Case No. 16-1871-EL-BGN

Icebreaker Windpower Inc.

Application-Part 6 of 13

Part 6 includes:

- Exhibit H. Wind Turbine Placement Favorability Analysis
- Exhibit I. Aquatic Geotechnical and Geophysical Surveys
- Exhibit J. Avian and Bat Assessment and Monitoring
- Exhibit K. Substation and Cable Route Design Report
- Exhibit L. PJM Studies

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Case No. 16-1871-EL-BGN

Icebreaker Windpower Inc.

Application-Part 6 of 13

- Exhibit H. Wind Turbine Placement Favorability Analysis

Wind Turbine Placement Favorability Analysis

Explanation of Notable Limiting Factors and Weighting

Shipping Lanes and Navigable Waterways

The location of shipping lanes, navigable waterways and harbors are identified as limiting factors due to the potential obstruction with large vessel/freighter transportation routes. The shipping lane and navigable waterway data was obtained from NOAA's navigational charts.

- Grid cells intersected by a shipping lane or navigable waterway are identified as extensive, and highly unfavorable wind turbine placement sites (in direct line with a shipping lane).

- Buffer areas of 1-, 2- and 3-miles were applied to shipping lanes and ferry routes to identify zones that may potentially impact wind turbine placement and weighted accordingly.

- Grid cells that are not in direct line of a shipping lane and not intersected by the one-nautical mile buffer are identified as the most favorable wind turbine placement sites.

Fish Habitat / Community

Fish habitat is broken into four classes based upon previously defined depth strata and extant data the Division of Wildlife has collected.

- Walleye Larval/Juvenile Production Areas: Defined by delineating where juvenile walleye were collected in bottom trawls conducted in June 2008 in the Western and Central basins and then relating physical characteristics (least favorable).

- Adult Walleye Habitat: Defined by delineating the 7 fathom bank which is currently used by the Lake Erie Commission for defining adult walleye habitat and for quota allocation purposes.

- Walleye/Perch Habitat: Defined by delineating the 55-foot depth contour which is generally the area where the thermocline intersects the bottom of Lake Erie and is generally the extent of influence of the Dead Zone.

- Dead Zone: Defined as bathymetry greater than 55 feet which is generally the area affected by bottom hypoxia (most favorable).

Lakebed Substrates

Lakebed substrates are broken into four classes based upon currently available, coarse level substrate mapping of Lake Erie (Haltuch et al), with wind power development having higher potential impact on coarse substrates, such as bedrock reefs and sand/gravel resources relative to finer materials, such as mud and glacial till.

- Bedrock and Sand/Gravel (least favorable)

- Sand/Mud

- Glacial Till

- Mud (most favorable)

Proximity to Raptor Nests

The proximity to protected raptor species nests was identified as a potential limiting factor. Raptor species include: bald eagle, osprey and peregrine falcon.

As a result of onshore monitoring protocols conducted by the Division of Wildlife, the following designations were applied to the weighting:

- Prohibition of wind turbine placement within a one-half mile radius of any raptor nest *[Weight of "0" applied to any grid cell completely or partially contained by this buffer]*.

- Further monitoring of raptor pairs if a wind turbine is proposed within a two mile radius of any raptor nest *[Weight of "1" applied]*.

- Grid cells completely located beyond the two mile radius were designated a more favorable weight.

Other Limiting Factors

Other limiting factors used to determine favorable and non-favorable locations for wind turbine placement in Lake Erie include the locations of:

- Reefs, shoals and artificial reefs

- Confirmed shipwrecks (as identified by Ohio Sea Grant)

- Underground salt mines, and open-lake areas permitted for sand & gravel extraction

- Federal, state and county boundaries

- Submerged land lease boundaries

- Natural heritage observances

- Military Exercise Zone and Dredge Disposal Areas

Distance from Shore

The distance from shore buffer-lines factored Ohio's mainland shoreline, all Lake Erie islands (including Canada), and out-of-state mainland shore (including Michigan, New York, Pennsylvania and Canada)

Areas between the shoreline and a the 3-mile buffer line are identified as impact zones due to aesthetic and habitat concerns. Locations within the 0-3 mile range are weighted into two categories: "0" for mainland and inhabited islands, and: "1" for uninhabited islands.

Locations beyond the 3-mile buffer are weighted into three categories (2 through 4) based on aesthetic preference (10 miles or farther, most favorable).

Sport Fishery Effort

This variable factors the average sport fishery effort of targeted walleye and perch from 2000-2006 by 10-minute grid.

- 106,000-700,000 hours of targeted percid effort (least favorable)

- 25,000-106,000 hours of targeted percid effort

- 4,000-25,000 hours of targeted percid effort

- 0-4,000 hours of targeted percid effort (most favorable)

Commercial Fishery Effort

This variable factors the average targeted commercial fishery trapnet lifts from 2000-2006 by 10-minute grid.

- 600-2,900 targeted trapnet lifts (least favorable)

- 250-600 targeted trapnet lifts

- 32-250 targeted trapnet lifts

- 0-32 targeted trapnet lifts (most favorable)

Important Bird Areas

Located at the intersection of the Atlantic and Mississippi flyways, Lake Erie is an important destination and stopover site for many migratory birds. Consequently, many areas along Ohio's shore have been designated as Important Bird Areas (IBA) by the Ohio Audubon Society.

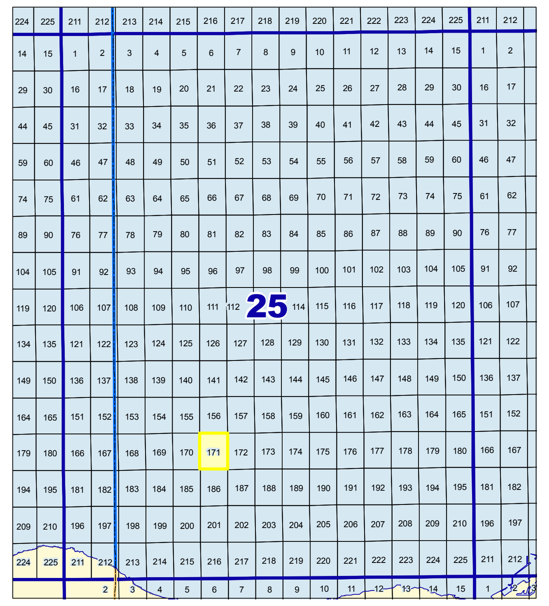
- Grid cells that are completely or partially contained by an IBA are given a lower weight *[Lowest value not given a weight of "0" due to the subjectivity of the areas]* (least favorable).

- Grid cells that are not completely or partially contained by an IBA are given a higher weight (more favorable).

GIS Data Sources

Bathymetry - National Oceanic and Atmospheric Administration, 2004
Confirmed Shipwrecks - Ohio Sea Grant, 2007
Fish Habitat - ODNR Division of Wildlife
Important Bird Areas - Ohio Audubon Society, 2005
Lakebed Substrates - Ohio Sea Grant, 1999
Military Exercise Zone - ODNR Office of Coastal Management, 2006 (from NOAA Navigation Charts)
Natural Heritage - ODNR Division of Natural Areas and Preserves, 2005
Raptor Nests - ODNR Division of Wildlife, 2008
Reefs and Shoals - ODNR Office of Coastal Management, 2006
Salt Mines - ODNR Division of Geological Survey, 2003
Shipping Lanes - ODNR Office of Coastal Management, 2008 (from NOAA Navigation Charts)
Submerged Land Leases - ODNR Office of Coastal Management, 2004-2008
Water Intake/Crib Facilities and Pipelines - ODNR Office of Coastal Management, 2009

Explanation of Grid System



Grid System

Each grid cell represents a geographic extent that is equal to one minute of latitude by one minute of longitude, or a "one-minute quadrangle." The four corners of each quadrangle can be individually identified with lat/long coordinates, to the minute. On the ground, one minute of distance is equal to one nautical mile. Although the angular dimensions of each grid cell are identical, they do not represent a square nautical mile. This is due to Lake Erie's mid-latitude position on Earth where quadrangles are taller than they are wide. The area of a one-minute quadrangle is approximately equal to 634 acres, whereas the area of one square nautical mile is approximately equal to 847 acres.

For identification purposes, the one minute quadrangle cells were grouped into 15 minute by 15 minute quadrangles (225 one-minute quadrangles, or cells, per 15-minute quadrangle). Within each 15-minute quadrangle, the one-minute cells were numbered 1 through 225 (from upper-left to lower-right). Each 15-minute quadrangle was also given a number from 1 through 34. As a result, each one minute grid cell can be identified with a unique indexing number by listing the 15-minute quadrangle number followed by the one minute grid cell number, i.e. "25-171."

Ohio Department of Natural Resources
Office of Coastal Management

105 West Shoreline Drive
Sandusky, Ohio 44870
(419) 626-7980

Version 1.5
Map created: 12/08/2008
Map updated: 04/22/2009

Exhibit I

Aquatic Geotechnical and Geophysical Surveys

CONFIDENTIAL

FILED UNDER SEAL

Icebreaker Windpower Incorporated has requested confidential treatment of this document in accordance with OAC Rule 4906-2-21.

This document contains critical infrastructure information, confidential research and development information, commercial information, trade secrets, and/or proprietary information and, as such, is entitled to confidential treatment under state and/or federal statutes and regulations.

An unredacted version of this document has been submitted to the Docketing Division of the OPSB in accordance with OAC Rule 4906-2-21(D)(2).

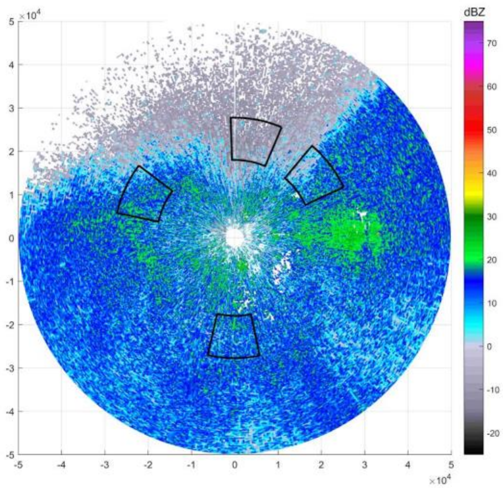
Case No. 16-1871-EL-BGN

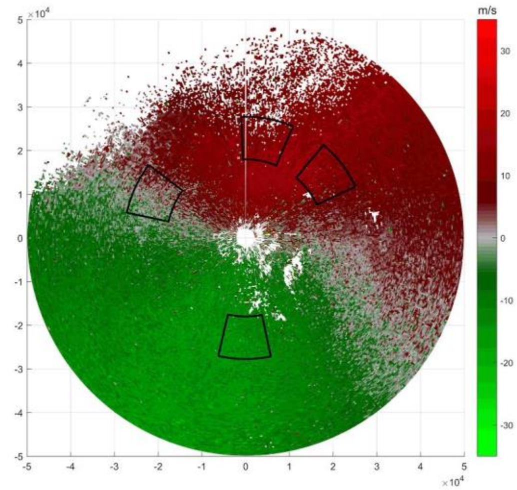
Icebreaker Windpower Inc.

Application-Part 6 of 13

- Exhibit J. Avian and Bat Assessment and Monitoring

Assessment of Nocturnal Bird Migration Activity from Weather Radar Data for the Proposed Icebreaker Wind Energy Facility, Lake Erie, Ohio





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January 23, 2017

Privileged and Confidential - Not For Distribution

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INTRODUCTION

This study examines NEXRAD weather radar data from Cleveland, Ohio and another radar station in Buffalo, New York for the purpose of assessing nocturnal bird and bat migration above the proposed site of the Icebreaker Wind Energy Facility in Lake Erie, and several comparison areas near Cleveland and Buffalo. The acronym NEXRAD represents “NEXt generation RADar”, a network of approximately 160 Doppler radar stations maintained by the National Weather Service, and designed to monitor precipitation throughout the United States. NEXRAD data are stored and disseminated in two forms–as raw, high resolution Level II data, and as more highly processed, lower resolution Level III data. Level II products include reflectivity (a measure of the density of reflecting targets), radial velocity (the component of velocity either toward or away from the radar unit), and several other products (NOAA 2016). Most radar ornithological studies published to date have relied on analysis of reflectivity and radial velocity (e.g., Diehl et al. 2003, Gauthreaux and Belser 2003, Bonter et al. 2008, Buler and Dawson 2014, Farnsworth et al. 2016).

During operation, a radar unit sweeps horizontally through 360 degrees at each of several elevation angles (usually including 0.5°, 1.5°, 2.5°, 3.5°, and 4.5°) (NOAA 2016). The half-power beam width is approximately 0.95 degrees (Raghavan 2013), though energy return is greatest in the center of that beam. As of 2008, so-called “super resolution” Level II data for the lowest two elevations (0.5 degrees and 1.5 degrees) available from most NEXRAD stations have azimuthal resolution of 0.5 degrees and range resolution of 250 m (Torres and Curtis 2007). Thus, returned energy represents all targets within a section of a cone with 0.5 degrees “width” and “depth” of 250 m. Because of beam spread, the volume of this cone section increases with increasing range. From an analysis standpoint, the cone section represents the most fundamental sample unit for NEXRAD data. In the Methods section below, these cone sections are referred to as “pixels” of the polar coordinate system defined by radar azimuth and range.

Analysis of NEXRAD data for ornithological research depends on separating targets that are most likely to be birds (and/or bats) from other radar targets (Gauthreaux and Belser 1998). This data filtering process operates on the assumption that birds can fly opposing the wind or, if flying in the same direction as the wind, they can fly at greater than wind speed. Other targets will move with the wind (e.g., light precipitation or airborne dust) or only slightly faster than the wind (e.g., large swarms of insects). Thus, filtering out the slower-moving targets relies on independent measurements of wind speed and direction. Radiosonde wind data are obtained from weather balloons that are launched regularly from 92 stations in North America and the Pacific Islands (http://www.ua.nws.noaa.gov/). Many, though not all, radiosonde locations are coincident with NEXRAD stations. Data collected by instruments suspended from the balloon are radioed back to the station on the ground. At stations without radiosonde operations, winds at altitude must be estimated by other means, for example, from ground-based measurements (e.g., Archibald et al. 2016) or atmospheric wind models (e.g., Livingston 2008).

METHODS

Project Site, NEXRAD Stations, and Radar Sample Areas

The proposed Icebreaker Wind Facility will consist of six turbines (with a seventh alternate) in a single row, located approximately 14 km (9 miles) from the nearest point on the Lake Erie shoreline and 23 km (14 miles) from the KCLE NEXRAD station in Cleveland, Ohio (Figure 1). For the purpose of creating a reasonably sized sample area above the project, first, a boundary was defined as the 3.2 km (2 mile) buffer around the line segment connecting the turbines. The buffer was a racetrack-shaped polygon that provided range and azimuth limits for a NEXRAD sample area (Figure 2a), hereafter referred to as the Project Area. The Project Area was a wedge-shaped polygon with minimum range of 18 km, maximum range of 27.75 km, and arc limits spanning 25 degrees. Given the radar resolution for range (250 m) and azimuth (0.5°), the Project Area covered 39 range gates and 50 radar azimuths, or a total of 1950 pixels (= 39 × 50). The entire Project Area was above water (Figure 2a). Several comparison areas were created with the same size, range limits, and arc length as the Project Area. By design, these areas sampled air spaces at the same ranges so that, for fixed target sizes and densities within

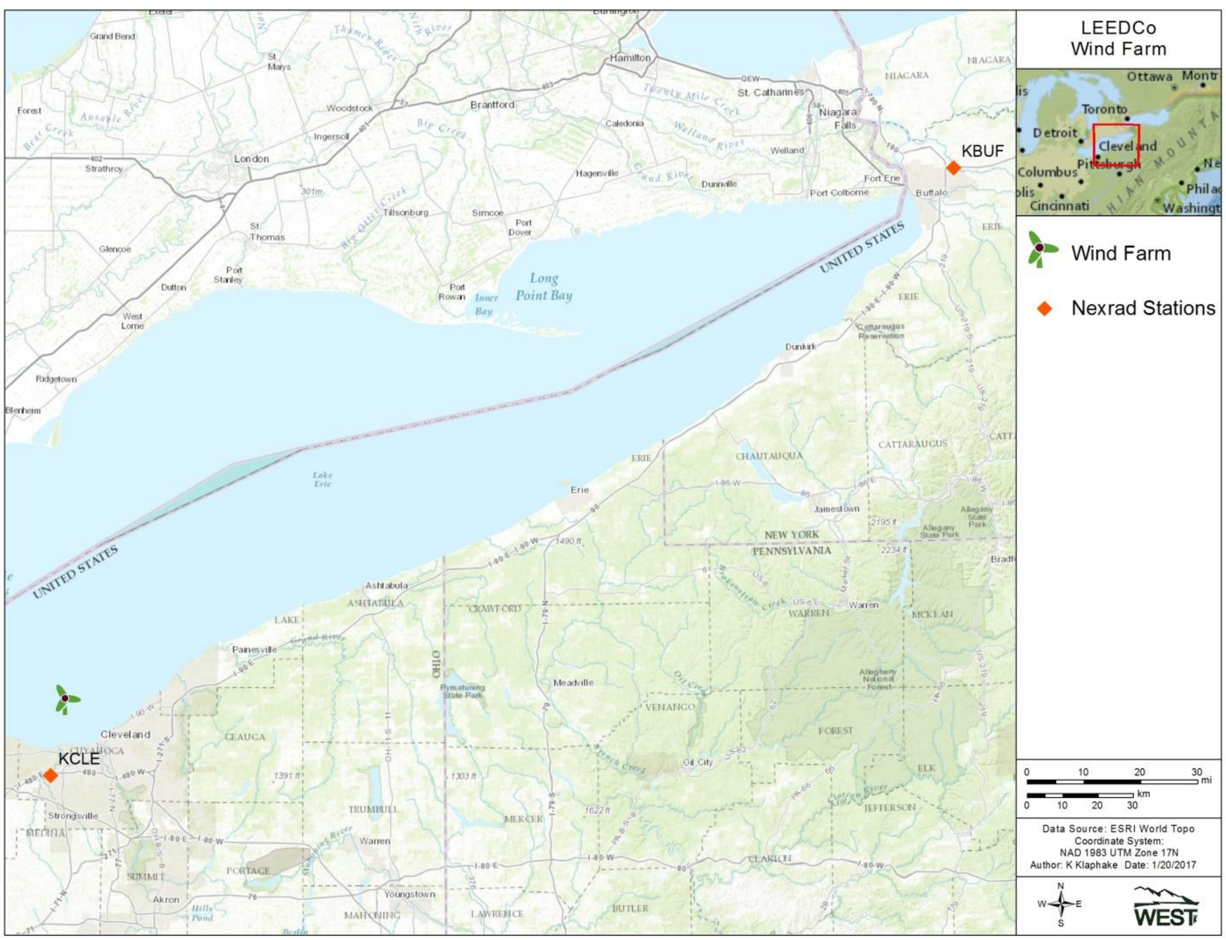
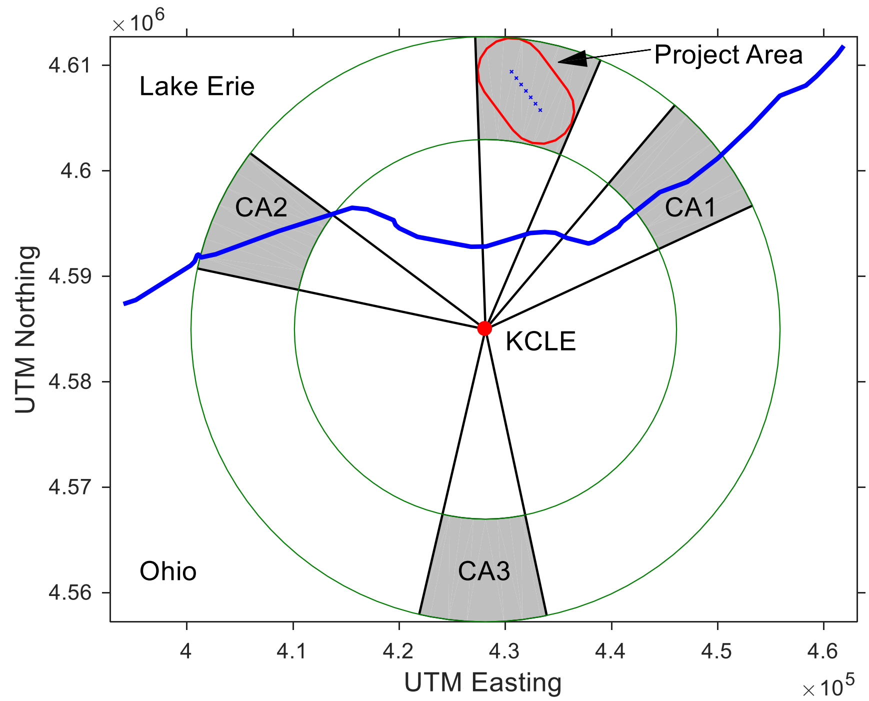


Figure 1. Location of the proposed Icebreaker Wind Energy Facility in Lake Erie, in relation to the KCLE NEXRAD station in Cleveland, OH and the KBUF station in Buffalo, NY.

(a)



(b)

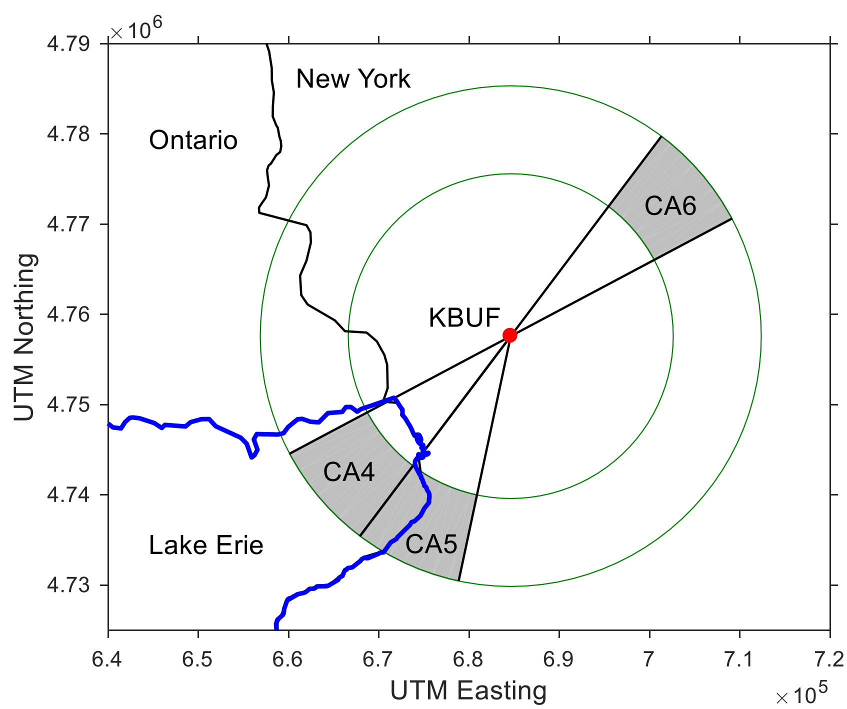


Figure 2. NEXRAD stations (red circles) and sample areas (gray shading), all at the same ranges (green circles) with same arc length (25 degrees) as the Project Area at (a) Cleveland (KCLE) and (b) Buffalo (KBUF). The Project Area in (a) shows the wind turbine locations (small blue circles) for the proposed Icebreaker Wind Energy Facility and bounding polygon (red line) used to define sample area dimensions.

each space, return energy would not differ. Furthermore, these areas sampled the same altitudes relative to the NEXRAD stations (though, altitude relative to ground or lake surface would vary somewhat). Three comparison areas were defined for KCLE (Figure 2). Comparison Areas 1 and 2 were situated above the Lake Erie shoreline such that approximately half of each area was above water and half was above land. Comparison Area 3 was located to the south of KCLE, entirely above land. Similarly, three comparison areas were defined for KBUF (Figure 2b). Comparison Area 4 was situated to the southwest of KBUF, entirely above water, though closer to the lake shore than the Project Area at KCLE. Comparison Area 5 was adjacent to Comparison Area 4, situated partly above water and partly above land, and Comparison Area 6 was entirely above land to the northeast of KBUF.

As described in the next section, only data from the lowest two radar elevations (0.5 degrees and 1.5 degrees) were retained for analysis. The height of the radar beam above the lake surface at the Project Area (i.e., the sample area shown in Figure 2a) was calculated accounting for radar height, earth curvature, and atmospheric refraction (Doviak and Zrnic 2006). In particular, beam height, *H*, was calculated as:

$$H = \sqrt{d^2 + \left(\frac{4}{3}r\right)^2 + 2d\frac{4}{3}r\sin(\theta)} + h_a - \frac{4}{3}r$$

where d = radar range (distance from the radar unit to the point of interest on the earth's surface), r = earth radius, θ = radar elevation, and h_a = height of the radar antenna relative to the point of interest. In addition to height of the beam center, the heights of the −3 dB (half-power) points were also calculated. As shown in Figure 3, the height of the center of the radar beam above the Project Area ranged from 257 to 366 m at the 0.5 degree elevation and from 574 to 847 m at the 1.5 degree elevation. Figure 3 also shows that at the 0.5 degree elevation the height of the lower −3 dB point ranged from 105 to 135 m above the Project Area. Thus, there was some overlap of the radar beam and the rotor-swept zone for the proposed turbines, which have a maximum blade tip height of 146 m. Figure 3 shows the area occupied by turbines (based on the proposed locations and height) as a semi-transparent gray rectangle, thus illustrating the overlap region. Table 1 provides more detail about radar beam height directly above the turbine locations. Note, for instance, that the lower −3 dB point ranged from 114.4 to 124.6 m directly above the turbine locations. Birds flying within the overlap region would likely be detected by the KCLE NEXRAD, though more detailed inference about target heights is not possible. Chilson et al. (2012) maintain that because birds are “bright” targets (relative to precipitation), a more appropriate characterization of beam width would be based on the −6 dB (quarter-power) points. That wider beam would imply greater overlap with the rotor-swept zone within the Project Area, i.e., detection of birds at lower heights (as well as at greater heights).

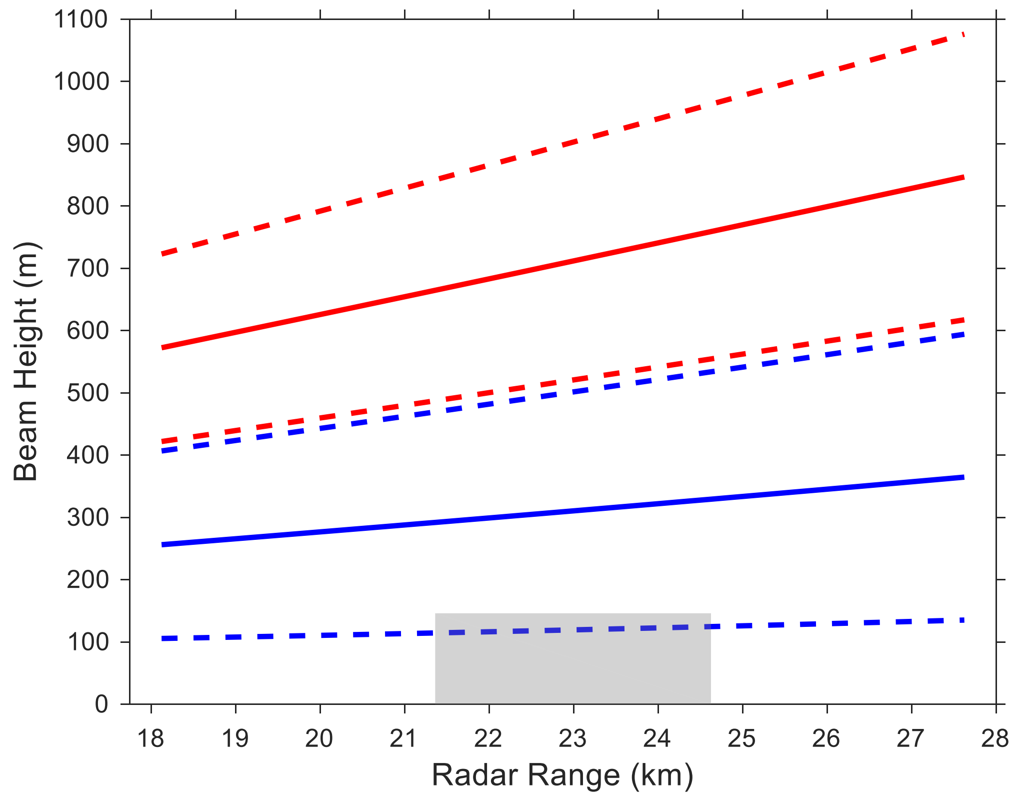


Figure 3. NEXRAD beam height relative to the lake surface, above the Project Area (X-axis limits) and, more specifically, above the wind turbines (gray shading). Solid lines indicate the beam centers, and dotted lines represent approximate beam boundaries of the 0.5^0 (blue) and 1.5^0 azimuth radar beams.

Table 1. Sampling heights of the radar beam from the KCLE station above the proposed Icebreaker Wind Energy Facility.

Radar Elevation	Position Within Beam	Beam Height (m) Near (21.36 km)	Far (24.63 km)
0.5°	Lower	114.4	124.6
	Center	291.9	329.2
	Upper	469.3	533.7
1.5°	Lower	487.2	554.4
	Center	664.6	758.9
	Upper	842.0	963.4

Heights are given for the nearest and farthest wind turbines from KCLE. “Lower” and “Upper” positions within the beam refer to the −3 dB (half-power) points for beam width of 0.95°. Beam heights account for land elevation and tower height at the KCLE site relative to the lake surface.

Data Selection, Downloading, and Pre-Processing

Level II NEXRAD data were downloaded from the database maintained by the National Centers for Environmental Information (NCEI) archival website (https://www.ncdc.noaa.gov/has/has.dsselect). Data were obtained from both the primary radar station (KCLE at Cleveland, OH) and the comparison station (KBUF at Buffalo, New York) for the nighttime hours during the spring and fall migratory periods, defined as April 1 – May 31 and August 20 – October 20, respectively. Fall data were obtained for the three years 2013 – 2015, and spring data were obtained for the years 2014 – 2016. While Fall 2016 data were available from KCLE, comparable data for the same period were not available from KBUF.

Each downloaded compressed file containing all data for an hour was decompressed into multiple files, each representing a separate radar scan at multiple elevations; typically, weather radars conduct 5 – 10 scans per hour. The NEXRAD data in these decompressed files were extracted from the native binary format using the Weather and Climate Toolkit, a Java program obtained from the NCEI (http://www.ncdc.noaa.gov/wct/). The Toolkit was used to export each file into NetCDF (Network Common Data Form) format (http://www.unidata.ucar.edu/software/netcdf/). NetCDF is a scientific data format that is machine independent and is readily imported by a variety of analysis software. Each NetCDF file contained all data from the native NEXRAD file in the original polar coordinate system (radar azimuth and range). NetCDF files were queried using Matlab, and only those files representing NEXRAD operation in Clear Air Mode (Volume Coverage Patterns 31 or 32) were retained for further processing and analysis. Files representing operation in Precipitation Mode, i.e., not in Clear Air Mode, were assumed to be dominated by precipitation and thus have little, if any, interpretable data indicative of bird migration. Other studies have excluded data due to precipitation (e.g., Farnsworth et al. 2016). Furthermore, Precipitation Mode data have lower resolution than data from Clear Air Mode, making analysis of biological targets more difficult (Diehl and Larkin 2005). Files were further filtered to retain only radar scans occurring between civil sunset (30 minutes after sunset) and civil sunrise (30 minutes before the following sunrise). This temporal filtering focused on the nocturnal period when migration is most intense (Diehl and Larkin 2005, Farnsworth et al. 2016), and also minimized contamination of scans due to sun strobes, which tend to occur near sunset and sunrise (Gauthreaux and Belser 2003).

All remaining NetCDF files were imported into Matlab and subset to retain “Super Resolution” reflectivity and radial velocity at 0.5 degree and 1.5 degree elevations; that is, all other Level II products and all higher elevations were discarded. Furthermore, data were subset to retain ranges less than 50 km. These subsetting steps led to greatly reduced file sizes and thus subsequently facilitated faster data processing and analysis. At the same time, 50 km range included substantial area beyond the Project site and similar comparison areas (described below) to facilitate visual pre-screening of radar scans.

Radar data were visually pre-screened in two stages to identify problems in radar scans. In the first stage, a technician viewed each scan at each elevation, displayed as a reflectivity-velocity pair, and flagged scans with potential problems such as precipitation (light precipitation may occur in Clear Air Mode), radar malfunction, or other anomalies. In the second stage, a more experienced person viewed those scans that had been flagged, and made a final determination regarding data acceptability. In particular, each sample area within each of the provisionally flagged scans was given a final flag if it was considered unacceptable, for example, because precipitation occurred within that area. In many cases, only one or two sample areas were flagged, while the remaining sample areas were considered acceptable. Flagged sample areas were not included in subsequent analysis. Other than pre-screening as described, all data were retained without regard to intensity of presumed migration (reflectivity values) or direction (inferred from radial velocity images); that is, there was no attempt made to pre-select occurrences of pronounced bird migration.

