Spring 2008 Radar Survey Report

for the Groton Wind Project
In Groton, New Hampshire

Prepared for

Groton Wind, LLC

Prepared by

Stantec Consulting
30 Park Drive
Topsham, ME 04086

Stantec

FINAL

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Executive Summary

During spring 2008, Stantec Consulting (Stantec) conducted field surveys of bird and bat migration activity at the Groton Wind Project area in Groton, New Hampshire (Project). The surveys are part of the planning process by Groton Wind, LLC (Groton Wind) for a proposed wind Project, which will include the erection of up to 25 wind turbines and associated infrastructure (e.g., access roads, transmission lines, electrical substation, turbine lay-down/staging area, and operations and maintenance building. The turbines will likely be 2.0 Megawatt (MW) machines mounted on tubular steel towers with an approximate hub height of 78 meters (m; 256 feet [‘]) and a rotor diameter of 87 m (285’). The proposed turbines would have a maximum height of approximately 121 m (400’). These surveys represent the first season of investigation undertaken at this site.

The results of the spring field surveys provide information on seasonal migration activity and patterns in the vicinity of the Project area and, once combined with data being collected during the fall 2008 migration season, will provide a full year of site-specific migration activity.

Nocturnal Radar Survey

The spring field survey targeted a 45-night period between April 15 and June 1, 2008. Of these 45 nights, a total of 40 were sampled due to inclement weather on 5 nights that created conditions in which the radar could not adequately document bird movements. Surveys were conducted using X-band radar, sampling from sunset to sunrise. Each hour of sampling included the recording of radar video files during horizontal and vertical operation. The radar site provided good visibility of the airspace around it, except for a small 20 degree portion to the south where the ridge increased in elevation and tree height was slightly taller; however, this limitation did not dramatically impede the collection and analysis of radar data. Although targets were obstructed by ground clutter in this area, targets were still detected as they flew into or out of this portion of the radar detection range.

The overall passage rate for the survey period was 234 ± 20 targets per kilometer per hour (t/km/h). Nightly passage rates varied from 35 t/km/h on April 27 to 549 t/km/h on May 6. Mean flight direction through the Project area was 77° ± 64°.

The seasonal average mean flight height of all targets was 321 ± 16 m (1051 ± 52’) above the radar site. The average nightly flight height ranged from 114 m (373’) on May 22 to 567 m (1860’) on April 19. The percent of targets observed flying below 125m (410’), the anticipated height of the proposed turbines with blades attached, averaged 12 percent for the season and varied by night from 1 to 59 percent.

The mean flight direction, qualitative analysis of the surrounding topography and landscape, and mean flight altitude of targets passing over the Project area indicates that avian migration in this

area involves a broad front type of landscape movement, rather than a concentration or funneling of flight movements over or through a particular part of the Project area. Moreover, the flight height of targets indicates that the vast majority of bird migration in the area is not directed or impeded by topography and occurs well above the height of the proposed wind turbines. This type of broad front movement, particularly in conjunction with the high flight heights, demonstrates a limited nocturnal migrant mortality risk during spring.

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1.0 Introduction

This report has been prepared to provide a summary of the findings documented during nocturnal radar surveys conducted during the spring 2008 bird and bat migration season at Groton Wind, LLC's (Groton Wind) Groton Wind Project, in Groton New Hampshire.

Following is a brief description of the Project, a review of the methods used to conduct scientific surveys, the results of those surveys, a discussion of those results, and the conclusions reached based on those results.

1.1 PROJECT CONTEXT

Groton Wind is considering construction of a wind Project located in Groton, New Hampshire (Figure 1-1). The Groton Wind Project (Project) will consist of up to 25 wind turbines and associated infrastructure (e.g., access roads, transmission lines, electrical substation, turbine lay-down/staging area, and an operations and maintenance building). The turbines will likely be 2.0 Megawatt (MW) machines mounted on tubular steel towers with an approximate hub height of 78 meters (m; 256 feet [']) and a rotor diameter of 87 m (285'). The proposed turbines would have a maximum height of 121 m (400').

In advance of permitting activities for the Project, Groton Wind contracted Stantec Consulting (Stantec) to conduct nocturnal radar migration surveys during spring 2008. The surveys will provide data to help assess the potential risk for the proposed Project to impact nocturnally migrating birds and bats. The scope of surveys was based on a combination of standard methods that are developing within the wind power industry for pre-construction surveys and is consistent with several other studies conducted recently in New Hampshire and throughout the Northeast region of the United States.

This document summarizes the results of the spring 2008 radar survey conducted at the Groton Wind Project. This survey represents the first of two seasons of radar surveys planned at the site. Additional surveys will take place in the fall of 2008.

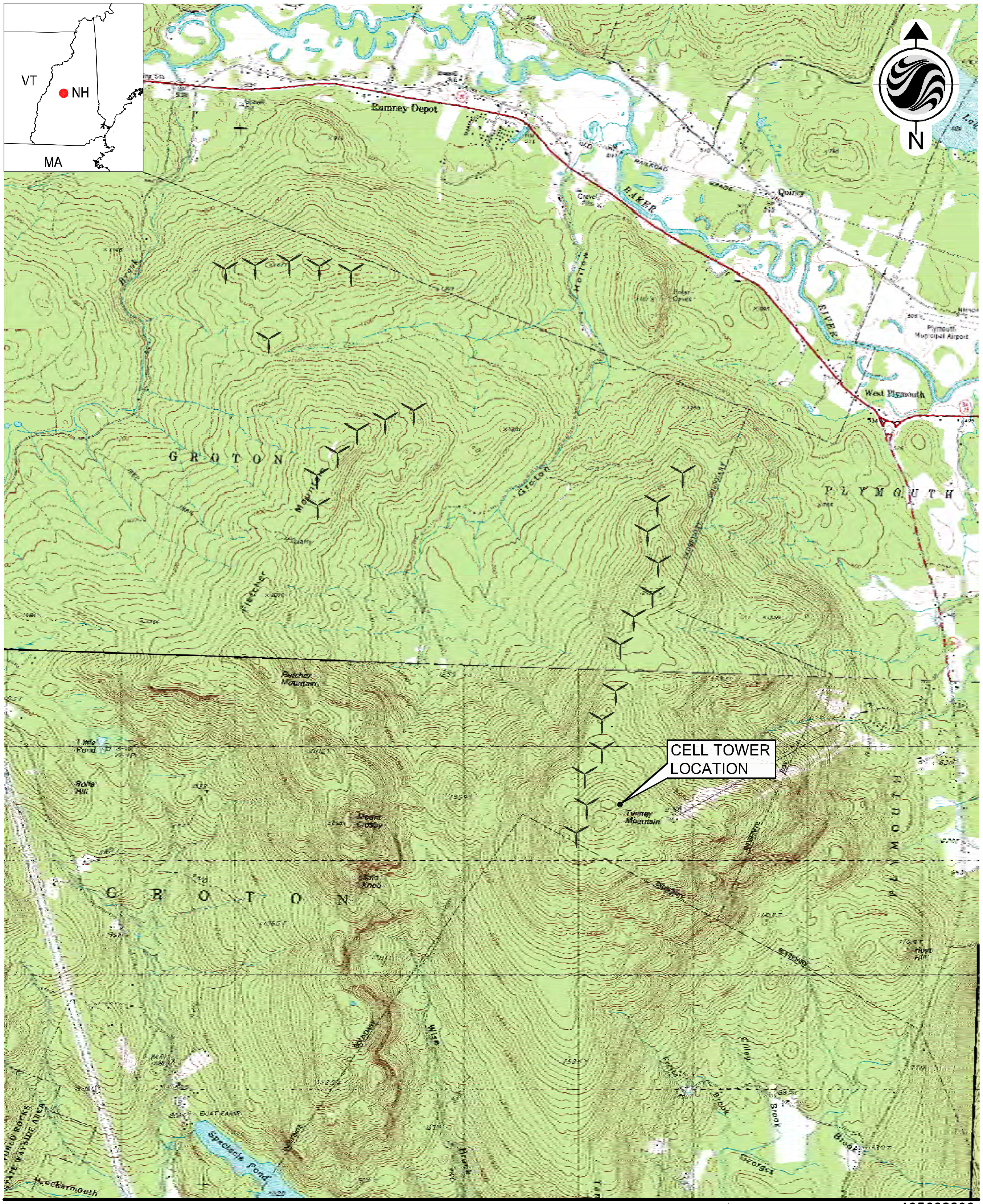
1.2 PROJECT AREA DESCRIPTION

The Project is located in Grafton County, New Hampshire within the Sunapee Uplands subsection as characterized by Sperduto and Nichols 2004 in *Natural Communities of New Hampshire*. This subsection of New Hampshire is classified by its moderate topography consisting of granite hills and peaks of shallow, nutrient poor soils interspersed with small lakes and narrow stream valleys (Sperduto and Nichols 2004).

