some bias in the "announcement" date, and that awareness of the project might precede the date used in this analysis. How this bias might affect the results in this report is addressed further in Section 5.3 and footnote 74 on page 38.

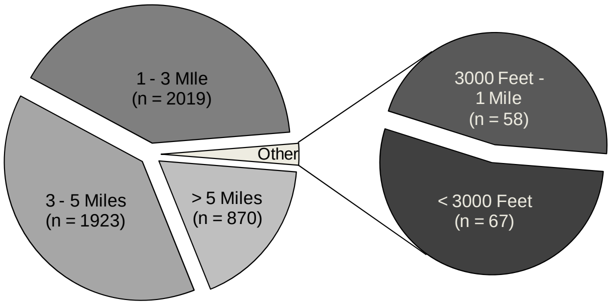
slightly better than average condition.[48] Within the full sample, 6% and 58% of homes had a poor or below average VISTA rating, respectively; 26% of homes received an average rating on this scale, with 9% above average and 2% experiencing premium vistas (see Figure 2).

Figure 2: Frequency of VISTA Ratings for All and Post-Construction Transactions



With respect to the variables of interest, among the post-construction subset of 4,937 transactions, the frequency of the DISTANCE categories is found to follow geometry with the smallest numbers of transactions occurring near the wind turbines and ever increasing numbers further away (see Figure 3). 67 transactions (1%) are situated inside of 3,000 feet (< 0.57 Miles), 58 (1%) are between 3,000 feet and one mile (0.57-1 mile), 2,019 (41%) occur outside of one mile but inside of three miles (1-3 miles), 1,923 (39%) occur between three and five miles (3-5 miles), and 870 (18%) occur outside of five miles (>5 miles).[49] In this same post-construction group, a total of 730 homes that sold (15%) have a view of the wind turbines (see Figure 4). A large majority of those homes have MINOR view ratings (*n* = 561, 11% of total), with 2% having MODERATE ratings (*n*=106) and the remaining transactions roughly split between SUBSTANTIAL and EXTREME ratings (*n*=35, 0.6%, and *n*=28, 0.5%, respectively). A full description of the variables of interest and how they are arrayed at the study area level is contained in Appendix A.

Figure 3: Frequency of DISTANCE Ratings for Post-Construction Transactions



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[48] The variable for the condition of the home was not uniform across study areas because, in some cases, it took into account construction grade while in others it did not.

[49] These numbers and percentages are skewed slightly from the overall population of transactions because homes outside of three miles were often under-sampled to reduce field data collection burdens. Further, higher numbers of homes fall into each of the categories when the post-announcement-pre-construction transactions are included, as they are in some models. These additional transactions are described below in Table 7 under "All Sales."

Figure 4: Frequency of VIEW Ratings for Post-Construction Transactions

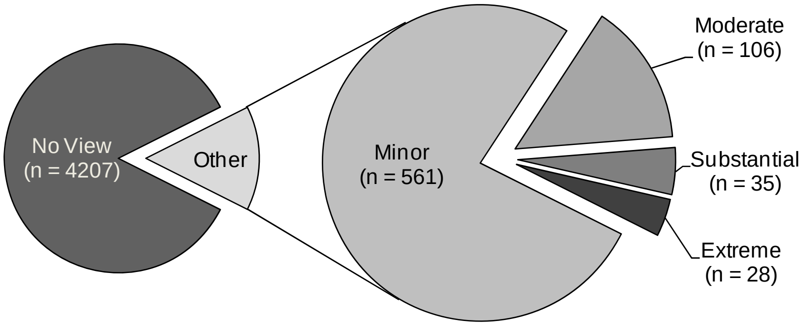

Table 6: Summary Statistics: All Sales and Post-Construction Sales

		All Sales			Post Construction Sales		
Variable Name	**Description**	**Freq. ***	**Mean**	**Std. Dev.**	**Freq. ***	**Mean**	**Std. Dev.**
SalePrice	The unadjusted sale price of the home (in US dollars)	7,459	102,968	64,293	4,937	110,166	69,422
SalePrice96	The sale price of the home adjusted to 1996 US dollars	7,459	79,114	47,257	4,937	80,156	48,906
LN_SalePrice96	The natural log transformation of the sale price of the home adjusted to 1996 US dollars	7,459	11.12	0.58	4,937	11.12	0.60
AgeatSale	The age of the home at the time of sale	7,459	46	37	4,937	47	36
AgeatSale_Sqrd	The age of the home at the time of sale squared	7,459	3,491	5,410	4,937	3,506	5,412
Sqft_1000	The number of square feet of above grade finished living area (in 1000s)	7,459	1.623	0.59	4,937	1.628	0.589
Acres	The number of Acres sold with the residence	7,459	1.13	2.42	4,937	1.10	2.40
Baths	The number of Bathrooms (Full Bath = 1, Half Bath = 0.5)	7,459	1.74	0.69	4,937	1.75	0.70
ExtWalls_Stone	If the home has exterior walls of stone, brick or stucco (Yes = 1, No = 0)	2,287	0.31	0.46	1,486	0.30	0.46
CentralAC	If the home has a Central AC unit (Yes = 1, No = 0)	3,785	0.51	0.50	2,575	0.52	0.50
Fireplace	The number of fireplace openings	2,708	0.39	0.55	1,834	0.40	0.55
Cul_De_Sac	If the home is situated on a cul-de-sac (Yes = 1, No = 0)	990	0.13	0.34	673	0.14	0.34
FinBsmt	If finished basement square feet is greater than 50% times first floor square feet (Yes = 1, No = 0)	1,472	0.20	0.40	992	0.20	0.40
Water_Front	If the home shares a property line with a body of water or river (Yes = 1, No = 0)	107	0.01	0.12	87	0.02	0.13
Cnd_Low	If the condition of the home is Poor (Yes = 1, No = 0)	101	0.01	0.12	69	0.01	0.12
Cnd_BAvg	If the condition of the home is Below Average (Yes = 1, No = 0)	519	0.07	0.25	359	0.07	0.26
Cnd_Avg	If the condition of the home is Average (Yes = 1, No = 0)	4,357	0.58	0.49	2,727	0.55	0.50
Cnd_AAvg	If the condition of the home is Above Average (Yes = 1, No = 0)	2,042	0.27	0.45	1,445	0.29	0.46
Cnd_High	If the condition of the home is High (Yes = 1, No = 0)	440	0.06	0.24	337	0.07	0.25
Vista_Poor	If the Scenic Vista from the home is Poor (Yes = 1, No = 0)	470	0.06	0.24	310	0.06	0.24
Vista_BAvg	If the Scenic Vista from the home is Below Average (Yes = 1, No = 0)	4,301	0.58	0.49	2,857	0.58	0.49
Vista_Avg	If the Scenic Vista from the home is Average (Yes = 1, No = 0)	1,912	0.26	0.44	1,247	0.25	0.44
Vista_AAvg	If the Scenic Vista from the home is Above Average (Yes = 1, No = 0)	659	0.09	0.28	448	0.09	0.29
Vista_Prem	If the Scenic Vista from the home is Premium (Yes = 1, No = 0)	117	0.02	0.12	75	0.02	0.12
SaleYear	The year the home was sold	7,459	2002	2.9	4,937	2004	2.3

** "Freq." applies to the number of cases the parameter's value is not zero*

Table 7: Summary of Variables of Interest: All Sales and Post-Construction Sales

		All Sales			Post Construction Sales		
Variable Name	**Description**	**Freq. ***	**Mean**	**Std. Dev.**	**Freq. ***	**Mean**	**Std. Dev.**
View_None	If the home sold after construction began and had no view of the turbines (Yes = 1, No = 0)	4,207	0.56	0.50	4,207	0.85	0.36
View_Minor	If the home sold after construction began and had a Minor View of the turbines (Yes = 1, No = 0)	561	0.08	0.26	561	0.11	0.32
View_Mod	If the home sold after construction began and had a Moderate View of the turbines (Yes = 1, No = 0)	106	0.01	0.12	106	0.02	0.15
View_Sub	If the home sold after construction began and had a Substantial View of the turbines (Yes = 1, No = 0)	35	-	0.07	35	0.01	0.08
View_Extrm	If the home sold after construction began and had a Extreme View of the turbines (Yes = 1, No = 0)	28	-	0.06	28	0.01	0.08
DISTANCE †	Distance to nearest turbine if the home sold after facility "announcement", otherwise 0	5,705	2.53	2.59	4,895	3.57	1.68
Mile_Less_0.57 †	If the home sold after facility "announcement" and was within 0.57 miles (3000 feet) of the turbines (Yes = 1, No = 0)	80	0.01	0.09	67	0.01	0.12
Mile_0.57to1 †	If the home sold after facility "announcement" and was between 0.57 miles (3000 feet) and 1 mile of the turbines (Yes = 1, No = 0)	65	0.01	0.09	58	0.01	0.11
Mile_1to3 †	If the home sold after facility "announcement" and was between 1 and 3 miles of the turbines (Yes = 1, No = 0)	2,359	0.27	0.44	2,019	0.41	0.49
Mile_3to5 †	If the home sold after facility "announcement" and was between 3 and 5 miles of the turbines (Yes = 1, No = 0)	2,200	0.26	0.44	1,923	0.39	0.49
Mile_Gtr5 †	If the home sold after facility "announcement" and was outside 5 miles of the turbines (Yes = 1, No = 0)	1,000	0.12	0.32	870	0.18	0.38

** "Freq." applies to the number of cases the parameter's value is not zero*

† "All Sales" freq., mean and standard deviation DISTANCE and DISTANCE fixed effects variables (e.g., Mile_1to3) include transactions that occurred after facility "announcement" and before "construction" as well as those that occured post-construction

4. Base Hedonic Model

This section uses the primary hedonic model ("Base Model") to assess whether residential sales prices are affected, in a statistically measurable way, by views of and proximity to wind power facilities. In so doing, it simultaneously tests for the presence of the three potential property value stigmas associated with wind power facilities: Area, Scenic Vista, and Nuisance. This section begins with a discussion of the dataset that is used and the form of the model that is estimated, and then turns to the results of the analysis. Various alternative hedonic models are discussed and estimated in Section 5, with Sections 6 and 7 providing a discussion of and results from the repeat sales and sales volume models.

4.1. Dataset

The data used for the Base Model were described in Section 3.3. A key threshold question is whether or not to include the residential transactions that pre-date the relevant wind facility. Specifically, though the complete dataset consists of 7,459 residential transactions, a number of these transactions (n = 2,522) occurred before the wind facility was constructed. Should these homes which, at the time of sale, would not have had any view of or distance to the wind facility, be included? Two approaches could be applied to address this issue. First, pre-construction transactions could be included in the hedonic model either as part of the reference category within which no wind-project property value impacts are assumed to exist, or instead by specifically identifying these pre-construction transactions through an indicator variable. Second, and alternatively, pre-construction transactions could simply be excluded from the analysis altogether.

For the purpose of the Base Model, the latter approach is used, therefore relying on only the post-construction subset of 4,937 residential transactions. This approach, as compared to the others, results in somewhat more intuitive findings because all homes have a distance greater than zero and have a possibility of some view of the turbines. More importantly, this approach minimizes the chance of inaccuracies that may otherwise exist due to inflation adjustment concerns or outdated home characteristics information.[50] Nonetheless, to test for the implications of this choice of datasets, alternative hedonic models that use the full dataset were estimated, and are discussed in detail in Sections 5.3 and 5.4.

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[50] Home characteristics were obtained as of the last property assessment. The timing of that assessment relative to the timing of the home sale transaction dictates how representative the assessed home characteristics are of the subject home when it was sold. For example, if a home sold early in the study period but subsequently had significant improvements made that are reflected in the current assessment data used in the analysis, the model would assign value to these home characteristics at the time of sale when, in fact, those characteristics were inaccurate. Additionally, the inflation adjustment index used in this analysis to translate home values to real 1996 dollars came from the nearest or more appropriate municipal statistical area (MSA). Many of the wind projects in the analysis are located in relatively rural parts of the country, and the housing market in the nearest metropolitan area could be different than the market surrounding wind projects. Although these areas have – in many instances – recently begun to attract home buyers willing to commute back to the metropolitan areas on which the index is based, the older index adjustments are likely less accurate than the more recent adjustments. Using a subset of the data for the majority of the analyses that removes the older, pre-construction, homes minimizes both of these biases.

4.2. Model Form

A standard semi-log functional form is used for the hedonic models (as was discussed in Section 2.1), where the dependent variable (sales price in inflation-adjusted 1996 dollars) is transformed to its natural log form and the independent variables (e.g., square feet and acres) are not transformed. Using this form to examine the effect that views of, and distance to, wind facilities have on sales prices, the following basic model is estimated:

$$\ln\left(\mathrm{P}\right) = \beta_0 + \beta_1 \mathrm{N} + \sum_{\mathrm{s}} \beta_2 \mathrm{S} + \sum_{\mathrm{k}} \beta_3 \mathrm{X} + \sum_{\mathrm{v}} \beta_4 \mathrm{VIEW} + \sum_{\mathrm{d}} \beta_5 \mathrm{DISTANCE} + \varepsilon \qquad (1)$$

where
P represents the inflation-adjusted sales price,
N is the spatially weighted neighbors' predicted sales price,
S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),
X is a vector of *k* home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),
VIEW is a vector of *v* categorical view of turbine variables (e.g., MINOR, MODERATE, etc.),
DISTANCE is a vector of *d* categorical distance to turbine variables (e.g., less than 3000 feet, between one and three miles, etc.),
β_0 is the constant or intercept across the full sample,
β_1 is a parameter estimate for the spatially weighted neighbor's predicted sales price,
β_2 is a vector of *s* parameter estimates for the study area fixed effects as compared to homes sold in the Washington/Oregon (WAOR) study area,
β_3 is a vector of *k* parameter estimates for the home and site characteristics,
β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to homes sold with no view of the turbines,
β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to homes sold situated outside of five miles, and
ε is a random disturbance term.

As such, this model, and all subsequent hedonic models, has four primary groups of parameters: variables of interest, spatial adjustments, study-area fixed effects, and home and site characteristics.

The variables of interest, VIEW and DISTANCE, are the focus of this study, and allow the investigation of the presence of Area, Scenic Vista, and Nuisance Stigmas. These variables were defined in Section 3, and are summarized in Table 8. Both VIEW and DISTANCE appear in the model together because a home's value may be affected in part by the magnitude of the view of the wind turbines, and in part by the distance from the home to those turbines, and both variables appear in the Base Model as ordered categorical values. The coefficients associated with these two vectors of variables (β_4 and β_5) represent the marginal impact of views of, and distances to, wind turbines on sales prices, as compared to a "reference" category of residential transactions, and should be ordered monotonically from low to high.[51] This form of variable was used to

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[51] "Reference category" refers to the subset of the sample to which other observations are compared, and is pertinent when using categorical or "fixed effect" variables.

impose the least structure on the underlying data.[52] For the purpose of the Base Model, the reference category for the DISTANCE variables are those transactions of homes that were situated outside of five miles from the nearest wind turbine. The reference category for the VIEW variables are those transactions of homes that did not have a view of the wind facility upon sale. Among the post-construction sample of homes, these reference homes are considered the least likely to be affected by the presence of the wind facilities.[53]

Table 8: List of Variables of Interest Included in the Base Model

Variable Name	**Description**	**Type**	**Expected Sign**
View_None	If the home sold after construction began and had no view of the turbines (Yes = 1, No = 0)	Reference	n/a
View_Minor	If the home sold after construction began and had a Minor View of the turbines (Yes = 1, No = 0)	OC	**-**
View_Mod	If the home sold after construction began and had a Moderate View of the turbines (Yes = 1, No = 0)	OC	**-**
View_Sub	If the home sold after construction began and had a Substantial View of the turbines (Yes = 1, No = 0)	OC	**-**
View_Extrm	If the home sold after construction began and had an Extreme View of the turbines (Yes = 1, No = 0)	OC	**-**
Mile_Less_0.57	If the home sold after facility "construction" and was within 0.57 miles (3000 feet) of the turbines (Yes = 1, No = 0)	OC	**-**
Mile_0.57to1	If the home sold after facility "construction" and was between 0.57 miles (3000 feet) and 1 mile of the turbines (Yes = 1, No = 0)	OC	**-**
Mile_1to3	If the home sold after facility "construction" and was between 1 and 3 miles of the turbines (Yes = 1, No = 0)	OC	**-**
Mile_3to5	If the home sold after facility "construction" and was between 3 and 5 miles of the turbines (Yes = 1, No = 0)	OC	**-**
Mile_Gtr5	If the home sold after facility "construction" and was outside 5 miles of the turbines (Yes = 1, No = 0)	Reference	n/a

"OC" Ordered Categorical (1 = yes, 0 = no) values are interpreted in relation to the reference categorical case and are expected to have a monotonic order from low to high.

The three stigmas are investigated though these VIEW and DISTANCE variables. Scenic Vista Stigma is investigated through the VIEW variables. Area and Nuisance Stigmas, on the other hand, are investigated through the DISTANCE variables. To distinguish between Area and

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[52] In place of the ordered categorical DISTANCE variables, practitioners often rely on a continuous DISTANCE form (e.g., Sims et al., 2008). Similar to ordered categorical variables, continuous variables have a natural ordering, either ascending or descending, but, unlike categorical variables, these "continuous" values are on a scale. Therefore, given any two of its values X_1 and X_2 and a specific functional form, the ratio "X_1/X_2" and the distance "$X_1 - X_2$" have a fixed meaning. Examples of continuous variables other than DISTANCE that are commonly used include the number of square feet of living area (in 1000s) in a home (SQFT_1000) or the acres in the parcel (ACRES). A continuous functional form of this nature "imposes structure" because practitioners must decide how price is related to the underlying variables through the selection of a specific functional relationship between the two. For instance, in the case of DISTANCE, is there a linear relationship (which would imply a similar marginal difference between two distances both near and far from the turbines), does it decay slowly as distance grows, or does it fade completely at some fixed distance? Because of the lack of literature in this area, no *a priori* expectations for which functional form is the best were established, and therefore unstructured categorical variables are used in the Base Model. Nonetheless, a continuous DISTANCE form is explored in Section 5.2.

[53] It is worth noting that these reference homes are situated in both rural and urban locales and therefore are not uniquely affected by influences from either setting. This further reinforces their worthiness as a reference category.

Nuisance Stigma, it is assumed that Nuisance effects are concentrated within one mile of the nearest wind turbine, while Area effects will be considered for those transactions outside of one mile. Any property value effects discovered outside of one mile and based on the DISTANCE variables are therefore assumed to indicate the presence of Area Stigma, while impacts within a mile may reflect the combination of Nuisance and Area Stigma.

The second set of variables in the Base Model - spatial adjustments - correct for the assumed presence of spatial autocorrelation in the error term (ε). It is well known that the sales price of a home can be systematically influenced by the sales prices of those homes that have sold nearby. Both the seller and the buyer use information from comparable surrounding sales to inform them of the appropriate transaction price, and nearby homes often experience similar amenities and disamenities. This lack of independence of home sale prices could bias hedonic regression results and, to help correct for this bias, a spatially (i.e., distance) weighted neighbors' sales price (N) is included in the model. Empirically, the neighbors' price has been found to be a strong (and sometimes even the strongest) predictor of home values (Leonard and Murdoch, forthcoming), and the coefficient β_1 is expected to be positive, indicating a positive correlation between the neighbors' and subject home's sales price. A more-detailed discussion of the importance of this variable, and how it was created, is contained in Appendix G.

The third group of variables in the Base Model - study area fixed effects - control for study area influences and the differences between them. The vector's parameters β_2 represent the marginal impact of being in any one of the study areas, as compared to a reference category. In this case, the reference category is the Washington/Oregon (WAOR) study area.[54] The estimated coefficients for this group of variables represent the combined effects of school districts, tax rates, crime, and other locational influences across an entire study area. Although this approach greatly simplifies the estimation of the model, because of the myriad of influences captured by these study-area fixed effects variables, interpreting the coefficient can be difficult. In general, though, the coefficients simply represent the mean difference in sales prices between the study areas and the reference study area (WAOR). These coefficients are expected to be strongly influential, indicating significant differences in sales prices across study areas.

The fourth group of variables in the Base Model are the core home and site characteristics (X), and include a range of continuous ("C"),[55] discrete ("D"),[56] binary ("B"),[57] and ordered categorical ("OC") variables. The specific home and site variables included in the Base Model are listed in Table 9 along with the direction of expected influence.[58] Variables included are age

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[54] Because there is no intent to focus on the coefficients of the study area fixed effect variables, the reference case is arbitrary. Further, the results for the other variables in the model are completely independent of this choice.

[55] See discussion in footnote 52 on previous page.

[56] Discrete variables, similar to continuous variables, are ordered and the distance between the values, such as X_1 and X_2, have meaning, but for these variables, there are only a relatively small number of discrete values that the variable can take, for example, the number of bathrooms in a home (BATHROOMS).

[57] Binary variables have only two conditions: "on" or "off" (i.e., "1" or "0" respectively). Examples are whether the home has central air conditioning ("CENTRAL_AC") or if the home is situated on a cul-de-sac ("CUL_DE_SAC"). The coefficients for these variables are interpreted in relation to when the condition is "off."

[58] For those variables with a "+" sign it is expected that as the variable increases in value (or is valued at "1" as would be the case for fixed effects variables) the price of the home will increase, and the converse is true for the variables with a "-" sign. The expected signs of the variables all follow conventional wisdom (as discussed in

of the home, home and lot size, number of bathrooms and fireplaces, the condition of the home, the quality of the scenic vista from the home, if the home has central AC, a stone exterior, and/or a finished basement, and whether the home is located in a cul-de-sac and/or on a water way.[59]

Table 9: List of Home and Site Characteristics Included in the Base Model

Variable Name	Description	Type	Expected Sign
AgeatSale	The age of the home at the time of sale in years	C	-
AgeatSale_Sqrd	The age of the home at the time of sale squared	C	+
Sqft_1000	The number of square feet of above grade finished living area (in 1000s)	C	+
Acres	The number of Acres sold with the residence	C	+
Baths	The number of Bathrooms (Full Bath = 1, Half Bath = 0.5)	D	+
ExtWalls_Stone	If the home has exterior walls of stone, brick or stucco (Yes = 1, No = 0)	B	+
CentralAC	If the home has a Central AC unit (Yes = 1, No = 0)	B	+
Fireplace	The number of fireplace openings	D	+
Cul_De_Sac	If the home is situated on a cul-de-sac (Yes = 1, No = 0)	B	+
FinBsmt	If finished basement sqft > 50% times first floor sqft (Yes = 1, No = 0)	B	+
Water_Front	If the home shares a property line with a body of water or river (Yes = 1, No = 0)	B	+
Cnd_Low	If the condition of the home is Poor (Yes = 1, No = 0)	OC	-
Cnd_BAvg	If the condition of the home is Below Average (Yes = 1, No = 0)	OC	-
Cnd_Avg	If the condition of the home is Average (Yes = 1, No = 0)	Reference	n/a
Cnd_AAvg	If the condition of the home is Above Average (Yes = 1, No = 0)	OC	+
Cnd_High	If the condition of the home is High (Yes = 1, No = 0)	OC	+
Vista_Poor	If the Scenic Vista from the home is Poor (Yes = 1, No = 0)	OC	-
Vista_BAvg	If the Scenic Vista from the home is Below Average (Yes = 1, No = 0)	OC	-
Vista_Avg	If the Scenic Vista from the home is Average (Yes = 1, No = 0)	Reference	n/a
Vista_AAvg	If the Scenic Vista from the home is Above Average (Yes = 1, No = 0)	OC	+
Vista_Prem	If the Scenic Vista from the home is Premium (Yes = 1, No = 0)	OC	+

"C" Continuous, "D" Discrete, and "B" Binary (1 = yes, 0 = no) values are interpreted in relation to "No"

"OC" Ordered Categorical (1 = yes, 0 = no) values are interpreted in relation to the reference categorical case and are expected to have a monotonic order from low to high.

Sirmans et al., 2005a), save AgeatSale and AgeatSale_Sqrd, which are expected to be negative and positive, respectively. The magnitude of the coefficient of AgeatSale is expected to be larger than that of AgeatSale_Sqrd indicating an initial drop in value as a home increases in age, and then an increase in value as the home becomes considerably older and more "historic."

[59] Some characteristics, such as whether the home had a deck, a pool, or is located on a public sewer, are not available consistently across the dataset and therefore are not incorporated into the model. Other characteristics, such as the number of bedrooms, the number of stories, or if the home had a garage, are available but are omitted from the final model because they are highly correlated with characteristics already included in the model and therefore do not add significantly to the model's explanatory power. More importantly, and as discussed in Appendix G, when their inclusion or exclusion are tested, the results are stable with those derived from the Base Model.

It should be emphasized that in the Base Hedonic Model - equation (1) - and in all subsequent models presented in Section 5, all variables of interest, spatial adjustments, and home and site characteristics are pooled, and therefore their estimates represent the average across all study areas. Ideally, one would have enough data to estimate a model at the study area level - a fully unrestricted model - rather than pooled across all areas. This fully unrestricted model form, along with 15 other model forms (with some variables restricted and others not), are discussed in detail in Appendix F. In total, these 16 different models were estimated to explore which model was the most parsimonious (had the fewest parameters), performed the best (e.g., had the highest adjusted R^2 and the lowest Schwarz information criterion[60]), and had the most stable coefficients and standard errors. The basic pooled model described by equation (1) is found to fit that description, and that model is therefore chosen as the Base Model to which others are compared. By making this choice the effort concentrates on identifying the presence of potential property value impacts across all of the study areas in the sample as opposed to any single study area.[61]

Finally, to assure that the model produces the best linear unbiased parameter estimates, the underlying assumptions of Ordinary Least Squares (OLS) regression techniques must be verified:

1) Homoskedastic error term;
2) Absence of temporal serial correlation;
3) Reasonably limited multicollinearity; and
4) Appropriate controls for outliers and influencers.[62]

These assumptions, and the specific approaches that are used to address them, are discussed in detail in Appendix G.

4.3. Analysis of Results

Table 10 (on page 32) presents the results of the Base Model (equation 1).[63] The model performs well, with an adjusted R^2 of 0.77.[64] The spatial adjustment coefficient (β_1) of 0.29 (*p* value 0.00) indicates that a 10% increase in the spatially weighted neighbor's price increases the subject home's value by an average of 2.9%. The study-area fixed effects (β_2) variables are all significant at the one percent level, demonstrating important differences in home valuations

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[60] The Schwarz information criterion measures relative parsimony between similar models (Schwarz, 1978).

[61] Because effects might vary between study areas, and the models estimate an average across all study areas, the full range of effects in individual study areas will go undetermined. That notwithstanding, there is no reason to suspect that effects will be completely "washed out." For that to occur, an effect in one study area would have to be positive while in another area it would have to be negative, and there is no reason to suspect that sales prices would increase because of the turbines in one community while decreasing in other communities.

[62] The absence of spatial autocorrelation is often included in the group of assumptions, but because it was discussed above (and in Appendix G), and is addressed directly by the variable (N_i) included in the model, it is not included in this list.

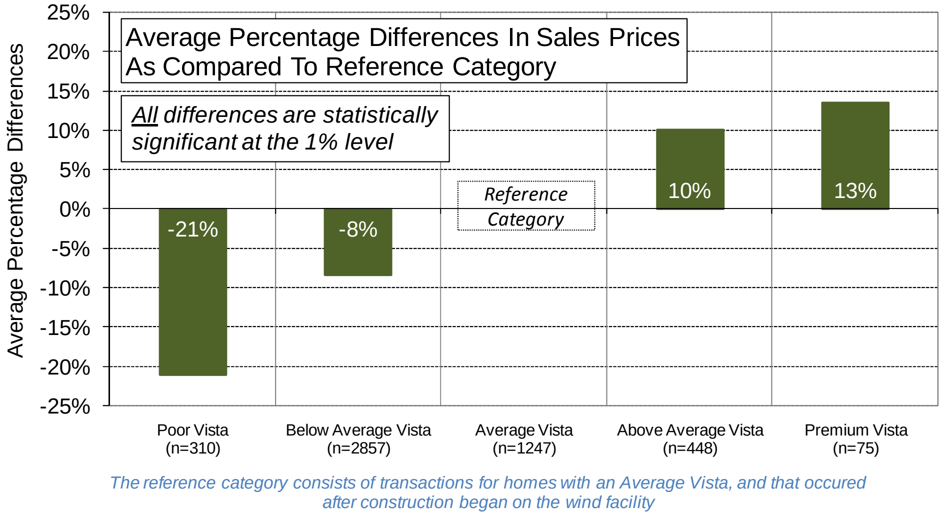
[63] This model and all subsequent models were estimated using the PROC REG procedure of SAS Version 9.2 TS1M0, which produces White's corrected standard errors.

[64] The appropriateness of the R^2 of 0.77 for this research is validated by the extensive hedonic literature that precedes it (see e.g., Kroll and Priestley, 1992; Boyle and Kiel, 2001; Simons, 2006b).

between the reference study area (WAOR) and the other nine study areas.[65] The sign and magnitudes of the home and site characteristics are all appropriate given the *a priori* expectations, and all are statistically significant at the one percent level.[66]

Of particular interest are the coefficient estimates for scenic vista (VISTA) as shown in Figure 5. Homes with a POOR vista rating are found, on average, to sell for 21% less (*p* value 0.00) than homes with an AVERAGE rating, while BELOW AVERAGE homes sell for 8% less (*p* value 0.00). Conversely, homes with an ABOVE AVERAGE vista are found to sell for 10% more (*p* value 0.00) than homes with an AVERAGE vista, while PREMIUM vista homes sell for 13% more than AVERAGE homes (*p* value 0.00). Based on these results, it is evident that home buyers and sellers capitalize the quality of the scenic vista in sales prices.[67]

Figure 5: Results from the Base Model for VISTA



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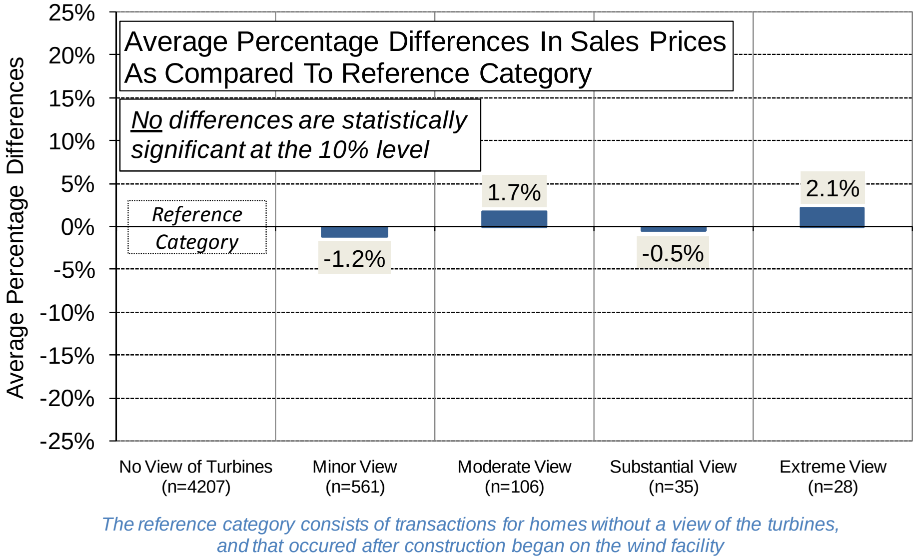
[65] The reference category WAOR study area has the highest mean and median house values in the sample (as shown in Appendix A) so the negative coefficients for all the study area fixed effect variables are appropriate.

[66] To benchmark the results against those of other practitioners the research by Sirmans et al. (2005a; 2005b) was consulted. They conducted a meta-analysis of 64 hedonic studies carried out in multiple locations in the U.S. during multiple time periods, and investigated the coefficients of ten commonly used characteristics, seven of which were included in the model. The similarities between their mean coefficients (i.e., the average across all 64 studies) and those estimated in the present Base Model are striking. The analysis presented here estimates the effect of square feet (in 1000s) on log of sales price at 0.28 and Sirmans et al. provide an estimate of 0.34, while ACRES was similarly estimated (0.02 to 0.03, Base Model and Sirmans et al., respectively). Further, AGEATSALE (age at the time of sale) (-0.006 to -0.009), BATHROOMS (0.09 to 0.09), CENTRALAC (0.09 to 0.08), and FIREPLACE (0.11 to 0.09) all similarly compare. As a group, the Base Model estimates differ from Sirmans et al. estimates in all cases by no more than a third of the Sirmans et al. mean estimate's standard deviation. This, taken with the relatively high adjusted R^2 of the Base Model, demonstrates the appropriateness of the model's specification.

[67] To benchmark these results they are compared to the few studies that have investigated the contribution of inland scenic vistas to sales prices. Benson et al. (2000) find that a mountain vista increases sales price by 8%, while Bourassa et al. (2004) find that wide inland vistas increase sales price by 7.6%. These both compare favorably to the 10% and 14% above average and premium rated VISTA estimates. Comparable studies for below average and poor VISTA were not found and therefore no benchmarking of those coefficients is conducted. Finally, it should again be noted that a home's scenic vista, as discussed in Section 3.2.3, was ranked without taking the presence of the wind turbines into consideration, even if those turbines were visible at the time of home sale.

Despite this finding for scenic vista, however, no statistically significant relationship is found between views of wind turbines and sales prices.[68] The coefficients for the VIEW parameters (β_4) are all relatively small, none are statistically significant, and they are not monotonically ordered (see Figure 6). Homes with EXTREME or SUBSTANTIAL view ratings, for which the Base Model is expected to find the largest differences, sell for, on average, 2.1% more (*p* value 0.80) and 0.5% less (*p* value 0.94) than NO VIEW homes that sold in the same post-construction period. Similarly, homes with MODERATE or MINOR view ratings sell, on average, for 1.7% more (*p* value 0.58) and 1.2% less (*p* value 0.40) than NO VIEW homes, respectively. None of these coefficients are sizable, and none are statistically different from zero. These results indicate that, among this sample at least, a statistically significant relationship between views of wind turbines and residential property values is not evident. In other words, there is an absence of evidence of a Scenic Vista Stigma in the Base Model.

Figure 6: Results from the Base Model for VIEW



The coefficients for the DISTANCE parameters (β_5) are also all relatively small and none are statistically significant (see Figure 7). Homes that are situated within 3000 feet (0.57 miles) of the nearest wind turbine, at the time of sale, are found to sell for 5.3% less (*p* value 0.40), on average, than homes outside of 5 miles that sold in the same "post-construction" period. Meanwhile, homes between 3000 feet and 1 mile sold for 5.5% less (*p* value 0.30), on average, than homes more than 5 miles away. Homes that are within 1 to 3 miles of the nearest turbine, as compared to homes outside of 5 miles, sold for essentially the same, on average (coefficient = 0.004, *p* value 0.80), while homes between 3 and 5 miles sold for 1.6% more (*p* value 0.23).

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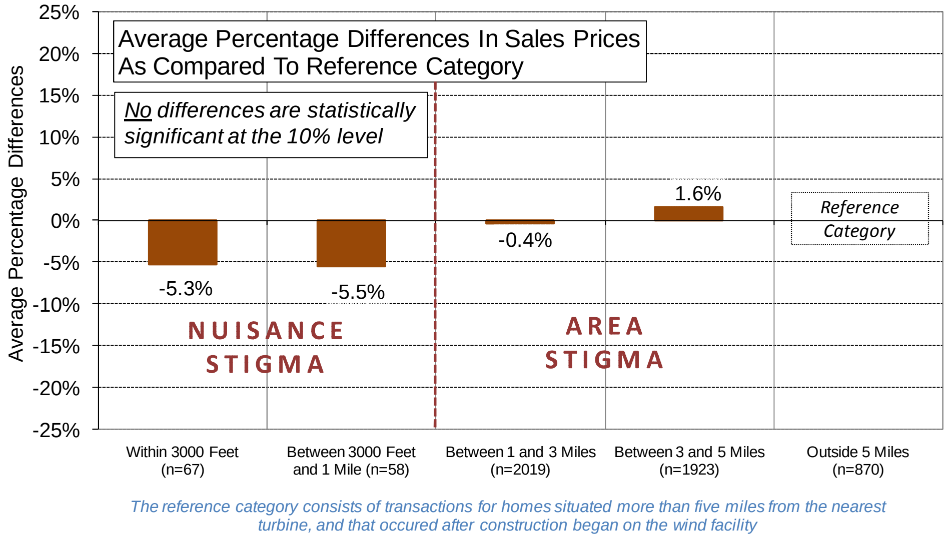
[68] A significance level of 10% is used throughout this report, which corresponds to a *p*-value at or above 0.10. Although this is more liberal than the often used 5% (*p*-value at or above 0.05), it was chosen to give more opportunities for effects that might be fairly weak to be considered significant.

Figure 7: Results from the Base Model for DISTANCE



Looking at these results as a whole, a somewhat monotonic order from low to high is found as homes are situated further away from wind facilities, but all of the coefficients are relatively small and none are statistically different from zero. This suggests that, for homes in the sample at least, there is a lack of statistical evidence that the distance from a home to the nearest wind turbine impacts sales prices, and this is true regardless of the distance band.[69] As such, an absence of evidence of an Area or Nuisance Stigma is found in the Base Model. That notwithstanding, the -5% coefficients for homes that sold within one mile of the nearest wind turbine require further scrutiny. Even though the differences are not found to be statistically significant, they might point to effects that exist but are too small for the model to deem statistically significant due to the relatively small number of homes in the sample within 1 mile of the nearest turbine. Alternatively, these homes may simply have been devalued even before the wind facility was erected, and that devaluation may have carried over into the post construction period (the period investigated by the Base Model). To explore these possibilities, transactions that occurred well before the announcement of the wind facility to well after construction are investigated in the Temporal Aspects Model in the following "Alternative Models" section.

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[69] It is worth noting that the number of cases in each of these categories (e.g., *n* = 67 for homes inside of 3000 feet and *n* = 58 between 3000 feet and one mile) are small, but are similar to the numbers of cases for other variables in the same model (e.g., LOW CONDITION, *n* = 69; PREMIUM VISTA, *n* = 75), the estimates of which were found to be significant above the 1% level.

Table 10: Results from the Base Model

	Coef.	**SE**	**p Value**	***n***
Intercept	7.62	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.33	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.14	0.01	0.00	1,445
Cnd High	0.23	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.01	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
Post Con NoView	Omitted	Omitted	Omitted	4,207
View Minor	-0.01	0.01	0.40	561
View Mod	0.02	0.03	0.58	106
View Sub	-0.01	0.07	0.94	35
View Extrm	0.02	0.09	0.80	28
Mile Less 0 57	-0.05	0.06	0.40	67
Mile 0 57to1	-0.05	0.05	0.30	58
Mile 1to3	0.00	0.02	0.80	2,019
Mile 3to5	0.02	0.01	0.23	1,923
Mile Gtr5	Omitted	Omitted	Omitted	870

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**1**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**37**
F Statistic	**442.8**
Adjusted R Squared	**0.77**

5. Alternative Hedonic Models

The Base Hedonic Model presented in Section 4 found that residential property values have, on average, not been measurably affected by the presence of nearby wind facilities. To test the robustness of this result and to test for other possible impacts from nearby wind projects, the report now turns to a number of other hedonic models. These Alternative Models were created to investigate different approaches to exploring the impact of the variables of interest (#1 and #2, below) and to assess the presence of impacts that are not otherwise fully captured by the Base Model (#3 through #6, below).

1) **View and Distance Stability Models:** Using only post-construction transactions (the same as the Base Model) these models investigate whether the Scenic Vista Stigma (as measured with VIEW) results are independent of the Nuisance and Area Stigma results (as measured by DISTANCE) and vice versa.[70]
2) **Continuous Distance Model:** Using only post-construction transactions, this model investigates Area and Nuisance Stigmas by applying a continuous distance parameter as opposed to the categorical variables for distance used in the previous models.
3) **All Sales Model:** Using all transactions, this model investigates whether the results for the three stigmas change if transactions that occurred before the announcement and construction of the wind facility are included in the sample.
4) **Temporal Aspects Model:** Using all transactions, this model further investigates Area and Nuisance Stigmas and how they change for homes that sold more than two years pre-announcement through the period more than four years post-construction.
5) **Home Orientation Model:** Using only post-construction transactions, this model investigates the degree to which a home's orientation to the view of wind turbines affects sales prices.
6) **View and Vista Overlap Model:** Using only post-construction transactions, this model investigates the degree to which the overlap between the view of a wind facility and a home's primary scenic vista affects sales prices.

Each of these models is described in more depth in the pages that follow. Results are shown for the variables of interest only; full results are contained in Appendix H.

5.1. View and Distance Stability Models

The Base Model (equation 1) presented in Section 4 includes both DISTANCE and VIEW variables because a home's value might be affected in part by the magnitude of the view of a nearby wind facility and in part by the distance from the home to that facility. These two variables may be related, however, in-so-far as homes that are located closer to a wind facility are likely to have a more-dominating view of that facility. To explore the degree to which these two sets of variables are independent of each other (i.e. not collinear) and to further test the robustness of the Base Model results two alternative hedonic models are run, each of which includes only one of the sets of parameters (DISTANCE or VIEW). Coefficients from these models are then compared to the Base Model results.

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[70] Recall that the qualitative VIEW variable incorporated the visible distance to the nearest wind facility.

5.1.1. Dataset and Model Form

The same dataset is used as in the Base Model, focusing again on post-construction transactions (*n* = 4,937). To investigate DISTANCE effects alone the following model is estimated:

$$\ln\left(\mathrm{P}\right) = \beta_0 + \beta_1\mathrm{N} + \sum_{\mathrm{s}} \beta_2\mathrm{S} + \sum_{\mathrm{k}} \beta_3\mathrm{X} + \sum_{\mathrm{d}} \beta_5\mathrm{DISTANCE} + \varepsilon \qquad (2)$$

where
P represents the inflation-adjusted sales price,
N is the spatially weighted neighbors' predicted sales price,
S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),
X is a vector of *k* home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),
DISTANCE is a vector of *d* categorical distance variables (e.g., less than 3000 feet, between one and three miles, etc.),
β_0 is the constant or intercept across the full sample,
β_1 is a parameter estimate for the spatially weighted neighbor's predicted sales price,
β_2 is a vector of *s* parameter estimates for the study area fixed effects as compared to transactions of homes in the WAOR study area,
β_3 is a vector of *k* parameter estimates for the home and site characteristics,
β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to transactions of homes situated outside of five miles, and
ε is a random disturbance term.

The parameters of primary interest are β_5, which represent the marginal differences between home values at various distances from the wind turbines as compared to the reference category of homes outside of five miles. These coefficients can then be compared to the same coefficients estimated from the Base Model.

Alternatively, to investigate the VIEW effects alone, the following model is estimated:

$$\ln\left(\mathrm{P}\right) = \beta_0 + \beta_1\mathrm{N} + \sum_{\mathrm{s}} \beta_2\mathrm{S} + \sum_{\mathrm{k}} \beta_3\mathrm{X} + \sum_{\mathrm{v}} \beta_4\mathrm{VIEW} + \varepsilon \qquad (3)$$

where
VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),
β_4 is a vector of *v* parameter estimates for the VIEW variables, and
all other components are as defined in equation (2).

The parameters of primary interest in this model are β_4, which represent the marginal differences between home values for homes with varying views of wind turbines at the time of sale as compared to the reference category of homes without a view of those turbines. Again, these coefficients can then be compared to the same coefficients estimated from the Base Model.

Our expectation for both of the models described here is that the results will not be dramatically different from the Base Model, given the distribution of VIEW values across the DISTANCE values, and vice versa, as shown in Table 11. Except for EXTREME view, which is concentrated inside of 3000 feet, all view ratings are adequately distributed among the distance categories.

Table 11: Frequency Crosstab of VIEW and DISTANCE Parameters

	Inside 3000 Feet	Between 3000 Feet and 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles	Outside 5 Miles	Total
No View	6	12	1653	1695	841	**4207**
Minor View	14	24	294	202	27	**561**
Moderate View	8	13	62	21	2	**106**
Substantial View	11	9	10	5	0	**35**
Extreme View	28	0	0	0	0	**28**
TOTAL	**67**	**58**	**2019**	**1923**	**870**	**4937**

5.1.2. Analysis of Results

Summarized results for the variables of interest from the Base Model and the two Alternative Stability Models are presented in Table 12. (For brevity, the full set of results for the models is not shown in Table 12, but is instead included in Appendix H.) The adjusted R^2 for the View and Distance Stability Models is the same as for the Base Model, 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level and are similar in magnitude to the estimates presented earlier for the Base Model.

The DISTANCE and VIEW coefficients, β_5 and β_4, are stable, changing no more than 3%, with most (7 out of 8) not experiencing a change greater than 1%. In all cases, changes to coefficient estimates for the variables of interest are considerably less than the standard errors. Based on these results, there is confidence that the correlation between the VIEW and DISTANCE variables is not responsible for the findings and that these two variables are adequately independent to be included in the same hedonic model regression. As importantly, no evidence of Area, Scenic Vista, or Nuisance Stigma is found in the sample, as none of the VIEW or DISTANCE variables are found to be statistically different from zero.

Table 12: Results from Distance and View Stability Models

		Base Model			Distance Stability			View Stability		
Variables of Interest	***n***	**Coef**	**SE**	**p Value**	**Coef**	**SE**	**p Value**	**Coef**	**SE**	**p Value**
No View	4207	Omitted	Omitted	Omitted				Omitted	Omitted	Omitted
Minor View	561	-0.01	0.01	0.39				-0.02	0.01	0.24
Moderate View	106	0.02	0.03	0.57				0.00	0.03	0.90
Substantial View	35	-0.01	0.07	0.92				-0.04	0.06	0.45
Extreme View	28	0.02	0.09	0.77				-0.03	0.06	0.58
Inside 3000 Feet	67	-0.05	0.06	0.31	-0.04	0.04	0.25			
Between 3000 Feet and 1 Mile	58	-0.05	0.05	0.20	-0.06	0.05	0.17			
Between 1 and 3 Miles	2019	0.00	0.02	0.80	-0.01	0.02	0.71			
Between 3 and 5 Miles	1923	0.02	0.01	0.26	0.01	0.01	0.30			
Outside 5 Miles	870	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted			

"Omitted" = reference category for fixed effects variables. "n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**1**	**2**	**3**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**	**4937**
Number of Predictors (k)	**37**	**33**	**33**
F Statistic	**442.8**	**496.7**	**495.9**
Adjusted R Squared	**0.77**	**0.77**	**0.77**

5.2. Continuous Distance Model

The potential impact of wind facilities on residential property values based on Area and Nuisance effects was explored with the Base Model by using five ordered categorical DISTANCE variables. This approach was used in order to impose the least restriction on the functional relationship between distance and property values (as discussed in footnote 52 on page 25). The literature on environmental disamenities, however, more commonly uses a continuous distance form (e.g., Sims et al., 2008), which imposes more structure on this relationship. To be consistent with the literature and to test if a more rigid structural relationship might uncover an effect that is not otherwise apparent with the five distance categories used in the Base Model, a hedonic model that relies upon a continuous distance variable is presented here. One important benefit of this model is that a larger amount of data (e.g., *n* = 4,937) is used to estimate the continuous DISTANCE coefficient then was used to estimate any of the individual categorical estimates in the Base Model (e.g., *n* = 67 inside 3000 feet, *n* = 2019 between one and three miles). The Continuous Distance Model therefore provides an important robustness test to the Base Model results.

5.2.1. Dataset and Model Form

A number of different functional forms can be used for a continuous DISTANCE variable, including linear, inverse, cubic, quadratic, and logarithmic. Of the forms that are considered, an inverse function seemed most appropriate.[71] Inverse functions are used when it is assumed that any effect is most pronounced near the disamenity and that those effects fade asymptotically as distance increases. This form has been used previously in the literature (e.g., Leonard et al., 2008) to explore the impact of disamenities on home values, and is calculated as follows:

$$\mathrm{InvDISTANCE} = 1/\mathrm{DISTANCE} \tag{4}$$

where
DISTANCE is the distances to the nearest turbine from each home as calculated at the time of sale for homes that sold in the post-construction period.

For the purpose of the Continuous Distance Model, the same dataset is used as in the Base Model, focusing again on post-construction transactions (*n* = 4,937). InvDISTANCE has a maximum of 6.67 (corresponding to homes that were 0.15 miles, or roughly 800 feet, from the nearest wind turbine), a minimum of 0.09 (corresponding to a distance of roughly 11 miles), and a mean of 0.38 (corresponding to a distance of 2.6 miles). This function was then introduced into the hedonic model in place of the DISTANCE categorical variables as follows:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_s \beta_2\mathrm{S} + \sum_k \beta_3\mathrm{X} + \sum_v \beta_4\mathrm{VIEW} + \beta_5\mathrm{InvDISTANCE} + \varepsilon \tag{5}$$

where
$\mathrm{InvDISTANCE}_i$ is the inverse of the distance to the nearest turbine,
β_5 is a parameter estimate for the inverse of the distance to the nearest turbine, and

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[71] The other distance functions (e.g., linear, quadratic, cubic & logarithmic) were also tested. Additionally, two-part functions with interactions between continuous forms (e.g., linear) and categorical (e.g., less than one mile) were investigated. Results from these models are briefly discussed below in footnote 72.

all other components are as defined in equation (1).

The coefficient of interest in this model is β_5, which, if effects exist, would be expected to be negative, indicating an adverse effect from proximity to the wind turbines.

5.2.2. Analysis of Results

Results for the variables of interest in the Continuous Distance Model and the Base Model are shown in Table 13. (For brevity, the full set of results for the model is not shown in Table 13, but is instead included in Appendix H.) The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at the one percent level. The coefficients for VIEW are similar to those found in the Base Model, demonstrating stability in results, and none are statistically significant. These results support the previous findings of a lack of evidence of a Scenic Vista Stigma.

Our focus variable InvDISTANCE produces a coefficient (β_5) that is slightly negative at -1%, but that is not statistically different from zero (*p* value 0.41), implying again that there is no statistical evidence of a Nuisance Stigma effect nor an Area Stigma effect and confirming the results obtained in the Base Model.[72]

Table 13: Results from Continuous Distance Model

	Base Model				**Continuous Distance**			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4,207	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.39	561	-0.01	0.01	0.32	561
Moderate View	0.02	0.03	0.57	106	0.01	0.03	0.77	106
Substantial View	-0.01	0.07	0.92	35	-0.02	0.07	0.64	35
Extreme View	0.02	0.09	0.77	28	0.01	0.10	0.85	28
Inside 3000 Feet	-0.05	0.06	0.31	67				
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58				
Between 1 and 3 Miles	0.00	0.02	0.80	2,019				
Between 3 and 5 Miles	0.02	0.01	0.26	1,923				
Outside 5 Miles	Omitted	Omitted	Omitted	870				
InvDISTANCE					-0.01	0.02	0.41	4,937

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

Model Equation Number	**1**	**5**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**34**
F Statistic	**442.8**	**481.3**
Adjusted R Squared	**0.77**	**0.77**

5.3. All Sales Model

The Base Model presented earlier relied on only those transactions that occurred after the construction of the relevant wind facility. This approach, however, leaves open two key questions. First, it is possible that the property values of all of the post-construction homes in the

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[72] As mentioned in footnote 71 on page 36, a number of alternative forms of the continuous distance function were also explored, including two-part functions, with no change in the results presented here. In all cases the resulting continuous distance function was not statistically significant.

sample have been affected by the presence of a wind facility, and therefore that the reference homes in the Base Model (i.e., those homes outside of five miles with no view of a wind turbine) are an inappropriate comparison group because they too have been impacted.[73] Using only those homes that sold before the announcement of the wind facility (pre-announcement) as the reference group would, arguably, make for a better comparison because the sales price of those homes are not plausibly impacted by the presence of the wind facility.[74] Second, the Base Model does not consider homes that sold in the post-announcement but pre-construction period, and previous research suggests that property value effects might be very strong during this period, during which an assessment of actual impacts is not possible and buyers and sellers may take a more-protective and conservative stance (Wolsink, 1989). This subsection therefore presents the results of a hedonic model that uses the full set of transactions in the dataset, pre- and post-construction.

5.3.1. Dataset and Model Form

Unlike the Base Model, in this instance the full set of 7,459 residential transactions is included. The following model is then estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1\mathrm{N} + \sum_s \beta_2\mathrm{S} + \sum_k \beta_3\mathrm{X} + \sum_v \beta_4\mathrm{VIEW} + \sum_d \beta_5\mathrm{DISTANCE} + \varepsilon \qquad (6)$$

where
VIEW is a vector of *v* categorical view variables (e.g., NONE, MINOR, MODERATE, etc.),
DISTANCE is a vector of *d* categorical distance variables (e.g., less than 3000 feet, between one and three miles, outside of five mile, etc.),
β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to pre-construction transactions,
β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to pre-announcement transactions, and
all other components are as defined in equation (1).

