Fall 2005 Radar Survey of Nighttime Migration Activity at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine

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TRC
and
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December 2006

WOODLOT ALTERNATIVES, INC.
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Final Fall 2005 Radar Survey of Bird and Bat Migration Report Submitted by:

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Date

Executive Summary

During Fall 2005, Woodlot Alternatives, Inc. (Woodlot) conducted nighttime radar surveys of migration activity at the proposed Kibby Wind Power Project site. The surveys are part of the planning process by TransCanada Energy, Ltd. for the project, which would include the erection of wind turbines on ridgelines in Kibby and Skinner townships, Maine. Nighttime surveys of birds and bats were conducted using radar.

The results of the field surveys provide useful information about site-specific migration activity through and above the project area. A total of 29 nights of radar surveys were completed between August 22 and October 13, 2005. Radar sampling occurred on two of the ridgelines proposed for wind turbine development and at four locations in the valleys between the development ridges.

The mean nightly passage rate was variable between nights, typical of bird and bat migration. Variation between sites is attributable the fact that different sites were sampled on different nights with differing weather conditions. The largest mean seasonal passage rate observed at any of the six survey locations was 565 targets/kilometer/hour (t/km/hr) at the Kibby Mountain ridgeline survey site and the smallest mean nightly passage rate was 201 t/km/hr at the Kibby Range ridgeline survey site. Mean seasonal passage rates at the valley sites ranged from 236 t/km/hr to 462 t/km/hr.

When pooled by landscape position, the overall seasonal mean passage rate over the two ridgelines (383 t/km/hr) was very similar to that of the pooled valley sites (398 t/km/hr). These rates are generally within the range of passage rates documented at other radar survey sites in the Northeast.

The mean flight height of targets documented over the ridgelines was 352 meters (m) (1,155 feet [ft]) above the radar elevation at Kibby Range and 370 m (1,214 ft) above the radar at Kibby Mountain. The mean flight height of the valley sites, when combined, was 391 m (1,283 ft). However, variation among the valley sites occurred, with mean nightly flight heights at the three northern sites ranging from 469 m (1,538 ft) to 495 m (1,624 ft) above the ground and a mean flight height at the southernmost site of only 158 m (518 ft).

Flight directions through and over the project area were also similar among the survey sites and, overall, ranged from 167º to 196º (relative to true north). Migration was generally in a north to south direction on most nights, particularly on the nights with the most suitable weather conditions (clear skies with northerly breezes).

Nights with the most suitable weather for nocturnal migration (clear skies with strong winds from the west, northwest, and north) were generally associated with higher mean nightly passage rates and flight heights. This relationship, however, was not consistent throughout the study.

The radar data indicate that migration through the project area, an area of varied topography, may be complex. Radar data from the valley sites indicate that some migration takes place within the confines of the valleys, with mean flight heights that are below the altitudes of the surrounding ridgelines. Flight direction and flight height data from the ridgeline survey sites, however, indicate a broad front type of night migration documented above the ridgelines, with mean flight heights largely above typical turbine heights.

Table of Contents

List of Appendices

List of Tables

List of Figures

1.0 Introduction

1.1 Project Context

TransCanada Maine Wind Development, Inc., is proposing to develop, own, and operate a 100–200 megawatt wind power generating facility in the Boundary Mountains of Western Maine known as the Kibby Wind Power Project. The project is in a location for which a similar project proposal by U.S. Windpower was previously approved by the Land Use Regulation Commission.

The project will be located in Kibby and Skinner Townships, an unincorporated area of Franklin County, Maine. At the time the study was conducted, up to four ridgelines were under consideration for turbine locations, as shown in Figure 1. The property is owned by Plum Creek, and the surrounding areas are currently actively managed for forest products. The Kibby Wind Power Project can take advantage of existing logging roads and cleared areas to access the ridgelines, and forestry activities can continue in a complementary fashion with the project in place. The project will utilize the superior wind resource found in this vicinity to create clean, renewable power generation.

The predominant peaks in the project vicinity include Smart, Caribou, Kibby, Tumbledown, Spencer Bale and Sisk mountains, all of which are over 975 meters (m) (3,199 feet [ft]) high. Caribou and Kibby mountains are the tallest of these mountains, at 1,051 m (3,448 ft) and 1,115 m (3,658 ft), respectively. Kibby Mountain is included as a potential wind turbine development area for the project, although turbines are currently proposed only at lower elevations of the southern end of the mountain. Kibby Range, also a potential wind turbine development area, is the largest of the mountain ranges in the project area in terms of area and number of peaks included within ridgelines. It has several peaks that are approximately 915 m to 1,000 m (3,002 ft to 3,281 ft) high. The valley bottoms in the study area average between 650 m and 750 m (2,133 ft and 2,461 ft) in elevation

The surveys for this project were conducted to provide data that will help characterize nighttime bird migration and bat activity in the project area. This information, along with other data, is intended to be used to assess the potential risk to birds and bats from this proposed project as a result of potential collisions.