More specifically, the Project is located on Tenney and Fletcher Mountains in Groton, New Hampshire. Both of these ridges are northeast/southwest oriented and range in elevation from 549 m (1801') to 701 m (2300'). Due to its moderate elevation, the most dominant tree species in the Project area include sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis)*, and American Beech (*Fagus grandifolia*), which are typical of northern hardwood – conifer forests. This forest community is the most common in the northern half of the state of New Hampshire. Some small pockets of red spruce (*Picea rubens*) and balsam fir (*Abie balsamea*) are present, but are limited to the summit of the ridges. Common understory species include; regenerating canopy species (e.g., sugar maple, yellow birch, and American beech), hobblebush (*Viburnum lantanoides*), striped maple (*Acer pensylvanicum*), and white birch (*Betula papyrifera*).

As currently planned, the majority of the Project site (the northern two-thirds of Tenney Mountain) is located on lands owned by Green Acres Woodlands and managed by FORECO, a local forest management company. The Fletcher Mountain portion of the Project area is owned and managed by Wagner Forest Management. Both companies actively manage these lands for commercial forestry products. Consequently, human disturbances are evident across the majority of the Project site. Historically and presently, the land within and surrounding this area, including the summits of the ridgeline, has been used for commercial timber production. This is evident by the recent and past cuts as well as the presence of a network of haul roads that extend through the site. These forest management operations have resulted in a variation of forest age classes. The Crosby Mountain State Park is located south of the Fletcher Mountain Project area. The Park includes 230 acres of state land, Jericho Lake, and Mount Crosby at an elevation of 676 m (2,218’). The Tenney Mountain downhill ski area is adjacent to the Project site and is located on the southeast side of the ridge and includes approximately 48 cleared ski trails. At this location, trails and maintenance roads provide access to the summit for servicing ski trails and chairlifts. A tall communication tower is also adjacent to the Project, on the summit of Tenney Mountain. The southern summit is the highest point of elevation within the Project area and is evident by a greater frequency of red spruce and balsam fir.

For the purposes of describing nocturnal migration within the Project area, the Project boundary or Project area refers to the proposed turbine areas as depicted in Figure 1-1.



Stantec Consulting Services Inc.
30 Park Drive
Topsham ME U.S.A.
04086
Tel. 207.729.1199
Fax. 207.729.2715
www.stantec.com

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LEGEND

Turbine

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Client/Project

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Groton Wind LLC
Groton Wind Project
Groton, New Hampshire

Figure No.

1-1

Title

Project Location Map

October 29, 2009

1.3 SURVEY OVERVIEW

Stantec conducted field surveys for nocturnal migration patterns during spring 2008. The overall goals of the surveys were to document passage rates for nocturnal migration in the vicinity of the Project area, including the number of migrants, their flight direction, and their flight altitude. The following sections outline the survey methodology and results. Discussion of survey results and subsequent conclusions follow the survey results.

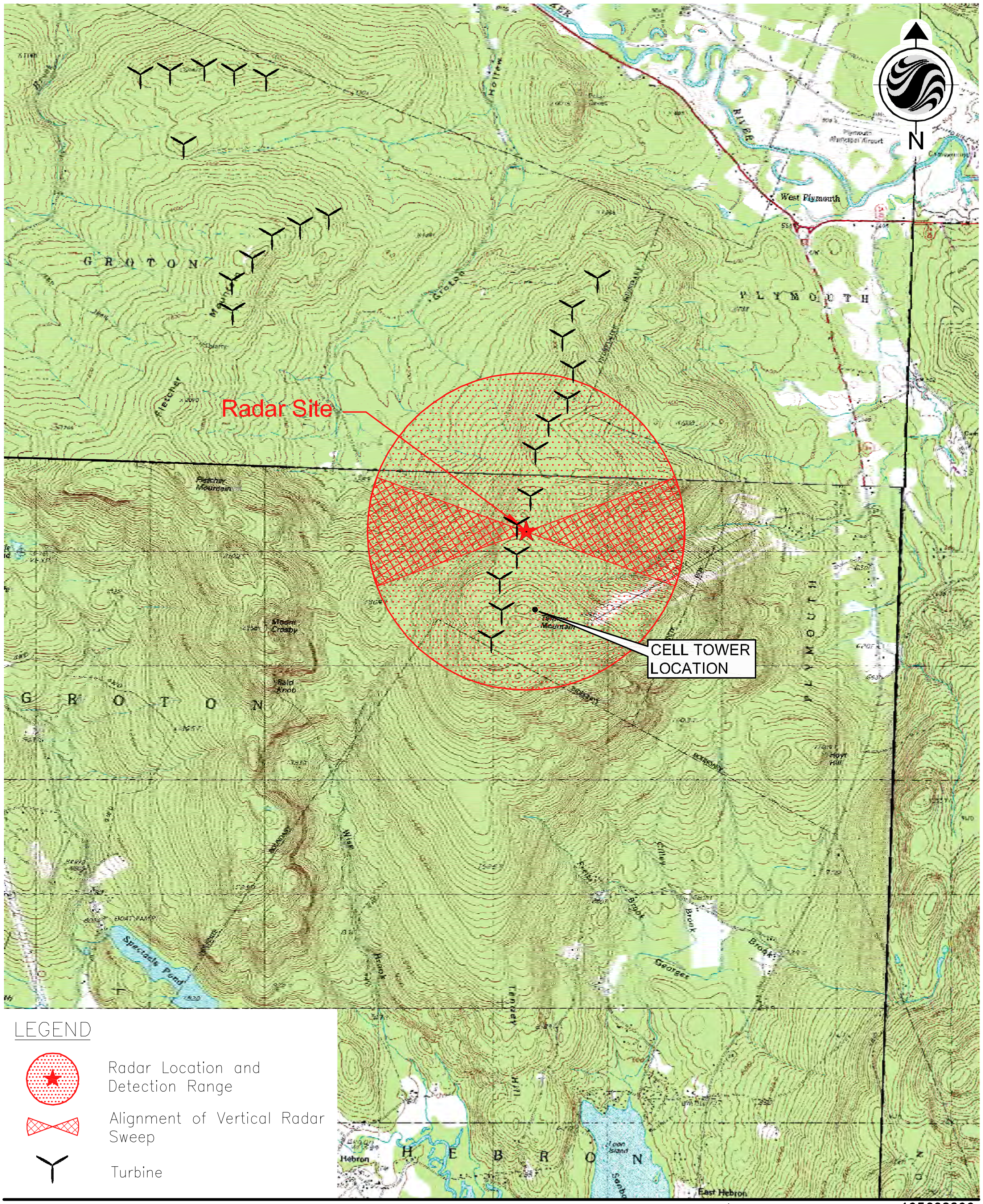
2.0 Nocturnal Radar Survey

2.1 INTRODUCTION

The majority of North American passerines migrate at night. The strategy to migrate at night may have evolved to take advantage of more stable atmospheric conditions for flapping flight (Kerlinger 1995). Additionally, night migration may allow more efficient regulation of body temperature during active, flapping flight and could reduce the potential for predation while in flight (Alerstam 1990, Kerlinger 1995). Conversely, species such as raptors use soaring daytime flight during migration to take advantage of warm rising air in thermals and laminar flow of air over the landscape, which can create updrafts along hillsides and ridgelines. Whereas raptor migration can be documented by visual daytime surveys, documenting the patterns of nocturnally migrating birds requires the use of radar or other non-visual technologies. Nocturnal radar surveys were conducted in the Project area to characterize spring nocturnal migration patterns. The goal of the surveys was to document the overall passage rates for nocturnal migration in the vicinity of the Project area, including the number of migrants, their flight direction, and their flight altitude.