Target Filtering

Identification of likely bird migration required separation of targets based on estimated air speeds under the assumption that targets with relatively high air speed were birds (or bats) and those with air speeds closer to the wind were either completely passive (e.g., dust, smoke, or light precipitation) or weak fliers such as insects. An air speed threshold of 5 m/s (Buler and Dawson 2014) was used to separate these two target classes; i.e., targets with air speed greater than 5 m/s were interpreted as birds. Calculation of air speed required estimates of both target ground speed and wind speed. Target ground speeds were calculated from NEXRAD radial velocities, while wind speeds were based on vertical wind profiles from either radiosonde or modeled wind data.

NEXRAD radial velocity data does not provide a direct estimate of target ground velocity, except in those cases when targets are moving directly towards or away from the radar station. Under the assumption that target speed and direction are uniform across broad areas (typically, though not necessarily, at 360 degrees around the radar unit), they can be estimated using the "wind retrieval" techniques developed by meteorologists. The Velocity Azimuth Display (VAD) algorithm (Browning and Wexler 1968) provides one such approach. Regression is generally used to estimate mean velocities and also yields estimates of variability in radial velocity, though it is computationally intensive when radar scans number in hundreds to thousands. Liang and Wang (2009) describe a VAD technique that is simpler than regression, though it does not yield any estimate of variance.

Target ground velocity was calculated following Liang and Wang (2009) with the assumption that velocity was uniform around the circle at a given radar range (thus, uniform at a given height), but potentially varying at different ranges (heights). Letting θ_i represent radar azimuth (i = 1, …, 720), $V_{\theta_{i,j}}$ represent radial velocity at the i^{th} azimuth and the j^{th} range (j = 1, …, 39, for ranges within the sample areas), then the east-west and north-south velocity components at the j^{th} range were calculated, respectively, as:

$$u_j = \frac{-\sum_i V_{\theta_{i,j}} \cos(\theta_i)}{\sum_i \cos^2(\theta_i)}$$

$$v_j = \frac{-\sum_i V_{\theta_{i,j}} \sin(\theta_i)}{\sum_i \sin^2(\theta_i)}$$

Then, ground speed, $V_{j,g}$, and direction, $\phi_{j,g}$, were recovered, respectively, as:

$$V_{j,g} = \sqrt{u_j^2 + v_j^2}$$

$$\phi_{j,g} = \tan^{-1}(v_j/u_j)$$

In addition to their use in calculating target air speeds (see below), calculated ground directions were retained for subsequent analysis of migration direction.

Radiosonde data including wind speed and direction were obtained for KBUF from a website maintained by the University of Wyoming Department of Atmospheric Science (http://weather.uwyo.edu/upperair/sounding.html). These data were available at 12-hour intervals (at 00:00 and 12:00 UTC). For KCLE, no radiosonde data were available, so modeled vertical profile wind data were obtained from the Earth Systems Research Laboratory (ESRL, part of the National Oceanic and Atmospheric Administration) (http://www.esrl.noaa.gov/ psd/map/profile/). The modeled R1 Reanalysis data from ESRL are based on radiosonde and other measurements, and are available on a global 2.5 degree grid (latitude and longitude) at 6-hour intervals (00:00, 06:00, 12:00, and 18:00 UTC). For KCLE at 41.41° north, 81.86° west, the nearest model grid point was 42.50° north, 82.50° west.

Two-dimensional linear interpolation of vertical profile wind (whether radiosonde or modeled) was performed to estimate wind speed and direction across (1) time, to match the times at which radar scans were conducted, and (2) height, to match the calculated height of the radar beam at each range value within the sample areas. Interpolation was conducted separately for each night of radar data. Given the relatively coarse temporal resolution of the wind data, there were typically two to four sets of wind data spanning each night (before, during, and after the night's radar scans). Similarly, given the height resolution of the wind data and the relatively low heights of the radar beam within the sample areas, there were at most six height observations in each modeled wind dataset and at most 30 height observations in each radiosonde dataset. Interpolation was conducted for all radar beam heights within the sample areas at both the 0.5 degree and 1.5 degree radar beam elevations. Wind speed was interpolated directly. For wind direction, the cosine and sine transformations were calculated first, each transform was separately interpolated across time and height, and then directions were recovered as the arctangent transformation of the two components. Aside from the trigonometric transformations for direction, linear interpolation was not substantially more complicated than nearest-neighbor interpolation since both required calculation of numerous differences in both time and height.

Representing wind speed and direction at the j^{th} range (height) as $V_{j,w}$ and $\phi_{j,w}$, respectively, air speed, $V_{j,a}$ was calculated as:

$$V_{j,a} = \sqrt{V_{j,g}^2 + V_{j,w}^2 - 2V_{j,g}V_{j,w}\cos(\phi_{j,g} - \phi_{j,w})}$$

If target air speed at the j^{th} range was less than 5 m/s, then the corresponding reflectivity values within each sample area were set to missing values, i.e., those reflectivity values were excluded from further analysis. Otherwise, if target air speed exceeded 5 m/s, reflectivity values at that range were considered to be migrating birds and were retained for analysis.

In a final filtering step, each radar scan was evaluated and the data within each sample area were retained for analysis if at least 20 percent of the pixels had non-missing reflectivity values. Thus, certain sample areas within a scan might have been eliminated while the remaining sample areas from that scan were retained.

For subsequent analysis, reflectivity values were transformed from the logarithmic (*dBZ*) to the linear (*Z*) domain using the relationship:

$$Z = 10^{dBZ/10}$$

as in Diehl et al. (2003).

Analysis

Before any further processing, target direction data were averaged for each radar scan, at each beam elevation. Given the limited spatial resolution of both the VAD “wind retrieval” technique and the vertical profile wind data (whether from radiosonde or wind model), calculated target direction was the same for all sample areas at each radar station, though it might vary somewhat with beam elevation. Because direction is a circular variable, average direction, $\bar{\phi}$, was calculated as

$$\bar{\phi} = tan^{-1}(Y/X), \text{ where}$$

$$X = \sum_{i=1}^{n} \cos(\phi_i)/n \quad \text{and} \quad Y = \sum_{i=1}^{n} \sin(\phi_i)/n$$

where ϕ_i was the direction at range *i* (Batschelet, 1981). On the other hand, target reflectivity data were averaged separately for each sample area, at each radar elevation within each scan. That is, each sample area was represented by a single mean reflectivity value (for each scan and elevation); those mean values were treated as the observations in subsequent data summaries.

Target Direction

Summaries of target direction included the mean (calculated as above) by station, season, and elevation, or by station, season, year, and elevation. In addition, summaries included angular concentration, *r*, and standard deviation, *s*. Angular concentration (Batschelet, 1981) was calculated as

$$r = \sqrt{X^2 + Y^2}$$

where *X* and *Y* were the averages of the cosine and sine components of direction, respectively, as above. Angular concentration can vary between 0 (low concentration) and 1 (high concentration), with 0 occurring if directions are uniformly distributed on the circle, and 1 occurring if all directions are coincident. Angular standard deviation (Mardia 1972) was calculated as

$$s = \sqrt{-2\log_{e}(r)}$$

Ninety-five percent confidence intervals for mean direction were calculated using bootstrapping (Manly 2006). In particular, 1000 bootstrap samples were taken in which the data were sampled with replacement, the mean direction was calculated for each sample, and the lower and upper 95% confidence limits were calculated as the 2.5th and 97.5th percentiles, respectively.

Target Density

Radar reflectivity representing target density was averaged in various ways to make comparisons between sample areas or radar stations, by radar elevation, hour of the night, date, season, or year. In all cases, means and standard errors were calculated for graphical presentation. Serial correlation in reflectivity was not assessed, nor were standard errors corrected for such correlation. Reflectivity was not converted to bird density since such conversion is based on the important assumptions that target size is known and is uniform (Chilson and Adams 2014). Furthermore, conversion does not facilitate comparisons within this study.

RESULTS

After eliminating radar scans due to precipitation or other problems, 24,029 scans remained for analysis. In this case, a single scan refers to the data collected at both the 0.5 degree and 1.5 degree elevations, and a scan would have been retained for analysis if there were useable data in at least one of the sample areas at one elevation, though for most scans, there was useable data in all sample areas at both elevations. There were roughly equal numbers of scans at the two stations, 12,285 at KCLE and 11,744 at KBUF (Table 2). However, number of scans differed by season: 9,857 in the spring, and 14,172 in the fall. In part, the smaller number of scans in the spring was due to shorter nighttime periods in that season. Table 3 summarizes the number of scans with useable data by sample area and radar elevation as well as season and year. For instance, for the Project Area, in spring 2014, there were 1,525 scans at the 0.5 degree elevation and 1,458 scans at the 1.5 degree elevation.

Table 2. Number of radar scans by station, season, and year

Season	Year	KCLE	KBUF	Total
Spring	2014	1834	1974	
	2015	1551	1720	
	2016	1798	980	
	Total	**5183**	**4674**	**9857**
Fall	2013	2364	2323	
	2014	2235	2075	
	2015	2503	2672	
	Total	**7102**	**7070**	**14172**
Total		**12285**	**11744**	**24029**

Table 3. Number of scans with useable data by sample area, season, year, and radar elevation. Sample areas are designated as in Figure 2: PA = Project Area; CA = Comparison Area.

Season	Year	Elevation	KCLE				KBUF		
			PA	CA1	CA2	CA3	CA4	CA5	CA6
Spring	2014	0.5°	1525	1573	1558	1573	1667	1816	1688
		1.5°	1458	1614	1610	1638	1378	1429	1300
	2015	0.5°	1180	1344	1305	1337	1496	1542	1516
		1.5°	1075	1246	1189	1262	1414	1475	1451
	2016	0.5°	1433	1499	1490	1517	696	876	706
		1.5°	1378	1540	1510	1516	535	634	533
Fall	2013	0.5°	1980	1989	1989	1991	1615	1601	1617
		1.5°	1907	1983	1942	1989	1936	1932	1936
	2014	0.5°	2120	2122	2127	2126	1683	1668	1677
		1.5°	2090	2137	2127	2140	1821	1809	1817
	2015	0.5°	2161	2163	2163	2172	2514	2525	2511
		1.5°	2123	2139	2150	2156	2563	2575	2543

Migration Direction

Target directions are summarized in Figures 4 and 5, and Table 4. Rose plots show the distribution of all direction data by season and radar elevation for KCLE (Figure 4) and KBUF (Figure 5). The corresponding mean directions and associated 95 percent confidence limits are shown by red lines on each plot. In general, target directions were consistent with expected seasonal migration patterns. In the fall, target directions were toward the southwest at KCLE (Figure 4a, c) and toward the south or south-southeast at KBUF (Figure 5a, c). In the spring, target directions were predominantly toward the north-northeast at both stations (Figures 4b, 4d, 5b, 5d). In terms of general patterns and means, target directions were similar at both radar elevations within seasons at each station. However, at KBUF in the fall, mean fall directions did differ somewhat between the two radar elevations. In all cases, there was substantial variation in direction; most of the rose plots show that at KCLE there were targets moving in all directions, irrespective of season and radar elevation. At KBUF, the patterns were more complicated. For instance, in the fall, there were very few targets with northerly headings between 270 degrees and 45 degrees, but otherwise, headings showed fairly wide dispersion (Figure 5a, c).

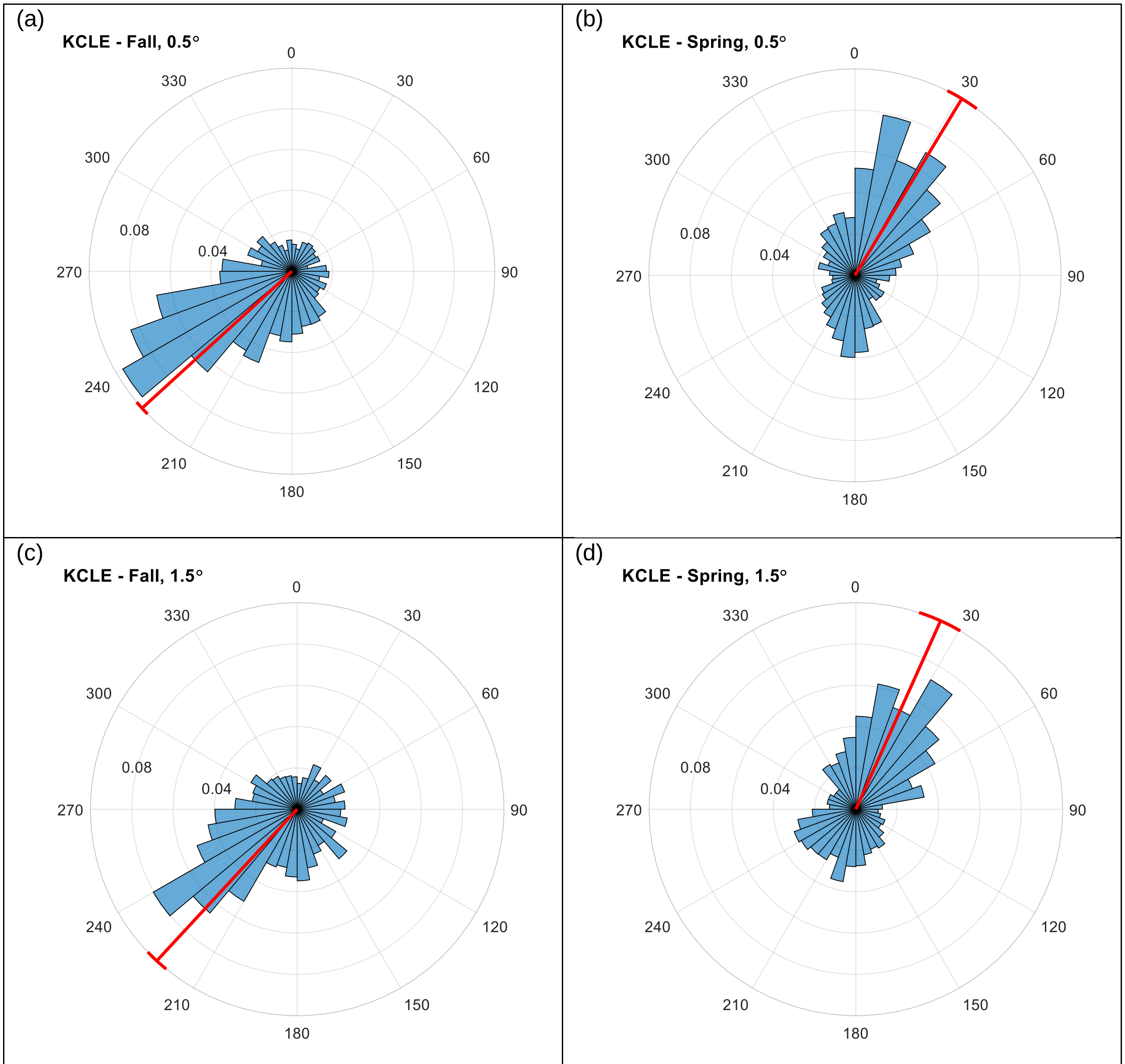


Figure 4. Rose plots showing target movement directions at KCLE at radar beam elevations of 0.5° (a and b) and 1.5° (c and d) in Fall (a and c) and Spring (b and d). Red lines indicate mean direction (radial segment) and 95% confidence interval (perpendicular "T" segment).

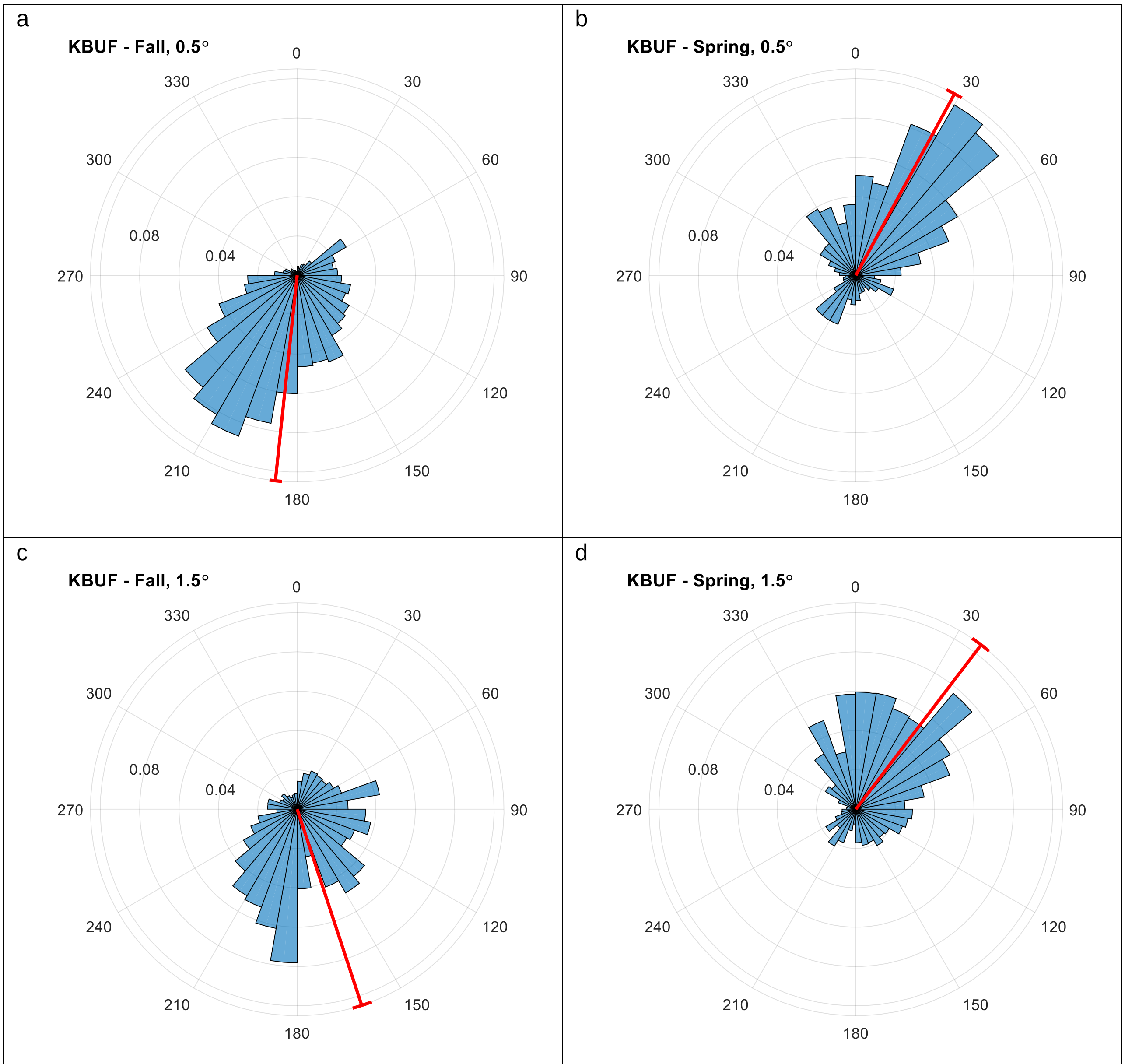


Figure 5. Rose plots showing target movement directions at KBUF at radar beam elevations of 0.5° (a and b) and 1.5° (c and d) in Fall (a and c) and Spring (b and d). Red lines indicate mean direction (radial segment) and 95% confidence interval (perpendicular "T" segment).

Table 4 provides statistical summaries (mean, concentration, and standard deviation) of direction by radar station, elevation, season, and year. For the most part, mean annual directions are consistent with the overall patterns in Figures 4 and 5. However, mean directions at KCLE in spring 2014 did not follow the expected pattern; that is, mean target headings were toward the southeast (154.5°) at the 0.5 degree elevation and toward the south-southwest (206.2°) at the 1.5 degree elevation. While there was also substantial variation in spring 2014 at KCLE; note that *r* was exceptionally low and, correspondingly, that *s* was high. More generally, target directions showed fairly high variability (low concentration); in most cases in Table 4, *r* was less than 0.5.

Table 4. Radar target direction summary: mean, concentration (*r*), and standard deviation (*s*) by station, season, year, and radar elevation.

			KCLE			KBUF		
Season	**Year**	**Elevation**	**Mean (°)**	***r***	***s* (°)**	**Mean (°)**	***r***	***s* (°)**
Spring	2014	0.5°	154.5	0.14	113.9	18.5	0.43	74.9
		1.5°	206.2	0.17	107.3	30.7	0.43	74.0
	2015	0.5°	14.1	0.41	76.3	43.3	0.54	63.7
		1.5°	14.9	0.40	77.3	49.1	0.46	71.7
	2016	0.5°	29.6	0.35	83.1	12.7	0.32	86.1
		1.5°	34.9	0.31	87.3	14.1	0.27	93.0
	All Years	0.5°	31.2	0.21	100.7	28.5	0.43	74.1
		1.5°	24.2	0.16	110.4	37.3	0.40	77.1
Fall	2013	0.5°	244.0	0.33	85.8	187.5	0.61	57.1
		1.5°	248.6	0.22	99.5	159.6	0.27	92.4
	2014	0.5°	219.2	0.49	68.4	199.5	0.68	50.5
		1.5°	217.1	0.38	79.6	175.3	0.36	82.3
	2015	0.5°	225.5	0.38	79.3	170.5	0.43	74.7
		1.5°	209.4	0.22	99.1	155.2	0.44	73.6
	All Years	0.5°	227.6	0.40	78.0	186.1	0.54	63.8
		1.5°	222.8	0.27	93.2	161.8	0.36	81.9

Migration Intensity

Migration intensity as represented by mean reflectivity varied among the seven sample areas at the two radar stations (Table 5, Figure 6). Overall mean reflectivity, averaged across season, year, and radar elevation, was lowest at the Project Area at KCLE (Figure 6a). Reflectivity was approximately twice as high at the two sample areas at KCLE overlapping the lakeshore (Comparison Areas 1 and 2) and somewhat greater at the inland sample area (Comparison Area 4). Mean reflectivity was highest at the two nearshore sample areas at KBUF (Comparison Areas 4 and 5), approximately eight times greater than mean reflectivity at the Project Area. At the inland KBUF sample area (Comparison Area 6), reflectivity was much lower than at the other two KBUF sample areas, though it was approximately 1.5 times greater than at the Project Area.

Table 5. Reflectivity by sample area (PA = Project Area, CA = Comparison Area). Each cell contains mean (top) and standard error (bottom) of reflectivity. (See also Figure 6.)

		KCLE				KBUF		
		PA	**CA1**	**CA2**	**CA3**	**CA4**	**CA5**	**CA6**
Overall		7.85 0.09	18.33 0.28	18.12 0.19	22.39 0.37	62.09 2.18	65.07 1.85	12.73 0.18
Elevation	0.5°	11.14 0.16	26.69 0.53	27.85 0.33	32.91 0.70	116.85 4.28	120.31 3.59	18.14 0.31
	1.5°	4.44 0.09	9.95 0.15	8.30 0.14	11.84 0.17	7.18 0.14	8.86 0.20	7.25 0.16
Season	Spring	6.44 0.13	16.13 0.58	16.11 0.28	20.63 0.76	65.71 3.66	56.14 2.64	6.89 0.15
	Fall	8.77 0.13	19.88 0.25	19.51 0.26	23.62 0.32	59.94 2.71	70.81 2.53	16.21 0.27
Year	2013 – 2014	6.02 0.12	15.55 0.33	14.42 0.29	19.22 0.47	116.69 5.38	103.15 4.36	13.07 0.29
	2014 – 2015	9.58 0.20	20.31 0.35	20.82 0.36	21.66 0.42	58.88 3.39	75.74 3.25	12.49 0.31
	2015 – 2016	8.05 0.16	19.21 0.68	19.23 0.34	26.16 0.87	8.25 0.22	15.55 0.59	12.63 0.34

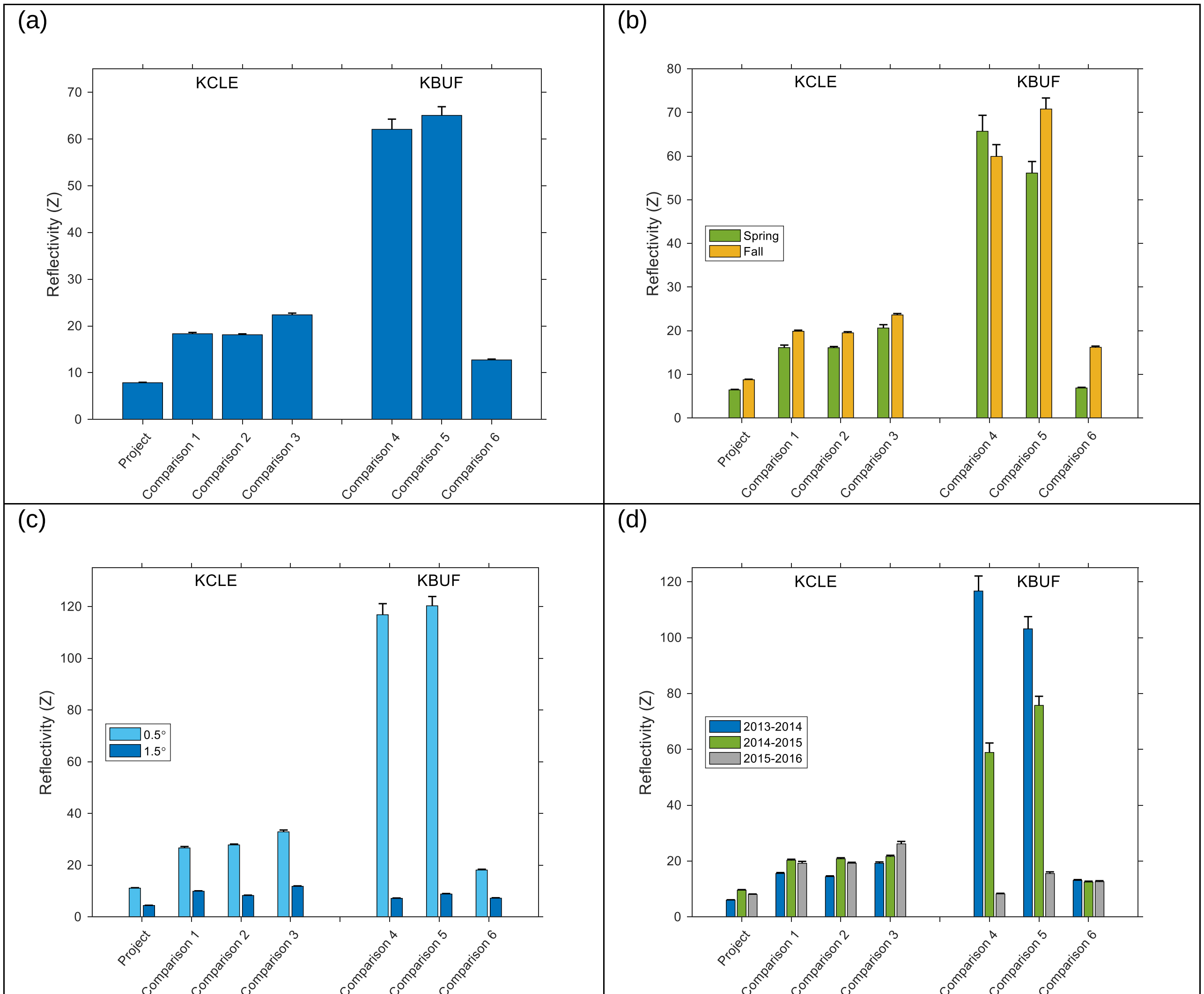


Figure 6. Mean reflectivity (bar heights) plus 1 standard error (error bars) at the seven sample areas:
(a) degrees overall – averaged across season, year, and elevation
(b) by season – averaged across year and elevation
(c) by elevation – averaged across season and year
(d) by year – averaged across season and elevation.

Reflectivity showed moderate seasonal variation at each of the sample areas, and was generally higher in the fall than in the spring, except at Comparison Area 4, where reflectivity was greater in the spring (Table 5, Figure 6b). For the seasonal analysis, reflectivity was averaged across year and radar elevation.

At each sample area there was substantial difference in mean reflectivity depending on radar elevation (reflectivity averaged across year and season) (Table 5, Figure 6c). In particular, reflectivity was at least twice as great at the 0.5 degree elevation as at the 1.5 degree elevation, though at Comparison Areas 4 and 5, the differences were particularly pronounced. That is, target densities were much greater at lower heights above the lake or land surface. In general, the differences among the sample areas seen in Figure 6a are due to reflectivity differences at the lower radar elevation (Figure 6c). At the greater radar elevation, the differences in reflectivity among the sample areas are relatively small.

For most of the sample areas, there was little to moderate annual variation in mean reflectivity (averaged across season and radar elevation) (Table 5, Figure 6d). Here, a year was arbitrarily defined as a fall season and the succeeding spring season, e.g., fall 2013 through spring 2014, such that there were three years of data. Interestingly, the annual variation in reflectivity was substantial at Comparison Areas 4 and 5; it can be seen that the high overall reflectivity at these two areas was due to exceptionally high values in 2013-2014, and 2014-2015. In contrast, mean reflectivity in 2015-2016 at these two areas was similar to values at the other sample areas.

Mean reflectivity varied by time of night, as defined by an hour after civil sunset, at both KCLE and KBUF, in both fall and spring (Figure 7). At KCLE, reflectivity increased each hour until five hours after civil sunset, and thereafter decreased hourly in both seasons (Figure 7a, b). At KBUF, the hourly pattern varied with season. In the fall, there was little if any initial increase, though reflectivity decreased from four hours after civil sunset until daylight (Figure 7c). In the spring, reflectivity increased until about seven hours after civil sunset, changed little for the next few hours, and then decreased substantially in the last hour before daylight (Figure 7d).

Reflectivity varied substantially by date throughout each season (Figures 8-11). No clear patterns are evident in the fall (panel a in Figures 7-10). In the spring, there is little activity throughout April compared to May, particularly at the Project Area (Figure 8b) and Comparison Area 2 (Figure 9b).

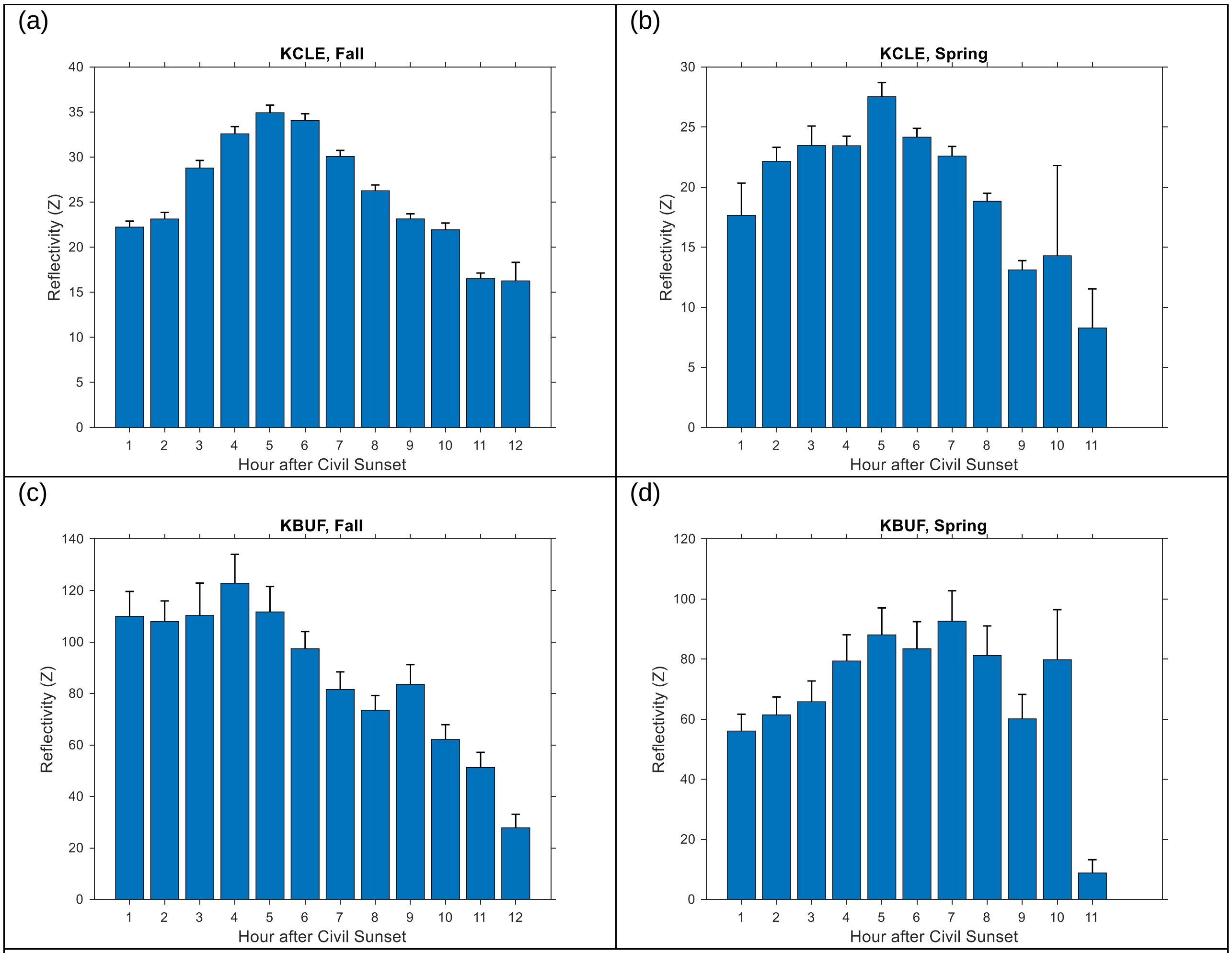


Figure 7. Mean reflectivity (bar heights) plus 1 standard error (error bars) by hour after civil sunset at KCLE and KBUF

(a) KCLE in fall
(b) KCLE in spring
(c) KBUF in fall
(d) KBUF in spring

All plots represent 0.5° elevation averaged across year and sample area. Note different Y-axis scaling in each plot.

