Deuel Harvest Wind Project

Invenergy

Deuel County, South Dakota

Obstruction Evaluation & Airspace Analysis

March 26, 2019

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Summary

Capitol Airspace conducted an obstruction evaluation and airspace analysis for the Deuel Harvest wind project in Deuel County, South Dakota. The purpose for this analysis was to identify obstacle clearance surfaces established by the Federal Aviation Administration (FAA) that could limit the placement of 499 foot above ground level (AGL) wind turbines. At the time of this analysis, 124 individual wind turbine locations had been identified (black points, ***Figure 1***). This analysis assessed height constraints overlying each location as well as an approximately 76 square mile project boundary (red outline, ***Figure 1***) and 14 square mile buffer area (black outline, ***Figure 1***) around Homan Field Airport (00SD) to aid in identifying optimal wind turbine locations.

14 CFR Part 77.9 requires that that all structures exceeding 200 feet AGL be submitted to the FAA so that an aeronautical study can be conducted. The FAA's objective in conducting aeronautical studies is to ensure that proposed structures do not have an effect on the safety of air navigation and the efficient utilization of navigable airspace by aircraft. The end result of an aeronautical study is the issuance of a determination of 'hazard' or 'no hazard' that can be used by the proponent to obtain necessary local construction permits. It should be noted that the FAA has no control over land use in the United States and cannot enforce the findings of its studies.

Height constraints overlying the Deuel Harvest wind project range from 2,300 to 2,400 feet above mean sea level (AMSL) and are associated with instrument approach procedures and a low altitude enroute airway. Proposed structures that exceed these surfaces would require an increase to instrument approach procedures minimum altitudes and enroute airway minimum obstruction clearance altitudes. If the FAA determines that these impacts would affect as few as one operation per week, it could result in determinations of hazard.

United States Geological Survey (USGS) elevation data indicates that these surfaces could limit 499 foot AGL wind turbines in northwestern and southwestern sections of the project boundary. However, none of the proposed wind turbines are located in these areas.

This analysis did not consider electromagnetic interference on FAA communication or surveillance radar systems.

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Methodology

Capitol Airspace studied the proposed project based upon location information provided by Invenergy. Using this information, Capitol Airspace generated graphical overlays to determine proximity to airports (***Figure 1***), published instrument procedures, enroute airways, FAA minimum vectoring altitude and minimum instrument flight rules (IFR) altitude charts, as well as military airspace and training routes.

Capitol Airspace evaluated all 14 CFR Part 77 imaginary surfaces, published instrument approach and departure procedures, visual flight rules operations, FAA minimum vectoring altitudes, minimum IFR altitudes, and enroute operations. All formulas, headings, altitudes, bearings and coordinates used during this study were derived from the following documents and data sources:

- 14 CFR Part 77 Safe, Efficient Use, and Preservation of the Navigable Airspace
- FAA Order 7400.2M Procedures for Handling Airspace Matters
- FAA Order 8260.3D United States Standard for Terminal Instrument Procedures
- FAA Order 8260.58A United States Standard for Performance Based Navigational (PBN) Instrument Procedure Design
- Technical Operations Evaluation Desk Guide for Obstruction Evaluation/Airport Airspace Analysis (1.3.0)
- United States Government Flight Information Publication, US Terminal Procedures
- National Airspace System Resource Aeronautical Data

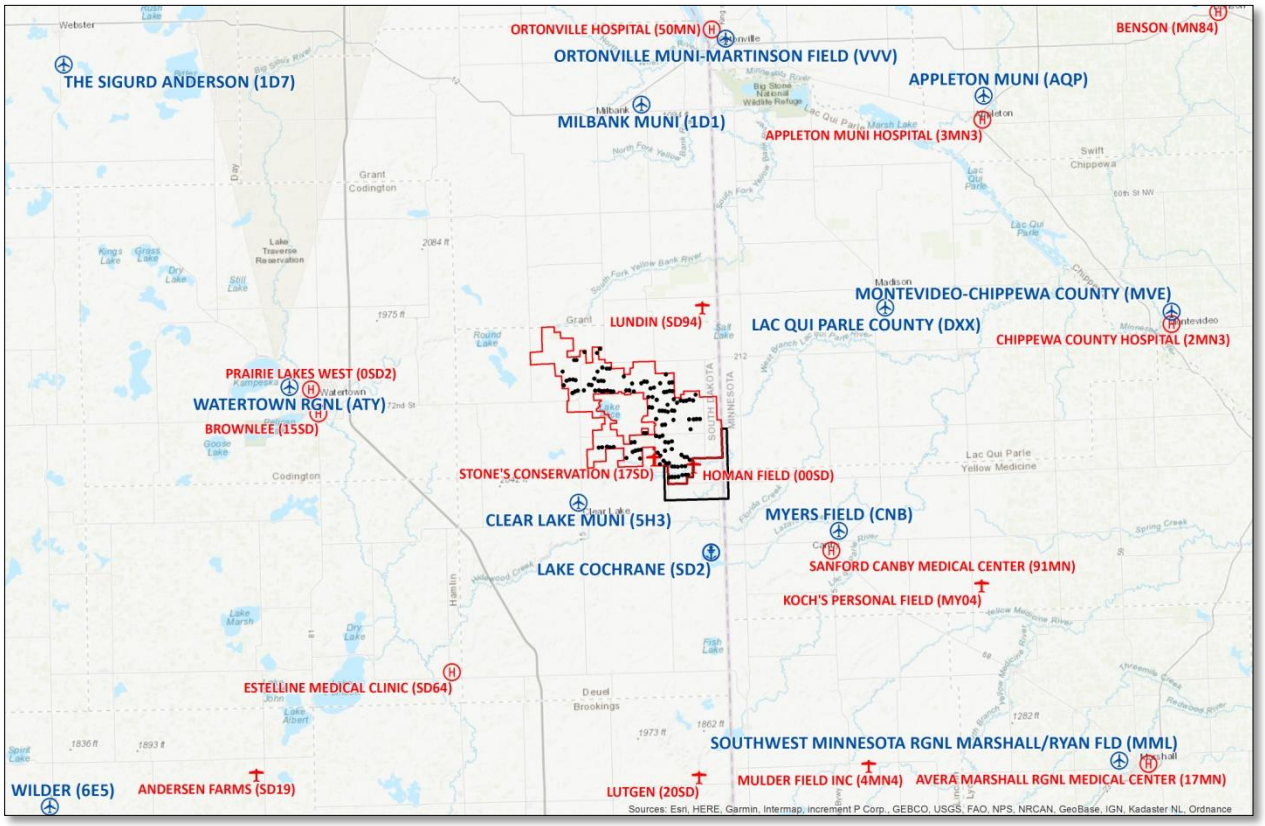

Figure 1: Public-use (blue) and private-use (red) airports and heliports in proximity to the Deuel Harvest wind project

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Study Findings

14 CFR Part 77 Imaginary Surfaces

The FAA uses level and sloping imaginary surfaces to determine if a proposed structure is an obstruction to air navigation. Structures that are identified as obstructions are then subject to a full aeronautical study and increased scrutiny. However, exceeding a Part 77 imaginary surface does not automatically result in the issuance of a determination of hazard. Proposed structures must have airspace impacts that constitute a substantial adverse effect in order to warrant the issuance of determinations of hazard.

Public-use airport 14 CFR Part 77.17(a)(2) and 77.19/21/23 imaginary surfaces do not overlie the Deuel Harvest wind project (***Figure 2***). However, if the planned wind turbine height is increased so that it exceeds 77.17(a)(1) – a height of 499 feet AGL at the site of the object – all wind turbines will be identified as obstructions regardless of location.