2.2 METHODS

The radar study was conducted within the forest opening at the on-site meteorological measurement tower (met tower) at the summit of Tenney Mountain (Figure 2-1). In anticipation of Groton Wind potentially acquiring additional land for the Project on Fletcher Mountain, Stantec decided to situate the radar on the Tenney ridgeline, the higher of the two, so that it would document activity over a 2.8 km wide area that included views into the valley west of Tenney Mountain. Considering that nocturnal migration has been documented to occur in a broad front movement at most all radar studies conducted in the northeast, including three in New Hampshire, it is expected that the radar data collected from Tenney Mountain provided a representative sampling of the airspace to the west and, consequently, Fletcher Mountain. Therefore, results from the radar survey will still be valid if the Project does make that expansion. The radar antenna was elevated approximately 8 m (25’) above the ground to be even with the surrounding tree height to increase the amount of visible airspace detectable by the radar and to minimize ground clutter obstructions to the center of the radar screen. This site, at an elevation of 640 m (2100’) and centrally located within the Project area, provided a good view in most directions. A small 20 degree portion to the south was obstructed due to an elevation increase and taller tree heights, but targets were still detected flying into or out of this area; therefore resulting in nearly 100 percent coverage of targets flying through the view of the radar. Steep topography to the west allowed for detection of some targets flying below the horizon in the valley below. However, this was only true during the brief period in early spring when leaves were not present on the trees. Once the trees leafed, views below the horizon into the valley became obstructed but did not have an effect on the detectability of targets flying at tree top height or above.



Stantec

Stantec Consulting Services Inc.
30 Park Drive
Topsham ME U.S.A.
04086
Tel. 207.729.1199
Fax. 207.729.2715
www.stantec.com

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Client/Project 195600299

Groton Wind LLC
Groton Wind Project
Groton, New Hampshire

Figure No.
2-1

Title
Radar Location Map

October 29, 2009

Marine surveillance radar, similar to that described by Cooper *et al.* (1991), was used during field data collection. The radar has a peak power output of 12 kilowatts (kW) and has the ability to track small targets, including birds, bats, and even insects, based on settings selected for the radar functions. It cannot, however, readily distinguish between different types of targets being detected. The radar has an "echo trail" function which captures past echoes of flight trails, enabling determination of flight direction. During all operations, the radar's echo trail was set to 30 seconds. The radar was equipped with a 2 m (6.5') waveguide antenna. The antenna has a vertical beam height of 20º (10º above and below horizontal), and the front end of the antenna was inclined approximately 5º to increase the proportion of the beam directed into the sky.

Objects on the ground detected by the radar cause returns on the radar screen (echoes) that appear as blotches called ground clutter. Large amounts of ground clutter reduce the ability of the radar to track birds and bats flying over those areas. However, vegetation, as mentioned above, and hilltops near the radar can be used to reduce or eliminate ground clutter by "hiding" clutter-causing objects from the radar. These nearby features also cause ground clutter, but their proximity to the radar antenna generally limits the ground clutter to the center of the radar screen (Figure 2-2). The presence or reduction of potential clutter producing objects was carefully considered during site selection and radar station configuration.

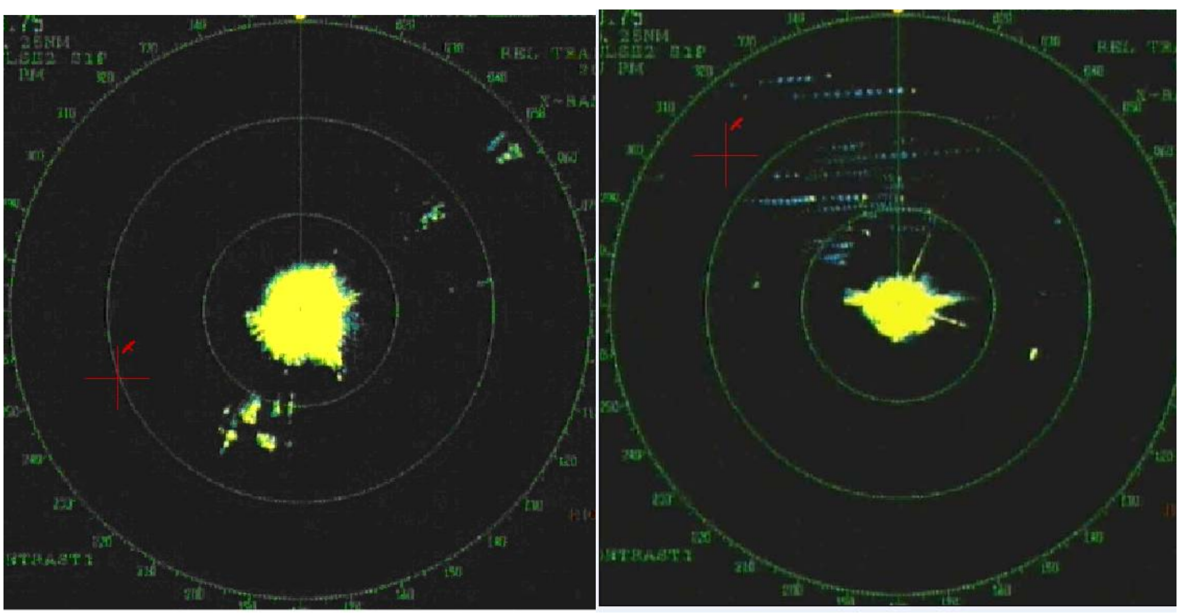

Figure 2-2. Horizontal (left) and Vertical (right) radar screen shots

Radar surveys were conducted from sunset to sunrise, targeting a 45-night period between April 15 and June 1, 2008. This level of survey effort was well above the 30 nights of radar surveys typically recommended in New Hampshire. Because the anti-rain function of the radar must be turned down to detect small songbirds and bats, surveys could not be conducted during 5 nights of inclement weather. Therefore, surveys were planned largely for nights without rain. However, in order to characterize migration patterns during nights without optimal conditions, some nights with weather forecasts including occasional showers were sampled.

The radar was operated in two modes throughout the night. In surveillance mode, the antenna spins horizontally to survey the airspace around the radar and detects targets moving through the area. By analyzing the echo trail, the flight direction of targets can be determined. In vertical mode, the radar unit is tilted 90º to vertically survey the airspace above the radar (Harmata *et al.* 1999). In vertical mode, target echoes do not provide directional data, but do provide information on the altitude of targets passing through the vertical, 20º radar beam. Both modes of operation were used during each hour of sampling.

The radar was operated at a range of 1.4 km (0.75 nautical miles). At this range, the echoes of small birds can be easily detected, observed, and tracked. At greater ranges, larger birds can be detected but the echoes of small birds are reduced in size and restricted to a smaller portion of the radar screen, thus limiting the ability to observe the movement pattern of individual targets.

2.2.1 Data Collection

The radar display was connected to video recording software of a computer enabling digital archiving of the radar data for subsequent analysis. This software recorded and archived video samples continuously every hour from sunset to sunrise of each survey night. Alternating the radar antenna every ten minutes from vertical mode to horizontal mode, a total of 30 minutes of vertical samples and 30 minutes of horizontal samples were collected within each hour. Video recordings were subsequently analyzed based on a random schedule for each night. These included 15 one-minute horizontal samples and 10 one-minute vertical samples. This analysis schedule allowed for randomization of sample selection and prevented double-counting of targets due to the 30-second echo trail used to determine the flight path vector.

During each hour, additional information was also recorded, including weather conditions and ceilometer/night vision observations. Ceilometer/night vision observations involved directing a one-million candlepower spotlight vertically into the sky in a manner similar to that described by Gauthreaux (1969), but fixed with a red filter lens. The ceilometer beam was observed by eye using ATN NVG7 Generation III night vision goggles for 5 minutes per survey hour to document and characterize low-flying targets. The detection range of the night vision goggles was generally within the rotor zone of the proposed turbines. The ceilometer was held in-hand so that any birds, bats, or insects passing through it could be tracked for several seconds, if needed. Ceilometer/night vision surveys were conducted from the radar survey site. Observations from each ceilometer observation period were recorded, including the number of birds, bats, and insects observed. This information was used during data analysis to help characterize activity of insects, birds, and bats.

