

FPL Energy Burleigh County Wind, LLC  
FPL Energy Oliver Wind, LLC  
Langdon Wind, LLC  
Baldwin Wind, LLC  
Ashtabula Wind III, LLC

October 19, 2015

Mr. Jerry Lein  
Public Utility Analyst  
North Dakota Public Service Commission  
600 East Boulevard, Dept 408  
Bismarck, ND 58505-0408

*UPS Overnight Mail*

RE: Case Nos. PU-05-205, PU-06-312, PU-07-722, PU-09-668 and PU-10-147 Compliance Issues

Dear Mr. Lein:

Please find responses below from FPL Energy Burleigh County Wind, LLC ("Burleigh Wind"), FPL Energy Oliver Wind, LLC ("Oliver Wind"), Langdon Wind, LLC ("Langdon Wind"), Baldwin Wind, LLC ("Baldwin Wind") and Ashtabula Wind III, LLC ("Ashtabula III") to your letter dated September 18, 2015. The following list provides responses to your inquiries and references to requested documentation. These documents can be found attached to this letter.

Burleigh Wind: PU-05-205.

- **Request:** Provide an update as to whether or not at the end of 2009 the Company experienced a 75 percent survival rate and if not, the Commission requests that the Company report as to the additional efforts the Company has undertaken to meet this requirement
  - Ordering Paragraph 17 states: "Trees and other wooded vegetation must be replaced at a rate of two for every one removed along the route. Landowners shall be given the option of having replacement trees/shrubs planted off the right-of-way on the landowners property or waiving that requirement in writing and allowing replacement plantings of trees/shrubs elsewhere. FPL/Central Power shall inspect tree replacements once a year for three years and send a report on or shortly before October 1 of 2006, 2007 and 2008 to the Commission documenting work completion and condition of woodlands planting. The Commission may order additional plantings if survival rates are less than 75% of the required ratio of two for one."
  - **Response:** The 2007 and 2008 inspection reports filed in PU-05-205, shows that a 75% survival rate was surpassed per all requirements in the order. Burleigh Wind has been unable to locate the 2006 inspection report, but believes that the

2008 report demonstrates that Burleigh Wind has met the 75% survival rate requirement in the order.

Oliver Wind: PU-06-312

- **Request:** Provide an update as to whether or not at the end of 2015 the Company experienced a 75 percent survival rate and if not, the Commission requests that the Company report as to the additional efforts the Company has undertaken to meet this requirement
  - Ordering Paragraph 15: “Trees and other wooded vegetation must be replaced with saplings that are two or more years old at a rate of two for every one removed along the route. The landowner shall be given the option of having replacement trees/shrubs planted off the right-of-way on the landowner's property or waiving that requirement in writing and allowing replacement plantings of trees/shrubs elsewhere. Oliver Wind shall inspect tree replacements once a year for three years and send a report on or shortly before November 1 of 2007, 2008 and 2009 to the Commission documenting work completion and condition of woodlands planting. The Commission may order additional plantings if survival rates are less than 75% of the required ratio of two for one.”
  - **Response:** Oliver Wind filed a tree mitigation plan and the plan was approved by the Commission in April, 2011. Oliver Wind then filed tree and shrub survival in November 2011, October 2012, October 2013 and September 2014. Oliver Wind notes that the replantings performed in 2011 and 2012 were done proactively after a heavy rainstorm and not because survival rates were below 75%. In the final report in 2014 the survival rate was above the required 75%, which demonstrates that Oliver Wind has met the survival rate requirement in Ordering Paragraph 15.

Langdon Wind: PU-07-722

- **Request:** “The Commission finds no record of tree and shrub mitigation efforts for the Langdon expansion project.”
  - **Response:** The attached letter from June 2010, which states that there were no trees removed during construction. Therefore we are not required to provide any tree and shrub mitigation efforts and are in compliance of this requirement.

Baldwin Wind: PU-09-668

- **Request:** Please confirm that “reclamation, fertilization and reseeding” has occurred.
  - Ordering paragraph 16: “Reclamation, fertilization and reseeding shall be completed by Baldwin Wind according to the Natural Resource Conservation Service recommendations, unless otherwise specified by the landowner and approved by the Commission.”
  - Baldwin Wind has confirmed via visual inspection that reclamation, fertilization, and reseeding has occurred. Baldwin Wind has not located additional documentation responsive to the request. Baldwin Wind notes that it is the company’s standard practice to bring the land back to its natural state after construction, unless otherwise specified by the landowner and approved by the Commission, and the condition of the land is consistent with this standard.

- **Request:** Staff requests further information on Finding of Fact 37 regarding shadow flicker.
  - Ordering paragraph 32: “Baldwin Wind shall work with landowners and residents in the area to mitigate any adverse effects that results from the construction of the energy conversion facility.”
  - Finding of Fact 37: “While though there are no established standards, the siting recommendation of the American Wind Energy Association for allowable shadow flicker is 30-40 hours per year. There are currently three occupied residences that exceed 30 hours per year and Baldwin Wind is working cooperatively with these owners to secure participation agreements. If such agreements cannot be secured, Baldwin Wind will utilize alternative turbine locations to avoid shadow impacts on these three residences. Should shadow flicker occur and result in complaints from occupants of residences, Baldwin Wind, at its expense, will work with the owner to promptly undertake measures, such as tree planting or installation of awnings to mitigate shadow flicker.”
  - **Response:** In the “Shadow Flicker Impact Analysis for the Baldwin Wind Energy Center” report prepared by Tetra Tech and filed on June 3, 2010, Table 1B shows three receptors that predicted shadow flicker greater than 30 hours per year. As mentioned in the order, the siting recommendation of the American Wind Energy Association for allowable shadow flicker is 30-40 hours per year. Of the three receptors that predicted shadow flicker greater than 30 hours, only one is occupied, receptor ID 40039. Baldwin Wind has a participation agreement in place with the resident near receptor ID 40039. Receptor ID 2027 is unoccupied and receptor ID 40074a is a non-residential building. Baldwin Wind therefore met the shadow flicker requirements in the Commission’s order. Baldwin Wind has not received any complaints regarding shadow flicker since commercial operation of the site.
- **Request:** Staff requests further information on Finding of Fact 38 regarding noise levels.
  - Ordering paragraph number 32: “Baldwin Wind shall work with landowners and residents in the area to mitigate any adverse effects that results from the construction of the energy conversion facility.”
  - Finding of Fact 38: “No turbines will be placed within 1400 feet of an occupied residence. The average noise levels at such residences should not exceed 48.6 decibels.”
  - In the attached “Baldwin Wind Energy Center Acoustic Assessment Burleigh County, North Dakota” report prepared by Tetra Tech in October 2009, Table 7 shows two unoccupied residence IDs with a noise level that exceeds the 48.6 decibel requirement. Consistent with Finding of Fact 38, Baldwin Wind did not locate turbines within 1400 feet of an occupied residence and average noise levels at occupied residences did not exceed 48.6 decibels. Although residence ID number 2027 is now occupied, at the time the site was built, both residences were unoccupied. Baldwin Wind has not received any complaints regarding noise levels since commercial operation of the site.
- **Request:** Staff requests further information on Tree and Shrub Mitigation Specifications
  - Ordering Paragraph 15: “Tree and shrub replacements shall be inspected once a year for three years, on about the anniversary of the plantings, and, on or shortly

before October 1 of each year, a report shall be submitted to the Commission documenting the condition of replacement planting and any woodlands work completed. If after three years from the anniversary of the plantings the survival rate is less than 75%, the Commission may order additional planting(s).”

- **Response:** Baldwin Wind filed three years of survival reports in October 2012, October 2013 and September 2014. Baldwin Wind notes that the replantings performed in 2013 and 2014 were done proactively after a heavy rainstorm and not because survival rates were below 75%. In the final report in 2014, notwithstanding the replantings, the survival rate was above the required 75%.

Ashtabula Wind III: PU-10-147

- **Request:** Please confirm that “reclamation, fertilization and reseeded” has occurred.
  - Ordering paragraph 14: “Reclamation, fertilization and reseeded will be completed by Ashtabula III according to the Natural Resource Conservation Service recommendations, unless otherwise specified by the landowner and approved by the Commission.”
  - **Response:** Ashtabula Wind III has confirmed via visual inspection that reclamation, fertilization, and reseeded has occurred. Ashtabula Wind III has not located additional documentation responsive to the request. Ashtabula Wind III notes that it is the company’s standard practice to bring the land back to its natural state after construction, unless otherwise specified by the landowner and approved by the Commission, and the condition of the land is consistent with this standard.

Thank you for your attention to this matter. Please feel free to contact me at (561) 304-5641 should you have any questions.

Sincerely,



Brian Duncan  
Director  
Business Management – Midwest Region

# Attachments for PU-09-668

**STATE OF NORTH DAKOTA  
PUBLIC SERVICE COMMISSION**

**Baldwin Wind, LLC  
102 MW Baldwin Wind Energy Center - Burleigh County  
Siting Application**

**Case No. PU-09-668**

**FINDINGS OF FACT, CONCLUSIONS OF LAW AND ORDER**

**JULY 14, 2010**

**Appearances:**

Commissioners Kevin Cramer, Tony Clark and Brian P. Kalk.

Brian R. Bjella and Wade C. Mann, Attorneys at Law, Crowley Fleck, PLLP, 400 East Broadway, Suite 600, Bismarck, North Dakota 58501, on behalf of the Applicant, Baldwin Wind, LLC.

Annette Bendish, Legal Counsel, Public Service Commission, State Capitol, Bismarck, North Dakota 58505, on behalf of the Public Service Commission.

Al Wahl, Administrative Law Judge, Office of Administrative Hearings, 1701 North Ninth Street, Bismarck, North Dakota 58501-1882, as Procedural Hearing Officer.

**Preliminary Statement**

On October 5, 2009, NextEra Energy Resources, LLC (NextEra) filed a Letter of Intent (LOI) to submit an application for a Certificate of Site Compatibility for a wind energy conversion facility in Burleigh County, North Dakota. NextEra requested in its LOI that the Commission shorten the one-year waiting period between the filing of the LOI and the filing of an application.

On October 14, 2009, the Public Service Commission (Commission) shortened the one-year waiting period to three weeks and assessed a filing fee of \$100,000.00.

On March 5, 2010, Baldwin Wind, LLC filed an Application for a Certificate of Site Compatibility authorizing construction of the Baldwin Wind Energy Center consisting of up to 62 1.6 MW wind turbine generators and associated facilities in Burleigh County, North Dakota (Application).

On March 10, 2010, NextEra filed a request with the Commission that this case be transferred to the entity of Baldwin Wind, LLC (Baldwin Wind). Baldwin Wind is a wholly owned subsidiary of NextEra, created November 24, 2009, and was registered to do business in the State of North Dakota effective December 1, 2009.

On April 8, 2010, the Commission deemed the Application complete and issued a Notice of Filing and Notice of Hearing, scheduling a public hearing for May 20, 2010, at 9:00 a.m. CDT, at the Brynhild Haugland Room, Ground Floor, State Capitol, 600 East Boulevard Avenue, Bismarck, North Dakota 58505.

On April 9, 2010, Baldwin Wind filed an amended Application stating its intent to construct up to a 102.4 MW wind energy facility consisting of up to 64 1.6 MW wind turbine generators and associated facilities in Burleigh County, North Dakota (Amended Application). Baldwin Wind indicated that the wind turbines will be located within the same footprint of land as set forth in the original Application.

On April 13, 2010, the Commission deemed the Amended Application complete and issued a Revised Notice of Filing and Notice of Hearing scheduling a public hearing for May 20, 2010, at 9:00 a.m CDT, at the Brynhild Haugland Room, Ground Floor, State Capitol, 600 East Boulevard Avenue, Bismarck, North Dakota 58505. The Revised Notice identified the following issues to be considered:

1. Will the location, construction, and operation of the proposed facilities produce minimal adverse effects upon the environment and upon the welfare of the citizens of North Dakota?
2. Are the proposed facilities compatible with the environmental preservation and the efficient use of resources?
3. Will the proposed facility location minimize adverse human and environmental impacts while ensuring continuing system reliability and integrity and ensuring that energy needs are met and filled in an orderly and timely fashion?

On May 12, 2010, Baldwin Wind filed its final turbine site plan.

On May 20, 2010, the public hearing was held as scheduled.

On June 1, 2010, Baldwin Wind filed an executed Certification Relating to Order Provisions – Wind Energy Conversion Facility Siting.

Having allowed all interested persons an opportunity to be heard, and having heard, reviewed and considered all testimony and evidence presented, the Commission makes the following:

#### **Findings of Fact**

1. Baldwin Wind is a Delaware Limited Liability Company headquartered in Juno Beach, Florida. Baldwin Wind is a subsidiary of NextEra, also of Juno Beach, Florida.
2. Baldwin Wind was created November 24, 2009, and was registered in the State of North Dakota effective December 1, 2009, as evidenced by Certificate of Good Standing issued by the North Dakota Secretary of State on March 3, 2010.
3. Baldwin Wind proposes to construct a wind energy facility (Baldwin Wind Energy Center) to be located in Burleigh County, North Dakota, near the City of Wilton. The Project Area consists of approximately 21,000 acres (33 square miles) in Crofte, Ecklund, and Grass Lake Townships. The wind turbines will be placed throughout the project site.
4. Associated facilities to be constructed within the project area include access roads, underground electrical and feeder lines, and an electrical substation.
5. North Dakota Century Code § 49-22-16 provides that no energy conversion facility site shall be designated if it violates any county or city land use, zoning, building rules,

regulations or ordinances. Burleigh County regulates zoning in Crofte Township, while Grass Lake Township and Ecklund Township have their own zoning ordinances.

#### Project Design

6. The project will have a name plate (gross) generating capacity of 102.4 MW, consisting of up to 64 1.6 MW wind turbines and associated facilities. Assuming net capacity factors of 45%, the projected average annual output is estimated at 197,100 MW hours per year.

7. Baldwin Wind plans to use General Electric 1.6 MW turbines. These are utility-grade wind turbines with a nominal name plate rating of 1.6 MW. Each turbine will have a 262 feet (80 meter) hub height and a 271 feet (82.5 meter) rotor diameter. The turbines begin operation at wind speeds of 7.8 miles per hour (3.5 meters per second) and reach their rated capacity at a wind speed of 28 miles per hour (12.5 meters per second). The turbines are designed to operate in wind speeds of up to 45 miles per hour (20 meters per second).

8. Each turbine is secured by a concrete foundation that can vary in design depending upon soil conditions. A typical foundation extends seven to ten feet below grade where it spreads to a final diameter of 40 to 60 feet at the base. Turbine lighting is limited to warning lights required by the Federal Aviation Administration (FAA). A control panel inside the base of each turbine tower houses communication and electronic circuitry. Each turbine is equipped with a wind speed and direction sensor that communicates with the turbine's control system to signal when sufficient winds are present for operation. Electricity generated by each turbine is brought to a pad-mounted transformer where the voltage is stepped up to a power collection line voltage of 34.5 kV. Electricity is collected by a series of underground collection lines.

9. The underground collection line feeder system will deliver the electricity to the project substation. At the substation the voltage will be stepped up to 230 kV for transmission via an existing 230 kV transmission line operated by Central Power Cooperative, which will connect to the Western Area Power Administration's (Western) Hilken substation.

10. The site for the wind energy facility was selected based primarily upon its wind resource, and also based upon operational history from the Wilton I and Wilton II Wind Energy Centers, operated by subsidiaries of NextEra. Baldwin Wind also utilized wind data from meteorological towers located on the project site. The data indicates that this site is well suited for a wind farm.

11. Construction of the Baldwin Wind Energy Center is expected to take approximately six months, at a total estimated cost of \$200 million.

12. Baldwin Wind anticipates commencing construction in July 2010. Testing and operations are set to begin in October 2010, and commercial operations to begin in December 2010.

13. An Engineering, Procurement, and Construction (EPC) contractor will be retained for construction management of the project. The EPC contractor will use services of local contractors, where possible, to assist in project construction.

14. Safety factors will be incorporated into the wind turbines. Each turbine will be equipped with a Supervisory Control and Data Acquisitions (SCADA) communication technology to control and monitor the turbines. In addition, each turbine is also equipped with a lightning protection system and is grounded and shielded to protect against lightning.

15. Baldwin Wind states that construction and operation of the Baldwin Wind Energy Center will conform to the requirements of the National Electric Safety Code.

#### Siting Criteria

16. North Dakota Administrative Code Chapter 69-06-08 sets forth certain criteria to guide the Commission in evaluating the suitability of granting an application for the certificate of site compatibility. The criteria set forth in North Dakota Administrative Code § 69-06-08-01 is classified as Exclusion Areas, Avoidance Areas, Selection Criteria, and Policy Criteria. With the exception of prime and unique farm land, an energy conversion facility must not be sited within an Exclusion Area. The exception for prime and unique farm land is if the Commission finds that the prime farm and unique farm land that will be removed from use for the life of the facility is of such small acreage as to be of negligible impact on agricultural production, then such exclusion shall not apply. An energy conversion facility must not be sited within an Avoidance Area unless the applicant shows that under the circumstances there is no reasonable alternative. In determining whether an Avoidance Area should be designated for a facility, the Commission may consider, among other things, the proposed management of adverse impacts; the orderly siting of facilities; system reliability and integrity; the efficient use of resources; and alternate sites. In accordance with the Commission's Selection Criteria, an energy conversion facility shall be approved only if it is demonstrated that no significant adverse impacts will result from the location, construction, and operation of the facility. In accordance with the Commission's Policy Criteria, preference may be given to an applicant demonstrating certain benefits of the energy conversion facility.

17. The Project Layout dated May 5, 2010, indicates up to 9 acres of project infrastructure in prime farmland, not including the collection lines that will be buried and would be a temporary disturbance of soil. Unique and prime farmland to be disturbed by this energy conversion facility is of such small acreage as to be of negligible impact on agricultural production.