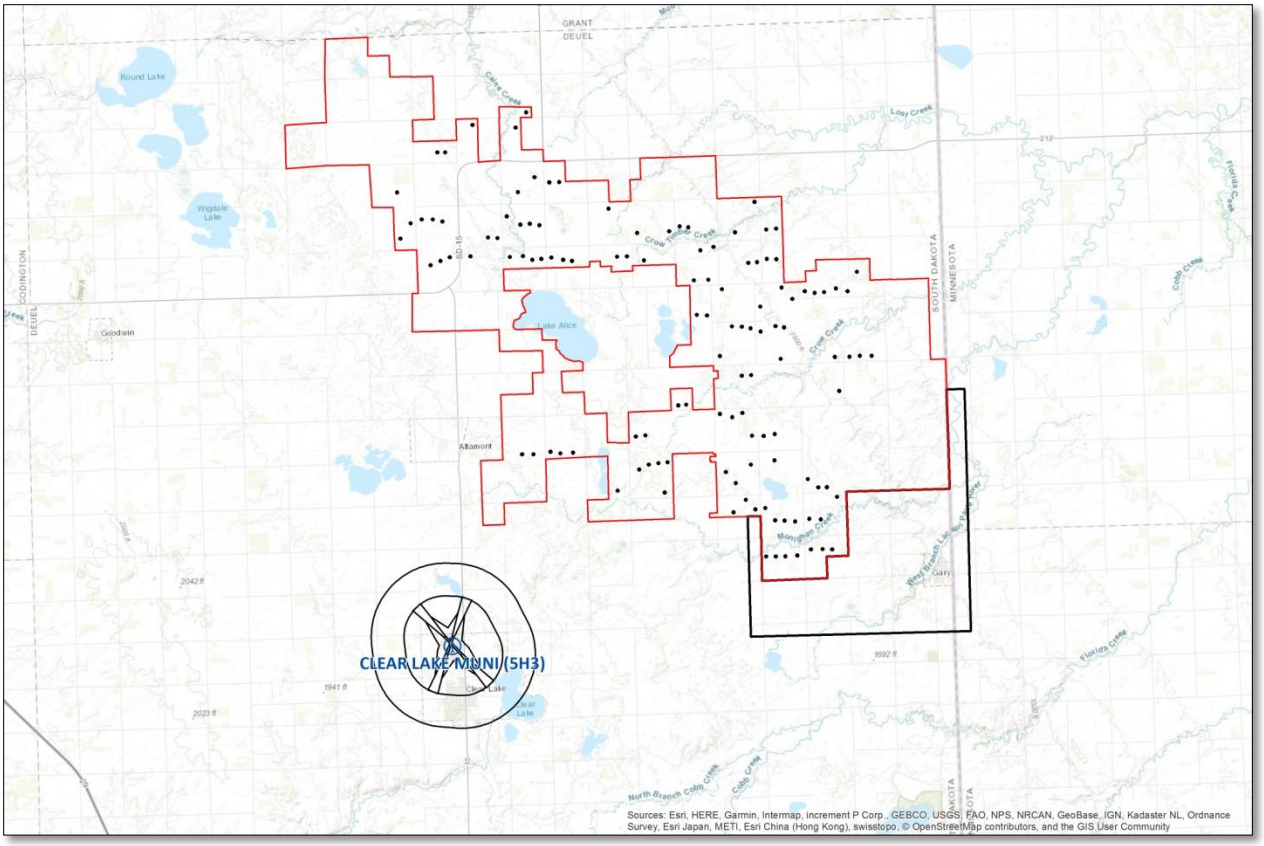

Figure 2: Clear Lake Municipal Airport (5H3) 77.19 (black) imaginary surfaces and the Deuel Harvest wind project

Visual Flight Rules (VFR) Traffic Pattern Airspace

VFR traffic pattern airspace is used by pilots operating during visual meteorological conditions. The airspace dimensions are based upon the category of aircraft which, in turn, is based upon the approach speed of the aircraft. 14 CFR Part 77.17(a)(2) and 77.19 (as applied to a *visual* runway) imaginary surfaces establish the obstacle clearance surface heights within VFR traffic pattern airspace.

Clear Lake Municipal Airport (5H3) VFR traffic pattern airspace overlies the Deuel Harvest wind project. While the FAA may initially protect for up to Category D VFR traffic pattern airspace (shaded gray, ***Figure 3***), not all airports are likely to support a significant volume of Category D operations. As a result, the FAA will apply VFR traffic pattern airspace considering the airport's likely operations and physical runway characteristics (***Table 1***).

The likely Clear Lake Municipal Airport VFR traffic pattern airspace application (solid outline, ***Figure 3***) does not overlie the Deuel Harvest wind project. Therefore, VFR traffic pattern airspace should not limit 499 foot AGL wind turbines within the defined study area.

	Dimensions (Feet)	Weight Bearing Capacity (Pounds)	Surface Type	Potential VFR Traffic Pattern Category	Likely VFR Traffic Pattern Category
Clear Lake Municipal (5H3)					
Runway 02/20	2,130 x 150	NA – Turf	Turf	-	B
Runway 13/31	3,000 x 150	NA – Turf	Turf	-	B

Table 1: Runway physical characteristics and likely VFR traffic pattern application

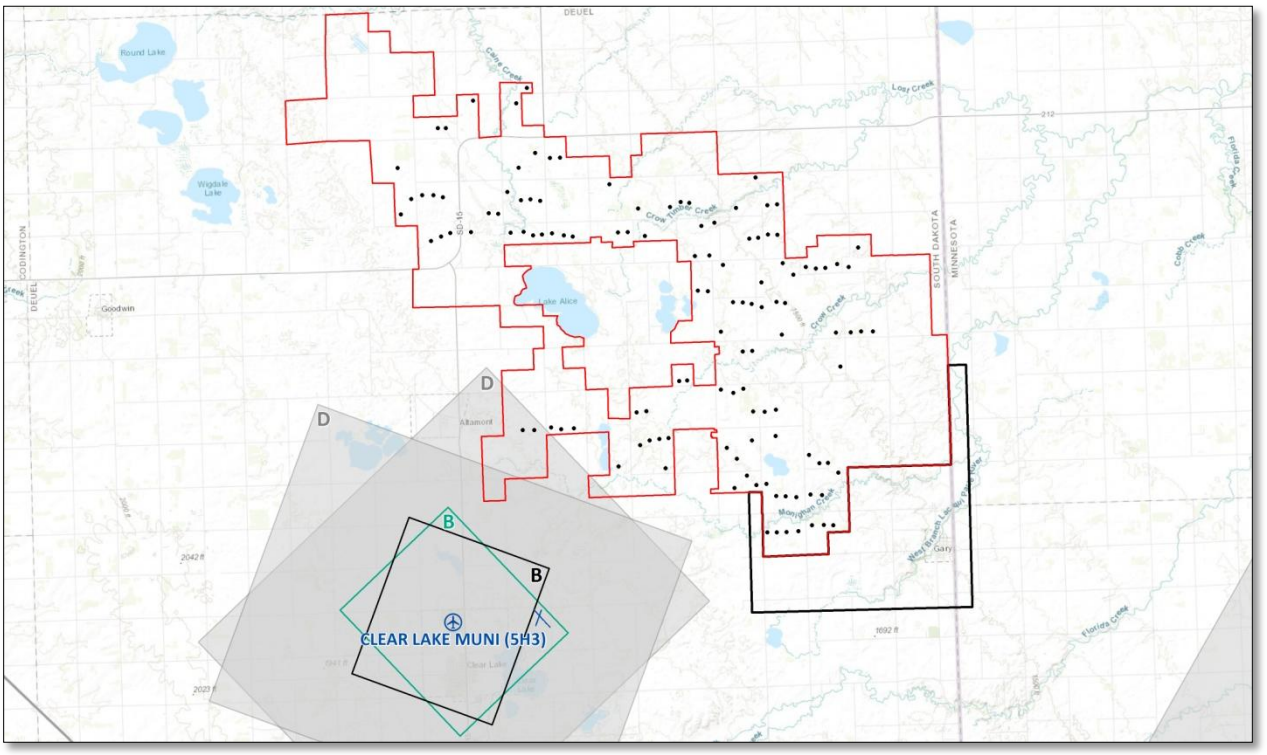

Figure 3: Clear Lake Municipal Airport (5H3) VFR traffic pattern airspace and the Deuel Harvest wind project