2.2.2 Weather Data

Temperature, relative humidity, and dew point were recorded for the duration of the survey period at 10-minute intervals by a weather station data logger (HOBO Pro v2 U23-001, Onset Computer Corporation) placed on the radar platform. The mean temperature, relative humidity, wind speed, and wind direction were calculated for each night.

2.2.3 Data Analysis

Video samples were analyzed using a digital analysis software tool developed by Stantec. For horizontal samples, targets (either birds or bats) were differentiated from insects based on their flight speed. Following adjustment for wind speed and direction, targets traveling faster than approximately 6 m (20') per second were identified as a bird or bat target (Larkin 1991, Bruderer and Boldt 2001). The software tool recorded the time, location, and flight vector for each target traveling fast enough to be a bird or bat within each horizontal sample, and these results were output to a spreadsheet. For vertical samples, the software tool recorded the entry point of targets passing through the vertical radar beam, the time, and flight altitude above the radar location, and then subsequently outputs the data to a spreadsheet. These datasets were then used to calculate passage rate (reported as targets per kilometer of migratory front per hour), flight direction, and flight altitude of targets.

Mean target flight directions (± 1 circular standard deviation) were summarized using software designed specifically to analyze directional data (Oriana2© Kovach Computing Services). The statistics used for this analysis are based on those used by Batschelet (1965), because they take into account the circular nature of the data. Weather data was collected from the nearest meteorological measurement tower (met tower) to the radar and nightly wind direction was summarized.

Flight altitude data were summarized using linear statistics. Mean flight altitudes (± 1 standard error [SE]) were calculated by hour, night, and overall season. The percent of targets flying below 125 m (410'), the approximate maximum height of the proposed wind turbines with blades, was also calculated hourly, for each night, and for the entire survey period.

2.3 RESULTS

Of the targeted 45 nights of survey, 40 nights of radar surveys were conducted from April 17 to June 1, 2008 (Appendix A, Table 1). Five nights were not surveyed due to periods of consistently steady rain. The radar site provided good visibility of the surrounding airspace and targets were observed in most areas of the radar display unit. The radar was located at the edge of a small clearing with surrounding tree heights of approximately 10 m (33') being level with, or slightly higher than, the height of the radar antenna. Some trees were slightly higher than the radar antenna to the south/southwest where elevation increased resulting in approximately a 20 degree "blind spot" in this area. Although targets could not be seen directly in that part of the radar screen targets, were observed flying through that area; therefore, resulting in nearly 100 percent coverage of targets flying through the radar viewshed. In vertical mode tree heights did not affect the radar view because the radar beam was directed vertically into the sky perpendicular (east to west) to the orientation of the ridge. Tree heights to the east and west were even with the height of the radar antenna allowing for the detection of targets flying at altitudes even with the tree-tops up to the range of the radar (4500').

2.3.1 Passage Rates

The overall passage rate for the entire survey period was 234 ± 20 targets per kilometer per hour (t/km/h). Nightly passage rates varied from 35 t/km/h on April 27 to 549 t/km/h on May 6 (Figure 2-3; also Appendix A, Table 1).

Individual hourly passage rates ranged from 0 to 1659 t/km/h (Appendix A, Table 2). Hourly passage rates varied between and within nights. For the entire season, passage rates were highest during the second hour after sunset and dropped off significantly during the eighth hour through sunrise (Figure 2-4).

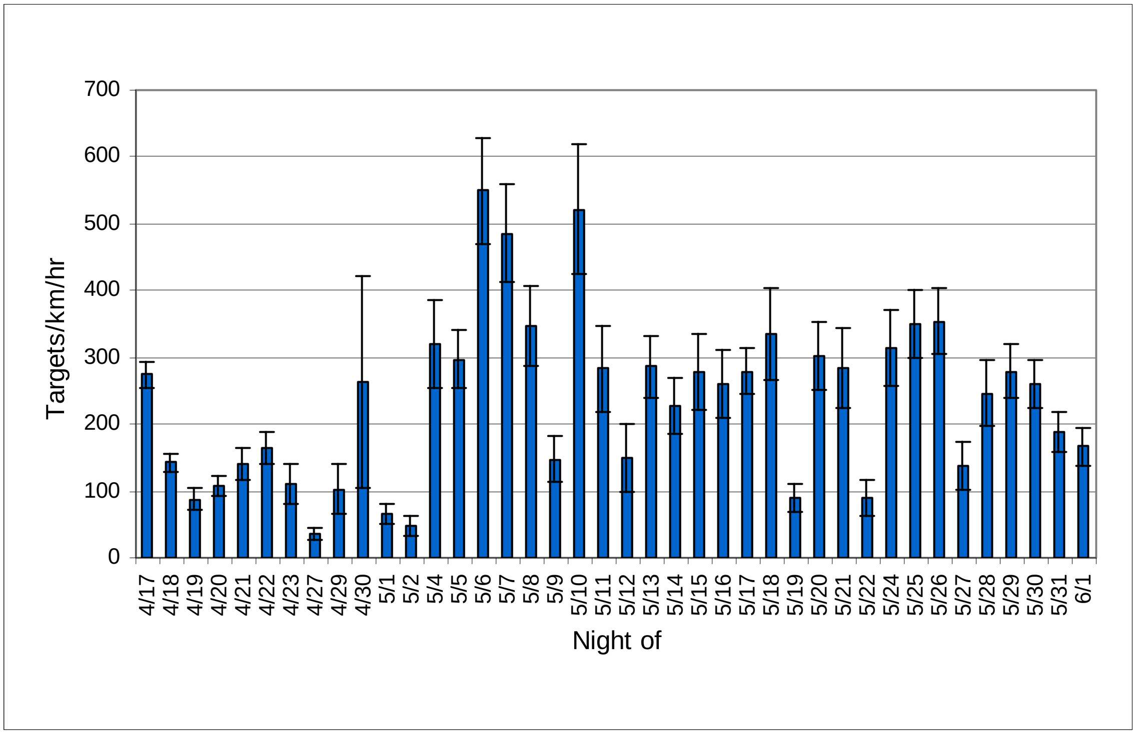

Figure 2-3. Nightly passage rates observed (error bars ± 1 SE)

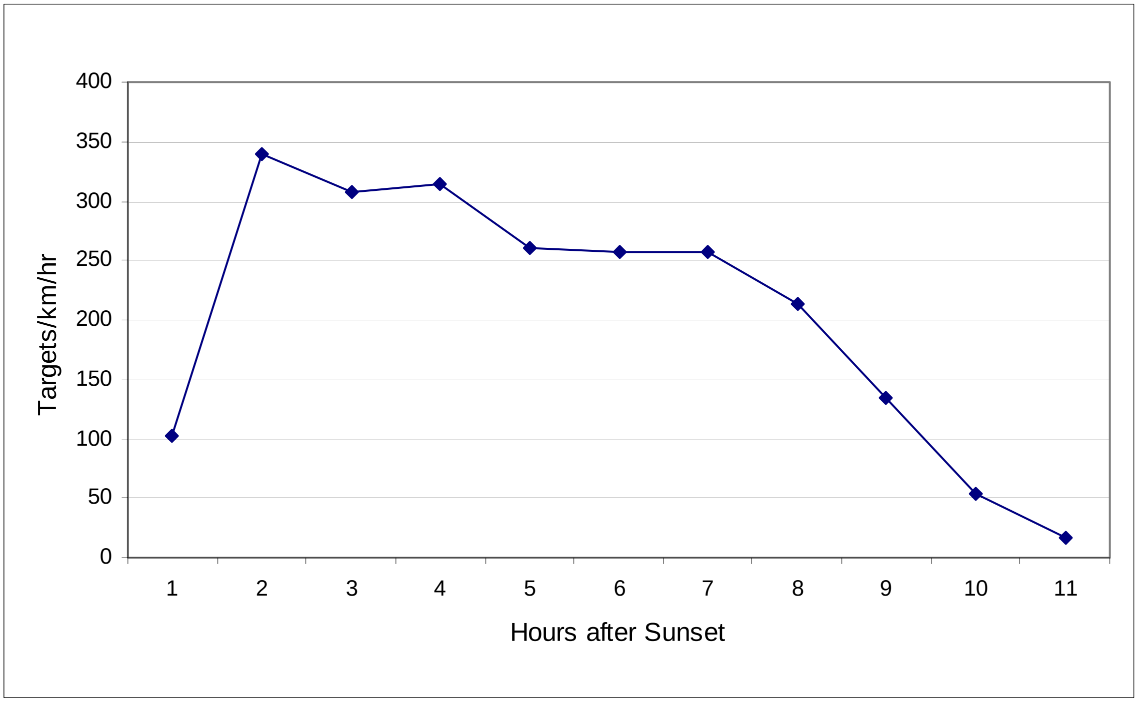

Figure 2-4. Hourly passage rates for entire season

2.3.2 Flight Direction

Mean flight direction through the Project area was 77° ± 64° (Figure 2-5). There was considerable variation between nights in mean flight direction, although most nights included flight directions generally to the east (Appendix A, Table 2).