It is important to emphasize that the VIEW and DISTANCE parameters in equation (6) have different reference categories than they do in the Base Model - equation (1). In the Base Model, DISTANCE and VIEW are estimated in the post-construction period in reference to homes that sold outside of five miles and with no view of the turbines respectively.[75] In the All Sales Model, on the other hand, the coefficients for VIEW (β_4) are estimated in reference to all pre-construction transactions (spanning the pre-announcement and post-announcement-pre-construction periods) and the coefficients for DISTANCE (β_5) are estimated in reference to all pre-announcement transactions. In making a distinction between the reference categories for VIEW and DISTANCE, it is assumed that awareness of the view of turbines and awareness of

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[73] This might be the case if there is an Area Stigma that includes the reference homes.

[74] As discussed in footnote 47 on page 19, it is conceivable that awareness might occur prior to the "announcement" date used for this analysis. If true, this bias is likely to be sporadic in nature and less of an issue in this model, when all pre-announcement transactions are pooled (e.g., both transactions near and far away from where the turbines were eventually located) than in models presented later (e.g., temporal aspects model). Nonetheless, if present, this bias may weakly draw down the pre-announcement reference category.

[75] See Section 4.1 and also footnote 51 on page 24 for more information on why the post-construction dataset and five-mile-no-view homes reference category are used in the Base Model.

the distance from them might not occur at the same point in the development process. Specifically, it is assumed that VIEW effects largely occur after the turbines are erected, in the post-construction period, but that DISTANCE effects might occur in the post-announcement-pre-construction timeframe. For example, after a wind facility is announced, it is not atypical for a map of the expected locations of the turbines to be circulated in the community, allowing home buyers and sellers to assess the distance of the planned facility from homes. Because of this assumed difference in when awareness begins for VIEW and DISTANCE, the DISTANCE variable is populated for transactions occurring in the post-announcement-pre-construction period as well as the post-construction period (see Table 14 below), but the VIEW variable is populated only for transactions in the post-construction period – as they were in the Base Model.[76]

Table 14: Frequency Summary for DISTANCE in All Sales Model

	< 0.57 Miles	**0.57 - 1 Miles**	**1 - 3 Miles**	**3 - 5 Miles**	**> 5 Miles**	**Total**
Post-Construction	67	58	2019	1923	870	**4937**
Post-Announcement-Pre-Construction	13	7	340	277	130	**767**
TOTAL	**80**	**65**	**2359**	**2200**	**1000**	**5704**

One beneficial consequence of the differences in reference categories for the VIEW and DISTANCE variables in this model, as opposed to the Base Model, is that this model can accommodate all of the possible VIEW and DISTANCE categories, including NO VIEW transactions and transactions of homes outside of five miles. Because of the inclusion of these VIEW and DISTANCE categories, the tests to investigate Area, Scenic Vista, and Nuisance Stigmas are slightly different in this model than in the Base Model. For Area Stigma, for example, how homes with no view of the turbines fared can now be tested; if they are adversely affected by the presence of the wind facility, then this would imply a pervasive Area Stigma impact. For Scenic Vista Stigma, the VIEW coefficients (MINOR, MODERATE, etc.) can be compared (using a *t*-Test) to the NO VIEW results; if they are significantly different, a Scenic Vista Stigma would be an obvious culprit. Finally, for Nuisance Stigma, the DISTANCE coefficients inside of one mile can be compared (using a *t*-Test) to those outside of five miles; if there is a significant difference between these two categories of homes, then homes are likely affected by their proximity to the wind facility.

5.3.2. Analysis of Results

Results for the variables of interest for this hedonic model are summarized in Table 15, and Base Model results are shown for comparison purposes. (For brevity, the full set of results for the model is not shown in Table 15, but is instead included in Appendix H.) The adjusted R^2 for the model is 0.75, down slightly from 0.77 for the Base Model, and indicating that this model has slightly more difficulty (i.e. less explanatory power) modeling transactions that occurred pre-

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[76] It is conceivable that VIEW effects could occur before the turbines are constructed. In some cases, for example, developers will simulate what the project will look like after construction during the post-announcement but pre-construction timeframe. In these situations, home buyers and sellers might adjust home values accordingly based on the expected views of turbines. It is assumed, however, that such adjustments are likely to be reasonably rare, and VIEW effects are therefore estimated using only post-construction sales.

construction.[77] All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level and are similar in sign and magnitude to the estimates derived from the post-construction Base Model.

The VIEW coefficients (β_4) are clearly affected by the change in reference category. All of the VIEW parameter estimates are higher than the Base Model estimates for the same categories. Of particular interest is the NO VIEW coefficient, which represents the values of homes without a view of the turbines and that sold in the post-construction period, as compared to the mean value of homes that sold in the pre-construction period, all else being equal. These homes, on average, are estimated to sell for 2% (*p* value 0.08) more than similar pre-construction homes. If an Area Stigma existed, a negative coefficient for these NO VIEW homes would be expected. Instead, a positive and statistically significant coefficient is found.[78] It is outside the ability of this study to determine whether the increase is directly related to the wind turbines, or whether some other factor is impacting these results, but in either instance, no evidence of a pervasive Area Stigma associated with the presence of the wind facilities is found.

To test for the possibility of Scenic Vista Stigma, the coefficients for MINOR, MODERATE, SUBSTANTIAL, and EXTREME views can be compared to the NO VIEW coefficient using a simple *t*-Test. Table 16 presents these results. As shown, no significant difference is found for any of the VIEW coefficients when compared to NO VIEW transactions. This reinforces the findings earlier that, within the sample at least, there is no evidence of a Scenic Vista Stigma.

The DISTANCE parameter estimates (β_5) are also found to be affected by the change in reference category, and all are lower than the Base Model estimates for the same categories. This result likely indicates that the inflation-adjusted mean value of homes in the pre-announcement period is slightly higher, on average, than for those homes sold outside of five miles in the post-construction period. This difference could be attributed to the inaccuracy of the inflation index, a pervasive effect from the wind turbines, or to some other cause. Because the coefficients are not systematically statistically significant, however, this result is not pursued further. What is of interest, however, is the negative 8% estimate for homes located between 3000 feet and one mile of the nearest wind turbine (*p* value 0.03). To correctly interpret this result, and to compare it to the Base Model, one needs to discern if this coefficient is significantly different from the estimate for homes located outside of five miles, using a *t*-Test.

The results of this *t*-Test are shown in Table 17. The coefficient differences are found to be somewhat monotonically ordered. Moving from homes within 3000 feet (-0.06, *p* value 0.22), and between 3000 feet and one mile (-0.08, *p* value 0.04), to between one and three miles (0.00, *p* value 0.93) and between three and five miles (0.01, *p* value 0.32) the DISTANCE coefficients are found to generally increase. Nonetheless, none of these coefficients are statistically significant except one, homes that sold between 3000 feet and one mile. The latter finding suggests the possibility of Nuisance Stigma. It is somewhat unclear why an effect would be found in this model, however, when one was not evident in the Base Model. The most likely

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[77] This slight change in performance is likely due to the inaccuracies of home and site characteristics and the inflation adjustment for homes that sold in the early part of the study period. This is discussed in more detail in footnote 50 on page 23.

[78] For more on the significance level used for this report, see footnote 68 on page 30.

explanation is that the additional homes that are included in this model, specifically those homes that sold post-announcement but pre-construction, are driving the results. A thorough investigation of these "temporal" issues is provided in the next subsection.

In summation, no evidence is found of an Area or Scenic Vista Stigma in this alternative hedonic model, but some limited not-conclusive evidence of a Nuisance Stigma is detected. To further explore the reliability of this latter result, the analysis now turns to the Temporal Aspects Model.

Table 15: Results from All Sales Model

	Base Model				All Sales			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
Pre-Construction Sales	n/a	n/a	n/a	n/a	Omitted	Omitted	Omitted	2,522
No View	Omitted	Omitted	Omitted	4,207	0.02	0.01	0.08	4,207
Minor View	-0.01	0.01	0.39	561	0.00	0.02	0.77	561
Moderate View	0.02	0.03	0.57	106	0.03	0.03	0.41	106
Substantial View	-0.01	0.07	0.92	35	0.03	0.07	0.53	35
Extreme View	0.02	0.09	0.77	28	0.06	0.08	0.38	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.06	0.05	0.18	80
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.08	0.05	0.03	65
Between 1 and 3 Miles	0.00	0.02	0.80	2,019	0.00	0.01	0.80	2,359
Between 3 and 5 Miles	0.02	0.01	0.26	1,923	0.01	0.01	0.59	2,200
Outside 5 Miles	Omitted	Omitted	Omitted	870	0.00	0.02	0.78	1,000
Pre-Announcement Sales	n/a	n/a	n/a	n/a	Omitted	Omitted	Omitted	1,755

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

Model Equation Number	**1**	**6**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**7459**
Number of Predictors (k)	**37**	**39**
F Statistic	**442.8**	**579.9**
Adjusted R Squared	**0.77**	**0.75**

Table 16: Results from Equality Test of VIEW Coefficients in the All Sales Model

	No View	**Minor View**	**Moderate View**	**Substantial View**	**Extreme View**
n	4,207	561	106	35	28
Coefficient	0.02	0.00	0.03	0.03	0.06
Coefficient Difference *	Reference	-0.02	0.00	0.01	0.04
Variance	0.0001	0.0003	0.0009	0.0030	0.0050
Covariance	n/a	0.00011	0.00010	0.00009	0.00008
Df	n/a	7419	7419	7419	7419
***t*-Test**	n/a	-1.20	0.17	0.23	0.58
Significance	n/a	0.23	0.87	0.82	0.57

** Differences are rounded to the nearest second decimal place.*
"n" = number of cases in category when category = "1"

Table 17: Results from Equality Test of DISTANCE Coefficients in the All Sales Model

	Inside 3000 Feet	**Between 3000 Feet and 1 Mile**	**Between 1 and 3 Miles**	**Between 3 and 5 Miles**	**Outside 5 Miles**
n	80	65	2,359	2,200	1,000
Coefficient	-0.06	-0.08	0.00	0.01	0.00
Coefficient Difference *	-0.05	-0.08	0.00	0.01	Reference
Variance	0.0019	0.0015	0.0002	0.0002	0.0003
Covariance	0.00010	0.00013	0.00013	0.00015	n/a
Df	7419	7419	7419	7419	n/a
***t* Test**	-1.23	-2.06	0.09	1.00	n/a
Significance	0.22	0.04	0.93	0.32	n/a

** Differences are rounded to the nearest second decimal place.*
"n" = number of cases in category when category = "1"

5.4. Temporal Aspects Model

Based on the results of the All Sales Model, a more thorough investigation of how Nuisance and Area Stigma effects might change throughout the wind project development period is warranted. As discussed previously, there is some evidence that property value impacts may be particularly strong after the announcement of a disamenity, but then may fade with time as the community adjusts to the presence of that disamenity (e.g., Wolsink, 1989). The Temporal Aspects Model presented here allows for an investigation of how the different periods of the wind project development process affect estimates for the impact of DISTANCE on sales prices.

5.4.1. Dataset and Model Form

Here the full set of 7,459 residential transactions is used, allowing an exploration of potential property value impacts (focusing on the DISTANCE variable) throughout time, including in the pre-construction period. The following model is then estimated:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_{s} \beta_2 \mathrm{S} + \sum_{k} \beta_3 \mathrm{X} + \sum_{v} \beta_4 \mathrm{VIEW} + \sum_{y} \beta_5 (\mathrm{DISTANCE} \cdot \mathrm{PERIOD}) + \varepsilon \qquad (7)$$

where
DISTANCE is a vector of categorical distance variables (e.g., less than one mile, between one and three miles, etc.),
PERIOD is a vector of categorical development period variables (e.g., after announcement and before construction, etc.),
β_5 is a vector of *y* parameter estimates for each DISTANCE and PERIOD category as compared to the transactions more than two years before announcement and outside of five miles, and
all other components are as defined in equation (1).

The PERIOD variable contains six different options:
1) More than two years before announcement;
2) Less than two years before announcement;
3) After announcement but before construction;
4) Less than two years after construction;
5) Between two and four years after construction; and

6) More than four years after construction.

In contrast to the Base Model, the two DISTANCE categories inside of one mile are collapsed into a single "less than one mile" group. This approach increases the number of transactions in each crossed subcategory of data, and therefore enhances the stability of the parameter estimates and decreases the size of the standard errors, thus providing an increased opportunity to discover statistically significant effects. Therefore, in this model the DISTANCE variable contains four different options:

1) Less than one mile;
2) Between one and three miles;
3) Between three and five miles; and
4) Outside of five miles.[79]

The number of transactions in each of the DISTANCE and PERIOD categories is presented in Table 18.

The coefficients of interest are β_5, which represent the vector of marginal differences between homes sold at various distances from the wind facility (DISTANCE) during various periods of the development process (PERIOD) as compared to the reference group. The reference group in this model consists of transactions that occurred more than two years before the facility was announced for homes that were situated more than five miles from where the turbines were ultimately constructed. It is assumed that the value of these homes would not be affected by the future presence of the wind facility. The VIEW parameters, although included in the model, are not interacted with PERIOD and therefore are treated as controlling variables.[80]

Although the comparisons of these categorical variables <u>between</u> different DISTANCE and PERIOD categories is be interesting, it is the comparison of coefficients <u>within</u> each PERIOD and DISTANCE category that is the focus of this section. Such comparisons, for example, allow one to compare how the average value of homes inside of one mile that sold two years before announcement compare to the average value of homes inside of one mile that sold in the post-announcement-pre-construction period. For this comparison, a *t*-Test similar to that in the All Sales Model is used.

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[79] For homes that sold in the pre-construction time frame, no turbines yet existed, and therefore DISTANCE is created using a proxy: the Euclidian distance to where the turbines were eventually constructed. This approach introduces some bias when there is more than one facility in the study area. Conceivably, a home that sold in the post-announcement-pre-construction period of one wind facility could also be assigned to the pre-announcement period of another facility in the same area. For this type of sale, it is not entirely clear which PERIOD and DISTANCE is most appropriate, but every effort was made to apply the sale to the wind facility that was most likely to have an impact. In most cases this meant choosing the closest facility, but in some cases, when development periods were separated by many years, simply the earliest facility was chosen. In general, any bias created by these judgments is expected to be minimal because, in the large majority of cases, the development process in each study area was more-or-less continuous and focused in a specific area rather then being spread widely apart.

[80] As discussed earlier, the VIEW variable was considered most relevant for the post-construction period, so delineations based on development periods that extended into the pre-construction phase were unnecessary. It is conceivable, however, that VIEW effects vary in periods following construction, such as in the first two years or after that. Although this is an interesting question, the numbers of cases for the SUBSTANTIAL and EXTREME ratings – even if combined – when divided into the temporal periods were too small to be fruitful for analysis.

Table 18: Frequency Crosstab of DISTANCE and PERIOD

	More Than 2 Years Before Announcement	Less Than 2 Years Before Announcement	After Announcement Before Construction	Less Than 2 Years After Construction	Between 2 and 4 Years After Construction	More Than 4 Years After Construction	Total
Less Than 1 Mile	38	40	20	39	45	43	**225**
Between 1 and 3 Miles	283	592	340	806	502	709	**3,232**
Between 3 and 5 Miles	157	380	277	572	594	757	**2,737**
Outside of 5 Miles	132	133	130	218	227	425	**1,265**
TOTAL	**610**	**1,145**	**767**	**1,635**	**1,368**	**1,934**	**7,459**

5.4.2. Analysis of Results

Results for the variables of interest for this hedonic model are presented in Table 19; as with previous models, the full set of results is contained in Appendix H. Similar to the All Sales Model discussed in the previous section, the adjusted R^2 for the model is 0.75, down slightly from 0.77 for the Base Model, and indicating that this model has slightly more difficulty (i.e., less explanatory power) modeling transactions that occurred before wind facility construction. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model.

All of the DISTANCE / PERIOD interaction coefficients for distances outside of one mile are relatively small ($-0.04 < \beta_5 < 0.02$) and none are statistically significant. This implies that there are no statistically significant differences in property values between the reference category homes – homes sold more than two years before announcement that were situated outside of five miles from where turbines were eventually erected – and any of the categories of homes that sold outside of one mile at any other period in the wind project development process. These comparisons demonstrate, arguably more directly than any other model presented in this report that Area Stigma effects likely do not exist in the sample.

The possible presence of a Nuisance Stigma is somewhat harder to discern. For homes that sold inside of one mile of the nearest wind turbine, in three of the six periods there are statistically significant negative differences between average property values when compared to the reference category. Transactions completed more than two years before facility announcement are estimated to be valued at 13% less (*p* value 0.02) than the reference category, transactions less than two years before announcement are 10% lower (*p* value 0.06), and transactions after announcement but before construction are 14% lower (*p* value 0.04). For other periods, however, these marginal differences are considerably smaller and are not statistically different from the reference category. Sales prices in the first two years after construction are, on average, 9% less (*p* value 0.15), those occurring between three and four years following construction are, on average, 1% less (*p* value 0.86), and those occurring more than four years after construction are, on average, 7% less (*p* value 0.37).

Table 19: Results from Temporal Aspects Model

		Temporal Aspects			
Variables of Interest		**Coef**	**SE**	**p Value**	***n***
Inside 1 Mile	**More Than 2 Years Before Announcement**	-0.13	0.06	0.02	38
	Less Than 2 Years Before Announcement	-0.10	0.05	0.06	40
	After Announcement Before Construction	-0.14	0.06	0.04	21
	2 Years After Construction	-0.09	0.07	0.11	39
	Between 2 and 4 Years After Construction	-0.01	0.06	0.85	44
	More Than 4 Years After Construction	-0.07	0.08	0.22	42
Between 1-3 Miles	**More Than 2 Years Before Announcement**	-0.04	0.03	0.18	283
	Less Than 2 Years Before Announcement	0.00	0.03	0.91	592
	After Announcement Before Construction	-0.02	0.03	0.54	342
	2 Years After Construction	0.00	0.03	0.90	807
	Between 2 and 4 Years After Construction	0.01	0.03	0.78	503
	More Than 4 Years After Construction	0.00	0.03	0.93	710
Between 3-5 Miles	**More Than 2 Years Before Announcement**	0.00	0.04	0.92	157
	Less Than 2 Years Before Announcement	0.00	0.03	0.97	380
	After Announcement Before Construction	0.00	0.03	0.93	299
	2 Years After Construction	0.02	0.03	0.55	574
	Between 2 and 4 Years After Construction	0.01	0.03	0.65	594
	More Than 4 Years After Construction	0.01	0.03	0.67	758
Outside 5 Miles	**More Than 2 Years Before Announcement**	Omitted	Omitted	Omitted	132
	Less Than 2 Years Before Announcement	-0.03	0.04	0.33	133
	After Announcement Before Construction	-0.03	0.03	0.39	105
	2 Years After Construction	-0.03	0.03	0.44	215
	Between 2 and 4 Years After Construction	0.03	0.03	0.44	227
	More Than 4 Years After Construction	0.01	0.03	0.73	424

"Omitted" = reference category for fixed effects variables.
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**7**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**7459**
Number of Predictors (k)	**56**
F Statistic	**404.5**
Adjusted R Squared	**0.75**

What these results suggest (as shown in Figure 8) is that homes inside of one mile in the sample, on average, were depressed in value (in relation to the reference category) before and after the announcement of the wind facility and up to the point that construction began, but that those values rebounded somewhat after construction commenced.[81] This conclusion also likely explains why a significant and negative effect for homes that sold between 3000 feet and one mile is found in the All Sales Model presented in Section 5.3: homes within this distance range that sold prior to facility construction were depressed in value and most likely drove the results for homes that sold after announcement. Regardless, these results are not suggestive of a pervasive Nuisance Stigma.

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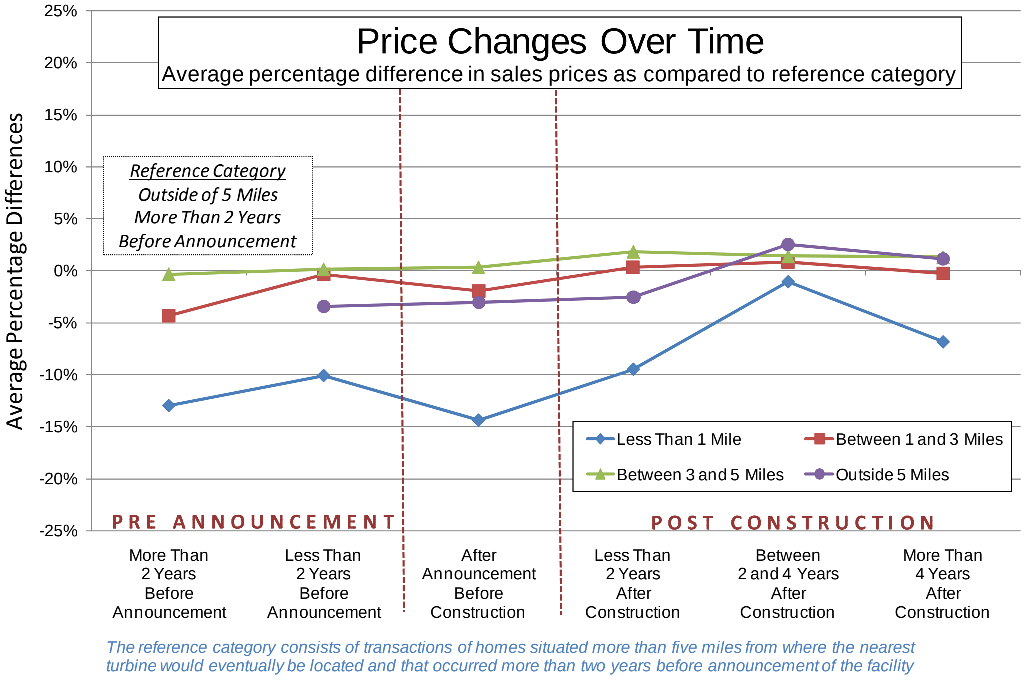
[81] As discussed in footnotes 47 (on page 19) and 74 (on page 38), the "announcement date" often refers to the first time the proposed facility appeared in the press. "Awareness" of the project in the community may precede this date, however, and therefore transactions occurring in the period "less than two years before announcement" could conceivably have been influenced by the prospective wind project, but it is considerably less likely that those in the period more than two years before announcement would have been influenced.

Figure 8: Results from the Temporal Aspects Model



To explore Nuisance Stigma further, the analysis again turns to the *t*-Test and compares the coefficients for transactions that occurred more than two years before wind facility announcement (during which time the future wind facility is not expected to have any impact on sales prices) to the estimates for the DISTANCE coefficients in the periods that follow. These results are shown in Table 20. Focusing on those transactions inside of one mile, it is found that all coefficients are greater in magnitude than the reference category except during the post-announcement-pre-construction period (which is 1% less and is not statistically significant; *p* value 0.90), indicating, on average, that home values are increasing or staying stable from the pre-announcement reference period onward. These increases, however, are not statistically significant except in the period of two to four years after construction (0.12, *p* value 0.08). With respect to Nuisance Stigma, the more important result is that, relative to homes that sold well before the wind facility was announced, no statistically significant adverse effect is found in any period within a one mile radius of the wind facility. Therefore, the -5% (albeit not statistically significant) average difference that is found in the Base Model, and the -8% (statistically significant) result that is found in the All Sales Model (for homes between 3000 feet and one mile) appear to both be a reflection of depressed home prices that preceded the construction of the relevant wind facilities. If construction of the wind facilities were downwardly influencing the sales prices of these homes, as might be deduced from the Base or All Sales Models alone, a diminution in the inflation adjusted price would be seen as compared to pre-announcement levels. Instead, an increase is seen. As such, no persuasive evidence of a Nuisance Stigma is evident among this sample of transactions.[82]

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[82] It should be noted that the numbers of study areas represented for homes situated inside of one mile but in the periods "more than two years before announcement" and "more than four years after construction" are fewer (*n* = 5) than in the other temporal categories (*n* = 8). Further, the "more than two years before announcement – inside of one mile" category is dominated by transactions from one study area (OKCC). For these reasons, there is less

Turning to the coefficient differences for distances greater than one mile in Table 20, again, no statistical evidence of significant adverse impacts on home values is uncovered. Where statistically significant differences are identified, the coefficients are greater than the reference category. These findings corroborate the earlier Area Stigma results, and re-affirm the lack of evidence for such an effect among the sample of residential transactions included in this analysis.

Table 20: Results from Equality Test of Temporal Aspects Model Coefficients

	More Than 2 Years Before Announcement	Less Than 2 Years Before Announcement	After Announcement Before Construction	Less Than 2 Years After Construction	Between 2 and 4 Years After Construction	More Than 4 Years After Construction
Less Than 1 Mile	Reference	0.03 (0.45)	-0.01 (-0.13)	0.04 (0.56)	0.12 (1.74)*	0.06 (0.88)
Between 1 and 3 Miles	Reference	0.04 (1.92)*	0.02 (0.86)	0.05 (2.47)**	0.05 (2.27)**	0.04 (1.82)*
Between 3 and 5 Miles	Reference	0.01 (0.37)	0.01 (0.34)	0.02 (0.77)	0.02 (0.78)	0.02 (0.79)
Outside of 5 Miles †	Reference	-0.04 (-0.86)	-0.03 (-0.91)	-0.03 (-0.77)	0.03 (0.81)	0.01 (0.36)

*Numbers in parenthesis are t-Test statistics. Significance = *** 1% level, ** 5% level, * 10% level, <blank> below the 10% level.*

† For homes outside of 5 miles, the coefficient differences are equal to the coefficients in the Temporal Aspects Model, and therefore the t-values were produced via the OLS.

5.5. Orientation Model

All of the hedonic models presented to this point use a VIEW variable that effectively assumes that the impact of a view of wind turbines on property values will not vary based on the orientation of the home to that view; the impact will be the same whether the view is seen from the side of the home or from the back or front. Other literature, however, has found that the impact of wind projects on property values may be orientation-dependent (Sims et al., 2008). To investigate this possibility further a parameter for orientation is included in the model.

5.5.1. Dataset and Model Form

The same dataset is used as in the Base Model, focusing on post-construction transactions (*n* = 4,937). To investigate whether the orientation of a home to the turbines (ORIENTATION) has a marginal impact on residential property values, over and above that of the VIEW impacts alone, the following hedonic model is estimated:[83]

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confidence in these two estimates (-13% and -7% respectively) than for the estimates for other temporal periods inside of one mile. Based on additional sensitivity analysis not included here, it is believed that if they are biased, both of these estimates are likely biased downward. Further, as discussed in footnote 47 on page 19, there is a potential for bias in the "announcement" date in that awareness of a project may precede the date that a project enters the public record (i.e., the "announcement" date used for this analysis). Taken together, these two issues might imply that the curve shown in Figure 8 for "less than one mile" transactions, instead of having a flat and then increasing shape, may have a more of an inverse parabolic (e.g., "U") shape. This would imply that a relative minimum in sales prices is reached in the period after awareness began of the facility but before construction commenced, and then, following construction, prices recovered to levels similar to those prior to announcement (and awareness). These results would be consistent with previous studies (e.g., Wolsink, 1989; Devine-Wright, 2004) but cannot be confirmed without the presence of more data. Further research on this issue is warranted. In either case, such results would not change the conclusion here of an absence of evidence of a pervasive Nuisance Stigma in the post-construction period.

[83] The various possible orientations of the home to the view of turbines will be, individually and collectively, referred to as "ORIENTATION" in this report.

$$\ln\left(\mathrm{P}\right)=\beta_0+\beta_1\mathrm{N}+\sum_{\mathrm{s}}\beta_2\mathrm{S}+\sum_{\mathrm{k}}\beta_3\mathrm{X}+\sum_{\mathrm{v}}\beta_4\mathrm{VIEW}+\sum_{\mathrm{d}}\beta_5\mathrm{DISTANCE}$$
$$+\sum_{\mathrm{o}}\beta_6\mathrm{ORIENTATION}+\varepsilon \qquad (8)$$

where
ORIENTATION is a vector of *o* ORIENTATION variables (e.g., SIDE, FRONT, and BACK),
β_6 is a vector of *o* parameter estimates for ORIENTATION variables, and
all other components are as defined in equation (1).[84]

The ORIENTATION categories include FRONT, BACK, and SIDE, and are defined as follows:

- SIDE: The orientation of the home to the view of the turbines is from the side.
- FRONT: The orientation of the home to the view of the turbines is from the front.
- BACK: The orientation of the home to the view of the turbines is from the back.

The orientation of the home to the view of the wind facilities was determined in the course of the field visits to each home. If more than one orientation to the turbines best described the home (e.g., back and side, or front, back, and side) they were coded as such (e.g., turbines visible from back and side: SIDE = 1; BACK = 1; FRONT = 0).[85]

Not surprisingly, ORIENTATION is related to VIEW. Table 21 and Table 22 provide frequency and percentage crosstabs of ORIENTATION and VIEW. As shown, those homes with more dramatic views of the turbines generally have more ORIENTATION ratings applied to them. For instance, 25 out of 28 EXTREME VIEW homes have all three ORIENTATION ratings (i.e., FRONT, BACK, and SIDE). Virtually all of the MINOR VIEW homes, on the other hand, have only one ORIENTATION. Further, MINOR VIEW homes have roughly evenly spread orientations to the turbines across the various possible categories of FRONT, BACK, and SIDE. Conversely, a majority of the MODERATE and SUBSTANTIAL VIEW ratings coincide with an ORIENTATION from the back of the house.[86]

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[84] Ideally, one would enter ORIENTATION in the model through an interaction with VIEW. There are two ways that could be accomplished: either with the construction of multiple fixed effects ("dummy") variables, which capture each sub-category of VIEW and ORIENTATION, or through a semi-continuous interaction variable, which would be created by multiplying the ordered categorical variable VIEW by an ordered categorical variable ORIENTATION. Both interaction scenarios are problematic, the former because it requires increasingly small subsets of data, which create unstable coefficient estimates, and the latter because there are no *a priori* expectations for the ordering of an ordered categorical ORIENTATION variable and therefore none could be created and used for the interaction. As a result, no interaction between the two variables is reported here.

[85] An "Angle" orientation was also possible, which was defined as being between Front and Side or Back and Side. An Angle orientation was also possible in combination with Back or Front (e.g., Back-Angle or Front-Angle). In this latter case, the orientation was coded as one of the two prominent orientations (e.g., Back or Front). An Angle orientation, not in combination with Front or Back, was coded as Side.

[86] The prevalence of BACK orientations for MODERATE and SUBSTANTIAL VIEW homes may be because BACK views might more-frequently be kept without obstruction, relative to SIDE views.

Table 21: Frequency Crosstab of VIEW and ORIENTATION

		VIEW				
		Minor	**Moderate**	**Substantial**	**Extreme**	**Total**
ORIENTATION	**Front**	217	33	17	27	**294**
	Back	164	67	24	25	**280**
	Side	194	17	15	27	**253**
	Total	**561**	**106**	**35**	**28**	**730**

Note: Total of ORIENTATION does not sum to 730 because multiple orientations are possible for each VIEW.

Table 22: Percentage Crosstab of VIEW and ORIENTATION

		VIEW				
		Minor	**Moderate**	**Substantial**	**Extreme**	**Total**
ORIENTATION	**Front**	39%	31%	49%	96%	**40%**
	Back	29%	63%	69%	89%	**38%**
	Side	35%	16%	43%	96%	**35%**

Note: Percentages are calculated as a portion of the total for each VIEW ratings (e.g., 24 of the 35 SUBSTANTIAL rated homes have a BACK ORIENTATION = 69%). Columns do not sum to 100% because multiple orientations are possible for each VIEW.

The parameter estimates of interest in this hedonic model are those for ORIENTATION (β_6) and VIEW (β_4). β_6 represent the marginal impact on home value, over and above that of VIEW alone, of having a particular orientation to the turbines. In the Base Model the VIEW coefficients effectively absorb the effects of ORIENTATION, but in this model they are estimated separately. Because a home's surrounding environment is typically viewed from the front or back of the house, one would expect that, to the extent that wind facility VIEW impacts property values, that impact would be especially severe for homes that have FRONT or BACK orientations to those turbines. If this were the case, the coefficients for these categories would be negative, while the coefficient for SIDE would be to be close to zero indicating little to no incremental impact from a SIDE ORIENTATION.

5.5.2. Analysis of Results

Results for the variables of interest for this hedonic model are shown in Table 23; as with previous models, the full set of results is contained in Appendix H. The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model. The coefficients for DISTANCE and VIEW are stable, in sign and magnitude, when compared to the Base Model results, and none of the marginal effects are statistically significant.

The coefficients for the variables of interest (β_6) do not meet the *a priori* expectations. The estimated effect for SIDE ORIENTATION, instead of being close to zero, is -3% (*p* value 0.36), while BACK and FRONT, instead of being negative and larger, are estimated at 3% (*p* value 0.37) and -1% (*p* value 0.72), respectively. None of these variables are found to be even marginally statistically significant, however, and based on these results, it is concluded that there is no evidence that a home's orientation to a wind facility affects property values in a measurable way. Further, as with previous models, no statistical evidence of a Scenic Vista Stigma is found among this sample of sales transactions.

Table 23: Results from Orientation Model

	Base Model				**Orientation Model**			
Variables of Interest	**Coef**	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4207	Omitted	Omitted	Omitted	4207
Minor View	-0.01	0.01	0.39	561	-0.01	0.06	0.88	561
Moderate View	0.02	0.03	0.57	106	0.00	0.06	0.96	106
Substantial View	-0.01	0.07	0.92	35	-0.01	0.09	0.85	35
Extreme View	0.02	0.09	0.77	28	0.02	0.17	0.84	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.04	0.07	0.46	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.05	0.05	0.26	58
Between 1 and 3 Miles	0.00	0.02	0.80	2019	0.00	0.02	0.83	2019
Between 3 and 5 Miles	0.02	0.01	0.26	1923	0.02	0.01	0.26	1923
Outside 5 Miles	Omitted	Omitted	Omitted	870	Omitted	Omitted	Omitted	870
Front Orientation					-0.01	0.06	0.72	294
Back Orientation					0.03	0.06	0.37	280
Side Orientation					-0.03	0.06	0.36	253

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

Model Equation Number	**1**	**8**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**40**
F Statistic	**442.8**	**410.0**
Adjusted R Squared	**0.77**	**0.77**

5.6. Overlap Model

The Orientation Model, presented above, investigated, to some degree, how the potential effects of wind turbines might be impacted by how a home is oriented to the surrounding environment. In so doing, this model began to peel back the relationship between VIEW and VISTA, but stopped short of looking at the relationship directly. It would be quite useful, though, to understand the explicit relationship between the VISTA and VIEW variables. In particular, one might expect that views of wind turbines would have a particularly significant impact on residential property values when those views strongly overlap ("OVERLAP") the prominent scenic vista from a home. To investigate this possibility directly, and, in general, the relationship between VIEW and VISTA, a parameter for OVERLAP is included in the model.

5.6.1. Dataset and Model Form

Data on the degree to which the view of wind turbines overlaps with the prominent scenic vista from the home (OVERLAP) were collected in the course of the field visits to each home.[87] The categories for OVERLAP included NONE, BARELY, SOMEWHAT, and STRONGLY, and are described in Table 24: [88]

Table 24: Definition of OVERLAP Categories

OVERLAP - NONE	The scenic vista does not contain any view of the turbines.
OVERLAP - BARELY	A small portion (~ 0 - 20%) of the scenic vista is overlapped by the view of turbines, and might contain a view of a few turbines, only a few of which can be seen entirely.
OVERLAP - SOMEWHAT	A moderate portion (~20-50%) of the scenic vista contains turbines, and likely contains a view of more than one turbine, some of which are likely to be seen entirely.
OVERLAP - STRONGLY	A large portion (~50-100%) of the scenic vista contains a view of turbines, many of which likely can be seen entirely.

A crosstab describing the OVERLAP designations and the VIEW categories is shown in Table 25. As would be expected, the more dramatic views of wind turbines, where the turbines occupy more of the panorama, are coincident with the OVERLAP categories of SOMEWHAT or STRONGLY. Nonetheless, STRONGLY are common for all VIEW categories. Similarly, SOMEWHAT is well distributed across the MINOR and MODERATE rated views, while BARELY is concentrated in the MINOR rated views.

The same dataset is used as in the Base Model, focusing on post-construction transactions (n = 4,937). To investigate whether the overlap of VIEW and VISTA has a marginal impact on residential property values, over and above that of the VIEW and VISTA impacts alone, the following hedonic model is estimated:[89]

$$\begin{aligned}\ln\left(\mathrm{P}\right) = \beta_0 + \beta_1\mathrm{N} + \sum_{s}\beta_2\mathrm{S} + \sum_{k}\beta_3\mathrm{X} + \sum_{v}\beta_4\mathrm{VIEW} + \sum_{d}\beta_5\mathrm{DISTANCE} + \sum_{t}\beta_6\mathrm{VISTA} \\ + \sum_{p}\beta_7\mathrm{OVERLAP} + \varepsilon\end{aligned} \tag{9}$$

where

VIEW is a vector of v categorical view variables (e.g., MINOR, MODERATE, etc.),
VISTA is a vector of t categorical scenic vista variables (e.g., POOR, BELOW-AVERAGE, etc.),
OVERLAP is a vector of p categorical overlap variables (e.g., BARELY, SOMEWHAT, etc.),

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[87] Scenic vista was rated while taking into account the entire panorama surrounding a home. But, for each home, there usually was a prominent direction that offered a preferred scenic vista. Often, but not always, the home was orientated to enjoy that prominent scenic vista. Overlap is defined as the degree to which the view of the wind facility overlaps with this prominent scenic vista.

[88] "…can be seen entirely" refers to being able to see a turbine from the top of the sweep of its blade tips to below the nacelle of the turbine where the sweep of the tips intersects the tower.

[89] Although VISTA appears in all models, and is usually included in the vector of home and site characteristics represented by X, it is shown separately here so that it can be discussed directly in the text that follows.

β_4 is a vector of *v* parameter estimates for VIEW fixed effects variables as compared to transactions of homes without a view of the turbines,
β_6 is a vector of *t* parameter estimates for VISTA fixed effect variables as compared to transactions of homes with an AVERAGE scenic vista,
β_7 is a vector of *o* parameter estimates for OVERLAP fixed effect variables as compared to transactions of homes where the view of the turbines had no overlap with the scenic vista, and all other components are as defined in equation (1).

The variables of interest in this model are VIEW, VISTA and OVERLAP, and the coefficients β_4, β_6, and β_7 are therefore the primary focus. Theory would predict that the VISTA coefficients in this model would be roughly similar to those derived in the Base Model, but that the VIEW coefficients may be somewhat more positive as the OVERLAP variables explain a portion of any negative impact that wind projects have on residential sales prices. In that instance, the OVERLAP coefficients would be negative, indicating a decrease in sales price when compared to those homes that experience no overlap between the view of wind turbines and the primary scenic vista.

Table 25: Frequency Crosstab of OVERLAP and VIEW

		VIEW					
		None	**Minor**	**Moderate**	**Substantial**	**Extreme**	**Total**
OVERLAP	**None**	4,207	317	3	0	0	**4,527**
	Barely	0	139	10	1	0	**150**
	Somewhat	0	81	42	7	2	**132**
	Strongly	0	24	51	27	26	**128**
	Total	**4,207**	**561**	**106**	**35**	**28**	**4,937**

5.6.2. Analysis of Results

Results for the variables of interest for this hedonic model are shown in Table 26; as with previous models, the full set of results is contained in Appendix H. The model performs well with an adjusted R^2 of 0.77. All study area, spatial adjustment, and home and site characteristics are significant at or above the one percent level, are of the appropriate sign, and are similar in magnitude to the estimates derived from the post-construction Base Model.

As expected from theory, the VISTA parameters are stable across models with no change in coefficient sign, magnitude, or significance. Counter to expectations, however, the VIEW coefficients, on average, decrease in value. MINOR VIEW is now estimated to adversely affect a home's sale price by 3% (*p* value 0.10) and is weakly significant, but none of the other VIEW categories are found to be statistically significant. Oddly, the OVERLAP rating of BARELY is found to significantly increase home values by 5% (*p* value 0.08), while none of the other OVERLAP ratings are found to have a statistically significant impact.

Taken at face value, these results are counterintuitive. For instance, absent any overlap of view with the scenic vista (NONE), a home with a MINOR view sells for 3% less than a home with no view of the turbines. If, alternatively, a home with a MINOR view BARELY overlaps the prominent scenic vista, it not only enjoys a 2% increase in value over a home with NO VIEW of the turbines but a 5% increase in value over homes with views of the turbines that do not overlap with the scenic vista. In other words, the sales price increases when views of turbines overlap the prominent scenic vista, at least in the BARELY category. A more likely explanation for these results are that the relatively high correlation (0.68) between the VIEW and OVERLAP parameters is spuriously driving one set of parameters up and the other down. More importantly, when the parameters are combined, they offer a similar result as was found in the Base Model. Therefore, it seems that the degree to which the view of turbines overlaps the scenic vista has a negligible effect on sales prices among the sample of sales transactions analyzed here.[90]

Despite these somewhat peculiar results, other than MINOR, none of the VIEW categories are found to have statistically significant impacts, even after accounting for the degree to which those views overlap the scenic vista. Similarly, none of the OVERLAP variables are simultaneously negative and statistically significant. This implies, once again, that a Scenic Vista Stigma is unlikely to be present in the sample. Additionally, none of the DISTANCE coefficients are statistically significant, and those coefficients remain largely unchanged from the Base Model, reaffirming previous results in which no significant evidence of either an Area or a Nuisance Stigma was found.

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[90] An alternative approach to this model was also considered, one that includes an interaction term between VIEW and VISTA. For this model it is assumed that homes with higher rated scenic vistas might have higher rated views of turbines, and that these views of turbines would decrease the values of the scenic vista. To construct the interaction, VISTA, which can be between one and five (e.g., POOR=1,…PREMIUM=5), was multiplied by VIEW, which can be between zero and four (e.g. NO VIEW=0, MINOR=1,…EXTREME=4). The resulting interaction (VIEW*VISTA) therefore was between zero and sixteen (there were no PREMIUM VISTA homes with an EXTREME VIEW), with zero representing homes without a view of the turbines, one representing homes with a POOR VISTA and a MINOR VIEW, and sixteen representing homes with either a PREMIUM VISTA and a SUBSTANTIAL VIEW or an ABOVE AVERAGE VISTA and an EXTREME VIEW. The interaction term, when included in the model, was relatively small (-0.013) and weakly significant (*p* value 0.10 – not White's corrected). The VISTA estimates were unchanged and the VIEW parameters were considerably larger and positive. For instance, EXTREME was 2% in the Base Model and 16% in this "interaction" model. Similarly, SUBSTANTIAL was -1% in the Base Model and 13% in this model. Therefore, although the interaction term is negative and weakly significant, the resulting VIEW estimates, to which it would need to be added, fully offset this negative effect. These results support the idea that the degree to which a VIEW overlaps VISTA has a likely negligible effect on sales prices, while also confirming that there is a high correlation between the interaction term and VIEW variables.

Table 26: Results from Overlap Model

Variables of Interest	Base Model				Overlap Model			
	Coef	**SE**	**p Value**	***n***	**Coef**	**SE**	**p Value**	***n***
No View	Omitted	Omitted	Omitted	4,207	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.39	561	-0.03	0.02	0.10	561
Moderate View	0.02	0.03	0.57	106	-0.02	0.04	0.65	106
Substantial View	-0.01	0.07	0.92	35	-0.05	0.09	0.43	35
Extreme View	0.02	0.09	0.77	28	-0.03	0.10	0.73	28
Inside 3000 Feet	-0.05	0.06	0.31	67	-0.05	0.06	0.32	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.20	58	-0.05	0.05	0.27	58
Between 1 and 3 Miles	0.00	0.02	0.80	2,019	0.00	0.02	0.82	2,019
Between 3 and 5 Miles	0.02	0.01	0.26	1,923	0.02	0.01	0.26	1,923
Outside 5 Miles	Omitted	Omitted	Omitted	870	Omitted	Omitted	Omitted	870
Poor Vista	-0.21	0.02	0.00	310	-0.21	0.02	0.00	310
Below Average Vista	-0.08	0.01	0.00	2,857	-0.08	0.01	0.00	2,857
Average Vista	Omitted	Omitted	Omitted	1,247	Omitted	Omitted	Omitted	1,247
Above Average Vista	0.10	0.02	0.00	448	0.10	0.02	0.00	448
Premium Vista	0.13	0.04	0.00	75	0.13	0.04	0.00	75
View Does Not Overlap Vista					Omitted	Omitted	Omitted	320
View Barely Overlaps Vista					0.05	0.03	0.08	150
View Somewhat Overlaps Vista					0.01	0.03	0.66	132
View Strongly Overlaps Vista					0.05	0.05	0.23	128

"Omitted" = reference category for fixed effects variables. "n" = number of cases in category when category = "1"

Model Information

Model Equation Number	**1**	**9**
Dependent Variable	**LN_SalePrice96**	**LN_SalePrice96**
Number of Cases	**4937**	**4937**
Number of Predictors (k)	**37**	**40**
F Statistic	**442.8**	**409.7**
Adjusted R Squared	**0.77**	**0.77**

6. Repeat Sales Analysis

In general, the Base and Alternative Hedonic Models presented in previous sections come to the same basic conclusion: wind power facilities in this sample have no demonstrable, widespread, sizable, and statistically significant affect on residential property values. These hedonic models contain 29 or more controlling variables (e.g., house and site characteristics) to account for differences in home values across the sample. Although these models perform well and explain nearly 80% of the variation in sales prices among homes in the sample, it is always possible that variables not included in (i.e., "omitted from") the hedonic models could be correlated with the variables of interest, therefore biasing the results.

A common method used to control for omitted variable bias in the home assessment literature is to estimate a repeat sales model (Palmquist, 1982). This technique focuses on just those homes that have sold on more than one occasion, preferably once before and once after the introduction of a possible disamenity, and investigates whether the price appreciation between these transactions is affected by the presence of that disamenity. In this section a repeat sales analysis is applied to the dataset, investigating in a different way the presence of the three possible property value stigmas associated with wind facilities, and therefore providing an important cross-check to the hedonic model results. The section begins with a brief discussion of the general form of the Repeat Sales Model and a summary of the literature that has employed this approach to investigate environmental disamenities. The dataset and model used in the analysis is then described, followed by a summary of the results from that analysis.

6.1. Repeat Sales Models and Environmental Disamenities Literature

Repeat sales models use the annual sales-price appreciation rates of homes as the dependent variable. Because house, home site, and neighborhood characteristics are relatively stable over time for any individual home, many of those characteristics need not be included in the repeat sales model, thereby increasing the degrees of freedom and allowing sample size requirements to be significantly lower and coefficient estimates to be more efficient (Crone and Voith, 1992). A repeat sales analysis is not necessarily preferred over a traditional hedonic model, but is rather an alternative analysis approach that can be used to test the robustness of the earlier results (for further discussion see Jackson, 2003). The repeat sales model takes the basic form:

Annual Appreciation Rate (AAR) = *f* (TYPE OF HOUSE, OTHER FACTORS)

where
TYPE OF HOUSE provides an indication of the segment of the market in which the house is situated (e.g., high end vs. low end), and
OTHER FACTORS include, but are not limited to, changes to the environment (e.g., proximity to a disamenity).

The dependent variable is the adjusted annual appreciation rate and is defined as follows:

$$\mathrm{AAR} = \exp\left[\frac{\ln\left(\mathrm{P}_1 / \mathrm{P}_2\right)}{\mathrm{t}_1 - \mathrm{t}_2}\right] - 1 \tag{10}$$

where

P_1 is the adjusted sales price at the first sale (in 1996 dollars),
P_2 is the adjusted sales price at the second sale (in 1996 dollars),
t_1 is the date of the first sale,
t_2 is the date of the second sale, and
$(t_1 – t_2)$ is determined by calculating the number of days that separate the sale dates and dividing by 365.

As with the hedonic regression model, the usefulness of the repeat sales model is well established in the literature when investigating possible disamenities. For example, a repeat sales analysis was used to estimate spatial and temporal sales price effects from incinerators by Kiel and McClain (1995), who found that appreciation rates, on average, are not sensitive to distance from the facility during the construction phase but are during the operation phase. Similarly, McCluskey and Rausser (2003) used a repeat sales model to investigate effects surrounding a hazardous waste site. They found that appreciation rates are not sensitive to the home's distance from the disamenity before that disamenity is identified by the EPA as hazardous, but that home values are impacted by distance after the EPA's identification is made.

6.2. Dataset

The 7,459 residential sales transactions in the dataset contain a total of 1,253 transactions that involve homes that sold on more than one occasion (i.e., a "pair" of sales of the same home). For the purposes of this analysis, however, the key sample consists of homes that sold once before the announcement of the wind facility, and that subsequently sold again after the construction of that facility. Therefore any homes that sold twice in either the pre-announcement or post-construction periods were not used in the repeat sales sample.[91] These were excluded because either they occurred before the effect would be present (for pre-announcement pairs) or after (for post-announcement pairs). This left a total of 368 pairs for the analysis, which was subsequently reduced to 354 usable pairs.[92]

The mean AAR for the sample is 1.0% per year, with a low of -10.5% and a high of 13.4%. Table 27 summarizes some of the characteristics of the homes used in the repeat sales model. The average house in the sample has 1,580 square feet of above-ground finished living area, sits on a parcel of 0.67 acres, and originally sold for $70,483 (real 1996 dollars). When it sold a second time, the average home in the sample was located 2.96 miles from the nearest wind turbine (14 homes were within one mile, 199 between one and three miles, 116 between three and five miles, and 25 outside of five miles). Of the 354 homes, 14% (*n* = 49) had some view of the facility (35 were rated MINOR, five MODERATE, and nine either SUBSTANTIAL or EXTREME). Because of the restriction to those homes that experienced repeat sales, the sample is relatively small for those homes in close proximity to and with dramatic views of wind facilities.

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[91] 752 pairs occurred after construction began, whereas 133 pairs occurred before announcement.

[92] Of the 368 pairs, 14 were found to have an AAR that was either significantly above or below the mean for the sample (mean +/- 2 standard deviations). These pairs were considered highly likely to be associated with homes that were either renovated or left to deteriorate between sales, and therefore were removed from the repeat sales model dataset. Only two of these 14 homes had views of the wind turbines, both of which were MINOR. All 14 of the homes were situated either between one and three miles from the nearest turbine (*n* = 8) or between three and five miles away (*n* = 6).

Table 27: List of Variables Included in the Repeat Sales Model

Variable Name	Description	Type	Sign	Freq.	Mean	Std. Dev.	Min.	Max.
SalePrice96_Pre	The Sale Price (adjusted for inflation into 1996 dollars) of the home as of the first time it had sold	C	+	354	$ 70,483	$ 37,798	$ 13,411	$ 291,499
SalePrice96_Pre_Sqr	SalePrice96_Pre Squared (shown in millions)	C	–	354	$ 6,393	$ 8,258	$ 180	$ 84,972
Acres	Number of Acres that sold with the residence	C	+	354	0.67	1.34	0.07	10.96
Sqft_1000	Number of square feet of finished above ground living area (in 1000s)	C	+	354	1.58	0.56	0.59	4.06
No View	If the home had no view of the turbines when it sold for the second time (Yes = 1, No = 0)	Omitted	n/a	305	0.86	0.35	0	1
Minor View	If the home had a Minor View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	35	0.10	0.30	0	1
Moderate View	If the home had a Moderate View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	5	0.01	0.12	0	1
Substantial/Extreme View	If the home had a Substantial or Extreme View of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	9	0.03	0.12	0	1
Less than 1 Mile	If the home was within 1 mile (5280 feet) of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	14	0.02	0.13	0	1
Between 1 and 3 Miles	If the home was between 1 and 3 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	199	0.56	0.50	0	1
Between 3 and 5 Miles	If the home was between 3 and 5 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	OC	–	116	0.33	0.47	0	1
Outside 5 Miles	If the home was outside 5 miles of the turbines when it sold for the second time (Yes = 1, No = 0)	Omitted	n/a	25	0.07	0.26	0	1

"C" Continuous, "OC" Ordered Categorical (1 = yes, 0 = no) values are interpreted in relation to the "Omitted" category. This table does not include the study area fixed effects variables that are included in the model (e.g., WAOR, TXHC, NYMC). The reference case for these variables is the WAOR study area.

6.3. Model Form

To investigate the presence of Area, Scenic Vista, and Nuisance Stigmas, the adjusted annual appreciation rate (AAR) is calculated for the 354 sales pairs in the manner described in equation (10), using inflation adjusted sales prices. The following model is then estimated:

$$\text{AAR} = \beta_0 + \sum_{s} \beta_1 \text{S} + \sum_{k} \beta_2 \text{X} + \sum_{v} \beta_3 \text{VIEW} + \sum_{d} \beta_4 \text{DISTANCE} + \varepsilon \tag{11}$$

where

AAR represents the inflation-adjusted Annual Appreciation Rate for repeat sales,

S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),

X is a vector of *k* home, site and sale characteristics (e.g., acres, square feet, original sales price),

VIEW is a vector of *v* categorical view variables (e.g., MINOR, MODERATE, etc.),

DISTANCE is a vector of *d* categorical distance variables (e.g., less than one mile, between one and three miles, etc.),

β_0 is the constant or intercept across the full sample,

β_1 is a vector of *s* parameter estimates for the study area fixed effects as compared to sales that occurred in the WAOR study area,

β_2 is a vector of *k* parameter estimates for the home, site, and sale characteristics,

β_3 is a vector of *v* parameter estimates for the VIEW variables as compared to transactions of homes with no view of the turbines,

β_4 is a vector of *d* parameter estimates for the DISTANCE variables as compared to transactions of homes outside of five miles, and

ε is a random disturbance term.