18. Approximately 365 acres of agricultural production will be impacted due to turbine placement, associated access roads, and project substation. Wind turbine configuration will not result in significant impacts to agricultural production. No impacts on the agricultural quality of the crop land are anticipated. If compaction of soils occurs during construction, Baldwin Wind will work with landowners to alleviate the compaction.

19. Abandoned coal mines, and mined areas that are filled with sinkholes are found throughout the project area. An area in the northwest portion of the project area will be avoided due to numerous abandoned underground coal mines.

20. Baldwin Wind submitted evidence to demonstrate that the proposed energy conversion facility will not have a significant impact on the Selection Criteria set forth in North Dakota Administrative Code § 69-06-08-01(3).

21. Baldwin Wind submitted evidence to demonstrate its commitment to maximize the benefits of the proposed energy conversion facility as far as possible so to meet the Policy Criteria set forth in North Dakota Administrative Code § 69-06-08-01(4).

22. No significant adverse impact is foreseen on the ability of the affected area to provide community services, such as housing, health care, schools, police and fire protection, water and sewer, solid waste management, transportation or public safety. The proposed project is expected to be of economic benefit to the affected area.

23. Avoidance Areas identified in the project area are the abandoned coal mines as discussed above, historical resources that are not designated as exclusion areas, woodlands and wetlands. The historical resources identified by project archeologists will be avoided. Woodland impacts are not anticipated. Wetlands will be avoided. As a result, it is not anticipated that Baldwin Wind will need to obtain permits from the U.S. Army Corps of Engineers with respect to jurisdictional wetlands.

#### Cultural Resources

24. Several sites potentially eligible for the National Register of Historic Places have been identified within the project area. Baldwin Wind will avoid all such sites.

25. With respect to historical resources that are not designated as Exclusion Areas, Baldwin Wind has consulted with the North Dakota State Historic Preservation Office (SHPO). Class I and Class III Cultural Resource Inventories, including review of SHPO's site manuscript files, were conducted by archeologists for the project area. During the course of the inventory, 18 prehistoric stone feature sites and a prehistoric rock-lined pit feature site were identified within the project area. None of these sites will be impacted by the project, as they will be avoided by project construction. The recommendations of the archeologists will be forwarded to SHPO for review, and concurrence.

#### Wetlands and Wildlife

26. Baldwin Wind has consulted with numerous local, state and federal agencies, which are identified in Appendix E of the Application. Two agencies providing significant input are the North Dakota Game and Fish Department and the United States Fish and Wildlife Service (USFWS). Neither agency has objected to construction of the project. Mr. Terry Ellsworth, a fish and wildlife biologist with the USFWS, Ecological Services Division, Bismarck, North Dakota, testified that the USFWS supports the reasonable development of wind energy. Mr. Ellsworth addressed the potential impact of wind farms upon wildlife resources. The USFWS encourages all wind power developers to plan, design, construct and operate their projects in a manner that fish and wildlife resource conservation is given equal consideration with other features of project development. Mr. Ellsworth testified that the project is in the center of the whooping crane migration corridor and expressed concern about cumulative effects from the existing wind farms and the proposed wind farm upon migrating whooping cranes and wildlife resources. He indicated that Baldwin Wind and Western have been working with the USFWS to demonstrate compliance.

27. The North Dakota Game and Fish Department indicated its primary concern is with disturbance of native prairie and wetlands. Native prairie is present within the project area. The disturbance of native prairie will be minimal.

28. Avian use surveys were conducted in the fall of 2008, spring of 2009, and spring of 2010 covering the project area. In addition, Baldwin Wind commissioned a detailed likelihood of occurrence assessment for whooping cranes. There are no historical records of whooping cranes occurring within the project area. Based upon the low magnitude of potential habitat loss, the low probability of site usage and the avoidance and minimization measures being implemented by Baldwin Wind, the assessment indicates that potential for adverse effects on whooping cranes is low.

29. Other minimization measures that Baldwin Wind states it will implement are modification or curtailment of construction activities within two miles of whooping cranes observed onsite during construction; post construction monitoring during spring and fall whooping crane migration seasons for three years post construction; and curtailment of turbines within two miles if a whooping crane is observed during operation of the wind energy center.

30. As a result of the interconnection with a Western transmission line, Western is preparing an Environmental Assessment (EA) to comply with the National Environmental Policy Act (NEPA). The EA will include compliance recommendations from the USFWS.

31. Baldwin Wind has prepared an Avian and Bat Protection Plan (ABPP) and an Adaptive Management Plan (AMP). Based upon the surveys, the potential for avian and bat collisions with turbines is anticipated to be relatively small.

32. Baldwin Wind states it will implement its Wildlife Response Reporting System (WRRS) once turbine construction is completed. The WRRS will include protocols for field technicians to report and document avian mortalities during routine maintenance operations.

33. A wetlands delineation was conducted pursuant to U.S. Army Corps of Engineers' guidance in September 2009 and completed in the spring of 2010. The project is below the 0.5 acre threshold, making it eligible under the U.S. Army Corps of Engineers Nationwide Permit (NWP) 12 for utility line activities. The project is also below the 0.1 acre notification and mitigation thresholds of NWP 12. As a result, a 404 Permit is unnecessary. All wetlands will be avoided during the construction phase of the project.

#### Sound and Flicker Studies

34. Baldwin Wind included an acoustic assessment in Appendix C of the Application, and also filed a revised assessment on June 1, 2010 to include Grass Lake Township. The results of the acoustic modeling were compared to the U.S. Environmental Protection Agency (EPA) environmental noise guidelines, and the Occupational Safety and Health Administration (OSHA) regulatory limits for worker exposure and public safety. In addition, the existing Wilton I and II turbines located near the project area were included in the analysis.

35. The acoustic assessment illustrated the worst case scenario (downwind, full rotational speed, high air density, low background sound levels). The analysis indicates that with respect to occupied residences within or adjacent to the wind farm that the average sound levels will be within EPA guidelines. Although turbines may be periodically audible, the sound will be in compliance with acoustic design goals set by EPA guidelines, which have been developed to protect both health and human welfare.

The acoustic modeling demonstrates that the wind farm will also comply with Occupational Safety and Health Administration (OSHA) safety standards at all inhabited residences considered to be noise sensitive areas.

36. Baldwin Wind included a Shadow Flicker Impact Analysis for the Baldwin Wind Energy Center in Appendix C of the Application, and also filed a revised analysis on June 3, 2010 to include Grass Lake Township. Baldwin Wind performed a shadow flicker impact study to determine potential impacts on occupied residences located in or near the project. Shadows cast by moving blades were assessed for all wind turbines located within 1.5 kilometers (4921.26 feet) of each occupied residence (receptor). The analysis was based assuming worst case conditions for shadow flicker (full sunlight and blades perpendicular to incoming sunlight) so as to conservatively estimate the potential amount of shadow impact hours for a year.

37. While though there are no established standards, the siting recommendation of the American Wind Energy Association for allowable shadow flicker is 30-40 hours per year. There are currently three occupied residences that exceed 30 hours per year and Baldwin Wind is working cooperatively with these owners to secure participation agreements. If such agreements cannot be secured, Baldwin Wind will utilize alternative turbine locations to avoid shadow impacts on these three residences. Should shadow flicker occur and result in complaints from occupants of residences, Baldwin Wind, at its expense, will work with the owner to promptly undertake measures, such as tree planting or installation of awnings to mitigate shadow flicker.

#### Further Mitigative Measures

38. No turbines will be placed within 1400 feet of an occupied residence. The average noise levels at such residences should not exceed 48.6 decibels.

39. In accordance with Burleigh County ordinances, no turbine will be placed within 1,750 feet of occupied non-participant residences in Crofte Township.

40. Baldwin Wind has proposed setbacks of 440 feet (1.1 x turbine height) from existing transmission lines, roads, railroads and property boundaries.

41. Baldwin Wind will maintain ground water protection and soil conservation practices to protect topsoil and adjacent resources, and to minimize soil erosion during construction and operation of the project. Best Management Practices (BMPs) for erosion and sediment control will be used to minimize wind and water erosion in the project area during and after construction. Only land needed for the facility will be impacted. Temporarily disturbed areas will be restored.

42. Baldwin Wind has developed a management plan to protect against the spread of noxious weeds throughout the project area or adjacent areas during construction and ongoing operations.

43. Baldwin Wind has a legal obligation to decommission the wind energy facilities.

44. Baldwin Wind made other representations and covenants as contained in the Certification Relating to Order Provisions - Wind Energy Conversion Facility Siting executed by Baldwin Wind and filed with the Commission on June 1, 2010, which is incorporated into these Findings of Fact.

From the foregoing Findings of Fact, the Commission now makes its:

### **Conclusions of Law**

1. The Commission has jurisdiction over this proceeding under North Dakota Century Code Chapter 49-22.
2. The energy conversion facility proposed by Baldwin Wind is an energy conversion facility as defined in North Dakota Century Code § 49-22-03(11).
3. The application submitted by Baldwin Wind meets the site evaluation criteria required by North Dakota Century Code Chapter 49-22.
4. The location, construction, and operation of the proposed energy conversion facility will produce only minimal adverse effects on the environment and upon the welfare of the citizens of North Dakota.
5. The proposed energy conversion facility is compatible with environmental preservation and the efficient use of resources.
6. The proposed energy conversion facility will minimize adverse human and environmental impact, while ensuring continuing system reliability and integrity, and ensuring that energy needs are met and fulfilled in an orderly and timely fashion.
7. The Commission has jurisdiction to ensure compliance with National Electric Safety Code standards in the construction and operation of the proposed energy conversion facility.
8. The proposed project is of such design, location, and purpose that it will produce minimal adverse effects.

From the foregoing Findings of Fact and Conclusions of Law, the Commission now makes its:

### **Order**

The Commission orders:

1. Certificate of Site Compatibility for an Energy Conversion Facility No. \_\_\_\_ is issued to Baldwin Wind for the construction, operation and maintenance of a wind energy facility known as the Baldwin Wind Energy Center.
2. The site as designated in the application is located in northern Burleigh County near Wilton, North Dakota, and is designated as the site for construction of the wind energy facility.
3. Within the permitted area, Baldwin Wind is authorized to site and construct up to 102.4 MW of wind turbines in proposed and alternate locations, along with electric collection and communication lines, a project substation, access roads, and other associated facilities as identified in the application and at the hearing.
4. Baldwin Wind shall comply with the rules and regulations of all other agencies having jurisdiction over any phase of the proposed project, including all city, township and county zoning regulations.

5. Baldwin Wind shall obtain all other necessary approvals and permits and provide copies to the Commission prior to any construction activity associated with the wind energy facility that requires said license, or permit.
6. Baldwin Wind shall obtain concurrence from the State Historic Preservation Office and provide copies to the Commission prior to any construction activity associated with the wind energy facility that requires concurrence.
7. Baldwin Wind shall file with the Commission a copy of the final federal Environmental Assessment and resulting findings prior to beginning construction.
8. Baldwin Wind shall conduct a pre-construction conference prior to the commencement of any construction, and must include a Baldwin Wind representative, its construction supervisor, and a representative of the Commission staff to ensure that Baldwin Wind fully understands the conditions set forth in this Order.
9. Baldwin Wind shall inform the Commission of its intent to start construction on the energy conversion facility prior to the commencement of construction, and while construction is underway, Baldwin Wind shall keep the Commission updated of construction activities on a weekly basis.
10. Baldwin Wind shall construct and operate the energy conversion facility in the manner described in this application, at the hearing, in late filed exhibits, and in accordance with all applicable safety requirements.
11. Baldwin Wind shall construct the energy conversion facility in compliance with the National Electric Safety Code.
12. Baldwin Wind shall report to the Commission the presence in the permit area of any critical habitat of threatened or endangered species, or a bald or golden eagle that Baldwin Wind becomes aware of and were not previously reported to the Commission.
13. If any cultural resources, paleontological resources, archeological site, historical resource, or grave site is discovered during construction of the facility, earth disturbing activities in the immediate vicinity of this discovery must be halted. The resource must be marked, preserved, and protected from any further disturbance until a professional examination can be made in consultation with the SHPO. A report of such examination must be filed with the Commission, and clearance to proceed must be given by the SHPO and the Commission.
14. All pre-existing township and county roads and lanes used during construction must be restored to a satisfactory condition and areas used as temporary roads during construction must be restored to their original condition.
15. Construction must be suspended when weather conditions are such that construction activities will cause irreparable damage, unless adequate protection measures approved by the Commission are taken.
16. Reclamation, fertilization and reseeding shall be completed by Baldwin Wind according to the Natural Resource Conservation Service recommendations, unless otherwise specified by the landowner and approved by the Commission.

17. Baldwin Wind's obligations for reclamation and maintenance of the site shall continue throughout the life of the energy conversion facility.
18. When the energy conversion facility is retired, structures and other facilities must be removed to a depth of at least four feet, or in accordance with applicable rules, and the areas restored to as near original condition as is practicable.
19. Baldwin Wind shall comply with the Commission's Tree and Shrub Mitigation Specifications attached to this Order.
20. Baldwin Wind shall repair or replace all fences and gates removed or damaged during all phases of construction and operation of the proposed energy conversion facility.
21. Baldwin Wind shall repair or replace all drainage tile, broken or damaged, during all phases of construction and operation of the proposed energy conversion facility.
22. Staging areas or equipment shall not be located on cultivated land unless otherwise negotiated with landowners.
23. Baldwin Wind shall remove all waste that is a product of construction and operation, restoration and maintenance of the site, and properly dispose of it on a regular basis.
24. Baldwin Wind shall, as soon as practicable, upon the completion of the construction of each wind turbine, restore the area affected by the construction to the condition as it existed prior to the beginning of construction as near as is practicable.
25. Baldwin Wind shall provide, if requested, educational material for landowners within the site boundaries about the proposed energy conversion facility, and any restriction of possible danger concerning the proposed energy conversion facility.
26. Baldwin Wind shall provide any necessary safety measures for traffic control or to restrict public access to the energy conversion facility.
27. Baldwin Wind shall advise the Commission of any extraordinary events which take place at the site of the energy conversion facility, such as tower collapse, extensive turbine failure, injured worker or private individual, mortality events of any threatened or endangered species or the discovery of a large number of dead birds or bats on the site within five business days of such event.
28. Baldwin Wind shall implement a procedure for how complaints concerning the proposed energy conversion facility will be handled by Baldwin Wind.
29. All underground electric line crossing of graded roads shall be bored unless the responsible governing agency permits Baldwin Wind to open cut the road.
30. Where available, at least 12 inches of topsoil over and along open cut areas, roadways, tower locations, and locations of associated facilities must be stripped and segregated from the subsoil and be replaced only after the subsoil is replaced.
31. Baldwin Wind shall bury all underground collection and feeder lines to a depth of at least 48 inches to the top of the lines.
32. Baldwin Wind shall work with landowners and residents in the area to mitigate any adverse effects that results from the construction of the energy conversion facility.

33. Baldwin Wind shall provide the Commission with as-built engineering design drawings and an electronic version of the as-built drawings that can be imported into ESRI GIS mapping software within six months after construction of the energy conversion facility is complete.

34. The Certificate of Site Compatibility is subject to suspension or revocation and may, in an appropriate and proper case, be suspended or revoked for failure to comply with the Commission's Order, the conditions and criteria of each Certificate or subsequent modification, or failure to comply with the applicable statutes, rules, regulations, standards, and permits of other state or federal agencies.

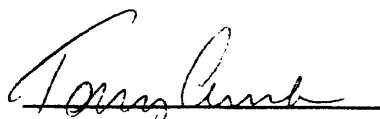
35. Baldwin Wind shall maintain records which will demonstrate that it has complied with the requirements of this Order and the Certificate of Site Compatibility, and that it will preserve these records for Commission inspection at any reasonable time upon reasonable notice.

36. Baldwin Wind shall inform the Commission of any plans to add additional turbines to the energy conversion facility or of any plans to modify the site plan for the energy conversion facility. Any additions or modifications to the site plan for the energy conversion facility must be approved in writing by the Commission or Commission staff.

37. When the facility is at the end of its useful life Baldwin Wind shall remove turbine structures and decommission the project area in accordance with all decommissioning rules adopted by the Commission and as delineated under North Dakota Century Code section 49-02-27.

38. The authorizations granted by the Certificate of Site Compatibility for this energy conversion facility are subject to modification by order of the Commission if deemed necessary to further protect the public or the environment.

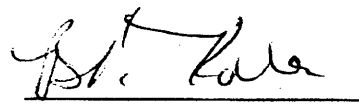
#### **PUBLIC SERVICE COMMISSION**



**Tony Clark**  
Commissioner



**Kevin Cramer**  
Chairman



**Brian P. Kalk**  
Commissioner

**STATE OF NORTH DAKOTA**  
**PUBLIC SERVICE COMMISSION**

**Baldwin Wind, LLC**  
**102 MW Baldwin Wind Energy Center - Burleigh County**  
**Siting Application**

**Case No. PU-09-668**

**Tree and Shrub Mitigation Specifications**

**Inventory**

1. Trees and shrubs anticipated to be cleared, including those that are considered invasive species or noxious weeds (e.g., *Caragana arborescens*, *Elaeagnus angustifolia*, *Rhamnus cathartica*, *Tamarix chinensis*, *T. parviflora*, *T. ramosissima*, *Ulmus pumila*), shall be inventoried before cutting. The inventory shall record the location, number, and species of trees and shrubs.
2. In windbreaks, shelterbelts, and other planted areas, trees or shrubs anticipated to be cleared, regardless of size, shall be inventoried for replacement.
3. In native growth areas, trees anticipated to be cleared that are 1-inch diameter at breast height (dbh) or greater shall be inventoried for replacement.
4. In native growth areas, shrubs anticipated to be cleared in the permanent right-of-way shall be inventoried for replacement.
5. In native growth areas outside the permanent right-of-way, shrubs shall be cut flush with the surface of the ground, taking care to leave the naturally occurring seed bank and root stock intact. If soil disturbance is necessary, the native topsoil shall be preserved and replaced after construction. Shrubs shall be allowed to regenerate naturally where native topsoil is preserved and replaced. Where native topsoil is not preserved and replaced, shrubs anticipated to be cleared shall be inventoried for replacement.
6. In native growth areas, trees and shrubs may be inventoried by actual count or by sampling method that will properly represent the woody vegetation population. A sampling plan developed by the company, filed with the North Dakota Public Service Commission (Commission), and approved prior to the start of construction shall define the sampling method to be used for trees, for tall shrubs and for low shrubs. The data from the sample plots shall be extrapolated to the total acreage of the wooded area to be cleared to determine the species and quantity of trees and shrubs to be replaced.