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Instrument Departures

In order to ensure that aircraft departing during marginal weather conditions do not fly into terrain or obstacles, the FAA publishes instrument departure procedures that provide obstacle clearance to pilots as they transition between the terminal and enroute environments. These procedures contain specific routing and minimum climb gradients to ensure clearance from terrain and obstacles.

Proposed structures that exceed instrument departure procedure obstacle clearance surfaces would require an increase to instrument departure procedure minimum climb gradients. If the FAA determines that this impact would affect as few as one operation per week, it could be used as the basis for determinations of hazard.

Instrument departure procedure obstacle clearance surfaces (e.g., ***Figure 4***) are in excess of other lower surfaces and should not limit 499 foot AGL wind turbines within the defined study area.

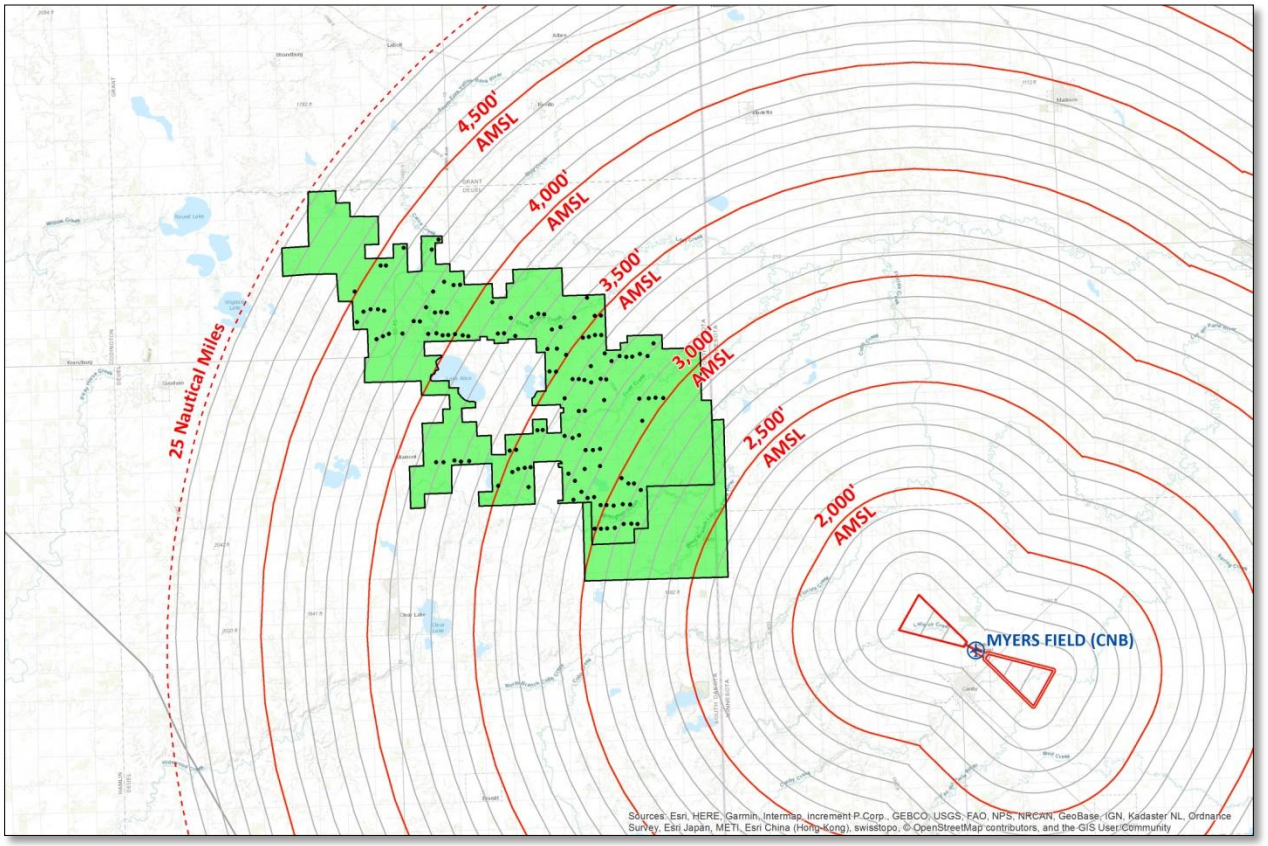

Figure 4: Myers Field (CNB) obstacle departure procedure assessment

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Instrument Approaches

Pilots operating during periods of reduced visibility and low cloud ceilings rely on terrestrial and satellite based navigational aids (NAVAIDS) in order to navigate from one point to another and to locate runways. The FAA publishes instrument approach procedures that provide course guidance to on-board avionics that aid the pilot in locating the runway. Capitol Airspace assessed a total of 14 published instrument approach procedures at five public-use airports in proximity to the Deuel Harvest wind project:

Myers Field (CNB)
RNAV (GPS) Approach to Runway 12
RNAV (GPS) Approach to Runway 30

Lac Qui Parle County (DXX)
RNAV (GPS) Approach to Runway 14
RNAV (GPS) Approach to Runway 32

Ortonville Municipal-Martinson Field (VVV)
RNAV (GPS) Approach to Runway 34
NDB Approach to Runway 34

Milbank Municipal (1D1)
RNAV (GPS) Approach to Runway 31

Watertown Regional (ATY)
ILS or Localizer Approach to Runway 35
RNAV (GPS) Approach to Runway 12
RNAV (GPS) Approach to Runway 17
RNAV (GPS) Approach to Runway 30
RNAV (GPS) Approach to Runway 35
Localizer Backcourse Approach to Runway 17
VOR or TACAN Approach to Runway 17

Proposed wind turbines that exceed instrument approach procedure obstacle clearance surfaces would require an increase to their minimum altitudes. Increases to these altitudes, especially critical *decision altitudes (DA)* and *minimum descent altitudes (MDA)*, can directly impact the efficiency of instrument approach procedures. If the FAA determines that this impact would affect as few as one operation per week, it could be used as the basis for determinations of hazard. [1]

[1] Multiple minimum safe altitudes (MSA) overlie the Deuel Harvest wind project. However, MSAs are for emergency use only and cannot be used as the basis for determinations of hazard in accordance with FAA Order 7400.2M Paragraph 6-3-9(e)(5). Therefore, height constraints associated with MSAs were not considered and are not included in the Composite Map (***Figure 11***).