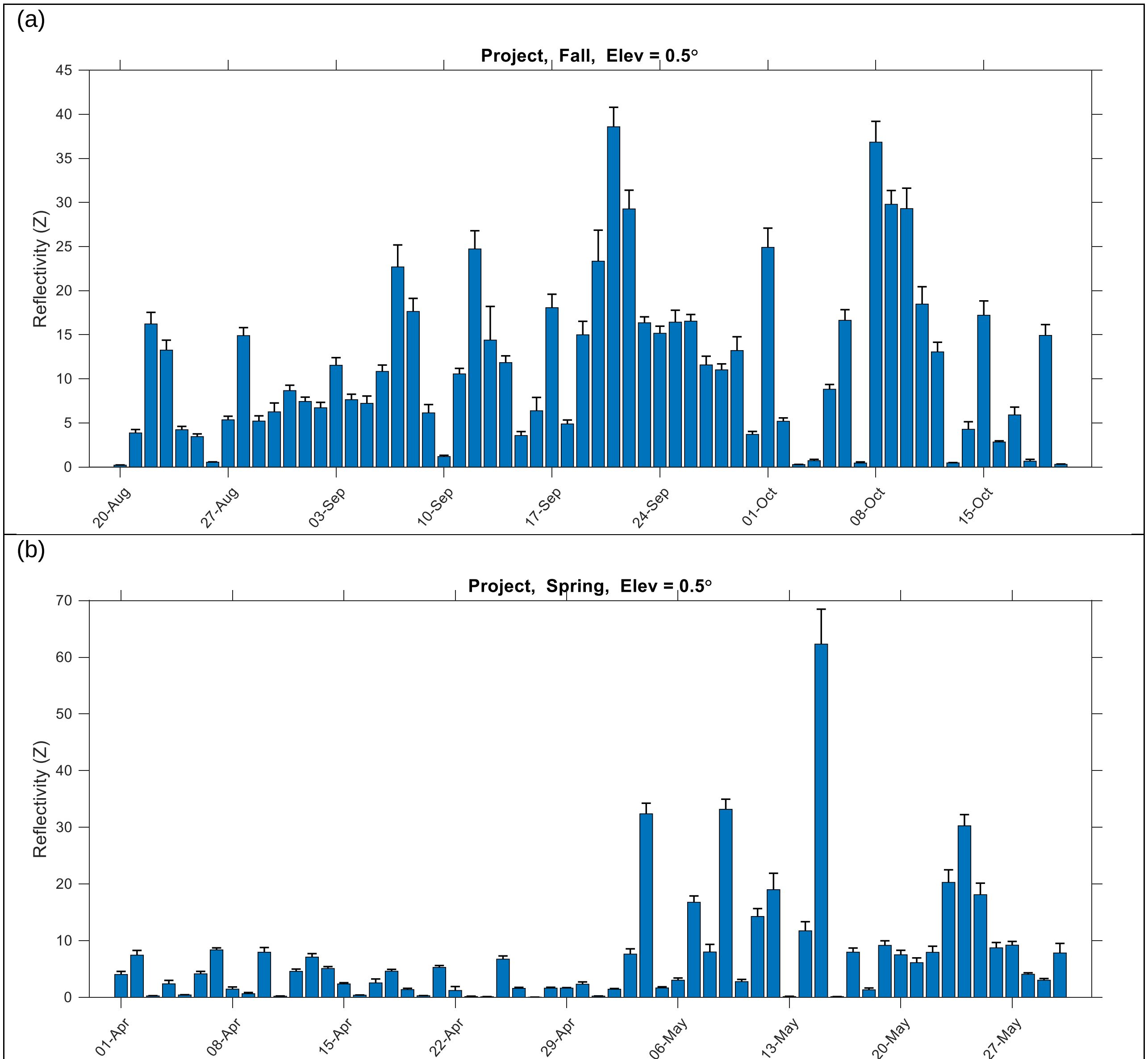
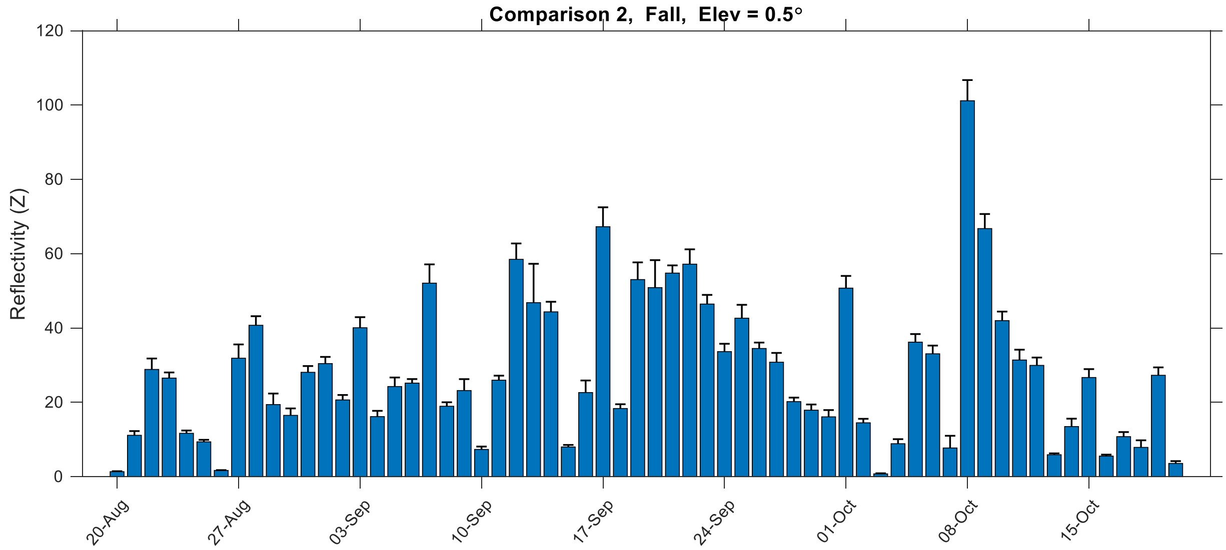


Figure 8. Mean reflectivity by day at the Project Area (KCLE) in (a) fall and (b) spring. Both plots represent 0.5° elevation averaged across year. Note different Y-axis scaling in each plot.

(a)



(b)

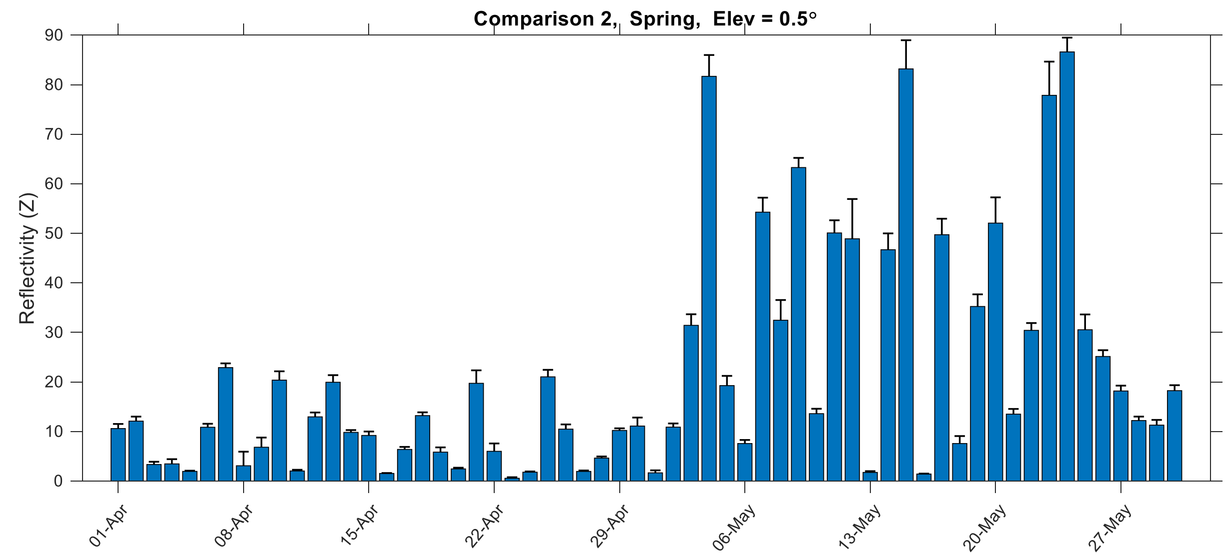


Figure 9. Mean reflectivity by day at Comparison Area 2 (KCLE) in (a) fall and (b) spring. Both plots represent 0.5° elevation averaged across year. Note different Y-axis scaling in each plot.

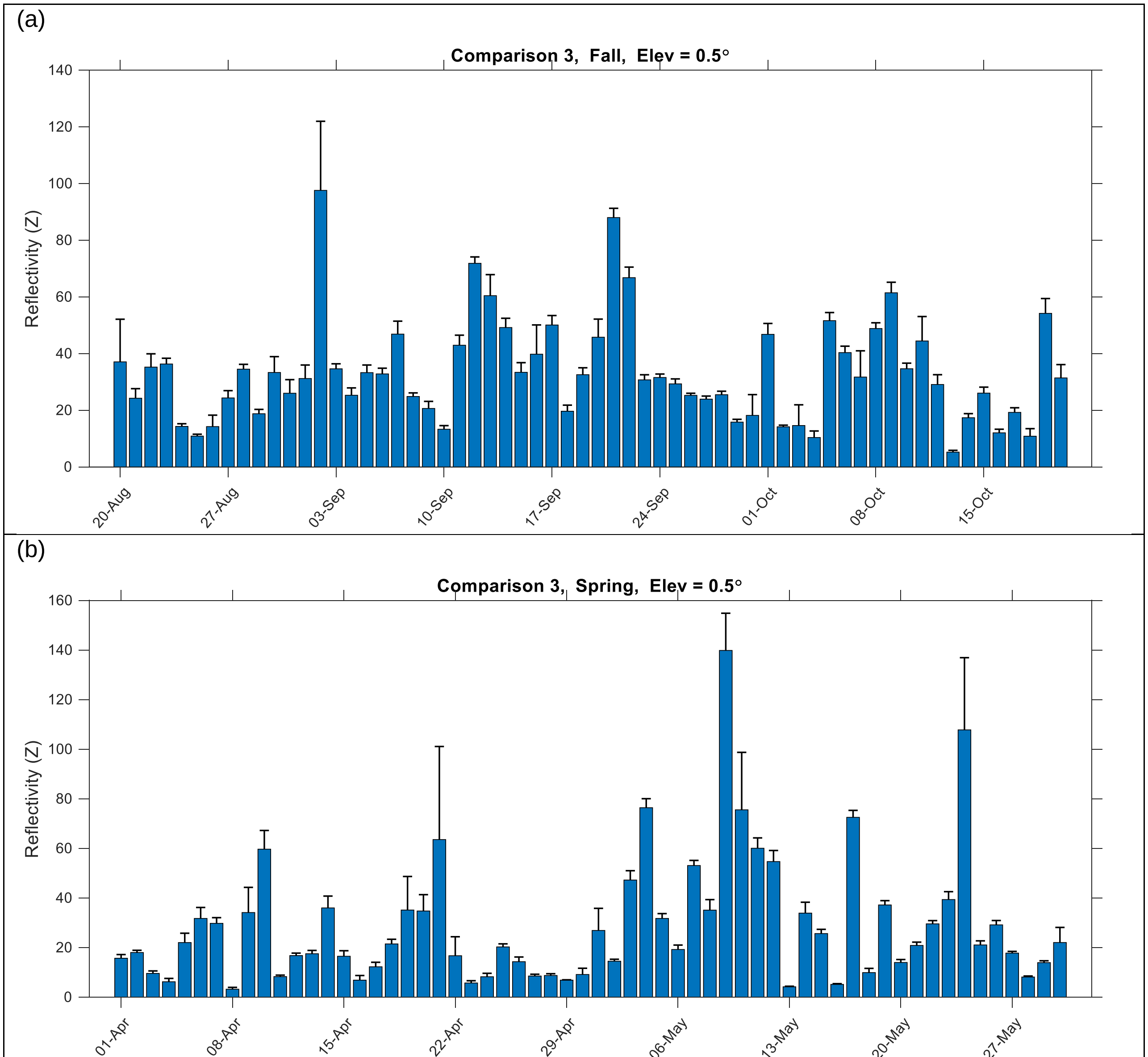


Figure 10. Mean reflectivity by day at Comparison Area 3 (KCLE) in (a) fall and (b) spring. Both plots represent 0.5° elevation averaged across year. Note different Y-axis scaling in each plot.

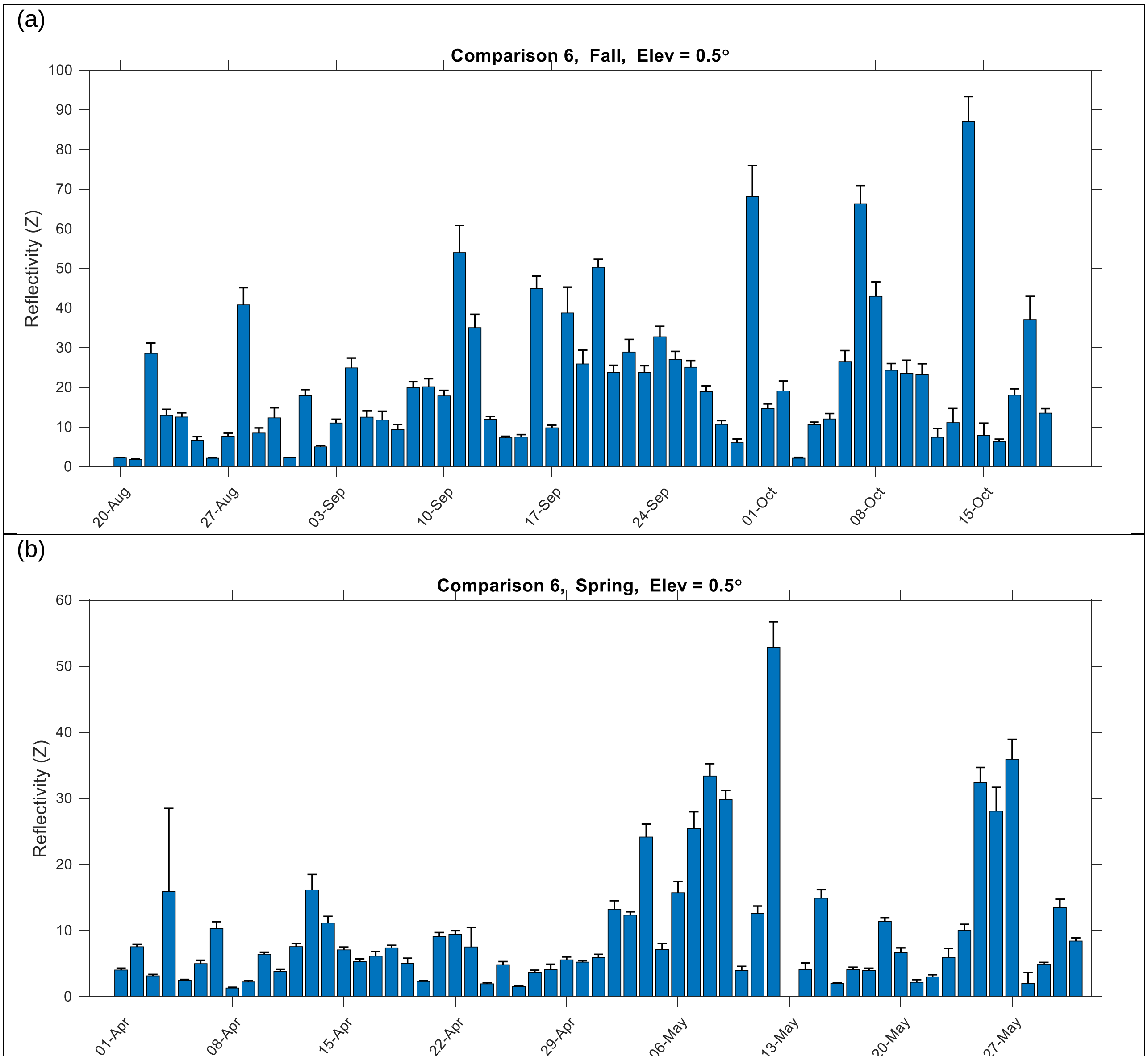


Figure 11. Mean reflectivity by day at Comparison Area 6 (KBUF) in (a) fall and (b) spring. Both plots represent 0.5° elevation averaged across year. Note different Y-axis scaling in each plot.

DISCUSSION

Caveats

The methods used here make at least two important assumptions. First, wind speed and direction from both radiosonde and wind models are assumed to be uniform over large spatial and temporal scales. That is, the wind is assumed to be constant over the region scanned by the radar for a relatively long period (up to 12 hours). Spatial and temporal variation in wind patterns will lead to errors in velocity filtering, which is intended to separate birds from slower-moving targets. Second, movement characteristics of radar targets (i.e., speed and direction) are treated as effectively uniform over large regions. Finer scale variation in target direction, velocity, or density will be obscured in this processing.

There are several other important limitations to this analysis. It cannot distinguish individual targets, nor can it distinguish birds from bats, nor any other target that might move faster than measured wind speed. Furthermore, the velocity filter is a fairly crude tool. For instance, slow-moving targets, such as birds soaring on the wind, will be automatically removed. Also, NEXRAD cannot detect targets that are close to the ground, except at very close range. In the case of KCLE, most near range data will necessarily be over land, or close to shore over Lake Erie.

Summary and Conclusion

Results from this analysis show that overall migration intensity inferred from mean reflectivity was lowest above the Project Area among all seven sample areas (Figure 6a). That relationship was also true when reflectivity was averaged by season (Figure 6b), radar elevation (Figure 6c), and year (Figure 6d). That is, migration intensity was lower at the Project Area than at all of the comparison sample areas in both spring and fall, at radar elevations of both 0.5 degrees and 1.5 degrees, and in all three years. Though, notably, migration at Comparison Area 6 in the spring was only slightly greater than at the Project Area in the same season (Figure 6b), and migration at Comparison Area 4 in 2015-2016 was only slightly greater than at the Project Area in the same year (Figure 6d).

At the KCLE station in Cleveland, the inland sample area, Comparison Area 3, had the greatest overall migration intensity, while the two areas above the shoreline, Comparison Areas 1 and 2, had migration that was intermediate to the inland and offshore areas (Figure 6a). Again, these patterns held true by season, radar elevation, and year (Figures 6b, 6c, 6d).

At the KBUF station in Buffalo, Comparison Areas 4 and 5, which were completely and partly above water, respectively, had much greater migration than any of the other sample areas (Figure 6). While this held true for both seasons, at the lower radar elevation, and for two of the three years of the study, it was not true at the 1.5 degree radar elevation nor in the last year (2015-2016). In those conditions, migration was generally greater in the other Comparison Areas. Thus, for the most part, the relative migration intensity at over-water and inland sites at KBUF was the reverse of the spatial pattern at KCLE. While the reason for these differences is not clear, it is noteworthy that Comparison Areas 4 and 5 at KBUF are situated at a very narrow section of Lake Erie at the eastern end of the Lake. Comparison Area 4 is entirely above water, but close to land on three sides (Figure 2b). The distance from south to north shore at this narrow end of the lake is less than 10 km.

Livingston (2008) conducted a study at KCLE for the proposed Icebreaker Wind Energy Facility. The methods in that earlier study differed from those of the current study in that the earlier study focused on a single sample area above the proposed project and, for that area, used data from the 0.5 degree radar elevation only. No other sample areas at that elevation were examined. Data from the 1.5 degree radar elevation were analyzed, though that analysis included the entire radar sweep, that is, a much larger area over both water and land. Thus, unambiguous comparisons of migration intensities over land and water, and, similarly, comparisons of migration intensities at the two radar elevations are difficult with the Livingston (2008) analysis. That said, the range of migration intensities over both seasons is comparable to values in this study. For instance, if bird densities in the upper panels of Figures 4 and 5 of Livingston (2008) are back-converted to reflectivity (Z), then it can be seen that on most nights of both spring and fall, mean reflectivity was less than 20 Z. Furthermore, on most of the remaining nights, mean reflectivity was in the range 20-40 Z. Those results are consistent with nightly variation seen in this study (Figure 8). Also, as in this study, fall migration intensity was generally greater than spring in Livingston (2008) (compare the upper panels of Figure 4 and 5, spring and fall, respectively, in Livingston, 2008).

Diehl et al. (2003) analyzed bird migration in the Great Lakes region using NEXRAD data from three stations (including KCLE and KBUF), and found that bird densities over land were generally greater than over water, consistent with results from KCLE in this study (Table 5 and Figure 6). Diehl et al. (2003) attributed this pattern in relative migration density to lake avoidance. That is, while large numbers of birds flew over the Great Lakes, even larger numbers remained over land during migration in both seasons.

Such avoidance behavior might account for the particularly high migration intensities seen at KBUF in two of the three years of this study. Bird migrating around the east end of Lake Erie might have chosen to cross this narrow section of water where land was nearby in three directions. Notably, while Diehl et al. found higher densities over land than over Lake Erie at both KBUF and KCLE, the difference at KBUF was small and not statistically significant.

In comparing seasonal patterns of migration, Diehl et al. observed that fall densities at KBUF were greater than spring densities over both land and water, though at KCLE densities were greater in spring than in fall. In this longer, three-year study, densities were generally greater in the fall than in the spring at both stations, though these seasonal differences were generally small (Figure 6b).

Results from this study suggest that bird/turbine collision risk for the proposed offshore project is lower than it would be for a similar project located near shore or onshore in the Cleveland area. Furthermore, based on variation in migration intensity, annual variation in risk and seasonal variation, with somewhat higher risk in fall, would be expected. Differences in migration intensity with radar elevation indicate that, at the Project Area, there are more than twice as many birds at the lower 0.5 degree elevation (Figure 6c). While the airspace sampled at this elevation does overlap with the rotor-swept zone, the extent of overlap is small (Figure 3), thus the migrant bird activity detected by this lower beam primarily comes from altitudes immediately above the rotor swept zone of the turbines. Given the limitations of NEXRAD resolution, it is not possible to determine the precise flight altitudes of birds within the radar beam.

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Icebreaker Survey Protocol Matrix

Monitoring Method				Monitoring Objectives (X = primary value, (x) = secondary value)							Monitoring Design			
General type	Specific system	Location	Platform	Bat Collision	Bird Collision	Displacement	Behavioral Attraction/ Avoidance	Exposure	Species specific data?	Comment	Season	Frequency	Duration	# units
Bat Nets: aerial net/mesh with cameras	Experiment -al (TBD) Limited (e.g. 25 m) radius net/grid for carcass capture, combined with density-weighted area correction	Project site	Turbine(s)	X					Partial	needs to be developed, along with methods for data collection and bias correction	March 15-Nov 15 (ODNR bat season)	continuous, daily photos w game cameras	continuous	3
THUNK: acoustic/vibrational collision detection with cameras	Experi-mental (OSU)	Project site	Turbine(s)	X	X				Partial	Species ID depends on camera components functioning. Not demon-strated in presentation	year-round	continuous	continuous	3
Identiflight Stationary video monitoring	Identiflight (RES-Boulder Imaging)	Project site	Turbine(s)	(x)	(x)		(x)	X	Yes	Designed for diurnal exposure monitoring, collisions and nocturnal would be experimental	year-round	continuous	continuous	2
Aerial High-resolution Imaging Survey	APEM	Project site	Fixed wing plane fly at 600m			X			Yes	Surveys safer and data quality superior to live-observer surveys	Oct 15 - May 15 (ODNR baseline season)	Twice per month (ODNR protocol	1-2 hours	1
Aerial High-resolution Imaging Survey	Hi-Def, Inc - BRI	Project site	Fixed wing plane fly at 600m			X			Yes	Surveys safer and data quality superior to live-observer surveys	Oct 15 - May 15 (ODNR baseline season)	Twice per month (ODNR protocol	1-2 hours	1

Monitoring Method				Monitoring Objectives (X = primary value, (x) = secondary value)							Monitoring Design			
General type	Specific system	Location	Platform	Bat Collision	Bird Collision	Displacement	Behavioral Attraction/ Avoidance	Exposure	Species specific data?	Comment	Season	Frequency	Duration	# units
Aerial Live Observer Survey		Project site	Fixed wing plane fly at 75m			X			Yes	Surveys more hazardous and data quality inferior to imaging surveys (birds disturbed, limited ID, imprecise sample area)	Oct 15 - May 15 (ODNR baseline season)	Twice per month (ODNR protocol	1-2 hours	1
Marine Radar	Detect Merlin (S band in both vertical and horizontal)	3 miles offshore, 5 miles from site	Crib (yr1, turbine yrs 2,3)				(x)	X	No	Detect says can't do it on a boat; Need approval from CLE water dept.; distance from site	Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	5 nights/week (ODNR protocol)	continuous	1
Marine Radar	DHI Scanter 5000	3 miles offshore, 5 miles from site	Crib (yr1, turbine yrs 2,3)				(x)	X	No	Would probably need approval from water dept.	Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	5 nights/week (ODNR protocol)	continuous	1
Marine Radar	DHI Furuno solid state (horiz) and x band (vert)	Project site	Boat (yr 1 only)					X	No	Boat based radar will have lower data quality; clutter issues; at the site	Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	5 nights/week, weather dependent (ODNR protocol)	2 hours/night	1
Marine Radar	Accipiter PS1-8A (X-band, with ability to rotate horiz and vert)	Project site	Boat (yr 1 only)					X	No	Boat based radar pros and cons (see above); provider says it can go on buoy	Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	5 nights/week weather dependent(ODNR protocol)	2 hours/night	1

Monitoring Method				Monitoring Objectives (X = primary value, (x) = secondary value)							Monitoring Design			
General type	Specific system	Location	Platform	Bat Collision	Bird Collision	Displacement	Behavioral Attraction/ Avoidance	Exposure	Species specific data?	Comment	Season	Frequency	Duration	# units
Marine Radar	Accipiter PS1-8A (X-band, with ability to rotate horiz and vert)	3 miles offshore, 5 miles from site	Crib (yr1, turbine yrs 2,3)				(x)	X	No	Crib pros and cons	Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	5 nights/week (ODNR protocol)	continuous	1
Marine Radar	SRC SR Hawk	3 miles offshore, 5 miles from site	Crib (yr 1, turbine yrs 2, 3)				(x)	X	No	Crib pros and cons	Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	5 nights/week (ODNR protocol)	continuous	1
NEXRAD Radar		Project site and comparison sites	KCLE and KBUF Weather Stations					X	No	limited info on target altitude	Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	flexible, extensive	continuous	N/A
Bird Acoustics	WA Songmeter SM4	Project site	Buoy (yr1), turbine (yrs 2, 3)					X	Partial		Apr 15-May 31, Aug 15-Oct 31 (ODNR songbird migr season)	continuous	nocturnal	2
Bat Acoustics	WA SM4Bat	Project site	Buoy (yr1), turbine (yrs 2, 3)					X	Partial		March 15-Nov 15 (ODNR bat season)	continuous	nocturnal	2
Stationary Live Observer		Project site	Turbine(s)		(x)		X	X	Yes		Apr 15-Nov 15 (based on suitable weather)	weekly	4 hours	4 people

ICEBREAKER WIND: SUMMARY OF RISKS TO BIRDS AND BATS

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EXECUTIVE SUMMARY

The Lake Erie Energy Development Corporation (LEEDCo) has proposed the Icebreaker Wind project, a small, demonstration 6-turbine, 20.7-megawatt (MW) offshore wind energy facility eight to 10 miles (13 to 21 kilometers [km]) from the shore of Cleveland, Ohio. WEST has completed a review and summary of baseline data and other publicly available data on bird and bat use and other information of the Project's environment for the purpose or evaluating the level of risk posed by the proposed project to birds and bats. The overall conclusion of this analysis is that the Project poses low risk of adverse impacts to birds and bats. This conclusion stems largely from two principal observations: 1) the Project is small in scale, consisting of six turbines; 2) the level of use of this area by birds and bats is low compared to bird and bat use of terrestrial or nearshore environments.

The potential for *displacement* effects, defined as the transformation of the Project area from suitable habitat to less suitable habitat by virtue of Project construction or operation, was evaluated by examining data on the use of the Project site and other offshore environments in the central Lake Erie basin by birds and bats for activities other than transit, in the context of technical literature on the subject. Our analysis indicated that the risk of displacement effects is likely low for Icebreaker Wind. This is because baseline data have shown that the use of the Project area as a habitat for anything other than migratory transit by any bird species is minimal or negligible. In a baseline aerial survey effort conducted by the Ohio Department of Natural Resources over a large portion of Lake Erie, including the Project site, between 2009 and 2011, only six species of waterbirds were documented within the vicinity of the Project area at densities that can be considered above negligible or occasional. Three of these species were gulls (Bonaparte's Gull, Ring-billed/Herring Gull), with averages roughly between one and five individual birds observed in the Project area and vicinity per survey during the baseline survey effort. For the other three species, (Horned Grebe, Common Loon, and Red-breasted Merganser), averages of roughly one individual or fewer were observed within the Project area and vicinity per survey during the baseline survey effort. At such low densities, statistically significant displacement effects would not likely be detectable with a realistic survey effort. For the same reason, there is not a reasonable likelihood that any such effects could be biologically significant for any species.

The potential for behavioral *avoidance or attraction* effects was evaluated by examining post-construction monitoring results of other offshore wind energy facilities, and by reviewing technical literature on this subject. Behavioral avoidance is defined as the avoidance of the Project by bird or bat species that would otherwise use the Project area strictly for transit. Behavioral attraction is defined as attraction to the Project area by bird or bat species that would otherwise utilize the area less frequently or not at all. The conclusion of our analysis is that Icebreaker Wind does have the potential to generate both behavioral avoidance and attraction effects in some groups of birds or bats. Although the passage rates of migrating birds through the Project area are expected to be lower than on land, along the shore of Lake Erie, or in near-shore waters, some migrating birds and bats from a variety of taxa are likely to migrate through the Project area on a regular basis. After construction some migrating birds and bats may detect the presence of the facility and fly around it. In such cases, the additional energy expenditure of this avoidance behavior is expected to be negligible, as has been demonstrated at offshore wind projects in Europe. Therefore, the potential for adverse effects from this behavior is likely negligible. Other birds and bats flying in the vicinity of the Project area may be attracted to the facility. This is not likely to occur in nocturnal migrant birds, as the Project will utilize flashing red aviation obstruction lights, which do not attract nocturnal migrants or other birds. Attraction effects are more likely to occur with some diurnal waterbirds such as gulls and cormorants, as has been demonstrated in Europe, and may also occur with additional taxa, including bats.

The potential for *collision* effects was evaluated by examining data on the use of the Project site and other offshore environments in the central Lake Erie basin by birds and bats, including merely for transit, contextualized with information on taxon-specific wind-turbine collision susceptibility patterns from technical literature and publicly available post-construction monitoring reports from other wind energy facilities. The overall conclusion of our analysis was that total fatality levels of birds and bats are expected to be lower for Icebreaker Wind than for land-based wind energy facilities in the region. Previous risk analyses and correspondence with the US Fish and Wildlife Service has indicated that no federally listed bird or bat species are likely to be affected. The Project is not likely to generate population-level effects for any species. These conclusions are based primarily on the low use of offshore environments within the central Lake Erie basin by birds and bats, as well as the small size of the Project, and are also influenced by known patterns of taxon-specific collision susceptibility and species' geographic ranges.

No eagles or other raptors regularly forage 8-10 miles offshore, minimizing exposure to collision risk in this group of birds. A small number of eagles and other raptors may be exposed to collision risk if they encounter the Project while migrating across Lake Erie; however, eagles and other raptors tend to avoid migrating over large water bodies such as Lake Erie, and no raptors were documented within 10 miles of the Project area during a 2-year baseline survey effort. Therefore, we conclude that collision risk is low for eagles and other raptors.

For waterfowl and other waterbirds, baseline aerial survey data have shown that the spatial utilization pattern of such birds is largely restricted to the first three to six miles (five to 10 km) from shore in the central/southern Lake Erie basin, with minimal or negligible density of waterfowl and other waterbirds in the vicinity of the proposed Project area. Furthermore, available evidence from both offshore and onshore wind energy facilities indicates that wind turbine collision susceptibility is generally low for these bird types. Certain waterbird species, notably Double-crested Cormorants and several species of gulls, may experience higher levels of exposure to potential collision risk if they are attracted to the Project subsequent to construction, but collision susceptibility is generally regarded to be low for these bird types, hence overall risk is low. Additional insight into the potential for such effects can only be gained from post-construction observations.