### **Clearing for Construction**

7. Trees and shrubs shall be selectively cleared, leaving mature trees and shrubs intact where practical.
8. The width of clear cuts through windbreaks, shelterbelts and all other wooded areas shall be limited to 50 feet or less unless otherwise approved by the Commission.
9. If the area of trees or shrubs actually cleared differs from the area inventoried, the difference in number of trees and shrubs to be replaced shall be noted on the inventory.

### **Replacement**

10. Prior to replacement, documentation identifying the number and variety of trees removed as well as the mitigation plan for the proposed number, variety, type, location and date of replacement plantings shall be filed with the Commission for approval.
11. Tree replacement shall be on a 2 to 1 basis with 2-year-old saplings. Shrub replacement shall be on a 2 to 1 basis with stem cuttings.
12. Trees and shrubs shall be replaced by the same species or similar species, except in the case of invasive species or noxious weeds, suitable for North Dakota growing conditions as recommended by the North Dakota Forest Service.
13. Landowners shall be given the option of having replacement trees or shrubs planted off the right-of-way on the landowner's property or waiving that requirement in writing and allowing those replacement trees or shrubs to be planted at alternative locations.
14. At the conclusion of the project, documentation identifying the actual number, variety, type, location, and date of the replacement plantings shall be filed with the Commission.
15. Tree and shrub replacements shall be inspected once a year for three years, on about the anniversary of the plantings, and, on or shortly before October 1 of each year, a report shall be submitted to the Commission documenting the condition of replacement planting and any woodlands work completed. If after three years from the anniversary of the plantings the survival rate is less than 75%, the Commission may order additional planting(s).

**PUBLIC SERVICE COMMISSION**

**STATE OF NORTH DAKOTA**

**Certificate of Site Compatibility for Energy Conversion Facility**

**Certificate Number 16**

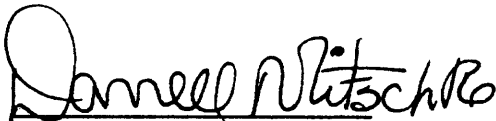
*This is to certify that the Commission has designated an energy conversion facility site for Baldwin Wind, LLC's , Baldwin Wind Energy Center consisting of up to 64 1.6 MW wind turbine generators and associated facilities in Burleigh County, North Dakota.*

*The facility may be sited in this designated location in compliance with the energy conversion facility siting criteria. This certificate is issued in accordance with the Finding of Fact, Conclusion of Law and Order of the Commission in Case No. PU-09-668 dated July 14, 2010 and is subject to the conditions and limitations noted in that order.*

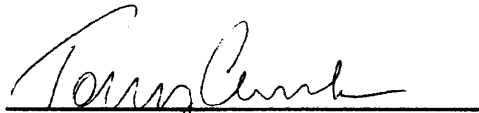
*Bismarck, North Dakota, July 14, 2010.*

**ATTEST:**

**PUBLIC SERVICE COMMISSION**



**Executive Secretary**



**Commissioner**

**Shadow Flicker Impact Analysis  
for the  
Baldwin Wind Energy Center**

*Prepared for*  
**Baldwin Wind, LLC**

*Prepared by*



**TETRA TECH, INC.**

**160 Federal Street  
Boston, MA 02110**

**May 2010**

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## ATTACHMENT

Attachment A Detailed Summary of WindPro Shadow Flicker Analysis Results

## 1.0 OVERVIEW

A wind turbine's moving blades can cast a moving shadow on locations within a certain distance of a turbine. These moving shadows are called shadow flicker, and can be a temporary phenomena experienced by people at nearby residences or public gathering places. The impact area depends on the time of year and day (which determines the sun's azimuth and altitude angles) and the wind turbine's physical characteristics (height, rotor diameter, blade width, and orientation of the rotor blades). Shadow flicker generally occurs during low angle sunlight conditions, typically during sunrise and sunset times of the day. However, when the sun angle gets very low (less than 3 degrees), the light has to pass through more atmosphere and becomes too diffused to form a coherent shadow. Shadow flicker will not occur when the sun is obscured by clouds or fog, at night, or when the source turbine(s) are not operating.

Shadow flicker intensity is defined as the difference in brightness at a given location in the presence and absence of a shadow. Shadow flicker intensity diminishes with greater receptor-to-turbine separation distance. Shadow flicker intensity for receptor-to-turbine distances beyond 1,500 meters is very low and generally considered imperceptible. Shadow flicker intensity for receptor-to-turbine distances between 1,000 and 1,500 meters (between 3,281 and 4,921 feet) is also low and considered barely noticeable. At this distance shadow flicker intensity would only tend to be noticed under conditions that would enhance the intensity difference, such as observing from a dark room with a single window directly facing the turbine casting the shadow. At distances less than 1,000 meters (3,281 feet), shadow flicker may be more noticeable. In general, the largest number of shadow flicker hours, along with greatest shadow flicker intensity, occurs nearest the wind turbines.

Baldwin Wind, LLC is proposing to install 64 wind turbines as part of the Baldwin Wind Energy Center (Project) in Burleigh County, North Dakota. Since the Project is using a minimum turbine siting setback requirement of 1,400 feet (to any residence), sensitive receptors (occupied residences) are generally not located in the worst case potential shadow flicker impact zones, which ensures that shadow flicker impacts are minimized. In Crofte Township, turbines must be at least 1,750 feet from non-participating residences.

The wind turbine being considered for the Project, and evaluated for potential shadow flicker impacts, has the following characteristics:

- **GE Wind Energy GE xle** – 3-blade 82.5-meter-diameter rotor, with a hub height of 80 meters. The GE xle has a nominal rotor speed of 18 rpm which translates to a blade pass frequency of 0.9 Hz (less than 1 alternation per second).

Shadow flicker frequency is related to the wind turbine's rotor blade speed and the number of blades on the rotor. From a health standpoint, such low frequencies are harmless. For comparison, strobe lights used in discotheques have frequencies which range from about 3 Hertz (Hz) to 10 Hz (1 Hz = 1 flash per second). As a result, public concerns that flickering light

from wind turbines can have negative health effects, such as triggering seizures in people with epilepsy are unfounded. The Epilepsy Action (working name for the British Epilepsy Foundation), states that there is no evidence that wind turbines can cause seizures (Epilepsy Action 2008). However, they recommend that wind turbine flicker frequency be limited to 3 Hz. Since the proposed Project's wind turbine blade pass frequency is approximately 0.9 Hz (less than 1 alternation per second), no negative health effects to individuals with photosensitive epilepsy are anticipated.

Shadow flicker impacts are not regulated in applicable state or federal law, and there is no permitting trigger with regard to hours per year of anticipated impacts to a receptor from a wind energy project. Due to the significant growth of the wind energy industry in recent years, some states have published model bylaws for local governments to adopt or modify at their own discretion which sometimes includes guidance and recommendations for shadow flicker levels and mitigation. However, a general precedent has been established in the industry both abroad and in the United States that fewer than 30 hours per year of shadow flicker impacts is acceptable to receptors in terms of nuisance and well below health hazard thresholds. In German court case for example, a judge found 30 hours of actual shadow flicker per year at a certain neighbor's property to be tolerable (WindPower 2003).

## **2.0 WINDPRO SHADOW FLICKER ANALYSIS**

An analysis of potential shadow flicker impacts from the Project was conducted using the WindPro software package. The turbine array dated April 30, 2010, which includes 64 turbines and 44 alternate locations, was included in the analysis. The analysis evaluated the following two turbine scenarios:

- Scenario A – 108 turbines (primary and alternates locations)
- Scenario B – 64 turbines (primary locations only)

In addition to the proposed Project turbines, there are existing turbines from the Wilton I and II Wind Energy Centers that are located in the central portion of the Baldwin Project Area. These existing turbines have also been taken into account in the shadow flicker analysis.

The WindPro analysis was conducted to determine shadow flicker impacts under realistic impact conditions (actual expected shadow). This analysis calculated the total amount of time (hours and minutes per year) that shadow flicker could occur at receptors out to 1,500 meters (4,921.3 feet). The realistic impact condition scenario is based on the following assumptions:

- The elevation and position geometries of the wind turbines and surrounding receptors (houses). Elevations were determined using USGS digital elevation model (DEM) data. Positions geometries were determined using GIS and referenced to UTM Zone 14 (NAD83).

- The position of the sun and the incident sunlight relative to the wind turbine and receptors on a minute-by-minute basis over the course of a year.
- Historical sunshine hours availability (percent of total available). Historical sunshine rates for the area (as summarized by the National Climatic Data Center (NCDC, 2008) for nearby Bismarck, ND) used in this analysis are as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
53%	53%	58%	58%	61%	64%	73%	72%	65%	58%	43%	47%

- Estimated wind turbine operations and orientation (based on approximately 16.5 years of wind data from 1/1/93 to 6/21/09 (wind speed / wind direction frequency distribution) measured at meteorological tower approximately 57 miles east of the proposed project site). The WindPro calculated wind direction frequency distribution for operating hour winds is as follows:

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW
7.1%	4.9%	5.4%	7.0%	9.1%	10.1%	8.3%	5.6%	6.3%	10.0%	13.8%	12.4%

- Receptor viewpoints (i.e., house windows) are assumed to always be directly facing turbine to sun line of sight (“greenhouse mode”).

WindPro incorporates terrain elevation contour information and the analysis accounts for terrain elevation differences. The sun’s path with respect to each turbine location is calculated by the software to determine the cast shadow paths every minute over a full year. Sun angles less than 3 degrees above the horizon were excluded, for the reasons identified earlier in this section.

A total of 134 sensitive receptor locations were identified within one mile of the Project Area. These receptors are based on the April 22, 2010 Farmstead Report, and supplementary input from the client based on local knowledge. These locations correspond to houses or other structures in the Project Area. In addition, non-residential receptors (such as a church, cemetery, and abandoned farm yards) were considered. A receptor in the model is defined as a 1 m<sup>2</sup> area (approximate size of a typical window), 1 meter (3.28 feet) aboveground level. Approximate eye level is set at 1.5 meters (4.94 feet). Figure 1 shows the sensitive receptor locations considered.

**3.0 WINDPRO SHADOW FLICKER ANALYSIS RESULTS**

WindPro predicts that shadow flicker impacts will primarily occur near the wind turbines. Figures 2A and 2B describe the WindPro predicted expected shadow flicker impact areas for turbine scenarios A and B, respectively. A detailed WindPro shadow flicker analysis results summary, for each of the modeling receptor locations, is provided in Attachment A. Tables 1A and 1B present the WindPro predicted expected shadow flicker impacts for the top ten worst case receptors for turbine scenarios A and B, respectively. For scenario A, only 7 of the 134 receptors modeled had expected shadow flicker impacts predicted for more than 30 hours per

year. For scenario B, only 3 of the 134 receptors modeled had expected shadow flicker impacts predicted for more than 30 hours per year.

Only four of the top ten impact receptors are actively occupied residential structures for both turbine scenarios A and B. The maximum predicted shadow flicker impact at any active residential receptor (#40039) is 43 hours, 43 minutes per year, which is approximately 1.0 percent of the potential available daylight hours.

**Table 1A. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts - Turbine Scenario A (with Alternates)**

Receptor ID*	Receptor Description / Status	Shadow Hours per Year (expected) [hh:mm / year]
2027	Unoccupied	85:21
40039	Occupied	43:43
60010a	Unoccupied	37:31
60062	Occupied	35:29
60005	Non-Residential	34:15
40074a	Non-Residential	32:34
40066	Occupied	30:27
2018	Occupied	29:57
40070a	Unoccupied	28:42
40125a	Non-Residential	27:35

**Table 1B. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts - Turbine Scenario B (No Alternates)**

Receptor ID*	Receptor Description / Status	Shadow Hours per Year (expected) [hh:mm / year]
2027	Unoccupied	84:43
40074a	Non-Residential	32:34
40039	Occupied	32:15
2018	Occupied	29:57
40066	Occupied	28:01
2050	Occupied	27:32
2025a	Unoccupied	26:26
41014a	Non-Residential	26:15
41013a	Non-Residential	25:46
2063	Occupied	22:59

Approximately 94.8 percent, or 127 of the 134 receptor locations evaluated (for turbine scenario A), have less than 30 hours per year of predicted shadow flicker impact. The shadow flicker impact prediction statistics are as summarized in Table 2.

**Table 2A. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Sensitive Receptor Locations (Turbine Scenario A)**

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	134
= 0 Hours	59
> 0 Hours < 10 hours	35
≥ 10 Hours < 20 hours	20
≥ 20 Hours < 30 hours	13
≥ 30 Hours < 40 hours	5
≥ 40 hours < 50 hours	1
≥ 50 hours	1

**Table 2B. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Sensitive Receptor Locations (Turbine Scenario B)**

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	134
= 0 Hours	80
> 0 Hours < 10 hours	22
≥ 10 Hours < 20 hours	19
≥ 20 Hours < 30 hours	10
≥ 30 Hours < 40 hours	2
≥ 40 hours < 50 hours	0
≥ 50 hours	1

#### 4.0 CONCLUSION

The analysis of potential shadow flicker impacts from the Project on nearby houses (receptors) shows that shadow flicker impacts within the area of study are expected to be minor. The analysis assumes that the houses all have a direct in line view of the incoming shadow flicker sunlight and does not account for trees or other obstructions which may block sunlight. In reality, the windows of many houses will not face the sun directly for the key shadow flicker impact times. In addition, potential shadow flicker impacts for wind turbines up to 1,500 meters (4,921 feet) away were determined. In reality, the shadow flicker impacts for turbines beyond 1,000 meters (3,281 feet) will be very low intensity. For these reasons, shadow flicker impacts are expected to be less than estimated with the conservative analysis, and shadow flicker is not expected to be a significant environmental impact.

Finally, there is no state or federal regulatory threshold for shadow flicker hours per year at a given receptor; therefore, the Project in no way violates state or federal permitting requirements or conditions according to the results of this shadow flicker impact analysis.

## 5.0 REFERENCES

Epilepsy Action. 2008. British Epilepsy Association.

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WindPower 2003. Danish Wind industry Association. Shadow Casting From Wind Turbines.

<http://guidedtour.windpower.org/en/tour/env/shadow/index.htm>, Accessed 4/28/10

National Climatic Data Center. 2008. – Sunshine Average Percent of Possible.

<http://www.ncdc.noaa.gov/oa/climate/online/ccd/pctpos.txt> . Accessed 3/1/10

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

FIGURE 1  
 SENSITIVE RECEPTORS MODELED  
 WITH WINDPRO TO PREDICT  
 EXPECTED SHADOW FLICKER IMPACTS

MAY 2010



TETRA TECH, INC.

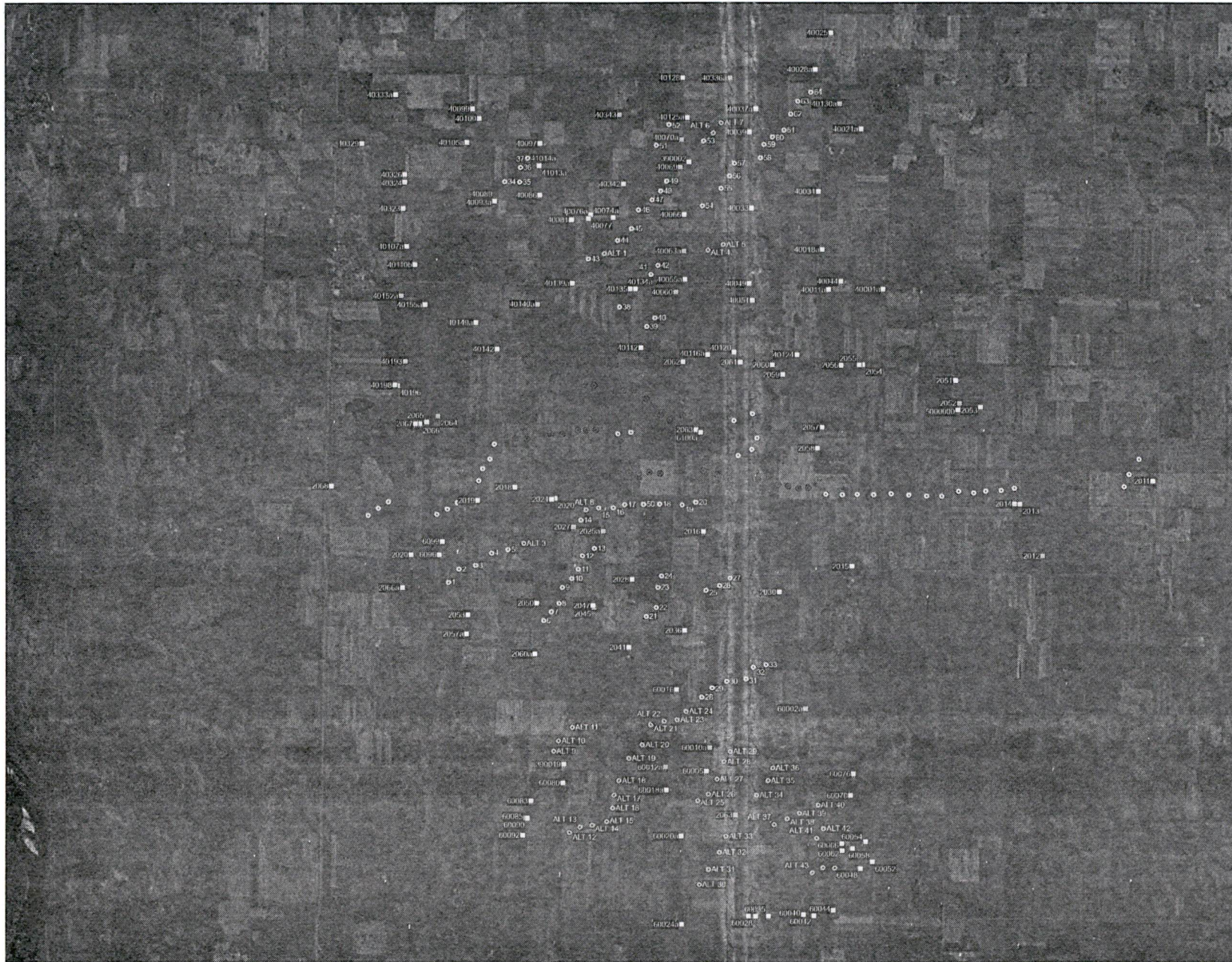
Legend

- Wilton I Turbine Location
- Wilton II Turbine Location
- Baldwin Turbine Location (4-30-2010 layout)**
- Planned
- Alternate
- Receptor (based on 4-22-2010 Farmstead Report)**
- Occupied
- Unoccupied
- Non-Residential



0 0.5 1 2 Miles

REFERENCE MAP



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

FIGURE 2A  
WINDPRO PREDICTED EXPECTED  
SHADOW FLICKER IMPACT AREAS  
TURBINE SCENARIO A  
(WITH ALTERNATES)

MAY 2010



TETRA TECH, INC.