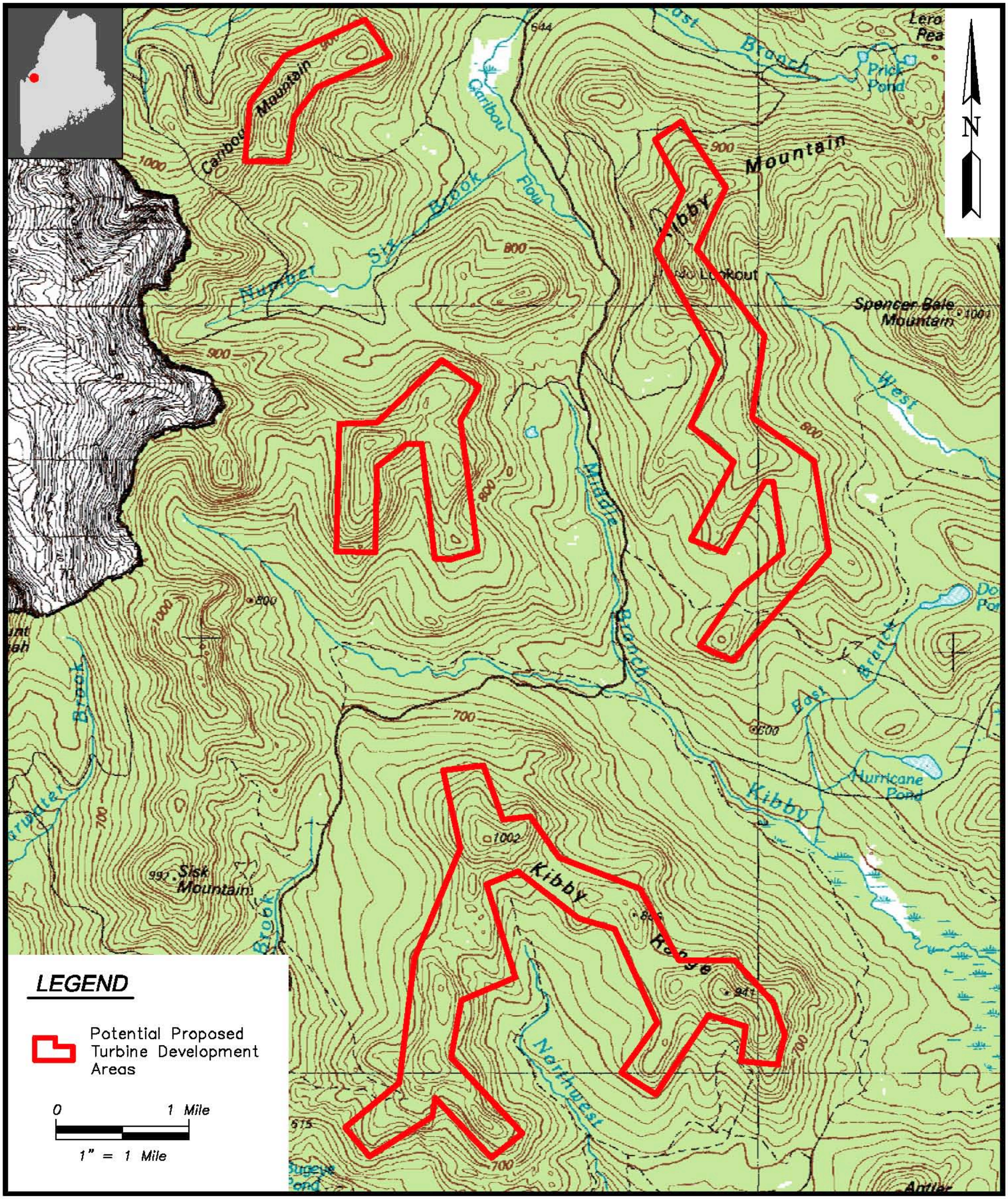

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Figure 1 - Project Area Location Map
Kibby Wind Power Project
TransCanada Energy, Ltd.

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1.2 Survey Overview

Woodlot Alternatives, Inc. (Woodlot) conducted field investigations of night migration during the fall of 2005. The goal of the investigations was to characterize nighttime migration through the project area using marine surveillance radar. Objectives included documenting 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 height. Radar surveys document both birds and bats. Based on overall population levels, it is anticipated that most of the activity documented by radar includes nighttime bird movements, although radar cannot readily distinguish between the two. Consequently, radar data is expressed as targets, rather than birds or bats.

The survey protocol was developed through consultation with state and federal natural resource agencies. A work scope was prepared and presented to agency personnel during a meeting held in August 2005 and attended by the Maine Land Use Regulation Commission, the Maine Department of Environmental Protection, the Maine Department of Inland Fisheries and Wildlife, and the U.S. Fish and Wildlife Service. Comments on the work scope were incorporated into the final study design.

The radar surveys were conducted from sunset to sunrise during each of 29 nights of sampling from August 22 to October 13, 2005[1], which brackets the peak of migration activity for northeastern forest songbirds. Two ridgeline locations were selected for sampling during two 6-night periods, each. The radar equipment was mounted on a stationary tower during each sampling event. In addition, six nights of mobile sampling along the road system in the project area were targeted to provide additional insight on the flight habits of migrants in the project area. Mobile surveys consisted of sampling one to four locations one to three times during the night using a radar unit mounted to a truck. The same radar equipment was used for the duration of this study and was moved between sample locations prior to each different sampling event.

[1] Thirty nights were originally intended for surveys but inclement weather precluded the use of the radar on one of the targeted survey nights.

2.0 Methods

2.1 Field Methods

Radar surveys were conducted from six locations in the project area (Figure 2). These included two ridgeline locations: one on the peak of Kibby Mountain (elevation 1,114 m, 3,654') and one on a peak near the southeastern end of Kibby Range (elevation 885 m, 2,903'). Four valley locations were selected for mobile sampling. These were located along the existing forest roads in the project area and will be referred to in this report as the Kibby Mountain Road (800 m or 2,624'), Spencer Bale Road (690 m or 2,263'), Wahl Road (555 m or 1,820'), and Mile 4 Road (705 m or 2,640') sites. The sites were chosen based on several criteria, including location within the overall project area, proximity to road or trail systems for relatively easy access, and the potential radar visibility (i.e., the view that the radar had of the surrounding airspace).

A marine surveillance radar unit 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 animals, including birds, bats, and even insects, based on settings selected for the radar functions. It cannot, however, readily distinguish between different types of animals being detected. Consequently, all animals observed on the radar screen are called targets. The radar has an echo trail function that maintains echoes of past migrants. During all operations, the radar's echo trail was set to 30 seconds. The radar was equipped with a 2-m (6.5-ft) waveguide antenna. The antenna has a vertical beam height of 20º (10º above and below horizontal) and the front end 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 (echoes) on the radar screen that appear as blotches called ground clutter (Figure 3). Large amounts of ground clutter reduce the ability of the radar to track birds and bats flying over those areas. However, vegetation near the radar can be used to reduce or eliminate ground clutter by 'hiding' clutter-causing objects from the radar (Figure 4). The presence of ground clutter and objects, such as treeline edges, that could reduce clutter were important factors considered during the survey site selection process. Due to the rugged terrain in the project area, ground clutter was unavoidable at the sites surveyed; the success of reducing clutter was variable from site to site. A description and images of the ground clutter that occurred at each survey site are provided in Appendix A.

Radar surveys were conducted from sunset to sunrise. Twenty-nine nights of surveys were conducted for sampling between August 22 and October 13, 2005. Surveys were targeted largely for nights without rain because the anti-rain function of the radar interferes with the detection of small songbirds and bats. However, to characterize migration patterns during nights without optimal conditions, sampling was conducted on nights with weather forecasts that included occasional showers. On those nights, data were not collected during periods of rain and data collection resumed after the showers passed.