For bats, the likely per megawatt bat fatality rate at Icebreaker Wind must be predicted with caution due to the well-known complexity of the relationship between pre-construction bat acoustic activity rates and post-construction bat fatality rates at land-based wind energy facilities in the Midwest and nation-wide. Although bats are primarily terrestrial animals, some species are likely to cross Lake Erie and the Project area on a regular basis, particularly as they are migrating, and the extent to which bats may be attracted to the Project's turbines as they are migrating across the Lake is not well-known and cannot be determined through additional baseline data gathering. The overall bat collision risk is low for Icebreaker Wind, nonetheless, because even if the Project results in fatality rates that are toward the upper end of the distribution of per megawatt bat fatality rates at regional land-based wind projects, the small size of the Project limits the total (facility-wide) bat fatality rate to one that would be moderate, at worst, in relation to land-based wind energy projects in the Great Lakes region.

Nocturnally migrating songbirds and similar birds may be exposed to collisions with Icebreaker Wind's turbines as they migrate across Lake Erie in spring and fall, though the terrestrial habitats of bird species in this category naturally restricts potential collision exposure to migratory flights. As a group, nocturnally migrating songbirds and similar birds exhibit low general susceptibility to collisions with wind turbines. Furthermore, a region-wide analysis of NEXRAD radar data performed by an independent research team of government and academic scientists demonstrated that the density of songbird migration over the central Lake Erie basin was less than one half of what it was over terrestrial environments within the region. Several recent studies employing marine radars in shoreline environments have demonstrated relatively high densities of nocturnal migrant birds along the shorelines of Lake Erie and Lake Ontario, reinforcing our understanding of the tendency of such migrants to concentrate along coastlines and avoid flying over large water bodies, such as Lake Erie, if possible. On the basis of this information, and also in light of the small size of the Project, we conclude that the collision risk for nocturnally migrating songbirds and similar birds is low.

The relationship between pre-construction bird and bat use, or "exposure" data and post-construction collision fatality at wind energy facilities is known to be complex. However, the baseline information on bird and bat abundance in the offshore environment of the central Lake Erie basin can be compared with publicly available, bias-corrected bird and bat fatality rates for land-based wind energy facilities in the Great Lakes region. We applied such comparisons to make rough, quantitative predictions of the collision fatality rates that Icebreaker Wind is likely to generate for bats and birds. Such comparisons indicate that bat fatality rates are most likely to be on the order of one to four bats/MW/year, which would lead to roughly 21 to 83 total bat fatalities/year for the facility. We note that bat fatality rates could be as high as 20-30 bats/MW/year if there is a substantial behavioral attraction effect, but the small size of the Project limits the magnitude of this risk to a moderate level in relation to other regional wind energy facilities even under this worst case scenario. For birds, fatality rates are most likely to be on the order of one or two birds/MW/year, or 21 to 42 total birds/year for the facility. At these levels, the collision fatalities caused by Project Icebreaker do not have a reasonable likelihood of generating a population-level impact for any species of bird or bat, particularly as these fatalities are not likely to affect any listed species, and will be distributed among many species, further lessening the impact on any one species.

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INTRODUCTION

This document presents an analysis of the nature, intensity, and likelihood of risks to birds and bats posed by the development of Icebreaker Wind (also known as the "Project" or "Icebreaker"). Icebreaker is a small-scale wind demonstration project (a six-turbine 20.7-megawatt [MW] facility) that would be located in Lake Erie eight to 10 miles (13 to 21 kilometers [km]) offshore of Cleveland, Ohio. The Project is being developed by the Lake Erie Energy Development Corporation (LEEDCo) and Icebreaker Windpower Inc., a subsidiary of Fred. Olsen Renewables USA. One of the key advantages of developing commercial wind energy facilities in the offshore environment is that bird and bat risks are generally regarded to be lower than on land, as all bats and most birds are generally terrestrial animals (Schuster et al. 2015). Nonetheless, there is still a great deal of uncertainty regarding the potential for offshore wind energy to create adverse impacts on birds and bats, owing partially to the newness of offshore wind energy relative to land-based wind energy development, particularly in the US, and also to the inherent difficulties in gathering data on wildlife risks and impacts in the offshore environment. This uncertainty is one of the primary reasons for constructing a small demonstration project such as Icebreaker Wind as the first offshore wind energy development in the Great Lakes. As such, Icebreaker will be able to serve as a platform for gathering information that will be useful for decision-making regarding future development in the region.

Beginning in 2008, LEEDCo conducted a variety of Project-specific bird and bat baseline studies for the purpose of providing information on the risks posed to birds and bats by the proposed Project to support the risk determinations and permitting processes required by state and federal authorities (Geo-Marine, Inc 2008; Svedlow et al. 2012). These baseline studies have been supplemented by several systematic expert reviews of bird and bat risk issues associated with the Project, in which Project-specific data have been interpreted in the context of available data from independently performed field studies, publicly available databases, and technical literature (Kerlinger and Guarnaccia 2013, Kerlinger 2016). The need for this additional summary stems from the availability of new information germane to bird and bat risk considerations that has arisen or been identified subsequent to the Project's most recent application for a Certificate of Environmental Compatibility and Public Need to the Ohio Power Siting Board in 2014.

The intent of the current analysis is to present an updated synthesis of available information relevant to the consideration of bird and bat risks posed by the Project. All of the information presented in the baseline studies and previous risk analyses for Icebreaker is not fully recapitulated in this document, but all of the available information germane to each risk-related topic has been incorporated into the current analysis, with particular sources of information weighted according to their relevance with regard to addressing the risk-related questions. The analysis is organized by effect type, and then by taxon (for collision effects).

DISPLACEMENT EFFECTS

The potential for generating a displacement effect, defined as the transformation of an area from being suitable habitat to being unsuitable habitat for one or more wildlife species, is an important wildlife risk consideration for some land-based and offshore wind energy facilities (Drewitt and Langston 2006, Strickland et al. 2011). In wind-wildlife literature, such effects are most often associated with wildlife species that are known or hypothesized to avoid occupying areas in which tall structures, or significant anthropogenic activity/disturbance is present. For land-based wind farms in the US, displacement effects have received the most attention in relation to grassland and shrub-steppe obligate species (e.g., Greater and Lesser Prairie-Chickens [*Tympanuchus cupido* and *T. pallidicinctus*], Sage Grouse [*Centrocercus urophasianus*], Grasshopper Sparrow [*Ammodramus savannarrm*]; Strickland et al. 2011, LeBeau et al .2016). In the offshore realm, displacement effects have been hypothesized or examined primarily in certain species of waterfowl and other waterbirds (e.g., loons, alcids) that are known to forage regularly in marine areas where offshore wind facilities have been proposed or installed (Petersen and Fox 2007, Walls et al. 2013). Displacement effects are considered herein in the sense most commonly applied in wind-wildlife literature, referring only to use or avoidance of foraging, roosting, breeding, or wintering habitats. The use or avoidance of areas that are occupied by wildlife species strictly for transit is considered separately below under “behavioral avoidance.”

In the case of Icebreaker Wind, there is minimal potential for displacement effects, as there is minimal to negligible utilization of the Project area by any bird or bat species for anything other than transit. This pattern was documented through an aerial baseline survey effort conducted over a two year period (2009-2010 and 2010-2011) by the Ohio Department of Natural Resources (ODNR) over a large portion of the south-central Lake Erie basin, including the Project area (Norris and Lott 2011). This survey effort consisted of weekly, low-altitude (ca. 76 meter [m; 248 foot (ft)]) flights during fall (mid-October through mid-December) and spring (mid-March through mid-May) seasons, with expert observers gathering bird observations from aboard a small twin-engine fixed-wing aircraft flying at a speed of roughly 120 knots (138 miles [222 km] per hour). The 2-year survey effort resulted in a total of 24,395 miles of flight along the transect pattern shown in Figure 1, during which a total of 725,785 individual bird observations was collected, representing at least 51 bird species.

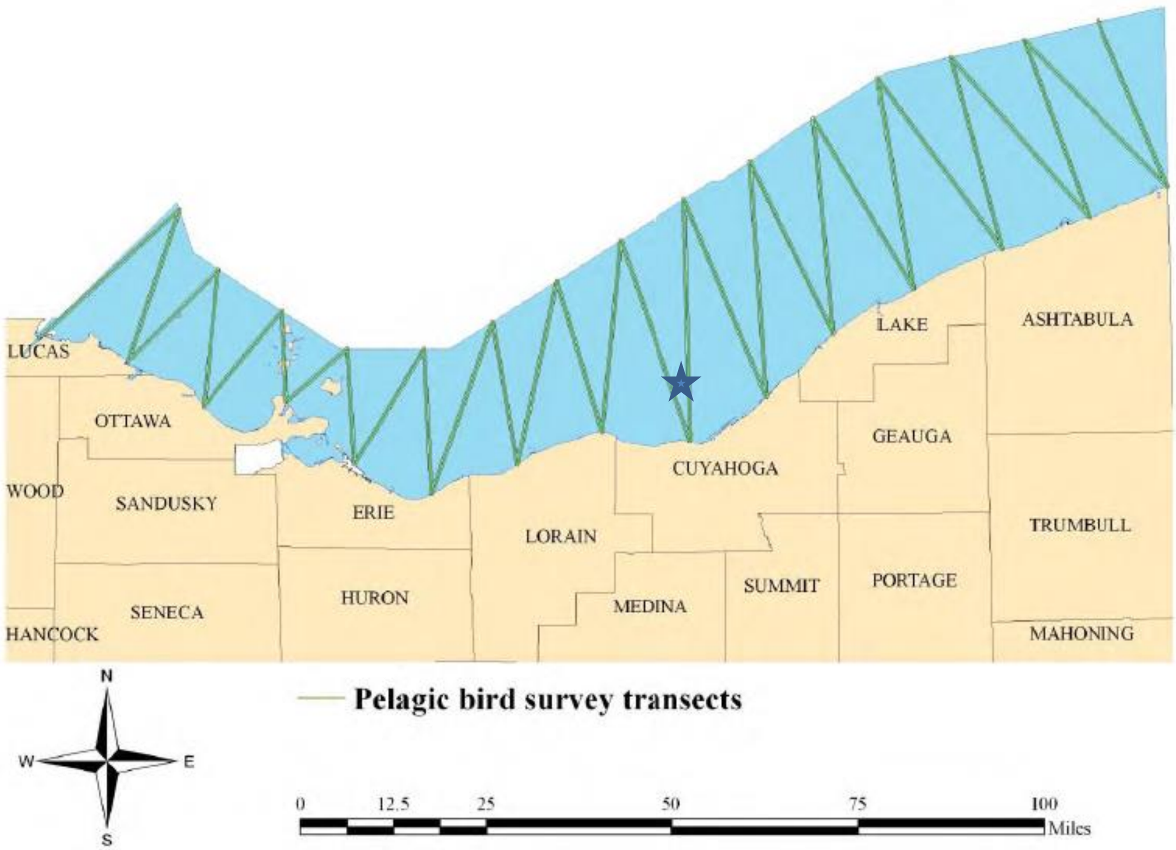

Figure 1. Aerial flight transect pattern flown during the Norris and Lott (2011) pelagic bird surveys in Lake Erie during 2009-2011. The approximate proposed location of Icebreaker Wind is shown by the blue star (Figure reproduced from Norris and Lott 2011).

In order for Icebreaker Wind to have the potential to generate a displacement effect, the Project area must be utilized by wildlife species prior to the construction of the facility. Data from both years of the ODNR survey effort indicate that the abundance of birds was negligible (Year 1) or minimal (Year 2) at distances between eight and 10 miles from shore, corresponding to the zone in which the Project has been proposed (Figures 2 and 3). Examination of species-specific and spatially-explicit patterns in the ODNR survey data (Norris and Lott 2011 appendix C) indicated that the only species that may occur in the vicinity of the Project area on a somewhat consistent basis are Red-breasted Merganser (*Mergus serrator*), Common Loon (*Gavia immer*), Horned Grebe (*Podiceps auritus*), Bonaparte's Gull (*Chroicocephalus philadelphia*), and Ring-billed/Herring Gull (*Larus delawarensis*/*L. argentatus*; Norris and Lott 2011). For the merganser, loon, and grebe, the density of birds in the vicinity of the Project area documented by Norris and Lott (2011) was roughly one bird per survey or lower. For the gulls, the density may have been as high as five birds per survey. At such low densities, a statistically significant displacement effect resulting from the presence of the Project would be difficult to detect. For the same reason, there is no reasonable likelihood that such an effect would be biologically significant for any species.

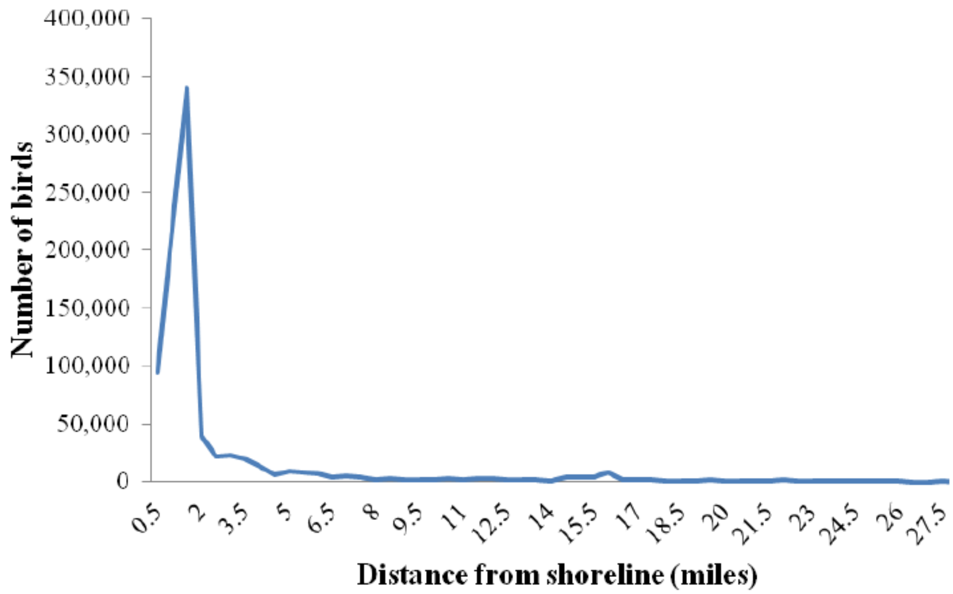

Figure 2. Total bird observations in relation to distance from shoreline along the southern shore of Lake Erie as recorded in Year one (fall 2009 – spring 2010) of the aerial pelagic bird survey effort conducted by the Ohio Department of Natural Resources. (Figure reproduced from Norris and Lott 2011).

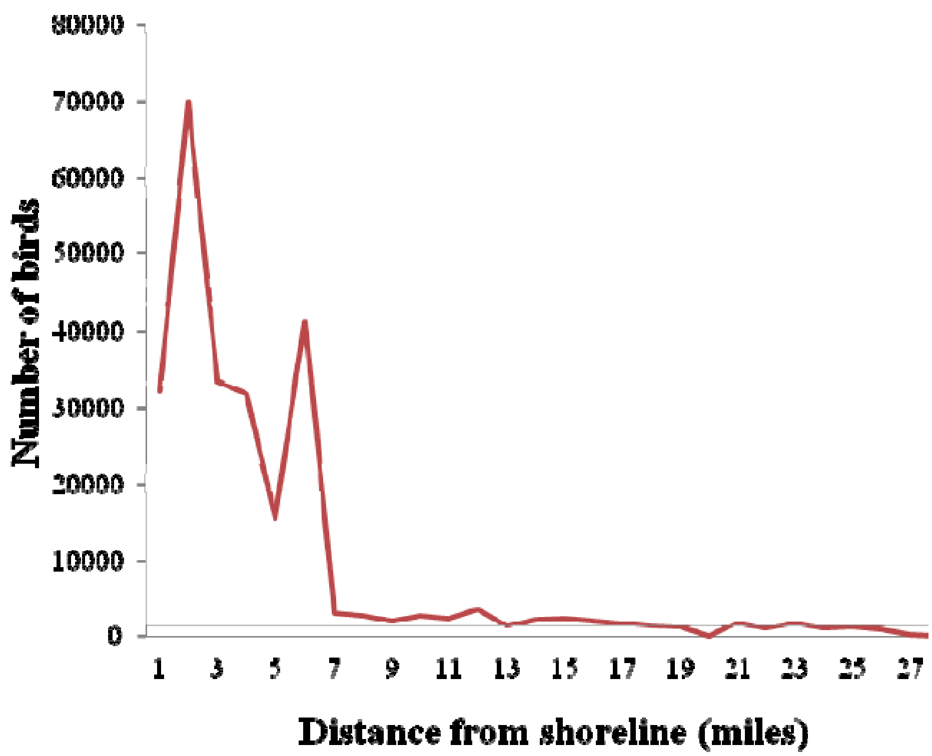

Figure 3. Total bird observations in relation to distance from shoreline along the southern shore of Lake Erie as recorded in Year two (fall 2010 – spring 2011) of the aerial pelagic bird survey effort conducted by the Ohio Department of Natural Resources (Figure reproduced from Norris and Lott 2011).

BEHAVIORAL AVOIDANCE/ATTRACTION EFFECTS

Behavioral avoidance effects are defined herein as the avoidance of a constructed facility by wildlife species whose only utilization of the Project area would be strictly for transit (i.e. passing through on migratory or "commuting" flights). Avoidance of the Project area by species that might otherwise use the area as foraging or roosting habitat is considered separately in this analysis as a displacement effect (see previous section). Behavioral avoidance of a wind facility by a bird or bat may have a beneficial effect, as it will generally reduce collision risk, but it may also generate an adverse effect in the form of increased energy expenditure required to fly around a turbine or the facility.

In the case of Icebreaker Wind, the potential for adverse effects on wildlife from behavioral avoidance is negligible, as the additional energetic expenditure required for migrating birds or bats to fly around the Project will be negligible. This conclusion is based on the findings of Masden et al. (2009), who found that the additional energetic expenditure required for migrating birds to circumvent the Nysted Offshore Wind Energy Facility in the Danish Baltic Sea was negligible in relation to the overall energetic cost of their migratory journey. The Project will occupy a relatively small above-water footprint, consisting of a linear array of six turbines and measuring roughly two miles (three km) in length, substantially smaller than the dimensions of the facility studied by Masden et al. (2009). In addition, the Project's turbines would be spaced at approximately 600 meter intervals, providing space for birds to fly between turbines.

Icebreaker Wind has a high likelihood of generating attraction effects in some species of birds and/or bats, as above water structures in general, and offshore wind turbines in particular, are known to attract certain species for whom such structures may represent places to perch and roost. The phenomenon of bats' potential attraction to wind turbines is still poorly understood, but recent studies have indicated that some bats may be attracted to wind turbines under some circumstances (McAlexander 2013, Cryan et al. 2014). Krijgsveld et al. (2011) demonstrated attraction of cormorants and gulls to the structures of the Egmond aan Zee Offshore Wind Energy Facility in the Netherlands. Several species of gulls and one species of cormorant occur regularly on Lake Erie, and may be similarly attracted to the structures of Icebreaker. Similar to behavioral avoidance, behavioral attraction to offshore wind turbines may have both beneficial and adverse effects on flying wildlife. Beneficial effects may include increased availability of roosting and/or foraging sites in an otherwise inhospitable or unfavorable environment. Adverse effects may include increased exposure to collision risk. One feature relevant to the likelihood of attracting flying wildlife is that flashing red aviation obstruction lighting will be installed on the nacelles of the turbines for Project Icebreaker. Such lighting does not appear to attract nocturnally migrating birds (Kerlinger et al. 2010, Gehring et al. 2012); hence, the Project is not likely to attract substantial numbers of such birds.

COLLISION EFFECTS

It is well-known that some birds and bats can experience mortality or injury due to collisions or near-collisions with wind turbines (Strickland et al. 2011, Schuster et al. 2015). Bird and bat collision fatality rates at land-based wind energy facilities have been particularly well-studied in North America, where intensive and systematic carcass searching studies have been accompanied by sophisticated methods for adjusting the raw data to account for biases caused by limited carcass detectability and carcass removal by scavengers. For birds, recent reviews of bias-corrected fatality rate estimates have indicated a fairly consistent pattern, with an overall average US rate of roughly four to five birds killed per MW of installed wind capacity per year (4.11 birds/MW/year reported by Loss et al. 2013). For bats, there is a greater degree of variation in fatality rates across land-based wind energy facilities, and overall fatality rates are generally higher than they are for birds (Arnett et al. 2013).

Beyond simple rates, one of the most important patterns that has emerged from bird and bat collision fatality studies at land-based wind energy studies to date is that collision susceptibility is highly taxon- or guild-specific for both birds and bats (Strickland et al. 2011, Arnett et al. 2013, Schuster et al. 2015). For many bird species, susceptibility appears to be most closely related to species' overall abundance, and the amount of time a species spends flying within rotor swept altitudes, with an additional influence of behavioral and morphological factors (Strickland et al. 2011). The majority of bird fatalities at land-based wind energy facilities in North America are nocturnal migrants (many songbirds and similar species), and some of the fatalities presumably occur during their high-altitude nocturnal migratory flights, particularly when storms or ascent/descent bring the birds below their normal migratory cruising altitudes (300-500 m [984-1,640 ft]) and into the rotor swept altitudes of commercial wind turbine rotors (Strickland et al. 2011). Certain common birds of agricultural habitats that exhibit tendencies to engage in high altitude flights, and certain widespread and abundant vulture and raptor species, are also commonly found among bird fatalities at land-based wind energy facilities (Strickland et al. 2011). Other birds, particularly species with a high degree of aerial maneuverability, such as swallows and swifts, are rarely encountered as fatalities at wind energy facilities even though they may be very abundant, and may spend a substantial amount of time flying within rotor-swept altitudes (Strickland et al. 2011). Birds that are rare, or that rarely fly within rotor swept altitudes, tend to be rarely encountered as wind-turbine fatalities (Strickland et al. 2011).

For bats, the pattern of collision susceptibility at land-based wind energy facilities in North America is also highly species-specific, but the underlying reasons that drive the pattern are less well-understood than they are for birds. Three species of migratory, tree-roosting insectivorous bats in the family Vespertilionidae (Eastern Red Bat [*Lasiurus borealis*], Silver-haired Bat [*Lasionycteris noctivagans*], and Hoary Bat [*Lasiurus cinereus*]) are among the most commonly found bats in North American wind farm fatality studies, comprising 78% of bat fatalities at US wind energy facilities (Arnett and Baerwald 2013). In these species, most fatalities occur during late summer and fall, typically late July through late September, a period that corresponds to fall migration and initiation of mating activities (Fleming and Eby 2003, Cryan and Barclay 2009). By contrast, many other species, particularly bats in the genus *Myotis*, are found as wind turbine collision fatalities much more rarely, for reasons not yet fully understood (Arnett et al. 2008, 2010, 2013).

In the offshore realm, the carcass-searching field study methodologies that have advanced our scientific understanding of bird and bat fatality rates at land-based wind energy facilities are generally unavailable. Direct monitoring of bird and bat fatalities has rarely been attempted at European offshore wind energy facilities to date. In one of the first and best known attempts, Mark Desholm and colleagues developed the Thermal Animal Detection System (TADS), and deployed it at the Nysted Offshore Wind Energy Facility in the Danish Baltic Sea. In vertical (collision) viewing mode, the system's infrared monitoring field of view covered roughly one third of the rotor of a single turbine, and it was deployed in this way for intensive monitoring periods during the peak period of spring and fall sea duck migration over a three year period (2004-2006; Desholm 2006). In spite of the fact that this facility is located within a major flight corridor for migrating sea ducks, with an estimated 235,136 Common Eiders (*Somateria mollissima*) passing by in the vicinity of the wind farm each autumn, no sea duck collisions were recorded during this monitoring effort in 1,086 hours of direct observation in collision-viewing mode (Desholm 2006). Only one collision event of any kind was recorded during this monitoring effort, a collision of a single small bird or bat (Desholm 2006). Perhaps influenced by this result, avian impact studies at European offshore wind energy facilities in recent years have focused on collision risk modeling efforts, in which bird passage rates are combined with collision avoidance rates to "predict" collision fatality rates (Cook et al. 2014). To date, no offshore wind energy facilities in Europe or elsewhere have reported bird or bat fatality rates generated from direct observations of bird or bat collisions with operating offshore wind turbines, though there are a variety of emerging remote sensing systems that show varying degrees of potential for producing such data in the future (see reviews by Collier et al. 2011, Sinclair et al. 2015).

Although empirical validation of predicted collision fatality rates has not yet been attained for an offshore wind energy facility, information on the turbine collision/avoidance probabilities for various bird taxa from European offshore wind studies, combined with known bird and bat fatality patterns from land-based wind energy facilities in North America, provides a reasonable foundation for assessing the levels of collision risk likely to be experienced by various bird and bat taxa from Icebreaker Wind. In the sections that follow, collision risk is reviewed for four separate categories of birds and bats, representing the bird and bat types of the highest potential interest with regard to potential collision risk from Icebreaker. In these discussions, the overall risk evaluations (e.g. "high" "moderate" "low") refer to how the range of potential fatality rates likely to be generated by Icebreaker Wind compares to fatality rates that have been documented at typical land-based wind energy facilities in the region.

We note that low collision risk for any ESA-listed species of birds or bats was established in earlier risk analyses for the Project (Guarnaccia and Kerlinger 2013, Kerlinger and Guarnaccia 2013), and was acknowledged by the USFWS (2014). For this reason, the discussion of risk to ESA-listed species is not repeated in the present analysis.

Eagles and Other Raptors

The level of collision risk for eagles or any other species of raptor at Icebreaker Wind is low, primarily because no species of eagle or other raptor regularly utilizes offshore environments eight to 10 miles from shore. Although Bald Eagles (*Haliaeetus leucocephalus*) and Osprey (*Pandion haliaetus*) regularly forage over water for fish, both of these species are typically restricted to areas within several miles of shore (Buehler 2000, Poole et al. 2016). This general pattern was evidenced specifically for the Project site and vicinity by the boat-based avian baseline surveys conducted in nearshore waters near the Project site during 2010 (Svedlow et al. 2012) and the aerial avian baseline surveys conducted in 2009-2011 by the ODNR (Norris and Lott 2011), neither of which resulted in any observations of any raptors within 10 miles of the Project area.

The potential for Bald Eagles or other raptors to be exposed to any risk of collision with Icebreaker's turbines is therefore almost exclusively limited to migratory transits of these species across Lake Erie (but see also waterfowl and ice discussion in the next section). Bald Eagles and a variety of other migratory raptor species may occasionally cross the open water of Lake Erie during migration. Nonetheless, such crossings are expected to be uncommon in the vicinity of Icebreaker Wind, as raptor migration in general (Kuvlesky et al. 2007), and specifically within the Great Lakes region (Hawk Migration Association of North America [HMANA] 2016) tends to be heavily concentrated along shorelines and at narrows and peninsulas due to the tendency of raptors to avoid migrating over large water bodies (Kerlinger 1989).

To the extent that a small amount of exposure of Bald Eagles and other raptors to potential collision risk at Project Icebreaker does exist, given the small project size, and offshore location, risk is anticipated to be low. In a recent review, Pagel et al. (2013) reported that a total of six Bald Eagle fatalities are known to have occurred over a 16-year period from 1997-2012 for all land-based wind energy facilities within the contiguous United States. To date, there are far fewer publicly available records of Bald Eagle fatalities or injuries at wind energy facilities than there are for Golden Eagles, which are rare in the Great Lakes region. According to Pagel et al. (2013), there were 85 eagle fatalities at wind energy facilities throughout the U.S. between 1997 and 2012 (excluding eagle fatalities at the Altamont Pass Wind Resource Area in California). Of these 85 mortalities, 79 were Golden Eagles and 6 were Bald Eagles (Pagel et al. 2013).

Waterfowl and Other Waterbirds

The level of collision risk for waterfowl, or other water-affiliated bird species at Icebreaker Wind is low, overall, with some variation among waterbird taxa. Several species of gulls (Ring-billed Gull, Herring Gull, Bonaparte's Gull) are the only bird species shown by baseline studies to utilize the Project area and vicinity at densities generally greater than one bird observed per survey (Norris and Lott 2011). Several additional gull species (e.g. Glaucous Gull [*Larus hyperboreus*], Iceland Gull [*L. glaucoides*], Great Black-backed Gull [*L. marinus*]) likely use the Project area, albeit on an occasional basis (Norris and Lott 2011, eBird 2016). The general behavioral patterns of gulls can lead to higher exposure to potential wind turbine collision risk, as gulls tend to spend a large fraction of time flying, and a substantial fraction of their flight activity may occur within the rotor swept altitudes of wind turbines (Winiarksi et al. 2012). However, gulls are very agile and acrobatic flyers, and possess a high degree of visual acuity, giving them a relatively high degree of aerial maneuverability and a relatively low level of susceptibility to collisions with wind turbines (Cook et al. 2014). For this reason, current practice in avian collision risk modeling for offshore wind facilities in Europe is to assign very high collision avoidance probabilities to gull species (e.g., 0.995 total avoidance probability recommended for Herring Gull and Great Black-backed Gull, Cook et al. 2014). Therefore, although some gull collisions with Icebreaker's turbines may be expected, particularly if gull species exhibit behavioral attraction to the Project (see Behavioral Avoidance/Attraction section), the general level of collision risk for this group is low, and there is no reasonable likelihood that it could affect the populations of any gull species.

In the case of waterfowl and similar species (loons, grebes, coots, cormorants), collision risk is low, both because of low levels of exposure, and also because of low wind-turbine collision susceptibility. Baseline data have shown that only a small number of species in this category utilize the Project area on a regular basis, and in all cases the density of such birds was generally below one bird observed in the vicinity of the Project area per survey (Norris and Lott 2011; and Displacement section). One possible exception to this pattern is Double-crested Cormorant (*Phalacrocorax auritus*), which may experience somewhat higher exposure to collision risk at Icebreaker if it is attracted to the Project's turbines once built, as was observed for Great Cormorants (*P. carbo*) at the Egmond aan Zee Offshore Wind Energy Facility in the Netherlands (Krijgsveld et al. 2011; see Behavioral Avoidance/Attraction section). Although protected by the Migratory Bird Treaty Act, it should be noted that Double-crested Cormorants have been actively managed as a pest species in recent years in the Great Lakes region, as this species' recent population growth is believed to have negatively impacted fish populations (USFWS 2003); hence some collision risk for this species from Icebreaker Wind does not represent a significant concern from a biological or conservation perspective.

Another possible exception to the overall pattern of low exposure could occur if high concentrations of waterfowl and/or similar waterbirds are attracted to ice-free refuges around the Project's turbines. It was recently hypothesized that such refuges could form during extreme ice-over events on Lake Erie by the US Fish and Wildlife Service (USFWS 2016). The USFWS (2016) extended this hypothesized effect to possibly include Bald Eagles as well, noting that eagles could also be attracted to ice free refuges in order to prey on waterfowl, fish, or carrion. In order to examine this possibility, we conducted a systematic analysis of Lake Erie ice formation patterns and movement dynamics, focused on identifying the likelihood that the Project's turbine towers could generate ice-free refuges that would attract concentrations of birds, potentially exposing them to increased collision risk. This analysis was facilitated by the effort that LEEDCo has dedicated to understanding the dynamics of ice formation and movement on Lake Erie as they relate to engineering aspects of the Project.

The overall finding of the analysis of ice-related bird risk is that this risk is low, since open areas will still exist closer to shore even during extreme ice cover events, while at other times when the ice is more open and mobile, there will be a predominance of alternative open areas closer to shore and scattered throughout the offshore ice cover. One factor that influences this conclusion is that extreme ice-over events capable of causing a general scarcity of open water as far as eight to 10 miles offshore in Lake Erie are rare. Table 1 shows the number of days during which ice cover on Lake Erie exceeded 96% dating back to 1973. There were a total of 41 such days over this 44-year period (Table 1).

Table 1. Number of days per year that ice cover exceeded 96% on Lake Erie from 1973 to 2016, according to the US National Oceanographic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory (J. Wang, NOAA Great Lakes ice climatologist, pers. comm., November 7, 2016).

	Decade				
Year	1970	1980	1990	2000	2010
0		0	0	0	0
1		0	0	0	0
2		5	0	0	0
3	0	0	0	0	0
4	0	0	5	0	1
5	0	0	0	0	10
6	0	0	6	0	0
7	5	0	1	0	
8	6	0	0	0	
9	2	0	0	0	

Figure 4 shows the mean winter-time ice cover percentage in Lake Erie over the same period. These ice cover patterns indicate that extreme ice-over events, where open water areas may become relatively scarce, are generally rare in Lake Erie.