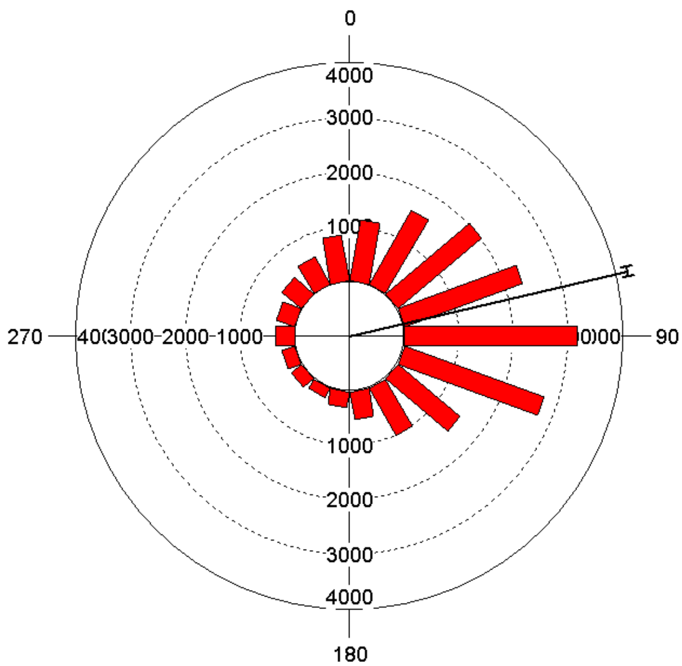

Figure 2-5. Mean flight direction for the entire season (the bracket along the margin of the histogram is the 95% confidence interval)

2.3.3 Flight Altitude

The seasonal average mean flight height of all targets was 321 ± 16 m (1051 ± 52') above the radar site. The average nightly flight height ranged from 114 m (373') on May 22 to 567 m (1860') on April 19 (Figure 2-6; Appendix A, Table 3). The percent of targets observed flying below 125m (410') averaged 12 percent for the season and varied by night from 1 to 59 percent (Figure 2-7). The two nights with the greatest percentage of targets flying below the height of the proposed turbines (5/2 and 5/22) occurred on nights with low passage rates. On these two nights passage rates were 47 t/km/hr and 90 t/km/hr respectively. The mean hourly flight height for the entire seasonal data was relatively constant throughout the first ten survey hours, but dropped off significantly in the eleventh hour (Figure 2-8). The same was true for each individual night, though overall nightly flight heights did vary between nights (Appendix A, Table 4) and is most likely attributed to varying weather conditions throughout the survey period.

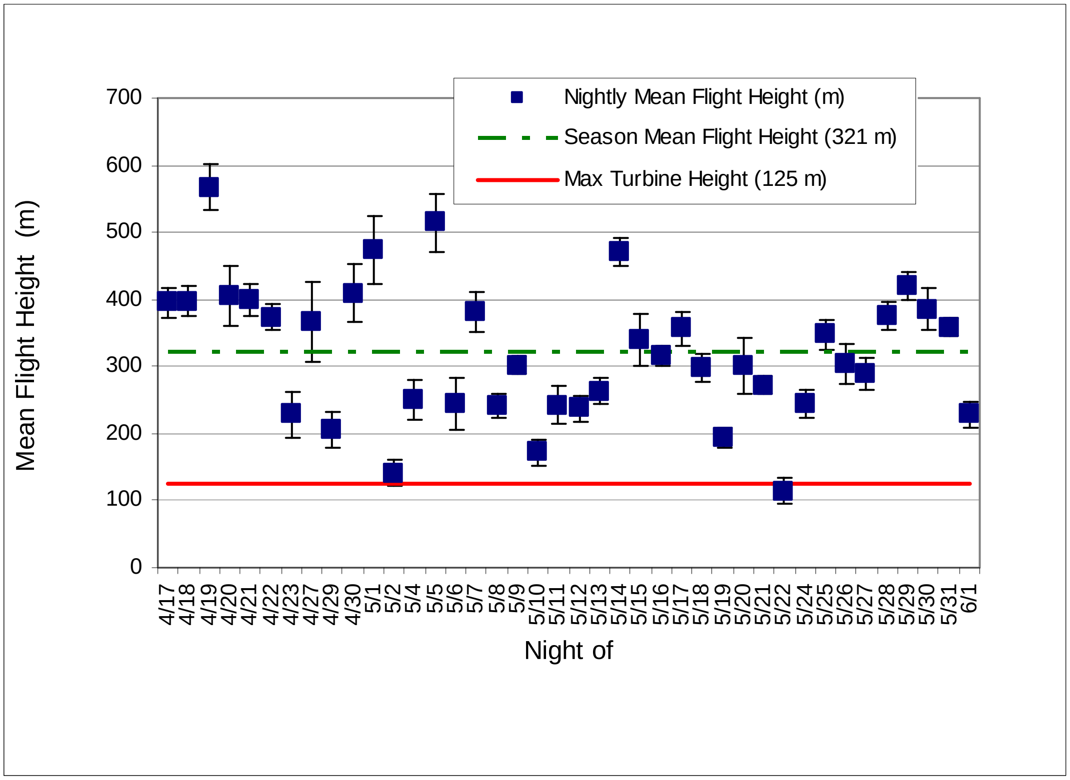

Figure 2-6. Mean nightly flight height of targets (error bars ± 1 SE)

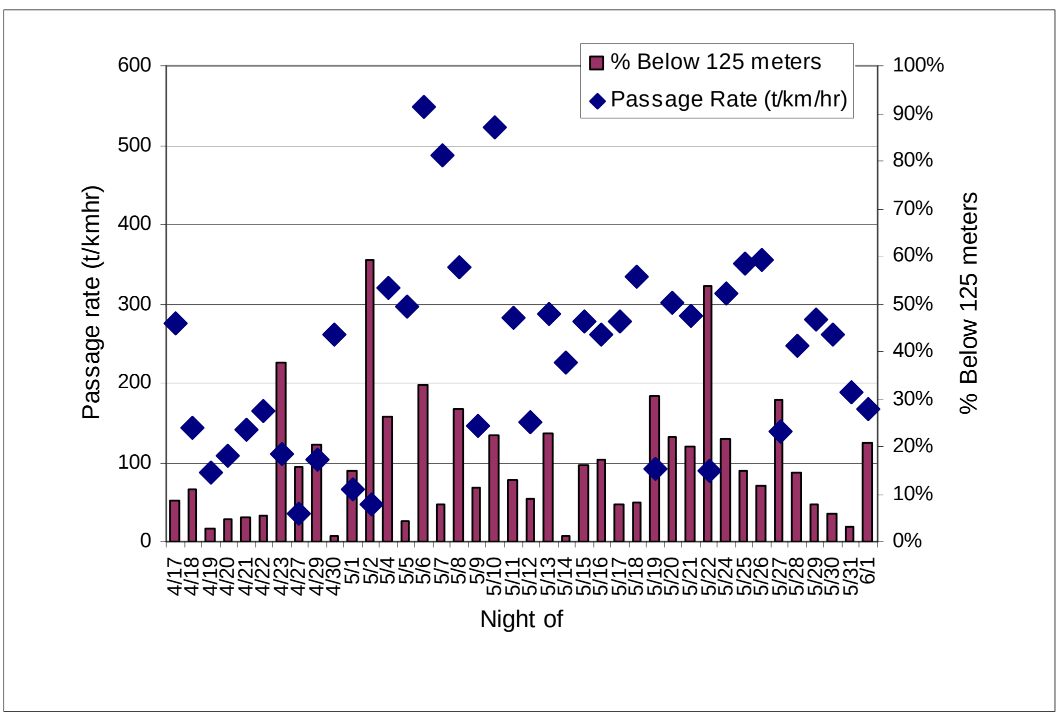

Figure 2-7. Percent of targets observed flying below a height of 125 m (410')