Effectively, this model seeks to identify reasons that AARs vary among those sales pairs in the sample. Reasons for such differences in AARs might include variations in home and site characteristics, the study area in which the sale occurs, or the degree to which the home is in proximity to or has a dramatic view of a wind facility. As such, the model as shown by equation (11) has three primary groups of parameters: variables of interest; home, site, and sale characteristics; and study area fixed effects.

The variables of interest are VIEW and DISTANCE, and the coefficients β_3 and β_4 are therefore the primary focus of this analysis. Because of the small numbers of homes in the sample situated inside of 3000 feet and between 3000 feet and one mile, they are collapsed into a single category (inside one mile). For the same reason, homes with SUBSTANTIAL or EXTREME VIEWS are collapsed into a single category (SUBSTANTIAL/EXTREME). In this model, therefore, the influence on appreciation rates of the following variables of interest is estimated: MINOR, MODERATE, and SUBSTANTIAL/EXTREME VIEWS, and less than one mile, between one and three mile, and between three and five mile DISTANCES. For the VIEW fixed-effects variables, the reference category is NO VIEW; for DISTANCE, it is homes outside of five miles. As with previous models, if effects exist, it is expected that all of the coefficients would be negative and monotonically ordered.

The number of home, site, and sale characteristics included in a repeat sales model is typically substantially lower than in a hedonic model. This is to be expected because, as discussed earlier, the repeat sales model explores variations in AARs for sales pairs from individual homes, and home and site characteristics are relatively stable over time for any individual home. Nonetheless, various characteristics have been found by others (e.g., Kiel and McClain, 1995; McCluskey and Rausser, 2003) to affect appreciation rates. For the purposes of the Repeat Sales Model, these include the number of square feet of living space (SQFT_1000), the number of acres (ACRES), the inflation-adjusted price of the home at the first sale (SalePrice96_Pre), and that sales price squared (SalePrice96_Pre_Sqr). Of those characteristics, the SQFT_1000 and ACRES coefficients are expected to be positive indicating that, all else being equal, an increase in living area and lot size increases the relative appreciation rate. Conversely, it is expected that the combined estimated effect of the initial sales prices (SalePrice96_Pre and SalePrice96_Pre_Sqr) will trend downward, implying that as the initial sales price of the house increases the appreciation rate decreases. These expectations are in line with the previous literature (Kiel and McClain, 1995; McCluskey and Rausser, 2003).

Finally, the study-area fixed effects variables (β_1) are included in this model to account for differences in inflation adjusted appreciation rates that may exist across study areas (e.g., WAOR, TXHC, NYMC). The WAOR study area is the reference category, and all study-area coefficients therefore represent the marginal change in AARs compared to WAOR (the intercept represents the marginal change in AAR for WAOR by itself). These study area parameters provide a unique look into Area Stigma effects. Recall that the appreciation rates used in this model are adjusted for inflation by using an inflation index from the nearby municipal statistical area (MSA). These MSAs are sometimes quite far away (as much as 20 miles) and therefore would be unaffected by the wind facility. As such, any variation in the study area parameters (and the intercept) would be the result of local influences not otherwise captured in the inflation adjustment, and represent another test for Area Stigma; if effects exist, it is expected that the β_0 and β_1 coefficients will be negative.

As with the hedonic models presented earlier, the assumptions of homoskedasticity, absence of spatial autocorrelation, reasonably little multicollinearity, and appropriate controls for outliers are addressed as described in the associated footnote and in Appendix G.[93]

6.4. Analysis of Results

The results from the Repeat Sales Model are presented in Table 28. The model performs relatively poorly overall, with an Adjusted R^2 of just 0.19 (and an *F*-test statistic of 5.2). Other similar analyses in the literature have produced higher performance statistics but have done so with samples that are considerably larger or more homogenous than ours.[94] The low R^2 found here should not be cause for undue concern, however, given the relatively small sample spread across ten different study areas. Moreover, many of the home and site characteristics are found to be statistically significant, and of the appropriate sign. The coefficient for the adjusted initial sales price (SalePrice96_Pre), for example, is statistically significant, small, and negative (-0.000001, *p* value 0.00), while the coefficient for the adjusted initial sales price squared (SalePrice96_Pre_Sqr) is also statistically significant and considerably smaller (<0.000000, *p* value 0.00). These results imply, consistent with the prior literature, that for those homes in the sample, an increase in initial adjusted sales price decreases the average percentage appreciation rate. ACRES (0.002, *p* value 0.10) and SQFT_1000 (0.02, *p* value 0.00) are both positive, as expected, and statistically significant.

Of particular interest are the intercept term and the associated study-area fixed effect coefficients, and what they collectively say about Area Stigma. The coefficient for the intercept (β_0) is 0.005 (*p* value 0.81), which is both extremely small and not statistically significant. Likewise, the study-area fixed effects are all relatively small (less than 0.03 in absolute terms) and none are statistically significant. As discussed above, if a pervasive Area Stigma existed, it would be expected to be represented in these coefficients. Because all are small and statistically insignificant, it can again be concluded that there is no persuasive evidence of an Area Stigma among this sample of home transactions.

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[93] All results are produced using White's corrected standard errors to control for heteroskedasticity. Spatial autocorrelation, with this small sample, is impossible to control. Because of the small sample, an even smaller number of neighboring sales exist, which are required to construct the spatial matrix. As such, spatial autocorrelation is not addressed in the repeat sales model. As with the hedonic models, some multicollinearity might exist, but that multicollinearity is unlikely to be correlated with the variables of interest. Outliers are investigated and dealt with as discussed in footnote 91 on page 56.

[94] McCluskey and Rausser (2003) had a sample of over 30,000 repeat sales and had an *F*-test statistic of 105; Kiel and McClain (1995) produced an R^2 that ranged from 0.40 to 0.63 with samples ranging from 53 to 145, but all sales took place in North Andover, MA.

Table 28: Results from Repeat Sales Model

	Coef.	SE	p Value	*n*
Intercept	0.005	0.02	0.81	354
WAOR	Omitted	Omitted	Omitted	6
TXHC	-0.01	0.02	0.63	57
OKCC	0.03	0.02	0.11	102
IABV	0.02	0.02	0.14	59
ILLC	-0.01	0.02	0.38	18
WIKCDC	0.02	0.03	0.50	8
PASC	-0.01	0.02	0.67	32
PAWC	0.02	0.02	0.16	35
NYMCOC	0.02	0.02	0.23	24
NYMC	0.03	0.02	0.13	13
SalePrice96 Pre	-0.000001	0.0000002	0.00	354
SalePrice96 Pre Sqr	0.0000000	0.0000000	0.00	354
Acres	0.002	0.001	0.10	354
Sqft 1000	0.02	0.01	0.00	354
No View	Omitted	Omitted	Omitted	305
Minor View	-0.02	0.01	0.02	35
Moderate View	0.03	0.03	0.29	5
Substantial/Extreme View	-0.02	0.01	0.09	9
Less than 1 Mile	0.03	0.01	0.01	14
Between 1 and 3 Miles	0.01	0.01	0.59	199
Between 3 and 5 Miles	0.01	0.01	0.53	116
Outside 5 Miles	Omitted	Omitted	Omitted	25

"Omitted" = reference category for fixed effects variables

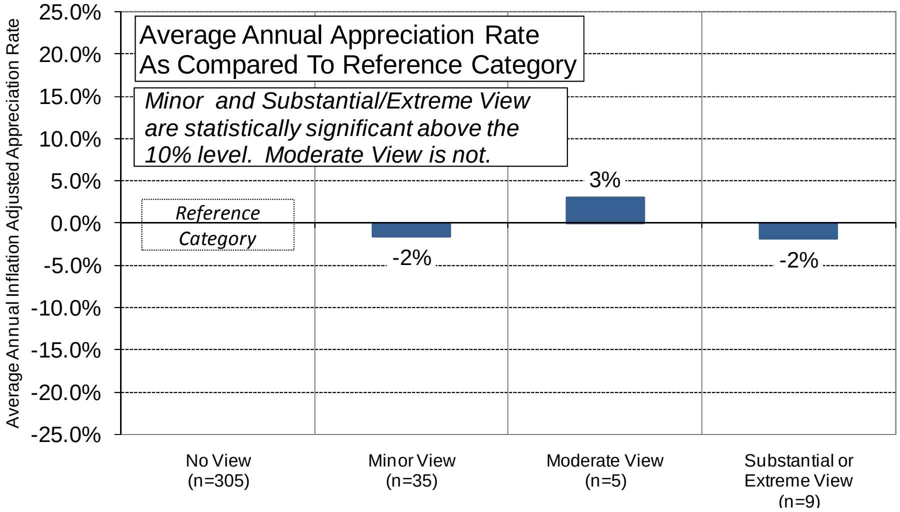
"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**11**
Dependent Variable	**SalePrice96_AAR**
Number of Cases	**354**
Number of Predictors (k)	**19**
F Statistic	**5.2**
Adjusted R2	**0.19**

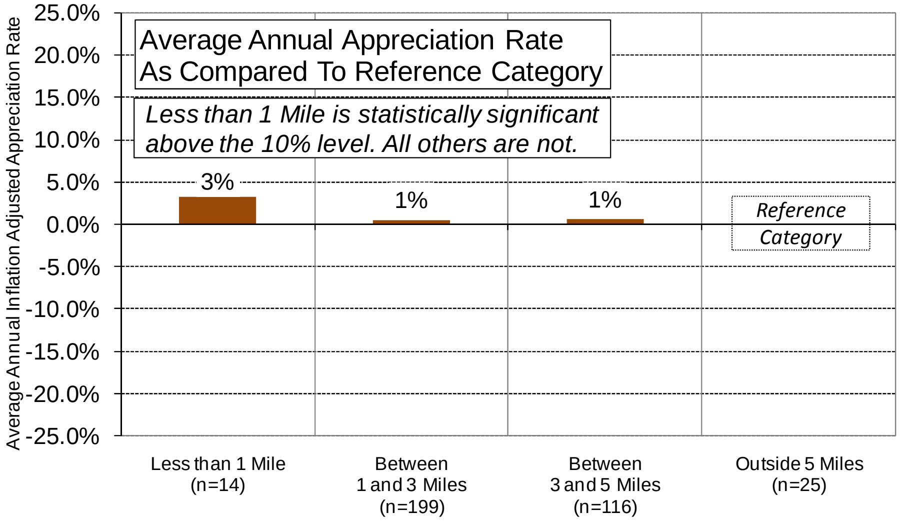
Turning to the variables of interest, mixed results (see Figure 9 and Figure 10) are found. For homes with MINOR or SUBSTANTIAL/EXTREME VIEWS, despite small sample sizes, appreciation rates after adjusting for inflation are found to decrease by roughly 2% annually (*p* values of 0.02 and 0.09, respectively) compared to homes with NO VIEW. Though these findings initially seem to suggest the presence of Scenic Vista Stigma, the coefficients are not monotonically ordered, counter to what one might expect: homes with a MODERATE rated view appreciated on average 3% annually (*p* value 0.29) compared to homes with NO VIEW. Adding to the suspicion of these VIEW results, the DISTANCE coefficient for homes situated inside of one mile, where eight out of the nine SUBSTANTIAL/EXTREME rated homes are located, is positive and statistically significant (0.03, *p* value 0.01). If interpreted literally, these results suggest that a home inside of one mile with a SUBSTANTIAL/EXTREME rated view would experience a decrease in annual appreciation of 2% compared to homes with no views of turbines, but simultaneously would experience an increase of 3% in appreciation compared to homes outside of five miles. Therefore, when compared to those homes outside of five miles and with no view of the wind facilities, these homes would experience an overall increase in AAR by 1%. These results are counterintuitive and are likely driven by the small number of sales pairs that are located within one mile of the wind turbines and experience a dramatic view of those turbines.

Figure 9: Repeat Sales Model Results for VIEW



The reference category consists of tranasctions of homes that had no view of the turbines

Figure 10: Repeat Sales Model Results for DISTANCE



The reference category consists of tranasctions of homes that are situated outside of five miles from the nearest turbine

Regardless of the reason for this result, again no persuasive evidence of consistent and widespread adverse effects is found from the presence of the wind facilities in the sample, reinforcing the findings from the previous hedonic analysis. Specifically, there is no evidence that an Area Stigma exists in that homes outside of one mile and inside of five miles do not appreciate differently than homes farther away. Similarly, there is no evidence of a Nuisance Stigma. Appreciation rates for homes inside of one mile are not adversely affected; in fact, significantly higher appreciation rates are found for these homes than for those homes located outside of five miles from the nearest wind facility. Finally, though some evidence is found that a Scenic Vista Stigma may exist in the sample of repeat sales, it is weak, fairly small, and somewhat counter-intuitive. This result is likely driven by the small number of sales pairs that are located within one mile of the wind turbines and that experience a dramatic view of those turbines.

7. Sales Volume Analysis

The analysis findings to this point suggest that, among the sample of sales transactions analyzed in this report, wind facilities have had no widespread and statistically identifiable impact on residential property values. A related concern that has not yet been addressed is that of sales volume: does the presence of wind facilities either increase or decrease the rate of home sales transactions? On the one hand, a decrease in sales volumes might be expected. This might occur if homeowners expect that their property values will be impacted by the presence of the wind facility, and therefore simply choose not to sell their homes as a result, or if they try to sell but are not easily able to find willing buyers. Alternatively, an increase in sales volume might be expected if homeowners that are located near to or have a dominating view of wind turbines are uncomfortable with the presence of those turbines. Though those homes may sell at a market value that is not impacted by the presence of the wind facilities, self-selection may lead to accelerated transaction volumes shortly after facility announcement or construction as homeowners who view the turbines unfavorably sell their homes to individuals who are not so stigmatized. To address the question of whether and how sales volumes are impacted by nearby wind facilities, sales volumes are analyzed for those homes located at various distances from the wind facilities in the sample, during different facility development periods.

7.1. Dataset

To investigate whether sales volumes are affected by the presence of wind facilities two sets of data are assembled: (1) the number of homes available to sell annually within each study area, and (2) the number of homes that actually did sell annually in those areas. Homes potentially "available to sell" are defined as all single family residences within five miles of the nearest turbine that are located on a parcel of land less than 25 acres in size, that have only one residential structure, and that had a market value (for land and improvements) above $10,000.[95] Homes that "did sell" are defined as every valid sale of a single family residence within five miles of the nearest turbine that are located on a parcel of land less than 25 acres in size, that have only one residential structure, and that sold for more than $10,000.

The sales data used for this analysis are slightly different from those used in the hedonic analysis reported earlier. As mentioned in Section 3.3, a number of study areas were randomly sampled to limit the transactions outside of 3 miles if the total number of transactions were to exceed that which could efficiently be visited in the field (*n* ~1,250). For the sales volume analysis, however, field data collection was not required, and all relevant transactions could therefore be used. Secondly, two study areas did not provide the data necessary for the sales volume analysis (WAOR and OKCC), and are therefore excluded from the sample. Finally, data for some homes that were "available to sell" were not complete, and rather than including only a small selection of these homes, these subsets of data were simply excluded from the analysis. These excluded homes include those located outside of five miles of the nearest wind turbine, and those available to sell or that did sell more than three years before wind facility announcement.[96] The resulting

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[95] "Market value" is the estimated price at which a home would sell as of a given point in time.

[96] For instance, some providers supplied sales data out to ten miles, but only provided homes available to sell out to five miles. As well, data on homes that did sell were not consistently available for periods many years before announcement.

dataset spans the period starting three years prior to facility announcement and ending four years after construction. All homes in this dataset are situated inside of five miles, and each is located in one of the eight represented study areas.[97]

The final set of homes potentially "available to sell" and that actually "did sell" are then segmented into three distance categories: inside of one mile, between one and three miles, and between three and five miles. For each of these three distance categories, in each of the eight study areas, and for each of the three years prior to announcement, the period between announcement and construction, and each of the four years following construction, the number of homes that sold as a percentage of those available to sell is calculated.[98] This results in a total of 24 separate sales volume calculations in each study area, for a total of 192 calculations across all study areas. Finally, these sales volumes are averaged across all study areas into four development period categories: less than three years before announcement, after announcement but before construction, less than two years after construction, and between two and four years after construction.[99] The resulting average annual sales volumes, by distance band and development period, are shown in Table 29 and Figure 11.

Table 29: Sales Volumes by PERIOD and DISTANCE

	Inside 1 Mile	**Between 1 and 3 Miles**	**Between 3 and 5 Miles**
Less Than 3 Years Before Announcement	2.2%	1.8%	2.3%
After Announcement Before Construction	3.0%	2.5%	3.7%
Less Than 2 Years After Construction	2.1%	3.0%	4.2%
Between 2 and 4 Years After Construction	2.8%	2.8%	4.2%

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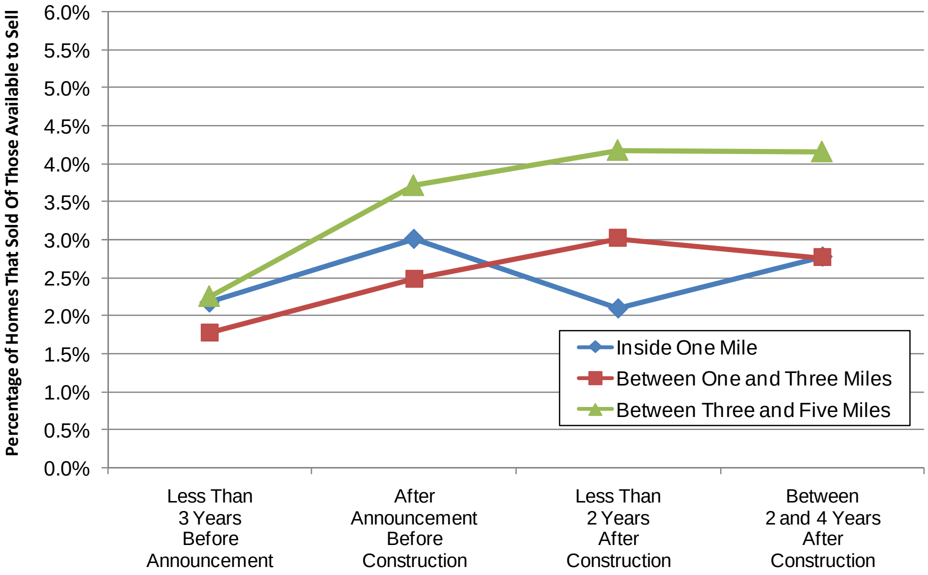
[97] The number of homes "available to sell" is constructed for each year after 1996 based on the year the homes in each study area were built. For many homes in the sample, the year built occurred more than three years before wind facility announcement, and therefore those homes are "available to sell" in all subsequent periods. For some homes, however, the home was built during the wind facility development process, and therefore becomes "available" some time after the first period of interest. For those homes, the build year is matched to the development dates so that it becomes "available" during the appropriate period. For this reason, the number of homes "available to sell" increases in later periods.

[98] For the period after announcement and before construction, which in all study areas was not exactly 12 months, the sales volume numbers are adjusted so that they corresponded to an average over a 12 month period.

[99] These temporal groupings are slightly different from those used in the hedonic Temporal Aspects Model. Namely, the period before announcement is not divided into two parts – more than two years before announcement and less than two years before announcement – but rather only one – less than three years before announcement. This simplification is made to allow each of the interaction categories to have enough data to be meaningful.

Figure 11: Sales Volumes by PERIOD and DISTANCE



7.2. Model Form

To investigate whether the rate of sales transactions is measurably affected by the wind facilities, the various resulting sales volumes shown above in Table 29 and Figure 11 are compared using a *t*-Test, as follows:

$$t = \frac{(\overline{x}_1 - \overline{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \qquad (12)$$

where

$\overline{x}_1$ and $\overline{x}_2$ are the mean sales volumes from the two categories being compared,

s_1^2 and s_2^2 are variances of the sales volumes from the two categories being compared, and

n_1 and n_2 are numbers of representative volumes in the two categories.[100]

The degrees of freedom used to calculate the *p*-value of the *t* statistic equals the lower of $(n_1 - 1)$ or $(n_2 - 1)$.

Three sets of *t*-Tests are conducted. First, to test whether sales volumes have changed with time and are correlated with wind facility construction, the volumes for each DISTANCE group in later periods (x_1) are compared to the volume in that same group in the pre-announcement period (x_2). Second, to test whether sales volumes are impacted by distance to the nearest wind turbine, the volumes for each PERIOD group at distances closer to the turbines (x_1) are compared to the volume in that same group in the three to five mile distance band (x_2). Finally, for reasons that will become obvious later, the sales volumes for each PERIOD group at distances within one

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[100] The number of representative volumes could differ between the two categories. For instance, the "less than three years before announcement" category represents three years – and therefore three volumes – for each study area for each distance band, while the "less than two years after construction" category represents two years – and therefore two volumes – for each study area for each distance band.

mile and outside of three miles of the turbines (x_1) are compared to the sales volume in that same group in the one to three mile distance band (x_2). These three tests help to evaluate whether sales volumes are significantly different after wind facilities are announced and constructed, and whether sales volumes near the turbines are affected differently than for those homes located farther away.[101]

7.3. Analysis of Results

Table 29 and Figure 11 above show the sales volumes in each PERIOD and DISTANCE category, and can be interpreted as the percentage of homes that are available to sell that did sell in each category, on an annual average basis. The sales volume between one and three miles and before facility announcement is the lowest, at 1.8%, whereas the sales volumes for homes located between three and five miles in both periods following construction are the highest, at 4.2%.

The difference between these two sales volumes can be explained, in part, by two distinct trends that are immediately noticeable from the data presented in Figure 11. First, sales volumes in all periods are highest for those homes located in the three to five mile distance band. Second, sales volumes at virtually all distances are higher after wind facility announcement than they were before announcement.[102]

To test whether these apparent trends are borne out statistically the three sets of *t*-Tests described earlier are performed, the results of which are shown in Table 30, Table 31, and Table 32. In each table, the difference between the subject volume (x_1) and the reference volume (x_2) is listed first, followed by the *t* statistic, and whether the statistic is significant at or above the 90% level ("*").

Table 30 shows that mean sales volumes in the post-announcement periods are consistently greater than those in the pre-announcement period, and that those differences are statistically significant in four out of the nine categories. For example, the post-construction sales volumes for homes in the three to five mile distance band in the period less than two years after construction (4.2%) and between three and four years after construction (4.2%) are significantly greater than the pre-announcement volume of 2.3% (1.9%, $t = 2.40$; 1.9%, $t = 2.31$). Similarly, the post-construction sales volumes between one and three miles are significantly greater than the pre-announcement volume. These statistically significant differences, it should be noted, could be as much related to the low reference volume (i.e., sales volume in the period less than

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[101] An alternative method to this model would be to pool the homes that "did sell" with the homes "available to sell" and construct a Discrete Choice Model where the dependent variable is zero (for "no sale") or one (for "sale") and the independent variables would include various home characteristics and the categorical distance variables. This would allow one to estimate the probability that a home sells dependent on distance from the wind facility. Because home characteristics data for the homes "available to sell," was not systematically collected it was not possible to apply this method to the dataset.

[102] It is not entirely clear why these trends exist. Volumes may be influenced upward in areas farther from the wind turbines, where homes, in general, might be more densely sited and homogenous, both of which might be correlated with greater home sales transactions. The converse might be true in more rural areas, nearer the wind turbines, where homes may be more unique or homeowners less prone to move. The increasing sales volumes seen in periods following construction, across all distance bands, may be driven by the housing bubble, when more transactions were occurring in general.

three years before announcement), as they are to the sales volumes to which the reference category is compared. Finally, when comparing post-construction volumes inside of a mile, none are statistically different than the 2.2% pre-announcement level.

Table 30: Equality Test of Sales Volumes between PERIODS

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	Reference	Reference	Reference
After Announcement Before Construction	0.8% (0.72)	0.7% (0.99)	1.5% (1.49)
Less Than 2 Years After Construction	-0.1% (-0.09)	1.2% (2.45) *	1.9% (2.4) *
Between 2 and 4 Years After Construction	0.6% (0.54)	1% (2.24) *	1.9% (2.31) *

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Turning to sales volumes in the same development period but between the different distance bands, consistent but less statistically significant results are uncovered (see Table 31). Although all sales volumes inside of three miles, for each period, are less than their peers outside of three miles, those differences are statistically significant in only two out of eight instances. Potentially more important, when one compares the sales volumes inside of one mile to those between one and three miles (see Table 32), small differences are found, none of which are statistically significant. In fact, on average, the sales volumes for homes inside of one mile are greater or equal to the volumes of those homes located between one and three miles in two of the three post-announcement periods. Finally, it should be noted that the volumes for the inside one mile band, in the period immediately following construction, are less than those in the one to three mile band in the same period. Although not statistically significant, this difference might imply an initial slowing of sales activity that, in later periods, returns to more normal levels. This possibility is worth investigating further and is therefore recommended for future research.

Table 31: Equality Test of Volumes between DISTANCES using 3-5 Mile Reference

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	-0.1% (-0.09)	-0.5% (-0.88)	Reference
After Announcement Before Construction	-0.7% (-0.56)	-1.2% (-1.13)	Reference
Less Than 2 Years After Construction	-2.1% (-2.41) *	-1.2% (-1.48)	Reference
Between 2 and 4 Years After Construction	-1.4% (-1.27)	-1.4% (-1.82) *	Reference

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Table 32: Equality Test of Sales Volumes between DISTANCES using 1-3 Mile Reference

	Inside 1 Mile	Between 1 and 3 Miles	Between 3 and 5 Miles
Less Than 3 Years Before Announcement	0.4% (0.49)	Reference	0.5% (0.88)
After Announcement Before Construction	0.5% (0.47)	Reference	1.2% (1.13)
Less Than 2 Years After Construction	-0.9% (-1.38)	Reference	1.2% (1.48)
Between 2 and 4 Years After Construction	0% (0.01)	Reference	1.4% (1.82) *

Numbers in parenthesis represent t-Test statistics. "" = significantly different at or below the 10% level*

Taken together, these results suggest that sales volumes are not conclusively affected by the announcement and presence of the wind facilities analyzed in this report. At least among this sample, sales volumes increased in all distance bands after the announcement and construction of the wind facilities. If this result was driven by the presence of the wind facilities, however, one would expect that such impacts would be particularly severe for those homes in close proximity to wind facilities. In other words, sales volumes would be the most affected inside of one mile, where views of the turbines are more frequent and where other potential nuisances are more noticeable than in areas farther away. This is not borne out in the data - no statistically significant differences are found for sales volumes inside of one mile as compared to those between one and three miles, and sales volumes outside of three miles are higher still. Therefore, on the whole, this analysis is unable to find persuasive evidence that wind facilities have a widespread and identifiable impact on overall residential sales volumes. It is again concluded that neither Area nor Nuisance Stigma are in evidence in this analysis.

8. Wind Projects and Property Values: Summary of Key Results

This report has extensively investigated the potential impacts of wind power facilities on the value (i.e., sales prices) of residential properties that are in proximity to and/or that have a view of those wind facilities. In so doing, three different potential impacts of wind projects on property values have been identified and analyzed: Area Stigma, Scenic Vista Stigma, and Nuisance Stigma. To assess these potential impacts, a primary (Base) hedonic model has been applied, seven alternative hedonic models have been explored, a repeat sales analysis has been conducted, and possible impacts on sales volumes have been evaluated. Table 33 outlines the resulting ten tests conducted in this report, identifies which of the three potential stigmas those tests were designed to investigate, and summarizes the results of those investigations. This section synthesizes these key results, organized around the three potential stigmas.

Table 33: Impact of Wind Projects on Property Values: Summary of Key Results

	Is there statistical evidence of:			
Statistical Model	**Area Stigma?**	**Scenic Vista Stigma?**	**Nuisance Stigma?**	**Section Reference**
Base Model	No	No	No	*Section 4*
View Stability	Not tested	No	Not tested	*Section 5.1*
Distance Stability	No	Not tested	No	*Section 5.1*
Continuous Distance	No	No	No	*Section 5.2*
All Sales	No	No	Limited	*Section 5.3*
Temporal Aspects	No	No	No	*Section 5.4*
Orientation	No	No	No	*Section 5.5*
Overlap	No	Limited	No	*Section 5.6*
Repeat Sales	No	Limited	No	*Section 6*
Sales Volume	No	Not tested	No	*Section 7*

"No"………………….	*No statistical evidence of a negative impact*
"Yes"…………………	*Strong statistical evidence of a negative impact*
"Limited"……………	*Limited and inconsistent statistical evidence of a negative impact*
"Not tested"………..	*This model did not test for this stigma*

8.1. Area Stigma

Area Stigma is defined as a concern that the general area surrounding a wind energy facility will appear more developed, which may adversely affect home values in the local community regardless of whether any individual home has a view of the wind turbines. Though these impacts might be expected to be especially severe at close range to the turbines, the impacts could conceivably extend for a number of miles around a wind facility. Modern wind turbines are visible from well outside of five miles in many cases, so if an Area Stigma exists, it is possible that all of the homes in the study areas inside of five miles would be affected.

As summarized in Table 33, Area Stigma is investigated with the Base, Distance Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, and Overlap hedonic models. It is also tested, somewhat differently, with the Repeat Sales and Sales Volume analyses. In each case, if an Area Stigma exists, it is expected that the sales prices (and/or sales volume) of homes located near wind facilities would be broadly affected by the presence of those facilities, with effects decreasing with distance.

The Base Model finds little evidence of an Area Stigma, as the coefficients for the DISTANCE variables are all relatively small and none are statistically different from zero. For homes in this sample, at least, there is no statistical evidence from the Base Model that the distance from a home to the nearest wind turbine impacts sales prices, regardless of the distance band. Perhaps a more direct test of Area Stigma, however, comes from the Temporal Aspects Model. In this model, homes in all distance bands that sold after wind facility announcement are found to sell, on average, for prices that are not statistically different from those for homes that sold more than two years prior to wind facility announcement. Again, no persuasive evidence of an Area Stigma is evident.

The Repeat Sales and Sales Volume Models also investigate Area Stigma. The Repeat Sales Model's 354 homes, each of which sold once before facility announcement and again after construction, show average inflation-adjusted annual appreciation rates that are small and not statistically different from zero. If homes in all study areas were subject to an Area Stigma, one would expect a negative and statistically significant intercept term. Similarly, if homes in any individual study area experienced an Area Stigma, the fixed effect terms would be negative and statistically significant. Neither of these expectations is borne out in the results. The Sales Volume Model tells a similar story, finding that the rate of residential transactions is either not significantly different between the pre- and post-announcement periods, or is greater in later periods, implying, in concert with the other tests, that increased levels of transactions do not signify a rush to sell, and therefore lower prices, but rather an increase in the level of transactions with no appreciable difference in the value of those homes.

The All Sales, Distance Stability, Continuous Distance, Orientation, and Overlap Models corroborate these basic findings. In the All Sales and Distance Stability Models, for example, the DISTANCE coefficients for homes that sold outside of one mile but within five miles, compared to those that sold outside of five miles, are very similar: they differ by no more than 2%, and this small disparity is not statistically different from zero. The same basic findings resulted from the Orientation and Overlap Models. Further, homes with No View as estimated in the All Sales Model are found to appreciate in value, after adjusting for inflation, when compared to homes that sold before wind facility construction (0.02, *p* value 0.06); an Area Stigma effect should be reflected as a negative coefficient for this parameter. Finally, despite using all 4,937 cases in a single distance variable and therefore having a correspondingly small standard error, the Continuous Distance Model discovers no measurable relationship between distance from the nearest turbine and the value of residential properties.

Taken together, the results from these models are strikingly similar: there is no evidence of a widespread and statistically significant Area Stigma among the homes in this sample. Homes in these study areas are not, on average, demonstrably and measurably stigmatized by the arrival of a wind facility, regardless of when they sold in the wind project development process and regardless of whether those homes are located one mile or five miles away from the nearest wind facility.

Drawing from the previous literature on environmental disamenities discussed in Section 2.1, one likely explanation for this result is simply that any effects that might exist may have faded to a level indistinguishable from zero at distances outside of a mile from the wind facilities. For other disamenities, some of which would seemingly be more likely to raise concerns, effects have been found to fade quickly with distance. For example, property value effects near a chemical plant have been found to fade outside of two and a half miles (Carroll et al., 1996), near a lead smelter (Dale et al., 1999) and fossil fuel plants (Davis, 2008) outside of two miles, and near landfills and confined animal feeding operations outside of 2,400 feet and 1,600 feet, respectively (Ready and Abdalla, 2005). Further, homes outside of 300 feet (Hamilton and Schwann, 1995) or even as little as 150 feet (Des-Rosiers, 2002) from a high voltage transmission line have been found to be unaffected. A second possible explanation for these results could be related to the view of the turbines. In the sample used for this analysis, a large majority of the homes outside of one mile (*n* = 4,812) that sold after wind-facility construction commenced cannot see the turbines (*n* = 4,189, 87%), and a considerably larger portion have – at worst – a minor view of the turbines (*n* = 4,712, 98%). Others have found that the sales prices for homes situated at similar distances from a disamenity (e.g., HVTL) depend, in part, on the , view of that disamenity (Des-Rosiers, 2002). Similarly, research has sometimes found that annoyance with a wind facility decreases when the turbines cannot be seen (Pedersen and Waye, 2004). Therefore, for the overwhelming majority of homes outside of a mile that have either a minor rated view or no view at all of the turbines, the turbines may simply be out of sight, and therefore, out of mind.

8.2. Scenic Vista Stigma

Scenic Vista Stigma is defined as concern that a home may be devalued because of the view of a wind energy facility, and the potential impact of that view on an otherwise scenic vista. It has as its basis an admission that home values are, to some degree, derived from the quality of what can be seen from the property and that if those vistas are altered, sales prices might be measurably affected. The Base, View Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, Overlap, and Repeat Sales Models each test whether Scenic Vista Stigma is present in the sample.

The Base Model, as well as subsequent Alternative Hedonic Models, demonstrates persuasively that the quality of the scenic vista – absent wind turbines – impacts sales prices. Specifically, compared to homes with an AVERAGE VISTA, those having a POOR or a BELOW AVERAGE rating are estimated to sell for 21% (*p* value 0.00) and 8% (*p* value 0.00) less, on average. Similarly, homes with an ABOVE AVERAGE or PREMIUM rating are estimated to sell for 10% (*p* value 0.00) and 13% (*p* value 0.00) more than homes with an AVERAGE vista rating. Along the same lines, homes in the sample with water frontage or situated on a cul-de-sac sell for 33% (*p* value 0.00) and 10% (*p* value 0.00) more, on average, than those homes that lack these characteristics. Taken together, these results demonstrate that home buyers and sellers consistently take into account what can be seen from the home when sales prices are established, and that the models presented in this report are able to clearly identify those impacts.[103]

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[103] Of course, cul-de-sacs and water frontage bestow other benefits to the home owner beyond the quality of the scenic vista, such as safety and privacy in the case of a cul-de-sac, and recreational potential and privacy in the case of water frontage.

Despite this finding, those same hedonic models are unable to identify a consistent and statistically significant Scenic Vista Stigma associated with wind facilities. Home buyers and sellers, at least among this sample, do not appear to be affected in a measurable way by the visual presence of wind facilities. Regardless of which model was estimated, the value of homes with views of turbines that were rated MODERATE, SUBSTANTIAL, or EXTREME are found to be statistically indistinguishable from the prices of homes with no view of the turbines. Specifically, the 25 homes with EXTREME views in the sample, where the home site is "unmistakably dominated by the [visual] presence of the turbines," are not found to have measurably different property values, and neither are the 31 homes with a SUBSTANTIAL view, where "the turbines are dramatically visible from the home."[104] The same finding holds for the 106 homes that were rated as having MODERATE views of the wind turbines. Moreover, the Orientation and Overlap Models show that neither the orientation of the home with respect to the view of wind turbines, nor the overlap of that view with the prominent scenic vista, have measurable impacts on home prices.

The All Sales Model compares homes with views of the turbines (in the post-construction period) to homes that sold before construction (when no views were possible), and finds no statistical evidence of adverse effects within any VIEW category. Moreover, when a *t*-Test is performed to compare the NO VIEW coefficient to the others, none of the coefficients for the VIEW ratings are found to be statistically different from the NO VIEW homes. The Repeat Sales Model comes to a similar result, with homes with MODERATE views appreciating at a rate that was not measurably different from that of homes with no views (0.03, *p* value 0.29). The same model also finds that homes with SUBSTANTIAL/EXTREME views appreciate at a rate 2% slower per year (*p* value 0.09) than their NO VIEW peers. Homes situated inside of one mile, however, are found to appreciate at a rate 3% more (*p* value 0.01) than reference homes located outside of five miles. Eight of the nine homes situated inside of one mile had either a SUBSTANTIAL or EXTREME view. Therefore, to correctly interpret these results, one would add the two coefficients for these homes, resulting in a combined 1% increase in appreciation as compared to the reference homes situated outside of five miles with no view of turbines, and again yielding no evidence of a Scenic Vista Stigma.

Although these results are consistent across most of the models, there are some individual coefficients from some models that differ. Specifically, homes with MINOR rated views in the Overlap and Repeat Sales Models are estimated to sell for 3% less (*p* value 0.10) and appreciate at a rate 2% less (*p* value 0.02) than NO VIEW homes. Taken at face value, these MINOR VIEW findings imply that homes where "turbines are visible, but, either the scope is narrow, there are many obstructions, or the distance between the home and the facility is large" are systematically impacted in a modest but measurable way. Homes with more dramatic views of a wind facility in the same models, on the other hand, are found to not be measurably affected. Because of the counterintuitive nature of this result, and because it is contradicted in the results of other models presented earlier, it is more likely that there is some aspect of these homes that was not modeled appropriately in the Overlap and Repeat Sales Models, and that the analysis is picking up the effect of omitted variable(s) rather than a systematic causal effect from the wind facilities.

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[104] See Section 3.2.3 and Appendix C for full description of VIEW ratings.

Taken together, the results from all of the models and all of the VIEW ratings support, to a large degree, the Base Model findings of no evidence of a Scenic Vista Stigma. Although there are 160 residential transactions in the sample with more dramatic views than MINOR, none of the model specifications is able to find any evidence that those views of wind turbines measurably impacted average sales prices, despite the fact that those same models consistently find that home buyers and sellers place value on the quality of the scenic vista.

8.3. Nuisance Stigma

Nuisance Stigma is defined as a concern that factors that may occur in close proximity to wind turbines, such as sound and shadow flicker, will have a unique adverse influence on home values. If these factors impact residential sales prices, those impacts are likely to be concentrated within a mile of the wind facilities. The Base, Distance Stability, Continuous Distance, All Sales, Temporal Aspects, Orientation, Overlap, Repeat Sales, and Sales Volume Models all investigate the possible presence of a Nuisance Stigma.

The Base Model finds that those homes within 3000 feet and those between 3000 feet and one mile of the nearest wind turbine sold for roughly 5% less than similar homes located more than five miles away, but that these differences are not statistically significant (*p* values of 0.40 and 0.30, respectively). These results remain unchanged in the Distance Stability Model, as well as in the Orientation and Overlap Models. Somewhat similarly, in the All Sales Model, when all transactions occurring after wind facility announcement are assumed to potentially be impacted (rather than just those occurring after construction, as in the Base Model), and a comparison is made to the average of all transactions occurring pre-announcement (rather than the average of all transactions outside of five miles, as in the Base Model), these same coefficients grow to -6% (*p* value 0.23) and -8% (*p* value 0.08) respectively. Although only one of these coefficients was statistically significant, they are large enough to warrant further scrutiny.

The Temporal Aspects Model provides a clearer picture of these findings. It finds that homes that sold prior to wind facility announcement and that were situated within one mile of where the turbines were eventually located sold, on average, for between 10% and 13% less than homes located more than five miles away and that sold in the same period. Therefore, the homes nearest the wind facility's eventual location were already depressed in value before the announcement of the facility. Most telling, however, is what occurred after construction. Homes inside of one mile are found to have inflation-adjusted sales prices that were either statistically undistinguishable from, or in some cases greater than, pre-announcement levels. Homes sold in the first two years after construction, for example, have higher prices (0.07, *p* value 0.32), as do those homes that sold between two and four years after construction (0.13, *p* value 0.06) and more than four years after construction (0.08, *p* value 0.24). In other words, there is no indication that these homes experienced a decrease in sales prices after wind facility construction began. Not only does this result fail to support the existence of a Nuisance Stigma, but it also indicates that the relatively large negative coefficients estimated in the Base and All Sales Models are likely caused by conditions that existed prior to wind facility construction and potentially prior to facility announcement.[105]

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[105] See footnote 82 on page 46 for a discussion of possible alternative explanations to this scenario.

These results are corroborated by the Continuous Distance Model, which finds no statistically significant relationship between an inverse DISTANCE function and sales prices (-0.01, sig 0.46). Similarly, in the Repeat Sales Model, homes within one mile of the nearest turbine are not found to be adversely affected; somewhat counter-intuitively, they are found to appreciate faster (0.03, *p* value 0.01) than their peers outside of five miles. Finally, the Sales Volume analysis does not find significant and consistent results that would suggest that the ability to sell one's home within one mile of a wind facility is substantially impacted by the presence of that facility.

Taken together, these models present a consistent set of results: the sales prices of homes in this sample that are within a mile of wind turbines, where various nuisance effects have been posited, are not measurably affected compared to those homes that are located more than five miles away from the facilities or that sold well before the wind projects were announced. These results imply that widespread Nuisance Stigma effects are either not present in the sample, or are too small or sporadic to be statistically identifiable.

Though these results may appear counterintuitive, it may simply be that property value impacts fade rapidly with distance, and that few of the homes in the sample are close enough to the subject wind facilities to be substantially impacted. As discussed earlier, studies of the property value impacts of high voltage transmission lines often find that effects fade towards zero at as little distance as 200 feet (see, e.g., Gallimore and Jayne, 1999; Watson, 2005). None of the homes in the present sample are closer than 800 feet to the nearest wind turbine, and all but eight homes are located outside of 1000 feet of the nearest turbine. It is therefore possible that, if any effects do exist, they exist at very close range to the turbines, and that those effects are simply not noticeable outside of 800 feet. Additionally, almost half of the homes in the sample that are located within a mile of the nearest turbine have either no view or a minor rated view of the wind facilities, and some high voltage transmission line (HVTL) studies have found a decrease in adverse effects if the towers are <u>not</u> visible (Des-Rosiers, 2002) and, similarly, decreases in annoyance with wind facility sounds if turbines cannot be seen (Pedersen and Waye, 2004). Finally, effects that existed soon after the announcement or construction of the wind facilities might have faded over time. More than half of the homes in the sample sold more than three years after the commencement of construction, while studies of HVTLs have repeatedly found that effects fade over time (Kroll and Priestley, 1992) and studies of attitudes towards wind turbines have found that such attitudes often improve after facility construction (Wolsink, 1989). Regardless of the explanation, the fact remains that, in this sizable sample of residential transactions, no persuasive evidence of a widespread Nuisance Stigma is found, and if these impacts do exist, they are either too small or too infrequent to result in any widespread and consistent statistically observable impact.

9. Conclusions

Though surveys generally show that public acceptance towards wind energy is high, a variety of concerns with wind development are often expressed at the local level. One such concern that is often raised in local siting and permitting processes is related to the potential impact of wind projects on the property values of nearby residences.

This report has investigated the potential impacts of wind power facilities on the sales prices of residential properties that are in proximity to and/or that have a view of those wind facilities. It builds and improve on the previous literature that has investigated these potential effects by collecting a large quantity of residential transaction data from communities surrounding a wide variety of wind power facilities, spread across multiple parts of the U.S. Each of the homes included in this analysis was visited to clearly determine the degree to which the wind facility was visible at the time of home sale and to collect other essential data. To frame the analysis, three potentially distinct impacts of wind facilities on property values are considered: Area, Scenic Vista, and Nuisance Stigma. To assess these potential impacts, the authors applied a base hedonic model, explored seven alternative hedonic models, conducted a repeat sales analysis, and evaluated possible impacts on sales volumes. The result is the most comprehensive and data-rich analysis to date on the potential impacts of wind projects on nearby property values.

Although each of the analysis techniques used in this report has strengths and weaknesses, the results are strongly consistent in that each model fails to uncover conclusive evidence of the presence of any of the three property value stigmas. Based on the data and analysis presented in this report, no evidence is found that home prices surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Although the analysis cannot dismiss the possibility that individual or small numbers of homes have been or could be negatively impacted, if these impacts do exist, they are either too small and/or too infrequent to result in any widespread and consistent statistically observable impact. Moreover, to the degree that homes in the present sample are similar to homes in other areas where wind development is occurring, the results herein are expected to be transferable.

Finally, although this work builds on the existing literature in a number of respects, there remain a number of areas for further research. The primary goal of subsequent research should be to concentrate on those homes located closest to wind facilities, where the least amount of data are available. Additional research of the nature reported in this paper could be pursued, but with a greater number of transactions, especially for homes particularly close to wind facilities. Further, it is conceivable that cumulative impacts might exist whereby communities that have seen repetitive development are affected uniquely, and these cumulative effects may be worth investigating. A more detailed analysis of sales volume impacts may also be fruitful, as would an assessment of the potential impact of wind facilities on the length of time homes are on the market in advance of an eventual sale. Finally, it would be useful to conduct a survey of those homeowners living close to existing wind facilities, and especially those residents who have bought and sold homes in proximity to wind facilities after facility construction, to assess their opinions on the impacts of wind project development on their home purchase and sales decisions.

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Appendix A: Study Area Descriptions

The analysis reported in the body of the report used data from ten different wind-project study areas, across nine different states and 14 counties, and surrounding 24 different wind facilities. Each of the study areas is unique, but as a group they provide a good representation of the range of wind facility sizes, hub heights, and locations of recent wind development activity in the U.S. (see Figure A - 1 and Table A - 1). This appendix describes each of the ten study areas, and provides the following information: a map of the study area; a description of the area; how the data were collected; statistics on home sales prices in the sample and census-reported home values for the towns, county, and state that encompass the area; data on the wind facilities contained within the study area; and frequency tables for the variables of interest (i.e., views of turbines, distance to nearest turbine ,and development period).

Figure A - 1: Map of Study Areas

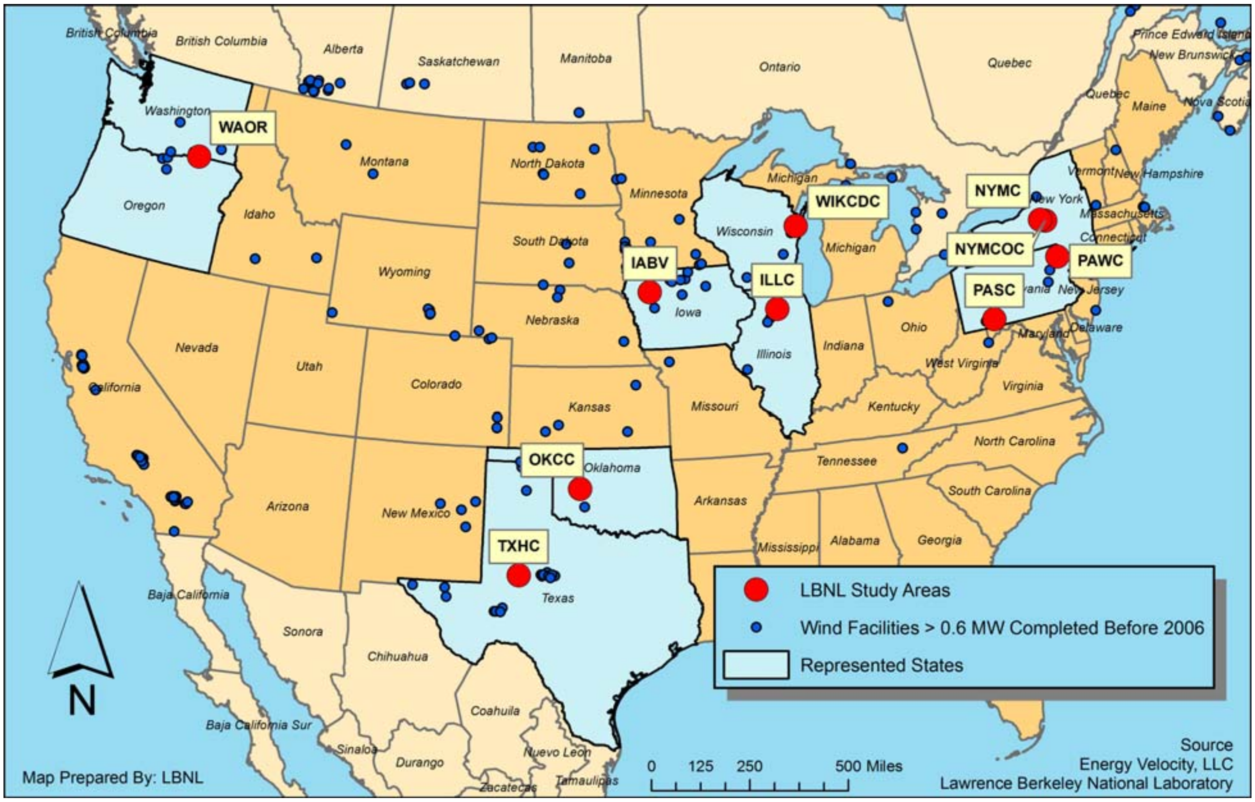
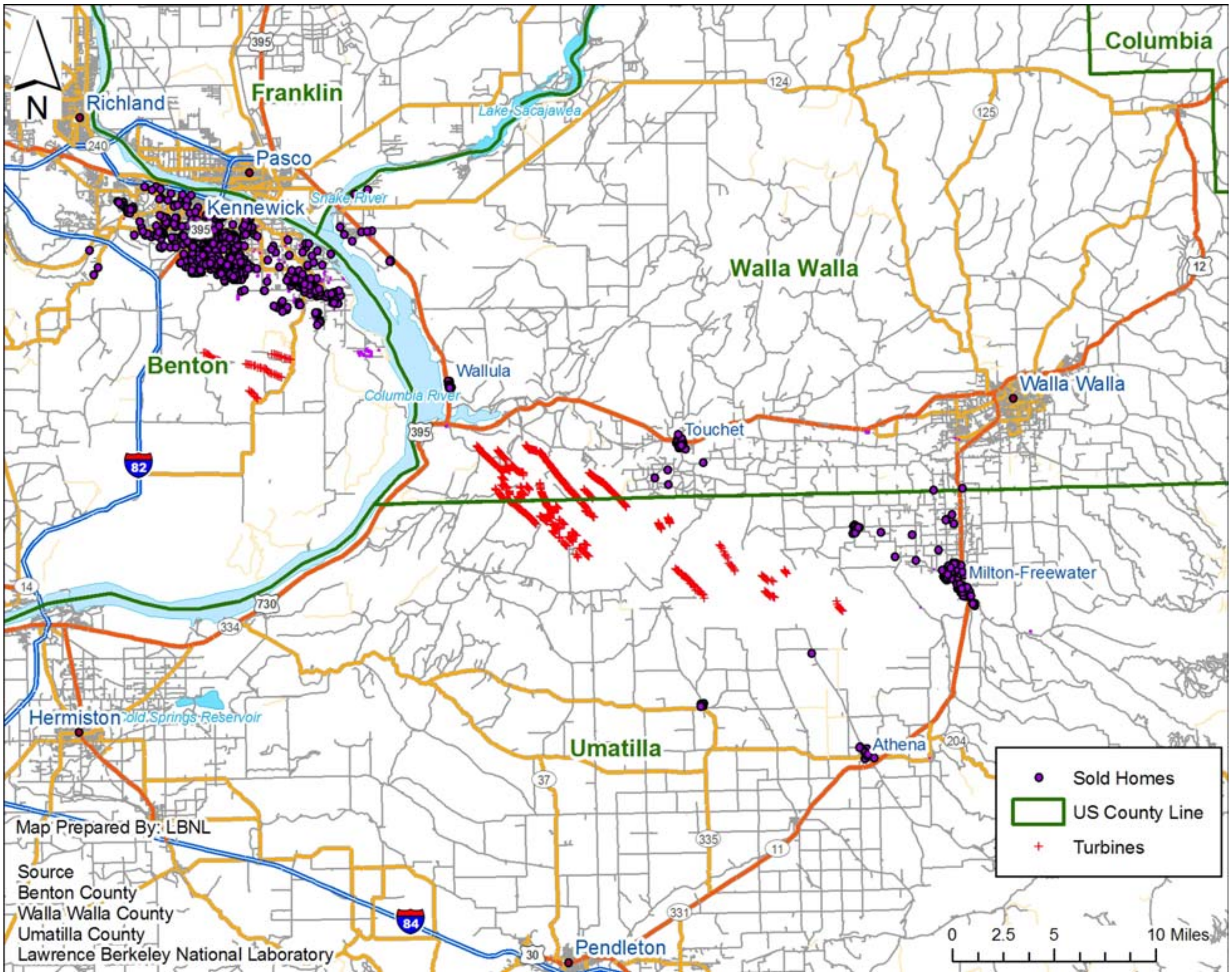


Table A - 1: Summary of Study Areas

Study Area Code	Study Area Counties, States	Facility Names	Number of Turbines	Number of MW	Max Hub Height (meters)	Max Hub Height (feet)
WAOR	Benton and Walla Walla Counties, WA and Umatilla County, OR	Vansycle Ridge, Stateline, Nine Canyon I & II, Combine Hills	582	429	60	197
TXHC	Howard County, TX	Big Spring I & II	46	34	80	262
OKCC	Custer County, OK	Weatherford I & II	98	147	80	262
IABV	Buena Vista County, IA	Storm Lake I & II, Waverly, Intrepid I & II	381	370	65	213
ILLC	Lee County, IL	Mendota Hills, GSG Wind	103	130	78	256
WIKCDC	Kewaunee and Door Counties, WI	Red River, Lincoln	31	20	65	213
PASC	Somerset County, PA	Green Mountain, Somerset, Meyersdale	34	49	80	262
PAWC	Wayne County, PA	Waymart	43	65	65	213
NYMCOC	Madison and Oneida Counties, NY	Madison	7	12	67	220
NYMC	Madison County, NY	Fenner	20	30	66	218
		TOTAL	**1345**	**1286**		

A.1 WAOR Study Area: Benton and Walla Walla Counties (Washington), and Umatilla County (Oregon)

Figure A - 2: Map of WAOR Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area combines data from the three counties - Benton and Walla Walla in Washington, and Umatilla in Oregon - that surround the Vansycle Ridge, Stateline, Combine Hills, and Nine Canyon wind projects. Wind development began in this area in 1997 and, within the sample of wind projects, continued through 2003. In total, the wind facilities in this study area include 582 turbines and 429 MW of nameplate capacity, with hub heights that range from 164 feet to almost 200 feet. The wind facilities are situated on an East-West ridge that straddles the Columbia River, as it briefly turns South. The area consists of undeveloped highland/plateau grassland, agricultural tracks for winter fruit, and three towns: Kennewick (Benton County), Milton-Freewater (Umatilla County), and Walla Walla (Walla Walla County). Only the first two of these towns are represented in the dataset because Walla Walla is situated more than 10 miles from the nearest wind turbine. Also in the area are Touchet and Wallula, WA, and Athena, OR, all very small communities with little to no services. Much of the area to the North and South of the ridge, and outside of the urban areas, is farmland, with homes situated on small parcels adjoining larger agricultural tracts.