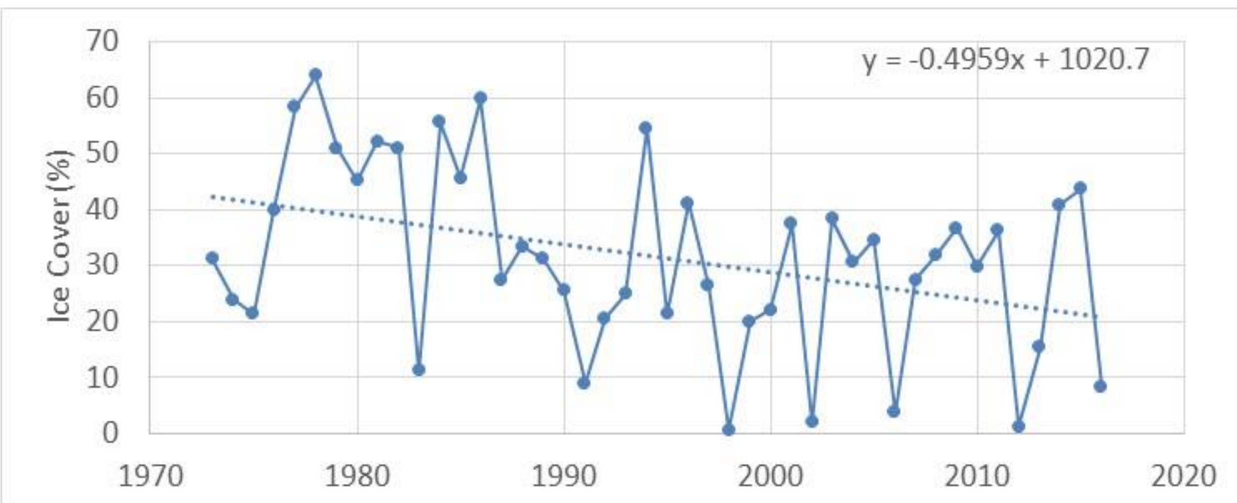

Figure 4. Mean annual winter ice cover on Lake Erie from 1973 to 2016, according to the US National Oceanographic and Atmospheric Administration (NOAA)/Great Lakes Environmental Research Laboratory (GLER; adapted from Wang et al. 2012, and J. Wang, NOAA Great Lakes ice climatologist, pers. comm., November 7, 2016).

The other factor indicating that the risk of bird-attracting ice-free refuges forming exclusively around Icebreaker Wind's turbines is low derives from the ice dynamics of Lake Erie and the Project. Icebreaker's turbine towers will measure seven m (23 ft) in diameter at the ice cone-surface interface. When ice moves past these turbine tower cones, it will fill in rapidly, since the design will cause broken ice chunks to flow around the towers and float in the wake, rather than pile up at the leading edges where the moving ice is contacting the towers (D. Dickins, pers. comm.). Ice pile-ups at the leading edge that could leave the wake relatively clear would only occur with much broader structures in shallower water where the ice could ground on the Lake bottom, such as is known to occur at the Cleveland water intake crib, which is 110' wide and does not have an ice cone (D. Dickins, pers. comm.). Therefore, ice-free wakes that may be created by the Project's turbines under rare circumstances are small, and will fill in rapidly, indicating that there is a minimal chance that they will attract birds.

There is a further fundamental physical consideration that supports the conclusion of low ice-related bird risk. Wakes can only form when ice is moving, and ice can only move when there is open water into which for it to move. Therefore, Icebreaker's turbine towers can only generate broken ice wakes under conditions in which other, larger areas of open water are available nearby; hence, the wakes are not likely to attract substantial numbers of birds. If ice is not moving, for example when extreme cold conditions are combined with calm winds, then Icebreaker's turbine towers will not generate wakes (D. Dickins, pers. comm.).

The image shown in Figure 5 illustrates the availability of ice-free areas on March 6, 2014, which was the day with the maximum ice coverage on Lake Erie that winter, which was the coldest in four decades. Even in this extreme case, large areas of open water are visible throughout most portions of the Lake. Areas of open water during such events may include areas where ice has been blown away from shore by the prevailing winds, cracks, leads, and polynyas created by the movement of ice, and open areas created by warm water outfalls, such as the Avon Lake Power Plant, located roughly 12 miles west of Cleveland (Figure 5). At least five additional outfalls are located along the Cleveland lakefront.

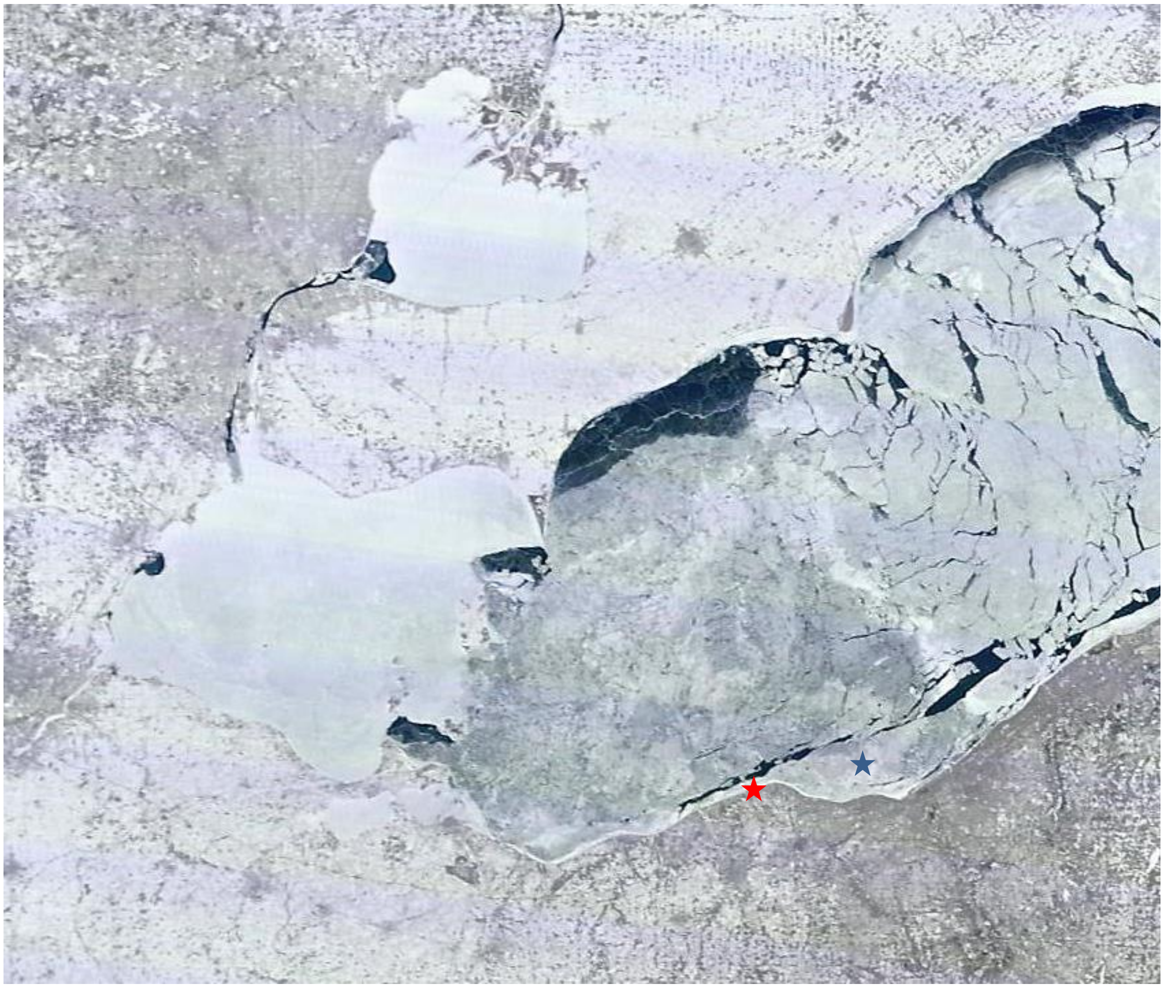

Figure 5. MODIS Terra true color image of western and central Lake Erie, on March 6, 2014, corresponding to the day with maximum ice coverage recorded in 2014 of 96.5% (Source: J. Wang - NOAA/GLERL). 2014 was an exceptionally severe winter, ranked as the coldest on record for the Great Lakes region since 1978/79 (Source: M. Herring - NOAA Boulder). In spite of the extensive ice cover in the central part of the Lake, there are numerous openings and fractures (dark blue areas) scattered throughout the offshore ice sheet as well as extensive shore-following leads with open water between Cleveland and the proposed location of Icebreaker Wind (approximate location shown with a blue star). The location of the Avon Power Plant, a coal-fired power plant that normally produces an ice-free refuge along the Lake Erie shore due to warm water outfall, is shown by the red star. Image courtesy of NASA, processed by the Space and Engineering Center, University of Wisconsin-Madison.

As a final consideration regarding waterfowl collision risk, it is important to note that European studies have demonstrated a strong tendency for flying ducks to avoid offshore wind facilities and turbines (Desholm and Kahlert 2005, Pettersson 2005, Desholm 2006, Larsen and Guillemette 2007, Masden et al. 2009). Furthermore, a variety of studies at land-based wind energy facilities in the US sited near waterfowl concentration areas have also demonstrated low wind-turbine collision susceptibility in waterfowl (Derby et al. 2009, 2010b, Jain 2005, Niemuth et al. 2013). For these reasons, waterfowl are expected to have a low probability of colliding with Icebreaker's turbines, even on the rare occasions when they may be exposed to such risk.

Bats

The level of collision risk for bats at Icebreaker Wind is low. This conclusion stems largely from the small size of the Project, which confers a correspondingly low scale to the possible level of overall bat collision fatality that the Project may generate. Furthermore, the exposure of bats to potential collision risk at the Project is also low, as indicated by the level of acoustic bat activity recorded offshore in the central Lake Erie basin during the baseline study. We recognize that the relationship between exposure and fatality rate is complex and must be interpreted with caution. The relatively low level of bat acoustical activity recorded at offshore studies to date (Ahlén et al. 2009, Pelletier et al. 2013, Boezaart and Edmonson 2014) is consistent with the basic observation that bats are primarily terrestrial animals. In the case of Icebreaker, bats' use of the Project site is expected to be restricted to migratory transits. In contrast to other primarily terrestrial groups with somewhat parallel predictions, such as raptors and songbirds, there is a higher level of residual uncertainty in this prediction for bats, as bats' utilization of Great Lakes offshore environment, and the phenomena associated with potential bat attraction to turbines, are not well understood (McAlexander 2013, Cryan et al. 2014, Schuster et al. 2015). Because this residual uncertainty stems primarily from the possibility of a behavioral attraction effect, we note that it can only be resolved with post-construction observations.

The most informative source of information on the level of bat activity likely to occur at Icebreaker Wind is the bat acoustic study conducted by Tetra Tech in 2010, as part of Icebreaker's wildlife baseline data gathering effort (Svedlow et al. 2012). In this effort, Anabat™ SD-1 (Titley Scientific™, Columbia, Massachusetts) ultrasound detectors were deployed at four land-based locations along the central Lake Erie shore to gather data on land-based bat activity, and four identical detectors were deployed on the Cleveland water intake crib, located roughly three miles offshore of Cleveland in Lake Erie, to gather data on offshore compared with onshore bat acoustic activity in the central Lake Erie basin. Ultrasound acoustic recordings were gathered at these locations during the entire spring and summer/fall migratory periods, the two periods during which most bat collision fatality occurs at Midwestern wind energy facilities (Arnett et al. 2008). Two of the crib-based offshore detectors were located on the crib's crow's nest, roughly 35 m (115 ft) above the surface of the water, and two of the detectors were elevated to a height of approximately 50 m (164 ft) above the water's surface on the guy wires of the crib's meteorological tower. During the spring 2010 deployment (April 1 through May 31, 2010), a total of 244 detector-nights of data were gathered at the onshore locations, and a total of 232 detector-nights of offshore data were gathered at the crib. During the summer/fall 2010 deployment (June 1 through November 10, 2010), a total of 616 detector-nights of data were gathered at the onshore locations, and a total of 482 detector-nights of offshore data were gathered at the crib. The levels of bat acoustic activity recorded over the course of this effort are shown in Table 2.

Table 2. Bat call rates, expressed as the number of calls recorded per detector-night, at onshore versus offshore locations in the central Lake Erie basin, as recorded during the baseline bat acoustic study conducted for Icebreaker Wind (Svedlow et al. 2012, see text for additional explanation).

Location	Spring Call Rate	Summer/Fall Call Rate
Onshore	4.95	51.1
Offshore	0.353	5.28

The Icebreaker Wind bat baseline acoustic study demonstrated that the bat activity level was roughly 10 times greater on land than offshore during both the spring and summer/fall study periods. We note that this comparison may overestimate the level of bat activity likely to occur at the Project site, as the location used to represent the offshore environment in this case, the Cleveland water intake crib, is located roughly three miles from shore, whereas the Project site is located between eight and 10 miles from shore where the abundance of bats is likely to be lower. Boezaart and Edmonson (2014) documented bat acoustic activity at a Great Lakes offshore location even further from shore in Lake Michigan (roughly 30 miles [48 km] from shore). Their study resulted in the detection of some bat calls attributable to several of the most common and widespread migratory bats in the region; however, the study only reported data on bat calls that were unambiguously identified to the species level, and many bat calls cannot be unambiguously identified using state-of-the-art call classification methods; hence, bat acoustic activity rates reported by Boezaart and Edmonson (2014) are not directly comparable to those reported by Svedlow et al. (2012).

Further insight into how the offshore bat acoustic activity data gathered at the Cleveland water intake crib by Svedlow et al. (2012) compare to onshore bat acoustic activity patterns can be gained by comparing the overall rate recorded by Svedlow et al. (2012) to rates recorded during baseline bat acoustic studies conducted for land-based wind energy projects within the region. Figure 6 illustrates such a comparison, showing Svedlow et al.'s (2012) summer/fall offshore bat acoustic data in relation to comparable data from 14 studies conducted at land-based wind energy projects in the Great Lakes region, representing all such studies for which data comparable to the Icebreaker offshore bat acoustic data are publicly available. References and date ranges for the data gathering efforts of these studies are presented in Table 3.

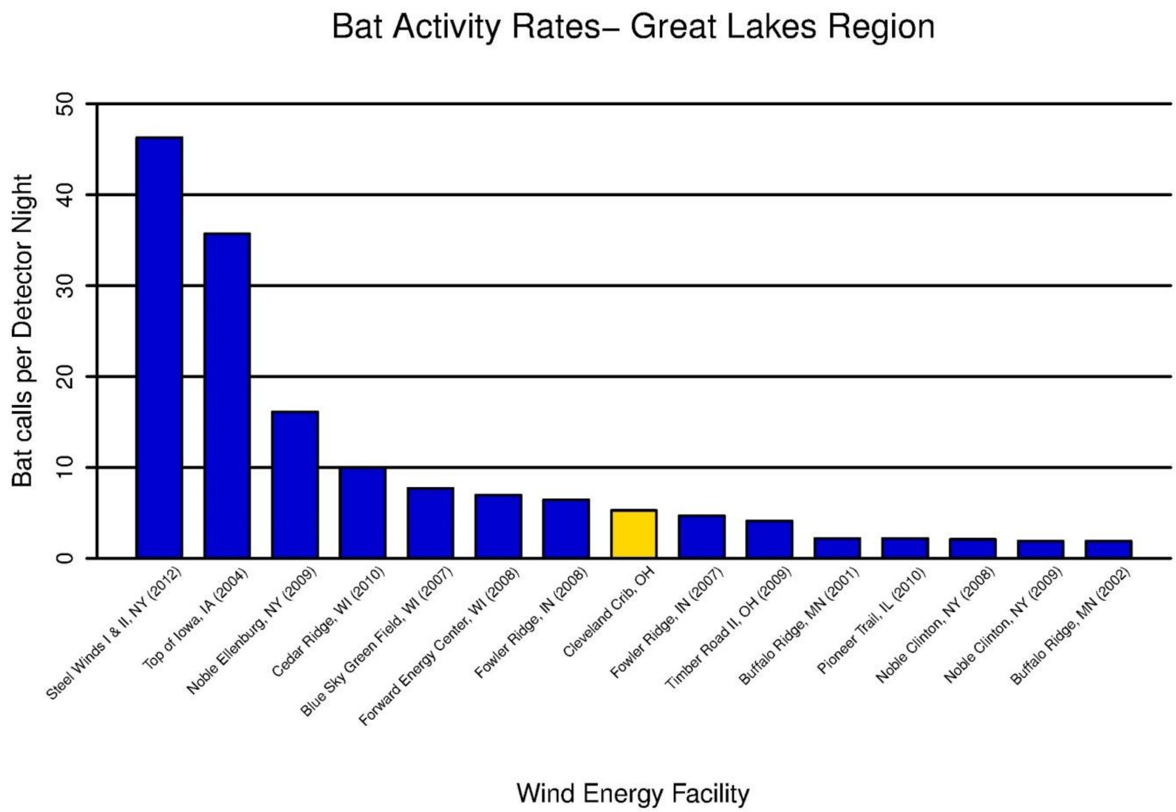

Figure 6. Bat acoustic data during the summer/fall season, expressed in terms of bat calls per detector-night, recorded three miles offshore of Cleveland in Lake Erie at the Cleveland water intake crib (yellow bar labeled "Cleveland Crib", data from Svedlow et al., 2012), in relation to comparable data gathered during 14 baseline studies conducted at land-based wind energy project areas in the Great Lakes region, representing all such projects for which comparable data are publicly available.

Table 3. Data sources and bat acoustic data recording date ranges for the bat acoustic studies whose data are illustrated in Figure 6.

Study	Reference	Date Range
Blue Sky Green Field (2007)	Gruver et al. 2009	7/24/07-10/29/07
Buffalo Ridge (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	6/15/01-9/15/01
Buffalo Ridge (Phase II; 2002/Lake Benton I)	Johnson et al. 2004	6/15/02-9/15/02
Cedar Ridge (2010)	BHE Environmental 2011	7/16/07-9/30/07
Cleveland Crib (2010)	Svedlow et al. 2012	6/02/10-11/10/10
Forward Energy Center (2008)	Grodsky and Drake 2011	8/5/08-11/08/08
Fowler Wind Farm (2007)	Gruver et al. 2007	8/15/07-10/19/07
Fowler Wind Farm (2008)	Carder et. al. 2010	7/17/08-10/15/08
Noble Clinton (2008)	Jain et al. 2009a	8/8/08-09/31/08
Noble Clinton (2009)	Jain et al. 2010a	8/1/09-09/31/09
Noble Ellenburg (2009)	Jain et al. 2010b	8/16/09-09/15/09
Pioneer Trail (2011)	Stantec Ltd. 2011b	7/16/10-10/31/10
Steel Winds I & II (2012)	Stantec Ltd. 2013	5/10/12-11/5/12
Timber Road II (2009)	Good et al. 2010	3/19/09-11/16/09
Top of Iowa (2004)	Jain 2005	5/26/04-9/24/04

Bat acoustic activity is the most commonly gathered form of baseline bat data gathered during the development of wind energy facilities in North America, and is widely regarded as the best indicator of bat exposure to collision risk that can be gathered during the development phase of wind energy projects (Strickland et al. 2011, USFWS 2012). Nonetheless, it is important to note that bat acoustic activity is an imperfect predictor of bat collision risk, as bat acoustic activity is not equivalent to bat abundance (Strickland et al. 2011). Furthermore, the relationship between pre-construction bat acoustic activity levels and bat fatality levels recorded at wind energy facilities subsequent to construction is complex and variable (Hein et al. 2013). For this reason, it is also useful to examine bat fatality rates that have been documented at land-based wind energy facilities in the Great Lakes region in order to generate a more quantitative, if rough, prediction of the level of bat fatality likely to be caused by the operation of Icebreaker Wind. Figure 7 illustrates 55 bias-corrected bat fatality rates that have been produced at land-based wind energy facilities in the Great Lakes region, representing all such studies for which bias-corrected bat fatality rate estimates are publicly available. Reference information for these studies is presented in Table 4. Figure 7 illustrates a distribution of bat fatality rates similar to that presented in an earlier analysis for all of North America by Strickland et al. (2011), with bat fatality rates ranging from roughly 1 to over 30 bats/MW/year.

Given the observation that the bat acoustic activity levels recorded offshore in the central Lake Erie basin were on the low end of the range for land-based wind projects in the region with comparable data (Figure 6), the most parsimonious prediction that can be made regarding the level of bat fatality likely to be generated by Icebreaker is that it will be toward the lower end of the distribution of bat fatality rates recorded at land-based wind energy projects in the region, on the order of 1-4 bats/MW/year (Figure 7). However, given the complexity of the relationship between pre-construction bat activity and post-construction bat fatality rates at land-based wind energy facilities in the US (Hein et al. 2013), and the possibility that bats migrating over Lake Erie may be attracted to the Project's turbines, increasing collision risk, the most precise prediction that is warranted by existing information in this case is that the bat fatality rate at Icebreaker Wind is likely to fall somewhere within the distribution shown in Figure 7, ranging from one to 30 bats/MW/year. Within this range, the overall level of bat fatality likely to be generated by the Project is still moderate, at worst, in relation to land-based wind energy projects in the Great Lakes region, due to the Project's small size.

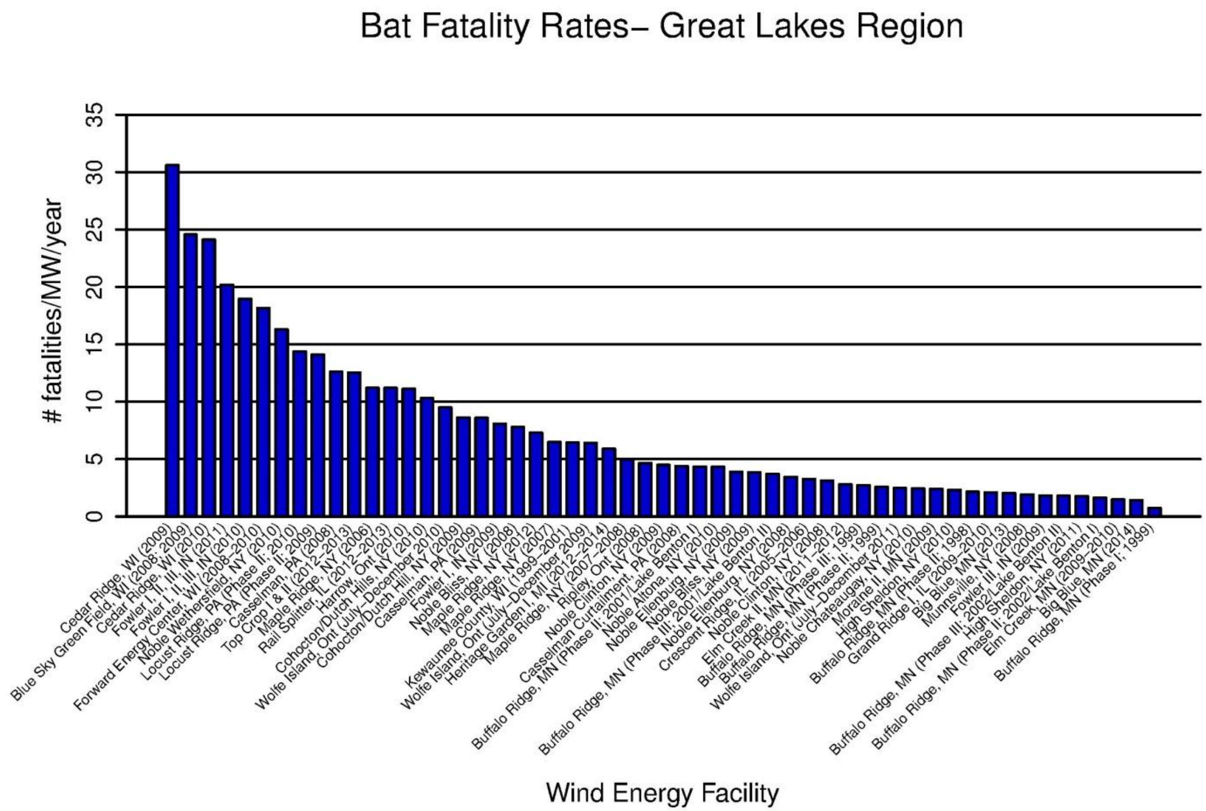

Figure 7. Bias-corrected bat fatality rates, expressed in terms of bat fatalities/megawatt of installed wind energy capacity/year, recorded in 55 studies from land-based wind energy projects in the Great Lakes region, representing all such projects for which comparable data are publicly available.

Table 4. Data sources for the bat fatality rate studies whose data are illustrated in Figure 7.

Facility and Study Year(s)	Report Reference
Big Blue, MN (2013)	Fagen Engineering 2014
Big Blue, MN (2014)	Fagen Engineering 2015
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009
Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004
Casselman, PA (2008)	Arnett et al. 2009a
Casselman, PA (2009)	Arnett et al. 2010
Casselman Curtailment, PA (2008)	Arnett et al. 2009b
Cedar Ridge, WI (2009)	BHE Environmental 2010
Cedar Ridge, WI (2010)	BHE Environmental 2011
Cohocton/Dutch Hill, NY (2009)	Stantec 2010a
Cohocton/Dutch Hills, NY (2010)	Stantec 2011c
Crescent Ridge, IL (2005-2006)	Kerlinger et al. 2007
Elm Creek, MN (2009-2010)	Derby et al. 2010a
Elm Creek II, MN (2011-2012)	Derby et al. 2012
Forward Energy Center, WI (2008-2010)	Grodsky and Drake 2011
Fowler I, IN (2009)	Johnson et al. 2010a
Fowler I, II, III, IN (2010)	Good et al. 2011
Fowler I, II, III, IN (2011)	Good et al. 2012
Fowler III, IN (2009)	Johnson et al. 2010b
Grand Ridge I, IL (2009-2010)	Derby et al. 2010b
Harrow, Ont (2010)	NRSI 2011
Heritage Garden I, MI (2012-2014)	Kerlinger et al. 2014
High Sheldon, NY (2010)	Tidhar et al. 2012a
High Sheldon, NY (2011)	Tidhar et al. 2012b
Kewaunee County, WI (1999-2001)	Howe et al. 2002
Locust Ridge, PA (Phase II; 2009)	Arnett et al. 2011
Locust Ridge, PA (Phase II; 2010)	Arnett et al. 2011
Maple Ridge, NY (2006)	Jain et al. 2007
Maple Ridge, NY (2007)	Jain et al. 2009b
Maple Ridge, NY (2007-2008)	Jain et al. 2009c
Maple Ridge, NY (2012)	Tidhar et al. 2013
Moraine II, MN (2009)	Derby et al. 2010c
Munnsville, NY (2008)	Stantec 2009
Noble Altona, NY (2010)	Jain et al. 2011a
Noble Bliss, NY (2008)	Jain et al.2009d
Noble Bliss, NY (2009)	Jain et al. 2010c
Noble Chateaugay, NY (2010)	Jain et al. 2011b
Noble Clinton, NY (2008)	Jain et al. 2009e
Noble Clinton, NY (2009)	Jain et al. 2010a
Noble Ellenburg, NY (2008)	Jain et al. 2009f
Noble Ellenburg, NY (2009)	Jain et al. 2010b
Noble Wethersfield, NY (2010)	Jain et al. 2011c
Rail Splitter, IL (2012-2013)	Good et al. 2013a
Ripley, Ont (2008)	Jacques Whitford 2009
Top Crop I & II (2012-2013)	Good et al. 2013b
Wolfe Island, Ont (July-December 2009)	Stantec Ltd. 2010b
Wolfe Island, Ont (July-December 2010)	Stantec Ltd. 2011a
Wolfe Island, Ont (July-December 2011)	Stantec Ltd. 2012

Nocturnally Migrating Songbirds and Similar Birds

The level of collision risk for nocturnally migrating birds (including various shorebirds, songbirds, and other small-bodied land birds) at Icebreaker Wind is low. This conclusion stems from three principal observations, as follows:

1) Nocturnally migrating birds are primarily terrestrial animals, and their expected level of activity at the Project site is expected to be low, and generally restricted to migratory transits.

2) Although substantial broad-front nocturnal migration activity occurs throughout the Great Lakes region, and extends to birds' passage directly over the Great Lakes, including Lake Erie, nocturnally migrating birds exhibit a well-known tendency to avoid flying over large bodies of water if possible, evidenced in the central Lake Erie basin by a radar study that demonstrated that the density of nocturnal migrant bird passage was more than twice as high over land than it was over the Lake during both spring and fall migration.

3) Numerous studies of bird fatality rates at land-based wind energy facilities have demonstrated that fatality rates of nocturnal migrant birds at wind energy facilities are sufficiently low that there is no reasonable likelihood of such fatalities causing population-level impacts to any nocturnal migrant bird species.

The most informative source of information on the passage rates of nocturnally migrating birds through the Icebreaker Wind site and vicinity is a study of nocturnal bird migration density over the Great Lakes vs. over terrestrial environments within the region, published by a team of independent academic ornithologists in *The Auk* (Diehl et al. 2003). This study relied on a region-wide analysis of NEXRAD (WSR-88D) radar data to study nocturnal bird migration patterns over large spatial scales for the entire spring and fall migration periods of a representative year (2000). The authors applied techniques that had been developed over the course of three previous decades of radar ornithology for separating the radar echoes of migrating birds from those of insects, ground clutter, and precipitation, and for controlling for known sources of signal variation, such as signal refraction as a function of distance to the antenna. These authors focused their research on direct comparisons of estimated migrant densities over land versus over water at four locations in the Great Lakes, taking advantage of the locations of four NEXRAD radar antennae with ample viewsheds of both land-based and water-based environments within suitable distance of the antennae, and with minimal or no terrain-related blockage of the portions of the radar beam needed for the comparisons.

One of the locations selected for this comparison was the central Lake Erie basin, using data from the KCLE WSR-88D radar antenna in Cleveland, Ohio. The beam of the KCLE radar is well-suited for detecting nocturnally migrating birds in the central Lake Erie basin out to at least 40 miles from the southern shore, including the Icebreaker site and vicinity. Diehl et al.'s (2003) analysis revealed that the density of nocturnally migrating birds was 2.72 times higher over land than it was over water in the central Lake Erie basin during the spring migration period, and 2.13 times higher over land than over the lake during the fall migration period. Diehl et al. (2003) were also able to document the signature of dawn ascent of migratory birds over water, as well as directional reorientation of migrating birds toward land, suggestive of these birds' tendency to avoid flying over water. These observations are consistent with recent studies by Rathbun et al. (2016) and Horton et al. (2016), who used marine surveillance radar systems deployed in shoreline environments in Lake Ontario and Lake Erie, respectively, to demonstrate high concentrations of nocturnal migrant birds in Great Lakes shoreline environments.

Similar to the case of bats, information on pre-construction patterns of nocturnal migratory bird activity must be interpreted with caution when generating collision risk predictions for wind energy facilities, as the relationship between pre-construction use data and post-construction fatality patterns in birds is complex. For this reason, radar-based studies of nocturnal migrant bird passage rates or nocturnal utilization of airspace within proposed wind facility areas are not included within typical baseline studies for land-based wind farms in the US (Strickland et al. 2011, USFWS 2012). In spite of the known limitations of pre-construction baseline data in general, and radar data specifically (USFWS 2012, Erickson et al. 2014, Kerlinger 2016), for predicting fatality levels of nocturnally migrating birds at wind energy facilities, such data, when considered alongside empirically-derived fatality rates generated from systematic, bias-corrected post-construction monitoring studies at land-based wind energy facilities within the Great Lakes region, can provide a reasonable basis for making a rough quantitative prediction regarding the level of nocturnal migrant songbird fatalities likely to be generated by Icebreaker Wind.

Figure 8 illustrates empirically-derived, bias-corrected bird fatality estimates from 42 studies conducted at operational, land-based wind energy facilities within the Great Lakes region, representing all such studies with publicly available data for the region. Reference information on the studies illustrated in Figure 8 is provided in Table 5. Figure 8 reveals a distribution of bird fatality rates similar to that reported in an earlier analysis of such rates for the entire US (Strickland et al. 2011), although there appears to be a tendency toward lower bird fatality rates at land-based wind energy facilities in the Great Lakes region than for the US as a whole. Commercial wind energy facilities in the Great Lakes region incur roughly two to three bird fatalities per MW of installed wind energy capacity per year on average (Figure 8). Before extrapolating from these data to a prediction of nocturnal songbird fatality rates at Icebreaker, it should also be noted that the rates shown in Figure 8 and considered in recent studies of bird fatalities at land-based wind energy facilities (Strickland et al. 2011, Loss et al. 2013) include a significant proportion of collisions by birds that are local, diurnally active residents in the environment of the wind energy facilities, and whose fatalities are not likely due to collisions during nocturnal migratory flights (e.g., Horned Larks [*Eremophila alpestris*], meadowlarks [*Sturnella spp.*], various doves, Killdeer [*Charadrius vociferus*], and others; Strickland et al. 2011). For this reason, using total bird fatality rates as a basis for predicting nocturnal migrant songbird fatality rates at Icebreaker would likely result in an overestimate of migrant songbird fatality. Nonetheless, it is well-known that nocturnal migrant songbirds comprise the majority of total bird fatality at land-based wind energy facilities in the US (NAS 2007, Strickland et al. 2011), and a recent study by Erickson et al. (2014) demonstrated that fatality rates are typically between 2.10 and 3.35 birds per MW of installed capacity per year for small passerines, most of which are nocturnal migrants. Therefore, total bird fatality rates can serve as a useful, if conservative, basis for predicting the likely fatality rates of nocturnally migrating land birds at Icebreaker, where no diurnal land bird activity is expected.