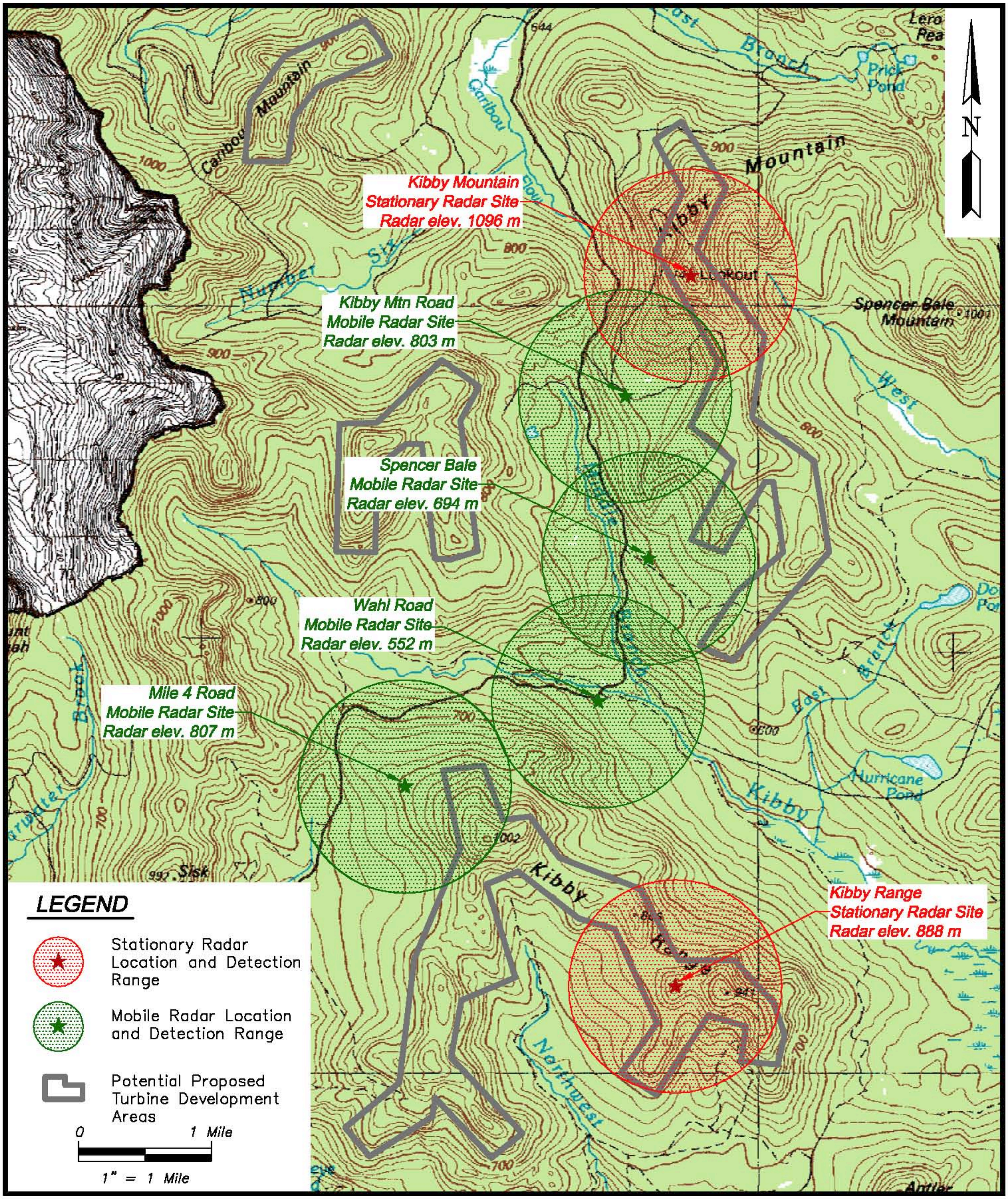

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Figure 2 - Radar Location Map
Kibby Wind Power Project
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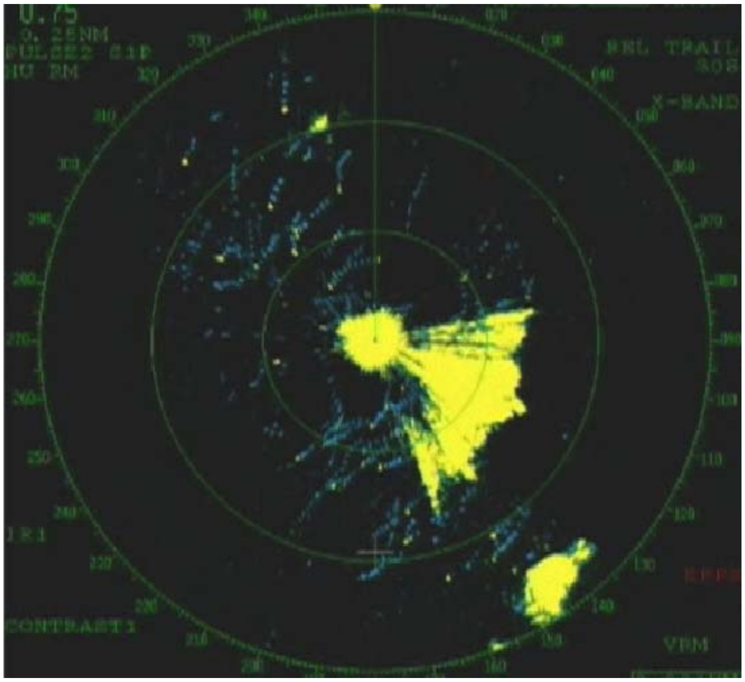

Figure 3 Example of ground clutter in project area

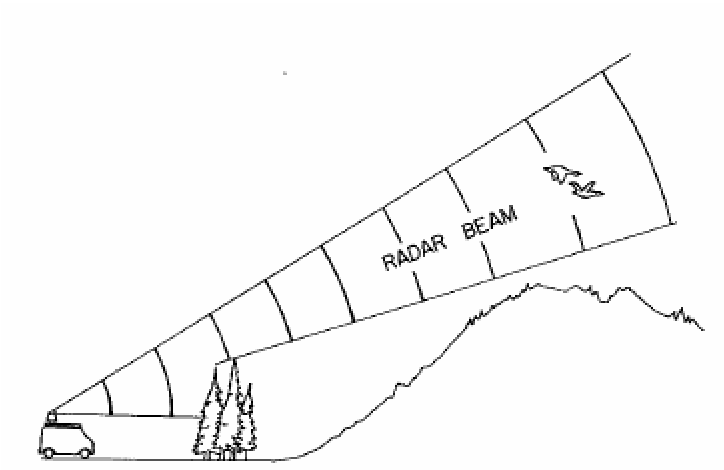

Figure 4 Example of how vegetation is used to screen out clutter-causing objects (taken from Sielman *et al.* 1981).

The radar equipment was operated in two modes throughout the night. In the first mode, surveillance, the antenna spins horizontally to survey the airspace around the radar and detect targets moving through the area. The flight direction of targets can be determined by analyzing the echo trail. In the second mode, vertical, the antenna is rotated 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 kilometers (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, reducing the ability to observe the movement pattern of individual targets. The limits of the range setting used are depicted for each of the survey sites in Figure 2.

2.2 Data Collection

The radar display was connected to computer video recording software. One-minute samples of the radar video display were recorded for data analysis. Depending on the type of sampling (stationary from the ridgelines or mobile in the valleys), different strategies for recording were employed.

During stationary sampling, 15 one-minute horizontal samples and 10 one-minute vertical samples were recorded during each survey hour. The timing and sequence of the horizontal and vertical samples were based on a random selection for each night. The randomly selected sequence was developed for a one-hour increment and was repeated once for each hour, throughout the entire night.

During mobile sampling, fewer samples were collected at each location to maximize both the number of sites that could be sampled each night and the number of times each site was sampled. Sampling at each site typically occurred for approximately 20 to 30 minutes, after which the radar station was driven to the next site. Because the amount of time spent at each site was brief, a sample of five to six video recordings of the radar display were collected in rapid succession during both horizontal and vertical operation. The exact number of samples in each operating mode varied from site-to-site and night-to-night due to differences in accessibility, site configuration, and the number of sites sampled on a given night.

Weather data, including wind speed and direction, temperature, cloud cover/visibility, and precipitation, were also recorded each hour. Some visual observations were also collected during stationary sampling by directing a one-million-candlepower light (commonly called a ceilometer) into the sky and documenting the movement of animals passing through the beam.

2.3 Data Analysis

Video samples were analyzed using a digital video analysis software tool developed by Woodlot. For horizontal samples, which provided passage rate estimates and flight directions, targets were identified as birds and bats rather than insects based on true flight speed. To do this, the speed and direction of targets on the radar screen were corrected using the wind speed and direction collected during the nightly sampling. Targets calculated as traveling faster than 6 m (19.7 ft) per second were identified as a bird or bat target, while targets traveling slower than this were identified as insects (Larkin 1991, Bruderer and Boldt 2001). Insect targets were not enumerated during the analysis of radar video files. Consequently, the percent radar targets attributable to insect contamination could not be calculated.

The software tool recorded the time, location, and flight vector for each target traveling fast enough to be a bird or bat. The results for each sample 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 relative to the radar location. The results for each sample were output to a spreadsheet for the calculation of passage rate, flight direction, and flight height of targets.

Passage rate was calculated for each hour of radar operation. Hourly passage rates (in 1-hour increments post sunset) were calculated for the ridgeline sites by tallying the total number of targets in the 1-minute samples for each hour and correcting for the number of samples collected in that hour. That estimate was then corrected for the radar range setting used in the field by dividing the calculated number of targets per hour by the diameter of the radar display range (2.8 km) and was expressed as targets/km/hour (t/km/hr) ± 1 standard error (SE). The hourly rates were used to calculate passage rates for each night. Nightly mean passage rates were then used to calculate the mean passage rates for the entire season.

Mobile sampling included sampling at each valley site several times throughout the night, rather than one or all sites throughout the entire night. Consequently, hourly passage rates for each hour of the night could not be calculated for each of these sites. Instead, hourly passage rate was calculated for only those hours of the night that were sampled at each site. These hourly samples were then used to calculate the nightly mean passage rate for each site.