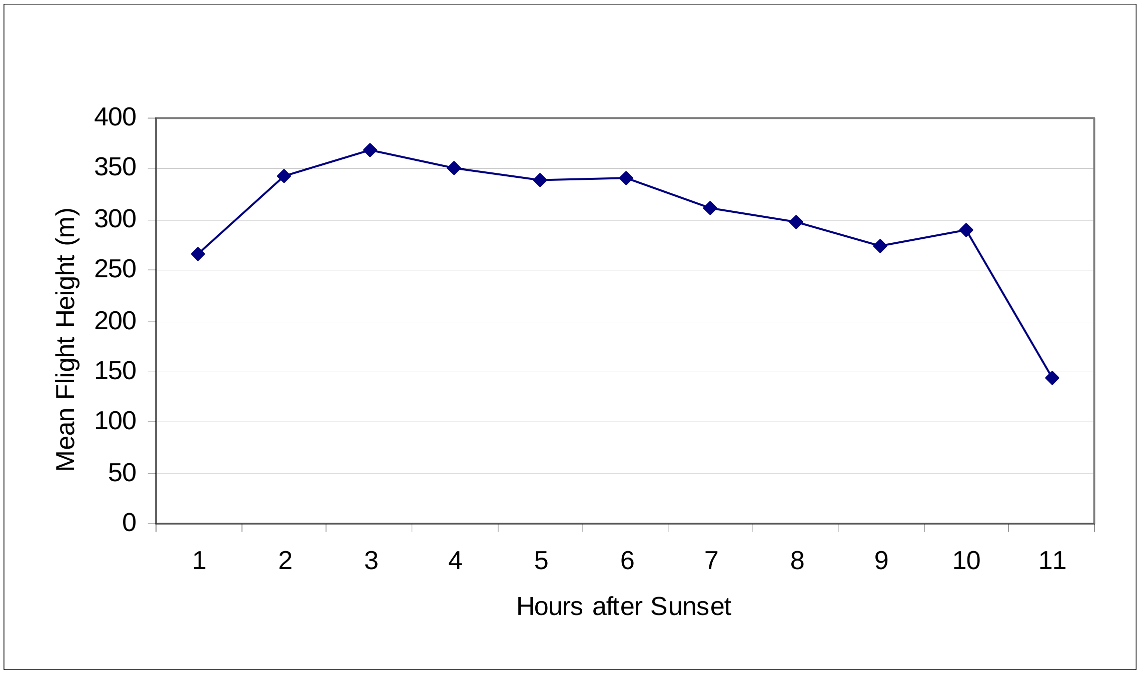

Figure 2-8. Hourly target flight height distribution

2.3.4 Ceilometer Observations

Ceilometer/night vision data collected during the radar survey yielded a total of 240 5-minute observations. Those observations resulted in 24 birds and 0 bats in the ceilometer beam.

2.3.5 Weather Data

Wind speeds and temperature in the Project area were recorded by Stantec's weather station situated at a height of 20 m (65'). During the survey period, mean nightly wind speeds varied between 1.0 and 6.5 meters per second (m/s). Mean nightly temperatures varied between -1.3ºC and 16.8ºC. No attempt was made to correlate weather variables with passage rates, flight heights, and flight direction due to the inability to collect accurate weather data from heights at which the majority of migration was observed to occur. Furthermore, it is thought that migration may be influenced by a combination of weather variables rather any single variable alone. Additionally, some variables (i.e., cloud ceiling height) can not be accurately collected using current technologies or technologies that are economically feasible.

2.4 DISCUSSION

Nightly variation in the magnitude and flight characteristics of nocturnally-migrating songbirds is not uncommon and is often attributed to weather patterns, such as cold fronts and winds aloft (Hassler *et al.* 1963, Gauthreaux and Able 1970, Richardson 1972, Able 1973, Bingman *et al.* 1982, Gauthreaux 1991). Data from regional surveys using similar methods and equipment conducted within the last several years are rapidly becoming available. These other studies provide an opportunity to compare the results from this Project with other projects in northern New England and the region. There are limitations in comparing data from previous years with data from 2008, as year-to-year variation in continental bird populations may influence how many birds migrate through an area. Additionally, differences in site characteristics, particularly the topography, local landscape conditions, and vegetation surrounding a radar survey location, can play a large role in any radar's ability to detect targets and the subsequent calculation of passage rate. These differences should be recognized as one of the more significant limiting factors in making direct site-to-site comparisons in passage rates.

Regardless of potential differences between radar survey locations, the results at the Project are within the typical range of results at projects in landscapes on forested ridges (see Table 2-1 below). There is currently no accurate quantitative method of directly correlating pre-construction passage rates at wind farms to operational impacts to birds and bats. Some research suggests that bird migration may be affected by landscape features, such as coastlines, large river valleys, and mountain ranges. This has been documented for diurnally migrating birds, such as raptors, but is not as well established for nocturnally migrating birds (Sielman *et al*. 1981; Bingman 1980; Bingman *et al*. 1982; Bruderer and Jenni 1990; Richardson 1998; Fortin *et al*. 1999; Williams *et al.* 2001; Diehl *et al*. 2003). Those studies that suggest night-migrating birds *are* influenced by topography have typically been conducted in areas of steep and abrupt topography, such as the most rugged areas of the northern Appalachians and the Alps.

The emerging body of studies characterizing nocturnal bird movements shows a relatively consistent pattern in flight altitude, with most birds appearing to fly at altitudes of several hundred meters or more above the ground (Table 2-1). Comparison of flight height between survey sites as measured by radar is generally less influenced by site characteristics as the main portion of the radar beam is directed skyward, and the potential effects of surrounding vegetation on the radar's view can be more easily controlled. The radar, centrally located on the summit of Tenney Mountain, allowed for unobstructed views in vertical mode and targets were observed flying in all areas of the vertical detection range. Although a small portion of ground clutter to the south obstructed some views in horizontal mode, targets were observed passing through that area resulting in nearly 100 percent coverage of targets flying within the radar viewshed. The radar view in horizontal mode was comparable to other studies conducted by Stantec in the state.