Given the observation that the nocturnal migrant bird passage density recorded in the offshore environment in the central Lake Erie basin was less than half of the level recorded at comparable sites over land during both spring and fall migrations (Diehl et al. 2003), it is reasonable to predict that nocturnal migrant bird fatality generated by Icebreaker Wind may be lower than typical land-based facilities in the region (Figure 8), assuming all other factors are equal. This would suggest that bird fatality rates at Icebreaker in the range of 1-2 birds per megawatt of installed capacity per year. Given that the Project will contain 20.7 megawatts of installed capacity, one estimate for Icebreaker is 21-42 total bird fatalities per year, most of which will likely be nocturnal migrant land birds. At this level, or even if rates were towards the higher end of U.S. estimates, there is no reasonable likelihood that the Project could have a population level impact on any species of nocturnal migrant bird (see Arnold and Zink 2011 and Erickson et al. 2014 for recent discussions of the likelihood of population level effects in nocturnal migrant songbirds resulting from collisions with wind turbines or other anthropogenic structures).

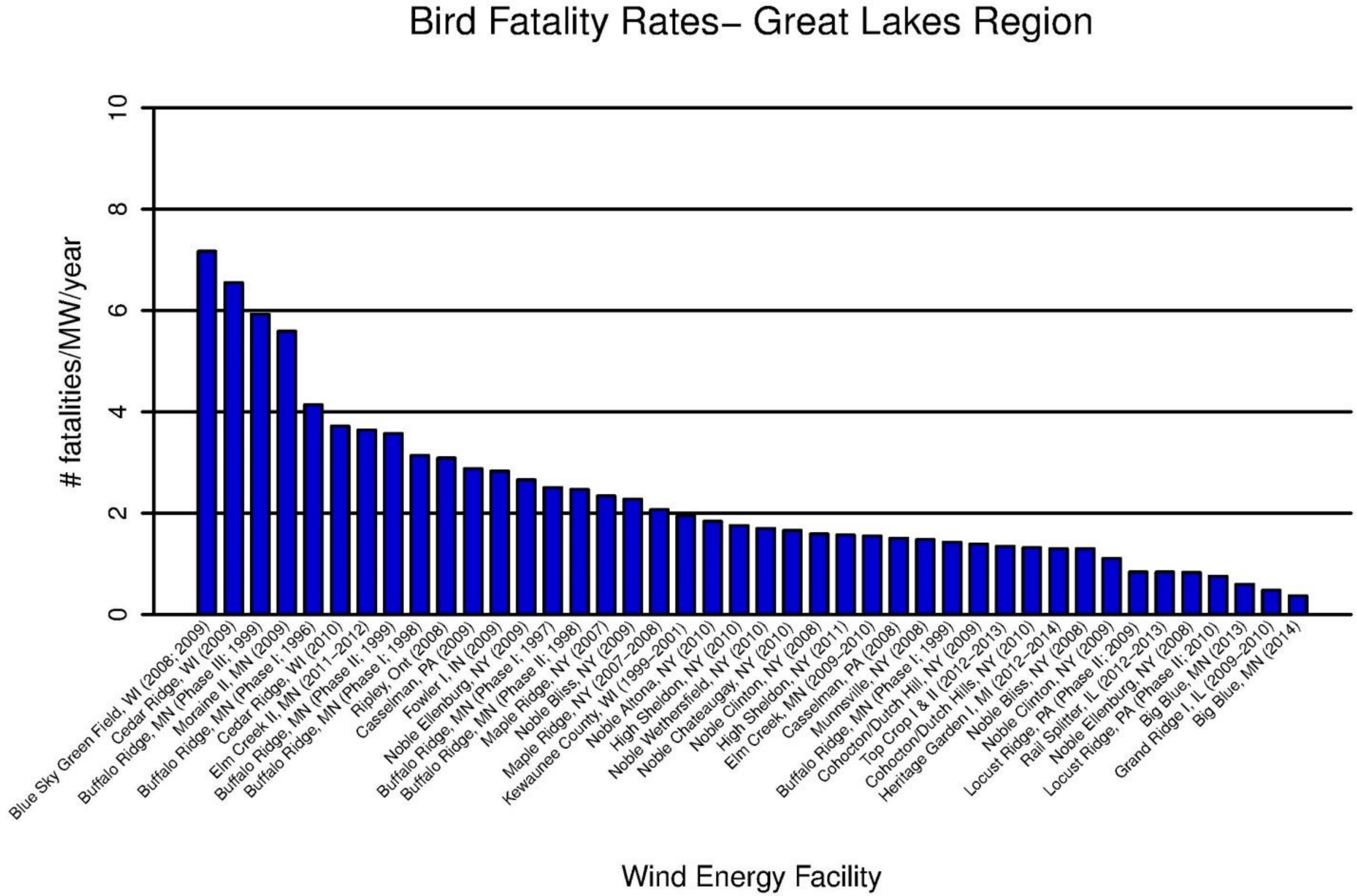

Figure 8. Bias-corrected bird fatality rates, expressed in terms of bird fatalities/megawatt of installed wind energy capacity/year, recorded in 42 studies from land-based wind energy projects in the Great Lakes region, representing all such projects for which comparable data are publicly available.

Table 5. Data sources for the bird fatality rate studies whose data are illustrated in Figure 8.

Facility and Study Year(s)	Report Reference
Big Blue, MN (2013)	Fagen Engineering 2014
Big Blue, MN (2014)	Fagen Engineering 2015
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009
Buffalo Ridge, MN (Phase I; 1996)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1997)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000
Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2000
Casselman, PA (2008)	Arnett et al. 2009a
Casselman, PA (2009)	Arnett et al. 2010
Cedar Ridge, WI (2009)	BHE Environmental 2010
Cedar Ridge, WI (2010)	BHE Environmental 2011
Cohocton/Dutch Hill, NY (2009)	Stantec 2010a
Cohocton/Dutch Hills, NY (2010)	Stantec 2011c
Elm Creek, MN (2009-2010)	Derby et al. 2010a
Elm Creek II, MN (2011-2012)	Derby et al. 2012
Fowler I, IN (2009)	Johnson et al. 2010a
Grand Ridge I, IL (2009-2010)	Derby et al. 2010b
Heritage Garden I, MI (2012-2014)	Kerlinger et al. 2014
High Sheldon, NY (2010)	Tidhar et al. 2012a
High Sheldon, NY (2011)	Tidhar et al. 2012b
Kewaunee County, WI (1999-2001)	Howe et al. 2002
Locust Ridge, PA (Phase II; 2009)	Arnett et al. 2011
Locust Ridge, PA (Phase II; 2010)	Arnett et al. 2011
Maple Ridge, NY (2006)	Jain et al. 2007
Maple Ridge, NY (2007-2008)	Jain et al. 2009b
Moraine II, MN (2009)	Derby et al. 2010c
Munnsville, NY (2008)	Stantec 2009
Noble Altona, NY (2010)	Jain et al. 2011a
Noble Bliss, NY (2008)	Jain et al.2009c
Noble Bliss, NY (2009)	Jain et al. 2010a
Noble Chateaugay, NY (2010)	Jain et al. 2011b
Noble Clinton, NY (2008)	Jain et al. 2009d
Noble Clinton, NY (2009)	Jain et al. 2010b
Noble Ellenburg, NY (2008)	Jain et al. 2009e
Noble Ellenburg, NY (2009)	Jain et al. 2010c
Noble Wethersfield, NY (2010)	Jain et al. 2011c
Rail Splitter, IL (2012-2013)	Good et al. 2013a
Ripley, Ont (2008)	Jacques Whitford 2009
Top Crop I & II (2012-2013)	Good et al. 2013b

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Case No. 16-1871-EL-BGN

Icebreaker Windpower Inc.

Application-Part 6 of 13

- Exhibit K. Substation and Cable Route Design Report

Substation and Cable Route Design Report

Prepared for LEEDCo by

DNV·GL

DNV KEMA Renewables, Inc.

LEEDCo Icebreaker™ Project

DOE EERE

Wind & Water Power Program

DE-EE0005989

February 14, 2014

The attached Report for LEEDCO Icebreaker Project, dated February 14, 2014, and consisting of 41 pages is provided as a deliverable under Cooperative Agreement No. DE-EE0005989 and contains information and data that is subject to the following Notice:

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List of Acronyms

BOS	Balance of System
CDF	Confined Disposal Facility
CPP	Cleveland Public Power
EPR	Ethylene Propylene Rubber
FEED	Front End Engineering Design
SCADA	Supervisory Control and Data Acquisition
HDD	Horizontal Directional Drilling
LEEDCo	Lake Erie Energy Development Corporation, Inc.
WTG	Wind Turbine Generator
XLPE	Cross-Linked Polyethylene

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EXECUTIVE SUMMARY

This report summarizes the 50% Front End Engineering Design of key components of the electrical balance of system for Project Icebreaker including the substation, the submarine cable system, and the supervisory control and data acquisition system. This report also describes the cable routing, the cable shore crossing, and cable installation for Icebreaker. The scope of work described herein includes assessment of multiple options for the cable route and shore crossing as well as multiple installation concepts. This report is primarily focused on the mechanical design of the submarine cable and does not include electrical design aspects of the cable (preliminary electrical design is addressed in the Lake Erie Energy Development Corporation, Inc. Grid Interconnect Report [1]). Additionally, the preliminary design presented herein is intended to form the basis for further design activities for Icebreaker and does not represent a comprehensive or complete electrical balance of system design.

During Budget Period 1, Lake Erie Energy Development Corporation, Inc. identified Cleveland Public Power's Lake Road Substation as the point of interconnection. The preliminary design includes a new project substation that will be constructed on Cleveland Public Power property adjacent to the Substation and includes a control building, bus structures, switchgear, and a step-up transformer. The project Substation will be connected to the existing 69 kV system at the Cleveland Public Power Substation via an overhead gen-tie circuit. Detailed engineering design of the substation will be part of the 100% Front End Engineering Design.

As part of the 50% Front End Engineering Design, the preliminary cable layout design was developed based on an assessment of multiple route options driven by the shore crossing route for the export cable. The cable route must cross or go around the breakwater, and then cross the Harbor to connect into the project substation. There is a confined disposal facility, a man-made confinement facility for disposal of dredged materials, inside the Harbor along the direct path to project Substation. As such, there are multiple options for entering and crossing the Harbor.

To compare the different route options, a qualitative comparative analysis was conducted to assess the benefits and risks of each option. This analysis considered multiple criteria including cable length, application of horizontal directional drilling, potential for external damage by third parties, environmental aspects, potential for thermal bottlenecks, permitting considerations, and potential future development plans near the shore crossing. Based on this assessment, the proposed export cable route includes a duct installed with horizontal directional drilling that would route the cable from the project Substation under the Harbor, the confined disposal facility, and the breakwater to a point in the open water of Lake Erie just beyond the breakwater. From that point, the cable route continues on a direct path to the first Wind Turbine Generator (ICE1). The proposed inter-array cable routes are direct paths between the Wind Turbine Generators.

Installation of the cable will be performed with commonly used methods. Horizontal directional drilling with a land-based drilling rig will be used to install a duct under the Harbor, the confined disposal facility, and the breakwater. The export cable will then be pulled through the duct from a cable installation vessel positioned near the entry point for the horizontal directional drilling in the open water of the lake to the exit point at the project Substation using a land-based winch. The portion of the export cable in the open water of the lake and the inter-array cables and will be installed using a jet plow, a device that utilizes high-velocity jets of water to fluidize the lake bottom soil to facilitate simultaneous laying and burial of the cable to a specified depth. The jet plow is towed by a cable installation vessel such as a self-propelled multi-purpose barge that is outfitted for cable installation.

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This report includes preliminary specifications for the supply of submarine 34.5 kV cables including the connections and equipment necessary for the installation and operation of the cables. These specifications include operating requirements, general cable construction, attributes and accessories, and requirements for protection, testing, and quality surveillance. The proposed submarine cables are 34.5kV three-core, cross-linked polyethylene or ethylene propylene rubber insulated submarine cables. Due to manufacturing limitations, submarine cables often include factory joints and depending on the capabilities of the manufacturer, field joints may be required. The submarine cables for Icebreaker should be delivered with a minimum number of factory joints. If necessary, field joints shall be installed and tested according to relevant standards to ensure that performance and reliability are not impacted.

The preliminary supervisory control and data acquisition system design reflects the key components for monitoring and controlling Icebreaker.

The preliminary design for the components of the electrical balance of system described in this report represent solutions that will support Icebreaker's objectives, particularly the following:

- Develop an innovative offshore wind system that can be installed in the most rapid and responsible manner possible; minimizes costs, development effort.
- Expedite the development and deployment of innovative offshore wind energy systems with a credible potential for lowering the levelized cost of energy.

This report identifies further studies and design work that will need to be completed to support the final designs of the electrical basis of system. This includes the following:

- Detailed design for the project Substation
- Additional site assessment including geophysical and geotechnical surveying
- Burial assessment for the cable route
- Detailed HDD design
- Vessel planning for cable installation
- Detailed cable design
- Detailed supervisory control and data acquisition system design

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Introduction

Lake Erie Energy Development Corporation (LEEDCo) retained DNV GL to develop a preliminary design for the substation and the submarine cable system including the layout of the subsea cable system, the cable shore crossing, and the cable installation for the proposed Project Icebreaker offshore wind project (Project Icebreaker or Icebreaker).

1.1 Scope of Work

This report summarizes the preliminary design of the electrical balance of system (BOS) including the substation, the submarine cable system, and the Supervisory Control and Data Acquisition (SCADA) system; the cable routing; the cable shore crossing; and cable installation for Icebreaker. This scope of work described herein includes assessment of multiple options for the cable route and shore crossing as well as multiple installation concepts. This report was prepared with support from Primo Marine, a global consultancy with extensive experience and expertise with subsea cable design and installation.

The scope of work described in this report is primarily focused on the mechanical design of the submarine cable and does not include electrical design aspects of the cable (preliminary electrical design is addressed in the LEEDCo Grid Interconnect Report. Additionally, the preliminary design presented herein is intended to form the basis for further design activities for Icebreaker and does not represent a comprehensive or complete electrical BOS design.

2 Design Basis

The design basis for the preliminary conceptual design of the electrical BOS is described in Appendix K of the Design Report. The design basis includes the overall project layout, environmental conditions, siting constraints, standards and performance requirements, specifications for the Wind Turbine Generators (WTGs), and existing electrical infrastructure at the point of interconnection.

3 Substation Layout

The project Substation will be situated on the northern edge of the Cleveland Public Power (CPP) property along the shoreline and will be connected to the existing 69 kV bus at the CPP Substation via overhead lines as shown in Figure 3-1. The project Substation will consist of new electrical equipment, including a 34.5 kV to 69 kV step-up transformer, switch gear, bus structures, and a control building, all contained within a fenced area adjacent to the CPP Substation. The conceptual design for the equipment arrangement for Icebreaker Substation is shown in Figure 3-2. The project Substation equipment is described in more detail in the Grid Interconnect Report. The preliminary layout design for the project Substation showing the connection to the CPP Substation is presented in Attachment A.

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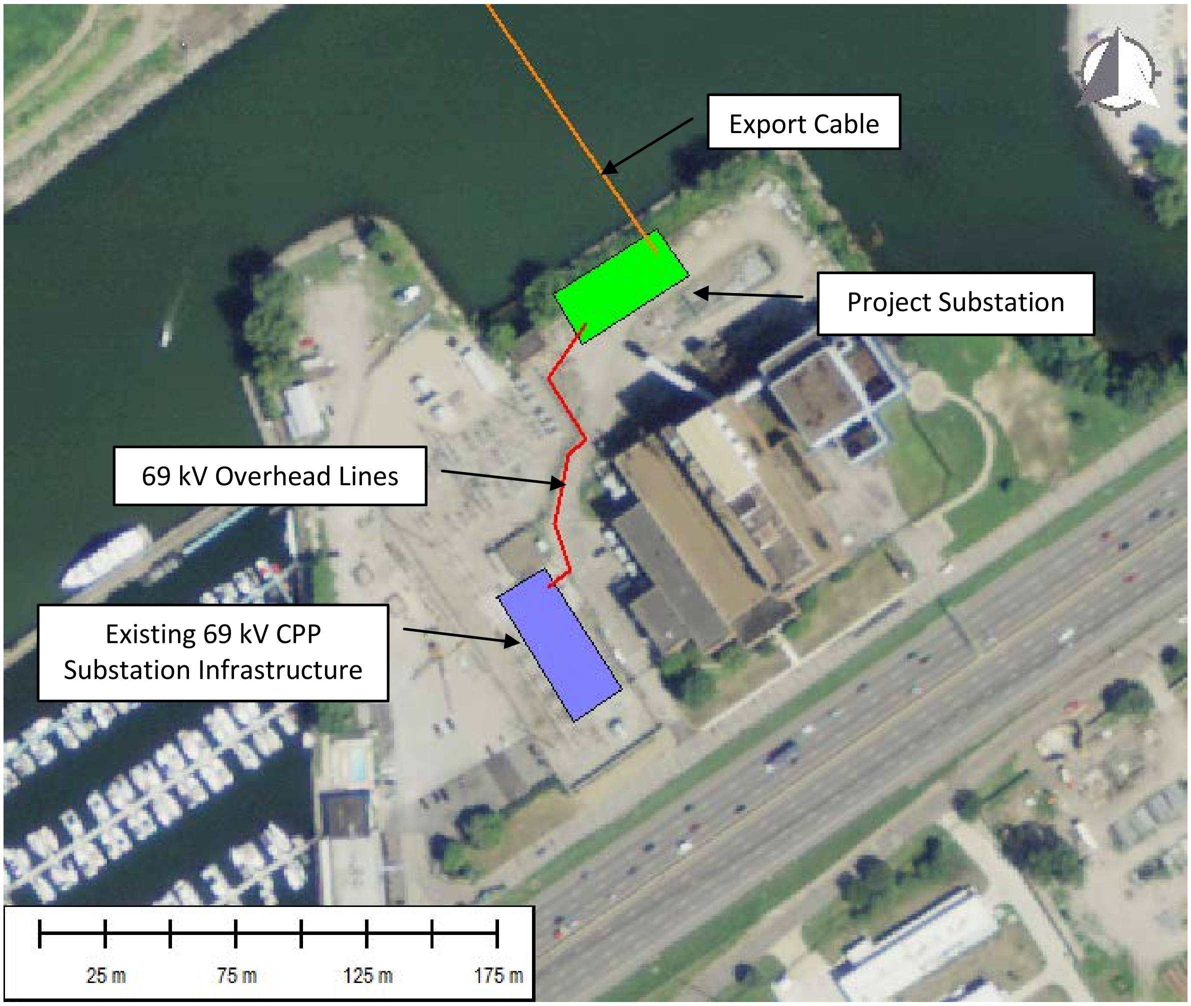

Figure 3-1. Conceptual substation layout

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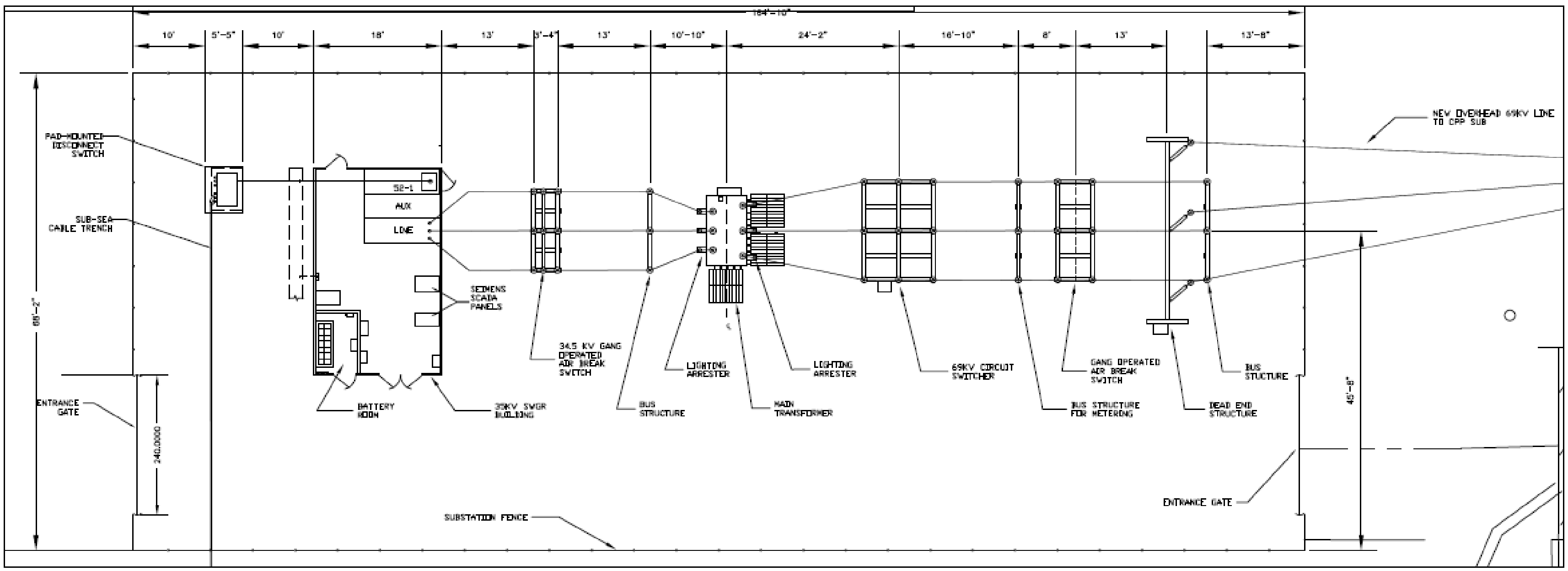

Figure 3-2. Project Substation layout

The layout for the project Substation reflects a compact arrangement that is intended to minimize space requirements. There may be opportunities for further reducing the space requirements for the Project Substation; however, there is a chance that additional space may be required. The ultimate size, arrangement, and location of the project Substation shall be determined as part of detailed design work for the electrical BOS.

4 Cable Layout Design

This section describes the preliminary cable layout design and alternative options.

4.1 General Cable Route

Figure 4-1 shows the export cable route that runs from wind turbine closest to shore (ICE1) to the lakeshore and the inter-array cables between the wind turbines (ICE1 through ICE6). The export cable will be connected to the project Substation.

Due to the relative length of the export cable (approximately 18.3 km (11.4 mi) to 21.1 km (13.1 mi)) compared to the inter-array cables (1 km (0.6 mi)) and the challenges associated with routing of the export cable and the shore crossing, the export cable is the primary focus of this section.

Figure 4-1. Inter-array and export cable route overview

4.2 Cable Route Options

The starting point for the export cable route is the most direct path from the turbines to the project Substation, as this should generally minimize costs of cable and installation costs. As discussed in the Electrical Design Basis Report, the information currently available does not present any constraints preventing a direct path. To connect the export cable to the project Substation, the cable route must cross or go around the breakwater, and then cross the Harbor to the project Substation. A confined disposal facility (CDF), a man-made confinement facility for disposal of dredged materials, is located inside the Harbor along the direct path to project Substation. As such, there are multiple options for entering and crossing the Harbor which is the primary driver for the overall cable route. For this analysis, three different route possibilities have been developed and these are depicted in Figure 4-2. Routes are defined as Option 1, Option 2, and Option 3.

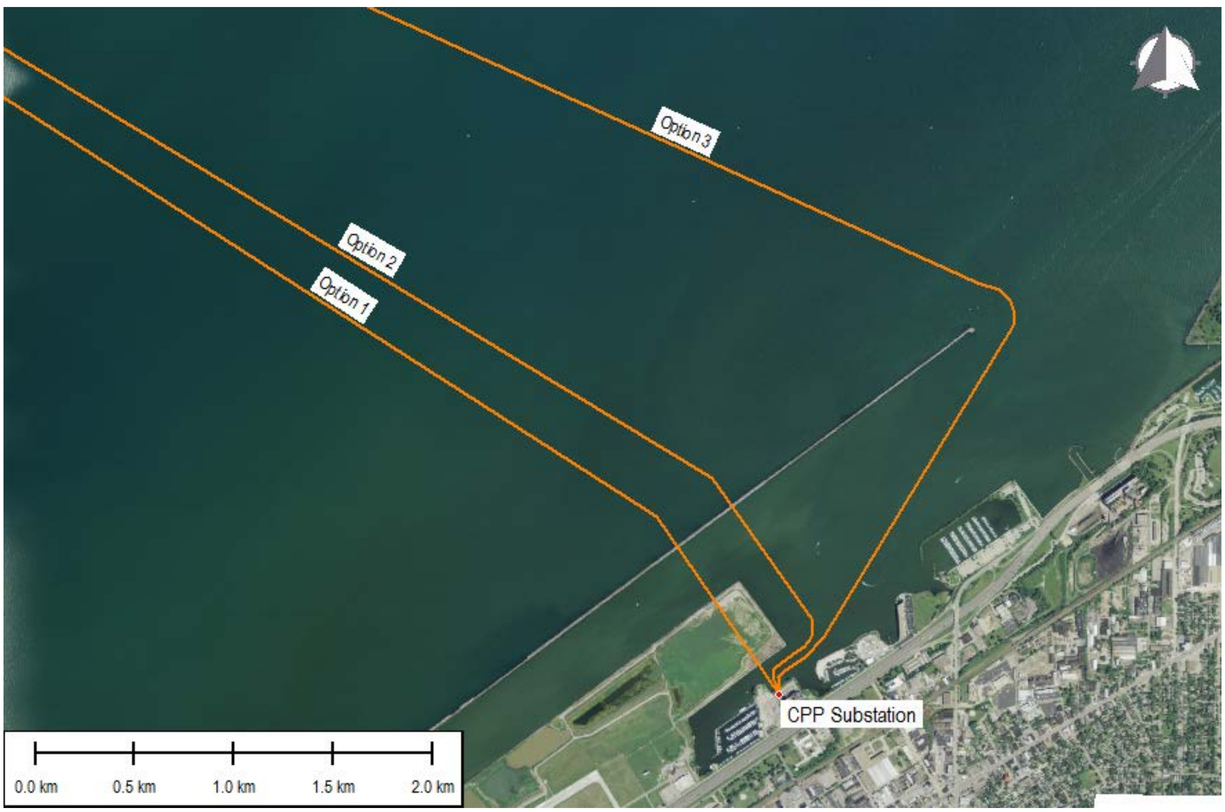

Figure 4-2. Options to route the export cable from the lake to the CPP Substation

These options (including Sub-Options 1a, 1b, and 1c) are described below and are depicted in the conceptual diagram in Figure 4-3.

Option 1

This route is the most direct route and consists of a straight path perpendicular to the general shoreline orientation from the project Substation, crossing the CDF and the breakwater to a point in the open water of Lake Erie beyond the breakwater, then making a bend and continuing in a straight path to ICE1. Option 1 has various implementation or installation options, which are described in brief below:

- **Option 1a:** For this option, the cable is installed completely in a duct which runs from the entry point in the open water of Lake Erie beyond the breakwater to the exit point at the project Substation. The duct, installed with horizontal directional drilling (HDD), would route the cable entirely under the Harbor, the CDF, and the breakwater.
- **Option 1b:** This option consists of an HDD duct from the project Substation under the Harbor to the CDF, a trench across the CDF, and a second HDD duct from the CDF under the Harbor and the Breakwater to an exit point in the open water of Lake Erie beyond the breakwater.
- **Option 1c:** This option consists of a conventional landfall at the project Substation, crossing of the Harbor channel by float-out installation, landfall at the CDF, trenching across the CDF, and an HDD duct from the CDF under the Harbor and the Breakwater to an exit point in the open water of Lake Erie beyond the breakwater.

For each option 1a, 1b, and 1c, from the exit point to the WTGs, the cable is installed using trenching.

Option 2

This route consists of a conventional landfall at the project Substation, crossing of the entrance channel (bypassing the CDF) by float-out installation, and an HDD duct under the breakwater from the Harbor channel to an exit point in the open water of Lake Erie beyond the breakwater. From the exit point towards the WTGs, the cable is installed using trenching.

Option 3

This is a conventional lay operation that comprises a conventional landfall at the project Substation (such as cut and cover), laying the cable in the Harbor bypassing the CDF and the breakwater, then making a bend after the end of the breakwater, then continuing along a straight path towards the WTGs.

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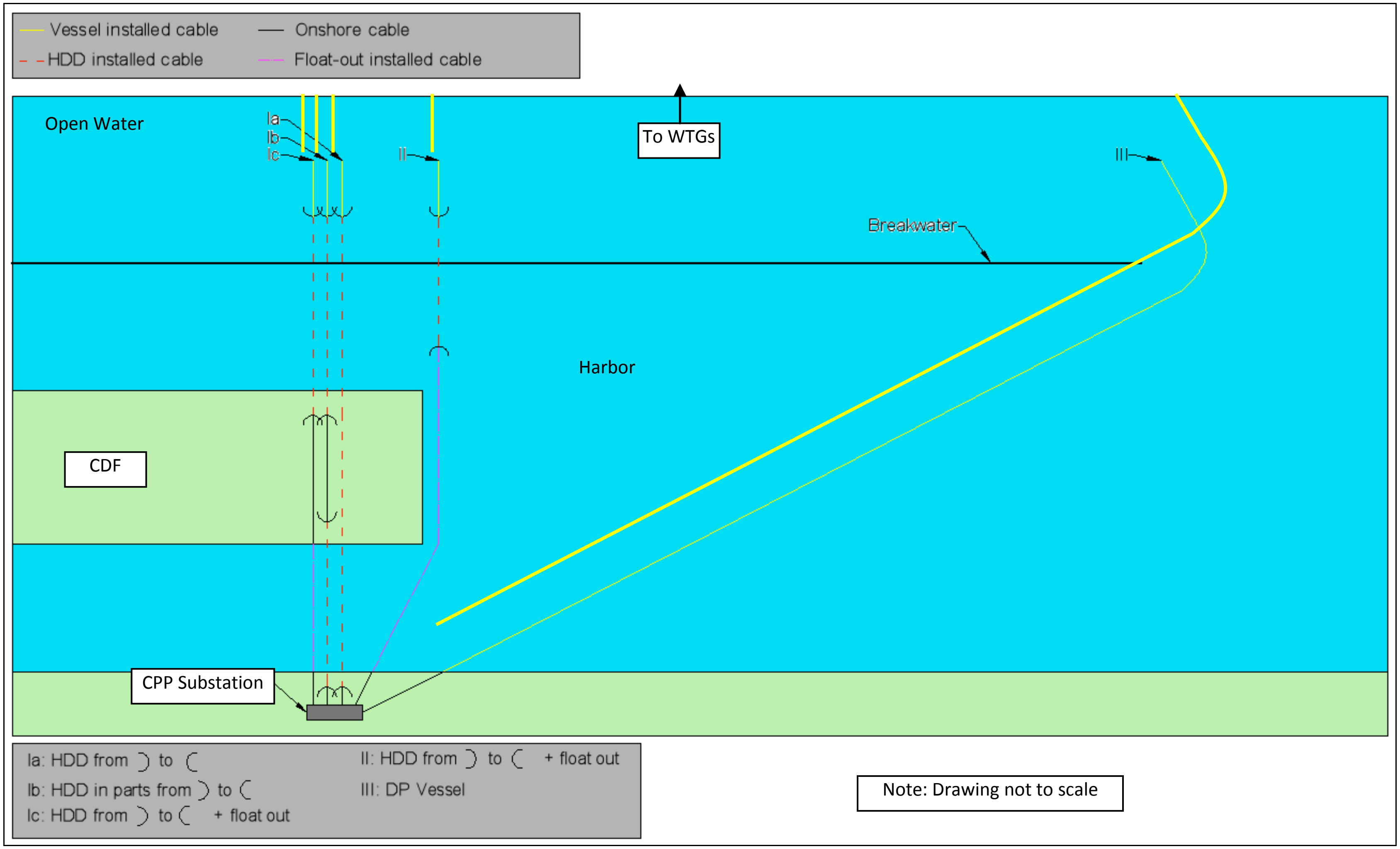

Figure 4-3. Cable route options for shore and harbor crossing

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4.3 Comparative Analysis

To compare the different route options, a qualitative comparative analysis was conducted to assess the benefits and risks of each option. The main criteria that have been considered in this analysis for the export cable route include the following:

Cable length

By bypassing the breakwater and the CDF using horizontal directional drilling(s), the total length of the export cable can be reduced by roughly 2.8 km (1.7 mi) compared with going around the breakwater. Reduced cable length will lead to lower capital expenditures.

Application of HDD

HDD can be applied to cross the breakwater, CDF, and Harbor shortening the total cable route and reducing the impact of the cable installation on the activities inside the Harbor. However, HDD will lead to higher installation costs.

External damage by third parties

Anchors in the Harbor, excavation on the CDF, etc., can damage the export cable if it is not well protected by sufficient burial depth and/or cable covers. This can increase the downtime risk for the project, leading to higher operating expenditures during the life time of the cable system and risk of lost revenue.