Data Collection and Summary

Data for this study area were collected from a myriad of sources. For Benton County, sales and home characteristic data and GIS parcel shapefiles were collected with the assistance of county officials Eric Beswick, Harriet Mercer, and Florinda Paez, while state official Deb Mandeville (Washington Department of State) provided information on the validity of the sales. In Walla Walla County, county officials Bill Vollendorff and Tiffany Laposi provided sales, house characteristic, and GIS data. In Umatilla County, county officials Jason Nielsen, Tracie Diehl, and Tim McElrath provided sales, house characteristic, and GIS data.

Based on the data collection, more than 8,500 homes are found to have sold within ten miles of the wind turbines in this study area from January 1996 to June 2007. Completing field visits to this number of homes would have been overly burdensome; as a result, only a sample of these home sales was used for the study. Specifically, all valid sales within three miles of the nearest turbine are used, and a random sample of those homes outside of three miles but inside of five miles in Benton County and inside ten miles in Walla Walla and Umatilla Counties. This approach resulted in a total of 790 sales, with prices that ranged from $25,000 to $647,500, and a mean of $134,244. Of those 790 sales, 519 occurred after wind facility construction commenced, and 110 could see the turbines at the time of sale, though all but four of these homes had MINOR views. No homes within this sample were located within one mile of the nearest wind turbine, with the majority occurring outside of three miles.

Area Statistics

Study Period Begin	**Study Period End**	**Number of Sales**	**Median Price**	**Mean Price**	**Minimum Price**	**Maximum Price**
1/23/1996	6/29/2007	790	$ 125,803	$ 134,244	$ 25,000	$ 647,500

Facility Statistics

Facility Name	**Number of MW**	**Number of Turbines**	**Announce Date**	**Construction Begin Date**	**Completion Date**	**Turbine Maker**	**Hub Height (Meters)**
Vansycle Ridge	25	38	Aug-97	Feb-98	Aug-98	Vestas	50
Stateline Wind Project, Phase I (OR)	83	126	Jun-00	Sep-01	Dec-01	Vestas	50
Stateline Wind Project, Phase I (WA)	177	268	Jun-00	Feb-01	Dec-01	Vestas	50
Stateline Wind Project, Phase II	40	60	Jan-02	Sep-02	Dec-02	Vestas	50
Nine Canyon Wind Farm	48	37	Jun-01	Mar-02	Sep-02	Bonus	60
Combine Hills Turbine Ranch I	41	41	Apr-02	Aug-03	Dec-03	Mitsubishi	55
Nine Canyon Wind Farm II	16	12	Jun-01	Jun-03	Dec-03	Bonus	60

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	**226**	**45**	**76**	**59**	**384**	**790**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	**271**	**409**	**106**	**4**	**0**	**0**	**790**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Benton/Walla Walla, WA & Umatilla, OR (WAOR)	**271**	**0**	**0**	**20**	**277**	**222**	**790**

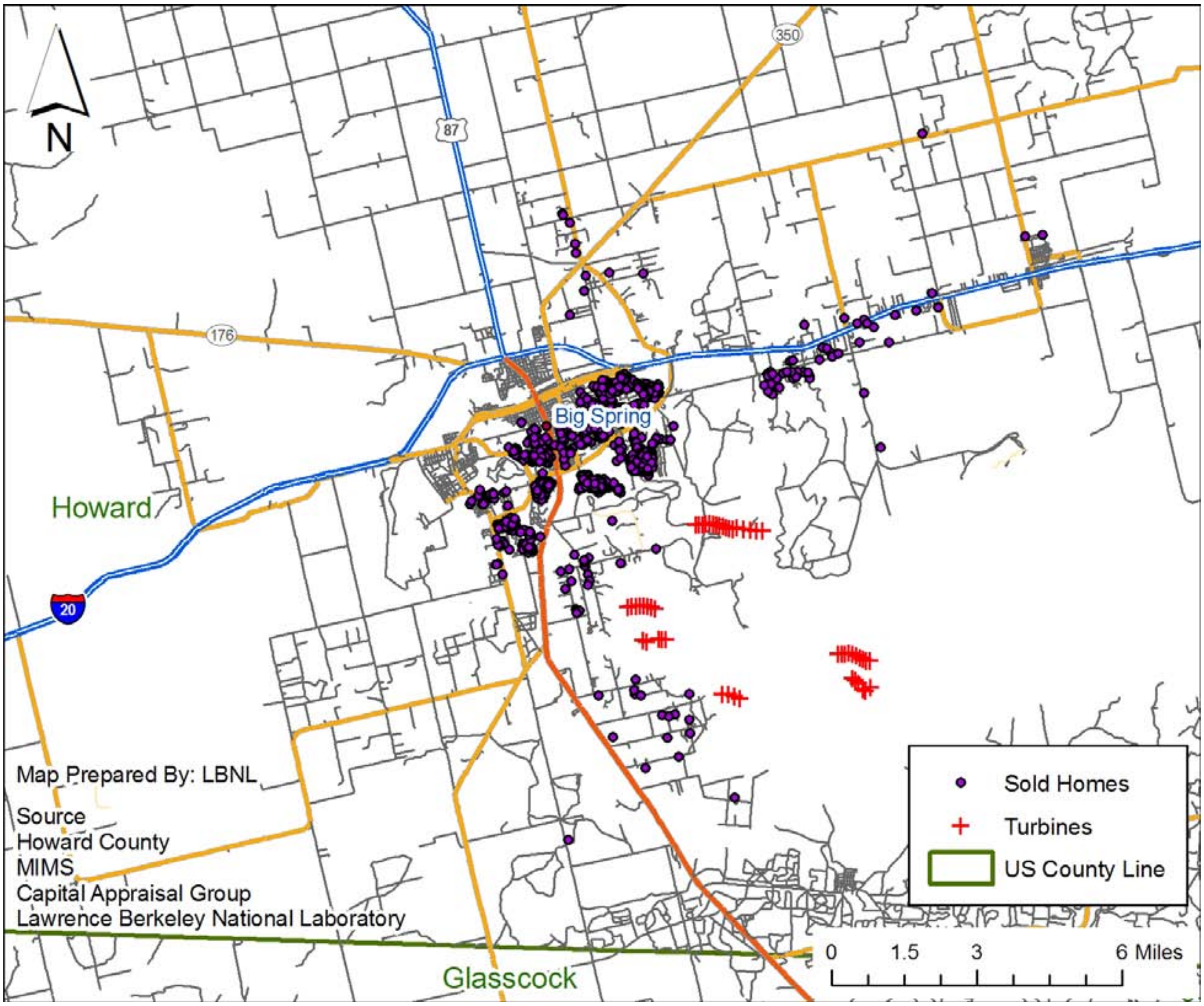
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Kennewich, WA	City	62,182	12.5%	2,711	32.3	$ 45,085	$ 155,531	46%
Walla Walla, WA	City	30,794	4.0%	2,847	33.8	$ 38,391	$ 185,706	91%
Milton Freewater, OR	Town	6,335	-2.0%	3,362	31.7	$ 30,229	$ 113,647	47%
Touchet, WA	Town	413	n/a	340	33.6	$ 47,268	$ 163,790	81%
Benton	County	159,414	3.6%	94	34.4	$ 51,464	$ 162,700	46%
Walla Walla	County	57,709	1.0%	45	34.9	$ 43,597	$ 206,631	89%
Umatilla	County	73,491	0.6%	23	34.6	$ 38,631	$ 138,200	47%
Washington	State	6,488,000	10.1%	89	35.3	$ 55,591	$ 300,800	79%
Oregon	State	3,747,455	9.5%	36	36.3	$ 48,730	$ 257,300	69%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.2 TXHC Study Area: Howard County (Texas)

Figure A - 3: Map of TXHC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area is entirely contained within Howard County, Texas, and includes the city of Big Spring, which is situated roughly 100 miles South of Lubbock and 275 miles West of Dallas in West Texas. On top of the Northern end of the Edwards Plateau, which runs from the Southeast to the Northwest, sits the 46 turbine (34 MW) Big Spring wind facility, which was constructed in 1998 and 1999. Most of the wind turbines in this project have a hub height of 213 feet, but four are taller, at 262 feet. The plateau and the wind facility overlook the city of Big Spring which, when including its suburbs, wraps around the plateau to the South and East. Surrounding the town are modest farming tracks and arid, undeveloped land. These lands, primarily to the South of the facility towards Forsan (not shown on map), are dotted with small oil rigs. Many of the homes in Big Spring do not have a view of the wind facility, but others to the South and East do have such views.

Data Collection and Summary

County officials Brett McKibben, Sally Munoz, and Sheri Proctor were extremely helpful in answering questions about the data required for this project, and the data were provided by two firms that manage it for the county. Specifically, Erin Welch of the Capital Appraisal Group provided the sales and house characteristic data and Paul Brandt of MIMS provided the GIS data.

All valid single-family home sales transactions within five miles of the nearest turbine and occurring between January 1996 and March 2007 were included in the dataset, resulting in 1,311 sales.[106] These sales ranged in price from $10,492 to $490,000, with a mean of $74,092. Because of the age of the wind facility, many of the sales in the sample occurred after wind facility construction had commenced (*n* = 1,071). Of those, 104 had views of the turbines, with 27 having views more dramatic than MINOR. Four homes sold within a mile of the facility, with the rest falling between one and three miles (*n* = 584), three to five miles (*n* = 467), and outside of five miles (*n* = 16).

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/2/1996	3/30/2007	1,311	$66,500	$74,092	$10,492	$490,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Big Spring I	27.7	42	Jan-98	Jul-98	Jun-99	Vestas	65
Big Spring II	6.6	4	Jan-98	Jul-98	Jun-99	Vestas	80

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Howard, TX (TXHC)	**169**	**71**	**113**	**131**	**827**	**1311**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Howard, TX (TXHC)	**240**	**967**	**77**	**22**	**5**	**0**	**1311**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Howard, TX (TXHC)	**240**	**0**	**4**	**584**	**467**	**16**	**1311**

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[106] If parcels intersected the five mile boundary, they were included in the sample, but were coded as being outside of five miles.

Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Big Spring	City	24,075	-5.4%	1,260	35.1	$ 32,470	$ 54,442	50%
Forsan	Town	220	-4.0%	758	36.8	$ 50,219	$ 64,277	84%
Howard	County	32,295	-1.9%	36	36.4	$ 36,684	$ 60,658	58%
Texas	State	23,904,380	14.6%	80	32.3	$ 47,548	$ 120,900	47%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

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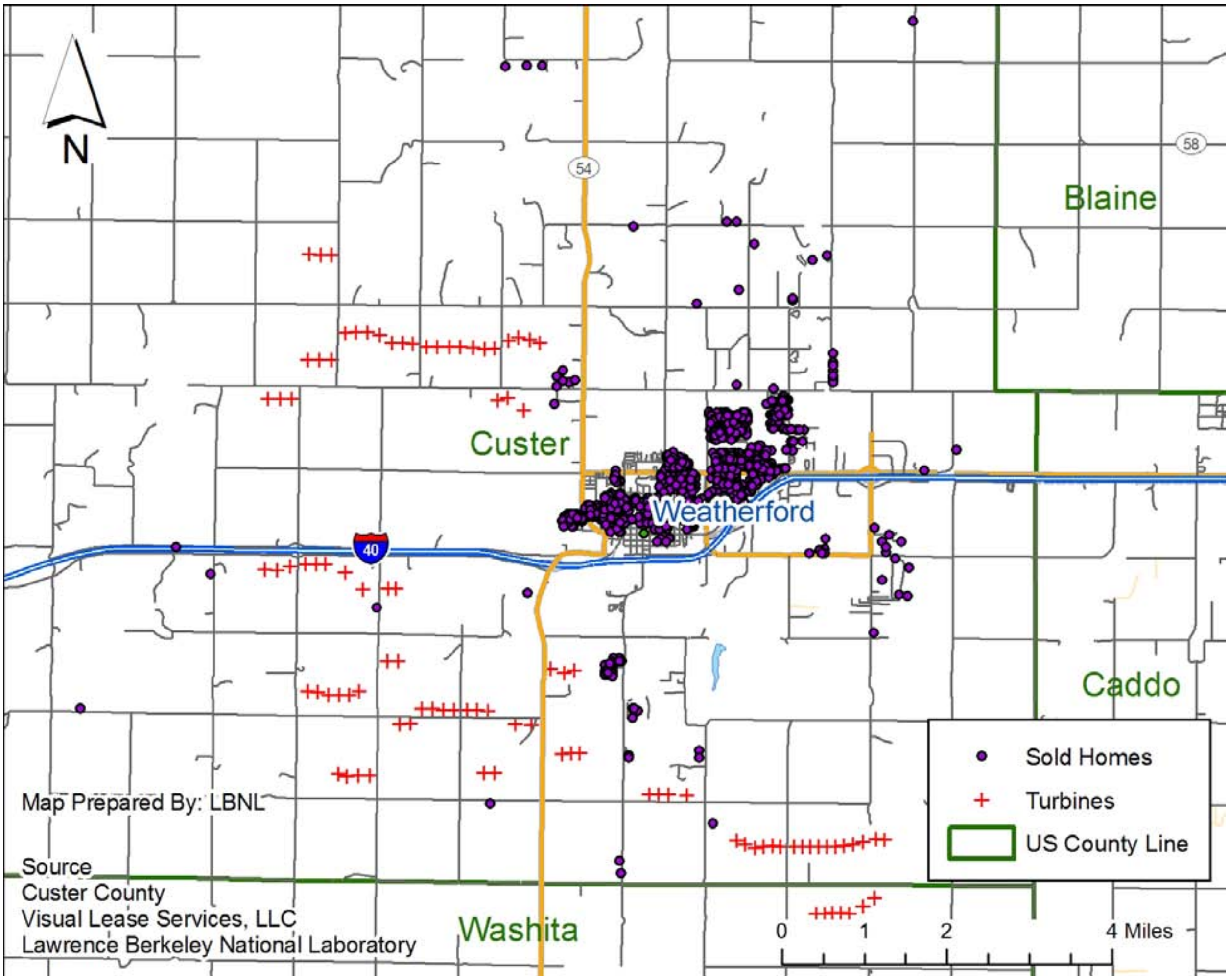
A.3 OKCC Study Area: Custer County (Oklahoma)

Figure A - 4: Map of OKCC Study Area



Map Prepared By: LBNL

Source
Custer County
Visual Lease Services, LLC
Lawrence Berkeley National Laboratory

Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>
This study area is entirely contained within Custer County, Texas, and includes the Weatherford wind facility, which is situated near the city of Weatherford, 70 miles due west of Oklahoma City and near the western edge of the state. The 98 turbine (147 MW) Weatherford wind facility straddles Highway 40, which runs East-West, and U.S. County Route 54, which runs North-South, creating an "L" shape that is more than six miles long and six miles wide. Development began in 2004, and was completed in two phases ending in 2006. The turbines are some of the largest in the sample, with a hub height of 262 feet. The topography of the study area is mostly flat plateau, allowing the turbines to be visible from many parts of the town and the surrounding rural lands. There are a number of smaller groupings of homes that are situated to the North and South of the city, many of which are extremely close to the turbines and have dramatic views of them.

Data Collection and Summary

County Assessor Debbie Collins and mapping specialist Karen Owen were extremely helpful in gathering data and answering questions at the county level. Data were obtained directly from the county and from Visual Lease Services, Inc and OKAssessor, where representatives Chris Mask, Terry Wood, Tracy Leniger, and Heather Brown helped with the request.

All valid single-family residential transactions within five miles of the nearest wind turbine and occurring between July 1996 and June 2007 were included in the dataset, resulting in 1,113 sales.[107] These sales ranged in price from $11,000 to $468,000, with a mean of $100,445. Because of the relatively recent construction of the facility, 58% of the sales (*n* = 637) occurred before construction, leaving 476 sales with possible views of the turbines. Of those 476 sales, 25 had more-dramatic view ratings than MINOR and 17 sales occurred inside of one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
7/7/1996	6/29/2007	1,113	$91,000	$100,445	$11,000	$468,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Weatherford Wind Energy Center	106.5	71	Mar-04	Dec-04	May-05	GE Wind	80
Weatherford Wind Energy Center Expansion	40.5	27	May-05	Oct-05	Jan-06	GE Wind	80

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Custer, OK (OKCC)	**484**	**153**	**193**	**187**	**96**	**1113**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Custer, OK (OKCC)	**637**	**375**	**76**	**6**	**7**	**12**	**1113**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Custer, OK (OKCC)	**637**	**16**	**1**	**408**	**50**	**1**	**1113**

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[107] Portions of the town of Weatherford, both North and South of the town center, were not included in the sample due to lack of available data. The homes that were mapped, and for which electronic data were provided, however, were situated on all sides of these unmapped areas and were similar in character to those that were omitted. None of the unmapped homes were within a mile of the nearest wind turbine.

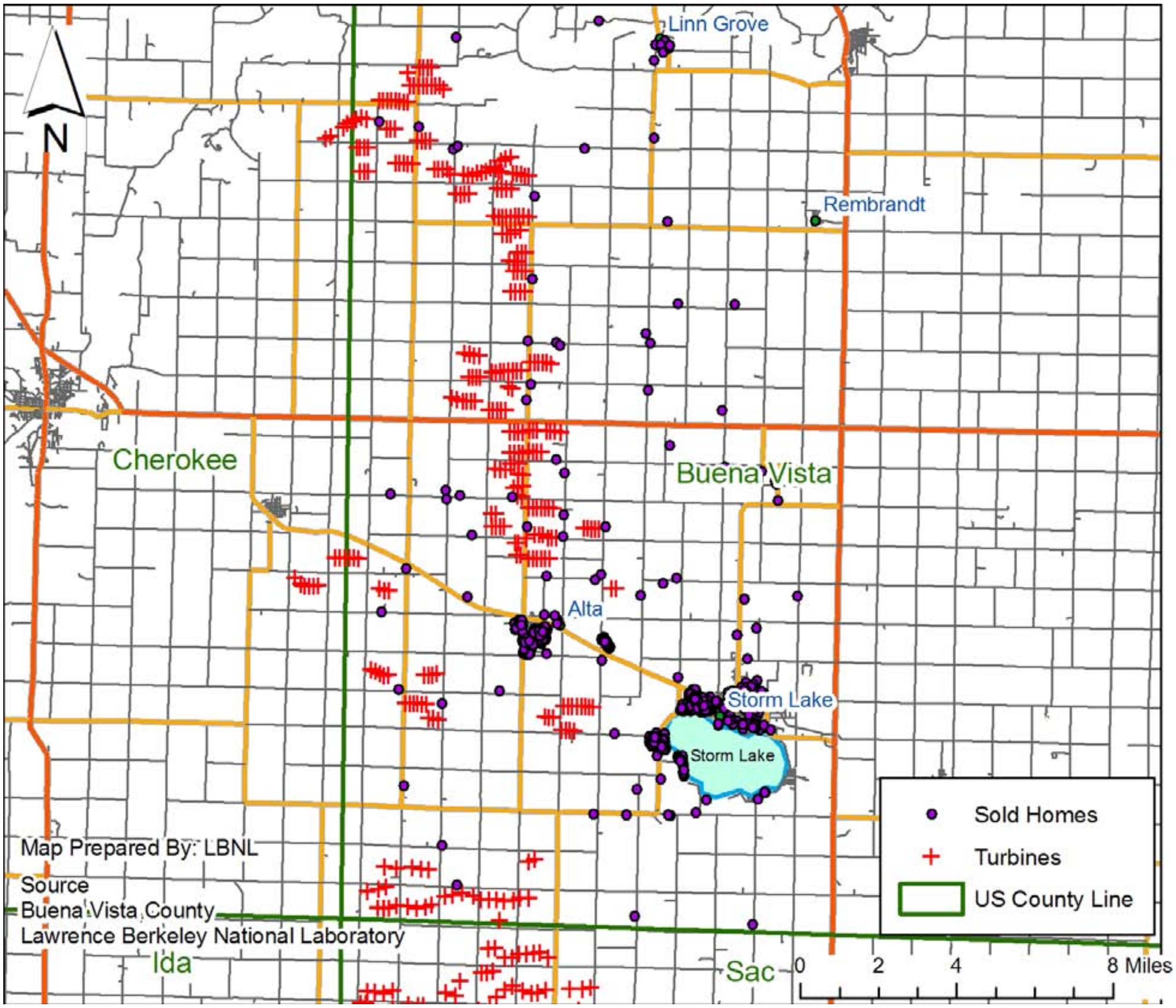
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Weatherford	City	10,097	1.2%	1,740	24.1	$ 32,543	$ 113,996	45%
Hydro	Town	1,013	-3.7%	1,675	39.2	$ 35,958	$ 66,365	68%
Custer	County	26,111	3.6%	26	32.7	$ 35,498	$ 98,949	52%
Oklahoma	State	3,617,316	4.8%	53	35.5	$ 41,567	$ 103,000	46%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

A.4 IABV Study Area: Buena Vista County (Iowa)

Figure A - 5: Map of IABV Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area includes the sizable Storm Lake and Intrepid wind facilities, which are mostly situated in Buena Vista County, located in Northwestern Iowa, 75 miles East of Sioux City. The facilities also stretch into Sac County to the South and Cherokee County to the West. The facilities total 381 turbines (370 MW) and are more than 30 miles long North to South and eight miles wide East to West. Development began on the first Storm Lake facility in 1998 and the last of the Intrepid development was completed in 2006. The largest turbines have a hub height of 213 feet at the hub, but most are slightly smaller at 207 feet. The majority of the homes in the sample surround Storm Lake (the body of water), but a large number of homes are situated on small residential plots located outside of the town and nearer to the wind facility. Additionally, a number of sales occurred in Alta - a small town to the East of Storm Lake -thatis straddled by the wind facilities and therefore provides dramatic views of the turbines. In general, except for the depression in which Storm Lake sits, the topography is very flat, largely made up corn fields, and the turbines are therefore visible from quite far away. The housing market is driven, to some extent, by the water body, Storm Lake, which is a popular recreational tourist destination, and therefore development is occurring to the East and South of the lake. Some development is also occurring, to a lesser degree, to the East of Alta.

Data Collection and Summary

County Assessor Kathy A. Croker and Deputy Assessor Kim Carnine were both extremely helpful in answering questions and providing GIS data. Sales and home characteristic data were provided by Vanguard Appraisals, Inc., facilitated by the county officials. David Healy from MidAmerican provided some of the necessary turbine location GIS files.

The county provided data on valid single-family residential transactions between 1996 and 2007 for 1,743 homes inside of five miles of the nearest wind turbine. This sample exceeded the number for which field data could reasonably be collected; as a result, only a sample of these homes sales was used for the study. Specifically, all transactions that occurred within three miles of the nearest turbine were used, in combination with a random sample (totaling roughly 10%) of those homes between three and five miles. This approach resulted in 822 sales, with prices that ranged from $12,000 to $525,000, and a mean of $94,713. Development of the wind facilities in this area occurred relatively early in the sample period, and therefore roughly 75% of the sales (*n* = 605) occurred after project construction had commenced. Of those 605 sales, 105 had views of the turbines, 37 of which were ranked with a view rating more dramatic than MINOR, and 30 sales occurred within one mile of the nearest wind turbine.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/2/1996	3/30/2007	822	$79,000	$94,713	$12,000	$525,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Storm Lake I	112.5	150	Feb-98	Oct-98	Jun-99	Enron	63
Storm Lake II	80.3	107	Feb-98	Oct-98	Apr-99	Enron	63
Waverly	1.5	2	Feb-98	Oct-98	Jun-99	Enron	65
Intrepid	160.5	107	Mar-03	Oct-04	Dec-04	GE Wind	65
Intrepid Expansion	15.0	15	Jan-05	Apr-05	Dec-05	Mitsubishi	65

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Buena Vista, IA (IABV)	152	65	80	70	455	822

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Buena Vista, IA (IABV)	217	500	68	18	8	11	822

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Buena Vista, IA (IABV)	217	22	8	472	101	2	822

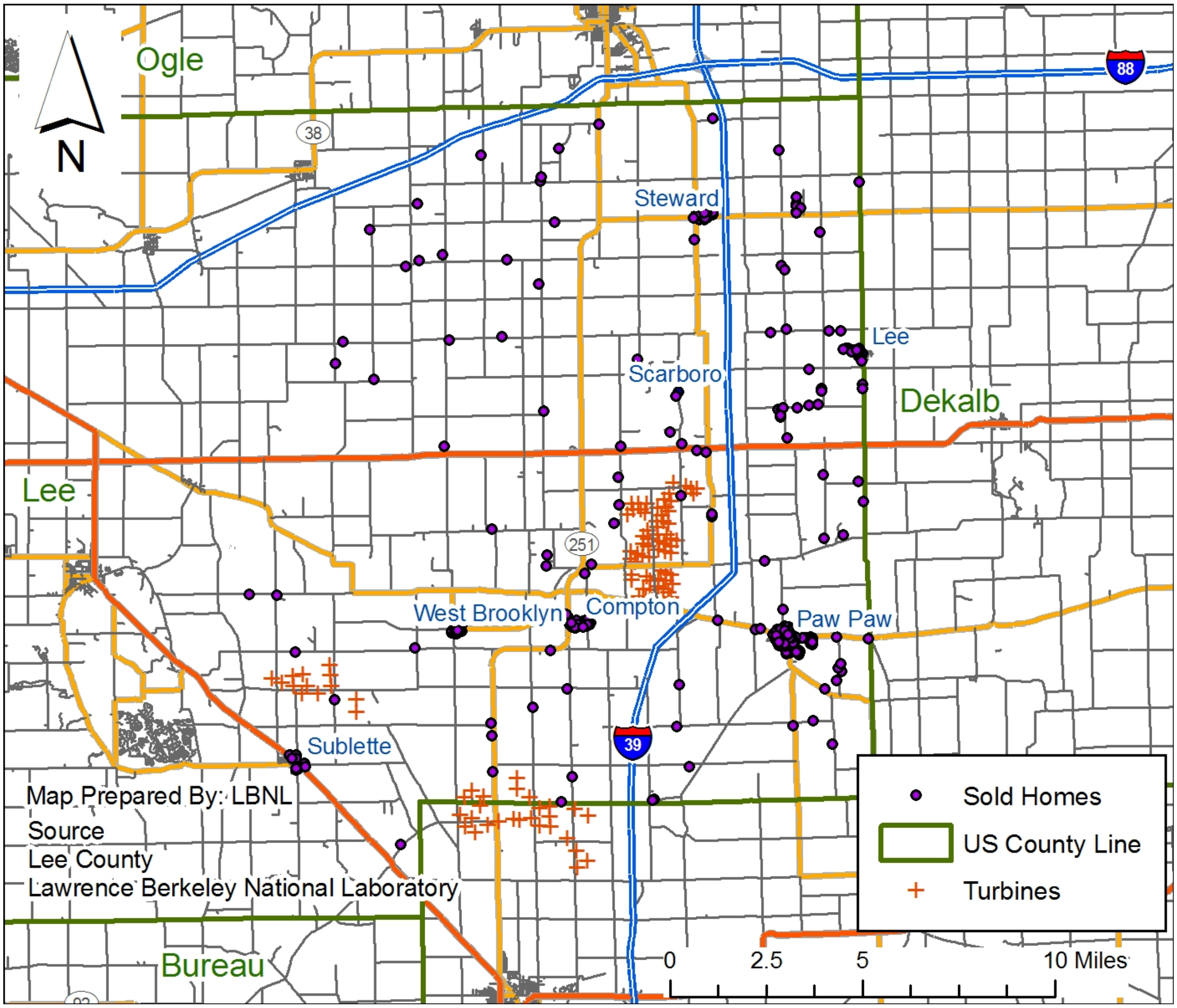
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Storm Lake	City	9,706	-3.9%	2,429	31.7	$ 39,937	$ 99,312	41%
Alta	Town	1,850	-1.0%	1,766	35.1	$ 40,939	$ 98,843	48%
Buena Vista	County	19,776	-3.1%	36	36.4	$ 42,296	$ 95,437	45%
Iowa	State	3,002,555	2.6%	52	36.6	$ 47,292	$ 117,900	43%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. “% Change Since 2000” refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). “Town” signifies any municipality with less than 10,000 inhabitants.

A.5 ILLC Study Area: Lee County (Illinois)

Figure A - 6: Map of ILLC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area is situated roughly 80 miles due West of Chicago, in Lee County, Illinois, and includes two wind facilities. The 63 turbine (53 MW) Mendota Hills Wind Project sits just West of North-South Highway 39, and 10 miles South of East-West Highway 88. Development began on the facility in 2001 and was completed in 2003. The second facility, the 40 turbine (80 MW) GSG Wind Farm is South and West of the Mendota Hills facility, and is broken into two parts: roughly one third of the turbines are situated two miles due north of the small town of Sublette, with the remainder located roughly six miles to the southeast and spanning the line separating Lee from La Salle County. Development began on this project in the fall of 2006 and was completed in April of the following year. The town of Paw Paw, which is East of Highway 38 and both facilities, is the largest urban area in the study area, but is further away from the facilities than the towns of Compton, West Brooklyn, Scarboro, and Sublette. Also, to the North of the facilities are the towns of Lee, to the East of Highway 38, and Steward, just to the West. Although many home sales occurred in these towns, a significant number of additional sales occurred on small residential tracts in more-rural areas or in small developments. The topography of the area is largely flat, but falls away slightly to the East towards Paw Paw. The area enjoyed significant development during the real estate boom led by commuters from the Chicago metropolitan area, which was focused in the Paw Paw area but was also seen in semi-rural subdivisions to the Southwest and North of the wind facility.

Data Collection and Summary

County Supervisor Wendy Ryerson was enormously helpful in answering questions and providing data, as were Carmen Bollman and GIS Director, Brant Scheidecker, who also work in the county office. Wendy and Carmen facilitated the sales and home characteristic data request and Brant provided the GIS data. Additionally, real estate brokers Neva Grevengoed of LNG Realtor, Alisa Stewart of AC Corner Stone, and Beth Einsely of Einsely Real Estate were helpful in understanding the local market.

The county provided information on 412 valid single-family transactions that occurred between 1998 and 2007 within 10 miles of the nearest wind turbine, all of which were included in the sample.[108] These sales ranged in price from $14,500 to $554,148, with a mean of $128,301. Of those sales, 213 occurred after construction commenced on the wind facility and, of those, 36 had views of the turbines – nine of which were rated more dramatically than MINOR. Only two sales occurred within one mile of the nearest wind turbine.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
5/1/1998	3/2/2007	412	$113,250	$128,301	$14,500	$554,148

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Mendota Hills	50.4	63	Nov-01	Aug-03	Nov-03	Gamesa	65
GSG Wind Farm	80	40	Dec-05	Sep-06	Apr-07	Gamesa	78

Source: AWEA & Ventyx Inc.

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[108] This county was not able to provide data electronically back to 1996, as would have been preferred, but because wind project development did not occur until 2001, there was ample time in the study period to establish pre-announcement sale price levels.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Lee, IL (ILLC)	**115**	**84**	**62**	**71**	**80**	**412**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Lee, IL (ILLC)	**199**	**177**	**27**	**7**	**1**	**1**	**412**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Lee, IL (ILLC)	**199**	**1**	**1**	**85**	**69**	**57**	**412**

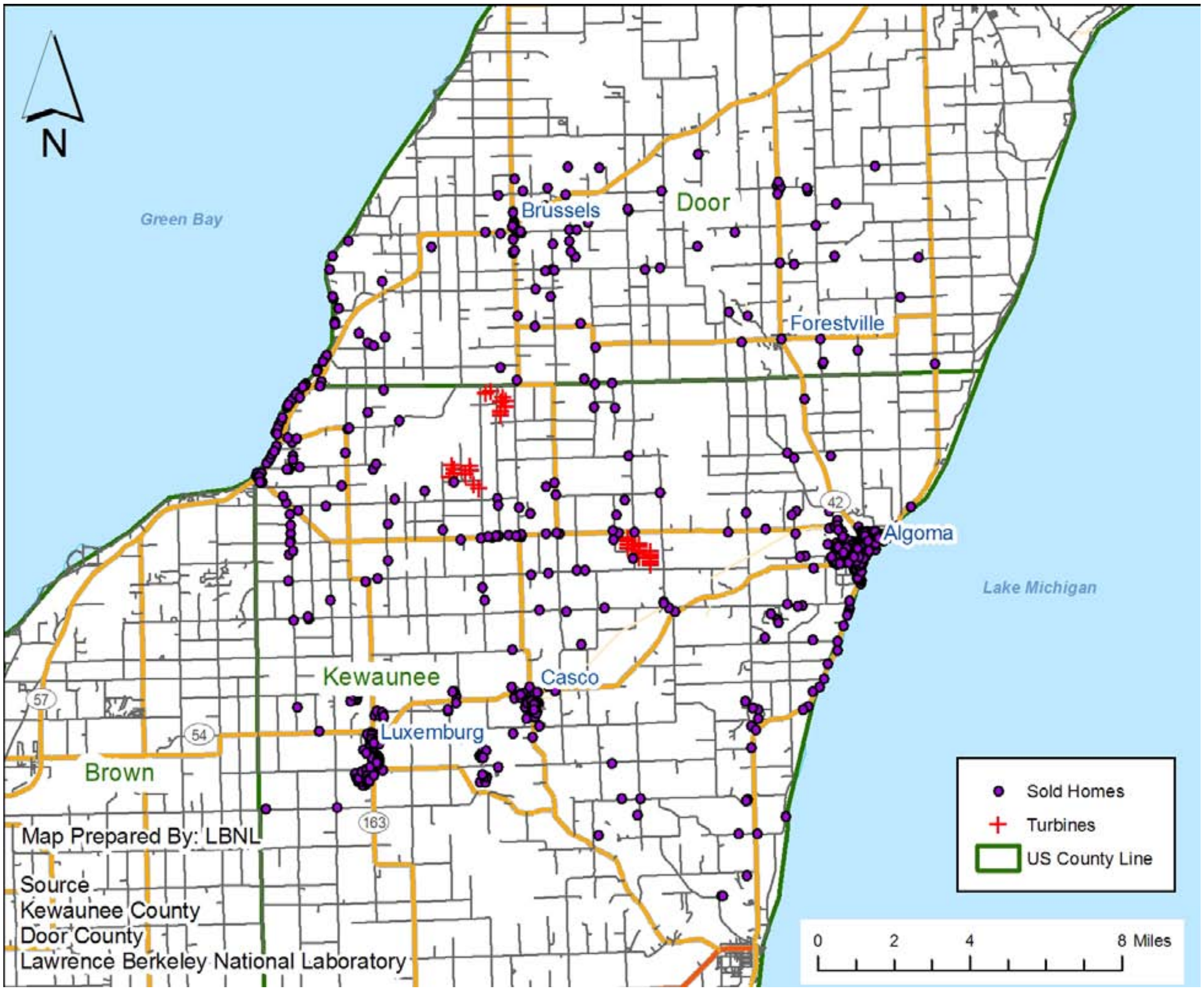
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Paw Paw	Town	884	2.6%	1,563	38.0	$ 48,399	$ 151,954	n/a
Compton	Town	337	-2.9%	2,032	32.8	$ 44,023	$ 114,374	n/a
Steward	Town	263	-3.0%	2,116	35.2	$ 59,361	$ 151,791	n/a
Sublette	Town	445	-2.4%	1,272	37.7	$ 55,910	$ 133,328	n/a
Lee	County	35,450	-1.7%	49	37.9	$ 47,591	$ 136,778	64%
Illinois	State	12,852,548	3.5%	223	34.7	$ 54,124	$ 208,800	60%
US	Country	301,139,947	7.0%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.6 WIKCDC Study Area: Kewaunee and Door Counties (Wisconsin)

Figure A - 7: Map of WIKCDC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area includes the Red River (17 turbines, 14 MW) and Lincoln (14 turbines, 9 MW) wind facilities. It is situated on the "thumb" jutting into Lake Michigan, Northeast of Green Bay, Wisconsin, and spans two counties, Kewaunee and Door. There is a mix of agricultural, small rural residential, waterfront, and urban land use in this area. The three largest towns are Algoma to the East of the facilities and on the lake, Casco, which is six miles due South of the turbines, and Luxemburg, four miles West of Casco. There is a smaller village, Brussels, to the North in Door County. The remainder of the homes is situated on the water or in small rural residential parcels between the towns. Topographically, the "thumb" is relatively flat except for a slight crown in the middle, and then drifting lower to the edges. The East edge of the "thumb" ends in bluffs over the water, and the western edge drops off more gradually, allowing those parcels to enjoy small beaches and easy boat access. There is some undulation of the land, occasionally allowing for relatively distant views of the wind turbines, which stand at a hub height of 213 feet.

Data Collection and Summary

Kewaunee and Door Counties did not have a countywide system of electronic data storage for either sales or home characteristic data. Therefore, in many cases, data had to be collected directly from the town or city assessor. In Kewaunee County, Joseph A. Jerabek of the town of Lincoln, Gary Taicher of the town of Red River, Melissa Daron of the towns of Casco, Pierce, and West Kewaunee, Michael Muelver of the town of Ahnapee and the city of Algoma, William Gerrits of the town of Casco, Joseph Griesbach Jr. of the town of Luxemburg, and David Dorschner of the city of Kewaunee all provided information. In Door County, Scott Tennessen of the town of Union and Gary Maccoux of the town of Brussels were similarly very helpful in providing information. Additionally, Andy Pelkey of Impact Consultants, Inc., John Holton of Associated Appraisal Consultants, Andy Bayliss of Dash Development Group, and Lue Van Asten of Action Appraisers & Consultants all assisted in extracting data from the myriad of storage systems used at the town and city level. The State of Wisconsin provided additional information on older sales and sales validity, with Mary Gawryleski, James Bender, and Patrick Strabala from the Wisconsin Department of Revenue being extremely helpful. GIS data were obtained from Steve Hanson from Kewaunee County and Tom Haight from Door County.

After collecting data from each municipality, a total of 810 valid single-family home sales transactions were available for analysis, ranging in time from 1996 to 2007. These sales ranged in price from $20,000 to $780,000, with a mean of $116,698. Because development of the wind facilities occurred relatively early in the study period, a large majority of the sales transactions, 75% (*n* = 725), occurred after project construction had commenced. Of those, 64 had views of the turbines, 14 of which had more dramatic than MINOR views, and 11 sales occurred within one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
2/2/1996	6/30/2007	810	$98,000	$116,698	$20,000	$780,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Red River	11.2	17	Apr-98	Jan-99	Jun-99	Vestas	65
Lincoln	9.2	14	Aug-98	Jan-99	Jun-99	Vestas	65

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Kewaunee/Door, WI (WIKCDC)	**44**	**41**	**68**	**62**	**595**	**810**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Kewaunee/Door, WI (WIKCDC)	**85**	**661**	**50**	**9**	**2**	**3**	**810**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Kewaunee/Door, WI (WIKCDC)	**85**	**7**	**4**	**63**	**213**	**438**	**810**

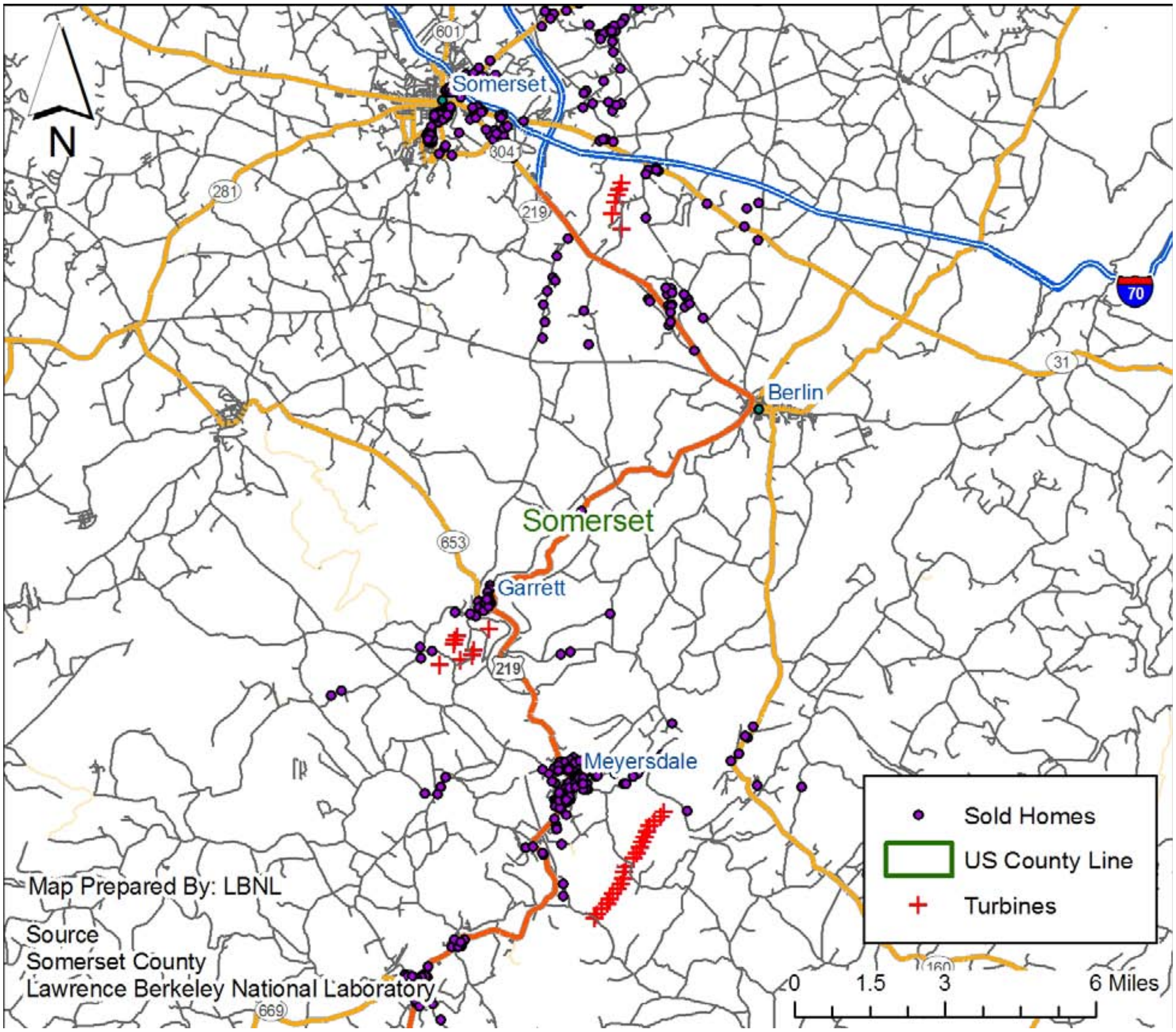
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Algoma	Town	3,186	-4.7%	1,305	41.8	$ 39,344	$ 112,295	51%
Casco	Town	551	-2.8%	985	35.6	$ 53,406	$ 141,281	n/a
Luxemburg	Town	2,224	15.3%	1,076	32.0	$ 53,906	$ 167,403	n/a
Kewaunee	County	20,533	1.4%	60	37.5	$ 50,616	$ 148,344	57%
Door	County	27,811	2.4%	58	42.9	$ 44,828	$ 193,540	57%
Wisconsin	State	5,601,640	0.3%	103	36.0	$ 50,578	$ 168,800	50%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.7 PASC Study Area: Somerset County (Pennsylvania)

Figure A - 8: Map of PASC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area includes three wind facilities, Somerset (6 turbines, 9 MW, 210 ft hub height) to the North, Meyersdale (20 turbines, 30 MW, 262 ft hub height) to the South, and Green Mountain (8 turbines, 10 MW, 197 ft hub height) between them. All of the projects are located in Somerset County, roughly 75 miles southeast of Pittsburg in the Southwest section of Pennsylvania. None of the three facilities are separated by more than 10 miles, so all were included in one study area. To the North of the facilities is East-West U.S. Highway 70, which flanks the city of Somerset. Connecting Somerset with points South is County Route 219, which zigzags Southeast out of Somerset to the smaller towns of Berlin (not included in the data), Garret to the Southwest, and Meyersdale, which is Southeast of Garret. These towns are flanked by two ridges that run from the Southwest to the Northeast. Because of these ridges and the relatively high elevations of all of the towns, this area enjoys winter recreation, though the coal industry, which once dominated the area, is still an integral part of the community with mining occurring in many places up and down the ridges. Although many of the home sales in the sample occurred in the towns, a number of the sales are for homes situated outside of town corresponding to either rural, rural residential, or suburban land uses.

Data Collection and Summary

The County Assessor, Jane Risso, was extremely helpful, and assisted in providing sales and home characteristic data. Glen Wagner, the IT director, worked with Gary Zigler, the county GIS specialist, to extract both GIS and assessment data from the county records. Both Gary and Jane were extremely helpful in fielding questions and providing additional information as needs arose.

The county provided a total of 742 valid residential single-family home sales transactions within four miles of the nearest wind turbine. All of the sales within three miles were used (*n* = 296), and a random sample (~ 44%) of those between three and four miles were used, yielding a total of 494 sales that occurred between May 1997 and March 2007. These sales ranged in price from $12,000 to $360,000, with a mean of $69,770. 291 sales (~ 60% of the 494) occurred after construction commenced on the nearest wind facility. Of these 291 sales, 73 have views of the turbines, 18 of which are more dramatic than MINOR, and 35 sales occurred within one mile.[109]

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
5/1/1997	3/1/2007	494	$62,000	$69,770	$12,000	$360,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
GreenMountain Wind Farm	10.4	8	Jun-99	Dec-99	May-00	Nordex	60
Somerset	9.0	6	Apr-01	Jun-01	Oct-01	Enron	64
Meyersdale	30.0	20	Jan-03	Sep-03	Dec-03	NEG Mico	80

Source: AWEA & Ventyx Inc.

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[109] This study area was one of the earliest to have field work completed, and therefore the field data collection process was slower resulting in a lower number of transactions than many other study areas.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Somerset, PA (PASC)	**175**	**28**	**46**	**60**	**185**	**494**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Somerset, PA (PASC)	**203**	**218**	**55**	**15**	**2**	**1**	**494**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Somerset, PA (PASC)	**203**	**17**	**18**	**132**	**124**	**0**	**494**

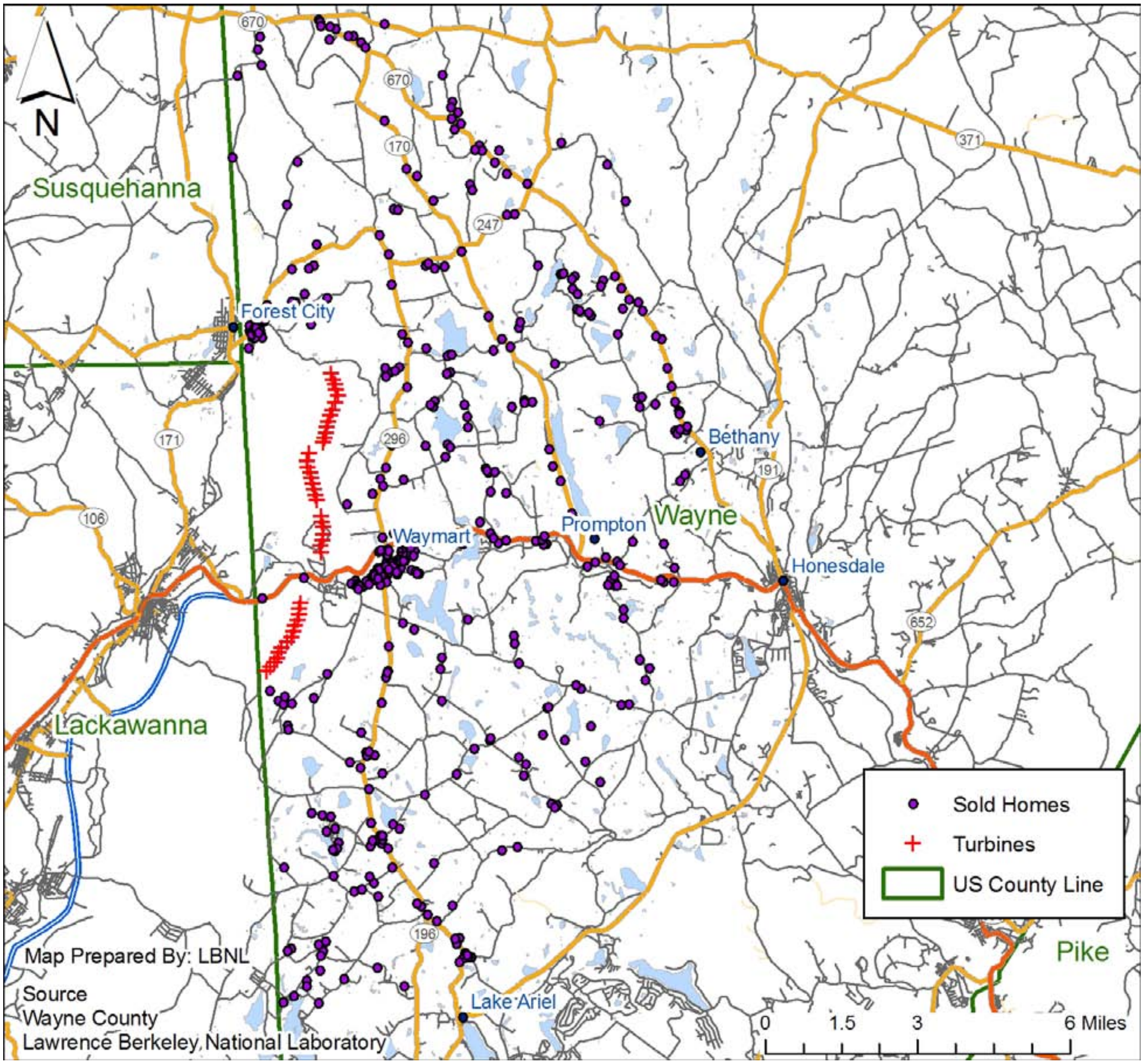
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Somerset	Town	6,398	-4.8%	2,333	40.2	$ 35,293	$ 123,175	n/a
Berlin	Town	2,092	-4.0%	2,310	41.1	$ 35,498	$ 101,704	n/a
Garrett	Town	425	-4.7%	574	34.5	$ 29,898	$ 54,525	n/a
Meyersdale	Town	2,296	-6.6%	2,739	40.9	$ 29,950	$ 79,386	n/a
Somerset Cou	County	77,861	-2.7%	72	40.2	$ 35,293	$ 94,500	41%
Pennsylvania	State	12,440,621	1.3%	277	38.0	$ 48,576	$ 155,000	60%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.8 PAWC Study Area: Wayne County (Pennsylvania)

Figure A - 9: Map of PAWC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area includes the Waymart wind facility, which sits atop the North-South ridge running along the line separating Wayne County from Lackawanna and Susquehanna Counties in Northeast Pennsylvania. The 43 turbine (65 MW, 213 ft hub height) facility was erected in 2003, and can be seen from many locations in the study area and especially from the towns of Waymart, which sits East of the facility, and Forest City, which straddles Wayne and Susquehanna Counties North of the facility. The study area is dominated topographically by the ridgeline on which the wind turbines are located, but contains rolling hills and many streams, lakes, and natural ponds. Because of the undulating landscape, views of the wind facility can be maintained from long distances, while some homes relatively near the turbines have no view of the turbines whatsoever. The area enjoys a substantial amount of second home ownership because of the bucolic scenic vistas, the high frequency of lakes and ponds, and the proximity to larger metropolitan areas such as Scranton, roughly 25 miles to the Southwest, and Wilkes-Barre a further 15 miles Southwest.