Legend

- Wilton I Turbine Location
- Wilton II Turbine Location
- Baldwin Turbine Location (4-30-2010 layout)**
- Planned
- Alternate
- Receptor (based on 4-22-2010 Farmstead Report)**
- Occupied
- Unoccupied
- Non-Residential

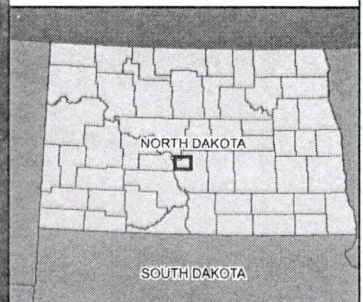
Shadow Flicker Iso Line

- 10 hrs/yr
- 25 hrs/yr
- 50 hrs/yr
- 100 hrs/yr
- 200 hrs/yr



0 0.5 1 2 Miles

REFERENCE MAP



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

FIGURE 2B  
WINDPRO PREDICTED EXPECTED  
SHADOW FLICKER IMPACT AREAS  
TURBINE SCENARIO B  
(NO ALTERNATES)

MAY 2010



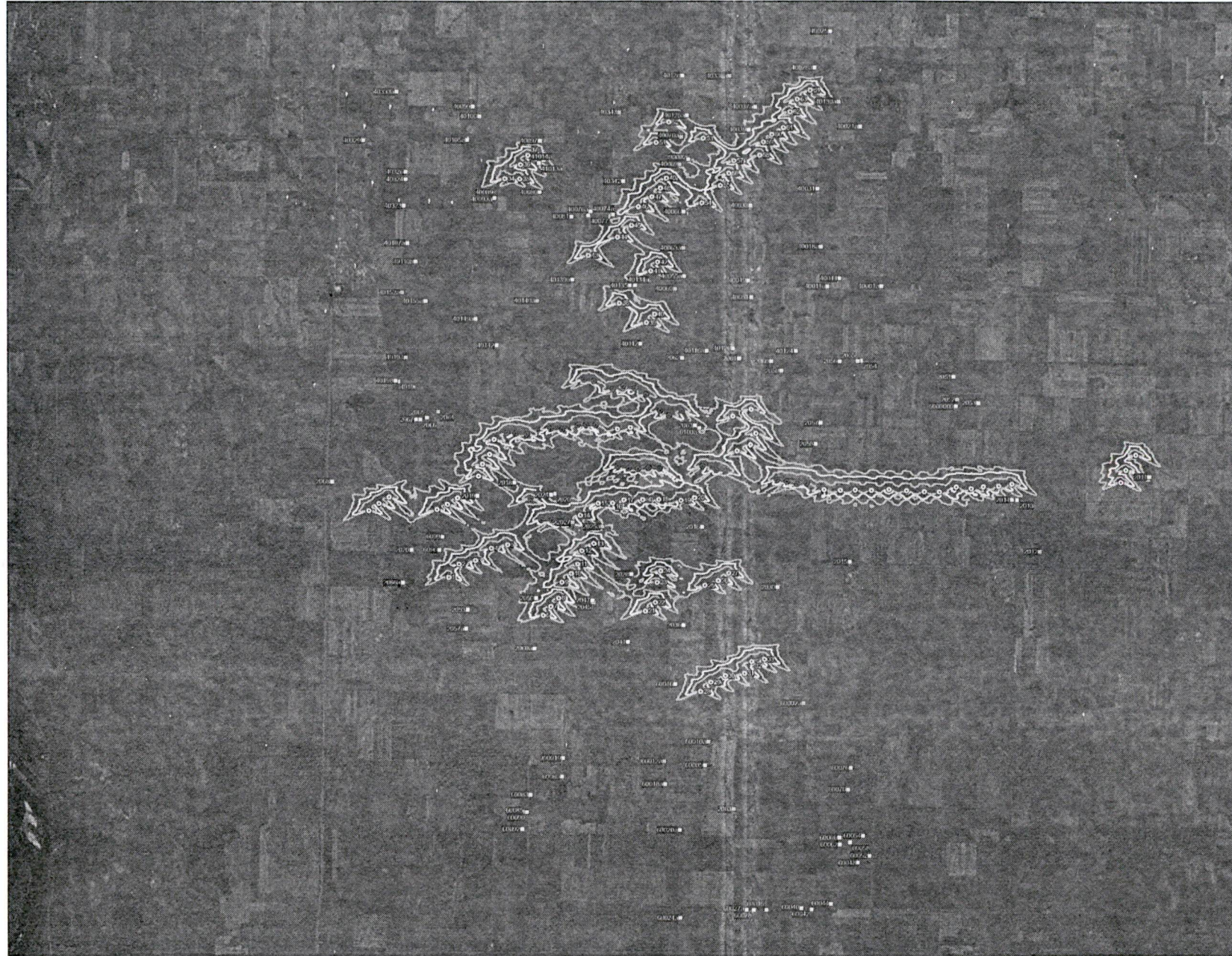
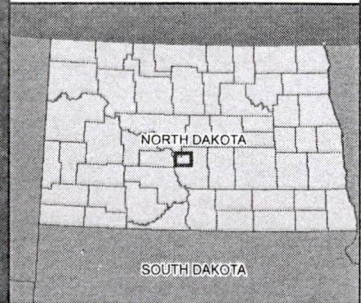
TETRA TECH, INC.

**Legend**

- Wilton I Turbine Location
- Wilton II Turbine Location
- Baldwin Turbine Location (4-30-2010 layout)
- Planned
- Receptor (based on 4-22-2010 Farmstead Report)
  - Occupied
  - Unoccupied
  - Non-Residential
- Shadow Flicker Iso Line
  - 10 hrs/yr
  - 25 hrs/yr
  - 50 hrs/yr
  - 100 hrs/yr
  - 200 hrs/yr



**REFERENCE MAP**



**ATTACHMENT A**

**Detailed Summary of WindPro Shadow Flicker Analysis Results**

**Baldwin Wind Energy Center  
WindPro Shadow Flicker Analysis Results Summary  
Turbine Scenario A (with Alternates)**

<b>Baldwin Receptor ID</b>	<b>UTM-E (m)</b>	<b>UTM-N (m)</b>	<b>WindPro Predicted Expected Shadow Flicker (Hours per Year)</b>	<b>Receptor Status</b>
2027	369,737	5,218,420	85:21:00	Unoccupied
40039	373,837	5,227,612	43:43:00	Occupied
60010a	372,900	5,213,255	37:31:00	Unoccupied
60062	375,973	5,210,859	35:29:00	Occupied
60005	372,824	5,212,708	34:15:00	Non-Residential
40074a	370,668	5,225,623	32:34:00	Non-Residential
40066	372,315	5,225,695	30:27:00	Occupied
2018	368,373	5,219,341	29:57:00	Occupied
40070a	372,259	5,227,439	28:42:00	Unoccupied
40125a	372,393	5,227,947	27:35:00	Non-Residential
2050	368,883	5,216,631	27:32:00	Occupied
2025a	370,431	5,218,318	26:26:00	Unoccupied
41014a	368,950	5,226,845	26:15:00	Non-Residential
41013a	368,951	5,226,825	25:46:00	Non-Residential
2063	372,584	5,220,687	22:59:00	Occupied
40063a	372,312	5,224,843	22:47:00	Unoccupied
2020	369,311	5,219,083	21:09:00	Occupied
6100a	372,687	5,220,626	21:09:00	Occupied
2028	371,097	5,217,187	20:54:00	Occupied
40069	372,228	5,226,802	20:11:00	Unoccupied
2024	369,232	5,219,059	19:35:00	Occupied
60058	376,209	5,210,903	19:35:00	Occupied
2019	367,510	5,219,031	19:24:00	Occupied
40037a	373,984	5,228,148	18:13:00	Occupied
40055a	372,334	5,224,178	18:07:00	Occupied
2047	370,195	5,216,578	17:31:00	Occupied
2011	383,232	5,219,483	17:15:00	Occupied
40130a	375,933	5,228,266	15:34:00	Unoccupied
60066	375,965	5,211,018	15:05:00	Occupied
60018a	371,895	5,212,263	14:52:00	Occupied
2014	379,983	5,218,952	14:51:00	Non-Residential
40097	368,972	5,227,351	14:12:00	Occupied
6096	366,619	5,217,768	14:05:00	Occupied
2045	370,218	5,216,534	13:34:00	Occupied
60054	376,515	5,211,062	13:16:00	Occupied
40076a	370,151	5,225,694	12:46:00	Non-Residential
60016	372,129	5,214,610	12:29:00	Occupied
60048	376,397	5,210,435	10:58:00	Occupied
40134a	371,186	5,223,960	10:49:00	Occupied
40342	370,909	5,226,405	10:49:00	Non-Residential
2063	373,499	5,211,684	9:24:00	Unoccupied
60012a	371,877	5,212,797	9:22:00	Unoccupied
40077	370,102	5,225,602	9:14:00	Occupied

<b>Baldwin Receptor ID</b>	<b>UTM-E (m)</b>	<b>UTM-N (m)</b>	<b>WindPro Predicted Expected Shadow Flicker (Hours per Year)</b>	<b>Receptor Status</b>
60080	369,491	5,212,432	8:33:00	Occupied
2013	380,100	5,218,948	8:04:00	Non-Residential
60052	376,671	5,210,591	6:59:00	Occupied
40086	368,967	5,226,144	5:51:00	Occupied
40343	370,818	5,228,021	5:35:00	Unoccupied
6099	366,688	5,218,078	5:22:00	Occupied
60020a	372,243	5,211,194	5:04:00	Occupied
2020	365,973	5,217,765	5:03:00	Occupied
60083	368,754	5,212,014	5:03:00	Occupied
60070	376,164	5,212,140	4:26:00	Occupied
40081	369,701	5,225,578	4:25:00	Occupied
2066a	365,765	5,216,992	4:15:00	Occupied
2068	364,110	5,219,367	4:10:00	Occupied
60090	368,671	5,211,608	4:03:00	Occupied
2036	372,317	5,216,000	3:57:00	Occupied
60092	368,562	5,211,213	3:53:00	Occupied
60085	368,637	5,211,618	3:52:00	Occupied
2030	374,516	5,216,892	3:30:00	Occupied
2016	372,754	5,218,312	3:24:00	Occupied
60076	376,229	5,212,642	3:13:00	Occupied
40112	371,312	5,222,602	2:45:00	Occupied
40033	373,882	5,225,842	2:43:00	Occupied
390019	369,513	5,212,867	2:42:00	Non-Residential
40105a	367,270	5,227,370	2:27:00	Occupied
40135	371,067	5,223,960	2:20:00	Occupied
2062	372,289	5,222,275	2:06:00	Occupied
2058	375,404	5,220,251	2:02:00	Occupied
40100	367,556	5,227,926	1:56:00	Occupied
60027a	373,800	5,209,328	1:45:00	Occupied
40139a	369,726	5,224,097	1:24:00	Non-Residential
2064	366,589	5,221,003	1:01:00	Unoccupied
40060	372,120	5,223,886	1:01:00	Unoccupied
2012	380,630	5,217,738	0:00:00	Unoccupied
2015	376,198	5,217,497	0:00:00	Occupied
2051	378,621	5,221,835	0:00:00	Occupied
2052	378,705	5,221,297	0:00:00	Unoccupied
2053	379,196	5,221,219	0:00:00	Occupied
2054	376,457	5,222,208	0:00:00	Occupied
2055	376,380	5,222,201	0:00:00	Occupied
2056	375,960	5,222,198	0:00:00	Occupied
2057	375,513	5,220,742	0:00:00	Occupied
2059	374,606	5,221,973	0:00:00	Occupied
2060	374,367	5,222,200	0:00:00	Occupied
2061	373,618	5,222,265	0:00:00	Non-Residential
2065	366,333	5,220,865	0:00:00	Occupied
2066	366,175	5,220,821	0:00:00	Occupied
2067	366,079	5,220,821	0:00:00	Occupied

<b>Baldwin Receptor ID</b>	<b>UTM-E (m)</b>	<b>UTM-N (m)</b>	<b>WindPro Predicted Expected Shadow Flicker (Hours per Year)</b>	<b>Receptor Status</b>
2041	371,025	5,215,602	0:00:00	Occupied
2053	367,280	5,216,355	0:00:00	Occupied
2057a	367,248	5,215,913	0:00:00	Occupied
2060a	368,839	5,215,450	0:00:00	Occupied
60002a	375,123	5,214,163	0:00:00	Unoccupied
60024a	372,255	5,209,130	0:00:00	Occupied
60035	374,268	5,209,331	0:00:00	Occupied
60040	375,079	5,209,360	0:00:00	Non-Residential
60042	375,320	5,209,336	0:00:00	Occupied
60044	375,770	5,209,460	0:00:00	Occupied
40001a	376,933	5,223,953	0:00:00	Occupied
40011a	375,671	5,223,949	0:00:00	Non-Residential
40018a	375,524	5,224,880	0:00:00	Occupied
40021a	376,428	5,227,682	0:00:00	Occupied
40025	375,732	5,229,916	0:00:00	Occupied
40028a	375,368	5,229,059	0:00:00	Non-Residential
40031	375,434	5,226,226	0:00:00	Occupied
40044	375,953	5,224,137	0:00:00	Occupied
40049	373,825	5,224,083	0:00:00	Non-Residential
40051	373,899	5,223,691	0:00:00	Occupied
40089	367,924	5,226,018	0:00:00	Occupied
40093a	367,907	5,226,008	0:00:00	Occupied
40099	367,401	5,228,151	0:00:00	Occupied
40107a	365,871	5,224,958	0:00:00	Occupied
40110b	366,065	5,224,523	0:00:00	Occupied
40116a	372,859	5,222,443	0:00:00	Occupied
40120	373,474	5,222,500	0:00:00	Occupied
40124	374,934	5,222,439	0:00:00	Occupied
40140a	368,909	5,223,606	0:00:00	Unoccupied
40142	367,963	5,222,567	0:00:00	Non-Residential
40149a	367,475	5,223,178	0:00:00	Occupied
40152a	365,746	5,223,799	0:00:00	Unoccupied
40155a	366,297	5,223,595	0:00:00	Occupied
40193	365,836	5,222,281	0:00:00	Unoccupied
40196	365,654	5,221,719	0:00:00	Occupied
40198	365,596	5,221,731	0:00:00	Occupied
40323	365,791	5,225,833	0:00:00	Occupied
40324	365,832	5,226,445	0:00:00	Non-Residential
40326	365,834	5,226,625	0:00:00	Non-Residential
40329	364,837	5,227,355	0:00:00	Occupied
40333a	365,619	5,228,487	0:00:00	Occupied
40336a	373,387	5,228,862	0:00:00	Unoccupied
60028	373,971	5,209,320	0:00:00	Occupied
40128	372,293	5,228,874	0:00:00	Non-Residential