Mean target flight directions (± 1 circular standard deviation [SD]) were summarized in a similar manner by hour, night, and for the entire season. Flight direction analysis and statistical analyses were conducted using software designed specifically to analyze directional data (Oriana2© Kovach Computing Services). The statistics used for this are based on Batschelet (1965), which take into account the circular nature of the data. This software also performs a variety of statistical tests on the data sets to test whether the observed flight directions are uniformly distributed (such as the Rao's test for uniformity). Mean wind speed was calculated using linear statistics (i.e., normal means and averages were calculated which did not have to account for circular (directional) data) and the on-site observations made during each hour of radar operation (Zar 1999).

Flight height data were summarized using linear statistics. Mean flight heights (± 1 SE) were calculated by hour, night, and overall season. The percent of targets flying below 100 m (328 ft) and 125 m (410 ft) was also calculated for the two ridgeline sites[2].

Data were summarized for each site and each landscape setting (ridgeline versus valley). Additionally, 'data plots' of the analysis output files from the mobile valley sites were overlain on topographic maps to depict examples of target locations and directions at a variety of locations in the project area within individual nights. Mobile sampling sites were typically 3.2 to 5 km (2 to 3 miles) apart; therefore, these data plots were placed on a single map to depict flight paths of migrants on each night that multiple sites were sampled.

3.0 Results

Radar surveys were conducted on 29 nights during the fall 2005 migration season. Field surveys were postponed prior to most nights of inclement weather to maximize the number of nights that would provide suitable migration data. Ultimately, only 1 of 30 nights targeted for surveys included weather that was too rainy to document adequately nighttime migration. Weather conditions during each night of sampling are provided in Table 1.

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[2] The final selection of turbines has not yet been made. Consequently, for the calculation of the percentage of targets assumed to be flying below the height of the proposed turbines, both 100 m (328 ft) and 125 m (410 ft) were used in the calculation, as these are the approximate maximum heights of most modern wind turbines.

Table 1 Survey dates, level of effort, and weather

Night of	Sunset	Sunrise	Hours of Survey	Weather	Wind Direction	Wind Speed (km/hr)	Temperature (°C)	Barometric Pressure (cm)
Aug 22	19:37	5:51	6	partly cloudy, calm	n/a	0	10	76
Aug 23	19:35	5:53	10	overcast, calm	n/a	0	11	76
Aug 24	19:34	5:54	10	overcast, fog, calm	n/a	0	9	77
Sep 2	19:17	6:05	7	partly cloudy, moderate winds	W	2	16	76
Sep 3	19:15	6:06	11	partly cloudy, rain late, moderate winds	W	2	10	76
Sep 4	19:14	6:07	11	mostly clear, strong winds	W	15	6	77
Sep 5	19:12	6:08	11	clear, light winds	W	2	7	77
Sep 6	19:10	6:09	11	mostly clear moderate gusting winds	W	3	8	77
Sep 7	19:08	6:11	6	clear, moderate winds	W	2	9	77
Sep 14	18:54	6:19	6	mostly clear, light winds, rain late	W	2	14	76
Sep 15	18:52	6:20	12	partly cloudy, light winds	W	2	17	77
Sep 16	18:50	6:21	4	overcast, light winds, rain	E	2	17	76
Sep 19	18:45	6:25	8	partly cloudy, light winds	W	2	12	77
Sep 20	18:43	6:26	12	partly cloudy, strong winds	W	33	17	76
Sep 21	18:41	6:27	7	mostly clear, light winds	W	8	6	76
Sep 24	18:35	6:31	7	mostly clear, fog, moderate winds	SW	8	1	77
Sep 25	18:33	6:32	11	overcast, fog, moderate winds	SW	15	13	76
Sep 27	18:29	6:35	12	mostly clear, moderate winds	NW	24	2	77
Sep 29	18:25	6:37	10	mostly cloudy, strong winds	NW	55	8	76
Sep 30	18:23	6:39	12	clear, light winds	NW to NE	2	2	77
Oct 1	18:21	6:40	12	clear, light winds	NW	2	6	77
Oct 3	18:18	6:42	5	clear and calm	n/a	0	7	77
Oct 4	18:16	6:44	11	clear and calm	n/a	0	10	77
Oct 5	18:14	6:45	11	clear, light winds	S	0	8	77
Oct 6	18:12	6:46	12	partly cloudy, fog, light winds	S	2	12	76
Oct 7	18:10	6:48	4	overcast, rain	n/a	0	17	76
Oct 10	18:05	6:51	9	overcast, fog, light winds	N	2	12	76
Oct 11	18:03	6:53	12	partly cloudy, light winds	N	8	8	77
Oct 12	18:01	6:54	12	partly cloudy, fog, light winds	S, SE	8	4	77

The six different radar survey sites sampled varied with respect to their landscape position and surrounding vegetation. Consequently, the views that the radar had of the surrounding airspace in both horizontal and vertical operation modes varied from site to site. Appendix A provides site descriptions and images of the radar display screen depicting the amount of ground clutter at each site. The coverage from the two ridgeline sites represents approximately one-quarter of the entire proposed development area (Figure 2).

3.1 Passage Rates

Passage rate was variable between sites and among sample periods (Table 2; Figure 5). The highest mean seasonal passage rate for an individual sample site was 565 ± 54 t/km/hr at the Kibby Mountain site. This site also had the highest single-night mean passage rate of 1,107 ± 77 t/km/hr on September 4, 2005. The lowest observed mean seasonal passage rate of all the sites was 201 ± 23 t/km/hr at the Kibby Range site, which also had the lowest single night passage rate of 7 ± 3 t/km/hr on October 3, 2005. The mean seasonal passage rates at the individual mobile sites ranged from 236 ± 51 t/km/hr at Wahl Road to 462 ± 101 t/km/hr at Spencer Bale Road. The mean seasonal passage rate for the mobile site data, when pooled, was 452 ± 77 t/km/hr.

When pooled by landscape position, the mean seasonal passage rate obtained at the ridgeline sites (383 ± 39 t/km/hr) was similar to, though slightly less than, the mean seasonal passage rate at the pooled valley sites (452 ±77 t/km/hr). Appendix B Tables 1 through 4 provide nightly passage rates for each survey site. Passage rates were typically highest on clear nights, with winds from a northerly direction. Proportionally more of these nights occurred while sampling at the Kibby Mountain site than at any other site.

Table 2. Summary of radar survey results for the entire season.

Landscape Position/ Survey Site	Passage Rate (t/km/hr)		Flight Height (m)			Direction (º)
	Range	**Mean**	**Range**	**Mean**	**% below 125 m**	**Mean**
Kibby Mountain	109 – 1,107	565	205 - 472	370	16%	167
Kibby Range	7 - 783	201	134 - 492	352	12%	196
Pooled Ridgeline Sites	**7 – 1,107**	**383**	**134 - 492**	**361**	**14%**	**173**
Kibby Mountain Road	68 - 395	255	432 - 582	481	3%	190
Spencer Bale Road	100 - 995	462	302 - 581	469	1%	185
Wahl Road	52 - 471	236	356 - 610	495	5%	187
Mile 4 Road	107 - 647	451	113 - 203	158	9%	203
Pooled Valley Sites[3]	**52 - 995**	**452**	**113 - 610**	**391**	**4%**	**193**

[3] As noted in Section 2.3, above, the mean nightly passage rates for the mobile sites represents the mean passage rates for the hours that were sampled, rather than the average of the mean hourly passage rate for the entire night.