Table 2-1. Summary of available spring radar survey results

Project Site	No. of Survey Nights	No. of Survey Hours	Landscape	Average Passage Rate (t/km/hr)	Range in Nightly Passage Rates	Average Flight Direction	Average Flight Height (m)	(Turbine Height) % Targets Below	Citation
Spring 2003									
Westfield Chautauqua Cty, NY	30	150	Great Lakes Shore	395	15-1702	29	528	(125 m) 4%	Cooper *et al.*2004
Spring 2005									
Churubusco, Clinton Cty, NY	39	310	Great Lakes plain/ADK foothills	254	3-728	40	422	(120 m) 11%	Woodlot 2005a
Ellenberg, Clinton Cty, NY	n/a	n/a	Great Lakes plain/ADK foothills	110	n/a	30	338	(n/a) 20%	Mabee *et al.* 2006a
Dairy Hills, Clinton Cty, NY	n/a	n/a	Great Lakes shore	117	n/a	14	397	(n/a) 15%	ED&R 2006b
Clayton, Jefferson Cty, NY	36	303	Agricultural plateau	450	71-1769	30	443	(150 m) 14%	Woodlot 2005b
High Sheldon, Wyoming Cty, NY	38	272	Agricultural plateau	112	6-558	25	418	(120 m) 6%	Woodlot 2006a
Prattsburgh, Steuben Cty, NY	20	183	Agricultural plateau	277	70-621	22	370	(125 m) 16%	Woodlot 2005c
Prattsburgh, Steuben Cty, NY	30	270	Agricultural plateau	170	3-844	18	319	(125 m) 18%	Mabee *et al.* 2005a
Cohocton, Steuben Cty, NY	3	29	Agricultural plateau	371	133-773	28	609	(125 m) 12%	ED&R 2006a
Munnsville, Madison Cty, NY	41	388	Agricultural plateau	160	6-1065	31	291	(118 m) 25%	Woodlot 2005d
Fairfield, Herkimer Cty, NY	40	369	Agricultural plateau	509	80-1175	44	419	(125 m) 20%	Woodlot 2005e
Jordanville, Herkimer Cty, NY	40	364	Agricultural plateau	409	26-1410	40	371	(125 m) 21%	Woodlot 2005f
Sheffield, Caledonia Cty, VT	20	179	Forested ridge	208	11-439	40	522	(125 m) 6%	Woodlot 2006b
Deerfield, Bennington Cty, VT	20	183	Forested ridge	404	74-973	69	523	(125 m) 4%	Woodlot 2005g
Franklin, Pendleton Cty, WV	23	204	Forested ridge	457	34-240	53	492	(125 m) 11%	Woodlot 2005h
Spring 2006									
Chateaugay, Franklin Cty, NY	35	300	Agricultural plateau	360	54-892	48	409	(120 m) 18%	Woodlot 2006c
Wethersfield, Wyoming Cty, NY	44	n/a	Agricultural plateau	324	41-907	12	355	(125 m) 19%	Mabee et al. 2006b
Centerville, Allegany Cty, NY	42	n/a	Agricultural plateau	290	25-1140	22	351	(125 m) 16%	Mabee et al. 2006b
Howard, Steuben Cty, NY	42	440	Agricultural plateau	440	35-2270	27	426	(125 m) 13%	Woodlot 2006d
Deerfield, Bennington Cty, VT	26	236	Forested ridge	263	5-934	58	435	(100 m) 11%	Woodlot 2006e
Kibby, Franklin Cty, ME (Mtn)	6	33	Forested ridge	456	88-1500	67	368	(120 m) 14%	Woodlot 2006f
Kibby, Franklin Cty, ME (Range 1)	10	80	Forested ridge	197	6-471	50	412	(120 m) 22%	Woodlot 2006f
Kibby, Franklin Cty, ME (Range 2)	7	57	Forested ridge	512	18-757	86	378	(120 m) 25%	Woodlot 2006f
Kibby, Franklin Cty, ME (Valley)	2	14	Forested valley	443	45-1242	61	334	(120 m) n/a	Woodlot 2006f
Mars Hill, Aroostook Cty, ME	15	85	Forested ridge	338	76-674	58	384	(120 m) 14%	Woodlot 2006g
Spring 2007									
Lempster, Sullivan Cty, NH	30	277	Forested ridge	542	49-1094	49	358	(125 m) 18%	Woodlot 2007c
Coos County, NH	30	212	Forested ridge	342	2 - 870	76	332	(125 m) 14%	Stantec Consulting 2007a
Spring 2008									
Groton, NH	40	373	Forested ridge	234	35-549	77	321	(125m) 12%	This report

2.5 CONCLUSIONS

Radar surveys during the spring 2008 migration period have provided important information on nocturnal migration patterns in the vicinity of the Project area. The results of the surveys indicate that migration patterns are generally similar to patterns observed at other forested ridge sites in the northeastern U.S. region. The mean passage rate is within or at the low end of the typical range of passage rates observed at other regional sites studied with similar methods and equipment. The combination of the flight height and flight direction data indicates that the majority of migrants are unimpeded by topography and flying at significantly high elevations (relative to the proposed turbines and blade heights).

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Appendix A

Radar Survey Data Tables

Appendix A Table 1. Survey dates, results, level of effort, and weather - Spring 2008								
Date	**Passage Rate t/km/h**	**Flight Direction**	**Flight Height (m)**	**% below 125 (m)**	**Hours of Survey**	**Temperature (°C)**	**Wind Speed (m/s)**	**Wind Direction (degree)**
4/17/2008	274	43	396	9%	6	9	2	113
4/18/2008	143	300	398	11%	11	13	3	89
4/19/2008	88	354	567	3%	11	6	5	127
4/20/2008	108	6	405	5%	11	6	2	120
4/21/2008	142	85	400	5%	11	10	2	240
4/22/2008	165	100	374	5%	11	13	2	264
4/23/2008	111	123	228	38%	8	10	3	317
4/27/2008	35	359	366	16%	10	5	2	133
4/29/2008	103	139	205	20%	10	-1	5	320
4/30/2008	262	138	409	1%	10	-1	1	297
5/1/2008	65	44	473	15%	10	3	2	89
5/2/2008	47	18	141	59%	8	3	3	149
5/4/2008	319	107	249	26%	10	4	2	318
5/5/2008	297	68	515	4%	9	9	1	54
5/6/2008	549	97	245	33%	10	10	2	331
5/7/2008	486	30	381	8%	7	12	2	181
5/8/2008	347	116	242	28%	10	7	3	339
5/9/2008	147	351	301	11%	10	8	2	108
5/10/2008	522	30	172	22%	9	7	2	123
5/11/2008	283	26	242	13%	10	6	4	131
5/12/2008	150	30	238	9%	10	7	2	98
5/13/2008	287	90	264	23%	10	10	2	35
5/14/2008	227	33	471	1%	10	9	3	153
5/15/2008	277	111	340	16%	10	8	2	345
5/16/2008	261	70	316	17%	8	9	1	310
5/17/2008	279	92	356	8%	9	11	4	294
5/18/2008	335	46	297	8%	9	6	3	253
5/19/2008	91	91	193	30%	10	3	5	300
5/20/2008	302	108	301	22%	9	9	1	331
5/21/2008	285	94	272	20%	9	5	2	296
5/22/2008	90	102	114	54%	9	6	4	317
5/24/2008	314	94	244	21%	9	9	2	332
5/25/2008	351	67	348	15%	9	13	3	282
5/26/2008	354	67	304	12%	9	17	4	259
5/27/2008	138	125	289	30%	9	5	3	341
5/28/2008	246	89	376	15%	9	7	3	309
5/29/2008	279	106	419	8%	9	12	2	321
5/30/2008	261	356	385	6%	7	12	3	149
5/31/2008	189	97	358	3%	8	15	4	282
6/1/2008	167	113	228	21%	9	11	4	305

Appendix A Table 2. Summary of passage rates by hour, night, and for entire season.