**Baldwin Wind Energy Center  
WindPro Shadow Flicker Analysis Results Summary  
Turbine Scenario B (no Alternates)**

<b>Baldwin Receptor ID</b>	<b>UTM-E (m)</b>	<b>UTM-N (m)</b>	<b>WindPro Predicted Expected Shadow Flicker (Hours per Year)</b>	<b>Receptor Status</b>
2027	369,737	5,218,420	84:43:00	Unoccupied
40074a	370,668	5,225,623	32:34:00	Non-Residential
40039	373,837	5,227,612	32:15:00	Occupied
2018	368,373	5,219,341	29:57:00	Occupied
40066	372,315	5,225,695	28:01:00	Occupied
2050	368,883	5,216,631	27:32:00	Occupied
2025a	370,431	5,218,318	26:26:00	Unoccupied
41014a	368,950	5,226,845	26:15:00	Non-Residential
41013a	368,951	5,226,825	25:46:00	Non-Residential
2063	372,584	5,220,687	22:59:00	Occupied
6100a	372,687	5,220,626	21:09:00	Occupied
2028	371,097	5,217,187	20:54:00	Occupied
40069	372,228	5,226,802	20:11:00	Unoccupied
40070a	372,259	5,227,439	19:04:00	Unoccupied
40055a	372,334	5,224,178	18:07:00	Occupied
40125a	372,393	5,227,947	17:51:00	Non-Residential
2047	370,195	5,216,578	17:31:00	Occupied
2019	367,510	5,219,031	17:20:00	Occupied
2011	383,232	5,219,483	17:15:00	Occupied
2020	369,311	5,219,083	16:44:00	Occupied
2024	369,232	5,219,059	15:54:00	Occupied
40130a	375,933	5,228,266	15:34:00	Unoccupied
2014	379,983	5,218,952	14:51:00	Non-Residential
40097	368,972	5,227,351	14:12:00	Occupied
6096	366,619	5,217,768	14:05:00	Occupied
40037a	373,984	5,228,148	13:44:00	Occupied
2045	370,218	5,216,534	13:34:00	Occupied
40076a	370,151	5,225,694	12:46:00	Non-Residential
60016	372,129	5,214,610	12:29:00	Occupied
40134a	371,186	5,223,960	10:49:00	Occupied
40342	370,909	5,226,405	10:49:00	Non-Residential
40063a	372,312	5,224,843	10:33:00	Unoccupied
40077	370,102	5,225,602	9:14:00	Occupied
2013	380,100	5,218,948	8:04:00	Non-Residential
40086	368,967	5,226,144	5:51:00	Occupied
40343	370,818	5,228,021	5:35:00	Unoccupied
6099	366,688	5,218,078	5:22:00	Occupied
2020	365,973	5,217,765	5:03:00	Occupied
2066a	365,765	5,216,992	4:15:00	Occupied
2068	364,110	5,219,367	4:10:00	Occupied
2036	372,317	5,216,000	3:57:00	Occupied
2030	374,516	5,216,892	3:30:00	Occupied

<b>Baldwin Receptor ID</b>	<b>UTM-E (m)</b>	<b>UTM-N (m)</b>	<b>WindPro Predicted Expected Shadow Flicker (Hours per Year)</b>	<b>Receptor Status</b>
2016	372,754	5,218,312	3:24:00	Occupied
40112	371,312	5,222,602	2:45:00	Occupied
40081	369,701	5,225,578	2:44:00	Occupied
40033	373,882	5,225,842	2:43:00	Occupied
40105a	367,270	5,227,370	2:27:00	Occupied
40135	371,067	5,223,960	2:20:00	Occupied
2062	372,289	5,222,275	2:06:00	Occupied
2058	375,404	5,220,251	2:02:00	Occupied
40100	367,556	5,227,926	1:56:00	Occupied
40139a	369,726	5,224,097	1:24:00	Non-Residential
2064	366,589	5,221,003	1:01:00	Unoccupied
40060	372,120	5,223,886	1:01:00	Unoccupied
2012	380,630	5,217,738	0:00:00	Unoccupied
2015	376,198	5,217,497	0:00:00	Occupied
2051	378,621	5,221,835	0:00:00	Occupied
2052	378,705	5,221,297	0:00:00	Unoccupied
2053	379,196	5,221,219	0:00:00	Occupied
2054	376,457	5,222,208	0:00:00	Occupied
2055	376,380	5,222,201	0:00:00	Occupied
2056	375,960	5,222,198	0:00:00	Occupied
2057	375,513	5,220,742	0:00:00	Occupied
2059	374,606	5,221,973	0:00:00	Occupied
2060	374,367	5,222,200	0:00:00	Occupied
2061	373,618	5,222,265	0:00:00	Non-Residential
2065	366,333	5,220,865	0:00:00	Occupied
2066	366,175	5,220,821	0:00:00	Occupied
2067	366,079	5,220,821	0:00:00	Occupied
2041	371,025	5,215,602	0:00:00	Occupied
2053	367,280	5,216,355	0:00:00	Occupied
2057a	367,248	5,215,913	0:00:00	Occupied
2060a	368,839	5,215,450	0:00:00	Occupied
2063	373,499	5,211,684	0:00:00	Unoccupied
60002a	375,123	5,214,163	0:00:00	Unoccupied
60005	372,824	5,212,708	0:00:00	Non-Residential
60010a	372,900	5,213,255	0:00:00	Unoccupied
60012a	371,877	5,212,797	0:00:00	Unoccupied
60018a	371,895	5,212,263	0:00:00	Occupied
60020a	372,243	5,211,194	0:00:00	Occupied
60024a	372,255	5,209,130	0:00:00	Occupied
60027a	373,800	5,209,328	0:00:00	Occupied
60035	374,268	5,209,331	0:00:00	Occupied
60040	375,079	5,209,360	0:00:00	Non-Residential
60042	375,320	5,209,336	0:00:00	Occupied
60044	375,770	5,209,460	0:00:00	Occupied
60048	376,397	5,210,435	0:00:00	Occupied
60052	376,671	5,210,591	0:00:00	Occupied

<b>Baldwin Receptor ID</b>	<b>UTM-E (m)</b>	<b>UTM-N (m)</b>	<b>WindPro Predicted Expected Shadow Flicker (Hours per Year)</b>	<b>Receptor Status</b>
60054	376,515	5,211,062	0:00:00	Occupied
60058	376,209	5,210,903	0:00:00	Occupied
60062	375,973	5,210,859	0:00:00	Occupied
60070	376,164	5,212,140	0:00:00	Occupied
60076	376,229	5,212,642	0:00:00	Occupied
60080	369,491	5,212,432	0:00:00	Occupied
60083	368,754	5,212,014	0:00:00	Occupied
60085	368,637	5,211,618	0:00:00	Occupied
60090	368,671	5,211,608	0:00:00	Occupied
60092	368,562	5,211,213	0:00:00	Occupied
40001a	376,933	5,223,953	0:00:00	Occupied
40011a	375,671	5,223,949	0:00:00	Non-Residential
40018a	375,524	5,224,880	0:00:00	Occupied
40021a	376,428	5,227,682	0:00:00	Occupied
40025	375,732	5,229,916	0:00:00	Occupied
40028a	375,368	5,229,059	0:00:00	Non-Residential
40031	375,434	5,226,226	0:00:00	Occupied
40044	375,953	5,224,137	0:00:00	Occupied
40049	373,825	5,224,083	0:00:00	Non-Residential
40051	373,899	5,223,691	0:00:00	Occupied
40089	367,924	5,226,018	0:00:00	Occupied
40093a	367,907	5,226,008	0:00:00	Occupied
40099	367,401	5,228,151	0:00:00	Occupied
40107a	365,871	5,224,958	0:00:00	Occupied
40110b	366,065	5,224,523	0:00:00	Occupied
40116a	372,859	5,222,443	0:00:00	Occupied
40120	373,474	5,222,500	0:00:00	Occupied
40124	374,934	5,222,439	0:00:00	Occupied
40140a	368,909	5,223,606	0:00:00	Unoccupied
40142	367,963	5,222,567	0:00:00	Non-Residential
40149a	367,475	5,223,178	0:00:00	Occupied
40152a	365,746	5,223,799	0:00:00	Unoccupied
40155a	366,297	5,223,595	0:00:00	Occupied
40193	365,836	5,222,281	0:00:00	Unoccupied
40196	365,654	5,221,719	0:00:00	Occupied
40198	365,596	5,221,731	0:00:00	Occupied
40323	365,791	5,225,833	0:00:00	Occupied
40324	365,832	5,226,445	0:00:00	Non-Residential
40326	365,834	5,226,625	0:00:00	Non-Residential
40329	364,837	5,227,355	0:00:00	Occupied
40333a	365,619	5,228,487	0:00:00	Occupied
40336a	373,387	5,228,862	0:00:00	Unoccupied
60028	373,971	5,209,320	0:00:00	Occupied
60066	375,965	5,211,018	0:00:00	Occupied
40128	372,293	5,228,874	0:00:00	Non-Residential
390019	369,513	5,212,867	0:00:00	Non-Residential

**Baldwin Wind Energy Center  
Acoustic Assessment  
Burleigh County, North Dakota**

**October 8, 2009**

**Prepared for**



**Prepared by**



**TETRA TECH EC, INC.  
133 Federal Street  
Boston, MA 02110  
617-457-8200**



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**ACRONYMS AND ABBREVIATIONS**

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

## EXECUTIVE SUMMARY

Tetra Tech EC, Inc. (Tetra Tech) has completed the acoustic assessment for the proposed 66-turbine wind energy project, the Baldwin Wind Energy Center (Project) located in Burleigh County, North Dakota. An engineering analysis was developed to address sound levels resulting from wind turbine operations, as well as the consideration of sound from the electrical substation and sound generated during Project construction and maintenance activities. The overall objectives of this study were to: (1) quantify Project sound sources and site-specific sound propagation characteristics; (2) computer simulate wind turbine generator (WTG) sound levels over the full range of future Project operational and meteorological conditions; and (3) determine the feasibility of the Project to operate in compliance with applicable noise standards and guidelines.

Wind turbine sound source data was obtained from General Electric (GE), the manufacturer of the GE xle 1.5 megawatt (MW) wind turbine model. Sound propagation modeling was conducted using the Computer-Aided Noise Abatement (CadnaA) software program (version 3.7.123), a comprehensive 3-dimensional acoustic modeling computer simulation software specifically developed for the power generation industry with calculations made in accordance with the Organization for International Standardization (ISO) 9613-2 "Attenuation of Sound During Propagation Outdoors.". The industry standard CadnaA acoustic modeling software is widely used by sound engineers due to its adaptability to describe complex acoustic scenarios. CadnaA, programmed with the ISO 9613-2 standard, has been shown to be a highly effective and accurate acoustic modeling assessment tool, assisting in the siting of wind energy projects in Europe, Canada, and the United States. The results of the acoustic modeling results were compared to U.S. Environmental Protection Agency (EPA) environmental noise guidelines and Occupational Safety and Health Administration (OSHA) regulatory limits for worker exposure and public safety.

The overall conclusions of the acoustic assessment are as follows:

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

## **1.0 INTRODUCTION**

NextEra Energy Resources, LLC (the Applicant) proposes to construct the 99 megawatt (MW) wind energy facility in Burleigh County, North Dakota, referred to as the Baldwin Wind Energy Center (the Project). The Project consists of a total of 66 1.5 MW GE xle wind turbine generators (WTGs) with a rotor diameter of 270 feet (82.5 meters) and an effective hub height of 262.5 feet (80 meters) above grade. The Project will also include an electrical substation, which transforms the power generated from on-site WTGs to a higher voltage suitable for the local distribution system.

In support of environmental permitting efforts, Tetra Tech EC, Inc. (Tetra Tech) was retained to perform the acoustic assessment of several iterative Project layouts. The acoustic assessment analyzed the total potential Project power production output of 99 MW; however, it is expected that the Project will primarily be operated at half of its potential capacity (i.e., 49.5 MW). The final project layout, dated September 10, 2009, includes six alternate WTG sites. This document presents the findings of the assessment, including calculated future sound levels resulting from project operation using the finalized layout and the electrical substation and an evaluation of the feasibility of the Project to operate in compliance with applicable noise regulations and guidelines. In addition, noise associated with Project construction and maintenance activities has been assessed in a semi-qualitative manner. While construction is required to erect the Project WTGs and supporting electrical substation, no transmission line construction is anticipated in support of this Project.

### **1.1 Project Acoustic Study Area**

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

The Project is located on privately owned lands in central North Dakota, consists of 14,300 acres, approximately 17 miles north of Bismarck in Burleigh County (Figure 1). The Project area is characteristic of the upland portion of this region, with the majority of the land surface currently covered by agriculture and rangelands with patches of native prairie. The area contains numerous small wetlands that vary from shallow, vegetated depressions to deeper, open water communities. Residences and abandoned farmsteads are widely scattered throughout the Project area. Patches of trees and shrubs exist throughout the Project area and are found primarily between agricultural fields, in drainages, and as shelter belts around homesteads and between agricultural fields.

A total of 46 potential Noise Sensitive Areas (NSAs) were identified within the designated acoustic study area using the Project Farmstead Location Report dated August 18, 2009. Figure 1 presents the Burleigh County acoustic study area, the locations of the proposed WTGs and NSAs. While all identified NSAs were included in the acoustic modeling analysis, as indicated in Figure 1, several NSAs were found to be abandoned or not currently used for residential purposes during the farmstead survey completed Swenson, Hagen & Co. P.C of Bismarck, North Dakota.

## **1.2 Existing Acoustic Environment**

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

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

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

FIGURE 1  
PROJECT LAYOUT

OCTOBER 2009



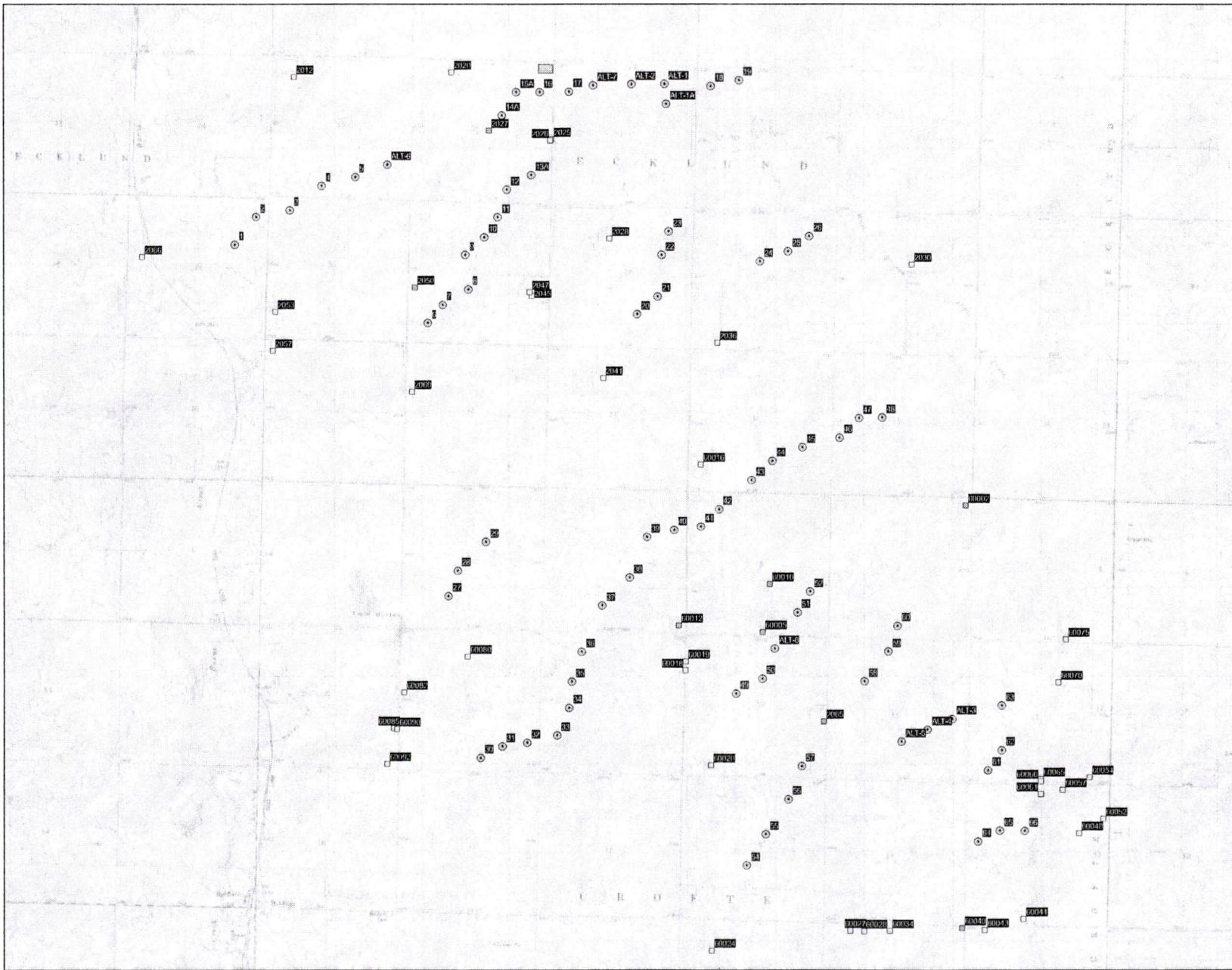
**Legend**

- ⊙ Turbine Location (9-9-2009)
- ▣ Substation
- Receptor**
- Occupied
- ▣ Unoccupied



0 0.5 1 Miles

**REFERENCE MAP**



### 1.3 Acoustic Terminology

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

Sound levels are described on a logarithmic scale to account for the large range of pressure that the human ear can perceive, and is expressed in units of decibels (dB). A decibel is defined as the ratio between a measured value and a reference value usually corresponding to the lower threshold of human hearing defined as 20 micropascals ( $\mu\text{Pa}$ ). Conversely, sound power is referenced to 1 picowatt (pW). Since the human ear does not perceive every frequency with equal loudness, complex sounds are often adjusted with a weighting filter. Sound exposure in acoustic assessments is commonly reported in A-weighted decibels. The A-weighted filter is applied to compensate for the frequency response of the human auditory system and sound levels are reported in units of dBA.