Myers Field (CNB)

RNAV (GPS) Approach to Runway 12

The intermediate segment minimum altitude is 2,800 feet AMSL. The primary area obstacle clearance surface (bold red outline, ***Figure 5***) is 2,300 feet AMSL and is one of the lowest height constraints overlying the southeastern section of the study area. However, USGS elevation data indicates that this surface should not limit 499 foot AGL wind turbines within the defined study area.

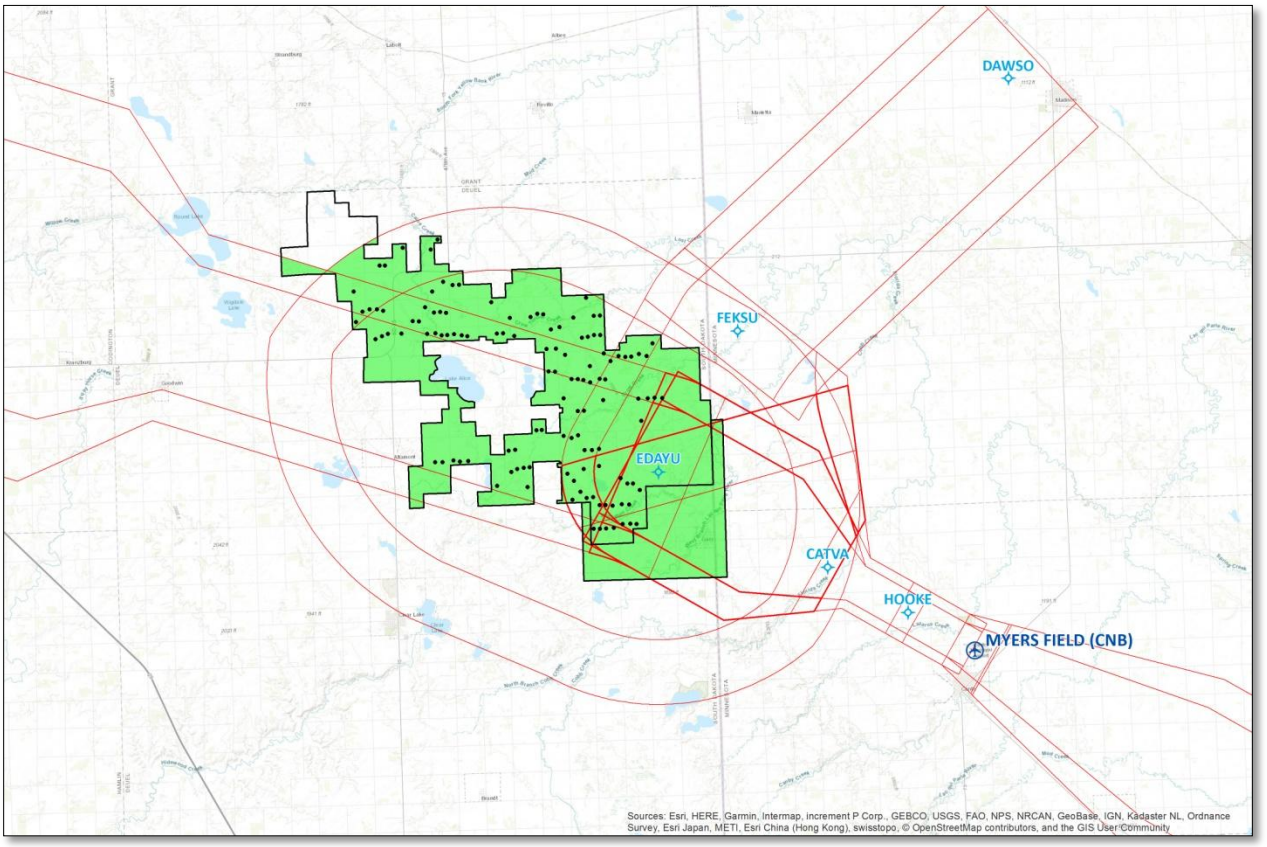

Figure 5: Myers Field Airport (CNB) RNAV (GPS) Approach to Runway 12

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Milbank Municipal (1D1)

RNAV (GPS) Approach to Runway 31 Terminal Arrival Area (TAA)

The *LUZOL* 18 nautical mile (NM) and *IYJER* 20NM TAA minimum altitudes are 3,400 feet AMSL. The obstacle clearance surfaces (hatched blue and purple, ***Figure 6***) are 2,400 feet AMSL and are some of the lowest height constraints overlying the majority of the study area. USGS elevation data indicates that the *IYJER* 20NM TAA could limit 499 foot AGL wind turbines in the southwestern section of the project boundary (red areas, ***Figure 6***). However, none of the proposed wind turbines are located in this area.

It is possible that the FAA would increase TAA minimum altitudes in order to accommodate 499 foot AGL wind turbines. This mitigation option is subject to FAA approval and requires that the resulting descent gradient meets FAA instrument approach procedure design criteria.

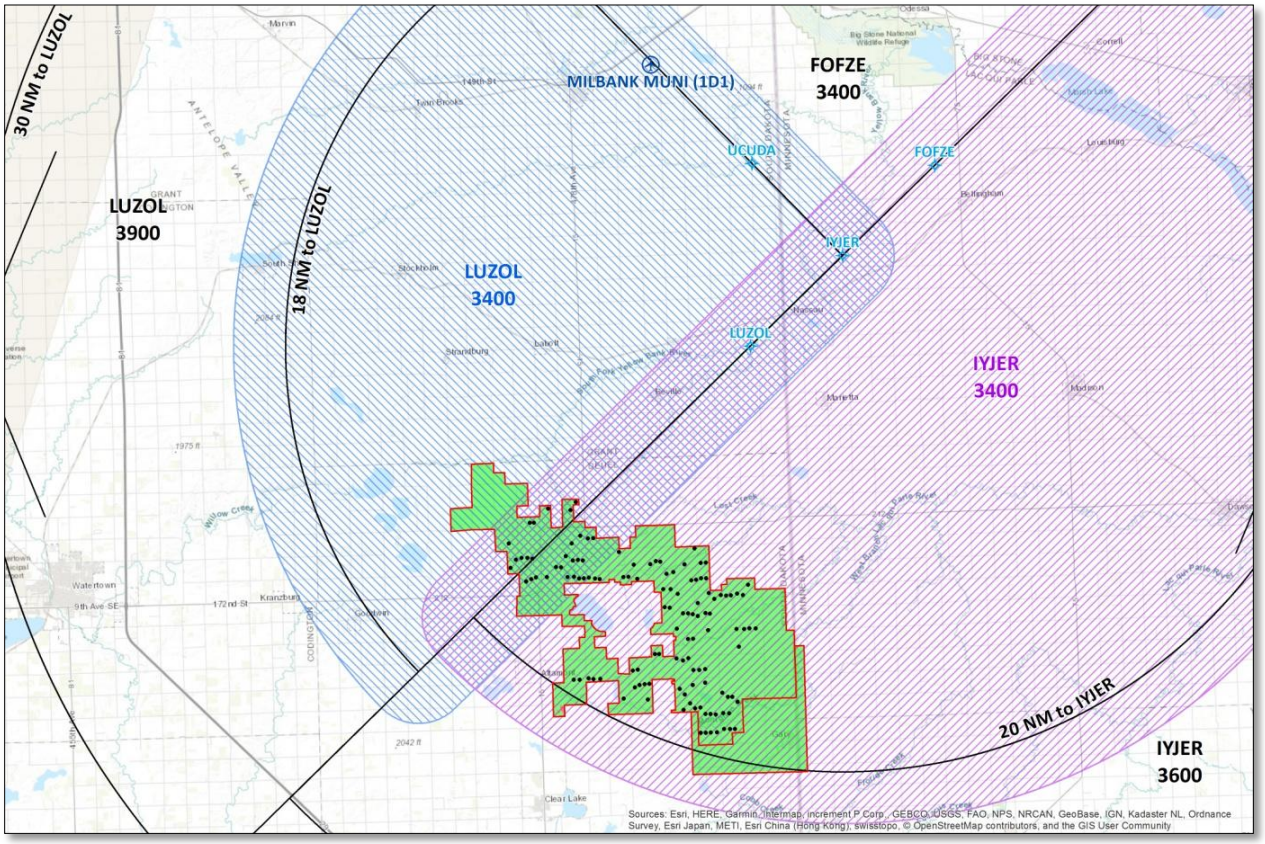

Figure 6: Milbank Municipal Airport (1D1) RNAV (GPS) Approach to Runway 31 TAAs (black) with LUZOL 18NM (hatched blue) and IYJER 20NM (hatched purple) obstacle evaluation areas