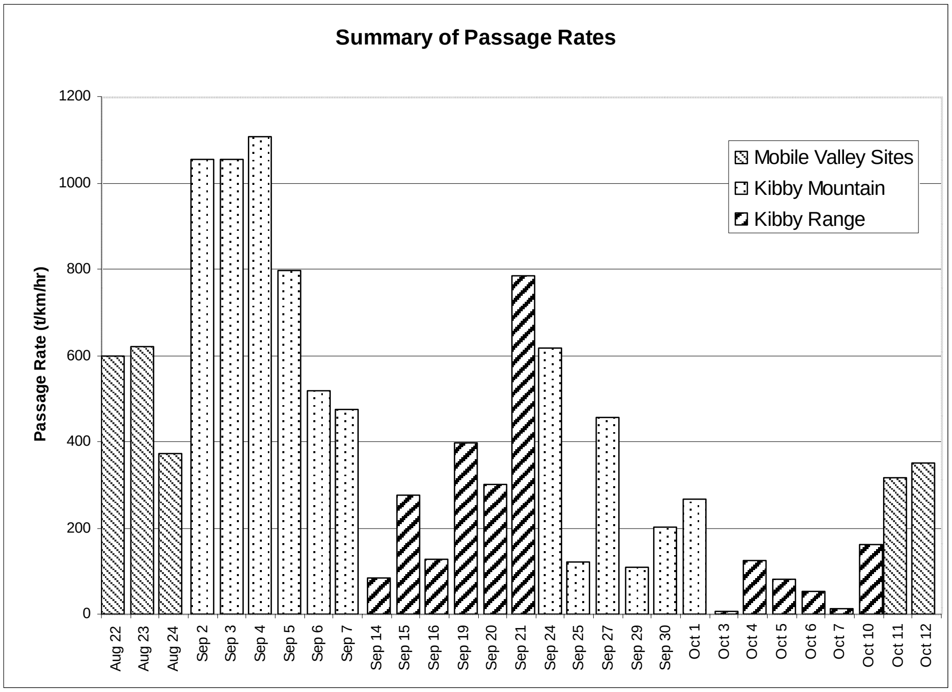


Figure 5 Nightly passage rates observed at the two ridgeline and mobile valley (pooled) sites

At both ridgeline sites, passage rates generally increased rapidly during the first hour after sunset and peaked six to seven hours after sunset (Figure 6). This was usually followed by a rapid decline. At both ridgeline sites, an increase in passage rates was documented near the end of the night, though this was more pronounced at Kibby Mountain.

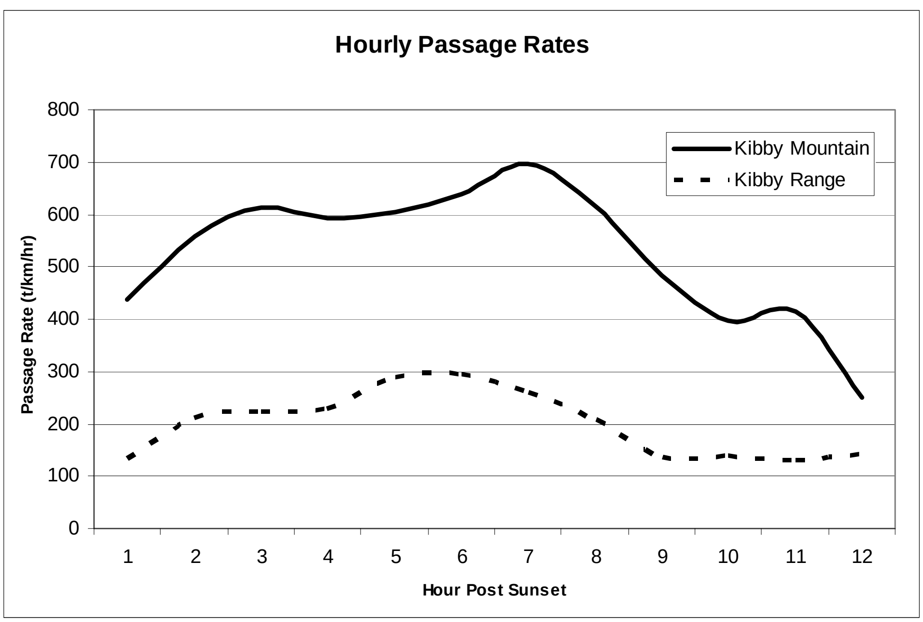


Figure 6 Hourly passage rates at the ridgeline survey sites

3.2 Flight Height

The mean target flight height ranged from 352 m (1,155 ft) above the radar at the Kibby Range site to 370 m (1,214 ft) at the Kibby Mountain site, and 391 m (1,282 ft) for the mobile (pooled data) sites (Appendix B Table 1).[4] Among the mobile sites, the lowest mean flight height was 158 m (518 ft) above the radar at Mile 4 Road. Mean flight heights documented at the other three mobile survey sites were quite similar to one another and were more than twice that observed at Mile 4 Road: from 469 m (1,538 ft) to 495 m (1,624 ft) (Appendix B Table 4).

Nightly flight heights were variable (Figure 7) though variation within individual nights was not as pronounced. No obvious relationship between flight height and weather (cloud cover, precipitation, fog) was observed at any individual survey site; there appeared to be equal variation in flight heights between nights with clear weather or poor weather.

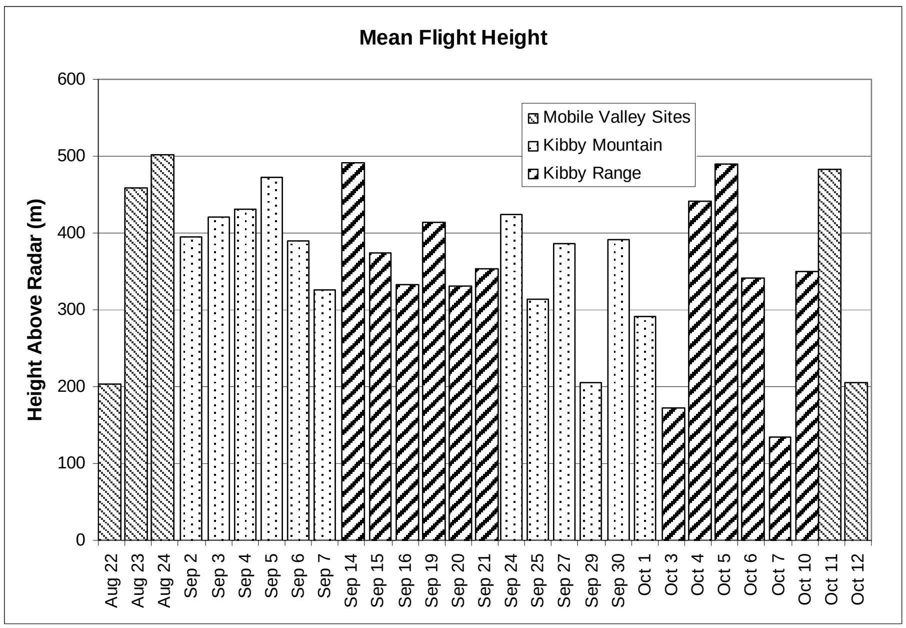


Figure 7 Mean flight heights documented at the ridgeline and mobile valley (pooled data) sites

The percent of targets flying less than 125 m (410 ft) (the approximate height of most modern turbines) above the ridgeline survey sites each night was variable and ranged from 5 to 56 percent at Kibby Mountain (Figure 8; Appendix B Table 5) and 3 to 35 percent at Kibby Range (Figure 8; Appendix B Table 6). The overall mean percent of targets below 125 m (410 ft) was 16 percent at Kibby Mountain and 12 percent at Kibby Range.