An inherent property of the logarithmic decibel scale is that the sound pressure levels of two separate sources are not directly additive. For example, if a sound of 50 dBA is added to another sound of 50 dBA, the result is a 3-decibel increase (or 53 dBA), not an arithmetic doubling of 100 dBA. The human ear does not sense changes in the sound pressure level as equal changes in perceived loudness. Scientific research demonstrates that the following general relationships hold between sound level and human perception for two broadband sound levels with the same or similar frequency characteristics:

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

While the concept of sound is defined by the laws of physics, the term 'noise' has further qualities of being excessive or loud. The perception of sound as noise is influenced by technical factors as intensity, sound quality, tonality, duration, and the existing background levels. The effects of noise on people can be classified into three general categories: (1) subjective responses such as annoyance, nuisance, and dissatisfaction; (2) activity interference, e.g., speech, sleep, and learning; and (3) physiological effects

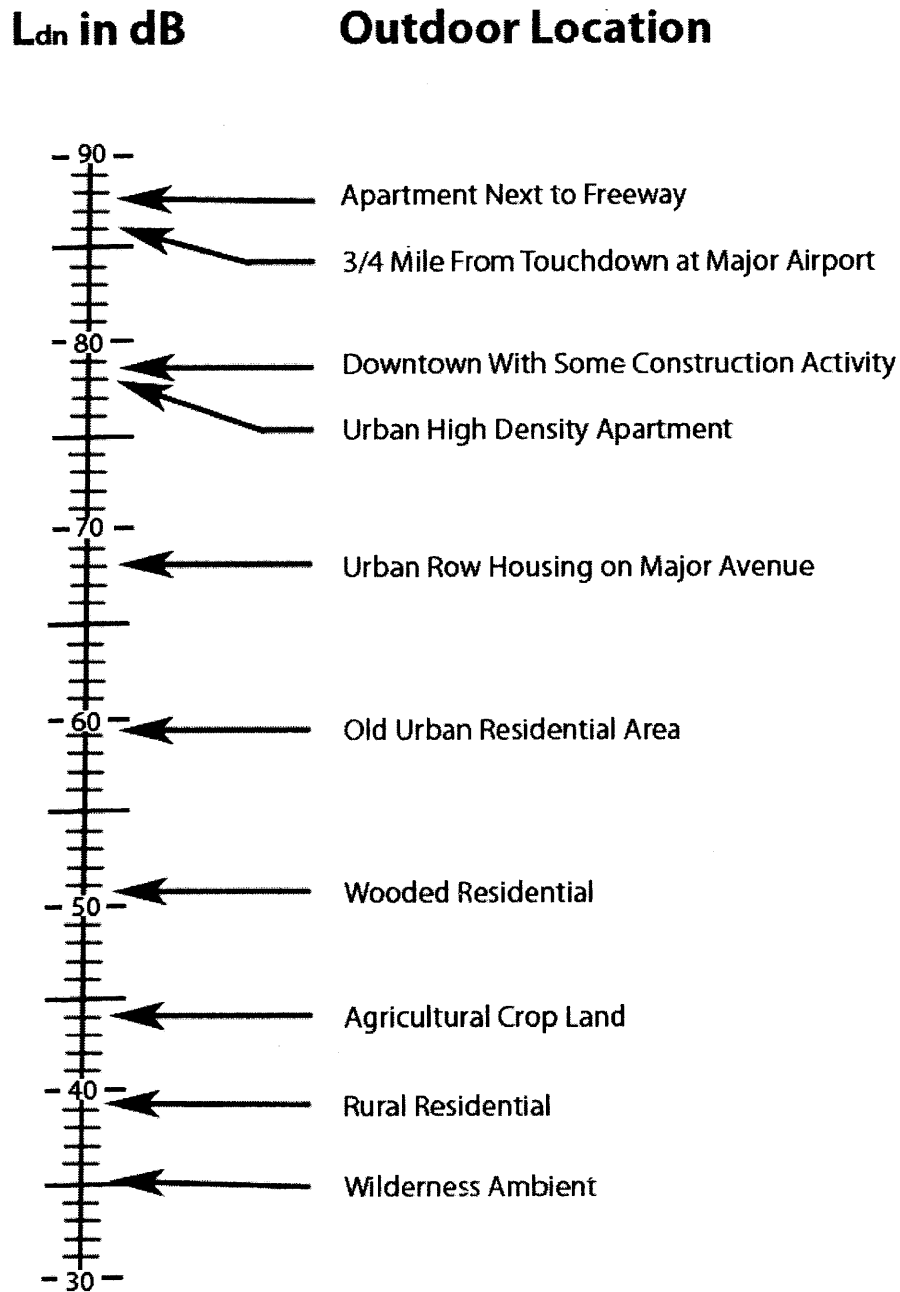
such as anxiety or hearing loss. Environmental sound levels associated with wind energy development projects have been found to generally produce effects only in the first two categories.

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level ( $L_{eq}$ ). The equivalent sound level has been shown to provide both an effective and uniform method for comparing time-varying sound levels and is widely used in acoustic assessments of wind energy projects. Community sound levels are also often described in terms of the day-night averaged sound level ( $L_{dn}$ ), which accounts for the increased potential for annoyance that comes with elevated sound levels at night. In addition, the maximum sound level ( $L_{max}$ ) can be used to quantify the maximum instantaneous sound pressure level generated by a source and is often used in establishing regulatory noise limits.

Broadband sound includes sound energy summed across the frequency spectrum. In addition to broadband sound pressure levels, data may also include the analysis of the various frequency components of the sound spectrum to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines 11 octave (or 1/3 octave) bands from 16 Hz (low) to 16,000 Hz (high).

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

**Table 1. Various Outdoor Sound Pressure ( $L_p$ ) Levels**



**Notes:**

$\mu$ Pa - Micropascals describe sound pressure levels (force/area).

dBA - A-weighted decibels describe sound pressure on a logarithmic scale referenced to 20  $\mu$ Pa.

Reference: USEPA, Protective Noise Levels. Condensed Version of EPA Levels Document. Publication EPA-550/9-79-100, November 1978.

**Table 2. Acoustic Terms and Definitions**

<b>Term</b>	<b>Definition</b>
Noise	Unwanted sound based on level, character, frequency or pitch, time of day, and sensitivity and perception of the listener.
Sound Pressure Level (L <sub>p</sub> )	Pressure fluctuations in a medium. It is the amplitude of the oscillating sound pressure and is measured in Pascals (Pa), Newtons per square meter, which is a metric equivalent of pounds per square inch. Sound pressure is reported on the decibel scale referenced to 20 micronewtons per square meter, the approximate threshold of human hearing to sound pressure level at a frequency of 1000 Hz.
Sound Power Level (L <sub>w</sub> )	The total acoustic power of a noise source measured in decibels referenced to 10 <sup>-12</sup> watts. The wind turbine noise source levels are reported by the manufacturer in these terms since sound power is independent of environment.
A-Weighted Decibels (dBA)	Environmental sound is typically composed of acoustic energy across a wide spectrum of frequencies. Noise exposure in a community is commonly expressed in terms of the A-weighted sound level and is referred to as dBA in this report. A-weighting approximates the frequency response of the human ear.
Unweighted Decibels (dBL)	Unweighted sound levels are referred to as linear, or dBL. Linear decibels are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise.
Propagation/Attenuation	The decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Other factors that can effect attenuation include air absorption, terrain effects, ground absorption, diffraction around objects and topographical features, trees, and meteorological conditions including wind velocity, temperature, humidity, and non-homogenous atmospheric conditions.
Aerodynamic noise	Aerodynamic noise is produced by the movement of an object through the air. For wind turbines, it is the noise caused by the rotor blades passing through the air. In general, the higher the rotational speed, the louder the sound. Recent improvements in the mechanical design of large WTGs have resulted in significantly reduced mechanical noise. As a result, aerodynamic noise is the dominant source from modern WTGs.
Acoustic Modulation	Technical term describing the variation of sound pressure levels (blade swish) caused by aerodynamic noise as the WTG blade passes through the air and the interaction with the WTG tower structure, i.e., shielding effect or blade/tower aerodynamic interaction.
Broadband	Containing sound energy at all frequencies across the entire audible spectra.
Octave Bands	The audible range of humans spans from 20 to 20,000 Hertz and is typically divided into center frequencies (Hz) ranging from 31 to 8,000 Hz.
Low Frequency Noise (LFN)	The frequency range of 10 Hz to 200 Hz is typically defined as low frequency noise. At sufficiently high levels, LFN can cause vibrations in structures and physiological effects in humans. LFN is generally associated with older wind turbines with downwind rotors. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz.
Directivity	Directivity accounts for the variation in sound intensity with orientation relative to the noise source. The Directivity correction is given as DI.
Wavelength	The distance between peaks of a propagating wave with a well defined frequency. It is related to the frequency through the following equation $\lambda=c/f$ where c is the sound speed and f is the frequency in Hz. It has the dimension of length.

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

## 2.0 NOISE REGULATIONS AND GUIDELINES

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

### 2.1 Environmental Protection Agency Environmental Noise Guidelines

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

**Table 3. Summary of EPA Cause and Effect Noise Levels**

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

The EPA sound level guidelines state that the levels identified are low enough to be protective with an adequate margin of safety. The EPA sound level guidelines do not impose arbitrary federal decisions about the appropriateness of noise environments upon any level of government, nor are they a source of instructions for solving local noise problems, but best viewed as a technical aid for local decision makers who seek to balance scientific information about effects of noise on people, and to reconcile local economic and political realities with scientific information such as cost and technical feasibility. It should also be noted that in any environment, a portion of the general population may be annoyed (and complain) due to the presence of any level of recurring audible sound regardless of the actual or perceived loudness.

## 2.2 Bureau of Land Management Guidance

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

## 2.3 Occupational Safety and Health Administration Noise Safety Standards

The federal government has long recognized the potential hazards caused by noise on industrial and construction projects. OSHA's current noise standard for the construction industry stems from the occupational noise standard originally published in 1969 by the Bureau of Labor Standards under the authority of the Construction Safety Act (40 U.S.C. 333). OSHA adopted the construction noise standard in 1971 (36 FR 7340, 4/27/ 71) and later recodified it as 29 CFR 1926.52. Another section of the construction standard (29 CFR 1926.101) contains a provision requiring employers to provide hearing protection devices when needed. Both sections 1926.52 and 1926.101 apply to employers engaged in construction where high noise levels are possible.

Paragraph (a) of section 1926.52 requires protection against the effects of noise exposure when 8-hour time-weighted average sound levels exceed a permissible exposure limit (PEL) of 90 dBA, measured on the A-scale of a sound level meter set at slow response. The exposure level is raised 5 dB for every halving of exposure duration as shown in Table 4. Furthermore, exposure to impulsive or impact noise should not exceed a 140 dB peak sound pressure level.

Paragraph 29 CFR 1926.52(b) states that when employees are subjected to noise doses exceeding those shown in Table 4, feasible administrative or engineering controls will be identified and implemented to lower employee noise exposure. If controls fail to reduce sound to the PEL, personal protective equipment must be provided and used to reduce noise exposure. In compliance with OSHA, Project contractors will be required to readily provide construction workers with OSHA-approved hearing protection devices (HPD) and to identify high noise areas and activities where hearing protection will be required. Operational sound generated from the Project will not approach OSHA noise exposure limits even in very close proximity to individual WTG locations.

## 2.4 Summary of Acoustic Criteria

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

**Table 4. OSHA Permissible Daily Noise Exposure Limits**

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

- EPA 70 dBA  $L_{eq}$  (24) at publicly accessible project property lines or extents of work areas where extended public exposure is possible;
- EPA 55 dBA  $L_{eq}$  (24) in outdoor areas where limited time is spent;
- 55 dBA  $L_{dn}$  (24) outdoors at all residential receptor locations where extended periods of time are spent outdoors, residential structures and areas in close proximity to the residential structure, e.g., yards. Wind turbines operate intermittently depending on wind conditions at hub height. Assuming the wind turbine is operating as a continuous steady state sound source and is the dominant contributor of environmental sound level at the receiver location, the  $L_{dn}$  is approximately 6.4 dB above the measured  $L_{eq}$ . Consequently, an  $L_{dn}$  of 55 dBA corresponds to a maximum instantaneous  $L_{eq}$  of 48.6 dBA; and
- OSHA regulatory limits for worker exposure and public safety.

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

### 3.0 ACOUSTIC MODELING METHODOLOGY

This section discusses the sound source characteristics, modeling procedures, and input parameters used in the acoustic assessment. Tetra Tech's procedures have been developed based on review of relevant databases and technical reports, Geographic Information System (GIS) data, manufacturers' sound emission data specifications, and extensive experience in the modeling and compliance measurements of operational wind energy facilities. Regulatory and GIS data sets were compiled through in-house libraries and verifiable federal, state, and local agency sources.

#### 3.1 Wind Turbine Sound Characteristics

There are two principal sound sources from an operating WTG: mechanical and aerodynamic sound. Mechanical sound is generated at the gearbox, generator, and cooling fan, and is radiated from the surfaces of the nacelle and machinery enclosure and by openings in the nacelle casing. Mechanical noise does not generally contribute significantly to the overall sound emissions from modern wind turbines. This is due to the improved design of mechanical components and the use of improved noise damping materials within the nacelle to contain and absorb acoustical energy. Aside from upset conditions that may result in abnormal mechanical sound emissions, the dominant sound generating components of utility scale WTGs is aerodynamic.

Aerodynamic sound is related to air flow and the interaction with the tower structure and rotor blades when in motion. Air flow entering the rotor swept area is not completely smooth, consisting of turbulent eddies of air that result in sound due to inflow turbulence. Air flow occurring across the blade produces turbulence at the surface boundary layer, resulting in trailing edge boundary sound. Trailing edge sound is considered the principal aerodynamic noise source component from WTGs. In addition, tip sound is created by vortex shedding as the blade tips pass through the air. Vortices that are shed from the tips of the WTG blades are blown back behind the rotating blades by the wind. When these eddies cut across the

wind support structure, this results in the characteristic amplitude modulated (time-varying) swooshing sound at the rate at which the blade passes the tower. Acoustic modulation is most perceptible in close proximity to the base of the WTG tower.

Wind turbine manufacturers have instituted sound reduction measures to both decrease aerodynamic sound and increase power generation efficiency by reducing trailing edge and tip sound generation. Efforts to reduce aerodynamic sounds have included the use of lower tip speed ratios, lower blade angles of attack, upwind rotor designs, variable speed operation, and the use of specially modified blade trailing edges to reduce turbulence. Early WTG designs had the blades located downwind of the support structure. As the blades passed through the vortex shed behind the support tower, the blade would become excited when it was momentarily deflected, resulting in a pressure pulse. This becomes the mechanism for the generation of excessive acoustic modulation and low frequency sound. The downwind rotor design is rarely used in modern utility-scale WTGs that employ the now-standard upwind rotor design with blades upstream of the tower structure. This change in rotor location has eliminated the issues associated with the downwind design and resulted in a decrease of 10 dB or greater, which corresponds to a perceived decrease in loudness by a factor of two.

A somewhat unique acoustic characteristic of wind energy projects is that the sound generated by each individual wind turbine will increase as the wind speed across the site increases, up to a certain maximum sound level under elevated wind conditions (i.e., greater than approximately 8 meters per second [m/s]). The GE 1.5 MW xle is a variable speed-type wind turbine with sound predominantly determined by the aerodynamic broadband sound of the rotor blades, which is directly related to the circumferential or blade tip speed. WTG sound is negligible when the rotor is at rest, increases as the rotor tip speed increases, and is generally constant once rated power output and full rotational speed is reached. As an offset, as wind speeds increase, the background ambient sound levels likely will continue to increase, resulting in acoustic masking effects.

### 3.2 Acoustic Modeling Software and Calculation Methods

The operational acoustic assessment was performed using the Project design layout as of September 10, 2009 and employing the most recent version of DataKustic GmbH's CadnaA, the computer-aided noise abatement program (v 3.7.123). CadnaA is a comprehensive 3-dimensional acoustic software model that conforms to the Organization for International Standardization (ISO) standard ISO 9613-2 "Attenuation of Sound During Propagation Outdoors." The engineering methods specified in this standard consist of 1/1 octave band algorithms that incorporate the following:

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

The CadnaA acoustic modeling software has been shown to be a highly accurate and effective acoustic modeling tool for wind energy projects when appropriate WTG acoustic modeling techniques and site-

specific terrain and topographical features are considered. Calculation correction factors have been applied to address inherent limitations in the ISO 9613-2 standard to account for specialized application of a large dimension-elevated sound source such as a WTG.

The ISO 9613-2 standard calculates received sound pressure levels for meteorological conditions favorable to propagation, i.e., downwind sound propagation or what might occur typically during a moderate atmospheric ground level inversion. Though a physical impracticality, the ISO 9613-2 standard simulates omnidirectional downwind propagation and worst-case WTG source directivity factors. For receptors located between discrete WTG locations or WTG groupings, the acoustic model will result in over-predicted received sound level results. In addition, the acoustic modeling algorithms essentially assume laminar atmospheric conditions, in which neighboring layers of air do not mix but flow at different velocities. This conservative assumption does not take into consideration turbulent eddies that form when winds change speed or direction, which can interfere with the sound wave propagation path and increase attenuation effects. Conversely, there may be anomalous meteorological conditions from time to time that will aid in the long range propagation of sound, potentially causing Project sound levels to increase, specifically at points of reception located further away from Project WTGs.

Topographical information was imported into the acoustic model using the official United States Geological Survey (USGS) digital elevation dataset to accurately represent terrain in three dimensions. Terrain conditions, vegetation type, ground cover, and the density and height of foliage can also influence the absorption that takes place when sound waves travel over land. The ISO 9613-2 standard accounts for ground absorption rates by assigning a numerical coefficient of 0 for acoustically hard, reflective surfaces and 1 for absorptive surfaces and soft ground. If the ground is hard-packed dirt, typically found in industrial complexes, pavement, or for sound traveling over bodies of water, the absorption coefficient is defined as  $G=0$  to account for reduced sound attenuation. In contrast, ground covered in snow (common in this particular area during the winter season), vegetation, including suburban lawns, livestock and agricultural fields (both fallow with bare soil and planted with crops), will be acoustically absorptive and aid in sound attenuation, i.e.,  $G=1.0$ . For the acoustic modeling analysis, a conservative ground absorption rate was selected, accounting for a semi-reflective ground surface. This ground absorption coefficient was further reduced for receiver locations in close proximity to WTGs to account for decreased ground attenuation effects associated with an elevated sound source relative to receiver height. Additional sound attenuation through foliage and diffraction around and over existing anthropogenic structures were disregarded for all modeling scenarios. The results are therefore representative of a worst-case defoliate winter time conditions.