Enroute Airways

Enroute airways provide pilots a means of navigation when flying from airport to airport and are defined by radials between VHF omni-directional ranges (VORs). The FAA publishes minimum altitudes for airways to ensure clearance from obstacles and terrain. The FAA requires that each airway have a minimum of 1,000 feet of obstacle clearance in non-mountainous areas and normally 2,000 feet in mountainous areas.

Proposed structures that exceed enroute airway obstacle clearance surfaces would require an increase to their minimum obstruction clearance altitudes (MOCA) and/or minimum enroute altitudes (MEA). If the FAA determines that this impact would affect as few as one operation per week, it could be used as the basis for determinations of hazard.

V78

Watertown VORTAC (ATY) to *Claps*

The MOCA is 3,300 feet AMSL. The primary area obstacle clearance surface (purple, ***Figure 7***) is 2,300 feet AMSL and is one of the lowest height constraints overlying the northwestern section of the study area.[2] USGS elevation data indicates that this surface could limit 499 foot AGL wind turbines in the northwestern corner of the study area (red areas, ***Figure 7***). However, none of the proposed wind turbines are located in this area.

The MEA is 5,500 feet AMSL. The primary area obstacle clearance surface (purple, ***Figure 7***) is 4,500 feet AMSL and is in excess of other lower surfaces. Additionally, USGS elevation data indicates that this surface should not limit 499 foot AGL wind turbines within the defined study area.

Other enroute airway obstacle clearance surfaces (e.g. orange, ***Figure 7***) are in excess of other lower surfaces and should not limit 499 foot AGL wind turbines within the defined study area.

[2] In accordance with FAA Order 7400.2M Paragraph 6-3-9(d)(2), proposed structures beyond 22 nautical miles from an airway's supporting NAVAIDs that impact only the MOCA are not considered to have a substantial adverse effect. Therefore, height constraints associated with the V78 MOCA were only considered within 22 nautical miles of its supporting NAVAIDs (dashed purple line, ***Figure 7***).

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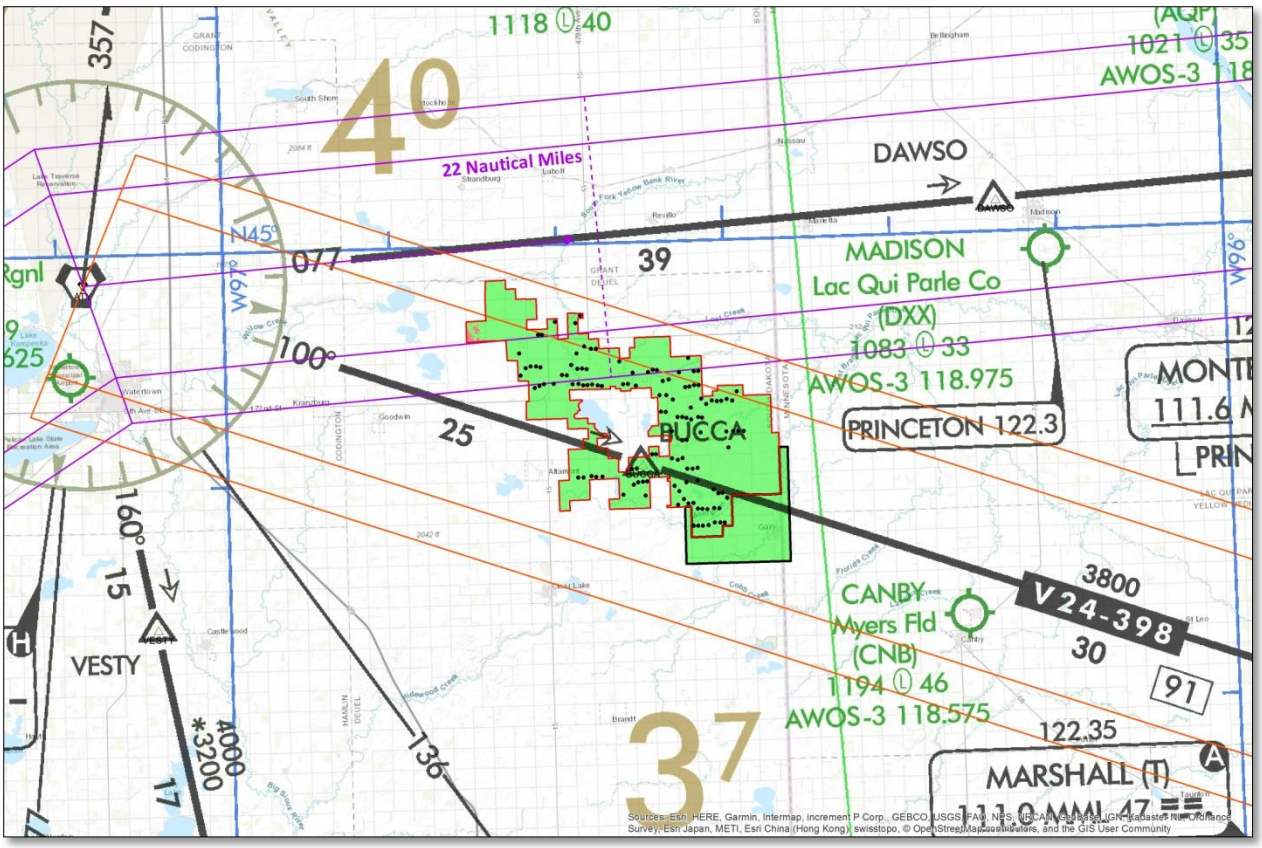

Figure 7: Low altitude enroute chart L-12 with V24-398 (orange) and V78 (purple) obstacle evaluation areas

Minimum Vectoring/IFR Altitudes

The FAA publishes minimum vectoring altitude (MVA) and minimum instrument flight rules (IFR) altitude (MIA) charts that define sectors with the lowest altitudes at which air traffic controllers can issue radar vectors to aircraft based on obstacle clearance. The FAA requires that sectors have a minimum of 1,000 feet of obstacle clearance in non-mountainous areas and normally 2,000 feet in mountainous areas.

Proposed structures that exceed MVA/MIA sector obstacle clearance surfaces would require an increase to the altitudes usable by air traffic control for vectoring aircraft. If the FAA determines that this impact would affect as few as one operation per week, it could result in determinations of hazard.

MVA/MIA sector obstacle clearance surfaces (e.g., ***Figure 8***) are in excess of other lower surfaces and should not limit 499 foot AGL wind turbines within the defined study area.