Data Collection and Summary

John Nolan, the County Chief Assessor, was very helpful in overseeing the extraction of the data from county records. GIS specialist Aeron Lankford provided the GIS parcel data as well as other mapping layers, and Bruce Grandjean, the IT and Data Specialist, provided the sales and home characteristic data as well as fielding countless questions as they arose. Additionally, real estate brokers Dotti Korpics of Bethany, Kent Swartz of Re Max, and Tom Cush of Choice #1 Country Real Estate were instrumental providing context for understanding the local market.

The county provided data on 551 valid single-family transactions that occurred between 1996 and 2007, all of which were included in the sample. These sales ranged in price from $20,000 to $444,500, with a mean of $111,522. Because of the relatively recent development of the wind facility, only 40% (*n* = 222) of the sales transaction occurred after the construction of the facility had commenced. Of those sales, 43 (19%) had views of the turbines, ten of which had more dramatic than MINOR views, and 11 were situated within one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
7/12/1996	9/25/2006	551	$96,000	$111,522	$20,000	$444,500

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Waymart Wind Farm	64.5	43	Feb-01	Jun-03	Oct-03	GE Wind	65

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Wayne, PA (PAWC)	**223**	**106**	**64**	**71**	**87**	**551**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Wayne, PA (PAWC)	**329**	**179**	**33**	**8**	**2**	**0**	**551**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Wayne, PA (PAWC)	**329**	**1**	**10**	**95**	**55**	**61**	**551**

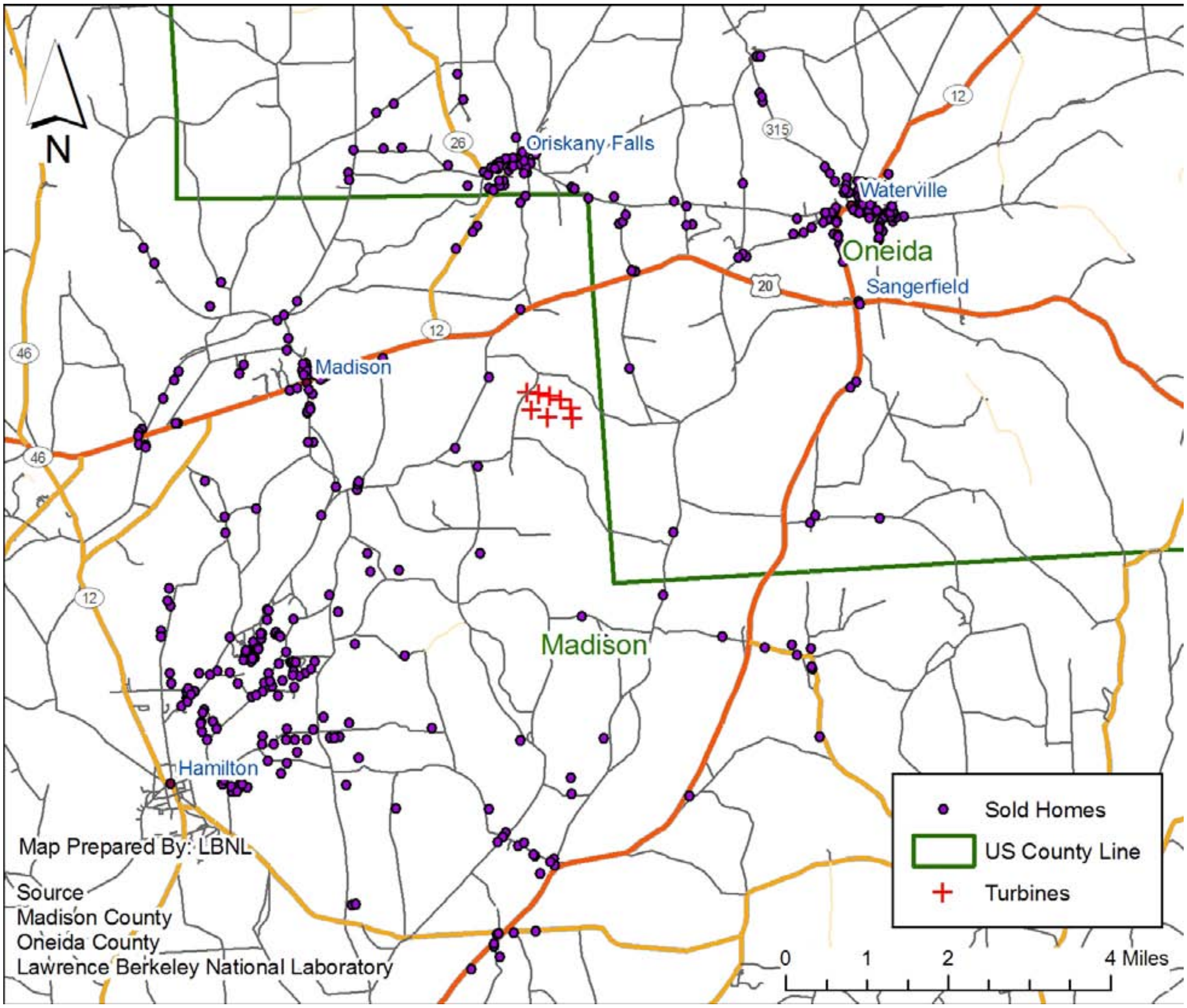
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Waymart	Town	3,075	116.0%	1,111	41.7	$ 43,797	$ 134,651	56%
Forest City	Town	1,743	-5.2%	1,929	45.6	$ 32,039	$ 98,937	67%
Prompton	Town	237	-1.6%	149	41.9	$ 30,322	$ 162,547	56%
Wayne	County	51,708	5.9%	71	40.8	$ 41,279	$ 163,060	57%
Lackawanna	County	209,330	-1.9%	456	40.3	$ 41,596	$ 134,400	48%
Pennsylvania	State	12,440,621	1.3%	277	38.0	$ 48,576	$ 155,000	60%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants.

A.9 NYMCOC Study Area: Madison and Oneida Counties (New York)

Figure A - 10: Map of NYMCOC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

<u>Area Description</u>

This study area surrounds the seven turbine (12 MW, 220 ft hub height) Madison wind facility, which sits atop an upland rise in Madison County, New York. The area is roughly 20 miles Southwest of Utica and 40 miles Southeast of Syracuse. The facility is flanked by the towns moving from the Southwest, clockwise around the rise, from Hamilton and Madison in Madison County, NY, to Oriskany Falls, Waterville, and Sangerfield in Oneida County, NY. Hamilton is the home of Colgate University, whose staff lives throughout the area around Hamilton and stretching up into the town of Madison. Accordingly, some development is occurring near the college. To the Northeast, in Oneida County, the housing market is more depressed and less development is apparent. The study area in total is a mix of residential, rural residential, and rural landscapes, with the largest portion being residential homes in the towns or immediately on their outskirts. The topography, although falling away from the location of the wind facility, does not do so dramatically, so small obstructions can obscure the views of the facility.

Data Collection and Summary

Data were obtained from both Madison and Oneida Counties for this study area. In Madison County, Kevin Orr, Mike Ellis, and Carol Brophy, all of County's Real Property Tax Services Department, were extremely helpful in obtaining the sales, home characteristic, and GIS data. In Oneida County, Jeff Quackenbush and Richard Reichert in the Planning Department were very helpful in obtaining the county data. Additionally, discussions with real estate brokers Susanne Martin of Martin Real Estate, Nancy Proctor of Prudential, and Joel Arsenault of Century 21 helped explain the housing market and the differences between Madison and Oneida Counties.

Data on 463 valid sales transactions of single family residential homes that occurred between 1996 and 2006 were obtained, all of which were located within seven miles of the wind facility. These sales ranged in price from $13,000 to $380,000, with a mean of $98,420. Roughly 75% (*n* = 346) of these sales occurred after construction commenced on the wind facility, of which 20 could see the turbines, all of which were rated as having MINOR views, except one which had a MODERATE rating; only two sales involved homes that were situated inside of one mile.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/6/1996	12/26/2006	463	$77,500	$98,420	$13,000	$380,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Madison Windpower	11.6	7	Jan-00	May-00	Sep-00	Vestas	67

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Madison/Oneida, NY (MYMCOC)	**108**	**9**	**48**	**30**	**268**	**463**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Madison/Oneida, NY (MYMCOC)	**117**	**326**	**19**	**1**	**0**	**0**	**463**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Madison/Oneida, NY (MYMCOC)	**117**	**1**	**1**	**80**	**193**	**71**	**463**

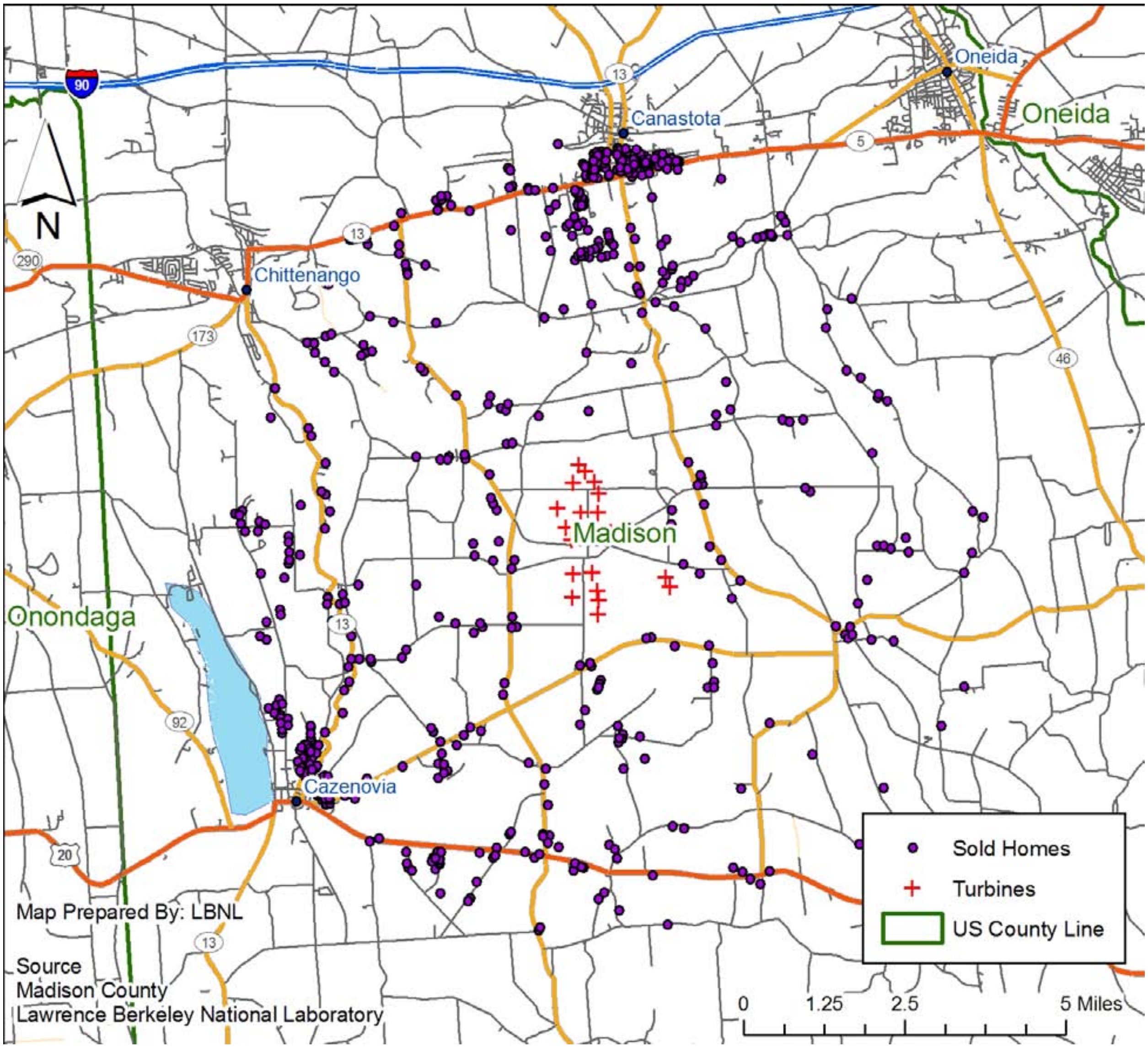
Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Madison	Town	304	-2.9%	605	38.1	$ 36,348	$ 94,734	n/a
Hamilton	Town	3,781	7.9%	1,608	20.8	$ 48,798	$ 144,872	n/a
Orinkany Fal	Town	1,413	-2.9%	1,703	40.8	$ 47,689	$ 105,934	n/a
Waterville	Town	1,735	-3.2%	1,308	37.8	$ 46,692	$ 104,816	n/a
Sangerfield	Town	2,626	-1.4%	85	37.6	$ 47,563	$ 106,213	n/a
Madison	County	69,829	0.6%	106	36.1	$ 53,600	$ 109,000	39%
Oneida	County	232,304	-1.3%	192	38.2	$ 44,636	$ 102,300	40%
New York	State	19,297,729	1.7%	408	35.9	$ 53,514	$ 311,000	109%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

A.10 NYMC Study Area: Madison County (New York)

Figure A - 11: Map of NYMC Study Area



Note: "Sold Homes" include all sold homes both before and after construction.

Area Description

This study area surrounds the 20 turbine (30 MW, 218 ft hub height) Fenner wind facility in Madison County, New York, roughly 20 miles East of Syracuse and 40 miles West of Utica in the middle of New York. The study area is dominated by two roughly parallel ridges. One, on which the Fenner facility is located, runs Southeast to Northwest and falls away towards the town of Canastota. The second ridge runs roughly North from Cazenovia, and falls away just South of the town of Chittenango. Surrounding these ridges is an undulating landscape with many water features, including the Chittenango Falls and Lake Cazenovia. A number of high-priced homes are situated along the ridge to the North of Cazenovia, some of which are afforded views of the lake and areas to the West, others with views to the East over the wind facility, and a few having significant panoramic views. The west side of the study area has a number of drivers to its real estate economy: it serves as a bedroom community for Syracuse, is the home to Cazenovia College, and enjoys a thriving summer recreational population. Canastota to the North, and Oneida to the East, are older industrial towns, both of which now serve as feeder communities for Syracuse because of easy access to Highway 90. Between the towns of Cazenovia and Canastota are many rural residential properties, some of which have been recently developed, but most of which are homes at least a half century old.

Data Collection and Summary

Data were obtained from the Madison County Real Property Tax Services department directed by Carol Brophy. As the first study area that was investigated, IT and mapping specialists Kevin Orr and Mike Ellis were subjected to a large number of questions from the study team and were enormously helpful in helping shape what became the blueprint for other study areas. Additionally, real estate brokers Nancy Proctor of Prudential, Joel Arsenault of Century 21, Don Kinsley of Kingsley Real Estate, and Steve Harris of Cazenovia Real Estate were extremely helpful in understanding the local market.

Data on 693 valid sales transactions of single family residential structures that occurred between 1996 and 2006 were obtained, most of which were within five miles of the wind facility. These sales ranged in price from $26,000 to $575,000, with a mean of $124,575. Roughly 68% of these sales (*n* = 469) occurred after construction commenced on the wind facility, 13 of which were inside of one mile, and 74 of which had views of the turbines. Of that latter group, 24 have more dramatic than MINOR views of the turbines.

Area Statistics

Study Period Begin	Study Period End	Number of Sales	Median Price	Mean Price	Minimum Price	Maximum Price
1/31/1996	9/29/2006	693	$109,900	$124,575	$26,000	$575,000

Facility Statistics

Facility Name	Number of MW	Number of Turbines	Announce Date	Construction Begin Date	Completion Date	Turbine Maker	Hub Height (Meters)
Fenner Wind Power Project	30	20	Dec-98	Mar-01	Nov-01	Enron	66

Source: AWEA & Ventyx Inc.

Variables of Interest Statistics

Development Period	Pre Announcement	Post Announcement Pre Construction	1st Year After Construction	2nd Year After Construction	2+ Years After Construction	Total
Madison, NY (NYMC)	**59**	**165**	**74**	**70**	**325**	**693**

View of Turbines	Pre Construction	None	Minor	Moderate	Substantial	Extreme	Total
Madison, NY (NYMC)	**224**	**395**	**50**	**16**	**8**	**0**	**693**

Distance to Nearest Turbine	Pre Construction	< 0.57 Miles	0.57 - 1 Miles	1 - 3 Miles	3 - 5 Miles	> 5 Miles	Total
Madison, NY (NYMC)	**224**	**2**	**11**	**80**	**374**	**2**	**693**

Census Statistics

Name	Type	2007 Population	% Change Since 2000	Population Per Mile^2	Median Age	Median Income	Median House 2007	% Change Since 2000
Cazenovia	Town	2,835	8.6%	1,801	32.3	$ 58,172	$ 159,553	n/a
Chittenango	Town	4,883	-0.5%	2,000	36.0	$ 58,358	$ 104,845	n/a
Canastota	Town	4,339	-1.7%	1,306	37.3	$ 45,559	$ 93,349	n/a
Oneida	City	10,791	-1.7%	490	36.9	$ 47,173	$ 99,305	n/a
Morrisville	Town	2,155	0.6%	1,869	20.4	$ 45,852	$ 102,352	n/a
Madison	County	69,829	0.6%	106	36.1	$ 53,600	$ 109,000	39%
New York	State	19,297,729	1.7%	408	35.9	$ 53,514	$ 311,000	109%
US	Country	301,139,947	6.8%	86	37.9	$ 50,233	$ 243,742	46%

Source: City-Data.com & Wikipedia. "% Change Since 2000" refers to the percentage change between 2000 and 2007 for the figures in the column to the left (population or median house price). "Town" signifies any municipality with less than 10,000 inhabitants. "n/a" signifies data not available.

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Appendix B: Methodology for Calculating Distances with GIS

For each of the homes in the dataset, accurate measurements of the distance to the nearest wind turbine at the time of sale were needed, and therefore the exact locations of both the turbines and the homes was required. Neither of these locations was available from a single source, but through a combination of techniques, turbine and home locations were derived. This section describes the data and techniques used to establish accurate turbine and home locations, and the process for then calculating distances between the two.

There were a number of possible starting points for mapping accurate wind turbine locations. First, the Energy Velocity data, which covered all study areas, provided a point estimate for project location, but did not provide individual turbine locations. The Federal Aviation Administration (FAA), because of permitting and aviation maps, maintains data on turbine locations, but at the time of this study, that data source did not cover all locations, contained data on structures that no longer exist, and was difficult to use.[110] Finally, in some cases, the counties had mapped the wind turbines into GIS.

In the end, because no single dataset was readily available to serve all study areas, instead the variety of data sources described above was used to map and/or confirm the location of every turbine in the 10 study areas. The process began with high-resolution geocoded satellite and aerial ortho imagery that the United States Department of Agriculture (USDA) collects and maintains under its National Agriculture Imagery Program (NAIP), and which covers virtually all of the areas in this investigation. Where needed, older ortho imagery from the USDA was used. Combining these data with the Energy Velocity data, and discussions with local officials, and maps provided by the county or the developer, locating and mapping all of the turbines in each study area was possible.

Home locations were provided directly by some counties; in other cases, a parcel centroid was created as a proxy. [111] In some situations, the centroid did not correspond to the actual house location, and therefore required further refinement. This refinement was only required and conducted if the parcel was near the wind turbines, where the difference of a few hundred feet, for example, could alter its distance rating in a meaningful fashion, or when the parcel included a considerable amount of acreage, where inaccuracy in home location could be considerable. Therefore, parcels inside of 1.5 miles of the nearest wind turbine and of any size, and parcels outside of 1.5 miles and larger than 5 acres, were both examined using the USDA NAIP imagery to determine the exact home location. In cases where the parcel centroid was not centered over the home, the location was adjusted, using the ortho image as a guide, to the actual house location.

With both turbine and home locations identified, the next step was to determine distances between the two. To do so, the date when each transaction in the sample occurred was taken into

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[110] A newer FAA database is now available that clears up many of these earlier concerns.

[111] A "parcel centroid" is the mathematical center point of a polygon, and was determined by XTools Pro (www.xtoolspro.com).

account, combined with the determination of which turbines were in existence at what time.[112] This required breaking the transactions in the sample into three categories: 1) those occurring before any wind facility was announced in the study area, 2) those occurring after the first wind facility was announced in the area but before all development was complete in the area, and 3) those occurring after all wind development in the area was complete. Any sale that occurred before wind development was announced in the study area was coded with a distance to the nearest turbine derived from the actual turbine locations after all wind development had occurred.[113] Homes that sold after all wind development had occurred were treated similarly, with distances derived from the set of turbines in place after all development had taken place. The final set of homes - those that sold after announcement of the first facility, but before the construction of the last - had to be treated, essentially, on a case by case basis. Some homes were located within five miles of one wind facility but more than five miles from another wind facility in the same study area (e.g., many homes in PASC). In this case the distance to that closer facility could be applied in a similar fashion as would be the case if only one facility was erected (e.g., NYMC or PAWC). Another group of homes, those that sold during the development of the first facility in the study area, were given the distance to that facility, regardless of distance to the other facilities in the study area. The final and most complicated group of homes consisted of those that were within five miles of multiple wind facilities, and that sold after the first facility had been erected. In those cases, the exact configuration of turbines was determined for each stage of the development process. In study areas with multiple facilities that were developed over multiple periods, there might be as many as six possible configurations (e.g., IABV). In this final scenario, the distance to the closest turbine was used, assuming it had been "announced" at the time of sale.

Once the above process was complete, the mechanics of calculating distances from the turbines to the homes was straightforward. After establishing the location of a set of turbines, for instance those constructed in the first development in the area, a euclidian distance raster was derived that encompassed every home in the study area. [114] The calculations were made using a 50-foot resolution state-plane projection and North American Datum from 1983 (NAD83). As discussed above, similar rasters were created for each period in the development cycle for each study area, depending on the turbine configuration at that time. Ultimately, a home's sale date was matched to the appropriate raster, and the underlying distance was extracted. Taking everything into account discussed above, it is expected that these measurements are accurate to

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[112] It is recognized that the formal date of sale will follow the date at which pricing decisions were made. It is also recognized, as mentioned in Section 3, that wind facility announcement and construction dates are likely to be preceded by "under the radar" discussions in the community. Taken together, these two factors might have the effect, in the model, of creating some apparent lag in when effects are shown, compared to the earlier period in which effects may begin to occur. For this to bias the results, however, effects would have to disappear or dramatically lesson with time (e.g., less than one year after construction) such that the effects would not be uncovered with the models in later periods. Based on evidence from other potentially analogous infrastructure (e.g., HVTL), any fading of effects would likely occur over many years, so it is assumed that any bias is likely minimal.

[113] These distances were used to compare homes sold, for instance, within 1 mile of where the turbines were eventually erected with similar homes sold after the turbines were erected (see, for example, the Temporal Aspects Model).

[114] A "Raster" is a grid of, in this case, 50 feet by 50 feet squares, each of which contains a number representing the number of feet from the center of the square to the nearest turbine.

within roughly 150 feet inside of 1.5 miles and within a maximum of roughly 1150 feet outside of 1.5 miles.[115]

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[115] The resolution of the raster is 50 feet, so the hypotenuse is 70 feet. If the home is situated in the top left of a raster cell and the turbine is situated in the bottom right of a diagonally adjacent cell, they could be separated by as much as 140 feet, yet the raster distance would only be 50 feet, a difference of 90 feet. Moreover, the resolution of the Ortho image is 40 feet so that location could additionally be off by another 55 feet along the diagonal. These two uncertainties total to roughly 150 feet for homes inside of 1.5 miles. Outside of 1.5 miles the variation between centroid and house location for parcels smaller than 5 acres could be larger still. If a 4.9 acre parcel had a highly irregular rectangular shape of 102 by 2100 feet, for instance, the centroid could be as much as 1050 feet from the property line. If the home was situated 50 feet from the property line then the actual house location could be off by as much as 1000 feet. Adding this to the 150 feet from above leads to a total discrepancy of 1150 feet (0.22 miles) for homes outside of 1.5 miles on parcels smaller than 5 acres. Of course, these extreme scenarios are highly unlikely to be prevalent.

Appendix C: Field Data Collection Instrument

Figure A - 12: Field Data Collection Instrument

House # (Control/ Key #)			County		
House Address					
Home Characteristics			**House Photo Number(s)**		
Cul-De-Sac?	No(0) / Yes(1)		Waterfront?	No(0) / Yes(1)	
Scenic Vista Characteristics			**Vista Photo Numbers**		
Overall Quality of Scenic Vista: Poor (1), Below Average (2), Average (3), Above Average (4), Premium (5)					
View of Turbines Characteristics			**View Photo Numbers**		
Total # of Turbines visible			Orientation of Home to View: See Below		
# of Turbines- blade tips only visible			Side (S), Front (F), Back (B), Angled (A)		
# of Turbines- nacelle/hub visible					
# of Turbines- tower visible			View Scope: Narrow(1), Medium(2), Wide(3)		
The Degree to which the View of Turbines Dominate the Site? Non-Existent (0), Minor (1), Moderate (2), Substantial (3), Extreme (4)					
Degree to which the Turbines Overlap the Prominent Scenic Vista? Not at all (0), Barely (1), Somewhat (2), Strongly (3), Entirely (4)					
Notes:					

Figure A - 13: Field Data Collection Instrument - Instructions - Page 1

Home Characteristics

Cul-De-Sac? No(0)/Yes(1)	Is the home situated on a cul-de-sac?
Waterfront? No(0)/Yes(1)	Is the home situated on the waterfront?

"Vista" Characteristics

Overall Quality of Scenic Vista: Poor (1)	This rating is reserved for vistas of unmistakably poor quality. These vistas are often dominated by visually discordant man-made alterations (not considering turbines), or are uncomfortable spaces for people, lack interest, or have virtually no recreational potential.
Overall Quality of Scenic Vista: Below Average (2)	The home's vista is of the below average quality. These vistas contain visually discordant man-made alterations (not considering turbines) but are not dominated by them. They are not inviting spaces for people, but are not uncomfortable. They have little interest, mystery and have minor recreational potential.
Overall Quality of Scenic Vista: Average (3)	The home's vista is of the average quality. These vistas include interesting views which can be enjoyed often only a narrow scope. These vistas may contain some visually discordant man-made alterations (not considering turbines), are moderately comfortable spaces for people, have some interest, and have minor recreational potential.
Overall Quality of Scenic Vista: Above Average (4)	The vista from the home is of above average quality. These vistas include interesting views which often can be enjoyed in a medium to wide scope. They might contain some man made alterations (not considering turbines), yet still possess significant interest and mystery, are moderately balanced and have some potential for recreation.
Overall Quality of Scenic Vista: Premium (5)	This rating is reserved for vistas of unmistakably premium quality. These vistas would include "picture post card" views which can be enjoyed in a wide scope. They are often free or largely free of any discordant man made alterations (not considering turbines), possess significant interest, memorable qualities, mystery and are well balanced and likely have a high potential for recreation.
Degree Turbines Overlap Prominent Vista? Not at all (0))	The vista does not contain any view of the turbines.
Degree Turbines Overlap Prominent Vista? Barely (1)	A small portion (~ 0 - 20%) of the vista is overlapped by the view of turbines therefore the vista might contain a view of a few turbines, only a few of which can be seen entirely (from below the sweep of the blades to the top of their tips).
Degree Turbines Overlap Prominent Vista? Somewhat (2)	A moderate portion (~20-50%) of the vista contains turbines, and likely contains a view of more than one turbine, some of which are likely to be seen entirely (from below the sweep of the blades to the top of their tips).
Degree Turbines Overlap Prominent Vista? Strongly (3)	A large portion (~50-80%) of the vista contains a view of turbines, many of which likely can be seen entirely (from below the sweep of the blades to the top of their tips).
Degree Turbines Overlap Prominent Vista? Entirely (4)	This rating is reserved for situations where the turbines overlap virtually the entire (~80-100%) vista from the home. The vista likely contains a view of many turbines, virtually all of which can be seen entirely (from below the sweep of the blades to the top of their tips).

Figure A - 14: Field Data Collection Instrument - Instructions - Page 2

View of Turbines Characterist

House Orientation to View of Turbines: Side (S)	Orientation of home to the view of the turbines is from the side.
House Orientation to View of Turbines: Front (F)	Orientation of home to the view of the turbines is from the front.
House Orientation to Vista of Turbines: Back (B)	Orientation of home to the view of the turbines is from the back.
House Orientation to Vista of Turbines: Angled (A)	Orientation of home to the view of the turbines is from an angle.
View of Turbines Scope: Narrow(1)	The view of the turbines is largely blocked by trees, large shrubs or man made features in the foreground (0-300 feet) allowing 0 - 30 degrees of view of the wind facility
View of Turbines Scope: Medium(2)	The view of turbines is partially blocked by trees, large shrubs or man made features in the foreground (0-300 feet) allowing only 30-90 degrees of view of the wind facility.
View of Turbines Scope: Wide(3)	The view of the turbines is free or almost free from blockages by trees, large shrubs or man made features in the foreground (0-300 feet) allowing at least 90 degrees of view of the wind facility.
Degree to which View of Turbines Dominates the Site? None (0)	The turbines are not visible at all frrom this home.
Degree to which View of Turbines Dominates the Site? Minor (1)	The turbines are visible but either the scope is narrow, there are many obstructions, or the distance between the home and the facility is large.
Degree to which View of Turbines Dominates the Site? Moderate (2)	The turbines are visible but the scope is either narrow or medium, there might be some obstructions, and the distance between the home and the facility is most likely a few miles.
Degree to which View of Turbines Dominates the Site? Substantial (3)	The turbines are dramatically visible from the home. The turbines are likely visible in a wide scope, and most likely the distance between the home and the facility is short.
Degree to which View of Turbines Dominates the Site? Extreme (4)	This rating is reserved for sites that are unmistakably dominated by the presence of the windfarm. The turbines are dramatically visible from the home and there is a looming quality to their placement. The turbines are often visible in a wide scope, or the distance to the facility is very small.

Appendix D: Vista Ratings with Photos

POOR VISTA

BELOW AVERAGE VISTA

AVERAGE VISTA

ABOVE AVERAGE VISTA

PREMIUM VISTA

Appendix E: View Ratings with Photos

MINOR VIEW

3 turbines visible from front orientation, nearest 1.4 miles (TXHC)

5 turbines visible from front orientation, nearest 0.9 miles (NYMC)

MODERATE VIEW

18 turbines visible from back orientation, nearest 1.6 miles (ILLC)

6 turbines visible from back orientation, nearest 0.8 miles (PASC)

SUBSTANTIAL VIEW

90 turbines visible from all orientations, nearest 0.6 miles (IABV)

27 turbines visible from multiple orientations, nearest 0.6 miles (TXHC)

EXTREME VIEW

6 turbines visible from multiple orientations, nearest 0.2 miles (WIKCDC)

212 turbines visible from all orientations, nearest 0.4 miles (IABV)

Appendix F: Selecting the Primary ("Base") Hedonic Model

Equation (1) as described in Section 4.2 is presented in this report as the primary (or "Base") model to which all other models are compared. As noted earlier, in the Base Hedonic Model and in all subsequent models presented in Section 5 all variables of interest, spatial adjustments, and home and site characteristics are pooled, and therefore their estimates represent the average across all study areas. Ideally, one would have enough data to estimate a model at the study area level - a fully unrestricted model - rather than pooled across all areas. In this appendix, alternative model forms are presented that unrestrict these variables at the level of study areas. As shown here, these investigations ultimately encouraged the selection of the somewhat simpler pooled Base Model as the primary model, and to continue to use restricted or pooled models in the alternative hedonic analyses.

F.1 Discussion of Fully Unrestricted Model Form

The Base Model described by equation (1) has variables that are pooled, and the coefficients for these variables therefore represent the average across all study areas (after accounting for study area fixed effects). An alternative (and arguably superior) approach would be to estimate coefficients at the level of each study area, thereby allowing coefficient values to vary among study areas.[116] This fully interacted – or unrestricted – model would take the following form:

$$\begin{aligned}\ln(\mathrm{P}) = \beta_0 + \sum_s \beta_1(\mathrm{N}\cdot\mathrm{S}) + \sum_c \beta_2(\mathrm{Y}) + \sum_k \beta_3(\mathrm{X}\cdot\mathrm{S}) + \sum_v \beta_4(\mathrm{VIEW}\cdot\mathrm{S}) + \\ \sum_d \beta_5(\mathrm{DISTANCE}\cdot\mathrm{S}) + \varepsilon\end{aligned} \qquad \text{(F13)}$$

where

P represents the inflation-adjusted sale price,

N is the spatially weighted neighbors' predicted sale price,

S is a vector of *s* study areas (e.g., WAOR, OKCC, etc.),

Y is a vector of *c* study area locational characteristics (e.g., census tract, school district, etc.),

X is a vector of k home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),

VIEW is a vector of v categorical view of turbine variables (e.g., MINOR, MODERATE, etc.),

DISTANCE is a vector of d categorical distance to turbine variables (e.g., less than 3000 feet, between one and three miles, etc.),

β_0 is the constant or intercept across the full sample,

β_1 is a vector of *s* parameter estimates for the spatially weighted neighbor's predicted sale price for S study areas,

β_2 is a vector of *c* parameter estimates for the study area locational fixed effect variables,

β_3 is a vector of *k* parameter estimates for the home and site characteristics for S study areas,

β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to homes sold with no view of the turbines for S study areas,

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[116] For instance, the marginal contribution of Acres (the number of acres) to the selling price would be estimated for each study area (i.e., Acres_WAOR, Acres_TXHC etc.), as would the variables of interest: VIEW and DISTANCE.

β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to homes sold situated outside of five miles for S study areas, and

ε is a random disturbance term.

To refresh, the fully restricted equation (1) takes the following form:

$$\ln(\mathrm{P}) = \beta_0 + \beta_1 \mathrm{N} + \sum_s \beta_2 \mathrm{S} + \sum_k \beta_3 \mathrm{X} + \sum_v \beta_4 \mathrm{VIEW} + \sum_d \beta_5 \mathrm{DISTANCE} + \varepsilon \qquad (1)$$

where

P represents the inflation-adjusted sale price,

N is the spatially weighted neighbors' predicted sale price,

S is the vector of *s* Study Area fixed effects variables (e.g., WAOR, OKCC, etc.),

X is a vector of *k* home and site characteristics (e.g., acres, square feet, number of bathrooms, condition of the home, age of home, VISTA, etc.),

VIEW is a vector of *v* categorical view of turbine variables (e.g., MINOR, MODERATE, etc.),

DISTANCE is a vector of *d* categorical distance to turbine variables (e.g., less than 3000 feet, between one and three miles, etc.),

β_0 is the constant or intercept across the full sample,

β_1 is a parameter estimate for the spatially weighted neighbor's predicted sale price,

β_2 is a vector of *s* parameter estimates for the study area fixed effects as compared to homes sold in the Washington/Oregon (WAOR) study area,

β_3 is a vector of *k* parameter estimates for the home and site characteristics,

β_4 is a vector of *v* parameter estimates for the VIEW variables as compared to homes sold with no view of the turbines,

β_5 is a vector of *d* parameter estimates for the DISTANCE variables as compared to homes sold situated outside of five miles, and

ε is a random disturbance term.

The significant change between equations (1) and (F13) is that each of the primary groups of variables in equation (F13) is interacted with the study areas (S) so that parameters can be estimated at the study area level. For example, whereas ACRES is estimated in equation (1) across all study areas, in equation (F13) it is estimated for each study area (i.e., Acres_WAOR, Acres_TXHC, etc).[117] Similarly, when considering the possible impact of wind facilities on residential sales prices, equation (1) seeks average effects that exist over the entire sample, while equation (F13) instead looks for differential effects in each individual study area. Additionally, in equation (F13), instead of estimating fixed effects using inter-study area parameters alone (e.g., WAOR, TXHC), a set of intra-study area effects (Y) - school district and census tract delineations - are added.[118] These latter coefficients represent not only effects that are presumed

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[117] This change is made because, theoretically, the contribution to sales prices of home or site characteristics may differ between study areas – for instance Central_AC in Texas vs. New York – and therefore estimating them at the study area level may increase the explanatory power of the model.

[118] In the evaluation and selection of the best model to use as the "Base Model" a set of census tract and school district delineations were used instead of the study area fixed effects. These more-granular fixed effects were extracted from GIS using house locations and census tract and school district polygons. Often, the school district and census tract delineations were not mutually exclusive. For example, in Wisconsin the WIKCDC study area contains four school districts and six census tracts, none of which completely overlap. Alternatively, in some study

to exist over each entire study area (inter-study area effects), but also intra-study area effects such as differences in home valuation due to school districts, distances to amenities, and other locationally bound influences. As with the inter-study area coefficients, because of the myriad influences captured by these variables, interpretation of any single coefficient can be difficult. However, it is expected that such coefficients would be influential, indicating significant differences in value between homes in each study area and across study areas due to school district quality and factors that differ between census tracts (e.g., crime rates).

Although the fully unrestricted model described by equation (F13) is arguably superior to the fully restricted model described in equation (1) because of its ability to resolve differences between and within study areas that are not captured by the Base Model, there are three potential drawbacks:

- Model parsimony and performance;
- Standard error magnitudes; and
- Parameter estimate stability.

Each of these potential drawbacks is discussed in turn below:

Model parsimony and performance: In general, econometricians prefer a simpler, more parsimonious statistical model. In this instance, variables should be added to a model only if their addition is strongly supported by theory and if the performance of the model is substantially improved by their inclusion. As such, if a model with a relatively small number of parameters performs well, it should be preferred to a model with more parameters unless the simple model can be "proven to be inadequate" (Newman, 1956). To prove the inadequacy of a simpler model requires a significant increase in performance to be exhibited from the more complex model. In this case, as presented later, performance is measured using the combination of Adjusted R^2, Modified R^2, and the Schwarz information criterion (see footnote 119 on page 127).

Standard error magnitudes: The magnitude of the standard errors for the variables of interest, as well as the other controlling variables, are likely to increase in the unrestricted model form because the number of cases for each variable will decrease when they are estimated at the study area level. Within each study area, there are a limited number of home transactions that meet the criteria for inclusion in the model, but even more limiting is the number of home transactions within each study area that have the characteristics of interest. For example, in Lee County, IL (ILLC), there are 205 post-construction home sales, while in Wayne County, PA (PAWC) there are 222. More importantly, in those areas, the data include a total of one and eleven sales inside of one mile, respectively, and a total of one and two homes with either EXTREME or SUBSTANTIAL rated views of turbines. With so few observations, there is increased likelihood that a single or small group of observations will strongly influence the sample mean of an independent variable. Since the standard error is derived from the variance of the parameter estimate, which in turn is derived from the summed deviation of each observation's actual level relative to its sample mean, this standard error is more likely to be larger than if a larger sample were considered. If the presence of wind facilities does have a detrimental effect on property

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areas the school district and census tracts perfectly overlapped, and in those cases either both were omitted as the reference category or one was included and the other withdrawn from the model to prevent perfect collinearity.

values, that effect seems likely to be relatively small, at least outside of the immediate vicinity of the wind turbines. The smaller sample sizes for the independent variables that come with the unrestricted model, which may decrease statistical precision by producing larger standard errors, would likely decrease the ability to accurately identify these possible effects statistically. To explore the magnitude of this concern, the difference in standard errors of the variables of interest is investigated among the restricted and unrestricted models.

Parameter estimate stability: In an unrestricted model, parameter estimates are more likely to be unstable because the sample of home transactions with any particular characteristic may be small and thus not representative of the population as a whole. As mentioned above, there are a limited number of transactions within each study area that have the characteristics of interest. Restricting the sample size by using an unrestricted model increases the likelihood that a limited number of observations, which in the population as a whole represent a very small segment, will drive the results in one direction or another, thereby leading to erroneous conclusions. The difference in parameter estimates is investigated by comparing the coefficients for the unrestricted variables of interest to those for the restricted variables of interest. Additionally, the sign of any significant variables will be investigated for the unrestricted models, which might help uncover potentially spurious results.

F.2 Analysis of Alterative Model Forms

Here the spectrum of alternative models is explored, from the fully restricted equation (1) to the fully unrestricted equation (F13). To do so, not only are these two ends of the spectrum estimated, but also 14 intermediate models are estimated that consist of every combination of restriction of the four variable groups (i.e., variables of interest, spatial adjustments, study area delineations, and home and site characteristics). This produces a total of 16 models over which to assess model parsimony and performance, standard error size, and coefficient stability. This process allows for an understanding of model performance but, more importantly, to ultimately define a "Base Model" that is parsimonious (i.e., has the fewest parameters), robust (i.e., high adjusted R^2), and best fits the purpose of investigating wind facility impacts on home sales prices.

Table A - 2 presents the performance statistics for each of the 16 models defined above, moving from the fully restricted model equation (1) ("Model 1") to the fully unrestricted model equation (F13) ("Model 16"). In columns 2 – 5 of the table, the "R" represents a restriction for this variable group (i.e., not crossed with the study areas) and the "U" represents the case when the variable group is unrestricted (i.e., crossed with the study areas). Also shown are summary model statistics (i.e., Adjusted R^2, Modified R^2, and Schwarz information criterion - "SIC"), as well as the number of estimated parameters (*k*).[119] All models were run using the post-construction data subset of the sample of home sales transactions (*n* = 4,937).

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[119] Goldberger (1991), as cited by Gujarati (2003), suggests using a Modified $R^2 = (1 – k/n) * R^2$ to adjust for added parameters. For example, Models 1 and 14 have Modified R^2 of 0.76, yet Adjusted R^2 of 0.77 and 0.78 respectively. Therefore the Modified R^2 penalizes their measure of explanatory power more than the Adjusted R^2 when taking into account the degrees of freedom. Similarly, the Schwarz information criterion penalizes the models for increased numbers of parameters (Schwarz, 1978). More importantly, practitioners often rely on the Schwarz criterion – over the Modified or Adjusted R^2 statistics - to rank models with the same dependent variable by their relative parsimony (Gujarati, 2003). Therefore it will be used for that purpose here.

Model Parsimony and Performance

Overall, the fully restricted model (1) performs well with only 37 independent variables, producing an Adjusted R^2 of 0.77. Despite the limited number of explanatory variables, the model explains ~77% of the variation in home prices in the sample. When the fully unrestricted model 16 (equation F13) is estimated, which lies at the other end of the spectrum, it performs only slightly better, with an Adjusted R^2 of 0.81, but with an additional 285 explanatory variables. It is therefore not surprising that the Modified R^2 is 0.76 for Model 1 and is only 0.77 for Model 16. Similarly, the Schwarz information criterion (SIC) increases from 0.088 to 0.110 when moving from model 1 to model 16 indicating relatively less parsimony. Combined, these metrics show that the improvement in the explanatory power of model 16 over model 1 is not enough to overcome the lack of parsimony. Turning to the 14 models that lie between Models 1 and 16, in general, little improvement in performance is found over Model 1, and considerably less parsimony, providing little initial justification to pursue a more complex specification than equation (1).

Table A - 2: Summarized Results of Restricted and Unrestricted Model Forms

Model [1]	Study Area [2]	Spatial Adjustment	Home and Site Characteristics	Variables of Interest	Adj R^2	Modified R^2	SIC	*k* †
1	R	R	R	R	0.77	0.76	0.088	37
2	U	R	R	R	0.74	0.73	0.110	111
3	R	U	R	R	0.77	0.76	0.088	46
4	R	R	U	R	0.80	0.78	0.095	188
5	R	R	R	U	0.77	0.76	0.093	88
6	U	U	R	R	0.78	0.76	0.094	120
7	R	U	U	R	0.80	0.77	0.096	197
8	R	R	U	U	0.80	0.77	0.101	239
9	U	R	U	R	0.80	0.77	0.107	262
10	U	R	R	U	0.76	0.75	0.107	162
11	R	U	R	U	0.77	0.76	0.094	97
12	U	U	U	R	0.81	0.77	0.103	271
13	R	U	U	U	0.80	0.77	0.103	248
14	U	U	R	U	0.78	0.76	0.100	171
15	U	R	U	U	0.80	0.76	0.113	313
16	U	U	U	U	0.81	0.77	0.110	322

"R" indicates parameters are pooled ("restricted") across the study areas.

"U" indicates parameters are not pooled ("unrestricted"), and are instead estimated at the study area level.

1 - *Model numbers do not correspond to equation numbers listed in the report; equation (1) is Model 1, and equation (F1) is Model 16.*

2 - *In its restricted form "Study Area" includes only inter-study area delineations, while unrestricted "Study Area" includes intra-study area delineations of school district and census tract.*

† - *Numbers of parameters do not include intercept or omitted variables.*

The individual contributions to model performance from unrestricting each of the variable groups in turn (as shown in Models 2-5) further emphasizes the small performance gains that are earned despite the sizable increases in the number of parameters. As a single group, the unrestricted Home and Site Characteristics model (Model 4) makes the largest impact on model performance, at least with respect to the Adjusted R^2 (0.80), but this comes with the addition of 151 estimated parameters a slight improvement in the Modified R^2 (0.78) and a worsening SIC (0.095). Adding unrestricted Study Area delineations (Model 2), on the other hand, adversely affects performance (Adj. $R^2 = 0.74$, Modified $R^2 = 0.73$) and adds 74 estimated parameters (SIC = 0.110). Similarly, unrestricting the Spatial Adjustments (Model 3) offers little improvement in performance (Adj. $R^2 = 0.77$, Modified $R^2 = 0.76$) despite adding nine additional variables (SIC = 0.088). Finally, unrestricting the Variables of Interest (Model 5) does not increase model performance (Adj. $R^2 = 0.77$, Modified $R^2 = 0.76$) and adds 51 variables to the model (SIC = 0.093). This pattern of little model improvement yet considerable increases in the number of estimated parameters (i.e., less parsimony) continues when pairs or trios of variable groups are unrestricted. With an Adjusted R^2 of 0.77, the fully restricted equation (1) performs more than adequately, and is, by far, the most parsimonious.

Standard Error Magnitudes

Table A - 3 summarizes the standard errors for the variables of interest for all of the 16 models, grouped into restricted and unrestricted model categories. The table specifically compares the medians, minimums, and maximums of the standard errors for the models with restricted variables of interest (1, 2, 3, 4, 6, 7, 9 and 12) to those with unrestricted variables of interest (5, 8, 10, 11, 13, 14, 15 and 16).[120] The table demonstrates that the unrestricted standard errors for the variables of interest are significantly larger than the restricted standard errors. In fact, the minimum standard errors in the unrestricted models are often higher than the maximum standard errors produced in the restricted models. For example, the maximum standard error for an EXTREME VIEW in the restricted models is 0.09, yet the minimum in the unrestricted models is 0.12, with a maximum of 0.34. To put this result in a different light, a median standard error for the unrestricted EXTREME VIEW variable of 0.25 would require an effect on house prices larger than 50% to be considered statistically significant at the 90% level. Clearly, the statistical power of the unrestricted models is weak.[121] Based on other disamenities, as discussed in Section 2.1, an effect of this magnitude is very unlikely. Therefore, based on these standard errors, there is no apparent reason to unrestrict the variables of interest.

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[120] For the restricted models, the medians, minimums, and maximums are derived across all eight models for each variable of interest. For the unrestricted models, they are derived across all study areas and all eight models for each variable of interest.

[121] At 90% confidence a standard error of 0.25 would produce a confidence interval of roughly +/- 0.42 (0.25 * 1.67). An effect of this magnitude represents a 52% change in sales prices because sales price is in a natural log form (*e* ^ 0.42-1 = 0.52).

Table A - 3: Summary of VOI Standard Errors for Restricted and Unrestricted Models

Standard Errors	Restricted Models			Unrestricted Models		
	Standard Errors			Standard Errors		
	Median	Min	Max	Median	Min	Max
Minor View	0.01	0.01	0.02	0.05	0.03	0.07
Moderate View	0.03	0.03	0.03	0.10	0.06	0.18
Substantial View	0.05	0.05	0.06	0.19	0.10	0.29
Extreme View	0.08	0.08	0.09	0.25	0.12	0.34
Inside 3000 Feet	0.05	0.05	0.06	0.21	0.09	0.33
Between 3000 Feet and 1 Mile	0.04	0.04	0.05	0.13	0.08	0.40
Between 1 and 3 Miles	0.02	0.02	0.02	0.05	0.02	0.11
Between 3 and 5 Miles	0.01	0.01	0.02	0.05	0.02	0.10

Parameter Estimate Stability

Table A - 4 summarizes the coefficient estimates for the variables of interest for all of the 16 models. The table specifically compares the medians, minimums, and maximums of the coefficients for the models with restricted variables of interest (1, 2, 3, 4, 6, 7, 9 and 12) to those with unrestricted variables of interest (5, 8, 10, 11, 13, 14, 15 and 16). As shown, the coefficients in the unrestricted models diverge significantly from those in the restricted models. For example, in the restricted models, the median coefficient for homes inside of 3000 feet is -0.03, with a minimum of -0.06 and a maximum of -0.01, yet in the unrestricted models the median coefficient is 0.06, with a minimum of -0.38 and a maximum of 0.32. Similarly, a MODERATE VIEW in the restricted models has a median of 0.00, with a minimum of -0.01 and a maximum of 0.03, whereas the unrestricted models produce coefficients with a median of -0.05 and with a minimum of -0.25 and a maximum of 0.35.

Table A - 4: Summary of VOI Coefficients for Restricted and Unrestricted Models

Parameters	Restricted Models			Unrestricted Models		
	Coefficients			Coefficients		
	Median	Min	Max	Median	Min	Max
Minor View	-0.02	-0.03	0.00	-0.02	-0.16	0.24
Moderate View	0.00	-0.01	0.03	-0.05	-0.25	0.35
Substantial View	-0.01	-0.04	0.02	-0.08	-0.31	0.13
Extreme View	0.03	0.02	0.05	-0.03	-0.23	0.09
Inside 3000 Feet	-0.03	-0.06	-0.01	0.06	-0.38	0.32
Between 3000 Feet and 1 Mile	-0.04	-0.06	-0.01	-0.10	-0.44	0.52
Between 1 and 3 Miles	-0.01	-0.03	0.02	0.00	-0.23	0.40
Between 3 and 5 Miles	0.02	0.01	0.04	0.05	-0.05	0.32

Turning from the levels of the coefficients to the stability of their statistical significance and sign across models more reasons for concern are found. Table A - 5 summarizes the results of the unrestricted models, and presents the number of statistically significant variables of interest as a percent of the total estimated. The table also breaks these results down into two groups, those with coefficients above zero and those with coefficients below zero.[122] It should be emphasized here that it is the *a priori* expectation that, if effects exist, all of these coefficients would be less than zero, indicating an adverse effect on home prices from proximity to and views of wind turbines. Despite that expectation, when the variables of interest are unrestricted it is found that they are as likely to be above zero as they are below.[123] In effect, the small numbers of cases available for analysis at the study area level produce unstable results, likely because the estimates are being unduly influenced by either study area specific effects that are not captured by the model or by a limited number of observations that represents a larger fraction of the overall sample in that model.[124]

Table A - 5: Summary of Significant VOI Above and Below Zero in Unrestricted Models

Significant Variables	Unrestricted Models		
	Total	Below Zero	Above Zero
Minor View	32%	14%	18%
Moderate View	23%	11%	13%
Substantial View	4%	4%	0%
Extreme View	0%	0%	0%
Inside 3000 Feet	23%	15%	8%
Between 3000 Feet and 1 Mile	30%	14%	16%
Between 1 and 3 Miles	56%	32%	24%
Between 3 and 5 Miles	45%	3%	43%

F.3 Selecting a Base Model

To conclude, it was found that all three concerns related to the estimation and use of an unrestricted model form are borne out in practice. Despite experimenting with 16 different combinations of interactions, little overall improvement in performance is discovered. Where performance gains are found they are at the expense of parsimony as reflected in the lack of increase in the Modified R^2 and the relatively higher Schwartz information criterion. Further, divergent and spurious coefficients of interest and large standard errors are associated with those coefficients. Therefore the fully restricted model, equation (1), is used in this report as the "Base Model".

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[122] The "Total" percentage of significant coefficients is calculated by counting the total number of significant coefficients across all 8 unrestricted models for each variable of interest, and dividing this total by the total number of coefficients. Therefore, a study area that did not have any homes in a group (for example, homes with EXTREME VIEWS) was not counted in the "total number of coefficients" sum. Any differences between the sum of "above" and "below" zero groups from the total are due to rounding errors.