At Kibby Mountain, the nights with the largest percentage of targets flying low over the ridgeline were typically associated with nightly passage rates that were well below the seasonal mean passage rate for that site. For example, on the night of September 29, 56 percent of the targets were flying below the potential turbine heights of 125 m (410 ft). The passage rate for that night, however, was the lowest documented at that site (109 ± 28 t/km/hr). The weather on that particular night included partly cloudy skies with strong winds from the northwest, which is generally good fall migration weather for night migrants.

[4] The approximate elevation of each radar site is depicted on Figure 2.

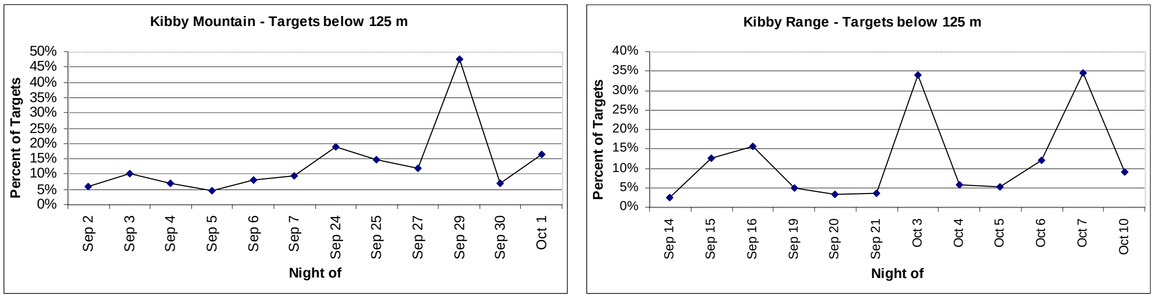


Figure 8 Percent of targets flying below 125 m (maximum height of proposed turbines).

A similar trend was observed at Kibby Range. The two nights with the largest percentage of low-flying targets (October 3 and 7) were the two nights with the lowest passage rates. The weather on these nights varied, with clear calm skies on October 3 and overcast conditions and occasional rain on October 7. Conversely, a night with a small percent of low-flying targets (September 21) was on the night with the highest passage rate and weather that included clear skies with light winds from the west.

Kibby Range and Kibby Mountain both resulted in similar distributions among 100 m flight height zones (Figure 9). At both sites, the highest percent of targets within any 100 m (328 ft) height zone was observed between 200 and 400 m (656 and 1312 ft) (well above typical turbine height). Less than ten percent of the targets at each site were documented flying less than 100 m (328') above the radar elevation.

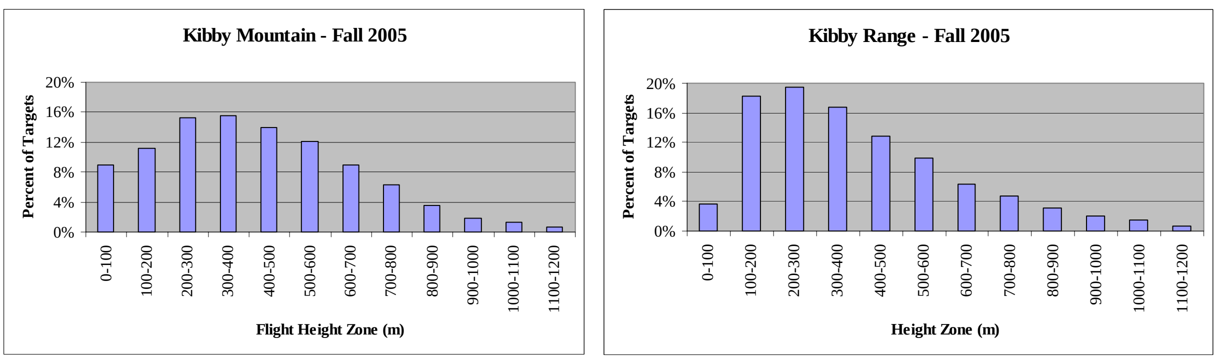


Figure 9 Target flight height distribution within 100 m (328 ft) height zones.

3.3 Flight Direction

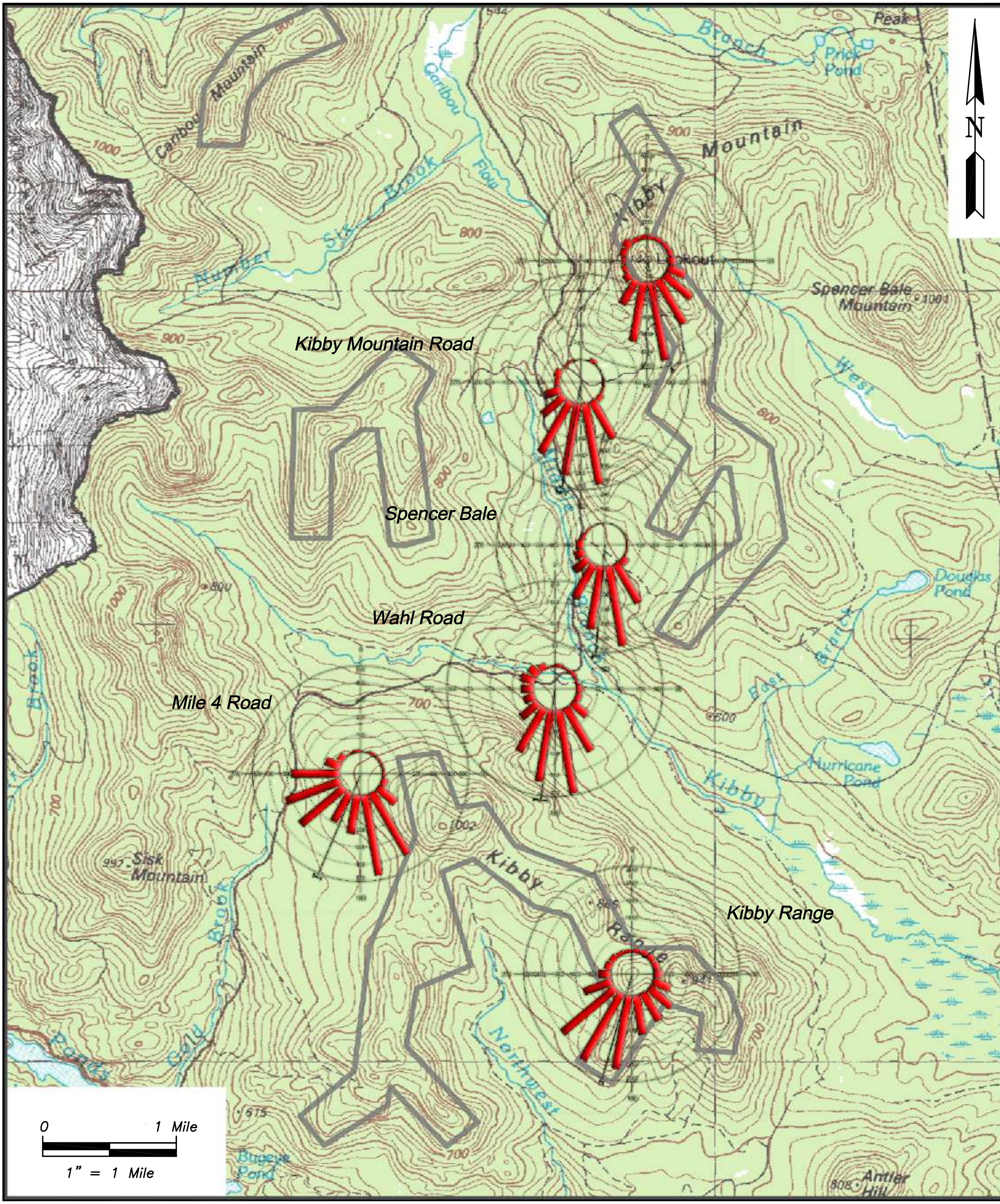
Mean nightly flight directions[5] were similar between the two ridgeline sites (167º at Kibby Mountain and 196º at Kibby Range) and the pooled mobile sites (193º) (Appendix B Table 1). Nightly flight direction histograms for each of the sites sampled are provided in Appendix C and the statistics summaries of the nightly direction data are provided in Appendix D. In general, flight was in a southerly direction across

[5] All flight directions provided are relative to true north.

the entire project area (Figure 10).[6] There was night-to-night variation, particularly at Kibby Range. Overall, the nights with the highest passage rates were associated with flights to the south, while those with lower passage rates sometimes included a majority of flights in directions contrary to typical fall migration patterns. On these latter nights, winds were often moderate to strong and from a southerly direction.