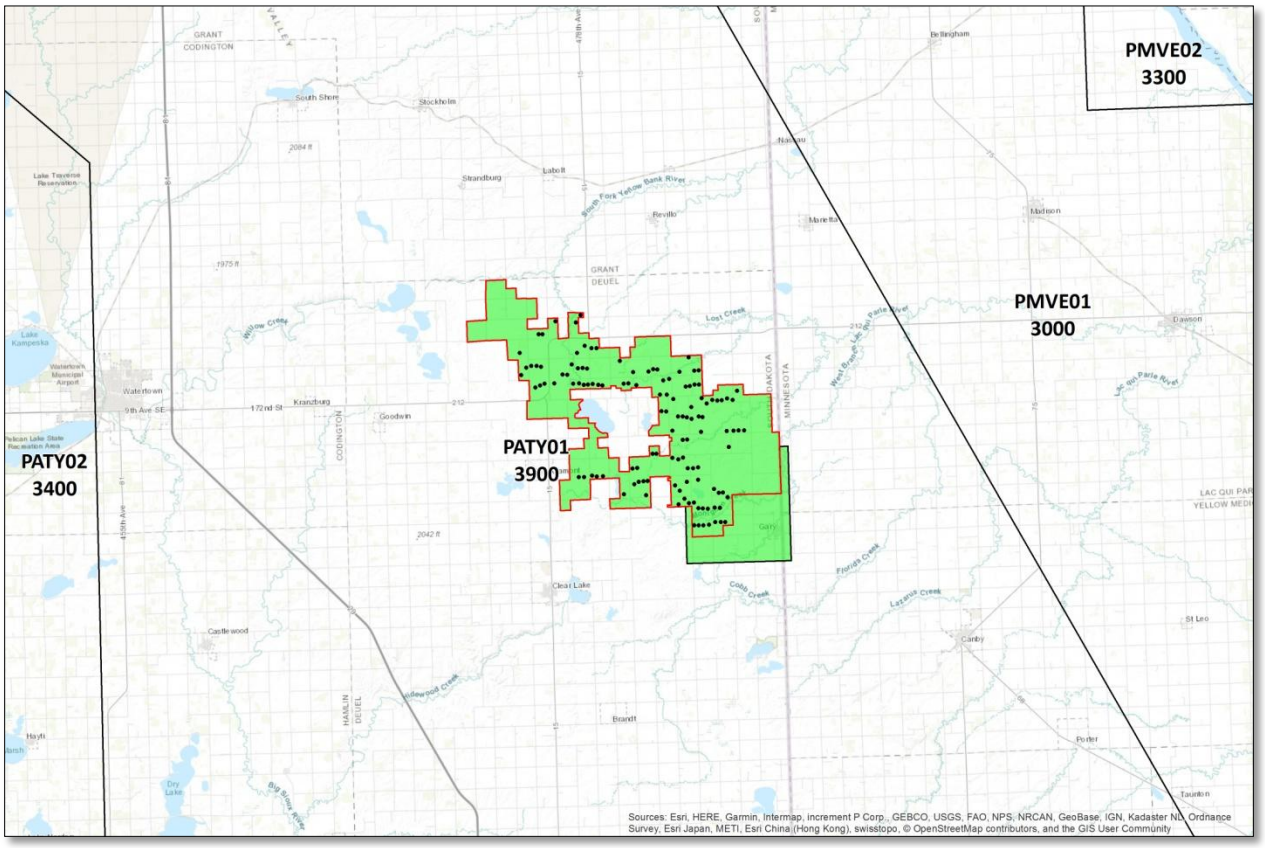

Figure 8: Minneapolis (ZMP) ARTCC MIA sectors (black)

Terminal and Enroute NAVAIDs

The FAA has established protection areas in order to identify proposed structures that may have physical and/or electromagnetic effect on navigational aids (NAVAIDs). The protection area dimensions vary based on the proposed structure type as well as the NAVAID type. Proposed structures located within these areas may interfere with NAVAID services and will require further review by FAA Technical Operations. If further review determines that proposed structures would have a significant physical and/or electromagnetic effect on NAVAIDs, it could result in determinations of hazard.

NAVAID protection areas do not overlie the Deuel Harvest wind project (***Figure 9***). As a result, it is unlikely that proposed wind turbines would have a physical or electromagnetic effect on terminal or enroute NAVAIDs.

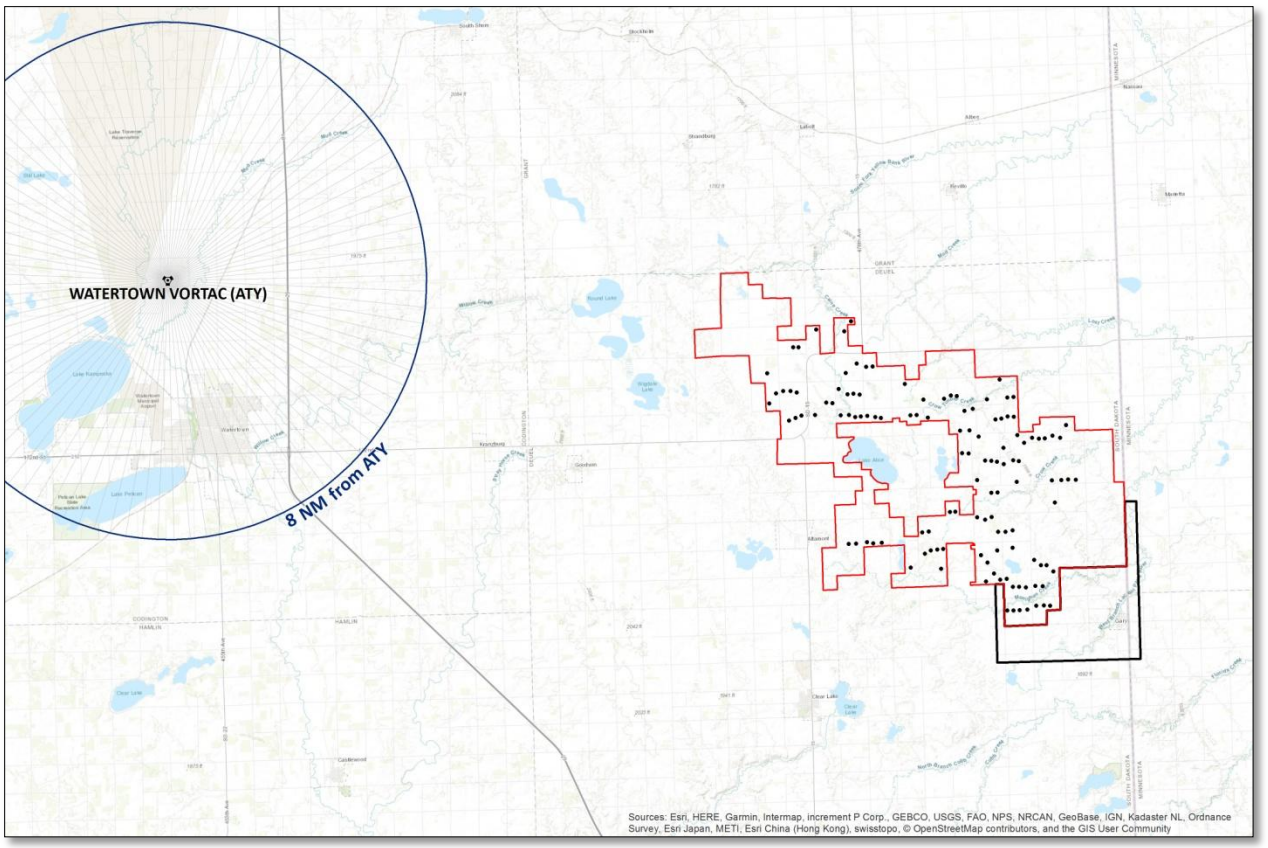

Figure 9: VOR protection areas in proximity to the Deuel Harvest wind project

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Military Airspace and Training Routes

Although the FAA does not consider impact on military airspace or training routes, they will notify the military of proposed structures located within these segments of airspace. Impact on these segments of airspace can result in military objections to the proposed development. If the planned development area is located on federal land, impact on military airspace or training routes may result in the denial of permits by the Bureau of Land Management.