For this model, each WTG was modeled as an elevated point source at the position of the hub, an approach which is valid when the distance from the source to receiver is large compared to the dimensions of the source. The equivalent continuous downwind octave band sound pressure level at a receiver location is calculated for each individual WTG source and its image sources on both a broadband and frequency dependent basis from 31 Hz to 8 kHz. Geometrical divergence accounts for spherical spreading in the free field from a point sound source according to the equation below:

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

Where:

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

For idealized point sources, sound levels will attenuate with increased distance from the source in accordance with the “inverse square law” due to geometric divergence that occurs as the sound energy is spread across a sphere of greater dimensions. The classical theory of spherical wave propagation may not be valid at large distances from a sound source when the influences of wind or temperature gradients are present i.e., anomalous meteorological conditions. The presence of anomalous meteorological conditions can cause sound waves to curve downward towards the ground and then reflect upwards towards the gradient, which is then repeated leading to a trapped sound wave. The wave refraction effects due to wind and temperature gradients during downwind conditions result into the convergence of modified cylindrical wave spreading, which has a reduced rate of sound attenuation. Though somewhat infrequent, Project operational sound levels resulting from anomalous meteorological conditions were also considered in the modeling analysis approach to ensure a complete and conservative acoustic assessment.

In addition to geometrical divergence, attenuation factors (A) include topographical features, terrain coverage, and/or other natural or anthropogenic obstacles that can affect sound attenuation and result in acoustical screening. Meteorological factors that can influence sound propagation include (in approximate order of increasing importance) humidity, precipitation, temperature, atmospheric stability, turbulence, wind speed and direction.

The acoustic model assumes that all WTGs are operating continuously and concurrently at the maximum manufacturer-rated sound level at the given operational condition and sound energy is summed using the following equation in accordance with ISO 9613-2:

$$L_{p,A}(DW) = 10 \log \left\{ \sum_{i=1}^n \left[ \sum_{j=1}^9 10^{0.1[L_{pi}(ij) + f(A-wtd)(j)]} \right] \right\}$$

Where:

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

The above equation determines the equivalent continuous A-weighted downwind sound pressure level at a point of reception (i.e., NSA), taking into account the contributing sound pressure levels produced by all Project WTGs. Calculations were completed using an 82-foot (25 meters) by 82-foot grid with a receiver

height of 5 feet (1.5 meters) above grade (the approximate height of ears of a standing person). Calculations were also completed at discrete receptor locations at all NSAs.

### 3.3 Acoustic Modeling Input Parameters

In order to assist project developers and acoustical engineers, wind turbine manufacturers report WTG sound power data at integer wind speeds referenced to a height of 32.8 feet (10 meters) above grade, ranging from cut-in to full rated power. This internationally accepted International Electrotechnical Commission (IEC) standard was developed to ensure consistent and comparable sound emission data of utility-scale wind turbines between manufacturers. These data are inclusive of both mechanical and aerodynamic source components. Wind turbines can be somewhat directional, radiating more sound in some directions than others. The IEC test measurement protocol requires that sound measurements are made for the maximum downwind directional location when reporting apparent sound power levels. Thus, worst-case WTG directivity and sound generating efficiencies are reported in the sound source data and used in the acoustic model calibration.

A summary of sound power data for the selected GE 1.5 MW xle WTG correlated by wind speed at a height of 32.8 feet (10 meters) above grade are presented in Table 5. Source data were modeled at the rotor hub height of 262.4 feet (80 meters). The GE 1.5 xle specification reports a confidence interval of K=2 dB to account for the manufacturer's warranty clause, which was incorporated into the acoustic model to ensure a conservative acoustic modeling assessment.

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

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

A summary of sound power data for the GE 1.5 xle by octave band center frequency is presented in Table 6.

**Table 6. GE 1.5 xle Sound Power Level by Octave Band Center Frequency**

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

#### 4.0 MODELING RESULTS AND COMPLIANCE DETERMINATION

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

##### 4.1 Acoustic Modeling Results

Acoustic modeling for the final Project layout was completed for WTG cut-in and full rotational operating conditions, thereby describing sound pressure levels over the entire range of future Project operational conditions. The acoustic modeling analysis consisted of calculating received sound levels at receptors in Burleigh County. A list of receptors, unique number identifier, Universal Transverse Mercator (UTM) coordinates, and received sound levels are provided in Table 7.

Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures 2 through 4. Figure 2 shows broadband (dBA) operational sound levels under low-level wind speeds sufficient for WTGs to operate at initial cut-in rotational speeds. Figures 3 and 4 show broadband (dBA) operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds for moderate downwind propagation and under worst-case anomalous meteorological conditions, respectively. The acoustic modeling was completed for all WTGs operating concurrently. The resultant sound contour plots are independent of the existing acoustic environment, i.e., the plots represent Project-generated sound levels only.

**Table 7. Summary of WTG Acoustic Model Output at Receptors (dBA)**

Residence ID	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
	Easting	Northing				
2012	367496	5219030	27.8	35.8	38.5	38.5
2020	369311	5219083	32.6	40.6	42.0	42.3
2025	370442	5218318	37.8	45.8	46.3	46.8
2026	370430	5218306	37.8	45.8	46.3	46.8
2027*	369737	5218420	42.4	50.4	50.6	50.7
2028	371097	5217187	34.6	42.6	43.8	43.9
2030	374515	5216892	27.6	35.6	38.5	38.5
2047	370195	5216577	34.3	42.3	43.6	43.6
2045	370219	5216534	34.0	42.0	43.4	43.4
2050	368883	5216631	38.2	46.2	46.6	46.6
2057	367253	5215913	27.1	35.1	38.0	38.0
2065	373513	5211697	35.6	43.6	44.6	44.6
2066	365766	5216977	26.4	34.4	36.8	36.8
60002	375122	5214148	28.3	36.3	39.4	39.4
60005*	372824	5212708	42.6	50.6	50.8	50.8
60010	372903	5213255	37.3	45.3	46.1	46.1
60012	371876	5212785	34.0	42.0	43.6	43.6
60016	372129	5214610	36.0	44.0	44.9	44.9
60018	371953	5212277	34.0	42.0	43.6	43.6
60019	371956	5212378	33.9	41.9	43.5	43.5
60020	372243	5211201	32.6	40.6	42.5	42.5
60024	372252	5209103	26.7	34.7	37.4	37.4

Residence ID	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
	Easting	Northing				
60027	373812	5209326	27.0	35.0	37.9	37.9
60028	373971	5209320	26.9	34.9	37.9	37.9
60034	374260	5209324	27.3	35.3	38.3	38.3
60040*	375079	5209360	28.4	36.4	38.6	38.6
60043	375335	5209337	28.7	36.7	38.9	38.9
60044	375770	5209460	29.4	37.4	39.2	39.2
60048	376397	5210430	32.0	40.0	40.9	40.9
60052	376671	5210591	29.3	37.3	39.1	39.1
60054	376515	5211062	30.3	38.3	39.9	39.9
60057	376211	5210921	33.3	41.3	41.9	41.9
60061	375965	5210874	36.1	44.1	44.4	44.4
60065	375966	5211041	35.4	43.4	43.8	43.8
60066	375965	5211018	35.4	43.4	43.7	43.7
60070	376164	5212140	31.2	39.2	40.6	40.6
60075	376245	5212627	28.3	36.3	38.8	38.8
60080	369491	5212432	32.4	40.4	41.8	41.8
60082	368755	5212024	28.9	36.9	39.2	39.2
60085	368637	5211618	28.3	36.3	38.8	38.8
60090	368671	5211608	28.5	36.5	38.9	38.9
60092	368562	5211213	27.5	35.5	38.0	38.0
2036	372317	5216001	32.5	40.5	42.5	42.5
2041	371025	5215602	31.1	39.1	41.4	41.5
2053	367280	5216355	29.7	37.7	39.6	39.6
2060	368847	5215446	30.5	38.5	40.6	40.6
<b>Number of Potential Exceedances of EPA Noise Guideline at NSAs</b>			<b>None</b>	<b>2</b>	<b>2</b>	<b>2</b>

\* Residence listed as 'Abandoned' in Farmstead Location Report dated 8-18-2009.

The manufacturers' guaranteed maximum sound power level of 106 dBA and worst-case directivity effects were incorporated into the modeling analysis to ensure conservative results. Reported sound pressure levels are representative of receptors located downwind of the WTGs; lower sound levels are expected in other directions dependent on wind velocities, speed, direction, and gustiness. The acoustic modeling results were compared to the broadband (dBA) guideline criteria as described in Section 2.0 of this report, specifically the EPA broadband guideline of 55 dBA  $L_{dn}$  (equivalent to a  $L_{eq (1-hour)}$  of 48.6 dBA assuming continuous 24-hour operation), which was used as an internal Project design goal.

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

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

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

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

#### 4.2 Compliance Determination

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

**Table 8. Summary of Modeling Results and Comparison to EPA Guidelines**

Operating Scenario	Receptor IDs of Potential Exceedances of EPA Guideline (NSAs)
Cut-in Operation	None
Maximum Rotational – Moderate Downwind Meteorological Conditions	2
Maximum Rotational – Anomalous Downwind Meteorological Conditions	2

As shown in Table 8 and the acoustic model contour isopleths, results showed potential exceedances of the 55 dBA  $L_{dn}$  EPA noise guideline at two NSAs. These exceedance conditions occur at Residence IDs 2027 and 60005, which have been categorized in the Farmstead Report as abandoned or not currently used for residential purposes; therefore, these exceedances can be considered insignificant. Results demonstrate that the Project has been designed to operate in full compliance with EPA noise guidelines at all remaining NSAs.

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

In conclusion, the Project has been designed to operate in compliance with guideline limits under all future WTG operational conditions. Acoustic modeling results inclusive of a number of conservative assumptions demonstrate compliance with the EPA guideline limits. Sound from the Project when audible will likely not be deemed excessive or unusually loud at the proposed setback distance and will be consistent with sound generated at similar wind energy projects successfully sited throughout the state of North Dakota employing similar noise criteria limits.

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

FIGURE 2  
RECEIVED SOUND LEVELS  
WTGS AT CUT-IN

OCTOBER 2009



TETRA TECH, INC.

**Legend**

- Turbine Location (9-9-2009)
- Substation
- Receptor**
- Occupied
- Unoccupied
- Isopleth Ranges (dBA)**
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



0 0.5 1 Miles

**REFERENCE MAP**



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

FIGURE 3  
 RECEIVED SOUND LEVELS  
 WTGS AT MAXIMUM ROTATION

OCTOBER 2009



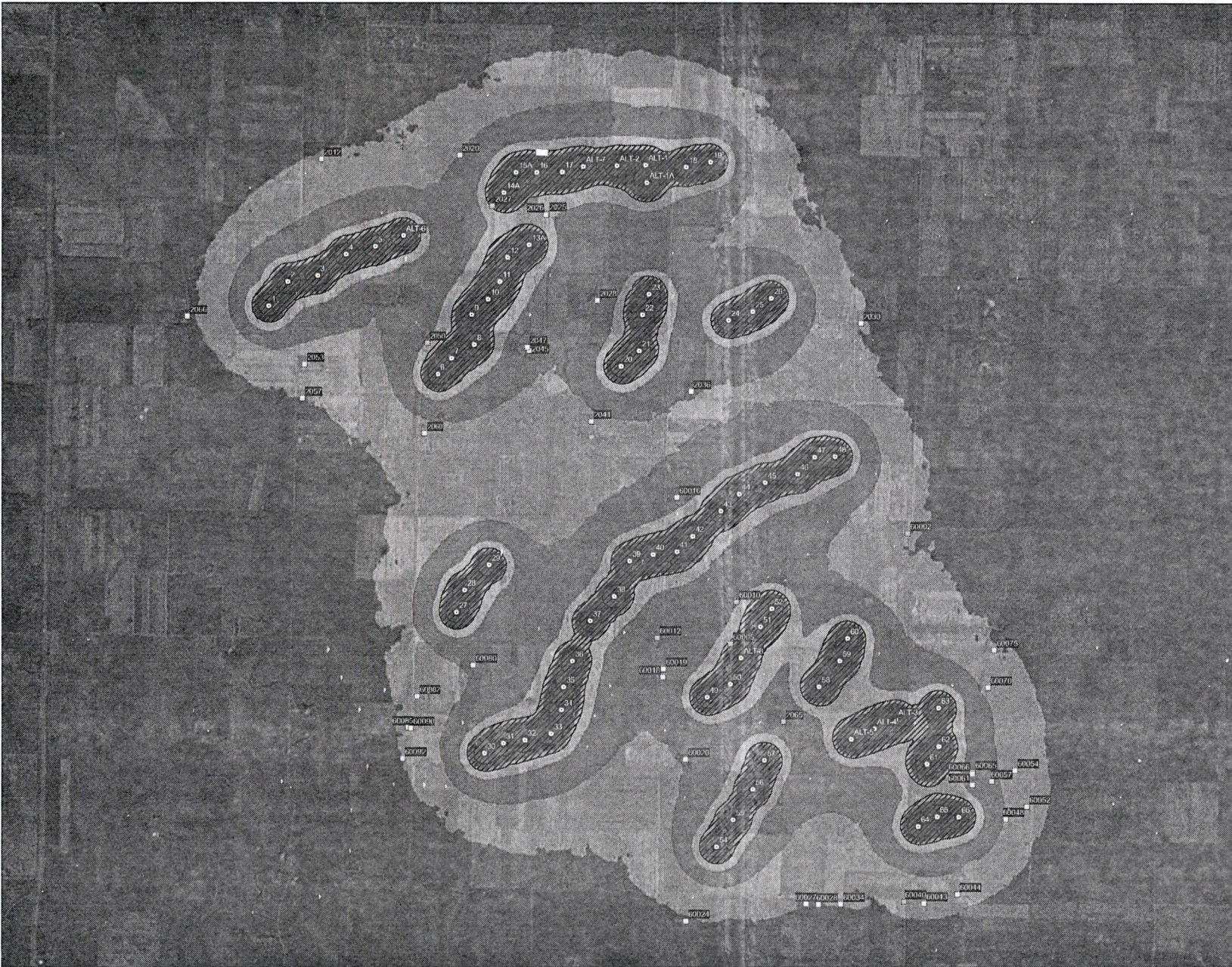
**Legend**

- Turbine Location (9-9-2009)
- Substation
- Receptor**
- Occupied
- Unoccupied
- Isopleth Ranges (dBA)**
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



0 0.5 1 Miles

**REFERENCE MAP**



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

FIGURE 4  
 RECEIVED SOUND LEVELS  
 WTGS AT MAXIMUM ROTATION  
 ANOMALOUS METEOROLOGICAL CONDITIONS

OCTOBER 2009



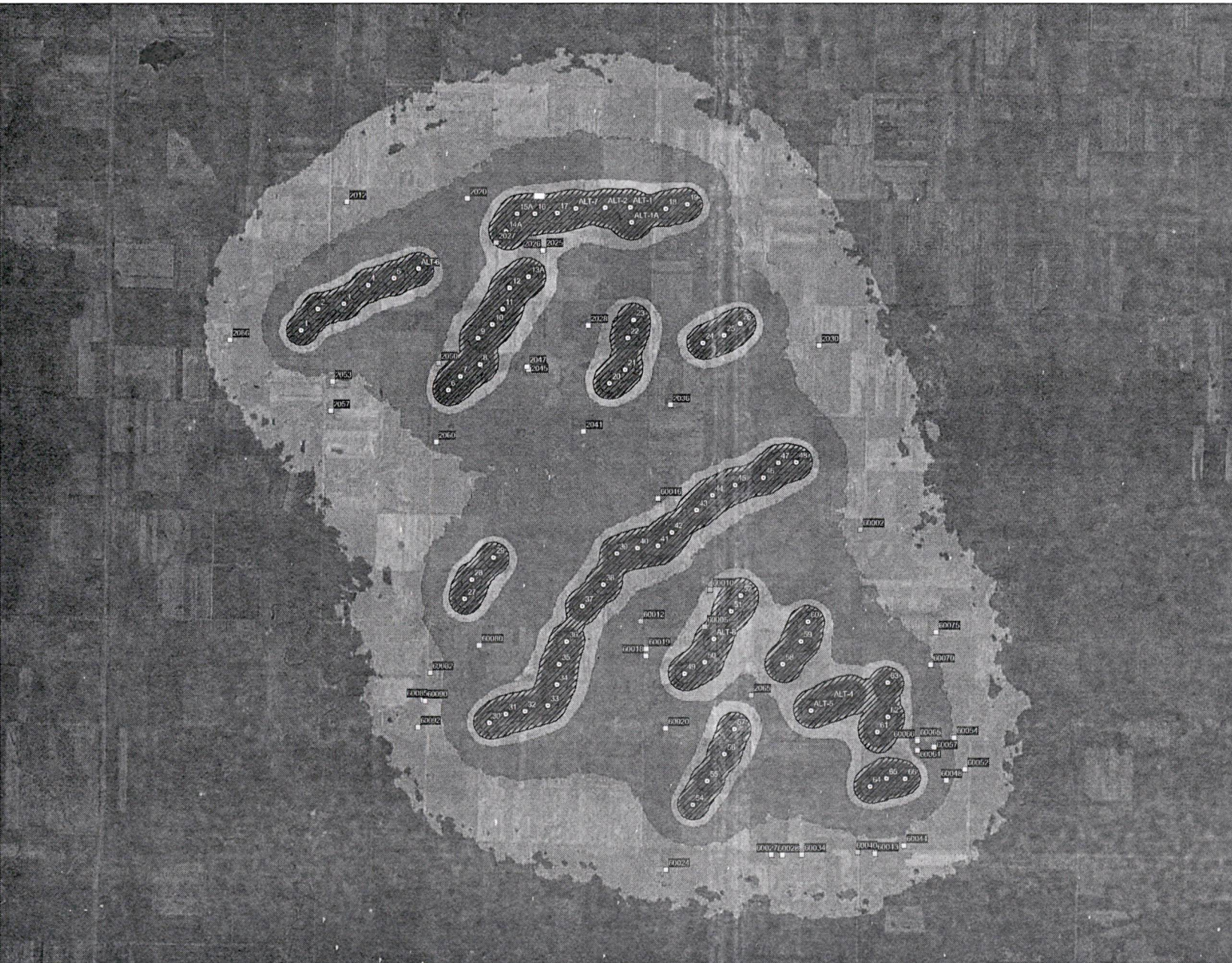
TETRA TECH, INC.