On the nights of mobile sampling, similar flight directions were observed at the four survey sites (Appendix B Table 4). In general, flight direction was oriented southward, down the Kibby Stream valley. On one of the two nights when all four valley sites were sampled (October 11), the Mile 4 Road site included typical flight directions that were more westerly than the other sites, though this was not the case on the following nights, when flight direction among the four sites was more similar. Example plots of radar target vector data are provided in Appendix E. These figures provide a visual depiction of the location where targets were seen at each of the mobile valley sites. Those figures illustrate the variation in the flight direction of targets observed at each site and between sites. Also included are sample plots of radar data from the two ridgeline survey sites.

[6] Note that the flight direction histograms depicted represent the distribution of flight directions documented across the entire radar detection area of the radar at each site and not flight directions of targets flying only directly over the radar location itself.



PREPARED BY:

WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

DATE:	December 2005
SCALE:	1" = 1 Mile
JOB NO. 105112	
FILE: 105112-00-Location.dwg	

Figure 10 - Fall 2005 Target Flight Direction
Kibby Wind Power Project
TransCanada Energy, Ltd.

REV.

3.4 Ceilometer Observations

Ceilometer data were recorded during 118 five-minute periods, for a total of 10 hours of survey time. Those observations, however, resulted in no bird or bat observations.

4.0 Discussion

This study was conducted to characterize night migration activity in the vicinity of the Kibby Wind Power Project. This work expanded upon radar surveys previously conducted at the site in 1994. The original surveys were conducted in May, June, August, September, and October 1994 (ND&T 1995a, b) using a marine surveillance radar nearly identical to the radar used in this study. The previous spring study was conducted on 17 nights at 2 locations; the fall study was conducted on 14 nights from 1 of those 2 locations. The results of those surveys are provided in Table 3 and Figure 11.

Table 3 Summary of spring and fall 1994 radar surveys

Site/Season	Passage Rate*			Flight Direction
	Mean	Min	Max	
Spring 1994	99	n/a	n/a	34° to 53°
Fall 1994	547	48	1,195	200°

* Passage rates were originally reported as total targets. Those results have been converted to t/km/hr, using the range limit used at that time to provide results that are more compatible with more recent studies. Insect data was not removed during data analysis for those surveys.

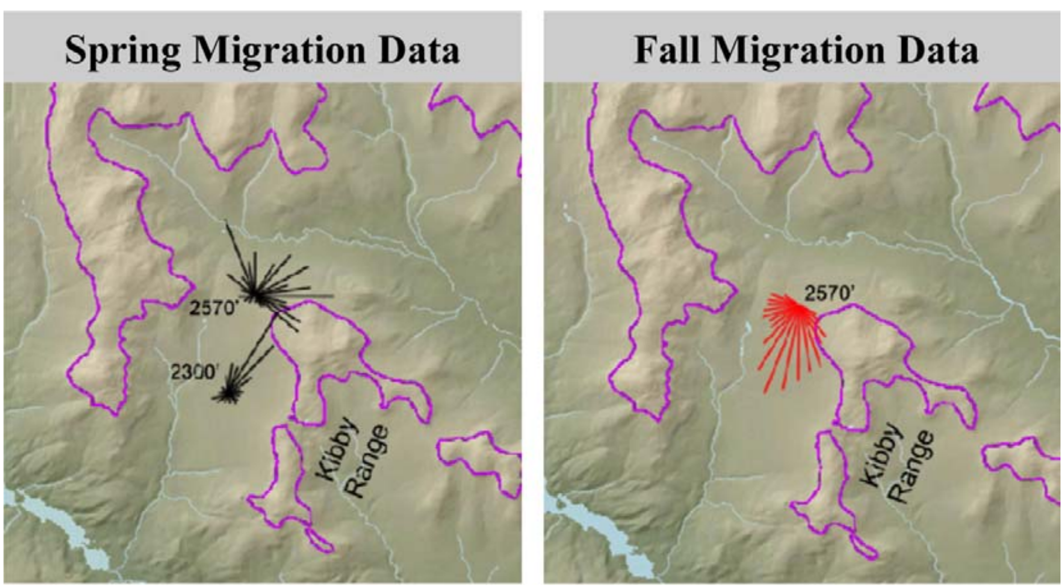


Figure 11 Spring and fall 1994 flight direction histograms of radar data. Numbers represent elevation of the radar sites.

4.1 Passage Rates

Variation in mean nightly passage rate from 109-1,107 t/km/hr at the ridgeline sites and 52-995 t/km/hr at the valley sites was observed during the fall 2005 radar surveys. This is typical of nighttime migration activity, as weather patterns have been shown to be the largest factor affecting the magnitude of bird migration, particularly at inland sites (Able 1970, Richardson 1972). In general, peaks in fall migration occur following the passage of cold fronts and low pressure systems, which create the southerly flow of cool winds and generally clear skies (Richardson 1972). The timing of the peak passage rates during the survey (early and mid-September) coincide with the typical peak migration period of northeastern forest songbirds.

The variable nightly passage rates documented at the Kibby Wind Power Project are consistent with this typical pattern. For example, passage rates were generally higher on clear nights with northerly breezes, which were typically associated with colder temperatures (see Table 1 and Appendix B Table 1 for documented weather and passage rates). Passage rates were variable on cloudy nights and generally low on nights with fog and passing showers, indicative of the role that weather can play on bird migration activity.

Relatively few surveys using the same methods and equipment are available for comparison with the results from the Kibby Wind Power Project (Table 4). As Table 4 indicates, the passage rates documented at the proposed Kibby Wind Power Project (383-452 t/km/hr for the pooled ridgeline and mobile valley sites, respectively) are generally within the range of those other studies.

Table 4 Summary of passage rates from other fall radar studies

Year	Location	Mean Passage Rate (t/km/hr)	Reference
1994	Kibby Township, Maine	547	ND&T 1995a
1994	Copenhagen, NY	121	Cooper *et al*. 1995
1994	Martinsburg, NY	225	Cooper *et al*. 1995
1998	Harrisburg, NY	122	Cooper and Mabee 1999
1998	Wethersfield, NY	168	Cooper and Mabee 1999
2002	Redington, ME	1,472*	MMP 2006
2003	Chautauqua, NY	238	Cooper *et al*. 2004a
2003	Mt. Storm, WV	241	Cooper *et al*. 2004b
2004	Prattsburgh, NY	200	Mabee *et al*. 2005
2005	Kibby Township, Maine	383	this report

* includes insect data

4.2 Flight Height

The altitude at which nocturnal migrants fly has been one of the least understood aspects of bird migration. Bellrose (1971) flew a small plane at night along altitudinal transects to document visually the occurrence and altitude of migrating songbirds. He found the majority of birds observed were between 150 and 450 m (492 and 1,475 ft) above the ground level but on some nights the majority of birds observed were from 450 to 762 m (1,475 to 2,500 ft) above the ground. Radar studies have largely confirmed those visual observations, with the majority of nocturnal bird migration appearing to occur less than 500 m to 700 m (1,640 ft to 2,300 ft) above the ground (Able 1970, Alerstam 1990, Gauthreaux 1991, Cooper and Ritchie 1995).