Military airspace and training routes do not overlie the Deuel Harvest wind project (***Figure 10***). Therefore, proximity to these segments of airspace should not result in military objections to proposed wind development.

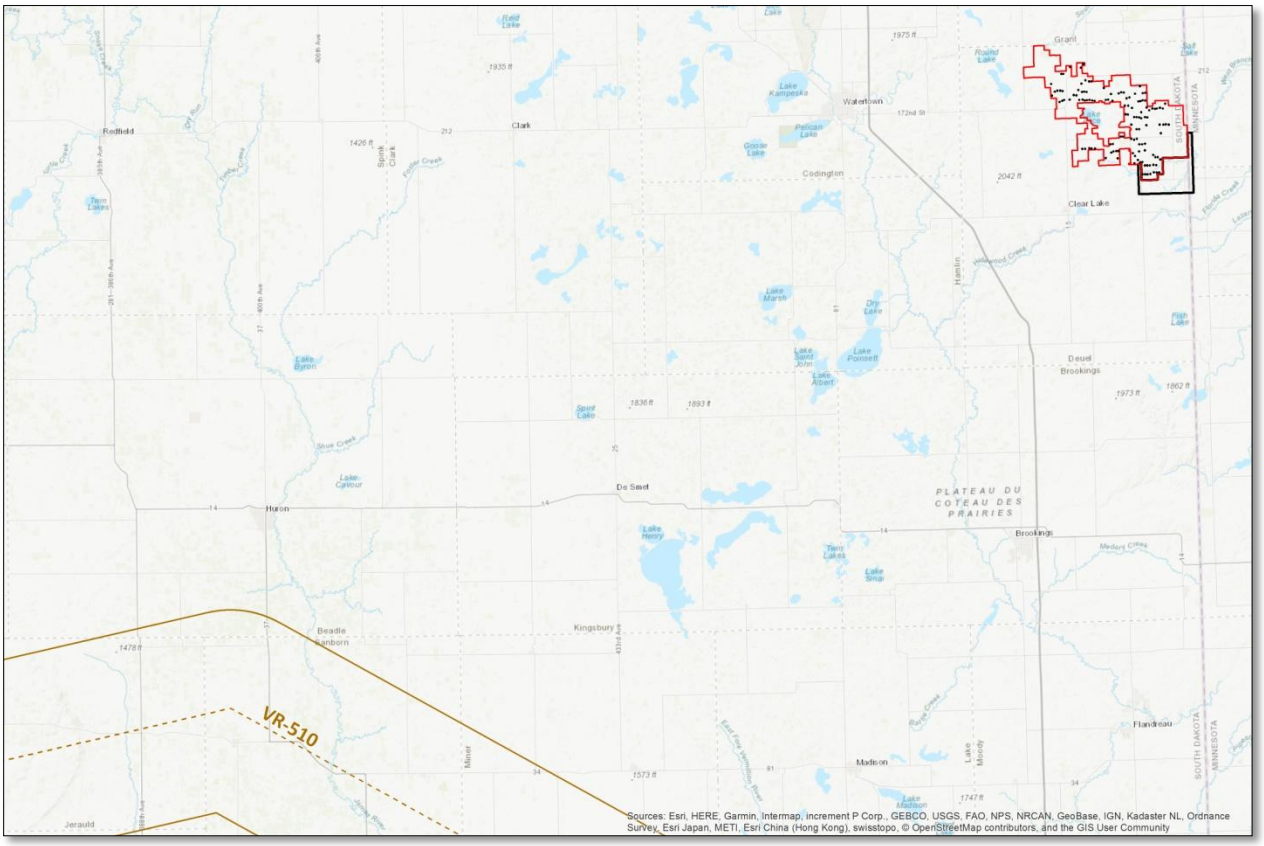

Figure 10: Military training routes in proximity to the Deuel Harvest wind project

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Conclusion

At 499 feet AGL, proposed wind turbines will not exceed 14 CFR Part 77.17(a)(1), 77.17(a)(2), or 77.19/21/19 imaginary surfaces. However, proposed wind turbines should remain below FAA obstacle clearance surfaces in order to avoid determinations of hazard.

The lowest obstacle clearance surfaces overlying the Deuel Harvest wind project range from 2,300 to 2,400 feet AMSL (***Figure 11***) and are associated with multiple instrument approach procedures (***Figure 5*** & ***Figure 6***) and enroute airway V78 (***Figure 7***). Proposed structures that exceed these surfaces would require an increase to instrument approach procedure minimum altitudes and enroute airway minimum obstruction clearance altitudes. If the FAA determines that these impacts would affect as few as one operation per week, it could result in determinations of hazard.

USGS elevation data indicates that these surfaces could limit 499 foot AGL wind turbines in northwestern and southwestern sections of the project boundary (red areas, ***Figure 12***). However, none of the proposed wind turbines are located in these areas.

The AGL Clearance Map (***Figure 12***) is based on USGS National Elevation Dataset (NED) 1/3 Arc Second data which has a vertical accuracy of 1.89 meters root-mean-square error (RMSE). Therefore, the AGL Clearance Map should only be used for general planning purposes and not exact structure siting. In order to avoid determinations of hazard, proposed structure heights should adhere to the height constraints depicted in the Composite Map (***Figure 11***).

If you have any questions regarding the findings of this study, please contact ***Dan Underwood*** or ***Orlando Olivas*** at (703) 256-2485.