Environmental aspects

Installation of the cable using trenching, HDD or other methods will impact the environment. Impacts could include disturbance of the lake bed sediments and release of bentonite into the environment (bentonite is used as in drilling fluids to lubricate and cool the drilling tools). During operational life, the heat produced by the export cable might increase the temperature of the seabed, having a possible effect on the environment.

Thermal bottleneck

Different installation methods, burial depths, etc., can impact the thermal bottleneck for the cable system. During operation of the cable system, the cable will heat up and the current rating is determined by the maximum allowed temperature of the cable. The installation method has an impact on the release of heat to the surrounding environment, and the part of the route that has the highest impact is called the thermal bottleneck. This may impact the cable specifications, which in turn may have an impact on capital expenditures.

Permitting

The necessary permits that are required for the export cable installation.

Future regional development plans

Various development plans in and around the Harbor have been proposed. Such developments may present risks to the cable and the presence of a power cable may limit future development plans. These interactions have been considered at a high level.

The key benefits and risks associated with each option are summarized below in Table 4-1.

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Table 4-1. Pros and cons of export cable route options

Route option	Pros	Cons
1a	• Shorter cable length • Well protected from external threats (e.g., vessels, anchors, etc.) during its design life	• Drilling (technically challenging) • Long drilling length, feasibility must be checked, feasible up to 3000m • Potential release of bentonite into the environment
1b	• Shorter cable length • Well protected from external threats (e.g.. vessels, anchors, etc.) during its design life except for the buried cable on the CDF • Shorter drilling length	• Two drillings instead of one (technically challenging) • Bentonite might enter environment • Potential thermal bottleneck for the onshore cable on the CDF • More vulnerable for external damage on the CDF • Impact on future development plans
1c	• Shorter cable length • Well protected from external threats (e.g.. vessels, anchors, etc.) during its design life except for the buried cable on the CDF and between the shore and CDF • Shorter drilling length	• Drilling (technically challenging) • Bentonite might enter environment • Potential thermal bottleneck for the onshore cable on the CDF • More vulnerable for external damage on the CDF and between shore and CDF • Impact on future development plans
2	• Shorter cable length • Shorter drilling length	• Drilling from jack-up barge • Bentonite might enter environment • Laying cable close to CDF not feasible • More vulnerable for external damage between shore and HDD • Partly closing of harbor during installation • Impact on future development plans, in particular extension of the CDF
3	• Technically easier • No drilling	• Longer cable length • Lateral movement towards breakwater when bottom tension is too high • More vulnerable for external damage • Potential extra engineering for anchoring pattern, ice • Partly closing of harbor during installation • Impact on future development plans, in particular extension of the CDF

The benefits and risks discussed above in Table 4-1 have been considered in a high level quantitative assessment of the different options whereby each option is assigned a score from 1 to 5 for each criterion (1 indicating high benefit/low risk and 5 indicating low benefit/high risk). Weightings have been assigned to each criterion to reflect the relative importance of each criterion. Total weighted average scores were then calculated to and these scores were used to rank the different options. The scoring and ranking of each option is presented in Table 4-2.

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Table 4-2. Quantitative assessment and ranking of the different cable route options

Criteria	Option 1a	Option 1b	Option 1c	Option 2	Option 3	Weight	Explanation
Cable length	1	1	1	1	2	20%	The total cable length is approximately 18.3 km (11.4 mi) for Option 1, approximately 18.7 km (11.6 mi) for Option 2 (considered similar to Option 1), and approximately 21.1 km (13.1 mi) for Option 3. Option 3 will result in a moderate increase in the cost for cable relative to Options 1 and 2.
Application of horizontal directional drilling(s)	3	5	3	4	1	20%	For Option 1a and 1c, one HDD is applied for the shore crossing, drilled from either the shore or the peninsula. Option 1b requires two drillings and, thus, is more expensive. Option 2 requires a shorter drilling, but the drilling would be from a vessel which would have higher associated costs and technical challenges relative to drilling from shore, and floating out of the cable along the peninsula which also requires a special vessel. Option 3 does not include any HDD and uses only traditional installation methods with relatively fewer technical challenges and lower costs. Once the shore and breakwater crossing is complete, the remaining cable will be installed using traditional methods that would be consistent for each option.
External damage by third parties	1	2	2	3	4	20%	Typically, the duct for an HDD-installed cable and the greater depth of cover relative to a cable buried via a plow ensures for additional protection of the cable. Therefore, Option 1 has the best score. For Options 1b and 1c, part of the cable is buried on the CDF in a traditional trench, increasing the risk for damage. The path for Option 2 generally avoids the vessel traffic lanes but would have greater exposure to risk of third-party damage relative to Option 1. Option 3 has the highest risk of third-party damage.
Environmental aspects	3	3	3	4	4	10%	During installation of the cable, the environment (lakebed) will be disturbed. Drillings have less impact compared to trenching. Due to the fact that the majority of the export cable will be installed with trenching (outside the breakwater), the relative difference between the options is minor.
Thermal bottleneck	5	4	4	4	2	15%	Typically, a drilling can be a potential thermal bottleneck due to the depth required for the drilling and the limited ability of the cable to radiate heat in the duct because of the lack of circulation of water within the duct and the thermal resistivity of the duct itself. The longer the drilling, the deeper the drilling will be and the higher the thermal resistivity of the surrounding soil. Therefore Option 1a has the worst score and Options 1b, 1c and 2 are scored

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							moderately better. Because Option 3 does not include a drilling, this option is less susceptible to thermal bottleneck issues at the shore crossing. All options will have a thermal bottleneck at some point along the cable. This is often at the point where the cable enters the base of the WTG tower and is exposed to air.
Permitting						0%	Based on the initial correspondence with the relevant authorities it is not expected that there are significant differences in permitting for the different options. Therefore, permitting is not ranked.
Future development plans region	1	5	5	4	3	15%	Various development plans have been proposed for the Harbor area including the CDF. As such, an HDD (Option 1a) around the CDF or deep under the CDF will offer the highest flexibility. A trench on the peninsula (Option 1b and 1c) will potentially present an obstacle for future development, and should be taken into consideration. Having the cable trenched in the seabed inside the Harbor will also limit the expansion of the CDF (Options 2 and 3). However, Option 3 would likely have less impact compared to Option 2.
Weighted Average Score	2.20	3.25	2.85	3.20	2.55		
Ranking	1	5	3	4	2		

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The results of this assessment indicate that Option 1a represents the best option. The main reason to opt for Option 1a is the fact that the cable is completely protected during its design life. However, a more detailed cost analysis considering capital expenditures and operating expenditures, as well as risk associated with each, should be conducted at a later stage of the project to confirm this conclusion.

Due to the fact that there is a potential for future development plans on or around the CDF, the HDD should cross the CDF at a position that is chosen based on consideration of such potential future developments, to the extent that such plans are known. If necessary, the HDD can go around the CDF. In this scenario, at the landfall the start angle in the horizontal plane shall be such that the HDD will clear the edge of the CDF. The route has to be chosen such that the total length does not exceed the maximum possible length of an HDD of that diameter. The length, dimensions and material of the duct shall follow from a detailed HDD engineering design.

4.4 Inter-Array Cables

The length of the inter-array cables between the WTGs is approximately 1 km (0.6 mi). These cables will follow a straight line between the WTGs and shall be buried. At the base of the of the WTG support structure, the maximum cable bending radius should be respected and limited by an appropriate bending stiffener before being inserted into the pile. To protect the cable against ice ridges, the cable shall be protected by appropriate means, which needs to be investigated in the detailed design stage. Given the predominant wind direction, the optimal side to insert the cable to minimize risk of damage from ice is on the east/north-east side of the support structure. Normally cables are protected by external J-tubes or I-tubes, but due to possible forces of the ice exerted on these tubes, internal tubes are likely a better option.

Protective measures might also be required to protect the cable from solar radiation, but this needs to be investigated in the detailed design stage as well.

4.5 Proposed Cable Route

Based on the analysis discussed above, the proposed cable route for Icebreaker reflects Option 1a as shown in Figure 4-4.

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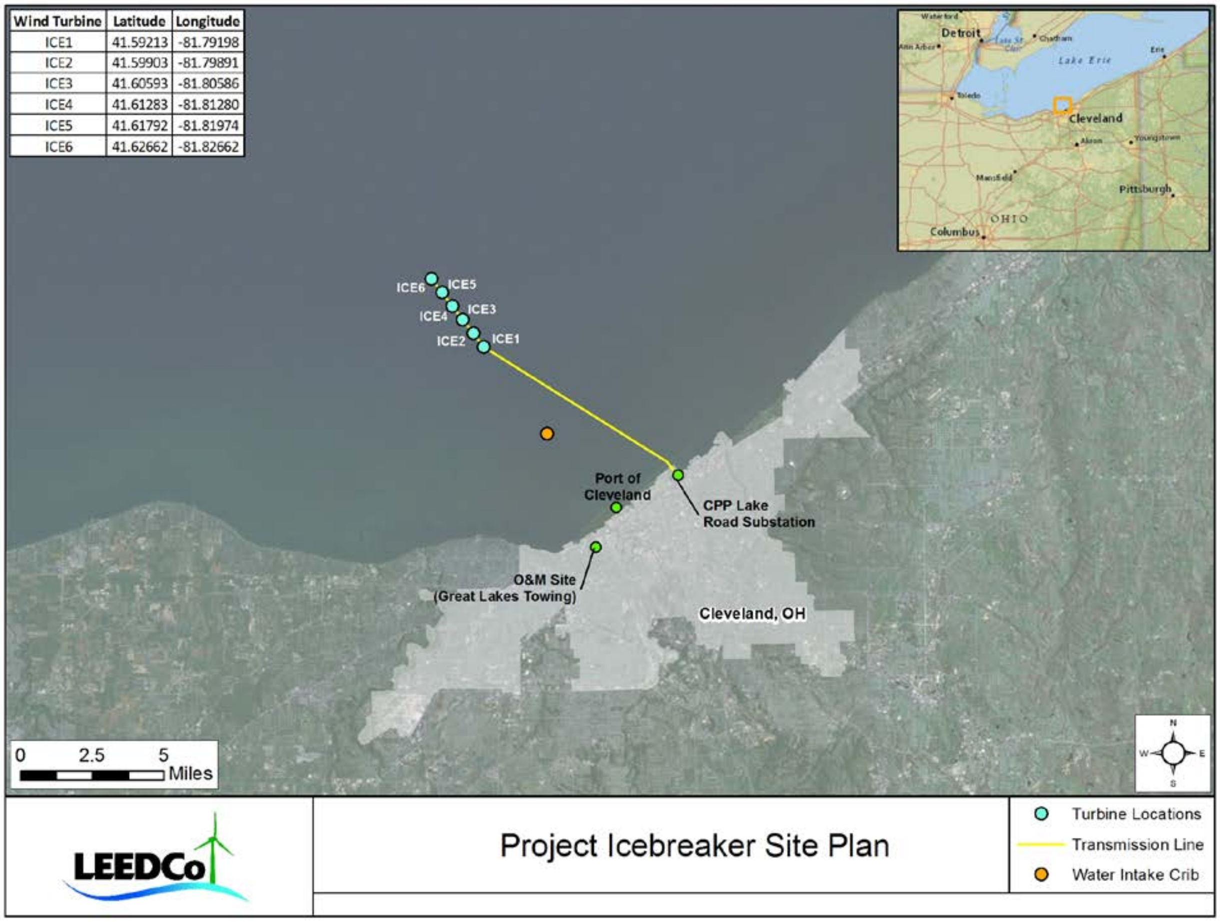

Figure 4-4. Proposed cable route

5 Cable Installation Concept Design

The installation of the cable will consist of a number of components including the inter-array cables, open-water section of the export cable, and the harbor/shore crossing. This section considers each of these components. The installation method for the inter-array cables and the open-water section of the export cable will likely be the same however the sequence of pull-in operations may differ slightly. As indicated in Section 4 the preferred option for the harbor/shore crossing is an HDD under the breakwater and CDF to the project Substation. The installation process for the HDD (Option 1a) is described in this section. Additionally, the installation process for the alternative option of laying the cable in the harbor (Option 3) is described in this section.

5.1 Open-Water Installation

The installation of the export cable in open water will be performed by a cable lay vessel. The direction of the export cable installation will depend on the shore crossing option, and will be from the entry point of the HDD to ICE1 for Option 1a or from ICE1 towards the east entrance of the Harbor for Option 3.

A survey should be carried out to find suitable cable lay vessels or vessels that can be converted in to a cable lay vessel. As an example of a typical vessel that could be used for the cable installation for Icebreaker, Figure 5-1 shows the S/B Victor, a self-propelled, multipurpose barge owned by JD Contractors in Denmark (Drunsic et al. Electrical Basis of Design, 2014). The S/B Victor is shown with a typical cable installation spread similar to what would be required for Icebreaker.

Figure 5-1. Cable installation vessel S/B Victor (courtesy of JD Contractors)

The cable likely will be delivered in two lengths, one for the export cable and one for the inter-array cables. The inter-array cable will be cut at appropriate locations in the field for each individual inter-array cable length. The total length of the cable is approximately 20 km. Jointing in the field is not necessary; although, depending on the cable supplier, field joints may be required (see Section 6 .

The weight of a typical 3-phase 34.5 kV submarine cable is approximately 26.3 kg/m dry weight and 19.6 kg/m in seawater. The total dry weight of the cable is approximately 500 metric tons. The cable can be transported on one cable lay vessel.

Tensile force in the cable will increase during the lay operation from shallow to deeper water. The water depth along the shore is approximately 9 m (30 ft) and increases to 18 m (60 ft) at the WTG. It is assumed that the tensile force will not exceed the specific tensile force of the manufactured cable during the lay operation. This should be evaluated as part of the detailed design work.

The installation process will consist of simultaneous laying and burial of the cable to a sufficient depth to protect the cable against external threats. The minimum burial depth target for Icebreaker is 1.5 m (4.9 ft). In areas with more morphological activity, like the near shore zone where sediment transport is likely greater and the risk of impact from ice ridges is higher, the cable may need to be buried deeper or non-burial protection techniques may be required. Cable protection is discussed further in Section 6.7.

Based on the current understanding of the site conditions along the cable route, a jet plow trenching tool will be used to install the cable. This technology is commonly used to install submarine cables for offshore wind projects and other applications. A jet plow is a specially designed device with an adjustable blade, or plow, which rests on the lake bottom and is either towed by a surface vessel or integrated into a self-propelled remote operated vehicle. The plow creates a narrow trench at the designated depth, while water jets fluidize the sediment within the trench. The cable is fed through the plow and is laid into the trench as it moves forward. The fluidized sediments then settle back down into the trench and bury the cable. In soft soils, the presently available jet plows can bury the cable in a continuous movement up to a depth of 3 meters. For specific areas where cable burial is not possible by a jetting trencher, other techniques, like mass flow excavation may be applicable. Mass flow excavation is a technique which uses a low velocity, high volume column of water to excavate non-cohesive sediments by erosion. In essence, it is the opposite of jetting which uses a high velocity, low volume column of water to cut soils. Jetting is typically applied from a sled-mounted unit which is placed directly on the seabed. Mass flow excavation is typically applied using an excavation unit that hangs above the seabed under a vessel.

As long as the soil in which the cable has to be buried consists of soft soils such as sand, mud, and soft clays, burial with a jet plow is possible. Boulders and cobbles might be present along the export and/or inter-array cable route. When the plow encounters boulders or cobbles, the cable route can be diverted. If possible, boulders and cobbles should be removed before trenching if their locations are known.

Based on the soil conditions along the proposed cable route, use of a self-propelled plow is probably not feasible due to potential problems with traction in the soft soils on the lakebed. The optimal solution likely will be a jet plow with skids that can be towed by the cable lay vessel. An example of a typical jet plow is the Oceanjet 200 Jetting Sled Trencher (Oceanteam Shippin) depicted in Figure 5-2. This jet plow is a remotely operated subsea jetting sled designed specifically for the trenching of submarine cables. The Oceanjet 200 consists of two parallel skids bridged by cross beam support units. The jetting tool is mounted from the central unit, and deployed by means of a hydraulic ram. It is capable of trenching cables down to a depth of approximately 3 m (10 feet) and can be operated in water depths of up to 40 m (130 feet). The requirements for the trenching equipment should be further defined as part of a burial assessment to be completed as part of future design work.

Figure 5-2. Oceanjet 200 Jetting Sled trencher

As stated above, for Option 1a, the cable lay installation starts from the HDD entry point and the cable lay operation terminates near ICE1. At the termination, the cable will be laid down on the lakebed with sufficient cable overlength and marked with a buoy. A pull-in wire is then connected to the cable end and a winch is used to pull the cable into the J-tube or I-tube of the WTG support structure and clamped at the support structure transition piece.

Due to the soft soils, it is possible that cable will bury itself in the lakebed sediments. A survey vessel may be required to determine the location of the cable end to connect the pull-in wire. Use of floatation devices may also be required.

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5.2 Shore-Crossing Design / Landfall

From Section 4.3, two options for the shore crossing were identified as the best solutions among the considered alternatives. The preferred alternative (Option 1a) routes the cable under major obstacles utilizing HDD; the second alternative (Option 3) routes the cable around major obstacles utilizing burial methods. Both alternatives are briefly described in this section.

5.2.1 Option 1a: HDD

One of the primary considerations for the HDD option is the amount of available area onshore for setting up the drill rig. **Error! Reference source not found.** shows the relation between the crossing length (length of the HDD) and the required space for drill rig installations. This figure was prepared by Nacap (Nacap, 2014), a global pipeline and HDD contractor, based on input from the North American Society for Trenchless Technologies Horizontal Directional Drilling Good Practices Guidelines, the American Society for Civil Engineers Manual of Practice No. 108 - Pipeline Design for Installation by Horizontal Directional Drilling, and the Drilling Contractors Association Technical Guidelines which all provide guidance on equipment layout and required area.

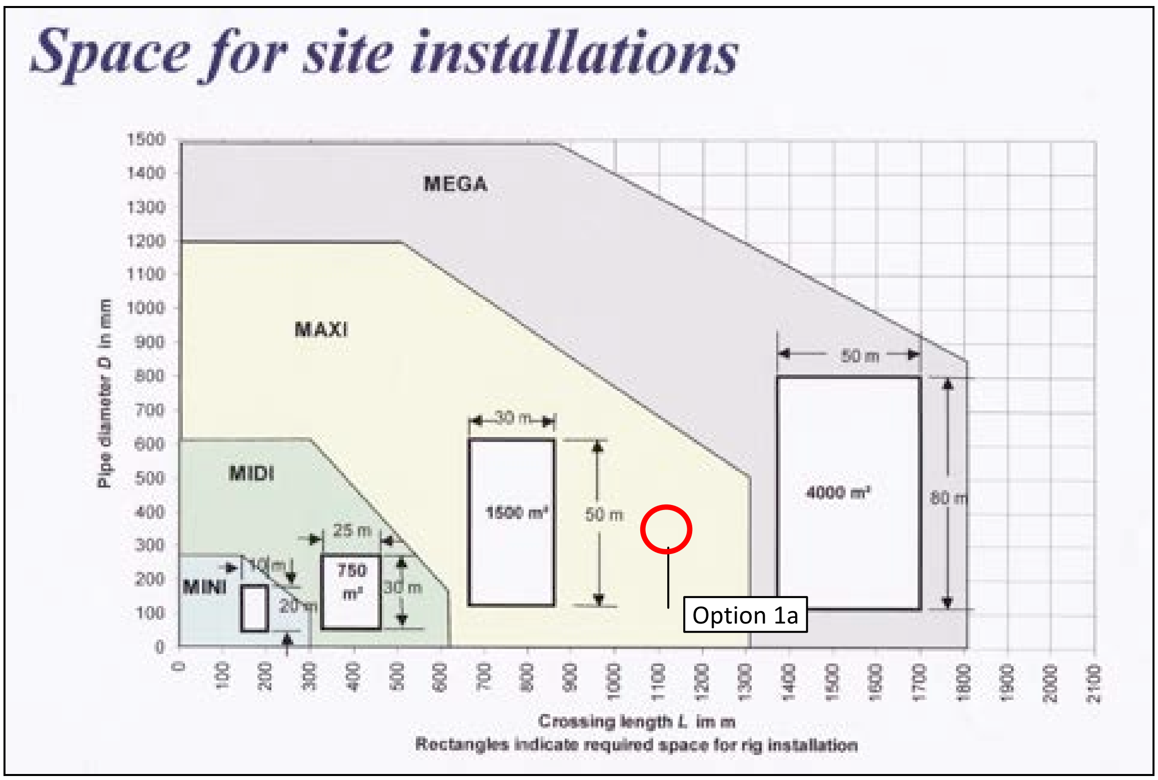

Figure 5-3. Relation between crossing length and space for drill rigs or site installations

Figure 5-3 is useful for determining the required space when either the crossing length L or the pipe diameter D is normative. When the crossing length or pipe diameter increases, the required surface for the site installation also increases. The estimated length of the HDD shore crossing from the project Substation under the breakwater into the lake is approximately 1150 m (0.70 mi). The inner diameter of the duct will depend on the cable size, pulling arrangement, cable weight, pull length, friction coefficient and bends. For long pull lengths, the inner duct diameter may need to be up to 2.5 times the cable outer diameter. For the purposes of this preliminary design, the outer diameter of the cable is assumed to be 120 mm and the inner diameter of the duct is estimated to be approximately 300 mm, but these shall be determined as part of further design work. The required space for the site installation to perform such a drilling is estimated according to **Error! Reference source not found.** to be 1500 m^2 (16145 ft^2). This results in a design basis for the HDD construction as depicted in **Error! Reference source not found.**.

Figure 5-4. Design basis of the HDD near the Substation

The location of the drill hole on land is determined as the ‘exit point’ of the power cable. The ‘entry point’ on the lake is where the cable will be pulled in and through to the exit point.

Because of the close proximity of the project Substation and the proposed exit point to the bank at the edge of the Harbor, an entry angle of approximately 12 degrees above horizontal is required to avoid a shallow position of the cable beneath the lake bottom in the Harbor. A minimal cover above the cable

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crossing the bank at the edge of the Harbor of at least 5 m (16 ft) should be maintained. With this entry angle, the HDD will cross the Harbor at a minimal depth of 7.5 m (24.5 ft) below the lakebed. The transition on the lakebed at the entry point is dredged and provided with a casing. The depth of cover for the portion of the HDD under the CDF is approximately 20 m (65 ft) and assumed to be sufficient, but should be specified as part of further design work.

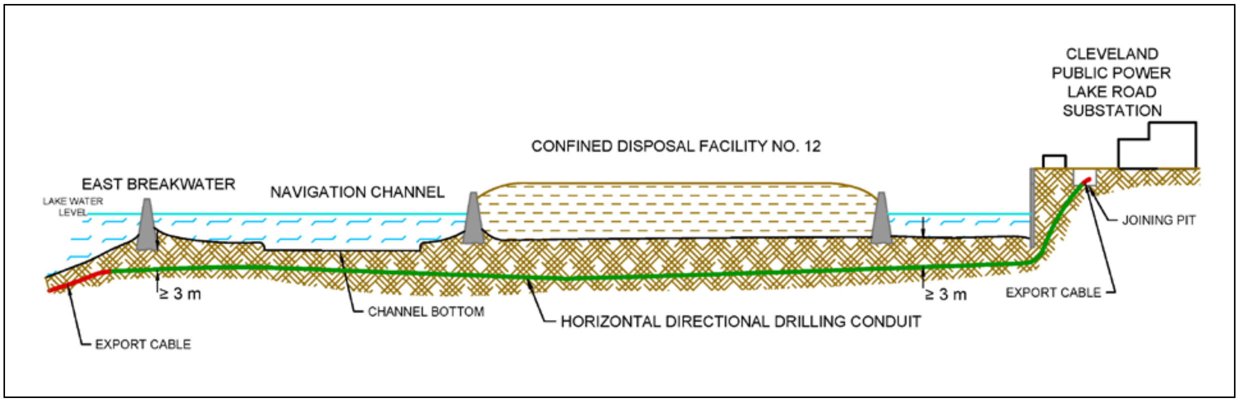

Figure 5-5 HDD cross section from the entry point in the lake to the exit point near the Substation

The equipment required for HDD includes specialized drilling equipment and auxiliary equipment that will need to be arranged on site to support a safe and efficient HDD operation. The size of the site installation (approximately 50 x 30 m or 164 x 98 ft) fits on the parking lot next to the CPP Substation where the exit point of the HDD is indicated in **Error! Reference source not found.**. All onshore drill activities and equipment should be located as close to the exit point as possible including placement of the following equipment:

- Drill rig
- Drill pipes
- Work containers
- Mud pump
- Mud tank
- Generator
- Power unit
- Control cab

An overview of a typical equipment arrangement is depicted in **Error! Reference source not found.**. An arrangement suitable for the requirements of Icebreaker and the site may look different from what is shown in **Error! Reference source not found.** and should be established as part of a detailed HDD engineering design. It should be noted that the 1500 m^2 space for site installations as indicated in **Error! Reference source not found.** is the required space if all equipment is arranged with no working space between the equipment.

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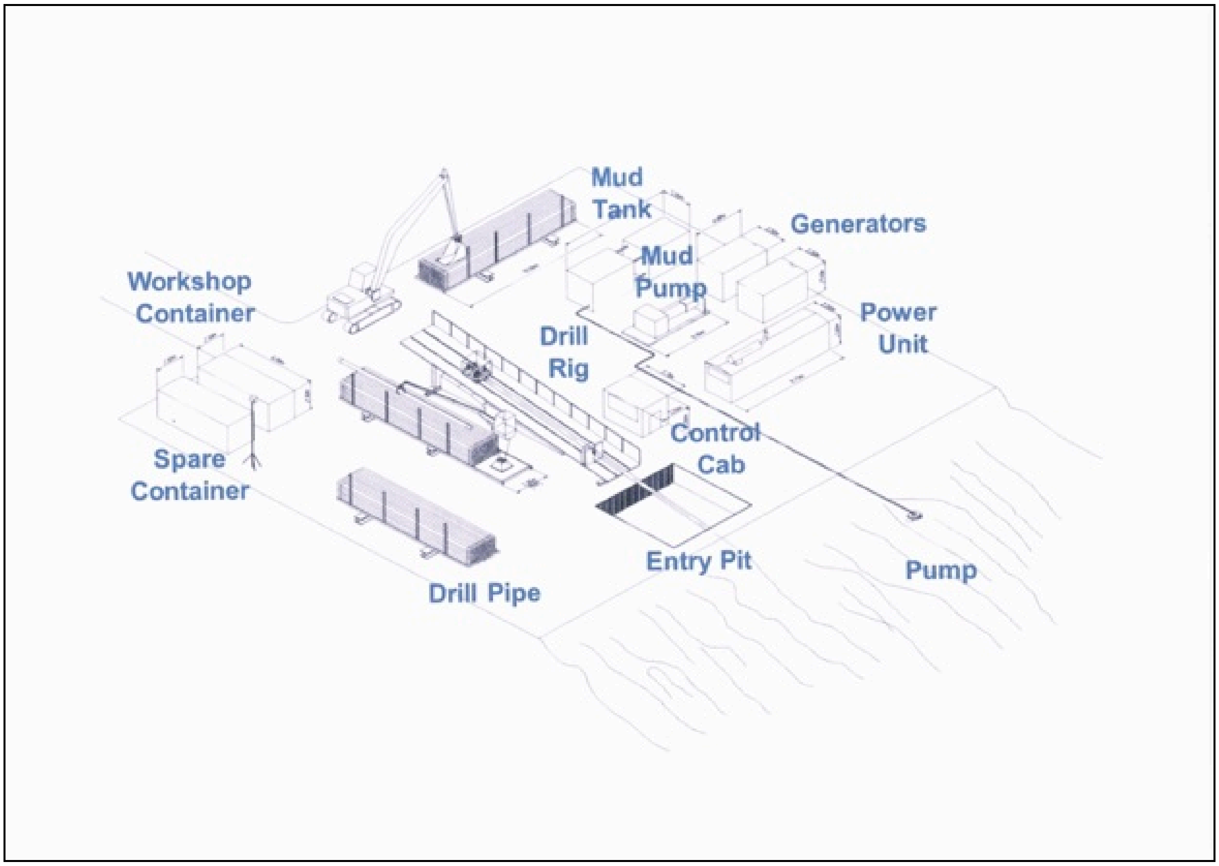

Figure 5-6. Overview of the equipment arrangement for the HDD

The following describes the general process associated with the HDD.

1. Preparation prior to cable initiation:
    a. Drilling of the pilot hole from the exit point to the entry point;
    b. Reaming of the pilot hole from the entry point to the exit point;
    c. Placing the duct the from exit point to the entry point;
    d. Pre-installation of the shore based winch at the HDD exit point; and
    e. Pull wire installation through the HDD duct.
2. Cable initiation:
    a. Positioning of the cable lay vessel at an appropriate location near the entry point of the HDD;
    b. Retrieval of the pull wire from the HDD duct and attachment to the free end of the cable;
    c. Cable pulling from the vessel through the duct by the shore based winch; and
    d. Upon arrival of cable at the landing point (joining pit), securing cable.

After securing of the cable at the landing point, the main lay operation will commence from the HDD entry point to ICE1.

The HDD duct will terminate on land at the pad-mounted disconnect switch at the project Substation where the cable will be terminated. From the landfall point to the project Substation, the HDD duct will provide the necessary protection for the cable.

5.2.2 Option 3: Trenched Installation in Harbor

The working space and the water depth in the harbor are restricted relative to the open lake and this limits the maneuverability of the lay vessel in the harbor for initializing the cable installation on the lakebed. Therefore, the proposed approach for this option includes initialization of the cable lay and burial at ICE1 and proceeding with the installation from ICE1 to the Harbor.

For this alternative, two aspects have been given attention:

1. A cable installation spread that can operate in these restricted areas;
2. A workable cable route and work methodology.

Due to the shallow water depth and the restricted space, a vessel like the self-propelled multipurpose barge S/B Victor depicted in Figure 5-1 should be considered. In order to lay the cable in the Harbor, the barge can be kept in position with harbor tugs and positioning anchors.

The work methodology is depicted in Figure 5-7 and the steps are described below.

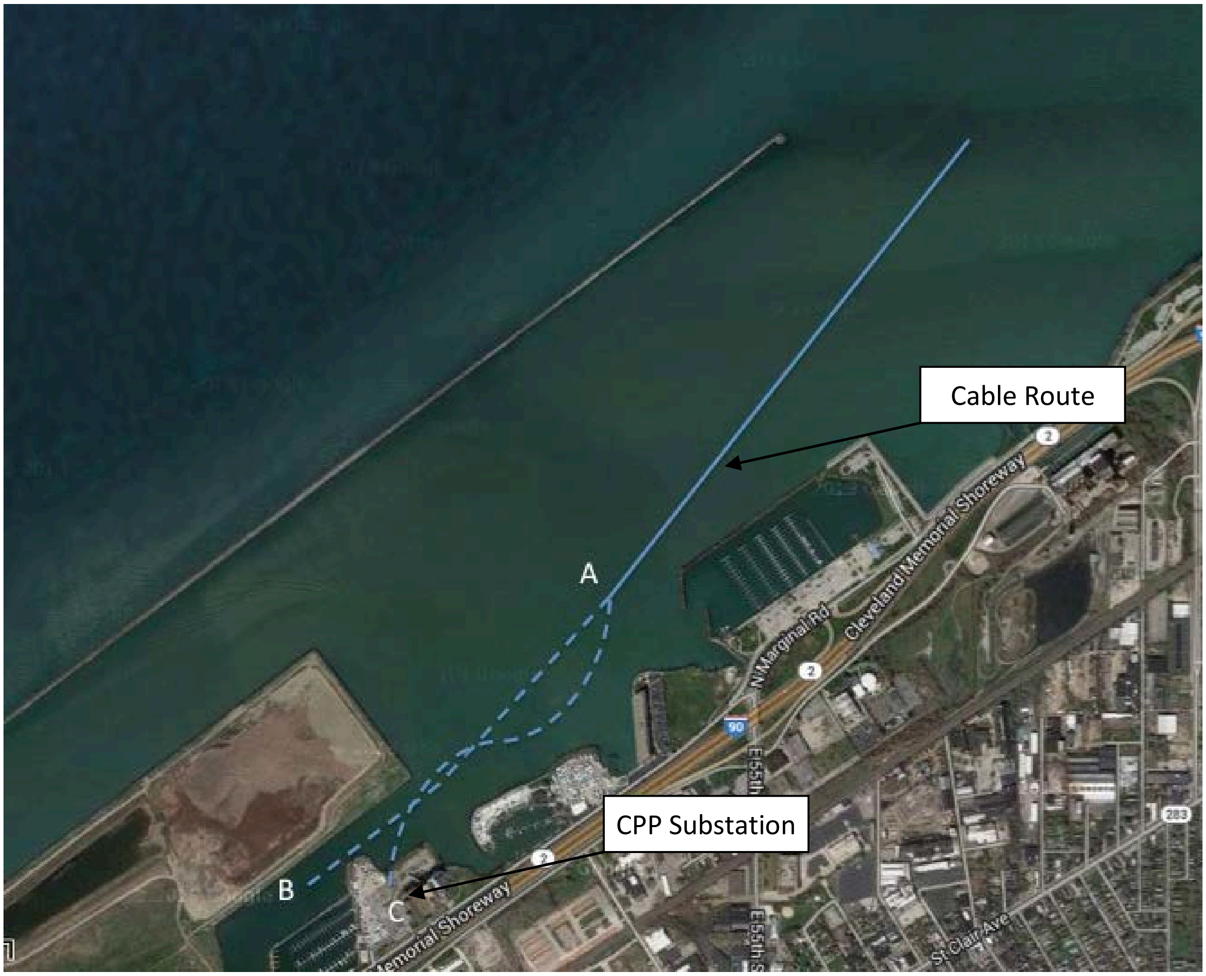

Figure 5-7. Work methodology for Option 3.