[123] The relatively larger number of significant variables for the MINOR rated view, MODERATE rated view, Mile 1 to 3, and Mile 3 to 5 parameters are likely related to the smaller standard errors for those categories, which result from larger numbers of cases.

[124] Another possible explanation for spurious results in general is measurement error, when parameters do not appropriately represent what one is testing for. In this case though, the VIEW variables have been adequately "ground truthed" during the development of the measurement scale, and are similar to the VISTA variables, which were found to be very stable across study areas. DISTANCE, or for that matter, distance to any disamenity, has been repeatedly found to be an appropriate proxy for the size of effects. As a result, it is not believed that measurement error is a likely explanation for the results presented here.

Appendix G: OLS Assumptions, and Tests for the Base Model

A number of criteria must be met to ensure that the Base Model and Alternative Hedonic Models produce unbiased coefficient estimates and standard errors: 1) appropriate controls for outliers and influencers; 2) homoskedasticity; 3) absence of serial or spatial autocorrelation; and 4) reasonably limited multicollinearity. Each of these criteria, and how they are addressed, is discussed below.

Outliers and Influencers: Home sale prices that are well away from the mean, also called outliers and influencers, can cause undue influence on parameter estimates. A number of formal tests are available to identify these cases, the most common being Mahalanobis' Distance ("M Distance") (Mahalanobis, 1936) and standardized residual screening. M Distance measures the degree to which individual observations influence the mean of the residuals. If any single observation has a strong influence on the residuals, it should be inspected and potentially removed. An auxiliary, but more informal, test for identifying these potentially influential observations is to see when the standardized absolute value of the residual exceeds some threshold. Both the Base Model and the All Sales Model were run using the original dataset of 7,464 transactions and the 4,940 transactions which occurred post-construction respectively. For both models the standardized residuals and the M Distance statistics were saved.[125] The histograms of these two sets of statistics from the two regressions are shown in Figure A - 15 through Figure A - 18.

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[125] For the M Distance statistics all variables of interest were removed from the model. If they were left in the M-Distance statistics could be influenced by the small numbers of cases in the variables of interest. If these parameters were strongly influenced by a certain case, it could drive the results upward. Inspecting the controlling variables in the model, and how well they predicted the sale prices of the transactions in the sample, was of paramount importance therefore the variables of interest were not included.

Figure A - 15: Histogram of Standardized Residuals for Base Model

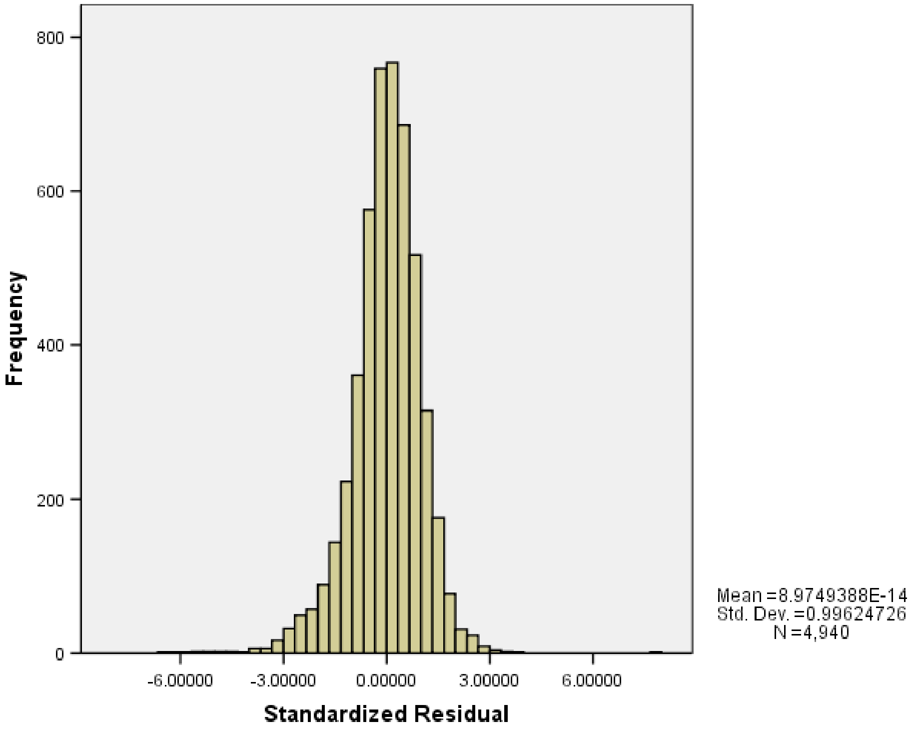


Figure A - 16: Histogram of Mahalanobis Distance Statistics for Base Model

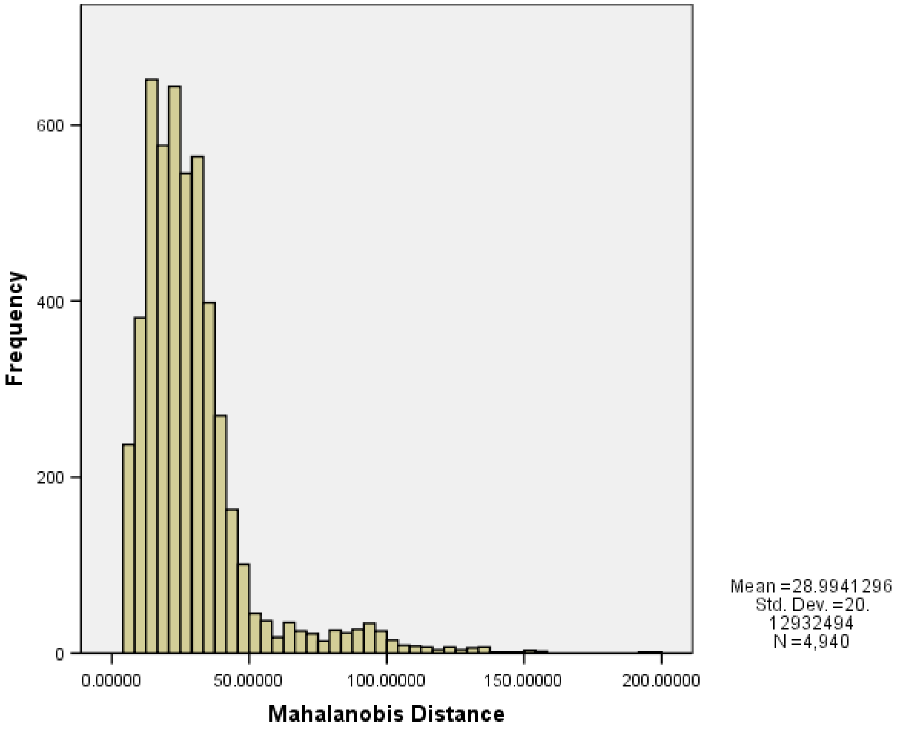


Figure A - 17: Histogram of Standardized Residuals for All Sales Model

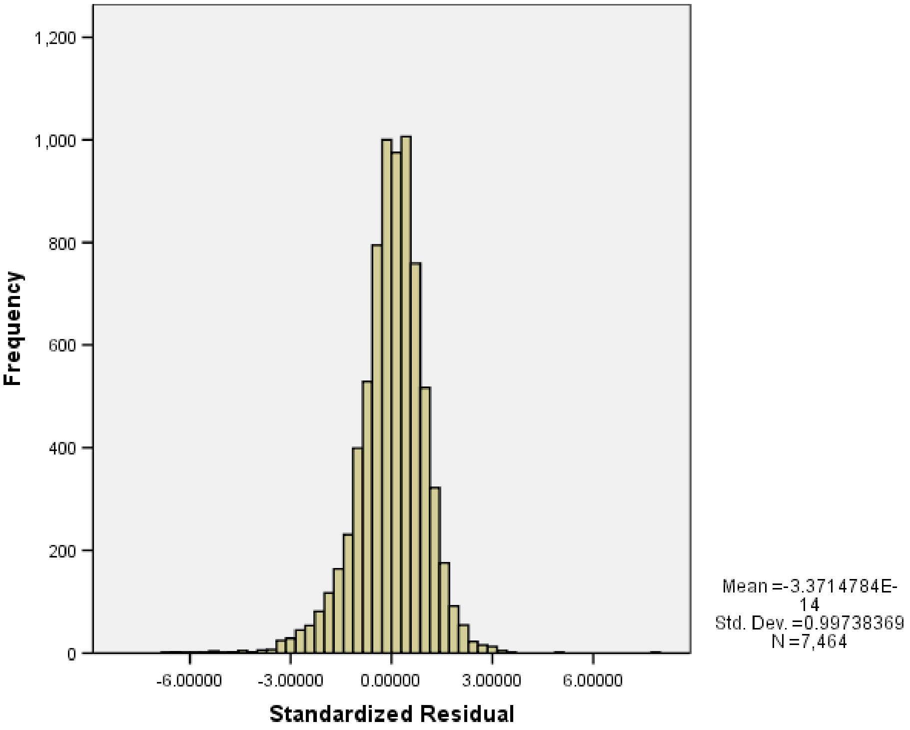
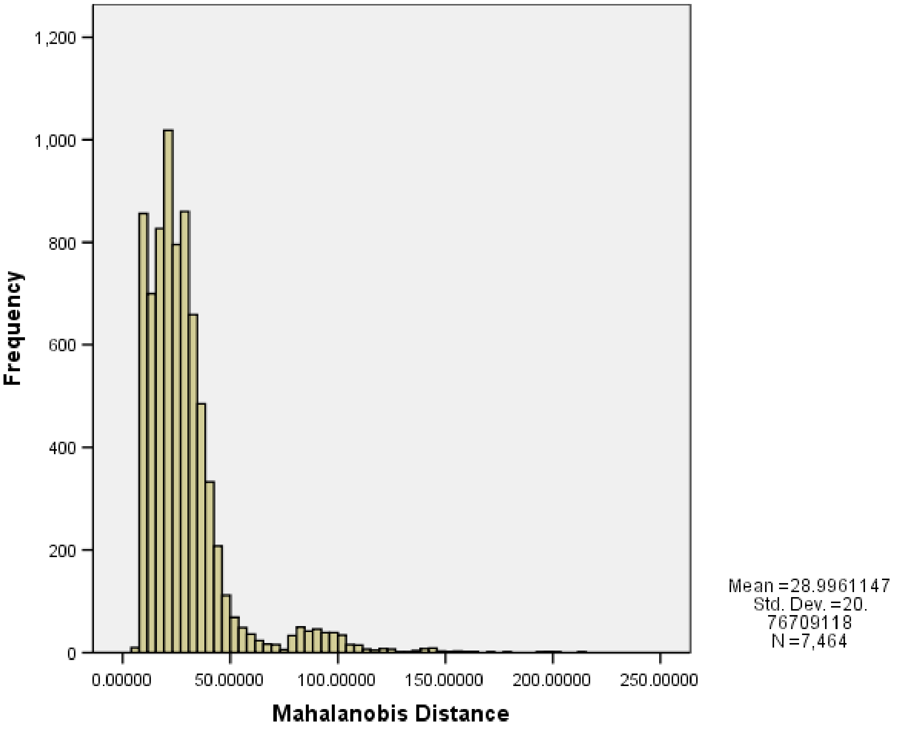


Figure A - 18: Histogram of Mahalanobis Distance Statistics for All Sales Model



The M Distance histograms suggested that a cutoff of 150 may be appropriate, which would exclude 15 cases from the All Sales Model and seven cases from the Base Model (all of the latter of which were among the 15 outliers in the All Sales Model). The Standardized Residual histograms suggested a cutoff of 4, 5, or 6, which would exclude 13, 8, and 3 cases from the Base Model, and 22, 12, and 5 cases from the All Sales Model. A case-by-case investigation of each of these sales transactions was then conducted by comparing their home characteristics (e.g., square feet, baths, age, etc.) against their study area and panel model cohorts to ensure that none had been inappropriately coded. None of the M Distance flagged cases seemed to be inappropriately coded, and none of those cases were removed from the final dataset as a result. Five cases that were flagged from the All Sales Model (which corresponded to three cases in the Base Model) with a Standardized Residual greater than six, however, were clearly outliers. One had a sale price that was more than $200,000 more than any other transaction in the model, and the other four had exceptionally low prices, yet high numbers of corresponding characteristics that would suggest higher home sales prices (such as over 2000 square feet – all four cases – or more than two bathrooms – three cases).

As a result of these investigations, these five cases were removed from the model. One of the five cases occurred prior to announcement, one occurred after announcement and before construction, and the other three occurred after construction began. None were within three miles of the nearest wind turbine except one, which was 0.6 miles from the nearest turbine and had a MINOR view of the wind facility. The other two had no views of the turbines. Although there was hesitancy in removing any cases from the model, these transactions were considered appropriately influential and keeping them in the model would bias the results inappropriately. Further, the one home that was situated inside of one mile was surrounded by five other transactions in the same study area that also occurred after construction began and were a similar distance from the turbines, but that were not flagged by the outliers screen. Therefore, its removal was considered appropriate given that other homes in the sample would likely experience similar effects.

After removing these five cases, the sensitivity of the model results were tested to the inclusion or exclusion of the “greater than five” and “greater than four” Standardized Residuals observations and the cases flagged by the M Distance screen, finding that parameter estimates for the variables of interest moved slightly with these cases removed but not enough to change the results significantly. Because they did not show a unique grouping across the variables of interest, nor any unusual potentially inappropriate coding, and, more importantly, did not substantially influence the results, no substantive reason was found to remove any additional transactions from the sample. Therefore, the final dataset included a total of 7,459 cases, of which 4,937 occurred post-construction.

Homoskedasticity: A standard formal test for the presence of homoskedastic error terms is the White's statistic (White, 1980). However, the requirements to perform this test were overly burdensome for the computing power available. Instead, an informal test was applied, which plots the regression errors against predicted values and various independent variables to observe whether a "heteroskedastic pattern" is in evidence (Gujarati, 2003). Although no evidence of heteroskedasticity was found using this method, to be conservative, nonetheless all models were run with White's heteroskedasticity correction to the parameter estimates' standard errors (which will not adversely influence the errors if they are homoskedastic).

Serial Autocorrelation: A standard formal test for the presence of serial autocorrelation in the error term is the Durbin-Watson statistic (Durbin and Watson, 1951). Applying this test as proposed by Durbin and Watson to the full panel dataset was problematic because the test looks at the error structure based on the order that observations are included in the statistical regression model. Any ordering choice over the entire panel data set invariably involves mixing home transactions from various study areas. Ideally, one would segment the data by study area for purposes of calculating this test, but that method was not easily implemented with the statistical software package used for this analysis (i.e., SAS). Instead, study area specific regression models were run with the data chronologically ordered in each to produce twelve different Durbin-Watson statistics, one for each study area specific model. The Durbin-Watson test statistics ranged from 1.98–2.16, which are all within the acceptable range.[126] Given that serial autocorrelation was not found to be a significant concern for each study area specific model, it is assumed that the same holds for the full dataset used in the analysis presented in this report.

Spatial Autocorrelation: It is well known that the sales price of a home can be systematically influenced by the sales prices of those homes that have sold nearby (Dubin, 1998; LeSage, 1999). Both the seller and the buyer use information from comparable surrounding sales to inform them of the appropriate transaction price, and nearby homes often experience similar amenities and disamenities. Therefore, the price for any single home is likely to be weakly dependent of the prices of homes in close temporal and spatial proximity. This lack of independence of home sale prices could bias the hedonic results (Dubin, 1998; LeSage, 1999), if not adequately addressed. A number of techniques are available to address this concern (Case et al., 2004; Espey et al., 2007), but because of the large sample and computing limits, a variation of the Spatial Auto Regressive Model (SAR) was chosen (Espey et al., 2007).

Specifically, an independent variable is included in the models: the predicted values of the weighted nearest neighbor's natural log of sales price in 1996 dollars.[127] To construct this vector of predicted prices, an auxiliary regression is developed using the spatially weighted average natural log of sales price in 1996 dollars as the independent variable and the spatially weighted average set of home characteristics as the dependent variables. This regression was used to produce the <u>predicted</u> weighted nearest neighbor's natural log of sales price in 1996 dollars that is then included in the Base and Alternative Models. This process required the following steps:

1) Selecting the neighbors for inclusion in the calculation;
2) Calculating a weighted sales price from these neighbors' transactions;
3) Selecting and calculating the weighted neighbors home characteristics; and
4) Forecasting the weighted average neighbor's sales price.

- **Selecting the neighbors**: To select the neighbors whose home transactions would most likely have affected the sales price of the subject home under review, all of the homes that

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[126] The critical values for the models were between 1.89 and 2.53, assuming 5% significance, greater than 20 variables, and more than 200 cases (Gujarati, 2003).

[127] The predicted value was used, instead of the actual value, to help correct for simultaneity or endogeneity problems that might otherwise exist.

sold within the preceding six months of a subject home's sale date in the same study area are identified and, from those, the five nearest neighbors based on Euclidian distance are selected. The inverse of each selected nearest neighbors' distance (in quarter miles) to the subject home was then calculated. Each of these values was then divided by the sum of the five nearest neighbor's inverse distance values to create a neighbor's distance weight (NDW) for each of the five nearest neighbors.[128]

- **Creating the weighted sales price**: Each of the neighbor's natural log of sales price in 1996 dollars (LN_Saleprice96) is multiplied by its distance weight (NDW). Then, each weighted neighbor's LN_Saleprice96 is summed to create a weighted nearest neighbor LN_Saleprice96 (Nbr_LN_Saleprice96).

- **Selecting and calculating the weighted neighbors home characteristics**: Nine independent variables are used from each of the neighbor's homes: square feet, age of the home at the time of sale, age of the home at the time of sale squared, acres, number of full baths, and condition (1-5, with Poor = 1, Below Average = 2, etc.). A weighted average is created of each of the characteristics by multiplying each of the neighbor's individual characteristics by their NDW, and then summing those values across the five neighbors to create the weighted average nearest neighbors' home characteristic.[129] Then each of the independent variables is interacted with the study area to allow each one to be independently estimated for each study area.

- **Forecasting the weighted average neighbors sales price**: To create the final predicted neighbor's price, the weighted nearest neighbor LN_Saleprice96 is regressed on the weighted average nearest neighbors' home characteristics to produce a predicted weighted nearest neighbor LN_Saleprice96 (Nbr_LN_SalePrice96_hat). These predicted values are then included in the Base and Alternative Models as independent variables to account for the spatial and temporal influence of the neighbors' home transactions.

In all models, the coefficient for this spatial adjustment parameter meets the expectations for sign and magnitude and is significant well above the 99% level, indicating both the presence of spatial autocorrelation and the appropriateness of the control for it.

Multicollinearity: There are several standard formal tests for detecting multicollinearity within the independent variables of a regression model. The Variance-Inflation Factor and Condition Index is applied to test for this violation of OLS assumptions. Specifically, a Variance-Inflation Factor (VIF) greater than 4 and/or a Condition Index of greater than 30 (Kleinbaum et al., 1988) are strong indicators that multicollinearity may exist. Multicollinearity is found in the model using both tests. Such a result is not uncommon in hedonic models because a number of characteristics, such as square feet or age of a home, are often correlated with other characteristics, such as the number of acres, bathrooms, and fireplaces. Not surprisingly, age of the home at the time of sale (AgeofHome) and the age of the home squared (AgeatHome_Sqrd)

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[128] Put differently, the weight is the contribution of that home's inverse distance to the total sum of the five nearest neighbors' inverse distances.

[129] Condition requires rounding to the nearest integer and then creating a dummy from the 1-5 integers.

exhibited some multicollinearity (VIF equaled 11.8 and 10.6, respectively). Additionally, the home condition shows a fairly high Condition Index with square feet, indicating collinearity. More importantly, though, are the collinearity statistics for the variables of interest. The VIF for the VIEW variables range from 1.17 to 1.18 and for the DISTANCE variables they range from 1.2 to 3.6, indicating little collinearity with the other variables in the model. To test for this in another way, a number of models are compared with various identified highly collinear variables removed (e.g., AgeatSale, Sqft) and found that the removal of these variables had little influence on the variables of interest. Therefore, despite the presence of multicollinearity in the model, it is not believed that the variables of interest are inappropriately influenced. Further, any corrections for these issues might cause more harm to the model's estimating efficiency than taking no further action (Gujarati, 2003); as such, no specific adjustments to address the presence of multicollinearity are pursued further.

Appendix H: Alternative Models: Full Hedonic Regression Results

Table A - 6: Full Results for the Distance Stability Model

	Coef.	SE	p Value	*n*
Intercept	7.61	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.33	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.13	0.01	0.00	1,445
Cnd High	0.23	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.08	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.30	0.03	0.00	291
PAWC	-0.07	0.03	0.01	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
Mile Less 0 57	-0.04	0.04	0.29	67
Mile 0 57to1	-0.06	0.05	0.27	58
Mile 1to3	-0.01	0.02	0.71	2,019
Mile 3to5	0.01	0.01	0.26	1,923
Mile Gtr5	Omitted	Omitted	Omitted	870

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	2
Model Name	**Distance Stability**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**33**
F Statistic	**496.7**
Adjusted R Squared	**0.77**

Table A - 7: Full Results for the View Stability Model

	Coef.	SE	Sig	*n*
Intercept	7.64	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.34	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.13	0.01	0.00	1,445
Cnd High	0.23	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.02	0.00	1,071
OKCC	-0.45	0.02	0.00	476
IABV	-0.25	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.08	0.03	0.00	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
Post Con NoView	Omitted	Omitted	Omitted	4,207
View Minor	-0.02	0.01	0.25	561
View Mod	0.00	0.03	0.90	106
View Sub	-0.04	0.06	0.56	35
View Extrm	-0.03	0.06	0.61	28

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**3**
Model Name	**View Stability**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**33**
F Statistic	**495.9**
Adjusted R Squared	**0.77**

Table A - 8: Full Results for the Continuous Distance Model

	Coef.	SE	p Value	*n*
Intercept	7.64	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.34	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.13	0.01	0.00	1,445
Cnd High	0.23	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.02	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.25	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.00	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
No View	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.01	0.33	561
Moderate View	0.01	0.03	0.77	106
Substantial View	-0.02	0.07	0.72	35
Extreme View	0.01	0.10	0.88	28
InvDISTANCE	-0.01	0.02	0.46	4,937

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**5**
Model Name	**Continuous Distance Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**34**
F Statistic	**481.3**
Adjusted R Squared	**0.77**

Table A - 9: Full Results for the All Sales Model

	Coef.	SE	p Value	*n*
Intercept	9.08	0.14	0.00	
Nbr LN SP96 hat All OI	0.16	0.01	0.00	7,459
AgeatSale	-0.007	0.0003	0.00	7,459
AgeatSale Sqrd	0.00003	0.000002	0.00	7,459
Sqft 1000	0.28	0.01	0.00	7,459
Acres	0.02	0.00	0.00	7,459
Baths	0.08	0.01	0.00	7,459
ExtWalls Stone	0.21	0.01	0.00	2,287
CentralAC	0.12	0.01	0.00	3,785
Fireplace	0.11	0.01	0.00	2,708
FinBsmt	0.09	0.01	0.00	990
Cul De Sac	0.09	0.01	0.00	1,472
Water Front	0.35	0.03	0.00	107
Cnd Low	-0.43	0.04	0.00	101
Cnd BAvg	-0.21	0.02	0.00	519
Cnd Avg	Omitted	Omitted	Omitted	4,357
Cnd AAvg	0.13	0.01	0.00	2,042
Cnd High	0.22	0.02	0.00	440
Vista Poor	-0.25	0.02	0.00	470
Vista BAvg	-0.09	0.01	0.00	4,301
Vista Avg	Omitted	Omitted	Omitted	1,912
Vista AAvg	0.10	0.01	0.00	659
Vista Prem	0.09	0.03	0.00	117
WAOR	Omitted	Omitted	Omitted	790
TXHC	-0.82	0.02	0.00	1,311
OKCC	-0.53	0.02	0.00	1,113
IABV	-0.31	0.02	0.00	822
ILLC	-0.05	0.02	0.02	412
WIKCDC	-0.17	0.01	0.00	810
PASC	-0.37	0.03	0.00	494
PAWC	-0.15	0.02	0.00	551
NYMCOC	-0.25	0.02	0.00	463
NYMC	-0.15	0.02	0.00	693
Pre-Construction Sales	Omitted	Omitted	Omitted	2,522
No View	0.02	0.01	0.06	4,207
Minor View	0.00	0.02	0.76	561
Moderate View	0.03	0.03	0.38	106
Substantial View	0.03	0.07	0.63	35
Extreme View	0.06	0.08	0.43	28
Inside 3000 Feet	-0.06	0.05	0.23	80
Between 3000 Feet and 1 Mile	-0.08	0.05	0.08	65
Between 1 and 3 Miles	0.00	0.01	0.79	2,359
Between 3 and 5 Miles	0.01	0.01	0.58	2,200
Outside 5 Miles	0.00	0.02	0.76	1,000
Pre-Announcement Sales	Omitted	Omitted	Omitted	1,755

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**6**
Model Name	**All Sales Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**7459**
Number of Predictors (k)	**39**
F Statistic	**579.9**
Adjusted R Squared	**0.75**

Table A - 10: Full Results for the Temporal Aspects Model

	Coef.	**SE**	**p Value**	***n***
Intercept	9.11	0.14	0.00	
Nbr LN SP96 hat All OI	0.16	0.01	0.00	7,459
AgeatSale	-0.007	0.0003	0.00	7,459
AgeatSale Sqrd	0.00003	0.000002	0.00	7,459
Sqft 1000	0.28	0.01	0.00	7,459
Acres	0.02	0.00	0.00	7,459
Baths	0.08	0.01	0.00	7,459
ExtWalls Stone	0.21	0.01	0.00	2,287
CentralAC	0.12	0.01	0.00	3,785
Fireplace	0.12	0.01	0.00	2,708
FinBsmt	0.09	0.01	0.00	990
Cul De Sac	0.09	0.01	0.00	1,472
Water Front	0.35	0.03	0.00	107
Cnd Low	-0.43	0.04	0.00	101
Cnd BAvg	-0.21	0.02	0.00	519
Cnd Avg	Omitted	Omitted	Omitted	4,357
Cnd AAvg	0.13	0.01	0.00	2,042
Cnd High	0.22	0.02	0.00	440
Vista Poor	-0.25	0.02	0.00	470
Vista BAvg	-0.09	0.01	0.00	4,301
Vista Avg	Omitted	Omitted	Omitted	1,912
Vista AAvg	0.10	0.01	0.00	659
Vista Prem	0.09	0.03	0.00	117
WAOR	Omitted	Omitted	Omitted	790
TXHC	-0.82	0.02	0.00	1,311
OKCC	-0.52	0.02	0.00	1,113
IABV	-0.30	0.02	0.00	822
ILLC	-0.04	0.02	0.05	412
WIKCDC	-0.17	0.02	0.00	810
PASC	-0.37	0.03	0.00	494
PAWC	-0.14	0.02	0.00	551
NYMCOC	-0.25	0.02	0.00	463
NYMC	-0.15	0.02	0.00	693

"Omitted" = reference category for fixed effects variables
"n" indicates number of cases in category when category = "1"

Note: Results for variables of interest shown on following page

	Coef.	SE	p Value	*n*
No View	Omitted	Omitted	Omitted	6,729
Minor View	-0.02	0.01	0.20	561
Moderate View	0.00	0.03	0.97	106
Substantial View	0.01	0.07	0.87	35
Extreme View	0.04	0.07	0.59	28
Pre_Anc_Gtr2Yr_Lt1Mile	-0.13	0.06	0.02	38
Pre_Anc_2Yr_Lt1Mile	-0.10	0.05	0.06	40
Post_Anc_Pre_Con_Lt1Mile	-0.14	0.06	0.02	21
Post_Con_2Yr_Lt1Mile	-0.09	0.07	0.15	39
Post_Con_2_4Yr_Lt1Mile	-0.01	0.06	0.86	44
Post_Con_Gtr5Yr_Lt1Mile	-0.07	0.08	0.37	42
Pre_Anc_Gtr2Yr_1_3Mile	-0.04	0.03	0.19	283
Pre_Anc_2Yr_1_3Mile	0.00	0.03	0.91	592
Post_Anc_Pre_Con_1_3Mile	-0.02	0.03	0.53	342
Post_Con_2Yr_1_3Mile	0.00	0.03	0.90	807
Post_Con_2_4Yr_1_3Mile	0.01	0.03	0.78	503
Post_Con_Gtr5Yr_1_3Mile	0.00	0.03	0.93	710
Pre_Anc_Gtr2Yr_3_5Mile	0.00	0.04	0.93	157
Pre_Anc_2Yr_3_5Mile	0.00	0.03	0.98	380
Post_Anc_Pre_Con_3_5Mile	0.00	0.03	0.93	299
Post_Con_2Yr_3_5Mile	0.02	0.03	0.56	574
Post_Con_2_4Yr_3_5Mile	0.01	0.03	0.66	594
Post_Con_Gtr5Yr_3_5Mile	0.01	0.03	0.68	758
Pre_Anc_Gtr2Yr_Gtr5Mile	Omitted	Omitted	Omitted	132
Pre_Anc_2Yr_Gtr5Mile	-0.03	0.04	0.39	133
Post_Anc_Pre_Con_Gtr5Mile	-0.03	0.03	0.36	105
Post_Con_2Yr_Gtr5Mile	-0.03	0.03	0.44	215
Post_Con_2_4Yr_Gtr5Mile	0.03	0.03	0.42	227
Post_Con_Gtr5Yr_Gtr5Mile	0.01	0.03	0.72	424

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	7
Model Name	**Temporal Aspects Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**7459**
Number of Predictors (k)	**56**
F Statistic	**404.5**
Adjusted R2	**0.75**

Table A - 11: Full Results for the Orientation Model

	Coef.	SE	p Value	*n*
Intercept	7.62	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.33	0.04	0.00	87
Cnd Low	-0.44	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.13	0.01	0.00	1,445
Cnd High	0.24	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.08	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.01	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
No View	Omitted	Omitted	Omitted	4,207
Minor View	-0.01	0.06	0.92	561
Moderate View	0.00	0.06	0.97	106
Substantial View	-0.01	0.09	0.87	35
Extreme View	0.02	0.17	0.89	28
Inside 3000 Feet	-0.04	0.07	0.55	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.37	58
Between 1 and 3 Miles	0.00	0.02	0.83	2,019
Between 3 and 5 Miles	0.02	0.01	0.22	1,923
Outside 5 Miles	Omitted	Omitted	Omitted	870
Front Orientation	-0.01	0.06	0.82	294
Back Orientation	0.03	0.06	0.55	280
Side Orientation	-0.03	0.06	0.55	253

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	**8**
Model Name	**Orientation Model**
Dependent Variable	**LN_SalePrice96**
Number of Cases	**4937**
Number of Predictors (k)	**40**
F Statistic	**410.0**
Adjusted R Squared	**0.77**

Table A - 12: Full Results for the Overlap Model

	Coef.	SE	p Value	*n*
Intercept	7.61	0.18	0.00	
Nbr LN SalePrice96 hat	0.29	0.02	0.00	4,937
AgeatSale	-0.006	0.0004	0.00	4,937
AgeatSale Sqrd	0.00002	0.000003	0.00	4,937
Sqft 1000	0.28	0.01	0.00	4,937
Acres	0.02	0.00	0.00	4,937
Baths	0.09	0.01	0.00	4,937
ExtWalls Stone	0.21	0.02	0.00	1,486
CentralAC	0.09	0.01	0.00	2,575
Fireplace	0.11	0.01	0.00	1,834
FinBsmt	0.08	0.02	0.00	673
Cul De Sac	0.10	0.01	0.00	992
Water Front	0.34	0.04	0.00	87
Cnd Low	-0.45	0.05	0.00	69
Cnd BAvg	-0.24	0.02	0.00	350
Cnd Avg	Omitted	Omitted	Omitted	2,727
Cnd AAvg	0.13	0.01	0.00	1,445
Cnd High	0.24	0.02	0.00	337
Vista Poor	-0.21	0.02	0.00	310
Vista BAvg	-0.08	0.01	0.00	2,857
Vista Avg	Omitted	Omitted	Omitted	1,247
Vista AAvg	0.10	0.02	0.00	448
Vista Prem	0.13	0.04	0.00	75
WAOR	Omitted	Omitted	Omitted	519
TXHC	-0.75	0.03	0.00	1,071
OKCC	-0.44	0.02	0.00	476
IABV	-0.24	0.02	0.00	605
ILLC	-0.09	0.03	0.00	213
WIKCDC	-0.14	0.02	0.00	725
PASC	-0.31	0.03	0.00	291
PAWC	-0.07	0.03	0.00	222
NYMCOC	-0.20	0.03	0.00	346
NYMC	-0.15	0.02	0.00	469
No View	Omitted	Omitted	Omitted	4,207
Minor View	-0.03	0.02	0.10	561
Moderate View	-0.02	0.04	0.67	106
Substantial View	-0.05	0.09	0.57	35
Extreme View	-0.03	0.10	0.77	28
Inside 3000 Feet	-0.05	0.06	0.41	67
Between 3000 Feet and 1 Mile	-0.05	0.05	0.38	58
Between 1 and 3 Miles	0.00	0.02	0.82	2,019
Between 3 and 5 Miles	0.02	0.01	0.22	1,923
Outside 5 Miles	Omitted	Omitted	Omitted	870
View Does Not Overlap Vista	Omitted	Omitted	Omitted	320
View Barely Overlaps Vista	0.05	0.03	0.09	150
View Somewhat Overlaps Vista	0.01	0.03	0.67	132
View Strongly Overlaps Vista	0.05	0.05	0.31	128

"Omitted" = reference category for fixed effects variables

"n" indicates number of cases in category when category = "1"

Model Information

Model Equation Number	9
Model Name	Overlap Model
Dependent Variable	LN_SalePrice96
Number of Cases	4937
Number of Predictors (k)	40
F Statistic	409.7
Adjusted R Squared	0.77

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A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States

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Environmental Energy
Technologies Division

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A Spatial Hedonic Analysis of the Effects of Wind Energy Facilities on Surrounding Property Values in the United States

Prepared for the

Office of Energy Efficiency and Renewable Energy
Wind and Water Power Technologies Office
U.S. Department of Energy

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Abstract

Previous research on the effects of wind energy facilities on surrounding home values has been limited by small samples of relevant home-sale data and the inability to account adequately for confounding home-value factors and spatial dependence in the data. This study helps fill those gaps. We collected data from more than 50,000 home sales among 27 counties in nine states. These homes were within 10 miles of 67 different wind facilities, and 1,198 sales were within 1 mile of a turbine—many more than previous studies have collected. The data span the periods well before announcement of the wind facilities to well after their construction. We use OLS and spatial-process difference-in-difference hedonic models to estimate the home-value impacts of the wind facilities; these models control for value factors existing before the wind facilities' announcements, the spatial dependence of unobserved factors effecting home values, and value changes over time. A set of robustness models adds confidence to our results. Regardless of model specification, we find no statistical evidence that home values near turbines were affected in the post-construction or post-announcement/pre-construction periods. Previous research on potentially analogous disamenities (e.g., high-voltage transmission lines, roads) suggests that the property-value effect of wind turbines is likely to be small, on average, if it is present at all, potentially helping to explain why no evidence of an effect was found in the present research.

Table of Contents

Tables

Figures

1. Introduction

In 2012, approximately 13 gigawatts (GW) of wind turbines were installed in the United States, bringing total U.S. installed wind capacity to approximately 60 GW from more than 45,000 turbines (AWEA, 2013). Despite uncertainty about future extensions of the federal production tax credit, U.S. wind capacity is expected by some to continue growing by approximately 5–6 GW annually owing to state renewable energy standards and areas where wind can compete with natural gas on economics alone (Bloomberg, 2013); this translates into approximately 2,750 turbines per year.[1] Much of that development is expected to occur in relatively populated areas (e.g., New York, New England, the Mid-Atlantic and upper Midwest) (Bloomberg, 2013).

In part because of the expected wind development in more-populous areas, empirical investigations into related community concerns are required. One concern is that the values of properties near wind developments may be reduced; after all, it has been demonstrated that in some situations market perceptions about an area's disamenities (and amenities)[2] are capitalized into home prices (e.g., Boyle and Kiel, 2001; Jackson, 2001; Simons and Saginor, 2006). The published research about wind energy and property values has largely coalesced around a finding that homes sold after nearby wind turbines have been constructed do not experience statistically significant property value impacts. Additional research is required, however, especially for homes located within about a half mile of turbines, where impacts would be expected to be the largest. Data and studies are limited for these proximate homes in part because setback requirements generally result in wind facilities being sited in areas with relatively few houses, limiting available sales transactions that might be analyzed.

This study helps fill the research gap by collecting and analyzing data from 27 counties across nine U.S. states, related to 67 different wind facilities. Specifically, using the collected data, the study constructs a pooled model that investigates average effects near the turbines across the sample while controlling for the local effects of many potentially correlated independent variables. Property-value effect estimates are derived from two types of models: (1) an ordinary

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[1] Assuming 2-MW turbines, the 2012 U.S. average (AWEA, 2013), and 5.5 GW of annual capacity growth.

[2] Disamenities and amenities are defined respectively as disadvantages (e.g., a nearby noxious industrial site) and advantages (e.g., a nearby park) of a location.

least squares (OLS) model, which is standard for this type of disamenity research (see, e.g., discussion in Jackson, 2003; Sirmans et al., 2005), and (2) a spatial-process model, which accounts for spatial dependence. Each type of model is used to construct a difference-in-difference (DD) specification—which simultaneously controls for preexisting amenities or disamenities in areas where turbines were sited and changes in the community after the wind facilities' construction was announced—to estimate effects near wind facilities after the turbines were announced and, later, after the turbines were constructed.[3]

The remainder of the report is structured as follows. Section 2 reviews the current literature. Section 3 details our methodology. Section 4 describes the study data. Section 5 presents the results, and Section 6 provides a discussion and concluding remarks.

2. Previous Literature

Although the topic is relatively new, the peer-reviewed literature investigating impacts to home values near wind facilities is growing. To date, results largely have coalesced around a common set of non-significant findings generated from home sales after the turbines became operational. Previous Lawrence Berkeley National Laboratory (LBNL) work in this area (Hoen et al., 2009, 2011) found no statistical evidence of adverse property-value effects due to views of and proximity to wind turbines after the turbines were constructed (i.e., post-construction or PC). Other peer-reviewed and/or academic studies also found no evidence of PC effects despite using a variety of techniques and residential transaction datasets. These include homes surrounding wind facilities in Cornwall, United Kingdom (Sims and Dent, 2007; Sims et al., 2008); multiple wind facilities in McLean County, Illinois (Hinman, 2010); near the Maple Ridge Wind Facility in New York (Heintzelman and Tuttle, 2011); and, near multiple facilities in Lee County, Illinois (Carter, 2011). Analogously, a 2012 Canadian case found a lack of evidence near a wind facility in Ontario to warrant the lowering of surrounding assessments (Kenney v MPAC, 2012). In contrast, one recent study did find impacts to land prices near a facility in North Rhine-Westphalia, Germany (Sunak and Madlener, 2012). Taken together, these results imply that the

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[3] Throughout this report, the terms "announced/announcement" and "constructed/construction" represent the dates on which the proposed wind facility (or facilities) entered the public domain and the dates on which facility construction began, respectively. Home transactions can either be pre-announcement (PA), post-announcement/pre-construction (PAPC), or post-construction (PC).

PC effects of wind turbines on surrounding home values, if they exist, are often too small for detection or sporadic (i.e., a small percentage overall), or appearing in some communities for some types of properties but not others.

In the post-announcement, pre-construction period (i.e., PAPC), however, recent analysis has found more evidence of potential property value effects: by theorizing the possible existence of, but not finding, an effect (Laposa and Mueller, 2010; Sunak and Madlener, 2012); potentially finding an effect (Heintzelman and Tuttle, 2011)[4]; and, consistently finding what the author terms an "anticipation stigma" effect (Hinman, 2010). The studies that found PAPC property-value effects appear to align with earlier studies that suggested lower community support for proposed wind facilities before construction—potentially indicating a risk-averse (i.e., fear of the unknown) stance by community members—but increased support after facilities began operation (Gipe, 1995; Palmer, 1997; Devine-Wright, 2005; Wolsink, 2007; Bond, 2008, 2010). Similarly, researchers have found that survey respondents who live closer to turbines support the turbines more than respondents who live farther away (Braunholtz and MORI Scotland, 2003; Baxter et al., 2013), which could also indicate more risk-adverse / fear of the unknown effects (these among those who live farther away). Analogously, a recent case in Canada, although dismissed, highlighted the fears that nearby residents have for a planned facility (Wiggins v. WPD Canada Corporation, 2013)

Some studies have examined property-value conditions existing before wind facilities were announced (i.e., pre-announcement or PA). This is important for exploring correlations between wind facility siting and pre-existing home values from an environmental justice perspective and also for measuring PAPC and PC effects more accurately. Hoen et al. (2009, 2011) and Sims and Dent (2007) found evidence of depressed values for homes that sold before a wind facility's announcement and were located near the facility's eventual location, but they did not adjust their PC estimates for this finding. Hinman (2010) went further, finding value reductions of 12%–20% for homes near turbines in Illinois, which sold prior to the facilities' announcements; then using these findings to deflate their PC home-value-effect estimates.

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[4] Heintzelman and Tuttle do not appear convinced that the effect they found is related to the PAPC period, yet the two counties in which they found an effect (Clinton and Franklin Counties, NY) had transaction data produced almost entirely in the PAPC period.

Some research has linked wind-related property-value effects with the effects of better-studied disamenities (Hoen et al., 2009). The broader disamenity literature (e.g., Boyle and Kiel, 2001; Jackson, 2001; Simons and Saginor, 2006) suggests that, although property-value effects <u>might</u> occur near wind facilities as they have near other disamenities, those effects (if they do exist) are likely to be relatively small, are unlikely to persist some distance from a facility, and might fade over time as home buyers who are more accepting of the condition move into the area (Tiebout, 1956).

For example, a review of the literature investigating effects near high-voltage transmission lines (a largely visual disturbance, as turbines may be for many surrounding homes) found the following: property-value reductions of 0%–15%; effects that fade with distance, often only affecting properties crossed by or immediately adjacent to a line or tower; effects that can increase property values when the right-of-way is considered an amenity; and effects that fade with time as the condition becomes more accepted (Kroll and Priestley, 1992). While potentially much more objectionable to residential communities than turbines, a review of the literature on landfills (which present odor, traffic, and groundwater-contamination issues) indicates effects that vary by landfill size (Ready, 2010). Large-volume operations (accepting more than 500 tons per day) reduce adjacent property values by 13.7% on average, fading to 5.9% one mile from the landfill. Lower-volume operations reduce adjacent property values by 2.7% on average, fading to 1.3% one mile away, with 20%–26% of lower-volume landfills not having any statistically significant impact. A study of 1,600 toxic industrial plant openings found adverse impacts of 1.5% within a half mile, which disappeared if the plants closed (Currie et al., 2012). Finally, a review of the literature on road noise (which might be analogous to turbine noise) shows property-value reductions of 0% –11% (median 4%) for houses adjacent to a busy road that experience a 10-dBA noise increase, compared with houses on a quiet street (Bateman et al., 2001).

It is not clear where wind turbines might fit into these ranges of impacts, but it seems unlikely that they would be considered as severe a disamenity as a large-volume landfill, which present odor, traffic, and groundwater-contamination issues. Low-volume landfills, with an effect near 3%, might be a better comparison, because they have an industrial (i.e., non-natural) quality, similar to turbines, but are less likely to have clear health effects. If sound is the primary concern, a 4% effect (corresponding to road noise) could be applied to turbines, which might correspond to a 10-dBA increase for houses within a half mile of a turbine (see e.g., Hubbard and Shepherd, 1991). Finally, as with transmission lines, if houses are in sight but not within sound distance of turbines, there may be no property-value effects unless those homes are immediately adjacent to the turbines. In summary, assuming these potentially analogous disamenity effects can be entirely transferred, turbine impacts might be 0%–14%, but more likely might coalesce closer to 3%–4%.

Of course, wind turbines have certain positive qualities that landfills, transmission lines, and roads do not always have, such as mitigating greenhouse gas emissions. no air or water pollution, no use of water during the generation of energy, and no generation of solid or hazardous waste that requires permanent storage/disposal (IPCC, 2011). Moreover, wind facilities can, and often do, provide economic benefits to local communities (Lantz and Tegen, 2009; Slattery et al., 2011; Brown et al., 2012; Loomis et al., 2012), which might not be the case for all other disamenities. Similarly, wind facilities can have direct positive effects on local government budgets through property tax or other similar payments (Loomis and Aldeman, 2011), which might, for example, improve school quality and thus increase nearby home values (e.g., Haurin and Brasington, 1996; Kane et al., 2006). These potential positive qualities might mitigate potential negative wind effects somewhat or even entirely. Therefore for the purposes of this research we will assume 3-4% is a maximum possible effect.

The potentially small average property-value effect of wind turbines, possibly reduced further by wind's positive traits, might help explain why effects have not been discovered consistently in previous research. To discover effects with small margins of error, large amounts of data are needed. However, previous datasets of homes very near turbines have been small. Hoen et al. (2009, 2011) used 125 PC transactions within a mile of the turbines, while others used far fewer PC transactions within a mile: Heintzelman and Tuttle (2012) (*n* ~ 35); Hinman (2010) (*n* ~ 11), Carter (2011) (*n* ~ 41), and Sunak and Madlener (2012) (*n* ~ 51). Although these numbers of observations are adequate to examine large impacts (e.g., over 10%), they are less likely to reveal small effects with any reasonable degree of statistical significance. Using results from Hoen et al. (2009) and the confidence intervals for the various fixed-effect variables in that study, estimates for the numbers of transactions needed to find effects of various sizes were obtained.

Approximately 50 cases are needed to find an effect of 10% and larger, 100 cases for 7.5%, 200 cases for 5%, 350 cases for 4%, 700 cases for 3%, and approximately 1,000 cases for a 2.5% effect.[5] Therefore, in order to detect an effect in the range of 3%–4%, a dataset of approximately 350–700 cases within a mile of the turbines will be required to detect it statistically, a number that to-date has not been amassed by any of the previous studies.

As discussed above, in addition to being relatively small on average, impacts are likely to decay with distance. As such, an appropriate empirical approach must be able to reveal spatially diminishing effects. Some researchers have used continuous variables to capture these effects, such as linear distance (Hoen et al., 2009; Sims et al., 2008) and inverse distance (Heintzelman and Tuttle, 2012; Sunak and Madlener, 2012), but doing so forces the model to estimate effects at the mean distance. In some cases, those means can be far from the area of expected impact. For example, Heintzelman and Tuttle (2012) estimated an inverse distance effect using a mean distance of more than 10 miles from the turbines, while Sunak and Madlener (2012) used a mean distance of approximately 1.9 miles. Using this approach weakens the ability of the model to quantify real effects near the turbines, where they are likely to be stronger. More importantly, this method encourages researchers to extrapolate their findings to the ends of the distance curve, near the turbines, despite having few data at those distances to support these extrapolations. This was the case for Heintzelman and Tuttle (2012), who had fewer than 10 cases within a half mile in the two counties where effects were found and only a handful that sold in those counties after the turbines were built, yet they extrapolated their findings to a quarter mile and even a tenth of a mile, where they had very few (if any) cases. Similarly, Sunak and Madlener (2012) had only six PC sales within a half mile and 51 within 1 mile, yet they extrapolated their findings to these distance bands.

One way to avoid using a single continuous function to estimate effects at all distances is to use a spline model, which breaks the distances into continuous groups (Hoen et al., 2011), but this method still imposes structure on the data by forcing the ends of each spline to tie together. A second and more transparent method is to use fixed-effect variables for discrete distances, which imposes little structure on the data (Hoen et al., 2009; Hinman, 2010; Carter, 2011; Hoen et al.,

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[5] This analysis is available upon request from the authors.

2011). Although this latter method has been used in a number of studies, because of a paucity of data, the resulting models are often ineffective at detecting what might be relatively small effects very close to the turbines. As such, when using this method (or any other, in fact) it is important that the underlying dataset is large enough to estimate the anticipated magnitude of the effect sizes.

Finally, one rarely investigated aspect of potential wind-turbine effects is the possibly idiosyncratic nature of spatially averaged transaction data used in the hedonic analyses. Sunak and Madlener (2012) used a geographically weighted regression (GWR), which estimates different regressions for small clusters of data and then allows the investigation of the distribution of effects across all of the clusters. Although GWR can be effective for understanding the range of impacts across the study area, it is not as effective for determining an average effect or for testing the statistical significance of the range of estimates. Results from studies that use GWR methods are also sometimes counter-intuitive.[6] As is discussed in more detail in the methodology section, a potentially better approach is to estimate a spatial-process model that is flexible enough to simultaneously control for spatial heterogeneity and spatial dependence, while also estimating an average effect across fixed discrete effects.

In summary, building on the existing literature, further research is needed on property-value effects in particularly close proximity to wind turbines. Specifically, research is needed that uses a large set of data near the turbines, accounts for home values before the announcement of the facility (as well as after announcement but before construction), accounts for potential spatial dependence in unobserved factors effecting home values, and uses a fixed-effect distance model that is able to accurately estimate effects near turbines.

3. Methodology

The present study seeks to respond to the identified research needs noted above, with this section describing our methodological framework for estimating the effects of wind turbines on the value of nearby homes in the United States.

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[6] For example, Sunak and Madlener (2012) find larger effects related to the turbines in a city that is farther from the turbines than they find in a town which is closer. Additionally, they find stronger effects in the center of a third town than they do on the outskirts of that town, which do not seem related to the location of the turbines.

3.1. Basic Approach and Models

Our methods are designed to help answer the following questions:

1. Did homes that sold prior to the wind facilities' announcement (PA)—and located within a short distance (e.g., within a half mile) from where the turbines were eventually located—sell at lower prices than homes located farther away?
2. Did homes that sold after the wind facilities' announcement but before construction (PAPC)—and located within a short distance (e.g., within a half mile)—sell at lower prices than homes located farther away?
3. Did homes that sold after the wind facilities' construction (PC)—and located within a short distance (e.g., within a half mile)—sell at lower prices than homes located farther away?
4. For question 3 above, if no statistically identifiable effects are found, what is the likely maximum effect possible given the margins of error around the estimates?

To answer these questions, the hedonic pricing model (Rosen, 1974; Freeman, 1979) is used in this paper, as it has been in other disamenity research (Boyle and Kiel, 2001; Jackson, 2001; Simons and Saginor, 2006). The value of this approach is that is allows one to disentangle and control for the potentially competing influences of home, site, neighborhood, and market characteristics on property values, and to uniquely determine how home values near announced or operating facilities are affected.[7] To test for these effects, two pairs of "base" models are estimated, which are then coupled with a set of "robustness" models to test and bound the estimated effects. One pair is estimated using a standard OLS model, and the other is estimated using a spatial-process model. The models in each pair are different in that one focuses on all homes within 1 mile of an existing turbine (*one-mile* models), which allows the maximum number of data for the fixed effect to be used, while the other focuses on homes within a half mile (*half-mile* models), where effects are more likely to appear but fewer data are available. We assume that, if effects exist near turbines, they are larger for the *half-mile* models than the *one-mile* models.

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[7] See Jackson (2003) for a further discussion of the Hedonic Pricing Model and other analysis methods.

As is common in the literature (Malpezzi, 2003; Sirmans et al., 2005), a semi-log functional form of the hedonic pricing model is used for all models, where the dependent variable is the natural log of sales price. The OLS *half-mile* model form is as follows:

$$\ln(SP_i) = \alpha + \sum_a \beta_1(T_i \bullet S_i) + \beta_2(W_i) + \sum_b \beta_3(X_i \bullet C_i) + \beta_4(D_i \bullet P_i) + \varepsilon_i \quad (1)$$

where

SP_i represents the sale price for transaction *i*,

α is the constant (intercept) across the full sample,

T_i is a vector of time-period dummy variables (e.g., sale year and if the sale occurred in winter) in which transaction *i* occurred,

S_i is the state in which transaction *i* occurred,

W_i is the census tract in which transaction *i* occurred,

X_i is a vector of home, site, and neighborhood characteristics for transaction *i* (e.g., square feet, age, acres, bathrooms, condition, percent of block group vacant and owned, median age of block group),[8]

C_i is the county in which transaction *i* occurred,

D_i is a vector of four fixed-effect variables indicating the distance (to the nearest turbine) bin (i.e., group) in which transaction *i* is located (e.g., within a half mile, between a half and 1 mile, between 1 and 3 miles, and between 3 and 10 miles),

P_i is a vector of three fixed-effect variables indicating the wind project development period in which transaction *i* occurred (e.g., PA, PAPC, PC),

$B_{1\text{-}3}$ is a vector of estimates for the controlling variables,

B_4 is a vector of 12 parameter estimates of the distance-development period interacted variables of interest,

ε_i is a random disturbance term for transaction *i*.