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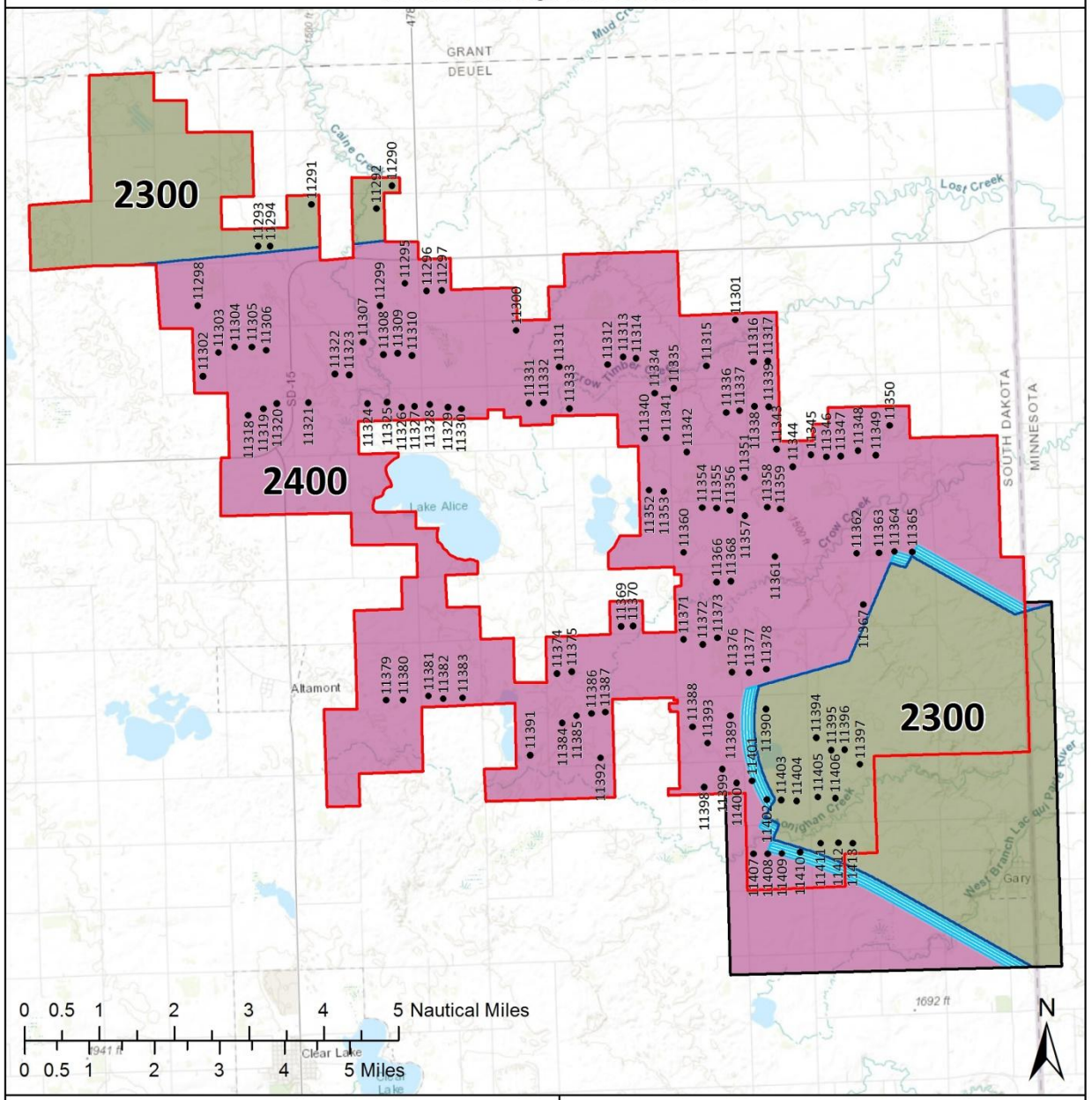
Proposed structures that exceed 14 CFR Part 77.17(a)(1) - a height of 499 feet AGL at the site of the object - will be identified as obstructions regardless of location.



Obstacle Clearance Surface

Height - AMSL Feet

High : 2,400

Low : 2,300

Surface Contour

100 Foot

20 Foot

Proposed Wind Turbine
(Labeled with 2018-WTW-XXXXX-OE)

All heights above mean sea level (AMSL)

Deuel Harvest Wind Project
Composite Height Constraint Map

Plot Date:
22 March 2019

Coordinate System:
NAD 1983 UTM Zone 14N

Orlando Olivas

Figure 11

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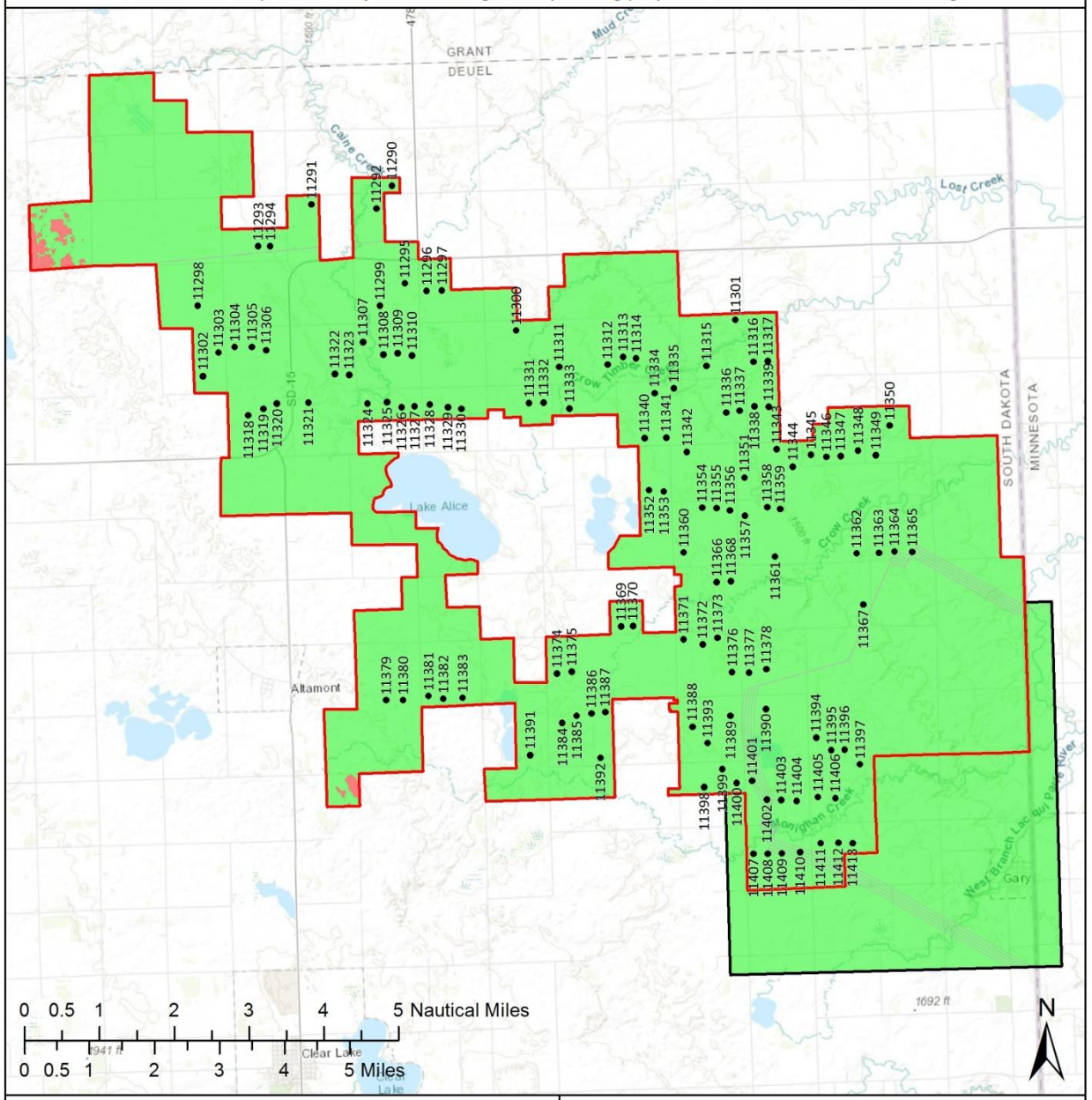
The USGS 1/3 Arc Second Digital Elevation Model (DEM) data used to create this map has a vertical accuracy of 1.89 meters RMSE. This map should only be used for general planning purposes and not exact structure siting.



Clearance

Height - AGL Feet

- < 499
- ≥ 499
- Proposed Wind Turbine (Labeled with 2018-WTW-XXXXX-OE)

Deuel Harvest Wind Project
Above Ground Level (AGL) Clearance Map

Plot Date:
22 March 2019

Coordinate System:
NAD 1983 UTM Zone 14N

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Figure 12

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