**Legend**

- Turbine Location (9-9-2009)
- Substation
- Receptor**
- Occupied
- Unoccupied
- Isopleth Ranges (dBA)**
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



**REFERENCE MAP**



## 5.0 OTHER CONSIDERATIONS

### 5.1 Electrical Substation

As a part of a thorough acoustic assessment completed for the Baldwin Wind Energy Center, not only was sound generated by Project WTGs reviewed, but also from the on-site electrical substation. The substation is an integral part of the Project as it collects and increases the voltage produced by the WTGs to the higher voltage needed for transmission by the local grid system.

Substations have switching, protection and control equipment and one or more transformers, which generate the sound generally described as a low humming. There are three main sound sources associated with a transformer: core noise, load noise and noise generated by the operation of the cooling equipment. The core is the principal noise source, dominating in the intermediate frequency range between 100 and 600 Hz. The relative magnitudes of the noise at these different frequency components is dependent on the design of the transformer (i.e., core material, core geometry) and does not vary significantly with the load on the transformer, meaning that the noise generated is largely independent of the transformer load. The load noise is primarily caused by the load current in the transformer's conducting coils (or windings) and consequently the main frequency of this sound is twice the supply frequency; 100 Hz for 50 Hz transformers and 120 Hz for 60 Hz transformers. The cooling equipment (fans and pumps) noise typically dominates the very low and very high frequency ends of the sound spectrum; however, cooling equipment sound is comparatively lower and considered secondary to the sound produced by the core and load.

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

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

The Baldwin electrical substation will be located in the northern section of the Project area, approximately 800 meters (2,625 feet) north of the closest receptors (IDs 2025 and 2026 as shown in Figure 1). To assess potential impacts of electrical substation operation on nearby residential receptors, a screening level acoustic analysis was conducted using the CadnaA model incorporating site-specific topographic and terrain data and modeled cumulatively with WTG operational scenarios. Transformer sound source levels were estimated for a NEMA sound rating of 82 dBA and are presented in Table 9. The octave band center frequencies were calculated linearly from standard engineering technical guidelines.

**Table 9. Transformer Sound Power Level (NEMA 82 dBA)**

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

Sound contour plots displaying operational broadband (dBA) sound levels in color-coded isopleths are provided in Figure 5 for maximum electrical output. Cumulative received sound levels resulting from the electrical substation concurrent with worst case WTG operation at all NSAs can be found in Table 7. These results demonstrate feasibility of the Project electrical substation to operate in compliance with the EPA guidelines at the proposed siting location.

## 5.2 Construction Noise

The development of the Baldwin Wind Energy Center will involve construction to establish access roads, excavate and form WTG foundations, works associated with preparing the site for crane-lifting, and actual WTG assembly and commissioning. Work on large-scale wind projects such as Burleigh County is generally divided into four phases consisting of the following:

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

Work on these construction activities is expected to overlap. It is likely that the wind turbines will be erected in small groupings. Each grouping may undergo testing and commissioning prior to commencement of full commercial operation. Other construction activities include those for the supporting infrastructure such as the substation, maintenance building, and the overhead transmission lines, though no transmission line construction is anticipated for Project.

The construction of the Project may cause short-term but unavoidable noise impacts. The sound levels resulting from construction activities vary significantly depending on several factors such as the type and age of equipment, the specific equipment manufacturer and model, the operations being performed, and the overall condition of the equipment and exhaust system mufflers. The list of construction equipment that may be used on the Project and estimates of near and far sound source levels are presented in Table 10.

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

FIGURE 5  
RECEIVED SOUND LEVELS  
ELECTRICAL SUBSTATION  
ANOMALOUS METEOROLOGICAL CONDITIONS

OCTOBER 2009



TETRA TECH, INC.

**Legend**

○ Turbine Location (9-9-2009)

□ Substation

**Receptor**

□ Occupied

■ Unoccupied

**Isopleth Ranges (dBA)**

□ 35 - 40

■ 40 - 45

■ 45 - 50

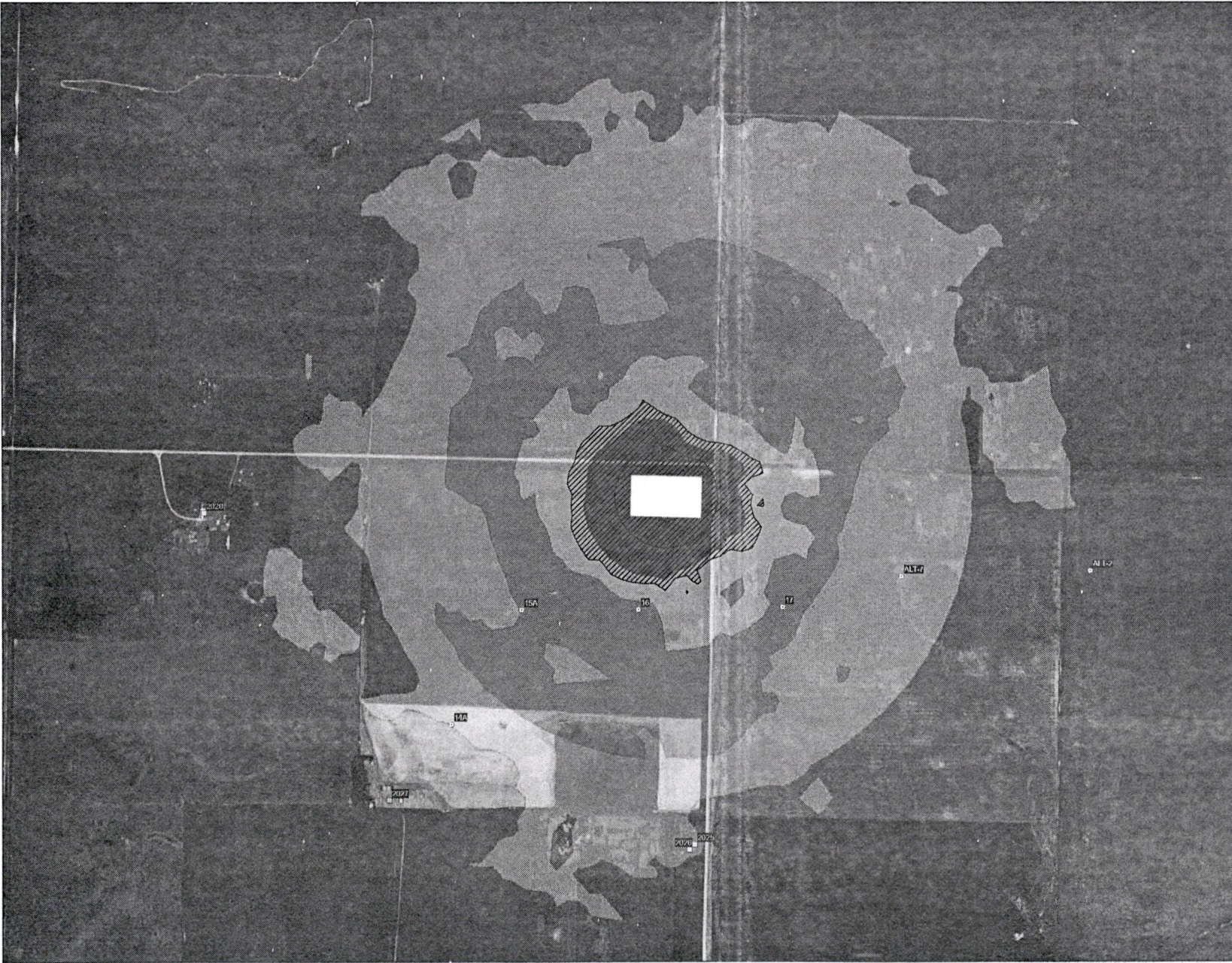
■ >50

▨ Isopleth Range Exceeding  
EPA Guideline (>48.6 dBA)



0 0.125 0.25 Miles

**REFERENCE MAP**



Sounds generated by construction activities are typically exempt from state and local noise oversight provided that they occur within weekday, daytime periods as may be specified under local zoning or legal codes. All reasonable efforts will be made to minimize the impact of noise resulting from construction activities. As the design of the Project progresses and construction scheduling is finalized, the construction engineer should notify the community via public notice or alternative method of expected Project construction commencement and duration to help minimize the effects of construction noise. In addition, the location of stationary equipment and the siting of construction laydown areas should be carefully selected to be as far removed from existing NSAs as is practical. Candidate construction noise mitigation measures include scheduling louder construction activities during daytime hours and treating internal combustion engines with appropriate sized muffler systems to minimize noise excessive emissions. If blasting for foundation or other noisy activities are required during the construction period, nearby residents shall be notified in advance.

**Table 10. Estimated  $L_{max}$  Sound Pressure Levels from Construction Equipment**

Equipment*	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2000 feet (dBA)
Crane	85	53
Forklift	80	48
Backhoe	80	48
Grader	85	53
Man basket	85	53
Dozer	83 - 88	51 - 56
Loader	83 - 88	51 - 56
Scissor Lift	85	53
Truck	84	52
Welder	73	41
Compressor	80	48
Concrete Pump	77	45

Data compiled in part from the following sources:

Federal Highway Administration, "Roadway Construction Noise Model User's Guide," Report FHWA-HEP-05-054 / DOT-VNTSC-FHWA-05-01, January 2006.

Power Plant Construction Noise Guide, Bolt Beranek and Newman, Inc. 1977.

Federal Highway Administration, "Procedures for Abatement of Highway Traffic Noise and Construction Noise." Code of Federal Regulations, Title 23, Part 772, 1992.

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

Federal laws prohibit state and local governments from regulating off-site sound levels generated by trucks and automobiles operating on a private site or public roadways. This federal regulatory preemption is specified in the Federal Noise Control Act of 1972 and in the Surface Transportation Assistance Act of 1982, both of which prohibit states and local authorities from regulating the noise emitted by trucks

engaged in interstate commerce, i.e., truck deliveries. A federal OSHA preemption also prohibits local and state governments from regulating safety signals on trucks and construction equipment.

## 6.0 TECHNICAL REFERENCES

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- Technical Documentation: Wind Turbine Generator Systems GE 1.5 xle – 50Hz and 60Hz, Noise emission characteristics Normal operation according to IEC, GE Wind Energy GmbH, 2005.
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- Wagner, S., Bareib, R. and Guidati, G. 1996. Wind Turbine Noise, Springer, Berlin.

FINAL REPORT AND ANY INFORMATION  
REMOVED SHOULD BE CONSIDERED AS:

**NON-INTERNET PUBLIC INFORMATION**



September 22, 2014

Mr. Darrell Nitschke  
North Dakota Public Service Commission  
600 E. Blvd. Dept. 408  
Bismarck, ND 58505-0480



**SUBJECT: Tree and Shrub Survival Report, 3 of 3 for Six Projects**

Dear Mr. Nitschke,

On behalf of NextEra Energy Resources, Inc., Tetra Tech is pleased to provide the third of three annual tree and shrub survival reports for the following six projects:

- Ashtabula (Case No. PU-08-32)
- Ashtabula II (Case No. PU-09-221)
- Ashtabula III (Case No. PU-10-147)
- Baldwin (Case No. PU-09-668)
- Langdon (Case No. PU-07-26)
- Oliver II (Case No. PU-06-312)

All six projects have met the 75% survival requirement. Please add these reports to the respective case files. An electronic copy of the six reports was submitted to [ndpsc@nd.gov](mailto:ndpsc@nd.gov).

Please feel free to contact me at (512) 338-2855 or [Anne-Marie.Griger@TetraTech.com](mailto:Anne-Marie.Griger@TetraTech.com) if you have any questions.

Sincerely,

**TETRA TECH, INC.**

**Anne-Marie Griger, AICP**  
Deputy Project Manager/Environmental Planner

- 112 PU-10-147 Filed: 9/22/2014 Pages: 22  
Tree and shrub survival report
- 132 PU-09-668 Filed: 9/22/2014 Pages: 22  
Tree and shrub survival report
- 37 PU-09-221 Filed: 9/22/2014 Pages: 22  
Tree and shrub survival report
- 329 PU-08-32 Filed: 9/22/2014 Pages: 22  
Tree and shrub survival report
- 184 PU-07-26 Filed: 9/22/2014 Pages: 22  
Tree and shrub survival report
- 100 PU-06-312 Filed: 9/22/2014 Pages: 22  
Tree and shrub survival report



Engineers • Scientists  
Business Professionals

Wenck File #2602-05

SEPTEMBER 2014



## Tree & Shrub Survival Report

*Baldwin Wind Energy Center  
Annual Report 3 of 3*

Prepared for:

**NEXTERA ENERGY RESOURCES  
BALDWIN WIND, LLC**

ND PSC Case Number: PU-09-668 (Wind Farm)

Prepared by:

**WENCK ASSOCIATES, INC.**

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On Behalf of:

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Mandan, ND  
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Minot, ND  
701-858-9999

Cheyenne, WY  
307-634-7848

Buffalo, WY  
307-684-7953

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# 1.0 Introduction & Background

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The Baldwin Wind Energy Center (Project) was completed in 2010 in Burleigh County, North Dakota, within portions of Township 143N, Range 79W, Township 142N, Range 80W, and Township 142N, Range 79W. The Project is operated by Baldwin Wind, LLC (Baldwin Wind), a subsidiary of NextEra Energy Resources, LLC, and comprises a 102-megawatt (MW) wind generation plant. The Project is under the jurisdiction of the North Dakota Public Service Commission (PSC). Its construction required the removal of trees and shrubs within Project rights-of-way.

A Tree and Shrub Replacement Plan for this Project, which discussed the approach that Baldwin Wind would follow, was submitted to the PSC and approved by the agency in July 2011. The plan was implemented in June 2011 prior to the PSC's approval in order to ensure that the trees were planted early enough in the season. This survival report documents the number of trees and shrubs surviving in the summer of 2014. This is the third and final year of three years of survival monitoring.

Baldwin Wind retained Tetra Tech, Inc. (Tetra Tech) and Wenck Associates, Inc. (Wenck) to assist in field checks and documentation of tree and shrub survival.

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## **2.0 Survival Report**

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### **2.1 SURVIVAL REQUIREMENTS**

The total number of trees and shrubs removed for the Project in 2010 was 206; the total number to be replaced was 412 based on the 2:1 replacement requirement. At the end of three years, 75% of these planted trees, or 309, will be required to have survived to meet the obligations of the PSC.

### **2.2 PLANTING REVIEW**

Six landowners within the Project area requested replacement on their property. The plantings for all landowners were installed early June 2011 in Sections 17 and 32, Township 143N, Range 79W and Sections 18, 22, 28, and 32, Township 142N, Range 79W by Prairie View Landscaping and Nursery. A total of 533 trees were planted, which exceeds the required 2:1 ratio.

A replacement planting was installed in July 2013 by Prairie View Landscaping and Nursery at the John Spitzer residence of 40 additional trees: 10 cottonwoods and 30 willows.

A replacement planting was installed in May 2014 by Plant Perfect at the Gene Hilken residence of 30 Colorado blue spruce.

### **2.3 2014 SURVIVAL**

The plantings of each of the landowners were visited in July 2014. Trees or shrubs which had any portion of living plant material were considered alive. Of the 533 trees originally planted for this Project and the 70 from additional plantings, 361 were alive in the summer of 2014 (Table 2-1). The current survival rate is above the required 75% at 88%.

**Table 2-1: Survival Counts**

Landowner	Number of Trees/Shrubs Planted	2012 Count	2013 Count	2014 Count	Comments
John Spitzer	108	54	36 (32 spruce, 4 deciduous)	65 (32 spruce, 33 deciduous)	The larger-sized spruce continue to do well with no loss from 2013 to 2014. The new cottonwood and willow saplings did well overall in the new area that they were planted to the northeast of the farmyard.
Jeffrey & Robyn Spitzer	50	6	48 (43 willows, 5 cottonwoods/ poplars)	37 (36 willows, 1 cottonwood)	Reason for high mortality in 2012 not clear. After 2012 field visit, Prairie View replanted trees (50 willows and 20 poplars). In 2013, mainly willows were alive at base with few leaves, but they did not show vigorous growth or health. In 2014 trees showed growth and appeared healthy.
Robert Anderson	200	184	180	98	The area of the planting is now covered in 3 ft of grass making it difficult to locate the trees which could account for the dramatic decrease in numbers reported.
Gene & Vivian Hilken	75*	63	29	87 (77 spruce, 4 juniper, 6 cedar)	*Only 58 trees had been planted in 2011, not the reported 75. The count of 63 in 2012 had included some trees that were not part of the wind farm planting. High mortality of spruce on margin of low, wet area. Replacement planting took place in May 2014 which accounts for the marked increase.
Nathan Speten	50	49	48	47	Planting was in excellent condition.
Theodore Adamyk	50**	32	30	27 (22 pine, 5 oak)	**During 2013 visit, could only locate 46 trees in original planting. During the 2014 visit the planting was covered in 3 ft of grass which made locating the trees difficult.
<b>TOTAL</b>	<b>533</b>	<b>388</b>	<b>371</b>	<b>361</b>	<b>This count exceeds the required 309.</b>