This pooled construction uses all property transactions in the entire dataset. In so doing, it takes advantage of the large dataset in order to estimate an average set of turbine-related effects across all study areas, while simultaneously allowing for the estimation of controlling characteristics at

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[8] A "block group" is a US Census Bureau geographic delineation that contains a population between 600 to 3000 persons.

the local level, where they are likely to vary substantially across the study areas.[9] Specifically, the interaction of county-level fixed effects (C_i) with the vector of home, site, and neighborhood characteristics (X_i) allows different slopes for each of these independent variables to be estimated for each county. Similarly, interacting the state fixed-effect variables (S_i) with the sale year and sale winter fixed effects variables (T_i) (i.e., if the sale occurred in either Q1 or Q4) allows the estimation of the respective inflation/deflation and seasonal adjustments for each state in the dataset.[10] Finally, to control for the potentially unique collection of neighborhood characteristics that exist at the micro-level, census tract fixed effects are estimated.[11] Because a pooled model is used that relies upon the full dataset, smaller effect sizes for wind turbines will be detectable. At the same time, however, this approach does not allow one to distinguish possible wind turbine effects that may be larger in some communities than in others.

As discussed earlier, effects might predate the announcement of the wind facility and thus must be controlled for. Additionally, the area surrounding the wind facility might have changed over time simultaneously with the arrival of the turbines, which could affect home values. For example, if a nearby factory closed at the same time a wind facility was constructed, the influence of that factor on all homes in the general area would ideally be controlled for when estimating wind turbine effect sizes.

To control for both of these issues simultaneously, we use a difference-in-difference (*DD)* specification (see e.g., Hinman, 2010; Zabel and Guignet, 2012) derived from the interaction of

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[9] The dataset does not include “participating” landowners, those that have turbines situated on their land, but does include “neighboring” landowners, those adjacent to or nearby the turbines. One reviewer notes that the estimated average effects also include any effects from payments “neighboring” landowners might receive that might transfer with the home. Based on previous conversations with developers (see Hoen et al, 2009), we expect that the frequency of these arrangements is low, as is the right to transfer the payments to the new homeowner. Nonetheless, our results should be interpreted as “net” of any influence whatever “neighboring” landowner arrangements might have.

[10] Unlike the vector of home, site, and neighborhood characteristics, sale price inflation/deflation and seasonal changes were not expected tovary substantially across various counties in the same states in our sample and therefore the interaction was made at the state level. This assumption was tested as part of the robustness tests though, where they are interacted at the county level and found to not affect the results.

[11] In part because of the rural nature of many of the study areas included in the research sample, these census tracts are large enough to contain sales that are located close to the turbines as well as those farther away, thereby ensuring that they do not unduly absorb effects that might be related to the turbines. Moreover each tract contains sales from throughout the study periods, both before and after the wind facilities’ announcement and construction, further ensuring they are not biasing the variables of interest.

the spatial (D_i) and temporal (P_i) terms. These terms produce a vector of 11 parameter estimates (β_4) as shown in Table 1 for the *half-mile* models and in Table 2 for the *one-mile* models. The omitted (or reference) group in both models is the set of homes that sold prior to the wind facilities' announcement and which were located more than 3 miles away from where the turbines were eventually located (A3). It is assumed that this reference category is likely not affected by the imminent arrival of the turbines, although this assumption is tested in the robustness tests.

Using the *half-mile* models, to test whether the homes located near the turbines that sold in the PA period were uniquely affected (*research question 1*), we examine A0, from which the null hypothesis is A0=0. To test if the homes located near the turbines that sold in the PAPC period were uniquely affected (*research question 2*), we first determine the difference in their values as compared to those farther away (B0-B3), while also accounting for any pre-announcement (i.e., pre-existing) difference (A0-A3) and any change in the local market over the development period (B3-A3). Because all covariates are determined in relation to the omitted category (A3), the null hypothesis collapses B0-A0-B3=0. Finally, in order to determine if homes near the turbines that sold in the PC period were uniquely affected (*research question 3*), we test if C0-A0-C3=0. Each of these *DD* tests are estimated using a linear combination of variables that produces the "net effect" and a measure of the standard error and corresponding confidence intervals of the effect, which enables the estimation of the maximum (and minimum) likely impacts for each research question. We use 90% confidence intervals both to determine significance and to estimate maximum likely effects (*research question 4*).

Following the same logic as above, the corresponding hypothesis tests for the *one-mile* models are as follows: *PA*, A1=0; *PAPC*, B1-A1-B3=0; and, *PC,* C1-A1-C3=0.

Table 1: Interactions between Wind Facility Development Periods and Distances – ½ Mile

	Distances to Nearest Turbine			
Wind Facility Development Periods	Within 1/2 Mile	Between 1/2 and 1 Mile	Between 1 and 3 Miles	Outside of 3 Miles
Prior to Announcement	A0	A1	A2	A3 (Omitted)
After Announcement but Prior to Construction	B0	B1	B2	B3
Post Construction	C0	C1	C2	C3

Table 2: Interactions between Wind Facility Development Periods and Distances - 1 Mile

	Distances to Nearest Turbine		
Wind Facility Development Periods	Within 1 Mile	Between 1 and 3 Miles	Outside of 3 Miles
Prior to Announcement	A1	A2	A3 (Omitted)
After Announcement but Prior to Construction	B1	B2	B3
Post Construction	C1	C2	C3

3.2. Spatial Dependence

As discussed briefly above, a common feature of the data used in hedonic models is the spatially dense nature of the real estate transactions. While this spatial density can provide unique insights into local real estate markets, one concern that is often raised is the impact of potentially omitted variables given that this is impossible to measure all of the local characteristics that affect housing prices. As a result, spatial dependence in a hedonic model is likely because houses located closer to each other typically have similar unobservable attributes. Any correlation between these unobserved factors and the explanatory variables used in the model (e.g., distance to turbines) is a source of omitted-variable bias in the OLS models. A common approach used in the hedonic literature to correct this potential bias is to include local fixed effects (Hoen et al., 2009, 2011; Zabel and Guignet, 2012), which is our approach as described in formula (1).

In addition to including local fixed effects, spatial econometric methods can be used to help further mitigate the potential impact of spatially omitted variables by modeling spatial dependence directly. When spatial dependence is present and appropriately modeled, more accurate (i.e., less biased) estimates of the factors influencing housing values can be obtained. These methods have been used in a number of previous hedonic price studies; examples include the price impacts of wildfire risk (Donovan et al., 2007), residential community associations (Rogers, 2006), air quality (Anselin and Lozano-Gracia, 2009), and spatial fragmentation of land use (Kuethe, 2012). To this point, however, these methods have not been applied to studies of the impact of wind turbines on property values.

Moran's I is the standard statistic used to test for spatial dependence in OLS residuals of the hedonic equation. If the Moran's I is statistically significant (as it is in our models – see Section 5.1.2), the assumption of spatial independence is rejected. To account for this, in spatial-process models, spatial dependence is routinely modeled as an additional covariate in the form of a spatially lagged dependent variable *Wy*, or in the error structure $\mu = \lambda W\mu + \varepsilon$, where ε is an identically and independently distributed disturbance term (Anselin, 1988). Neighboring criterion determines the structure of the spatial weights matrix *W*, which is frequently based on contiguity, distance criterion, or *k*-nearest neighbors (Anselin, 2002). The weights in the spatial-weights matrix are typically row standardized so that the elements of each row sum to one.

The spatial-process model, known as the SARAR model (Kelejian and Prucha, 1998)[12], allows for both forms of spatial dependence, both as an autoregressive process in the lag-dependent and in the error structure, as shown by:

$$\begin{aligned} y &= \rho Wy + X\beta + \mu, \\ \mu &= \lambda W\mu + \varepsilon. \end{aligned} \tag{2}$$

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[12] SARAR refers to a "spatial-autoregressive model with spatial autoregressive residuals".

Equation (2) is often estimated by a multi-step procedure using generalized moments and instrumental variables (Arraiz et al., 2009), which is our approach. The model allows for the innovation term ε in the disturbance process to be heteroskedastic of an unknown form (Kelejian and Prucha, 2010). If either λ or ρ are not significant, the model reduces to the respective spatial lag or spatial error model (SEM). In our case, as is discussed later, the spatial process model reduces to the SEM, therefore both *half-mile* and *one-mile* SEMs are estimated, and, as with the OLS models discussed above, a similar set of *DD* "net effects" are estimated for the PA, PAPC, and PC periods. One requirement of the spatial model is that the x/y coordinates be unique across the dataset. However, the full set of data (as described below) contains, in some cases, multiple sales for the same property, which consequently would have non-unique x/y coordinates.[13] Therefore, for the spatial models, only the most recent sale is used. An OLS model using this limited dataset is also estimated as a robustness test.

In total, four "base" models are estimated: an OLS *one-mile* model, a SEM *one-mile* model, an OLS *half-mile* model, and a SEM *half-mile* model. In addition, a series of robustness models are estimated as described next.

3.3. Robustness Tests

To test the stability of and potentially bound the results from the four base models, a series of robustness tests are conducted that explore: the effect that outliers and influential cases have on the results; a micro-inflation/deflation adjustment by interacting the sale-year fixed effects with the county fixed effects rather than state fixed effects; the use of only the most recent sale of homes in the dataset to compare results to the SEM models that use the same dataset; the application of a more conservative reference category by using transactions between 5 and 10 miles (as opposed to between 3 and 10 miles) as the reference; and a more conservative

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[13] The most recent sale weights the transactions to those occurring after announcement and construction, that are more recent in time. One reviewer wondered if the frequency of sales was affected near the turbines, which is also outside the scope of the study, though this "sales volume" was investigated in Hoen et al. (2009), where no evidence of such an effect was discovered. Another correctly noted that the most recent assessment is less accurate for older sales, because it might overestimate some characteristics of the home (e.g., sfla, baths) that might have changed (i.e., increased) over time. This would tend to bias those characteristics' coefficients downward. Regardless, it is assumed that this occurrence is not correlated with proximity to turbines and therefore would not bias the variables of interest.

reference category by using transactions more than 2 years PA (as opposed to simply PA) as the reference category. Each of these tests is discussed in detail below.

3.3.1. Outliers and Influential Cases

Most datasets contain a subset of observations with particularly high or low values for the dependent variables, which might bias estimates in unpredictable ways. In our robustness test, we assume that observations with sales prices above or below the 99% and 1% percentile are potentially problematic outliers. Similarly, individual sales transactions and the values of the corresponding independent variables might exhibit undue influence on the regression coefficients. In our analysis, we therefore estimate a set of Cook’s Distance statistics (Cook, 1977; Cook and Weisberg, 1982) on the base OLS *half-mile* model and assume any cases with an absolute value of this statistic greater than one to be potentially problematic influential cases. To examine the influence of these cases on our results, we estimate a model with both the outlying sales prices and Cook’s influential cases removed.

3.3.2. Interacting Sale Year at the County Level

It is conceivable that housing inflation and deflation varied dramatically in different parts of the same state. In the base models, we interact sale year with the state to account for inflation and deflation of sales prices, but a potentially more-accurate adjustment might be warranted. To explore this, a model with the interaction of sale year and county, instead of state, is estimated.

3.3.3. Using Only the Most Recent Sales

The dataset for the base OLS models includes not only the most recent sale of particular homes, but also, if available, the sale prior to that. Some of these earlier sales occurred many years prior to the most recent sale. The home and site characteristics (square feet, acres, condition, etc.) used in the models are populated via assessment data for the home. For some of these data, only the most recent assessment information is available (rather than the assessment from the time of sale), and therefore older sales might be more prone to error as their characteristics might have changed since the sale.[14] Additionally, the SEMs require that all x/y coordinates entered into the model are unique; therefore, for those models only the most recent sale is used. Excluding older sales therefore potentially reduces measurement error, and also enables a more-direct comparison of effects between the base OLS model and SEM results.

3.3.4. Using Homes between 5 and 10 Miles as Reference Category

The base models use the collection of homes between 3 and 10 miles from the wind facility (that sold before the announcement of the facility) as the reference category in which wind facility effects are not expected. However, it is conceivable that wind turbine effects extend farther than 3 miles. If homes outside of 3 miles are affected by the presence of the turbines, then effects estimated for the target group (e.g., those inside of 1 mile) will be biased downward (i.e., smaller) in the base models. To test this possibility and ensure that the results are not biased, the group of homes located between 5 and 10 miles is used as a reference category as a robustness test.

3.3.5. Using Transactions Occurring More than 2 Years before Announcement as Reference Category

The base models use the collection of homes that sold before the wind facilities were announced (and were between 3 and 10 miles from the facilities) as the reference category, but, as discussed in Hoen et al. (2009, 2011), the announcement date of a facility, when news about a facility enters the public domain, might be after that project was known in private. For example, wind facility developers may begin talking to landowners some time before a facility is announced, and these landowners could share that news with neighbors. In addition, the developer might erect an anemometer to collect wind-speed data well before the facility is formally "announced," which might provide concrete evidence that a facility may soon to be announced. In either case, this news might enter the local real estate market and affect home prices before the formal facility announcement date. To explore this possibility, and to ensure that the reference category

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[14] As discussed in more detail in the Section 4, approximately 60% of all the data obtained for this study (that obtained from CoreLogic) used the most recent assessment to populate the home and site characteristics for all transactions of a given property.

is unbiased, a model is estimated that uses transactions occurring more than 2 years before the wind facilities were announced (and between 3 and 10 miles) as the reference category.

Combined, this diverse set of robustness tests allows many assumptions used for the base models to be tested, potentially allowing greater confidence in the final results.

4. Data

The data used for the analysis are comprised of four types: wind turbine location data, real estate transaction data, home and site characteristic data, and census data. From those, two additional sets of data are calculated: distance to turbine and wind facility development period. Each data type is discussed below. Where appropriate, variable names are shown in *italics*.

4.1. Wind Turbine Locations

Location data (i.e., x/y coordinates) for installed wind turbines were obtained via an iterative process starting with Federal Aviation Administration obstacle data, which were then linked to specific wind facilities by Ventyx[15] and matched with facility-level data maintained by LBNL. Ultimately, data were collected on the location of almost all wind turbines installed in the U.S. through 2011 ($n \sim 40{,}000$), with information about each facility's announcement, construction, and operation dates as well as turbine nameplate capacity, hub height, rotor diameter, and facility size.

4.2. Real Estate Transactions

Real estate transaction data were collected through two sources, each of which supplied the home's sale price (*sp*), sale date (*sd*), x/y coordinates, and address including zip code. From those, the following variables were calculated: natural log of sale price (*lsp*), sale year (*sy*), if the sale occurred in winter (*swinter*) (i.e., in Q1 or Q4).

The first source of real estate transaction data was CoreLogic's extensive dataset of U.S. residential real estate information.[16] Using the x/y coordinates of wind turbines, CoreLogic

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[15] See the EV Energy Map, which is part of the Velocity Suite of products at www.ventyx.com.

[16] See www.corelogic.com.

selected all arms-length single-family residential transactions between 1996 and 2011 within 10 miles of a turbine in any U.S. counties where they maintained data (not including New York – see below) on parcels smaller than 15 acres.[17] The full set of counties for which data were collected were then winnowed to 26 by requiring at least 250 transactions in each county, to ensure a reasonably robust estimation of the controlling characteristics (which, as discussed above, are interacted with county-level fixed effects), and by requiring at least one PC transaction within a half mile of a turbine in each county (because this study's focus is on homes that are located in close proximity to turbines).

The second source of data was the New York Office of Real Property Tax Service (NYORPTS),[18] which supplied a set of arms-length single-family residential transactions between 2001 and 2012 within 10 miles of existing turbines in any New York county in which wind development had occurred prior to 2012. As before, only parcels smaller than 15 acres were included, as were a minimum of 250 transactions and at least one PC transaction within a half mile of a turbine for each New York county. Both CoreLogic and NYORPTS provided the most recent home sale and, if available, the prior sale.

4.3. Home and Site Characteristics

A set of home and site characteristic data was also collected from both data suppliers: 1000s of square feet of living area (*sfla1000*), number of acres of the parcel (*acres*), year the home was built (or last renovated, whichever is more recent) (*yrbuilt*), and the number of full and half bathrooms (*baths*).[19] Additional variables were calculated from the other variables as well: log of 1,000s of square feet (*lsfla1000*),[20] the number of acres less than 1 (*lt1acre)*,[21] age at the time of sale (*age*), and age squared (*agesqr*).[22]

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[17] The 15 acre screen was used because of a desire to exclude from the sample any transaction of property that might be hosting a wind turbine, and therefore directly benefitting from the turbine's presence (which might then increase property values). To help ensure that the screen was effective, all parcels within a mile of a turbine were also visually inspected using satellite and ortho imagery via a geographic information system.

[18] See www.orps.state.ny.us

[19] *Baths* was calculated in the following manner: full bathrooms + (half bathrooms x 0.5). Some counties did not have *baths* data available, so for them *baths* was not used as an independent variable.

[20] The distribution of *sfla1000* is skewed, which could bias OLS estimates, thus *lsfla1000* is used instead, which is more normally distributed. Regression results, though, were robust when *sfla1000* was used instead.

Regardless of when the sale occurred, CoreLogic supplied the related home and site characteristics as of the most recent assessment, while NYORPTS supplied the assessment data as of the year of sale.[23]

4.4. Census Information

Each of the homes in the data was matched (based on the x/y coordinates) to the underlying census block group and tract via ArcGIS. Using the year 2000 block group census data, each transaction was appended with neighborhood characteristics including the median age of the residents (*medage*), the total number of housing units (*units*), the number vacant (*vacant*) homes, and the number of owned (*owned*) homes. From these, the percentages of the total number of housing units in the block group that were vacant and owned were calculated, i.e., *pctvacant* and *pctowned*.

4.5. Distances to Turbine

Using the x/y coordinates of both the homes and the turbines, a Euclidian distance (in miles) was calculated for each home to the nearest wind turbine (*tdis*), regardless of when the sale occurred (e.g., even if a transaction occurred prior to the wind facility's installation).[24] These were then broken into four mutually exclusive distance bins (i.e., groups) for the base *half-mile* models: inside a half mile, between a half and 1 mile, between 1 and 3 miles, and between 3 and 10 miles. They were broken into three mutually exclusive bins for the base *one-mile* models: inside 1 mile, between 1 and 3 miles, and between 3 and 10 miles.

4.6. Wind Facility Development Periods

After identifying the nearest wind turbine for each home, a match could be made to Ventyx' dataset of facility-development announcement and construction dates. These facility-development dates in combination with the dates of each sale of the homes determined in which

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[21] This variable allows the separate estimations of the 1st acre and any additional acres over the 1st.

[22] *Age* and *agesqr* together account for the fact that, as homes age, their values usually decrease, but further increases in age might bestow countervailing positive "antique" effects.

[23] See footnote 13.

[24] Before the distances were calculated, each home inside of 1 mile was visually inspected using satellite and ortho imagery, with x/y coordinates corrected, if necessary, so that those coordinates were on the roof of the home.

of the three facility-development periods (*fdp*) the transaction occurred: *pre-announcement* (PA), *post-announcement-pre-construction* (PAPC), or *post-construction* (PC).

4.7. Data Summary

After cleaning to remove missing or erroneous data, a final dataset of 51,276 transactions was prepared for analysis.[25] As shown in the map of the study area (Figure 1), the data are arrayed across nine states and 27 counties (see Table 4), and surround 67 different wind facilities.

Table 3 contains a summary of those data. The average unadjusted sales price for the sample is $122,475. Other average house characteristics include the following: 1,600 square feet of living space; house age of 48 years[26]; land parcel size of 0.90 acres; 1.6 bathrooms; in a block group in which 74% of housing units are owned, 9% are vacant, and the median resident age is 38 years; located 4.96 miles from the nearest turbine; and sold at the tail end of the PA period.

The data are arrayed across the temporal and distance bins as would be expected, with smaller numbers of sales nearer the turbines, as shown in Table 5. Of the full set of sales, 1,198 occurred within 1 mile of a then-current or future turbine location, and 376 of these occurred post construction; 331 sales occurred within a half mile, 104 of which were post construction. Given these totals, the models should be able to discern a post construction effect larger than ~3.5% within a mile and larger than ~7.5% within a half mile (see discussion in Section 2). These effects are at the top end of the expected range of effects based on other disamenities (high-voltage power lines, roads, landfills, etc.).

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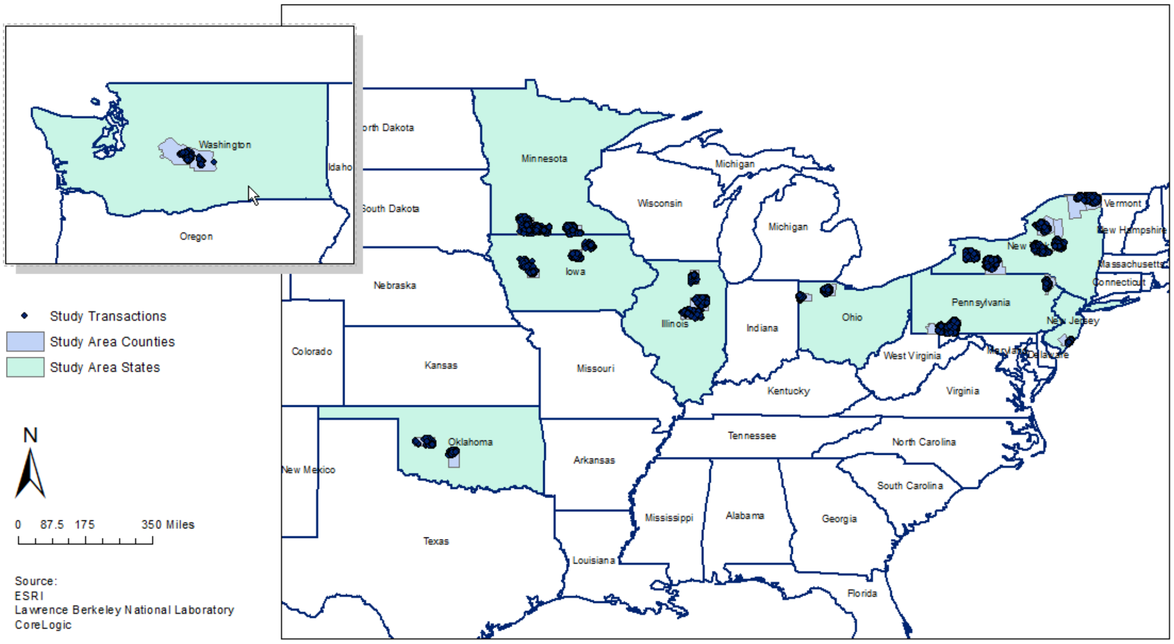
[25] Cleaning involved the removal of all data that did not have certain core characteristics (sale date, sale price, *sfla, yrbuilt, acres, median age*, etc.) fully populated as well as the removal of any sales that had seemingly miscoded data (e.g., having a *sfla* that was greater than *acres,* having a *yrbuilt* more than 1 year after the sale, having less than one *bath*) or that did not conform to the rest of the data (e.g., had *acres* or *sfla* that were either larger or smaller, respectively, than 99% or 1% of the data). OLS models were rerun with those "nonconforming" data included with no substantive change in the results in comparison to the screened data presented in the report.

[26] Age could be as low as -1(for a new home) for homes that were sold before construction was completed.

Figure 1: Map of Transactions, States, and Counties



Source:
ESRI
Lawrence Berkeley National Laboratory
CoreLogic

Table 3: Summary Statistics

Variable	Description	Mean	Std. Dev.	Min	Max
sp	sale price in dollars	$ 122,475	$ 80,367	$ 9,750	$ 690,000
lsp	natural log of sale price	11.52	0.65	9.19	13.44
sd	sale date	1/18/2005	1,403 days	1/1/1996	9/30/2011
sy	sale year	2005	3.84	1996	2011
sfla1000	living area in 1000s of square feet	1.60	0.57	0.60	4.50
lsfla1000	natural log of sfla1000	0.41	0.34	-0.50	1.50
acres	number of acres in parcel	0.90	1.79	0.03	14.95
acreslt1*	acres less than 1	-0.58	0.34	-0.97	0.00
age	age of home at time of sale	48	37	-1	297
agesq	age squared	3689	4925	0	88209
baths**	number of bathrooms	1.60	0.64	1.00	5.50
pctowner	fraction of house units in block group that are owned (as of 2000)	0.74	0.17	0.63	0.98
pctvacant	fraction of house units in block group that are vacant (as of 2000)	0.09	0.10	0.00	0.38
med_age	median age of residents in block group (as of 2000)	38	6	20	63
tdis	distance to nearest turbine (as of December 2011) in miles	4.96	2.19	0.09	10.00
fdp***	facility development period of nearest turbine at time of sale	1.94	0.87	1.00	3.00

Note: The number of cases for the full dataset is 51,276

** acreslt1 is calculated as follows: acres (if less than 1) * - 1*

*** Some counties did not have bathrooms populated; for those, these variables are entered into the regression as 0.*

**** fdp periods are: 1, pre-announcement,; 2, post-announcement-pre-construction; and, 3, post-construction.*

Table 4: Summary of Transactions by County

County	State	<1/2 mile	1/2-1 mile	1-3 miles	3-10 miles	Total
Carroll	IA	12	56	331	666	1,065
Floyd	IA	3	2	402	119	526
Franklin	IA	8	1	9	322	340
Sac	IA	6	77	78	485	646
DeKalb	IL	4	8	44	605	661
Livingston	IL	16	6	237	1,883	2,142
McLean	IL	18	88	380	4,359	4,845
Cottonwood	MN	3	10	126	1,012	1,151
Freeborn	MN	17	16	117	2,521	2,671
Jackson	MN	19	28	36	149	232
Martin	MN	7	25	332	2,480	2,844
Atlantic	NJ	34	96	1,532	6,211	7,873
Paulding	OH	15	58	115	309	497
Wood	OH	5	31	563	4,844	5,443
Custer	OK	45	24	1,834	349	2,252
Grady	OK	1	6	97	874	978
Fayette	PA	1	2	10	284	297
Somerset	PA	23	100	1,037	2,144	3,304
Wayne	PA	4	29	378	739	1,150
Kittitas	WA	2	6	61	349	418
Clinton	NY	4	6	49	1,419	1,478
Franklin	NY	16	41	75	149	281
Herkimer	NY	3	17	354	1,874	2,248
Lewis	NY	5	6	93	732	836
Madison	NY	5	26	239	3,053	3,323
Steuben	NY	5	52	140	1,932	2,129
Wyoming	NY	50	50	250	1,296	1,646
Total		331	867	8,919	41,159	51,276

Table 5: Frequency Crosstab of Wind Turbine Distance and Development Period Bins

	<1/2 mile	1/2-1 mile	1-3 miles	3-10 miles	total
PA	143	383	3,892	16,615	21,033
PAPC	84	212	1,845	9,995	12,136
PC	104	272	3,182	14,549	18,107
total	331	867	8,919	41,159	51,276

As shown in Table 6, the home sales occurred around wind facilities that range from a single-turbine project to projects of 150 turbines, with turbines of 290–476 feet (averaging almost 400 feet) in total height from base to tip of blade and with an average nameplate capacity of 1,637 kW. The average facility was announced in 2004 and constructed in 2007, but some were announced as early as 1998 and others were constructed as late as 2011.

Table 6: Wind Facility Summary

	mean	min	25th percentile	median	75th percentile	max
turbine rotor diameter (feet)	262	154	253	253	269	328
turbine hub height (feet)	256	197	256	262	262	328
turbine total height (feet)	388	290	387	389	397	476
turbine capacity (kW)	1637	660	1500	1500	1800	2500
facility announcement year	2004	1998	2002	2003	2005	2010
facility construction year	2007	2000	2004	2006	2010	2011
number of turbines in facility	48	1	5	35	84	150
nameplate capacity of facility (MW)	79	1.5	7.5	53	137	300

Note: The data correspond to 67 wind facilities located in the study areas. Mean values are rounded to integers

4.8. Comparison of Means

To provide additional context for the analysis discussed in the next section, we further summarize the data here using four key variables across the sets of development period (*fdp*) and distance bins (*tdis*) used in the *one-mile* models.[27] The variables are the dependent variable log of sale price *(lsp)* and three independent variables: *lsfla100, acres*, and *age*. These summaries are provided in Table 7; each sub-table gives the mean values of the variables across the three *fdp* bins and three *tdis* bins, and the corresponding figures plot those values.

The top set of results are focused on the log of the sales price, and show that, based purely on price and not controlling for differences in homes, homes located within 1 mile of turbines had lower sale prices than homes farther away; this is true across all of the three development periods. Moreover, the results also show that, over the three periods, the closer homes appreciated to a somewhat lesser degree than homes located farther from the turbines. As a result, focusing only on the post-construction period, these results might suggest that home prices near turbines are

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[27] Summaries for the *half-mile* models reveal a similar relationship, so only the *one-mile* model summaries are shown here.

adversely impacted by the turbines. After all, the logarithmic values for the homes within a mile of the turbines (11.39) and those outside of a three miles (11.72) translate into an approximately 40% difference, in comparison to an 21% difference before the wind facilities were announced (11.16 vs. 11.35).[28] Focusing on the change in average values between the pre-announcement and post-construction periods might also suggest an adverse effect due to the turbines, because homes inside of 1 mile appreciated more slowly (11.16 to 11.39, or 25%) than those outside of 3 miles (11.35 to 11.72, or 45%). Both conclusions of adverse turbine effects, however, disregard other important differences between the homes, which vary over the periods and distances. Similarly, comparing the values of the PA inside 1 mile homes (11.16) and the PC outside of 3 miles homes (11.72), which translates into a difference of 75%, and which is the basis for comparison in the regressions discussed below, but also ignores any differences in the underlying characteristics.

The remainder of Table 7, for example, indicates that, although the homes that sold within 1 mile are lower in value, they are also generally (in all but the PA period) smaller, on larger parcels of land, and older. These differences in home size and age across the periods and distances might explain the differences in price, while the differences in the size of the parcel, which add value, further amplifying the differences in price. Without controlling for these possible impacts, one cannot reliably estimate the impact of wind turbines on sales prices.

In summary, focusing solely on trends in home price (or price per square foot) alone, and for only the PC period, as might be done in a simpler analysis, might incorrectly suggest that wind turbines are affecting price when other aspects of the markets, and other home and sites characteristic differences, could be driving the observed price differences. This is precisely why researchers generally prefer the hedonic model approach to control for such effects, and the results from our hedonic OLS and spatial modeling detailed in the next section account for these and many other possible influencing factors.

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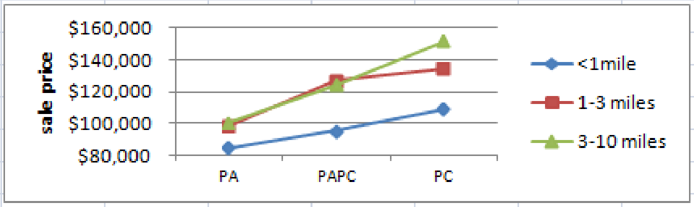
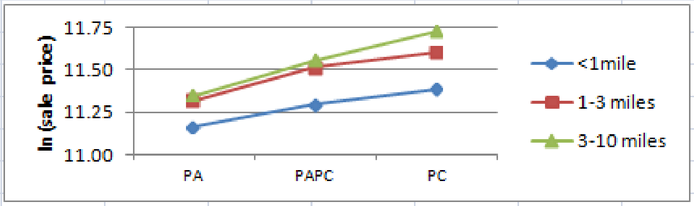
[28] Percentage differences are calculated as follows: exp(11.72-11.39)-1=0.40 and exp(11.35-11.16)-1=0.21.

Table 7: Dependent and Independent Variable Means

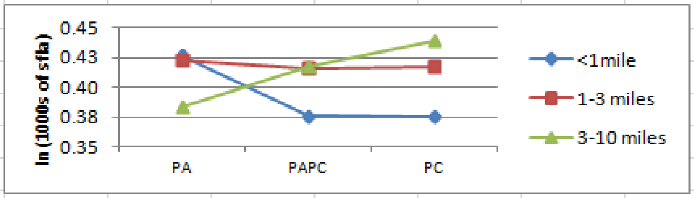
Sale Price			
	<1mile	1-3 miles	3-10 miles
PA	$ 84,830	$ 98,676	$100,485
PAPC	$ 95,223	$127,054	$124,532
PC	$109,133	$134,647	$151,559



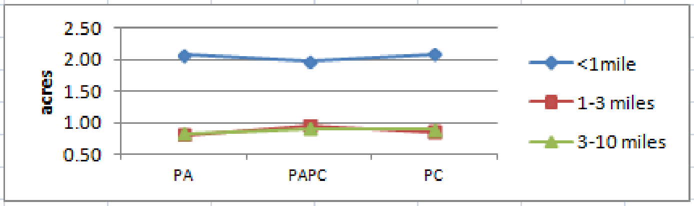
Log of Sale Price			
	<1mile	1-3 miles	3-10 miles
PA	11.16	11.32	11.35
PAPC	11.30	11.52	11.56
PC	11.39	11.61	11.72



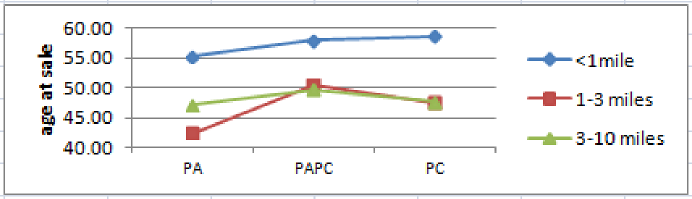
Log of Square Feet (in 1000s)			
	<1mile	1-3 miles	3-10 miles
PA	0.43	0.42	0.38
PAPC	0.38	0.42	0.42
PC	0.38	0.42	0.44



Number of Acres			
	<1mile	1-3 miles	3-10 miles
PA	2.08	0.80	0.83
PAPC	1.98	0.94	0.90
PC	2.09	0.84	0.89



Age at the Time of Sale			
	<1mile	1-3 miles	3-10 miles
PA	55.32	42.34	47.19
PAPC	58.01	50.34	49.73
PC	58.63	47.39	47.73



5. Results

This section contains analysis results and discussion for the four base models, as well as the results from the robustness models.

5.1. Estimation Results for Base Models

Estimation results for the "base" models are shown in Table 8 and Table 9.[29] In general, given the diverse nature of the data, the models perform adequately, with adjusted R^2 values ranging from 0.63 to 0.67 (bottom of Table 9).

5.1.1. Control Variables

The controlling home, site, and block group variables, which are interacted at the county level, are summarized in Table 8. Table 8 focuses on only one of the base models, the *one-mile* OLS model, but full results from all models are shown in the Appendix.[30] To concisely summarize results for all of the 27 counties, the table contains the percentage of all 27 counties for which each controlling variable has statistically significant (at or below the 10% level) coefficients for the *one-mile* OLS model. For those controlling variables that are found to be statistically significant, the table further contains mean values, standard deviations, and minimum and maximum levels.

Many of the county-interacted controlling variables (e.g., *lsfla1000, lt1acre, age, agesqr, baths,* and *swinter*) are consistently (in more than two thirds of the counties) statistically significant (with a *p*-value < 0.10) and have appropriately sized mean values. The seemingly spurious minimum and maximum values among some of the county-level controlling variables (e.g., *lt1acre* minimum of -0.069) likely arise when these variables in particular counties are highly correlated with other variables, such as square feet (*lsfla1000*), and also when sample size is limited.[31] The other variables (*acres* and the three block group level census variables: *pctvacant, pctowner,* and *med_age*) are statistically significant in 33-59% of the counties. Only one variable's mean value—the percent of housing units vacant in the block group as of the 2000 census (*pctvacant*)—was counterintuitive. In that instance, a positive coefficient was estimated, when in fact, one would expect that increasing the percent of vacant housing would lower prices;

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[29] The OLS models are estimated using the areg procedure in Stata with robust (White's corrected) standard errors (White, 1980). The spatial error models are estimated using the *gstslshet* routine in the sphet package in R, which also allows for robust standard errors to be estimated. See: http://cran.r-project.org/web/packages/sphet/sphet.pdf

[30] The controlling variables' coefficients were similar across the base models, so only the *one-mile* results are summarized here.

[31] The possible adverse effects of these collinearities were fully explored both via the removal of the variables and by examining VIF statistics. The VOI results are robust to controlling variable removal and have relatively low (< 5) VIF statistics.

this counter-intuitive effect may be due to collinearity with one or more of the other variables, or possible measurement errors.[32]

The sale year variables, which are interacted with the state, are also summarized in Table 8, with the percentages indicating the number of states in which the coefficients are statistically significant. The inclusion of these sale year variables in the regressions control for inflation and deflation across the various states over the study period. The coefficients represent a comparison to the omitted year, which is 2011. All sale year state-level coefficients are statistically significant in at least 50% of the states in all years except 2010, and they are significant in two thirds of the states in all except 3 years. The mean values of all years are appropriately signed, showing a monotonically ordered peak in values in 2007, with lower values in the prior and following years. The minimum and maximum values are similarly signed (negative) through 2003 and from 2007 through 2010 (positive), and are both positive and negative in years 2003 through 2006, indicating the differences in inflation/deflation in those years across the various states. This reinforces the appropriateness of interacting the sale years at the state level. Finally, although not shown, the model also contains 250 fixed effects for the census tract delineations, of which approximately 50% were statistically significant.

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[32] The removal of this, as well as the other block group census variables, however, did not substantively influence the results of the VOI.

Table 8: Levels and Significance for County- and State-Interacted Controlling Variables[33]

	% of Counties/States Having Significant (*p* -value <0.10) Coefficients	Statistics for Significant Variables			
Variable		Mean	St Dev	Min	Max
lsfla1000	100%	0.604	0.153	0.332	0.979
acres	48%	0.025	0.035	-0.032	0.091
lt1acre	85%	0.280	0.170	-0.069	0.667
age	81%	-0.006	0.008	-0.021	0.010
agesqr	74%	-0.006	0.063	-0.113	0.108
*baths**	85%	0.156	0.088	0.083	0.366
pctvacant	48%	1.295	3.120	-2.485	9.018
pctowner	33%	0.605	0.811	-0.091	2.676
med_age	59%	-0.016	0.132	-0.508	0.066
swinter	78%	-0.034	0.012	-0.053	-0.020
sy1996	100%	-0.481	0.187	-0.820	-0.267
sy1997	100%	-0.448	0.213	-0.791	-0.242
sy1998	100%	-0.404	0.172	-0.723	-0.156
sy1999	100%	-0.359	0.169	-0.679	-0.156
sy2000	88%	-0.298	0.189	-0.565	-0.088
sy2001	88%	-0.286	0.141	-0.438	-0.080
sy2002	67%	-0.261	0.074	-0.330	-0.128
sy2003	67%	-0.218	0.069	-0.326	-0.119
sy2004	75%	-0.084	0.133	-0.208	0.087
sy2005	67%	0.082	0.148	-0.111	0.278
sy2006	67%	0.128	0.158	-0.066	0.340
sy2007	67%	0.196	0.057	0.143	0.297
sy2008	56%	0.160	0.051	0.084	0.218
sy2009	50%	0.138	0.065	0.071	0.219
sy2010	33%	0.172	0.063	0.105	0.231

** % of counties significant is reported only for counties that had the baths variable populated (17 out of 27 counties)*

5.1.2. Variables of Interest

The variables of interest, the interactions between the *fdp* and *tdis* bins, are shown in Table 9 for the four base models. The reference (i.e., omitted) case for these variables are homes that sold prior to the wind facilities' announcement (PA) and are located between 3 and 10 miles from the

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[33] Controlling variable statistics are provided for only the *one-mile* OLS model but did not differ substantially for other models. All variables are interacted with counties, except for sale year (sy), which is interacted with the state.

wind turbines' eventual locations. In relation to that group of transactions, three of the eight interactions in the *one-mile* models and four of the 11 interactions in the *half-mile* models produce coefficients that are statistically significant (at the 10% level).

Across all four base models none of the PA coefficients show statistically significant differences between the reference category (outside of 3 miles) and the group of transactions within a mile for the *one-mile* models (OLS: -1.7%, *p*-value 0.48; SEM: -0.02%, *p*-value 0.94)[34] or within a half- or between one-half and one-mile for the *half-mile* models (OLS inside a half mile: 0.01%, *p*-value 0.97; between a half and 1 mile: -2.3%, *p*-value 0.38; SEM inside a half mile: 5.3%, *p*-value 0.24; between a half and 1 mile: -1.8%, *p*-value 0.60). Further, none of the coefficients are significant, and all are relatively small (which partially explains their non-significance). Given these results, we find an absence of evidence of a PA effect for homes close to the turbines (*research question 1*). These results can be contrasted with the differences in prices between within-1-mile homes and outside-of-3-miles homes as summarized in Section 4.8 when no differences in the homes, the local market, the neighborhood, etc. are accounted for. The approximately 75% difference in price (alone) in the pre-announcement period 1-mile homes, as compared to the PC 3-mile homes, discussed in Section 4.8, is largely explained by differences in the controlling characteristics, which is why the pre-announcement distance coefficients shown here are not statistically significant.

Turning to the PAPC and PC periods, the results also indicate statistically insignificant differences in average home values, all else being equal, between the reference group of transactions (sold in the PA period) and those similarly located more than 3 miles from the turbines but sold in the PAPC or PC periods. Those differences are estimated to be between -0.8% and -0.5%.

The results presented above, and in Table 8, include both OLS and spatial models. Prior to estimating the spatial models, the Moran's I was calculated using the residuals of an OLS model that uses the same explanatory variables as the spatial models and the same dataset (only the most recent transactions). The Moran's I statistic (0.133) was highly significant (*p*-value 0.00),

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[34] p-values are not shown in the table can but can be derived from the standard errors, which are shown.

which allows us to reject the hypothesis that the residuals are spatially independent. Therefore, there was justification in estimating the spatial models. However, after estimation, we determined that only the spatial error process was significant. As a result, we estimated spatial error models (SEMs) for the final specification. The spatial autoregressive coefficient, lambda (bottom of Table 9), which is an indication of spatial autocorrelation in the residuals, is sizable and statistically significant in both SEMs (0.26, *p*-value 0.00). The SEM models' variable-of-interest coefficients are quite similar to those of the OLS models. In most cases, the coefficients are the same sign, approximately the same level, and often similarly insignificant, indicating that although spatial dependence is present it does not substantively bias the variables of interest. The one material difference is the coefficient size and significance for homes outside of 3 miles in the PAPC and PC periods, 3.3% (*p*-value 0.000) and 3.1% (*p*-value 0.008), indicating there are important changes to home values over the periods that must be accounted for in the later DD models in order to isolate the potential impacts that occur due to the presence of wind turbines.

Table 9: Results of Interacted Variables of Interest: *fdp* and *tdis*

		one-mile	*one-mile*	*half-mile*	*half-mile*
		OLS	SEM	OLS	SEM
fdp	tdis	β (se)	β (se)	β (se)	β (se)
PA	< 1 mile	-0.017	0.002		
		(0.024)	*(0.031)*		
PA	1-2 miles	-0.015	0.008		
		(0.011)	*(0.016)*		
PA	> 3 miles	Omitted	Omitted		
		n/a	*n/a*		
PAPC	< 1 mile	-0.035	-0.038		
		(0.029)	*(0.033)*		
PAPC	1-2 miles	-0.001	-0.033.		
		(0.014)	*(0.018)*		
PAPC	> 3 miles	-0.006	-0.033***		
		(0.008)	*(0.01)*		
PC	< 1 mile	0.019	-0.022		
		(0.026)	*(0.032)*		
PC	1-2 miles	0.044***	-0.001		
		(0.014)	*(0.019)*		
PC	> 3 miles	-0.005	-0.031**		
		(0.010)	*(0.012)*		
PA	< 1/2 mile			0.001	0.053
				(0.039)	*(0.045)*
PA	1/2 - 1 mile			-0.023	-0.018
				(0.027)	*(0.035)*
PA	1-2 miles			-0.015	0.008
				(0.011)	*(0.016)*
PA	> 3 miles			Omitted	Omitted
				n/a	*n/a*
PAPC	< 1/2 mile			-0.028	-0.065
				(0.049)	*(0.056)*
PAPC	1/2 - 1 mile			-0.038	-0.027
				(0.033)	*(0.036)*
PAPC	1-2 miles			-0.001	-0.034.
				(0.014)	*(0.017)*
PAPC	> 3 miles			-0.006	-0.033***
				(0.008)	*(0.009)*
PC	< 1/2 mile			-0.016	-0.036
				(0.041)	*(0.046)*
PC	1/2 - 1 mile			0.032	-0.016
				(0.031)	*(0.035)*
PC	1-2 miles			0.044***	-0.001
				(0.014)	*(0.018)*
PC	> 3 miles			-0.005	-0.031**
				(0.010)	*(0.012)*
lambda			0.247 ***		0.247 ***
			(0.008)		*(0.008)*
*Note: p-values: < 0.1 *, < 0.05 **, <0.01 ***.*					
n		51,276	38,407	51,276	38,407
adj R-sqr		0.67	0.64	0.67	0.64

5.1.3. Impact of Wind Turbines

As discussed above, there are important differences in property values between development periods for the reference group of homes (those located outside of 3 miles) that must be accounted for. Further, although they are not significant, differences between the reference category and those transactions inside of 1 mile in the PA period still must be accounted for if accurate measurements of PAPC or PC wind turbine effects are to be estimated. The DD specification accounts for both of these critical effects.

Table 10 shows the results of the DD tests across the four models, based on the results for the variables of interest presented in Table 9.[35] For example, to determine the net difference for homes that sold inside of a half mile (drawing from the *half-mile* OLS model) in the PAPC period, we use the following formula: PAPC half-mile coefficient (-0.028) less the PAPC 3-mile coefficient (-0.006) less the PA half-mile coefficient (0.001), which equals -0.024 (without rounding), which equates to 2.3% difference,[36] and is not statistically significant.

None of the DD effects in either the OLS or SEM specifications are statistically significant in the PAPC or PC periods, indicating that we do not observe a statistically significant impact of wind turbines on property values. Some small differences are apparent in the calculated coefficients, with those for PAPC being generally more negative/less positive than their PC counterparts, perhaps suggestive of a small announcement effect that declines once a facility is constructed. Further, the inside-a-half-mile coefficients are more negative/less positive than their between-a-half-and-1-mile counterparts, perhaps suggestive of a small property value impact very close to turbines.[37] However, in all cases, the sizes of these differences are smaller than the margins of error in the model (i.e., 90% confidence interval) and thus are not statistically significant. Therefore, based on these results, we do not find evidence supporting either of our two core hypotheses (*research questions 2 and 3*). In other words, there is no statistical evidence that homes in either the PAPC or PC periods that sold near turbines (i.e., within a mile or even a half

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[35] All DD estimates for the OLS models were calculated using the post-estimation "lincom" test in Stata, which uses the stored results' variance/covariance matrix to test if a linear combination of coefficients is different from 0. For the SEM models, a similar test was performed in R.

[36] All differences in coefficients are converted to percentages in the table as follows: exp(coef)-1.

[37] Although not discussed in the text, this trend continues with homes between 1 and 2 miles being less negative/more positive than homes closer to the turbines (e.g., those within 1 mile).

mile) did so for less than similar homes that sold between 3 and 10 away miles in the same period.

Further, using the standard errors from the DD models we can estimate the maximum size an average effect would have to be in our sample for the model to detect it (*research question 4*). For an average effect in the PC period to be found for homes within 1 mile of the existing turbines (therefore using the *one-mile* model results), an effect greater than 4.9%, either positive or negative, would have to be present to be detected by the model.[38] In other words, it is highly unlikely that the true average effect for homes that sold in our sample area within 1 mile of an existing turbine is larger than +/-4.9%. Similarly, it is highly unlikely that the true average effect for homes that sold in our sample area within a half mile of an existing turbine is larger than +/-9.0%.[39] Regardless of these maximum effects, however, as well as the very weak suggestion of a possible small announcement effect and a possible small effect on homes that are very close to turbines, the core results of these models show effect sizes that are not statistically significant from zero, and are considerably smaller than these maximums.[40]

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[38] Using the 90% confidence interval (i.e., 10% level of significance) and assuming more than 300 cases, the critical t-value is 1.65. Therefore, using the standard error of 0.030, the 90% confidence intervals for the test will be +/-0.049.

[39] Using the critical t-value of 1.66 for the 100 PC cases within a half mile in our sample and the standard error of 0.054.

[40] It is of note that these maximum effects are slightly larger than those we expected to find, as discussed earlier. This likely indicates that there was more variation in this sample, causing relatively higher standard errors for the same number of cases, than in the sample used for the 2009 study (Hoen et al., 2009, 2011).

Table 10: "Net" Difference-in-Difference Impacts of Turbines

		< 1 Mile	< 1 Mile	< 1/2 Mile	< 1/2 Mile
		OLS	SEM	OLS	SEM
fdp	tdis	b/se	b/se	b/se	b/se
PAPC	< 1 mile	-1.2% ^{NS}	-0.7% ^{NS}		
		(0.033)	*(0.037)*		
PC	< 1 mile	4.2% ^{NS}	0.7% ^{NS}		
		(0.030)	*(0.035)*		
PAPC	< 1/2 mile			-2.3% ^{NS}	-8.1% ^{NS}
				(0.060)	*(0.065)*
PAPC	1/2 - 1 mile			-0.8% ^{NS}	2.5% ^{NS}
				(0.039)	*(0.043)*
PC	< 1/2 mile			-1.2% ^{NS}	-5.6% ^{NS}
				(0.054)	*(0.057)*
PC	1/2 - 1 mile			6.3% ^{NS}	3.4% ^{NS}
				(0.036)	*(0.042)*
Note: p-values: > 10% ^{NS}*, < 10% *, < 5% **, <1 % ****					

5.2. Robustness Tests

Table 11 summarizes the results from the robustness tests. For simplicity, only the DD coefficients are shown and only for the *half-mile* OLS models.[41] The first two columns show the base OLS and SEM *half-mile* DD results (also presented earlier, in Table 9), and the remaining columns show the results from the robustness models as follows: exclusion of outliers and influential cases from the dataset (*outlier*); using sale year/county interactions instead of sale year/state (*sycounty*); using only the most recent sales instead of the most recent and prior sales (*recent*); using homes between 5 and 10 miles as the reference category, instead of homes between 3 and 10 miles (*outside5*); and using transactions occurring more than 2 years before announcement as the reference category instead of using transactions simply *before* announcement (*prior*).

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[41] Results were also estimated for the *one-mile* OLS models for each of the robustness tests and are available upon request: the results do not substantively differ from what is presented here for the *half-mile* models. Because of the similarities in the results between the OLS and SEM "base" models, robustness tests on the SEM models were not prepared as we assumed that differences between the two models for the robustness tests would be minimal as well.

The robustness results have patterns similar to the base model results: none of the coefficients are statistically different from zero; all coefficients (albeit non-significant) are lower in the PAPC period than the PC period; and, all coefficients (albeit non-significant) are lower (i.e., less negative/more positive) within a half mile than outside a half mile.[42] In sum, regardless of dataset or specification, there is no change in the basic conclusions drawn from the base model results: there is no evidence that homes near operating or announced wind turbines are impacted in a statistically significant fashion. Therefore, if effects do exist, either the average impacts are relatively small (within the margin of error in the models) and/or sporadic (impacting only a small subset of homes). Moreover, these results seem to corroborate what might be predicted given the other, potentially analogous disamenity literature that was reviewed earlier, which might be read to suggest that any property value effect of wind turbines might coalesce at a maximum of 3%–4%, on average. Of course, we cannot offer that corroboration directly because, although the size of the coefficients in the models presented here are reasonably consistent with effects of that magnitude, none of our models offer results that are statistically different from zero.

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[42] This trend also continues outside of 1 mile, with those coefficients being less negative/more positive than those within 1 mile.

Table 11: Robustness Half-Mile Model Results

				Robustness OLS Models				
		Base OLS	Base SEM	outlier	sycounty	recent	outside5	prior
fdp	tdis	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)	β (se)
PAPC	< 1/2 mile	-2.3% ^{NS}	-8.1% ^{NS}	-4.7% ^{NS}	-4.2% ^{NS}	-5.6% ^{NS}	-1.7% ^{NS}	0.1% ^{NS}
		(0.060)	*(0.065)*	*(0.056)*	*(0.060)*	*(0.066)*	*(0.060)*	*(0.062)*
PAPC	1/2 - 1 mile	-0.8% ^{NS}	2.5% ^{NS}	-1.7% ^{NS}	-2.5% ^{NS}	2.3% ^{NS}	-0.2% ^{NS}	0.4% ^{NS}
		(0.039)	*(0.043)*	*(0.036)*	*(0.039)*	*(0.043)*	*(0.039)*	*(0.044)*
PC	< 1/2 mile	-1.2% ^{NS}	-5.6% ^{NS}	-0.5% ^{NS}	-1.8% ^{NS}	-4.3% ^{NS}	-0.3% ^{NS}	1.3% ^{NS}
		(0.054)	*(0.057)*	*(0.047)*	*(0.054)*	*(0.056)*	*(0.054)*	*(0.056)*
PC	1/2 - 1 mile	6.3% ^{NS}	3.4% ^{NS}	6.2% ^{NS}	3.8% ^{NS}	4.1% ^{NS}	7.1% ^{NS}	7.5% ^{NS}
		(0.036)	*(0.041)*	*(0.033)*	*(0.036)*	*(0.042)*	*(0.036)*	*(0.041)*
*Note: p-values: > 0.1 ^{NS}, < 0.1 *, <0.5 **, <0.01 ****								
	n	51,276	38,407	50,106	51,276	38,407	51,276	51,276
	adj R-sqr	0.67	0.64	0.66	0.67	0.66	0.67	0.67

6. Conclusion

Wind energy facilities are expected to continue to be developed in the United States. Some of this growth is expected to occur in more-populated regions, raising concerns about the effects of wind development on home values in surrounding communities.