Night of	Passage Rate (targets/km/hr) by hour after sunset											Entire Night			
	1	2	3	4	5	6	7	8	9	10	11	Mean	Median	Stdev	SE
4/17/2008	--	179	282	276	312	289	308	--	--	--	--	274	286	49	20
4/18/2008	182	157	145	159	182	150	179	150	120	129	21	143	150	45	14
4/19/2008	48	60	86	99	139	150	200	86	59	43	0	88	86	57	17
4/20/2008	82	96	107	139	107	139	168	124	168	59	0	108	107	49	15
4/21/2008	48	81	64	197	107	274	177	236	198	133	43	142	133	80	24
4/22/2008	96	90	150	154	257	229	209	261	236	107	21	165	154	80	24
4/23/2008	--	--	96	266	57	121	186	115	47	0	--	111	106	84	30
4/27/2008	21	114	39	32	14	28	21	36	27	15	--	35	27	29	9
4/29/2008	11	346	273	107	129	73	43	14	27	7	--	103	58	118	37
4/30/2008	150	1659	375	103	107	102	43	32	37	16	--	262	102	501	159
5/1/2008	17	32	38	60	118	145	114	75	43	11	--	65	51	46	15
5/2/2008	51	116	21	95	67	12	13	0	--	--	--	47	36	43	15
5/4/2008	36	193	321	600	246	375	636	434	336	15	--	319	329	208	66
5/5/2008	150	--	293	275	289	295	364	507	418	86	--	297	293	128	43
5/6/2008	305	754	739	800	771	566	597	536	423	0	--	549	581	252	80
5/7/2008	270	358	354	--	--	--	825	536	632	429	--	486	429	193	73
5/8/2008	279	530	478	621	343	525	283	129	268	14	--	347	313	192	61
5/9/2008	70	279	314	286	124	113	129	99	57	0	--	147	118	108	34
5/10/2008	92	1039	703	654	629	407	418	589	166	--	--	522	589	289	96
5/11/2008	163	429	499	611	364	314	288	96	43	21	--	283	301	199	63
5/12/2008	107	450	437	193	107	75	50	50	17	16	--	150	91	163	52
5/13/2008	102	249	279	300	159	306	519	429	439	86	--	287	289	145	46
5/14/2008	69	193	231	274	336	461	252	309	132	14	--	227	242	132	42
5/15/2008	90	404	505	386	422	311	399	214	43	0	--	277	348	179	56
5/16/2008	86	351	429	383	271	359	139	70	--	--	--	261	311	143	51
5/17/2008	121	243	354	414	272	300	343	346	114	--	--	279	300	104	35
5/18/2008	34	312	615	587	434	386	327	296	21	--	--	335	327	208	69
5/19/2008	7	214	114	39	81	121	143	132	56	0	--	91	98	67	21
5/20/2008	75	307	284	311	197	300	557	520	166	--	--	302	300	156	52
5/21/2008	56	536	421	477	326	240	329	136	48	--	--	285	326	178	59
5/22/2008	75	246	189	75	0	107	75	32	12	--	--	90	75	81	27
5/24/2008	86	497	543	477	343	243	300	254	83	--	--	314	300	169	56
5/25/2008	146	530	351	386	504	517	311	300	118	--	--	351	351	152	51
5/26/2008	261	373	403	548	557	407	268	266	107	--	--	354	373	145	48
5/27/2008	47	230	193	312	220	158	48	29	5	--	--	138	158	109	36
5/28/2008	40	252	331	286	477	370	248	204	11	--	--	246	252	149	50
5/29/2008	193	343	356	400	399	286	243	279	13	--	--	279	286	122	41
5/30/2008	64	281	328	279	316	321	236	--	--	--	--	261	281	92	35
5/31/2008	75	206	270	321	168	221	141	107	--	--	--	189	187	83	29
6/1/2008	89	143	264	257	214	221	193	99	21	--	--	167	193	84	28
Entire Season	102	339	307	314	261	257	258	214	135	55	17	**234**	**267**	**124**	**20**

Appendix A Table 3. Mean Nightly Flight Direction		
Night of	**Mean Flight Direction**	**Circular Stdev**
4/17/2008	43°	56°
4/18/2008	300°	106°
4/19/2008	355°	55°
4/20/2008	6°	88°
4/21/2008	85°	68°
4/22/2008	100°	51°
4/23/2008	123°	47°
4/27/2008	360°	35°
4/29/2008	139°	31°
4/30/2008	138°	31°
5/1/2008	44°	75°
5/2/2008	18°	50.°
5/4/2008	107°	28°
5/5/2008	68°	61°
5/6/2008	97°	28°
5/7/2008	30°	45°
5/8/2008	116°	53°
5/9/2008	351°	62°
5/10/2008	30°	40°
5/11/2008	26°	39°
5/12/2008	30°	62°
5/13/2008	90°	80°
5/14/2008	33°	42°
5/15/2008	111°	49°
5/16/2008	70°	80°
5/17/2008	92°	44°
5/18/2008	46°	53°
5/19/2008	91°	63°
5/20/2008	108°	54°
5/21/2008	94°	46°
5/22/2008	102°	41°
5/24/2008	94°	46°
5/25/2008	67°	29°
5/26/2008	67°	39°
5/27/2008	125°	66°
5/28/2008	89°	73°
5/29/2008	106°	67°
5/30/2008	356°	61°
5/31/2008	97°	42°
6/1/2008	113°	54°
Entire Season	77°	64°

Appendix A Table 4. Summary of mean flight heights by hour, night, and for entire season.

Night of	Mean Flight Height (m) by hour after sunset											Entire Night				% of targets below 125 meters
	1	2	3	4	5	6	7	8	9	10	11	Mean	Median	STDV	SE	
4/17/2008	--	460	441	447	397	393	310	320	--	--	--	396	397	61	23	9%
4/18/2008	260	414	410	432	368	462	439	405	499	420	265	398	414	75	22	11%
4/19/2008	288	622	649	629	584	575	487	621	590	628	--	567	605	108	34	3%
4/20/2008	245	436	482	474	495	512	466	465	426	434	23	405	465	145	44	5%
4/21/2008	260	404	465	490	453	427	472	382	328	313	--	400	416	77	24	5%
4/22/2008	286	431	417	439	391	430	378	383	312	271	--	374	387	63	20	5%
4/23/2008	--	--	--	--	315	311	269	179	197	98	--	228	233	85	35	38%
4/27/2008	199	207	421	483	502	582	586	409	229	47	--	366	415	184	58	16%
4/29/2008	--	245	397	157	220	180	168	194	180	104	--	205	180	82	27	20%
4/30/2008	525	452	403	408	257	--	--	--	--	--	--	409	408	98	44	1%
5/1/2008	161	363	521	544	642	595	605	586	437	275	--	473	533	160	51	15%
5/2/2008	166	213	181	150	83	103	92	--	--	--	--	141	150	50	19	59%
5/4/2008	289	352	305	273	216	420	175	166	116	183	--	249	244	95	30	26%
5/5/2008	205	417	622	621	604	560	643	550	512	414	--	515	555	136	43	4%
5/6/2008	360	407	422	344	186	165	157	146	159	103	--	245	175	123	39	33%
5/7/2008	312	425	469	--	--	--	436	426	357	244	--	381	425	80	30	8%
5/8/2008	316	302	313	245	212	187	216	183	201	--	--	242	216	55	18	28%
5/9/2008	266	359	348	304	333	299	286	289	230	--	--	301	299	41	14	11%
5/10/2008	91	208	206	228	227	225	159	170	152	55	--	172	188	60	19	22%
5/11/2008	272	360	313	270	315	227	172	135	114	--	--	242	270	86	29	13%
5/12/2008	261	238	280	260	280	--	162	282	139	--	--	238	260	56	20	9%
5/13/2008	202	274	256	258	274	267	199	268	219	419	--	264	262	62	20	23%
5/14/2008	313	446	487	506	511	488	486	444	472	556	--	471	486	64	20	1%
5/15/2008	257	385	275	280	243	245	322	517	539	--	--	340	280	115	38	16%
5/16/2008	332	382	322	322	310	257	289	--	--	--	--	316	322	38	14	17%
5/17/2008	319	295	418	412	370	338	310	291	271	540	--	356	328	82	26	8%
5/18/2008	320	311	336	313	342	275	377	213	182	--	--	297	313	63	21	8%
5/19/2008	--	204	253	194	207	147	246	153	141	--	--	193	199	43	15	30%
5/20/2008	189	353	342	321	362	535	305	128	172	--	--	301	321	124	41	22%
5/21/2008	229	256	274	306	264	264	218	363	274	--	--	272	264	43	14	20%
5/22/2008	105	155	164	197	135	116	36	100	15	--	--	114	116	59	20	54%
5/24/2008	219	290	235	227	283	353	157	185	249	--	--	244	235	59	20	21%
5/25/2008	--	405	364	374	418	368	336	277	239	--	--	348	366	62	22	15%
5/26/2008	380	259	274	221	353	414	--	229	--	--	--	304	274	77	29	12%
5/27/2008	245	299	346	412	292	321	185	185	313	--	--	289	299	74	25	30%
5/28/2008	306	367	504	310	322	386	391	382	415	--	--	376	382	62	21	15%
5/29/2008	306	392	441	458	438	446	454	--	--	--	--	419	441	55	21	8%
5/30/2008	304	413	451	371	--	--	--	--	--	--	--	385	392	63	31	6%
5/31/2008	--	--	--	386	356	323	368	--	--	--	--	358	362	26	13	3%
6/1/2008	--	259	185	265	315	254	225	229	202	120	--	228	229	56	19	21%
Entire Season	266	344	368	351	339	341	312	298	275	290	144	**321**	**317**	**101**	**16**	**12%**
-- indicates no data for that hour																