1. Installation of the cable with the jet plow will terminate at Point A. Here the trencher has to be recovered in a controlled way on board the lay vessel, maintaining sufficient lay tension on the cable. From this position, the cable will only be laid and not buried further. In the event the cable cannot be released from the trencher, it can be laid through the blade of the trencher. Here attention should be given to the departure of the cable at the sword, such that the overbend radius of the cable is higher than the mininum bending radius.
2. The cable lay vessel will continue to lay towards the lay down point (at B in **Error! Reference source not found.**), where the cable will be cut to its required length. The end of the cable will be capped and prepared for the pull-in operation. For this portion of the lay operation, floatation will be attached to the cable and the cable will be held in position by small workboats as depicted in Figure 5-8.

3. One of the small workboats will apply the required tension to the cable, such that the sag-bend radius of the cable is higher than the mininum bending radius. The other workboats will bring the cable end from Point B to the shore crossing at Point C. The S-curve as shown in **Error! Reference source not found.** is an illustrative example of this maneuver.

Figure 5-8. Small workboats keep the cable in position

4. At this point the pull-in wire from a shore based pull-in winch will be connected to the cable end. The cable will be pulled through a pre-excavated trench at the shore crossing. At a predetermined point, the floatation will be removed to allow the cable to be laid in the trench. Where floatation is no longer present, the cable friction can be reduced by using roller boxes.
5. When the cable has been pulled in completely the remaining floatation can be removed, such that the cable can be lowered into the pre-excavated trench. This pre-excavated trench has been constructed between Point A and Point C, where no trenching with the jet plow can take place.

On land, the cable will be installed in the trench, which will be backfilled and the landfall reinstated to its original shape. From landfall to the pad-mounted disconnect switch at the project Substation, the cable will be installed in a duct according to appropriate standards for the protection of land cables.

6 Cable Specification

The preliminary cable design is described in the Grid Interconnection Report. The detailed cable design shall be the responsibility of the cable supply vendor. This section provides preliminary specifications for the supply of submarine 34.5 kV cables including the connections and equipment necessary for the safe installation and operation of the cables inside the WTGs. The proposed cable route is shown in Figure 4-4 and consists of the following components:

- The export cable, which consists of an HDD of approximately 1.1 km (0.7 mi) from the Substation underneath the CDF and the breakwater into the lake and an approximately 12.0 km (7.5 mi) section laid in the lakebed from the exit point of the HDD to ICE1, for a total export cable length of 13.1 km (8.2 mi).
- The inter-array cable, which consists of five cable lengths of approximately 1.0 km (0.6 mi) between the WTGs.

The exact cable lengths to be supplied shall be determined by the cable manufacturer following additional field surveys and investigations.

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6.1 Operating and Service Conditions

Unless otherwise stated, cables shall be designed to ensure satisfactory operations under site and system conditions as defined in the Electrical Design Basis Report. In addition to conditions described in the Electrical Design Basis Report, the following conditions should be specified:

- Maximum outdoor ambient temperature (shade)
- Temperature at the bottom of the lake in the winter
- Temperature at the laying depth in the winter
- Temperature at the bottom of the lake in the summer
- Temperature at the laying depth in the summer
- Thermal resistivity of the soil (Km/W)
- Laying depth of the cables

6.2 Electrical Data for 34.5 kV Grid

The electrical data for the cable are given in Table 6-1.

Table 6-1. Electrical data

System parameter	Value
Nominal system voltage (U)	34.5 kV
Voltage fluctuation	+/- 5%
Highest voltage for equipment	38 kV
Nominal frequency	60 Hz
Short circuit current (1-phase; imp. grounded)	To be determined from the PJM Feasibility Study
Short circuit current (3-phase; max.)	To be determined from the PJM Feasibility Study

The maximum conductor and screen temperatures are given in Table 6-2.

Table 6-2. Maximum temperatures

Operating Condition	Temperature
Conductor normal operating temperature	90^{o}C
Max. short circuit temperature on conductor/metallic screen	250/200^{o}C

6.3 Site Surveys

The cable manufacturing/installation contractor shall carry out all necessary pre-design site surveys to determine site conditions. Post installation surveys shall be carried out, where necessary, to determine the actual installation of the cables.

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The pre-design surveys shall at least include:

- Site surveys to determine thermal bottlenecks based on soil properties along the route as required for the current carrying capacity calculations
- Site surveys to determine the composition of the layers under the CDF and breakwater, required to determine the optimum depth of horizontal directional drilling.

All results of the surveys shall be submitted to LEEDCo or its representative for approval.

6.4 Current Rating

The 34.5 kV cables shall be designed for the required current rating (20MVA=330A). For calculating the current rating according to IEC 60287 (International Electrotechnical Commision, *IEC 60287*), the losses have to be calculated, together with the thermal resistivities for the operating and service conditions as discussed in Section 6.1. The inter-array cables will be for practical reasons equal to the export cable, although the conductor sizes could be different.

6.5 Submarine Cable Design

The proposed submarine cables are 34.5kV three-core, cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) insulated submarine cables. These types of cables are commonly used for offshore wind power applications; however, it should be noted that most manufacturers use XLPE insulation and global experience with EPR-insulated cables for offshore wind applications is relatively low. The cable construction typically includes the following parts:

- Stranded copper conductor with longitudinal water barrier, consisting of swelling tape or yarn
- Extruded semiconducting conductor screening
- XLPE or EPR insulation
- Extruded semiconducting insulation screening
- Copper wire screen
- Longitudinal water barrier
- Polyethylene sheath[1]
- Fiber optic cable and fillers of polypropylene strings
- Binder tapes
- Bedding made of polypropylene strings or polyester tape
- Steel armor
- Serving, with bituminous compound and polypropylene strings

XLPE insulated cables are the most commonly used cables for offshore wind projects; almost all offshore wind farm cables (inter-array and export) use XLPE as insulating material. Ethylene propylene rubber (EPR) insulation has higher water resistance and greater flexibility than XLPE, but incurs higher dielectric losses. The insulation material should be considered in the evaluation of bids for cable supply.

[1] The combination of longitudinal water barrier and a polyethylene sheath functions as a radial water barrier.

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Figure 6-1 shows a schematic representation of a typical submarine cable construction. Figure 6-2 is a photograph of a typical submarine cable cross section. A detailed cross-sectional drawing of a typical 34.5 kV submarine cable design is included in Attachment B.

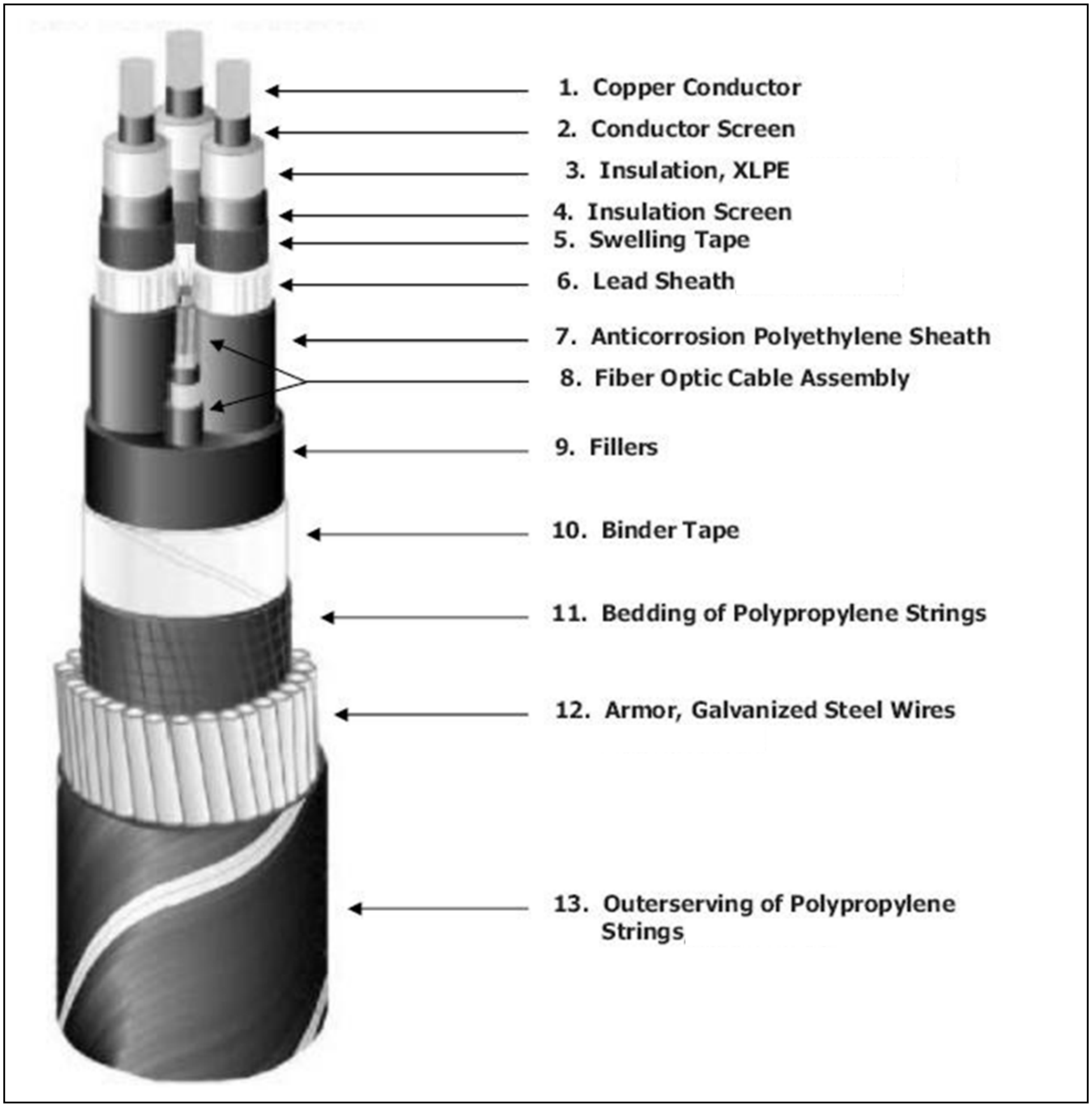

Figure 6-1. Schematic construction for typical 34.5 kV XLPE or EPR submarine cable

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Figure 6-2. Typical 34.5 kV Cable Cross Section

The export cable should be delivered as one length with a minimum number of factory joints. Field joints may be acceptable if the supplier is not able to provide the export cable in a single length; however, the cable supplier shall provide evidence that the presence of field joints will not impact the long-term reliability and performance of the cable. The presence of field joints and the number of factory joints should be considered in the evaluation of bids for cable supply.

6.6 Attributes and Accessories

The cable design also includes applicable accessories, including the 34.5 kV terminations. The cable(s) and its accessories shall be compatible on electrical and mechanical aspects and all components shall be proven technologies.

Terminations shall be suitable for and connected to the cable connections of the applicable switchgear. Detailed information about the design of the outgoing bay for the submarine 34.5kV cable is defined in the technical specification for the 34.5kV switchgear (to be determined in the detailed electrical system design).

Terminations shall be suitable to conduct regular measurements such as AC/DC testing and diagnostic testing like 0.1 Hz including partial discharge measurements.

The installation of the cables as well as the connection of the cables to the terminations shall be designed in such a way that neither cables in operation nor cables out of operation will mechanically stress the accessories. The cable length of each individual circuit shall have sufficient length to allow a termination to be repaired twice at the project Substation site.

Factory joints are manufactured prior to the armoring process, so that the section of cable containing the joint is continuously armored without any discontinuity. The main feature of a factory joint is that it shall not impose any restrictions on further cable handling or installation operations. This generally implies that factory joints are fully flexible, with the same bending radius, pulling force limit and coiling performance (if applicable), as specified in CIGRE TB 490.

A repair joint is made on the complete cable and usually onboard on a repair vessel or barge. Repair joints should be available and fully type tested before the start of the installation. Repair joints shall be on stock and appropriate storage conditions should be provided as specified in CIGRE TB 490.

6.7 Cable Protection

Burial should be used as the primary method of protection of a cable to provide adequate and economic mitigation against hazards that may exist along the cable route. Based on the information currently available, sufficient burial will likely be possible to provide adequate protection for the cable. A risk-based burial assessment should be conducted as part of future design work to identify risks along the cable route, determine appropriate burial depth for cable sections, determine the appropriate burial and lay methods, and identify areas where additional protection may be needed. In the event that non-burial protection is required, options include tubular products, concrete mattresses, and/or rock placement.

6.8 Testing

The testing of the cable system, including factory joints, field joints, and repair joints, shall be performed according to CIGRE TB 490. The inter-array cables are connected to the WTG's using terminations, and the export cable is connected to the substation using terminations. The tests on terminations will be according to IEC 60502-4 (International Electrotechnical Commission, IEC 60502-4).

6.9 Quality Surveillance

The submarine cables are considered special equipment which means that manufacturers are required to be certified on their conformity to ISO 9001 (International Organization for Standardization, 2008) by an accredited certification organization.

The cable manufacturer/installer shall prove competence to supply products and services that comply with all requirements mentioned in the applicable specification(s).

The cable manufacturer/installer shall explicitly agree with allowing tests and inspections to be performed at any time by LEEDCo or its representative. It shall be stated that the tenderer shall supply copies of quality documents requested by LEEDCo or its representative.

7 SCADA System Design

The preliminary SCADA system conceptual design is provided in Attachment C and describes the various components to support the control of the Icebreaker WTGs and project Substation components and also includes various communication and network components. The SCADA system design includes the following components:

- Sensors to measure turbine parameters including blade rotational speed and pitch
- Sensors to measure converter parameters such as power, voltage, and current
- Meteorological sensors
- Turbine controllers
- Turbine network switches
- Signal converters

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- Fiber optic network
- Fiber optic patch panels
- Ethernet connections
- Servers
- User interfaces
- Project controller
- Network communication and security systems
- Power supply

8 Conclusions and recommendations

This report reflects the preliminary design of the electrical BOS. The preliminary conceptual designs for the project Substation, submarine cable system, and the SCADA system are all subject to change pending further information regarding site conditions and detailed engineering.

Based on the analysis of the available information, the following conclusions about the cable route can be drawn:

1. The cable route is primarily influenced by the selected route for crossing the Harbor and the shore.
2. The preferred alternative for the crossing the Harbor and the shore is by applying an HDD of approximately 1.15 km (0.7 mi) from the CPP substation, underneath the breakwater, into the lake.
3. The cable can be installed using commonly employed installation techniques from the entry point of the HDD up to ICE1 and between WTGs.
4. The exact route for the export cable and the inter-array cables cannot be defined at this point, but based on the information currently available a direct path should be feasible.
5. Environmental conditions including wind, waves, currents and seismic activities are relatively benign and likely will not pose significant challenges for design and installation of the cable system.
6. Cable burial should provide sufficient protection for the cable along the cable route. However, the potential for ice ridges, damage from vessel activity, and near-shore erosion of the lakebed may present a risk of cable damage.

The following investigations are scheduled for BP 2 to assess the detailed cable route, installation, and burial depth:

1. Geophysical investigation of the bathymetry of lakebed using multi-beam echo-sounder or side-scan sonar) along the cable route, geophysical investigation of the sub-bottom geology using sub-bottom profiling, and geotechnical investigations (e.g., soil sampling, thermal conductivity measurements, and/or CPT).

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2. Additional investigation regarding ice movements along the export cable route, inter-array cables and within the Harbor should be conducted.
3. Investigation of near shore morphological processes.
4. A burial assessment study to identify risks along the cable route, determine appropriate burial depth for cable sections, determine the appropriate burial and lay methods, and identify areas where additional protection may be needed.
5. A detailed design of the HDD operation, including the length, dimensions, and material of the duct and the required space and layout for site installation equipment.
6. Investigation of the vessel options for the cable installation.

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Case No. 16-1871-EL-BGN

Icebreaker Windpower Inc.

Application-Part 6 of 13

- Exhibit L. PJM Studies

Revised
Generation Interconnection
System Impact Study Report

For

PJM Generation Interconnection Request Queue
Position Z1-035

Lake Road 69kV

May 2015

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

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General

The Interconnection Customer (IC) is proposing an 18MW (2.34MW Capacity) wind facility to be interconnected to the ATSI transmission system and near Cleveland, OH. ATSI is a FirstEnergy (FE) company. This means that the remaining 15.66 MW can be curtailed should a system reliability constraint occur. The proposed in-service date for this project is **September 30, 2017**.

The intent of the System Impact Study is to determine system reinforcements and associated costs and construction time estimates required to facilitate the addition of the new generating plant to the transmission system. The reinforcements include the direct connection of the generator to the system and any network upgrades necessary to maintain the reliability of the transmission system.

Point of Interconnection

Z1-035 will interconnect with the Cleveland Public Power (CPP) transmission system via a tap to the Lake Road 69kV substation, which connects to the ATSI transmission system.

Facilities to Accommodate the Interconnection

Scope of Direct Connection Work

The Z1-035 project will tap the Lake Road 69kV substation owned by Cleveland Public Power (CPP), which connects to the ATSI transmission system. Z1-035 is an offshore wind project with six 3MW wind turbines to be located in Lake Erie approximately 7 miles offshore northwest of downtown Cleveland, OH in the Cleveland Public Power (CPP) area. To accommodate this interconnection, installation of one 69kV breaker, two disconnects, one potential transformer, metering and telecommunications will be required (See Figure 1 below). The direct connects are estimated to cost approximately **$769,000**. The cost estimate above does not include any of the upgrades listed in the Network Impacts section of the report.

Revenue Metering and SCADA Requirements

For PJM: IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

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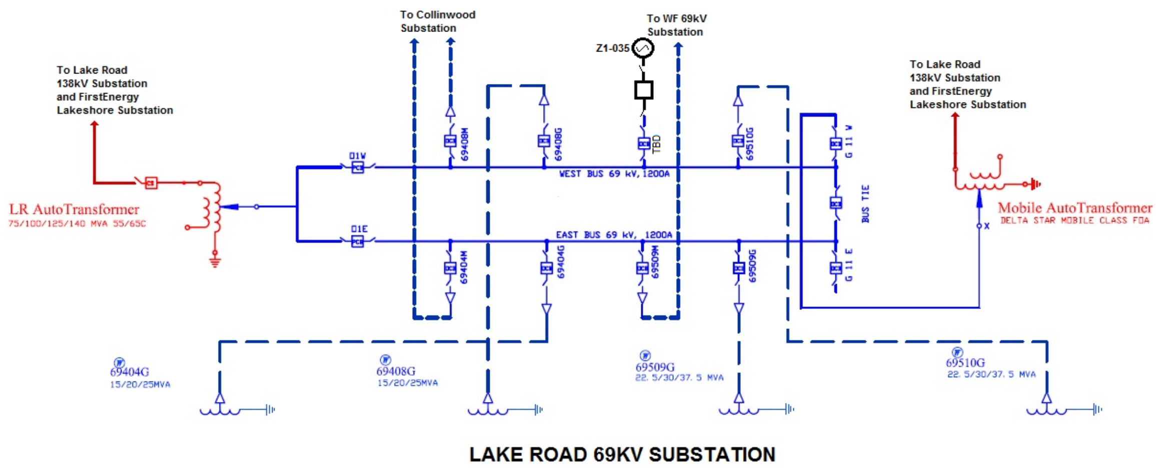

Figure 1. Single Line Diagram

Network Impacts

The Queue Project Z1-035 was studied as a 18.0 MW (2.3 MW Capacity) injection CPP Lake Rd 69kV substation in the ATSI area. Project Z1-035 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project Z1-035 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2017

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No violations were identified.

Multiple Facility Contingency

(Double Circuit Tower Line(DCTL), Line with Failed Breaker(LFFB) and Bus Fault(Bus) contingencies for the full energy output)

No violations were identified.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

No violations were identified.

Short Circuit

(Summary of impacted circuit breakers)

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PJM has completed the short circuit analysis of the Z1-035 queue project Lake Erie Wind 69kV. One option was considered during this study: the primary option was a direct connection to the Lake Road 66kV substation. PJM analysis found **no breakers** to be over duty in the ATSI transmission area.

Steady-State Voltage Requirements

(Summary of VAR requirements based upon the results of the steady-state voltage studies)

None.

Stability and Reactive Power Requirement

(Summary of VAR requirements based upon the results of the dynamic studies.)

PJM queue project Z1-035 is a Generator Interconnection Request for the addition of a 18 MW wind farm consisting of 6 x 3 MW Siemens wind turbine generators. Z1-035 has a Point of Interconnection (POI) at the Lake Road 69 kV substation in the American Transmission Systems, Inc. (ATSI) system, in Ohio. This report describes a dynamic simulation analysis of Z1-035 as part of the overall system impact study. The load flow scenario for the analysis was based on the RTEP 2017 summer peak case, modified to include applicable queue projects. Z1-035 was dispatched at maximum power output and unity power factor at the generator bus.

Z1-035 was tested for compliance with NERC, PJM and other applicable criteria. 40 contingencies were studied, each with a 10 second simulation time period. Studied faults included:

a) Steady state operation
b) Three phase faults with normal clearing time
c) Single phase faults with single phase stuck breaker
d) Single phase faults with delayed clearing at remote end due to primary relaying failure

For all simulations, the queue project under study along with the rest of the PJM system were required to maintain synchronism and with all states returning to an acceptable new condition following the disturbance.

The results indicate that for the 40 fault contingencies tested on the 2017 light load case:

a) Z1-035 was able to ride through the faults (except for faults where protective action tripped Z1-035),
b) the system with Z1-035 included was found to be transiently stable,
c) voltages at the POI and nearby buses returned to an acceptable range for all but one contingency (1B02), with system stability being maintained.

The post-contingency voltage at Lake Road 69 kV following contingency 1B02 was approximately 0.84 p.u. Contingency 1B02 results in the loss of the 138/69 kV transformer at Lake Road substation[1], along

[1] The Cleveland Public Power one line diagram shows two 138/69 kV transformers at Lake Road. The second transformer is labeled as a “Mobile AutoTransformer” and is assumed not to be in place for the present study.

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with two of the three 69 kV circuits out of Lake Road substation. Following contingency 1B02, Z1-035 is connected to the system via a single 69 kV circuit to Collinwoood 69 kV substation. This contingency was re-evaluated with Z1-035 offline, with the post-fault voltage at Lake Road 69 kV found to continue to not meet the recovery criterion, implying that the issue is not attributable to Z1-035.

No mitigations were found to be required.

MISO Impacts:

No violations were identified.

Light Load Analysis - 2017

(Summary of any reinforcements required to mitigate system reliability issues during light load periods. This light load study was evaluated for compliance with reliability criteria for ***Light Load conditions*** *in 2017.)*

No violations were identified.

System Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None.

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Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

As a result of the aggregate energy resources in the area, no violations were identified.

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PJM Generation Interconnection Request

Queue Z1-035

Lake Erie 69kV

Feasibility Study

778478v2
February 2014
Updated March 2014

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Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an interconnection customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

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General

The Interconnection Customer is proposing an 18MW (2.34MW Capacity) wind facility to be interconnected to the ATSI transmission system and near Cleveland, OH. ATSI is a FirstEnergy (FE) company. The proposed in-service date for this project is September 30, 2017.

This Generation Interconnection Feasibility Study provides analysis results to aid the Interconnection Customer in assessing the practicality and cost of incorporating the facility into the PJM system.

Facilities to Accommodate the Interconnection

Scope of Direct Connection Work

The Z1-035 project will tap the Lake Road 69kV substation owned by Cleveland Public Power (CPP), which connects to the ATSI transmission system. Z1-035 is an offshore wind project with six 3MW wind turbines to be located in Lake Erie approximately 7 miles offshore northwest of downtown Cleveland, OH in the Cleveland Public Power (CPP) area. To accommodate this interconnection, installation of one 69kV breaker, two disconnects, one potential transformer, metering and telecommunications will be required (See **Figure 1** below). The direct connects are estimated to cost approximately **$769,000**. The cost estimate above does not include any of the upgrades listed in the Network Impacts section of the report. Additional upgrades may be required pending the results of the AC analysis (thermal and voltage) and CPP short circuit study.

The Interconnection Customer is responsible for constructing all of the Interconnection Customer-owned facilities on the Interconnection Customer's side of the Point of Interconnection.

Revenue Metering and SCADA Requirements

For PJM: The Interconnection Customer will install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for Interconnection Customer's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 24.1 to 24.2.

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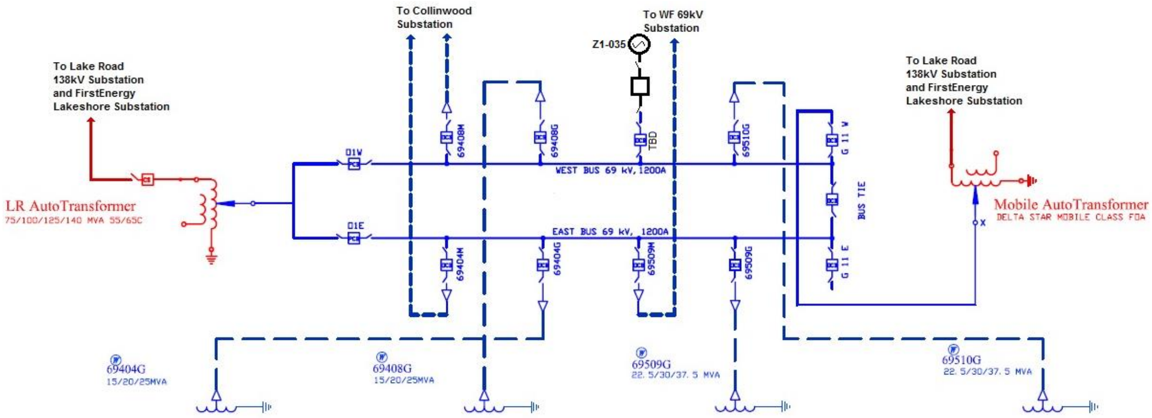

Figure 1. One Line Diagram

Network Impacts

The Z1-035 project was studied as an 18.0MW (2.34MW Capacity) injection at Lake Road 69kV substation into the ATSI area. Project Z1-035 was evaluated for compliance with reliability criteria for summer peak conditions in 2017.

Potential network impacts were as follows:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No violations were found.

Multiple Facility Contingency

(Double Circuit Tower Line contingencies were studied for the full energy output. The contingencies of Line with Failed Breaker and Bus Fault will be performed for the Impact Study.)

No violations were found.

Short Circuit

(Summary of impacted circuit breakers)

PJM:

PJM has completed the short circuit analysis of the Z1-035 queue project **Lake Erie Wind 69 kV**. One option was considered during this study: the option was a direct connection to Lake Erie 69 kV substation. Our analysis found **no new breakers** to be over-duty in the ATSI transmission area.

CPP:

CPP will complete a short circuit study as a part of the System Impact Study.

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Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

No violations were found.

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, I.e. "Network Impacts", initially caused by the addition of this project's generation.)

None.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contributions to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study.)

None.

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

As a result of the aggregate energy resources in the area, no violations were identified.

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Generation Interconnection System Impact Study Report

For

PJM Generation Interconnection Request Queue Position Z1-035

Lake Road 69kV

September 2014

Preface

The intent of the System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. The possibility of sharing the reinforcement costs with other projects may be identified in the Feasibility Study, but the actual allocation will be deferred until the System Impact Study is performed.

The System Impact Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

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General

The Interconnection Customer (IC) is proposing an 18MW (2.34MW Capacity) wind facility to be interconnected to the ATSI transmission system and near Cleveland, OH. ATSI is a FirstEnergy (FE) company. This means that the remaining 15.66 MW can be curtailed should a system reliability constraint occur. The proposed in-service date for this project is **September 30, 2017**.

The intent of the System Impact Study is to determine system reinforcements and associated costs and construction time estimates required to facilitate the addition of the new generating plant to the transmission system. The reinforcements include the direct connection of the generator to the system and any network upgrades necessary to maintain the reliability of the transmission system.

Point of Interconnection

Z1-035 will interconnect with the Cleveland Public Power (CPP) transmission system via a tap to the Lake Road 69kV substation, which connects to the ATSI transmission system.

Facilities to Accommodate the Interconnection

Scope of Direct Connection Work

The Z1-035 project will tap the Lake Road 69kV substation owned by Cleveland Public Power (CPP), which connects to the ATSI transmission system. Z1-035 is an offshore wind project with six 3MW wind turbines to be located in Lake Erie approximately 7 miles offshore northwest of downtown Cleveland, OH in the Cleveland Public Power (CPP) area. To accommodate this interconnection, installation of one 69kV breaker, two disconnects, one potential transformer, metering and telecommunications will be required (See Figure 1 below). The direct connects are estimated to cost approximately **$769,000**. The cost estimate above does not include any of the upgrades listed in the Network Impacts section of the report.

Revenue Metering and SCADA Requirements

For PJM: IC will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Sections 24.1 and 24.2.

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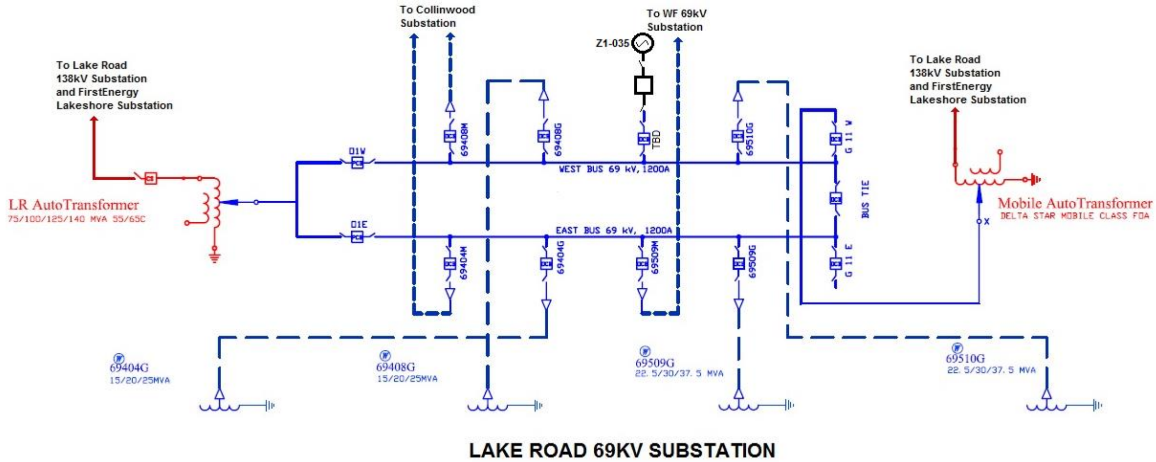

Figure 1. Single Line Diagram

Network Impacts

The Queue Project Z1-035 was studied as a 18.0 MW (2.3 MW Capacity) injection CPP Lake Rd 69kV substation in the ATSI area. Project Z1-035 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project Z1-035 was studied with a commercial probability of 100%. Potential network impacts were as follows:

Summer Peak Analysis - 2017

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No violations were identified.

Multiple Facility Contingency

(Double Circuit Tower Line(DCTL), Line with Failed Breaker(LFFB) and Bus Fault(Bus) contingencies for the full energy output)

No violations were identified.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

No violations were identified.

Short Circuit

(Summary of impacted circuit breakers)

PJM has completed the short circuit analysis of the Z1-035 queue project Lake Erie Wind 69kV. One option was considered during this study: the primary option was a direct connection to the Lake Road 66kV substation. PJM analysis found **no breakers** to be over duty in the ATSI transmission area.

Steady-State Voltage Requirements

(Summary of VAR requirements based upon the results of the steady-state voltage studies)

None.

Stability and Reactive Power Requirement

(Summary of VAR requirements based upon the results of the dynamic studies.)

Stability and Reactive Power Requirements will be performed as a part of the Facilities Study.

MISO Impacts:

MISO impacts to be determined during the Facilities Study phase.

Light Load Analysis - 2017

*(Summary of any reinforcements required to mitigate system reliability issues during light load periods. This light load study was evaluated for compliance with reliability criteria for **Light Load conditions** in 2017.)*

Light Load Analysis will be performed as a part of the Facilities Study.

System Reinforcements

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None.

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None.

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Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

As a result of the aggregate energy resources in the area, no violations were identified.

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Case No(s). 16-1871-EL-BGN

Summary: Application - Part 6 of 13 Exhibits H through L electronically filed by Christine M.T. Pirik on behalf of Icebreaker Windpower Inc.