Previous published and academic research on this topic has tended to indicate that wind facilities, after they have been constructed, produce little or no effect on home values. At the same time, some evidence has emerged indicating potential home-value effects occurring after a wind facility has been announced but before construction. These previous studies, however, have been limited by their relatively small sample sizes, particularly in relation to the important population of homes located very close to wind turbines, and have sometimes treated the variable for distance to wind turbines in a problematic fashion. Analogous studies of other disamenities—including high-voltage transmission lines, landfills, and noisy roads—suggest that if reductions in property values near turbines were to occur, they would likely be no more than 3%–4%, on average, but to discover such small effects near turbines, much larger amounts of data are needed than have been used in previous studies. Moreover, previous studies have not accounted adequately for potentially confounding home-value factors, such as those affecting home values before wind facilities were announced, nor have they adequately controlled for spatial dependence in the data, i.e., how the values and characteristics of homes located near one another influence the value of those homes (independent of the presence of wind turbines).

This study helps fill those gaps by collecting a very large data sample and analyzing it with methods that account for confounding factors and spatial dependence. We collected data from more than 50,000 home sales among 27 counties in nine states. These homes were within 10 miles of 67 different then-current or existing wind facilities, with 1,198 sales that were within 1 mile of a turbine (331 of which were within a half mile)—many more than were collected by previous research efforts. The data span the periods well before announcement of the wind facilities to well after their construction. We use OLS and spatial-process difference-in-difference hedonic models to estimate the home-value impacts of the wind facilities; these models control for value factors existing prior to the wind facilities' announcements, the spatial dependence of home values, and value changes over time. We also employ a series of robustness models, which provide greater confidence in our results by testing the effects of data outliers and influential cases, heterogeneous inflation/deflation across regions, older sales data for multi-sale homes, the distance from turbines for homes in our reference case, and the amount of time before wind-facility announcement for homes in our reference case.

Across all model specifications, we find no statistical evidence that home prices near wind turbines were affected in either the post-construction or post-announcement/pre-construction periods. Therefore, if effects do exist, either the average impacts are relatively small (within the margin of error in the models) and/or sporadic (impacting only a small subset of homes). Related, our sample size and analytical methods enabled us to bracket the size of effects that would be detected, if those effects were present at all. Based on our results, we find that it is *highly unlikely* that the actual average effect for homes that sold in our sample area within 1 mile of an existing turbine is larger than +/-4.9%. In other words, the average value of these homes could be as much as 4.9% higher than it would have been without the presence of wind turbines, as much as 4.9% lower, the same (i.e., zero effect), or anywhere in between. Similarly, it is highly unlikely that the average actual effect for homes that sold in our sample area within a half mile of an existing turbine is larger than +/-9.0%. In other words, the average value of these homes could be as much as 9% higher than it would have been without the presence of wind turbines, as much as 9% lower, the same (i.e., zero effect), or anywhere in between.

Regardless of these potential maximum effects, the core results of our analysis consistently show no sizable statistically significant impact of wind turbines on nearby property values. The maximum impact suggested by potentially analogous disamenities (high-voltage transmission lines, landfills, roads etc.) of 3%-4% is at the far end of what the models presented in this study would have been able to discern, potentially helping to explain why no statistically significant effect was found. If effects of this size are to be discovered in future research, even larger samples of data may be required. For those interested in estimating such effects on a more micro (or local) scale, such as appraisers, these possible data requirements may be especially daunting, though it is also true that the inclusion of additional market, neighborhood, and individual property characteristics in these more-local assessments may sometimes improve model fidelity.

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8. Appendix – Full Results

	OneMile OLS		**HalfMile OLS**		**OneMile SEM**		**HalfMile SEM**	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
Intercept	11.332***	(0.058)	11.330***	(0.058)	11.292***	(0.090)	11.292***	(0.090)
fdp3tdis3_11	-0.017	(0.024)			0.002	(0.031)		
fdp3tdis3_12	-0.015	(0.011)			0.008	(0.016)		
fdp3tdis3_21	-0.035	(0.029)			-0.038	(0.033)		
fdp3tdis3_22	-0.001	(0.014)			-0.033*	(0.017)		
fdp3tdis3_23	-0.006	(0.008)			-0.033***	(0.009)		
fdp3tdis3_31	0.019	(0.026)			-0.022	(0.031)		
fdp3tdis3_32	0.044***	(0.014)			-0.001	(0.018)		
fdp3tdis3_33	-0.005	(0.010)			-0.031***	(0.012)		
fdp3tdis4_10			0.001	(0.039)			0.053	(0.045)
fdp3tdis4_11			-0.023	(0.027)			-0.018	(0.035)
fdp3tdis4_12			-0.015	(0.011)			0.008	(0.016)
fdp3tdis4_20			-0.028	(0.049)			-0.065	(0.056)
fdp3tdis4_21			-0.038	(0.033)			-0.027	(0.036)
fdp3tdis4_22			-0.001	(0.014)			-0.034*	(0.017)
fdp3tdis4_23			-0.006	(0.008)			-0.033***	(0.009)
fdp3tdis4_30			-0.016	(0.041)			-0.036	(0.046)
fdp3tdis4_31			0.032	(0.031)			-0.016	(0.035)
fdp3tdis4_32			0.044***	(0.014)			-0.001	(0.018)
fdp3tdis4_33			-0.005	(0.010)			-0.031***	(0.012)
lsfla1000_ia_car	0.750***	(0.042)	0.749***	(0.042)	0.723***	(0.045)	0.722***	(0.045)
lsfla1000_ia_flo	0.899***	(0.054)	0.900***	(0.054)	0.879***	(0.060)	0.88***	(0.060)
lsfla1000_ia_fra	0.980***	(0.077)	0.980***	(0.077)	0.932***	(0.083)	0.934***	(0.083)
lsfla1000_ia_sac	0.683***	(0.061)	0.683***	(0.061)	0.633***	(0.065)	0.633***	(0.064)
lsfla1000_il_dek	0.442***	(0.037)	0.441***	(0.037)	0.382***	(0.040)	0.38***	(0.040)
lsfla1000_il_liv	0.641***	(0.030)	0.641***	(0.030)	0.643***	(0.046)	0.643***	(0.046)
lsfla1000_il_mcl	0.512***	(0.019)	0.512***	(0.019)	0.428***	(0.029)	0.428***	(0.029)
lsfla1000_mn_cot	0.800***	(0.052)	0.800***	(0.052)	0.787***	(0.077)	0.787***	(0.077)
lsfla1000_mn_fre	0.594***	(0.028)	0.595***	(0.028)	0.539***	(0.031)	0.539***	(0.031)
lsfla1000_mn_jac	0.587***	(0.101)	0.587***	(0.101)	0.551***	(0.102)	0.55***	(0.102)
lsfla1000_mn_mar	0.643***	(0.025)	0.643***	(0.025)	0.603***	(0.029)	0.603***	(0.029)
lsfla1000_nj_atl	0.421***	(0.012)	0.421***	(0.012)	0.389***	(0.014)	0.389***	(0.014)
lsfla1000_ny_cli	0.635***	(0.044)	0.635***	(0.044)	0.606***	(0.045)	0.606***	(0.045)
lsfla1000_ny_fra	0.373***	(0.092)	0.375***	(0.092)	0.433***	(0.094)	0.436***	(0.094)
lsfla1000_ny_her	0.520***	(0.034)	0.520***	(0.034)	0.559***	(0.035)	0.559***	(0.035)
lsfla1000_ny_lew	0.556***	(0.054)	0.556***	(0.054)	0.518***	(0.057)	0.518***	(0.057)
lsfla1000_ny_mad	0.503***	(0.025)	0.503***	(0.025)	0.502***	(0.025)	0.502***	(0.025)
lsfla1000_ny_ste	0.564***	(0.032)	0.564***	(0.032)	0.534***	(0.034)	0.534***	(0.034)
lsfla1000_ny_wyo	0.589***	(0.034)	0.589***	(0.034)	0.566***	(0.034)	0.566***	(0.034)
lsfla1000_oh_pau	0.625***	(0.080)	0.624***	(0.080)	0.567***	(0.090)	0.565***	(0.090)
lsfla1000_oh_woo	0.529***	(0.030)	0.529***	(0.030)	0.487***	(0.035)	0.487***	(0.035)
lsfla1000_ok_cus	0.838***	(0.037)	0.838***	(0.037)	0.794***	(0.046)	0.793***	(0.046)
lsfla1000_ok_gra	0.750***	(0.063)	0.750***	(0.063)	0.706***	(0.072)	0.706***	(0.072)
lsfla1000_pa_fay	0.332***	(0.111)	0.332***	(0.111)	0.335***	(0.118)	0.334***	(0.118)
lsfla1000_pa_som	0.564***	(0.025)	0.564***	(0.025)	0.548***	(0.031)	0.548***	(0.031)
lsfla1000_pa_way	0.486***	(0.056)	0.486***	(0.056)	0.44***	(0.063)	0.44***	(0.063)
lsfla1000_wa_kit	0.540***	(0.073)	0.540***	(0.073)	0.494***	(0.078)	0.494***	(0.078)

	OneMile OLS		**HalfMile OLS**		**OneMile SEM**		**HalfMile SEM**	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
acres_ia_car	0.033	(0.030)	0.033	(0.030)	0.013	(0.032)	0.013	(0.032)
acres_ia_flo	0.050***	(0.014)	0.050***	(0.014)	0.044***	(0.014)	0.044***	(0.014)
acres_ia_fra	-0.008	(0.022)	-0.008	(0.022)	-0.009	(0.022)	-0.009	(0.022)
acres_ia_sac	0.064***	(0.014)	0.064***	(0.014)	0.054***	(0.015)	0.054***	(0.015)
acres_il_dek	0.068**	(0.027)	0.064**	(0.027)	0.055*	(0.029)	0.048*	(0.029)
acres_il_liv	0.023	(0.014)	0.023	(0.014)	0.014	(0.018)	0.014	(0.018)
acres_il_mcl	0.091***	(0.010)	0.091***	(0.010)	0.092***	(0.011)	0.092***	(0.011)
acres_mn_cot	-0.030***	(0.011)	-0.030***	(0.011)	-0.024*	(0.013)	-0.024*	(0.013)
acres_mn_fre	-0.002	(0.007)	-0.002	(0.007)	0.002	(0.008)	0.002	(0.008)
acres_mn_jac	0.019	(0.016)	0.020	(0.016)	0.03*	(0.016)	0.03*	(0.016)
acres_mn_mar	0.020**	(0.008)	0.020**	(0.008)	0.017*	(0.009)	0.017*	(0.009)
acres_nj_atl	-0.041	(0.031)	-0.041	(0.031)	-0.013	(0.026)	-0.013	(0.026)
acres_ny_cli	0.019***	(0.007)	0.019***	(0.007)	0.022***	(0.007)	0.022***	(0.007)
acres_ny_fra	0.009	(0.010)	0.009	(0.010)	0.014	(0.011)	0.014	(0.011)
acres_ny_her	-0.004	(0.008)	-0.004	(0.008)	0.012	(0.008)	0.012	(0.008)
acres_ny_lew	0.014*	(0.008)	0.014*	(0.008)	0.014	(0.009)	0.014	(0.009)
acres_ny_mad	0.021***	(0.003)	0.021***	(0.003)	0.021***	(0.004)	0.021***	(0.004)
acres_ny_ste	0.009*	(0.005)	0.009*	(0.005)	0.007	(0.005)	0.007	(0.005)
acres_ny_wyo	0.016***	(0.004)	0.016***	(0.004)	0.019***	(0.004)	0.019***	(0.004)
acres_oh_pau	-0.010	(0.020)	-0.010	(0.020)	0.01	(0.024)	0.009	(0.024)
acres_oh_woo	-0.007	(0.010)	-0.007	(0.010)	0.002	(0.010)	0.002	(0.010)
acres_ok_cus	-0.037*	(0.019)	-0.037*	(0.019)	-0.034	(0.022)	-0.034	(0.022)
acres_ok_gra	0.014	(0.010)	0.014	(0.010)	0.019*	(0.011)	0.019*	(0.011)
acres_pa_fay	-0.006	(0.023)	-0.006	(0.023)	0.01	(0.023)	0.01	(0.023)
acres_pa_som	0.003	(0.009)	0.004	(0.009)	0.009	(0.010)	0.009	(0.010)
acres_pa_way	0.017**	(0.007)	0.017**	(0.007)	0.024***	(0.007)	0.024***	(0.007)
acres_wa_kit	0.009	(0.010)	0.009	(0.010)	0.014	(0.011)	0.014	(0.011)
acreslt1_ia_car	0.446***	(0.136)	0.448***	(0.136)	0.559***	(0.144)	0.56***	(0.143)
acreslt1_ia_flo	0.436***	(0.112)	0.435***	(0.112)	0.384***	(0.118)	0.383***	(0.118)
acreslt1_ia_fra	0.670***	(0.124)	0.668***	(0.124)	0.684***	(0.139)	0.68***	(0.139)
acreslt1_ia_sac	0.159	(0.115)	0.160	(0.115)	0.222*	(0.123)	0.221*	(0.123)
acreslt1_il_dek	0.278***	(0.066)	0.285***	(0.066)	0.282***	(0.073)	0.294***	(0.073)
acreslt1_il_liv	0.278***	(0.063)	0.276***	(0.063)	0.383***	(0.088)	0.38***	(0.088)
acreslt1_il_mcl	-0.069***	(0.021)	-0.070***	(0.021)	-0.007	(0.032)	-0.007	(0.032)
acreslt1_mn_cot	0.529***	(0.093)	0.529***	(0.093)	0.466***	(0.120)	0.465***	(0.120)
acreslt1_mn_fre	0.314***	(0.053)	0.314***	(0.053)	0.294***	(0.061)	0.293***	(0.061)
acreslt1_mn_jac	0.250*	(0.144)	0.247*	(0.145)	0.169	(0.146)	0.162	(0.146)
acreslt1_mn_mar	0.452***	(0.062)	0.452***	(0.062)	0.461***	(0.069)	0.462***	(0.069)
acreslt1_nj_atl	0.135***	(0.048)	0.135***	(0.048)	0.044	(0.047)	0.043	(0.047)
acreslt1_ny_cli	0.115***	(0.044)	0.115***	(0.044)	0.108**	(0.047)	0.108**	(0.047)
acreslt1_ny_fra	0.118	(0.100)	0.118	(0.100)	0.113	(0.115)	0.113	(0.115)
acreslt1_ny_her	0.364***	(0.047)	0.364***	(0.047)	0.331***	(0.050)	0.332***	(0.050)
acreslt1_ny_lew	0.119*	(0.061)	0.120**	(0.061)	0.117*	(0.067)	0.117*	(0.067)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
acreslt1_ny_mad	0.017	(0.031)	0.018	(0.031)	0.043	(0.032)	0.043	(0.032)
acreslt1_ny_ste	0.100**	(0.042)	0.100**	(0.042)	0.18***	(0.047)	0.18***	(0.047)
acreslt1_ny_wyo	0.144***	(0.035)	0.144***	(0.035)	0.137***	(0.039)	0.137***	(0.039)
acreslt1_oh_pau	0.426***	(0.087)	0.425***	(0.087)	0.507***	(0.120)	0.507***	(0.120)
acreslt1_oh_woo	0.124***	(0.034)	0.124***	(0.034)	0.114***	(0.041)	0.114***	(0.041)
acreslt1_ok_cus	0.103	(0.070)	0.104	(0.070)	0.091	(0.092)	0.093	(0.092)
acreslt1_ok_gra	-0.038	(0.054)	-0.038	(0.054)	-0.065	(0.066)	-0.065	(0.066)
acreslt1_pa_fay	0.403***	(0.153)	0.403***	(0.153)	0.42**	(0.165)	0.42**	(0.164)
acreslt1_pa_som	0.243***	(0.039)	0.243***	(0.039)	0.223***	(0.047)	0.223***	(0.047)
acreslt1_pa_way	0.138**	(0.062)	0.138**	(0.062)	0.108	(0.077)	0.109	(0.077)
acreslt1_wa_kit	0.335**	(0.134)	0.335**	(0.134)	0.342**	(0.164)	0.342**	(0.164)
age_ia_car	-0.013***	(0.001)	-0.013***	(0.001)	-0.011***	(0.001)	-0.011***	(0.001)
age_ia_flo	-0.013***	(0.002)	-0.013***	(0.002)	-0.013***	(0.002)	-0.013***	(0.002)
age_ia_fra	-0.012***	(0.003)	-0.012***	(0.003)	-0.011***	(0.003)	-0.011***	(0.003)
age_ia_sac	-0.013***	(0.003)	-0.013***	(0.003)	-0.011***	(0.003)	-0.011***	(0.003)
age_il_dek	-0.004***	(0.001)	-0.004***	(0.001)	-0.004***	(0.001)	-0.004***	(0.001)
age_il_liv	-0.001	(0.001)	-0.002	(0.001)	-0.003	(0.002)	-0.003	(0.002)
age_il_mcl	-0.004***	(0.001)	-0.004***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)
age_mn_cot	-0.021***	(0.003)	-0.021***	(0.003)	-0.013***	(0.005)	-0.013***	(0.005)
age_mn_fre	-0.013***	(0.001)	-0.013***	(0.001)	-0.012***	(0.002)	-0.012***	(0.002)
age_mn_jac	-0.018***	(0.005)	-0.018***	(0.005)	-0.018***	(0.005)	-0.018***	(0.005)
age_mn_mar	-0.010***	(0.001)	-0.010***	(0.001)	-0.009***	(0.002)	-0.009***	(0.002)
age_nj_atl	-0.004***	(0.000)	-0.004***	(0.000)	-0.003***	(0.001)	-0.003***	(0.001)
age_ny_cli	-0.005***	(0.001)	-0.005***	(0.001)	-0.005***	(0.001)	-0.005***	(0.001)
age_ny_fra	-0.004	(0.003)	-0.005	(0.003)	-0.005*	(0.003)	-0.005*	(0.003)
age_ny_her	-0.008***	(0.001)	-0.008***	(0.001)	-0.008***	(0.001)	-0.008***	(0.001)
age_ny_lew	-0.008***	(0.001)	-0.008***	(0.001)	-0.009***	(0.001)	-0.009***	(0.001)
age_ny_mad	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)
age_ny_ste	-0.006***	(0.001)	-0.006***	(0.001)	-0.007***	(0.001)	-0.007***	(0.001)
age_ny_wyo	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)	-0.006***	(0.001)
age_oh_pau	0.003	(0.003)	0.003	(0.003)	0.003	(0.004)	0.003	(0.004)
age_oh_woo	0.008***	(0.001)	0.008***	(0.001)	0.01***	(0.001)	0.01***	(0.001)
age_ok_cus	-0.000	(0.002)	-0.000	(0.002)	0.002	(0.003)	0.002	(0.003)
age_ok_gra	-0.000	(0.002)	-0.000	(0.002)	0.001	(0.002)	0.001	(0.002)
age_pa_fay	0.010**	(0.004)	0.010**	(0.004)	0.01**	(0.005)	0.01**	(0.005)
age_pa_som	-0.006***	(0.001)	-0.006***	(0.001)	-0.008***	(0.001)	-0.008***	(0.001)
age_pa_way	0.006***	(0.002)	0.006***	(0.002)	0.007***	(0.002)	0.007***	(0.002)
age_wa_kit	0.010***	(0.003)	0.010***	(0.003)	0.014***	(0.003)	0.014***	(0.003)
agesq_ia_car	0.034***	(0.011)	0.034***	(0.000)	0.022*	(0.012)	0.022*	(0.012)
agesq_ia_flo	0.040***	(0.016)	0.040**	(0.016)	0.044***	(0.016)	0.044***	(0.016)
agesq_ia_fra	0.025	(0.022)	0.025	(0.022)	0.02	(0.023)	0.021	(0.023)
agesq_ia_sac	0.032	(0.022)	0.032	(0.022)	0.025	(0.023)	0.025	(0.023)
agesq_il_dek	0.008	(0.010)	0.008	(0.010)	0.013	(0.012)	0.013	(0.011)
agesq_il_liv	-0.023**	(0.009)	-0.023**	(0.009)	-0.011	(0.014)	-0.011	(0.014)
agesq_il_mcl	0.005	(0.007)	0.005	(0.007)	0.021*	(0.011)	0.021*	(0.011)
agesq_mn_cot	0.109**	(0.043)	0.109**	(0.043)	0.032	(0.069)	0.033	(0.069)
agesq_mn_fre	0.046***	(0.010)	0.045***	(0.010)	0.044***	(0.012)	0.044***	(0.012)
agesq_mn_jac	0.103***	(0.035)	0.104***	(0.035)	0.1***	(0.034)	0.101***	(0.034)
agesq_mn_mar	0.012	(0.012)	0.012	(0.012)	0.006	(0.014)	0.006	(0.014)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
agesq_nj_atl	0.010***	(0.003)	0.010***	(0.003)	0.003	(0.005)	0.003	(0.005)
agesq_ny_cli	0.011*	(0.006)	0.011*	(0.006)	0.011*	(0.006)	0.011*	(0.006)
agesq_ny_fra	-0.011	(0.022)	-0.011	(0.022)	-0.002	(0.020)	-0.002	(0.020)
agesq_ny_her	0.022***	(0.005)	0.022***	(0.005)	0.022***	(0.006)	0.022***	(0.006)
agesq_ny_lew	0.031***	(0.006)	0.031***	(0.006)	0.032***	(0.007)	0.032***	(0.007)
agesq_ny_mad	0.017***	(0.003)	0.017***	(0.003)	0.023***	(0.003)	0.023***	(0.003)
agesq_ny_ste	0.013**	(0.005)	0.013**	(0.005)	0.018***	(0.005)	0.018***	(0.005)
agesq_ny_wyo	0.016***	(0.005)	0.016***	(0.005)	0.017***	(0.005)	0.017***	(0.005)
agesq_oh_pau	-0.044**	(0.022)	-0.045**	(0.022)	-0.043	(0.028)	-0.043	(0.028)
agesq_oh_woo	-0.074***	(0.007)	-0.074***	(0.007)	-0.091***	(0.009)	-0.091***	(0.009)
agesq_ok_cus	-0.091***	(0.019)	-0.091***	(0.019)	-0.113***	(0.026)	-0.113***	(0.026)
agesq_ok_gra	-0.081***	(0.023)	-0.081***	(0.023)	-0.097***	(0.029)	-0.097***	(0.029)
agesq_pa_fay	-0.112***	(0.032)	-0.112***	(0.032)	-0.105***	(0.034)	-0.106***	(0.034)
agesq_pa_som	0.000	(0.008)	0.002	(0.008)	0.016*	(0.009)	0.016*	(0.009)
agesq_pa_way	-0.000***	(0.012)	-0.052***	(0.012)	-0.053***	(0.014)	-0.053***	(0.014)
agesq_wa_kit	-0.000***	(0.027)	-0.097***	(0.027)	-0.132***	(0.031)	-0.132***	(0.031)
bathsim_ia_sac	-0.050	(0.073)	-0.050	(0.073)	-0.082	(0.077)	-0.081	(0.077)
bathsim_il_dek	-0.005	(0.015)	-0.005	(0.015)	0.001	(0.018)	0.001	(0.018)
bathsim_ny_cli	0.090***	(0.025)	0.090***	(0.025)	0.087***	(0.024)	0.087***	(0.024)
bathsim_ny_fra	0.246***	(0.062)	0.245***	(0.062)	0.213***	(0.064)	0.212***	(0.064)
bathsim_ny_her	0.099***	(0.022)	0.099***	(0.022)	0.079***	(0.022)	0.079***	(0.022)
bathsim_ny_lew	0.168***	(0.030)	0.167***	(0.030)	0.142***	(0.031)	0.142***	(0.031)
bathsim_ny_mad	0.180***	(0.014)	0.180***	(0.014)	0.157***	(0.013)	0.157***	(0.013)
bathsim_ny_ste	0.189***	(0.019)	0.189***	(0.019)	0.166***	(0.020)	0.166***	(0.020)
bathsim_ny_wyo	0.107***	(0.021)	0.107***	(0.021)	0.1***	(0.021)	0.1***	(0.021)
bathsim_oh_pau	0.095*	(0.051)	0.095*	(0.051)	0.149***	(0.057)	0.149***	(0.057)
bathsim_oh_woo	0.094***	(0.017)	0.094***	(0.017)	0.092***	(0.019)	0.092***	(0.019)
bathsim_pa_fay	0.367***	(0.077)	0.367***	(0.077)	0.301***	(0.082)	0.302***	(0.082)
bathsim_pa_way	0.082**	(0.036)	0.082**	(0.036)	0.081**	(0.041)	0.081**	(0.041)
pctvacant_ia_car	-2.515*	(1.467)	-2.521*	(1.468)	-2.011	(1.936)	-2.019	(1.937)
pctvacant_ia_flo	0.903	(1.152)	0.921	(1.152)	1.358	(1.409)	1.339	(1.410)
pctvacant_ia_fra	8.887**	(3.521)	8.928**	(3.518)	-2.596	(1.703)	-2.6	(1.703)
pctvacant_ia_sac	0.672	(0.527)	0.673	(0.527)	1.267***	(0.377)	1.266***	(0.377)
pctvacant_il_dek	0.052	(0.639)	0.062	(0.638)	0.037	(0.964)	0.069	(0.961)
pctvacant_il_liv	-0.475	(0.474)	-0.476	(0.474)	-0.699	(0.872)	-0.701	(0.872)
pctvacant_il_mcl	-0.365	(0.397)	-0.366	(0.397)	0.445	(0.670)	0.442	(0.670)
pctvacant_mn_cot	1.072*	(0.592)	1.072*	(0.592)	0.272	(1.039)	0.273	(1.039)
pctvacant_mn_fre	-1.782**	(0.703)	-1.787**	(0.703)	-1.372	(0.965)	-1.384	(0.965)
pctvacant_mn_jac	-1.345	(0.883)	-1.318	(0.884)	-1.285	(1.084)	-1.313	(1.084)
pctvacant_mn_mar	2.178***	(0.502)	2.175***	(0.502)	1.53**	(0.622)	1.528**	(0.622)
pctvacant_nj_atl	-0.054	(0.062)	-0.054	(0.062)	0.096	(0.085)	0.095	(0.085)
pctvacant_ny_cli	0.709***	(0.224)	0.709***	(0.224)	0.842***	(0.251)	0.841***	(0.251)
pctvacant_ny_fra	6.173***	(2.110)	6.104***	(2.113)	0.519	(0.710)	0.499	(0.709)
pctvacant_ny_her	-1.226***	(0.247)	-1.226***	(0.247)	-1.347***	(0.288)	-1.347***	(0.288)
pctvacant_ny_lew	-0.125	(0.127)	-0.125	(0.127)	-0.266*	(0.159)	-0.266*	(0.159)
pctvacant_ny_mad	0.750***	(0.196)	0.752***	(0.196)	0.767***	(0.246)	0.765***	(0.246)
pctvacant_ny_ste	0.280	(0.190)	0.281	(0.190)	0.039	(0.242)	0.04	(0.242)
pctvacant_ny_wyo	0.179*	(0.101)	0.178*	(0.101)	0.225*	(0.119)	0.224*	(0.119)
pctvacant_oh_pau	-1.473	(1.498)	-1.473	(1.499)	-1.341	(1.951)	-1.256	(1.952)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
pctvacant_oh_woo	-0.565	(0.400)	-0.565	(0.400)	-0.304	(0.563)	-0.306	(0.563)
pctvacant_ok_cus	-0.127	(0.358)	-0.140	(0.359)	-0.167	(0.521)	-0.189	(0.521)
pctvacant_ok_gra	1.413*	(0.777)	1.414*	(0.777)	0.537	(1.045)	0.536	(1.045)
pctvacant_pa_fay	0.227	(0.596)	0.229	(0.596)	0.232	(0.807)	0.235	(0.807)
pctvacant_pa_som	0.517***	(0.098)	0.516***	(0.098)	0.562***	(0.138)	0.562***	(0.138)
pctvacant_pa_way	0.445***	(0.156)	0.444***	(0.156)	0.446**	(0.175)	0.446**	(0.175)
pctvacant_wa_kit	-0.076	(0.546)	-0.075	(0.546)	-0.377	(0.282)	-0.377	(0.281)
pctowner_ia_car	-0.225	(0.244)	-0.225	(0.244)	-0.156	(0.324)	-0.156	(0.324)
pctowner_ia_flo	0.579**	(0.238)	0.578**	(0.238)	0.75***	(0.290)	0.75***	(0.290)
pctowner_ia_fra	0.207	(0.310)	0.206	(0.310)	0.172	(0.393)	0.169	(0.393)
pctowner_ia_sac	0.274	(0.585)	0.261	(0.586)	-0.34	(0.545)	-0.345	(0.545)
pctowner_il_dek	0.075	(0.088)	0.073	(0.087)	0.032	(0.123)	0.028	(0.123)
pctowner_il_liv	0.176	(0.140)	0.176	(0.140)	0.265	(0.200)	0.264	(0.200)
pctowner_il_mcl	0.389***	(0.051)	0.388***	(0.051)	0.331***	(0.101)	0.331***	(0.101)
pctowner_mn_cot	0.375***	(0.138)	0.375***	(0.138)	0.609**	(0.254)	0.609**	(0.254)
pctowner_mn_fre	-0.119	(0.090)	-0.120	(0.090)	-0.072	(0.124)	-0.073	(0.124)
pctowner_mn_jac	-0.206	(0.474)	-0.205	(0.474)	-0.175	(0.569)	-0.185	(0.570)
pctowner_mn_mar	0.262***	(0.076)	0.262***	(0.076)	0.151	(0.103)	0.151	(0.103)
pctowner_nj_atl	-0.087**	(0.037)	-0.087**	(0.037)	-0.036	(0.052)	-0.037	(0.052)
pctowner_ny_cli	-0.229	(0.171)	-0.229	(0.171)	-0.305	(0.199)	-0.303	(0.199)
pctowner_ny_fra	2.743*	(1.500)	2.693*	(1.505)	-0.315	(1.447)	-0.398	(1.442)
pctowner_ny_her	0.246***	(0.095)	0.246***	(0.095)	0.213*	(0.109)	0.213*	(0.109)
pctowner_ny_lew	-0.034	(0.185)	-0.034	(0.185)	-0.126	(0.219)	-0.126	(0.219)
pctowner_ny_mad	0.750***	(0.075)	0.750***	(0.075)	0.723***	(0.084)	0.723***	(0.084)
pctowner_ny_ste	0.192	(0.128)	0.191	(0.128)	-0.083	(0.162)	-0.084	(0.162)
pctowner_ny_wyo	-0.089	(0.111)	-0.089	(0.111)	-0.109	(0.138)	-0.108	(0.138)
pctowner_oh_pau	-0.187	(0.347)	-0.185	(0.348)	-1.245***	(0.473)	-1.249***	(0.474)
pctowner_oh_woo	0.263***	(0.092)	0.264***	(0.092)	0.274**	(0.136)	0.274**	(0.136)
pctowner_ok_cus	0.068	(0.104)	0.068	(0.104)	-0.041	(0.146)	-0.043	(0.146)
pctowner_ok_gra	0.271*	(0.159)	0.271*	(0.159)	0.253	(0.217)	0.253	(0.217)
pctowner_pa_fay	-0.413	(1.736)	-0.420	(1.736)	-0.15	(2.037)	-0.165	(2.037)
pctowner_pa_som	0.171	(0.114)	0.170	(0.114)	0.098	(0.173)	0.098	(0.173)
pctowner_pa_way	-0.351	(0.441)	-0.348	(0.441)	-0.251	(0.345)	-0.252	(0.345)
pctowner_wa_kit	0.257	(2.139)	0.259	(2.139)	-0.358	(1.889)	-0.361	(1.890)
med_age_ia_car	0.002	(0.002)	0.002	(0.002)	0.003	(0.003)	0.003	(0.003)
med_age_ia_flo	0.003	(0.002)	0.003	(0.002)	0.004	(0.003)	0.004	(0.003)
med_age_ia_fra	0.066***	(0.015)	0.066***	(0.015)	0.014**	(0.006)	0.014**	(0.006)
med_age_ia_sac	0.028**	(0.014)	0.028**	(0.014)	0.012	(0.010)	0.012	(0.010)
med_age_il_dek	-0.001	(0.002)	-0.001	(0.002)	-0.001	(0.003)	-0.001	(0.003)
med_age_il_liv	-0.004	(0.004)	-0.004	(0.004)	-0.005	(0.005)	-0.005	(0.005)
med_age_il_mcl	-0.006***	(0.002)	-0.006***	(0.002)	-0.006**	(0.003)	-0.006**	(0.003)
med_age_mn_cot	0.017***	(0.005)	0.017***	(0.005)	0.018**	(0.008)	0.018**	(0.008)
med_age_mn_fre	0.012***	(0.002)	0.012***	(0.002)	0.013***	(0.002)	0.013***	(0.002)
med_age_mn_jac	0.013	(0.008)	0.013	(0.008)	0.012	(0.010)	0.012	(0.010)
med_age_mn_mar	0.013***	(0.003)	0.013***	(0.003)	0.012***	(0.003)	0.012***	(0.003)
med_age_nj_atl	0.010***	(0.001)	0.010***	(0.001)	0.016***	(0.002)	0.016***	(0.002)
med_age_ny_cli	0.020***	(0.004)	0.020***	(0.004)	0.02***	(0.004)	0.02***	(0.004)
med_age_ny_fra	-0.517***	(0.198)	-0.511***	(0.198)	0.008	(0.040)	0.01	(0.039)
med_age_ny_her	0.007*	(0.003)	0.007*	(0.003)	0.005	(0.003)	0.005	(0.003)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
med_age_ny_lew	0.013***	(0.005)	0.013***	(0.005)	0.008	(0.005)	0.008	(0.005)
med_age_ny_mad	0.004**	(0.002)	0.004**	(0.002)	0.004*	(0.002)	0.004*	(0.002)
med_age_ny_ste	0.012***	(0.003)	0.012***	(0.003)	0.001	(0.004)	0.001	(0.004)
med_age_ny_wyo	0.008	(0.005)	0.007	(0.005)	0.008	(0.006)	0.008	(0.006)
med_age_oh_pau	0.034***	(0.013)	0.034***	(0.013)	0.019	(0.012)	0.019	(0.012)
med_age_oh_woo	-0.004	(0.003)	-0.004	(0.003)	-0.004	(0.004)	-0.004	(0.004)
med_age_ok_cus	0.004	(0.002)	0.004	(0.002)	0.008**	(0.004)	0.008**	(0.004)
med_age_ok_gra	0.011	(0.009)	0.011	(0.009)	0	(0.006)	0	(0.006)
med_age_pa_fay	0.049	(0.073)	0.049	(0.073)	0.052	(0.095)	0.052	(0.095)
med_age_pa_som	0.008***	(0.002)	0.008***	(0.002)	0.012***	(0.004)	0.012***	(0.004)
med_age_pa_way	-0.005	(0.012)	-0.005	(0.012)	0.002	(0.007)	0.002	(0.007)
med_age_wa_kit	-0.015	(0.095)	-0.015	(0.095)	0.025	(0.034)	0.025	(0.034)
swinter_ia	-0.034**	(0.015)	-0.034**	(0.015)	-0.039***	(0.015)	-0.039***	(0.015)
swinter_il	-0.020**	(0.008)	-0.020**	(0.008)	-0.013	(0.012)	-0.013	(0.012)
swinter_mn	-0.053***	(0.009)	-0.053***	(0.009)	-0.057***	(0.011)	-0.057***	(0.011)
swinter_nj	-0.007	(0.006)	-0.007	(0.006)	-0.008	(0.007)	-0.008	(0.007)
swinter_ny	-0.030***	(0.007)	-0.030***	(0.007)	-0.026***	(0.007)	-0.026***	(0.007)
swinter_oh	-0.048***	(0.012)	-0.048***	(0.012)	-0.055***	(0.014)	-0.055***	(0.014)
swinter_ok	-0.039**	(0.015)	-0.039**	(0.015)	-0.024	(0.018)	-0.024	(0.018)
swinter_pa	-0.025*	(0.015)	-0.025*	(0.015)	-0.02	(0.017)	-0.02	(0.017)
swinter_wa	-0.004	(0.046)	-0.004	(0.046)	0.014	(0.051)	0.013	(0.051)
sy_1996_ia	-0.436***	(0.137)	-0.433***	(0.137)	-0.493***	(0.157)	-0.489***	(0.157)
sy_1996_il	-0.267***	(0.037)	-0.267***	(0.037)	-0.344***	(0.061)	-0.344***	(0.061)
sy_1996_mn	-0.521***	(0.058)	-0.521***	(0.059)	-0.585***	(0.065)	-0.585***	(0.065)
sy_1996_nj	-0.820***	(0.022)	-0.820***	(0.022)	-0.717***	(0.038)	-0.717***	(0.038)
sy_1996_oh	-0.298***	(0.042)	-0.298***	(0.042)	-0.43***	(0.053)	-0.43***	(0.053)
sy_1996_ok	-0.444***	(0.073)	-0.444***	(0.073)	-0.846***	(0.079)	-0.846***	(0.079)
sy_1996_pa	-0.584***	(0.060)	-0.584***	(0.060)	-0.604***	(0.067)	-0.604***	(0.067)
sy_1997_il	-0.242***	(0.036)	-0.242***	(0.036)	-0.234***	(0.052)	-0.232***	(0.052)
sy_1997_mn	-0.445***	(0.055)	-0.445***	(0.055)	-0.535***	(0.060)	-0.535***	(0.060)
sy_1997_nj	-0.791***	(0.021)	-0.791***	(0.021)	-0.686***	(0.038)	-0.686***	(0.038)
sy_1997_oh	-0.302***	(0.043)	-0.302***	(0.043)	-0.39***	(0.053)	-0.39***	(0.053)
sy_1997_pa	-0.458***	(0.057)	-0.458***	(0.057)	-0.51***	(0.066)	-0.51***	(0.066)
sy_1998_ia	-0.442***	(0.078)	-0.441***	(0.078)	-0.633***	(0.099)	-0.634***	(0.099)
sy_1998_il	-0.156***	(0.031)	-0.156***	(0.031)	-0.175***	(0.048)	-0.175***	(0.048)
sy_1998_mn	-0.391***	(0.054)	-0.391***	(0.054)	-0.484***	(0.059)	-0.484***	(0.059)
sy_1998_nj	-0.723***	(0.020)	-0.723***	(0.021)	-0.633***	(0.037)	-0.633***	(0.037)
sy_1998_oh	-0.217***	(0.040)	-0.217***	(0.040)	-0.302***	(0.047)	-0.302***	(0.047)
sy_1998_ok	-0.394***	(0.048)	-0.395***	(0.048)	-0.816***	(0.059)	-0.818***	(0.059)
sy_1998_pa	-0.481***	(0.059)	-0.480***	(0.059)	-0.554***	(0.068)	-0.552***	(0.067)
sy_1998_wa	-0.433***	(0.115)	-0.433***	(0.115)	-0.356**	(0.161)	-0.356**	(0.161)
sy_1999_ia	-0.347***	(0.085)	-0.345***	(0.086)	-0.568***	(0.117)	-0.565***	(0.117)
sy_1999_il	-0.155***	(0.031)	-0.156***	(0.031)	-0.215***	(0.046)	-0.214***	(0.046)
sy_1999_mn	-0.302***	(0.055)	-0.303***	(0.055)	-0.367***	(0.059)	-0.368***	(0.059)
sy_1999_nj	-0.679***	(0.020)	-0.679***	(0.020)	-0.583***	(0.036)	-0.583***	(0.036)
sy_1999_oh	-0.161***	(0.040)	-0.161***	(0.040)	-0.243***	(0.047)	-0.243***	(0.047)
sy_1999_ok	-0.347***	(0.044)	-0.348***	(0.044)	-0.743***	(0.050)	-0.743***	(0.050)
sy_1999_pa	-0.452***	(0.058)	-0.452***	(0.058)	-0.515***	(0.066)	-0.515***	(0.066)
sy_1999_wa	-0.432***	(0.114)	-0.432***	(0.114)	-0.454***	(0.166)	-0.453***	(0.165)

	OneMile OLS		**HalfMile OLS**		**OneMile SEM**		**HalfMile SEM**	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
sy_2000_ia	-0.165	(0.145)	-0.164	(0.146)	-0.246	(0.183)	-0.246	(0.183)
sy_2000_il	-0.088***	(0.031)	-0.088***	(0.031)	-0.172***	(0.045)	-0.171***	(0.045)
sy_2000_mn	-0.148***	(0.051)	-0.149***	(0.051)	-0.224***	(0.053)	-0.224***	(0.053)
sy_2000_nj	-0.565***	(0.020)	-0.565***	(0.020)	-0.461***	(0.036)	-0.462***	(0.036)
sy_2000_oh	-0.098**	(0.041)	-0.098**	(0.041)	-0.161***	(0.047)	-0.16***	(0.047)
sy_2000_ok	-0.330***	(0.050)	-0.331***	(0.050)	-0.748***	(0.059)	-0.749***	(0.059)
sy_2000_pa	-0.394***	(0.057)	-0.395***	(0.057)	-0.478***	(0.067)	-0.478***	(0.067)
sy_2000_wa	-0.463***	(0.115)	-0.463***	(0.115)	-0.403**	(0.160)	-0.402**	(0.160)
sy_2001_ia	-0.334***	(0.065)	-0.332***	(0.065)	-0.435***	(0.066)	-0.433***	(0.066)
sy_2001_il	-0.080**	(0.031)	-0.080***	(0.031)	-0.101**	(0.048)	-0.101**	(0.048)
sy_2001_mn	-0.119**	(0.050)	-0.119**	(0.050)	-0.204***	(0.051)	-0.204***	(0.052)
sy_2001_nj	-0.438***	(0.018)	-0.438***	(0.018)	-0.333***	(0.034)	-0.333***	(0.034)
sy_2001_oh	-0.033	(0.036)	-0.033	(0.036)	-0.078**	(0.040)	-0.078**	(0.040)
sy_2001_ok	-0.250***	(0.041)	-0.251***	(0.041)	-0.648***	(0.044)	-0.648***	(0.044)
sy_2001_pa	-0.402***	(0.055)	-0.402***	(0.055)	-0.446***	(0.063)	-0.447***	(0.063)
sy_2001_wa	-0.378***	(0.122)	-0.378***	(0.122)	-0.275*	(0.163)	-0.275*	(0.163)
sy_2002_ia	-0.130**	(0.059)	-0.128**	(0.059)	-0.264***	(0.064)	-0.261***	(0.064)
sy_2002_il	0.008	(0.030)	0.007	(0.030)	-0.013	(0.043)	-0.013	(0.043)
sy_2002_mn	-0.072	(0.050)	-0.072	(0.050)	-0.138***	(0.051)	-0.139***	(0.051)
sy_2002_nj	-0.330***	(0.019)	-0.330***	(0.019)	-0.195***	(0.035)	-0.195***	(0.035)
sy_2002_ny	-0.307***	(0.020)	-0.307***	(0.020)	-0.342***	(0.020)	-0.342***	(0.020)
sy_2002_oh	-0.022	(0.038)	-0.022	(0.038)	-0.053	(0.042)	-0.053	(0.042)
sy_2002_ok	-0.249***	(0.045)	-0.249***	(0.045)	-0.649***	(0.052)	-0.649***	(0.052)
sy_2002_pa	-0.313***	(0.053)	-0.313***	(0.053)	-0.355***	(0.059)	-0.354***	(0.059)
sy_2002_wa	-0.241**	(0.123)	-0.241**	(0.123)	-0.216	(0.166)	-0.216	(0.166)
sy_2003_ia	-0.195**	(0.081)	-0.194**	(0.081)	-0.311***	(0.085)	-0.314***	(0.084)
sy_2003_il	0.034	(0.030)	0.034	(0.030)	0.021	(0.040)	0.021	(0.040)
sy_2003_mn	0.034	(0.049)	0.034	(0.049)	-0.026	(0.049)	-0.026	(0.049)
sy_2003_nj	-0.119***	(0.017)	-0.119***	(0.017)	0.023	(0.033)	0.023	(0.033)
sy_2003_ny	-0.247***	(0.020)	-0.247***	(0.020)	-0.276***	(0.020)	-0.276***	(0.020)
sy_2003_oh	0.005	(0.036)	0.005	(0.036)	-0.019	(0.039)	-0.019	(0.039)
sy_2003_ok	-0.229***	(0.046)	-0.229***	(0.046)	-0.632***	(0.053)	-0.632***	(0.053)
sy_2003_pa	-0.191***	(0.052)	-0.191***	(0.052)	-0.213***	(0.054)	-0.213***	(0.054)
sy_2003_wa	-0.326***	(0.114)	-0.326***	(0.114)	-0.335**	(0.159)	-0.337**	(0.159)
sy_2004_ia	-0.209***	(0.076)	-0.208***	(0.076)	-0.307***	(0.087)	-0.308***	(0.087)
sy_2004_il	0.087***	(0.029)	0.087***	(0.029)	0.105***	(0.034)	0.105***	(0.034)
sy_2004_mn	0.082*	(0.049)	0.081*	(0.049)	0.036	(0.049)	0.036	(0.049)
sy_2004_ny	-0.179***	(0.019)	-0.179***	(0.019)	-0.2***	(0.020)	-0.2***	(0.020)
sy_2004_oh	0.059	(0.037)	0.059	(0.037)	0.067*	(0.039)	0.067*	(0.039)
sy_2004_ok	-0.143***	(0.041)	-0.143***	(0.041)	-0.511***	(0.044)	-0.511***	(0.044)
sy_2004_pa	-0.146***	(0.052)	-0.146***	(0.052)	-0.145***	(0.053)	-0.145***	(0.053)
sy_2004_wa	-0.144	(0.113)	-0.144	(0.113)	-0.082	(0.152)	-0.081	(0.152)
sy_2005_ia	-0.074**	(0.037)	-0.075**	(0.037)	-0.151***	(0.040)	-0.151***	(0.040)
sy_2005_il	0.125***	(0.027)	0.125***	(0.027)	0.139***	(0.032)	0.138***	(0.032)
sy_2005_mn	0.163***	(0.048)	0.162***	(0.048)	0.12**	(0.048)	0.119**	(0.048)
sy_2005_nj	0.278***	(0.018)	0.278***	(0.018)	0.453***	(0.034)	0.453***	(0.034)
sy_2005_ny	-0.110***	(0.019)	-0.111***	(0.019)	-0.122***	(0.019)	-0.122***	(0.019)
sy_2005_oh	0.112***	(0.036)	0.112***	(0.036)	0.099***	(0.037)	0.098***	(0.037)
sy_2005_ok	-0.018	(0.038)	-0.018	(0.038)	-0.354***	(0.038)	-0.354***	(0.038)

	OneMile OLS		HalfMile OLS		OneMile SEM		HalfMile SEM	
Variables	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**
sy_2005_pa	-0.060	(0.051)	-0.060	(0.051)	-0.058	(0.053)	-0.058	(0.053)
sy_2005_wa	-0.070	(0.111)	-0.070	(0.111)	0.025	(0.153)	0.025	(0.153)
sy_2006_ia	-0.050*	(0.028)	-0.051*	(0.028)	-0.106***	(0.028)	-0.106***	(0.028)
sy_2006_il	0.192***	(0.026)	0.192***	(0.026)	0.215***	(0.030)	0.215***	(0.030)
sy_2006_mn	0.206***	(0.049)	0.206***	(0.049)	0.164***	(0.049)	0.164***	(0.049)
sy_2006_nj	0.340***	(0.017)	0.340***	(0.017)	0.514***	(0.032)	0.514***	(0.032)
sy_2006_ny	-0.066***	(0.019)	-0.066***	(0.019)	-0.073***	(0.019)	-0.073***	(0.019)
sy_2006_oh	0.147***	(0.034)	0.147***	(0.034)	0.144***	(0.035)	0.144***	(0.035)
sy_2006_ok	0.025	(0.039)	0.026	(0.039)	-0.3***	(0.037)	-0.3***	(0.037)
sy_2006_pa	0.008	(0.051)	0.008	(0.051)	-0.001	(0.052)	-0.001	(0.052)
sy_2006_wa	-0.066	(0.131)	-0.066	(0.131)	0.02	(0.160)	0.021	(0.160)
sy_2007_ia	0.013	(0.028)	0.012	(0.028)	-0.019	(0.028)	-0.019	(0.028)
sy_2007_il	0.218***	(0.025)	0.218***	(0.025)	0.251***	(0.028)	0.251***	(0.028)
sy_2007_mn	0.177***	(0.049)	0.177***	(0.049)	0.145***	(0.048)	0.144***	(0.048)
sy_2007_nj	0.297***	(0.017)	0.297***	(0.017)	0.459***	(0.031)	0.459***	(0.031)
sy_2007_ny	-0.020	(0.019)	-0.020	(0.019)	-0.022	(0.019)	-0.022	(0.019)
sy_2007_oh	0.144***	(0.035)	0.143***	(0.035)	0.138***	(0.036)	0.138***	(0.036)
sy_2007_ok	0.149***	(0.037)	0.150***	(0.037)	-0.154***	(0.034)	-0.154***	(0.034)
sy_2007_pa	0.030	(0.051)	0.030	(0.051)	0.067	(0.052)	0.067	(0.052)
sy_2007_wa	0.189*	(0.110)	0.189*	(0.110)	0.209	(0.147)	0.209	(0.147)
sy_2008_ia	0.011	(0.029)	0.010	(0.029)	-0.029	(0.029)	-0.029	(0.029)
sy_2008_il	0.219***	(0.026)	0.218***	(0.026)	0.217***	(0.029)	0.217***	(0.029)
sy_2008_mn	0.149***	(0.050)	0.149***	(0.050)	0.108**	(0.049)	0.108**	(0.049)
sy_2008_nj	0.195***	(0.018)	0.195***	(0.018)	0.35***	(0.032)	0.35***	(0.032)
sy_2008_ny	-0.000	(0.019)	-0.000	(0.019)	-0.008	(0.019)	-0.008	(0.019)
sy_2008_oh	0.084**	(0.036)	0.084**	(0.036)	0.061*	(0.037)	0.061*	(0.037)
sy_2008_ok	0.154***	(0.039)	0.153***	(0.039)	-0.145***	(0.035)	-0.145***	(0.035)
sy_2008_pa	0.044	(0.053)	0.044	(0.053)	0.055	(0.053)	0.056	(0.053)
sy_2008_wa	0.178	(0.117)	0.179	(0.117)	0.326**	(0.148)	0.325**	(0.148)
sy_2009_ia	-0.056	(0.036)	-0.057	(0.036)	-0.102***	(0.036)	-0.102***	(0.036)
sy_2009_il	0.158***	(0.026)	0.158***	(0.026)	0.176***	(0.028)	0.176***	(0.028)
sy_2009_mn	0.104**	(0.051)	0.104**	(0.051)	0.089*	(0.050)	0.089*	(0.050)
sy_2009_nj	0.071***	(0.019)	0.071***	(0.019)	0.238***	(0.032)	0.238***	(0.032)
sy_2009_ny	-0.005	(0.019)	-0.005	(0.019)	-0.013	(0.019)	-0.013	(0.019)
sy_2009_oh	0.036	(0.035)	0.036	(0.035)	0.028	(0.036)	0.028	(0.036)
sy_2009_ok	0.219***	(0.038)	0.219***	(0.038)	-0.102***	(0.034)	-0.101***	(0.034)
sy_2009_pa	0.009	(0.053)	0.010	(0.053)	0.0003	(0.054)	0.0004	(0.054)
sy_2010_ia	0.018	(0.029)	0.017	(0.029)	-0.004	(0.028)	-0.004	(0.028)
sy_2010_il	0.105***	(0.028)	0.105***	(0.028)	0.104***	(0.029)	0.104***	(0.029)
sy_2010_mn	0.181***	(0.050)	0.180***	(0.050)	0.137***	(0.049)	0.137***	(0.049)
sy_2010_nj	0.010	(0.019)	0.010	(0.019)	0.177***	(0.032)	0.178***	(0.032)
sy_2010_ny	0.003	(0.021)	0.003	(0.021)	-0.006	(0.020)	-0.006	(0.020)
sy_2010_oh	-0.017	(0.036)	-0.017	(0.036)	-0.024	(0.036)	-0.024	(0.036)
sy_2010_ok	0.231***	(0.038)	0.231***	(0.038)	-0.074**	(0.033)	-0.074**	(0.033)
sy_2010_pa	0.013	(0.057)	0.013	(0.057)	0.013	(0.057)	0.013	(0.057)
sy_2010_wa	0.207	(0.127)	0.207	(0.127)	0.305*	(0.165)	0.305*	(0.165)
note: *** p<0.01, ** p<0.05, * p<0.1								
N	51,276		51,276		38,407		38,407	
Adjusted R^2	0.66		0.66		0.64		0.64	