Recent studies at other proposed wind facilities in the Northeast and Mid-Atlantic states are consistent with this as well. In western New York, Cooper *et al*. (2004a) documented a mean flight altitude of 532 m (1,745 ft) with a small percentage (4%) of targets flying less 125 m above the ground. At Mount Storm, West Virginia, Cooper *et al.* (2004b) documented a mean flight height of 421 m (1,381 ft) above a high Appalachian ridgeline.

The mean flight heights documented at the Kibby Wind Power Project site are slightly lower than those at other survey sites. The terrain of the project area is varied and large differences in elevation occur between the valley bottoms and ridge tops. The overall mean flight height at the different landscape settings in the project area (ridgeline versus valley) were similar (Table 2). More variation in mean flight height occurred between one of the valley sites (Mile 4 Road) and the other three valley sites.

An explanation for this difference may be the general landscape configuration along the valley and the location of the survey sites. The northern two valley sites are along the side slope of the Kibby Stream valley. The Wahl Road site is located slightly lower than these two sites, at the foot of the east-to-west aligned northern slope of Kibby Range (see Figure 2). The slopes south of the Wahl Road site increase rapidly over a short distance. The Mile 4 Road site is located on that slope and approximately 250 m (820 ft) in elevation above the Wahl Road site. It is likely that the migrants documented at these sites are flying within the project area valleys and their height above the ground decreases rapidly as they fly from the vicinity of the Wahl Road site to the vicinity of the Mile 4 Road site.

Data collected at the valley sites provide evidence that some migrants fly within the confines of the valleys, as the mean flight height of targets documented by the valley sites was below the ridge elevations. However, data from the ridgelines indicate that many migrants also fly well above the ridges of the project area.

4.3 Flight Direction

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 *et al*. 1982; Bruderer and Jenni 1990; Richardson 1998; Fortin *et al.* 1999; Williams *et al.* 2001; Diehl *et al*. 2003).

Published research supports the idea that some night migrants may be affected by topography. Bingman *et al*. (1982) found that the Hudson River acted as a visual cue to direct movement of low-flying nocturnal migrants. At Hawk Mountain, Pennsylvania, Sielman *et al.* (1981) found that birds on the upwind side of a ridge were moving along the ridge, birds at the crest were moving along and over it, and few birds were observed at low altitude on the downwind side of the ridge. Another study, in the Franconia Notch area of New Hampshire, used ceilometers, a small marine surveillance radar, and daytime observations to study the flight patterns of migrating birds (Williams *et al*. 2001). They found that birds observed north of the Franconia Range tended to fly southwesterly, parallel to the northern face of the range, while those observed flying over the mountain tops were flying in a southerly direction. Additionally, one survey point within a pass in the mountain range documented birds moving south-southeastward, down the pass, while those documented at points outside the pass continued southwest, parallel to the range.

The studies conducted in the study area in 1994 also suggested that night migrants may be affected by topography. That study, along with the two referenced above, did not document the flight height of the targets that were observed during the studies. In areas of varied topography, flight height would be the most important factor affecting the movement of migrants; flight direction would be the most obvious visual clue that topographic-related effects are occurring. Essentially, when migrants fly below the elevation of a ridgeline and are disinclined to gain altitude to cross the ridge, flight direction would be expected to be parallel to the ridge rather than perpendicular to it. It is interesting to note that sampling in 2005, near the site where the 1994 surveys were conducted, showed that targets were flying well below the elevation of the surrounding ridgelines (the mean target flight height of 158 m (518') above the radar is still below the elevation of the adjacent ridgeline, which is approximately 300 m (1,000') above the radar site). Flight directions in this area varied but indicated some form of valley-following, rather than ridge-crossing, movement.

Consequently, the valley sampling corroborates conclusions drawn from the 1994 data: that night migrants in the project area can be affected by the topography of the area. However, the 2005 sampling indicates that this is true only for some of the migrants in the vicinity of the project area. The flight directions documented at the ridgeline sites shows that night migrants at higher altitudes move in directions parallel with and perpendicular to the high ridgelines of the project area. This, combined with the documented flight heights of those targets, indicates that some of the migrants fly well above the varied topography.

5.0 Conclusions

Radar surveys conducted during the fall 2005 migration period have provided important information on nocturnal bird migration patterns at the Kibby Wind Power Project site. The results of the surveys indicate that bird migration patterns in the area are complex, which is likely attributable to the varied topography. Where other studies have demonstrated broad-front movement of night migrants over flat and rolling topography, results of this study indicate that some migrants are following valleys and flying below the project area ridgelines while others are flying at heights well above those same ridgelines.

The variable passage rates documented at each survey site and at different landscape positions is typical of pulsed migration activity associated with weather systems and not necessarily due to the concentration of migrants in any one specific area. No pattern in the flight characteristics at the ridgeline sites was observed and migrants were observed throughout the radar display screen at each site. Movements were generally to the south, though this varied by night. The flight directions observed documented migrants moving both parallel and perpendicular to the ridgelines, indicating that the ridges themselves were not obstacles to their movement. Additionally, the high mean flight altitude of migrants over the ridgelines indicates that the ridges generally do not impede their movements.

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Appendix A

Radar Survey Site Descriptions

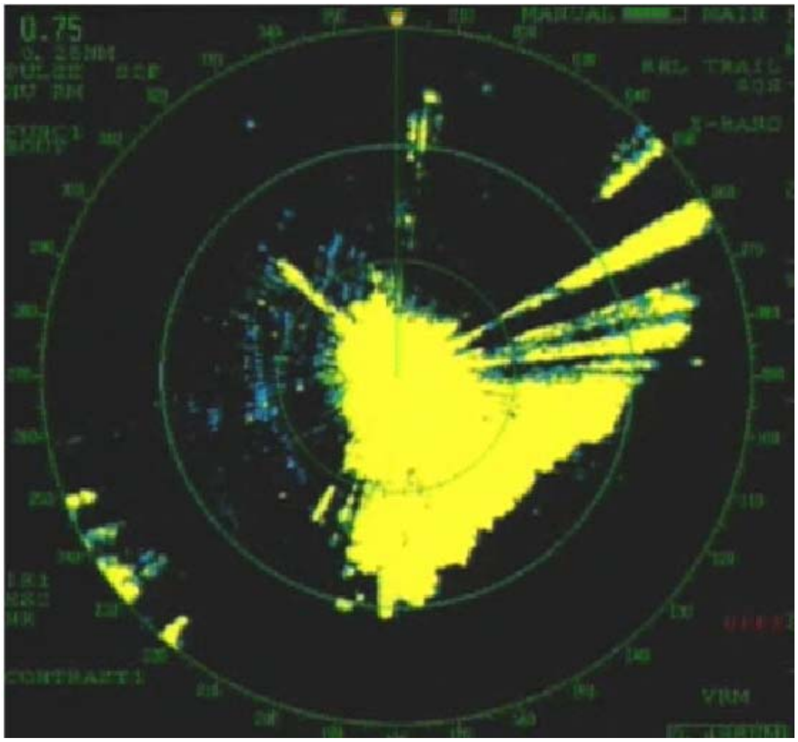
Key to Radar Survey Site Descriptions

Following are site descriptions for each of the six radar sites used during the fall 2005 survey. Provided in each description is a picture of the radar screen, followed by a description of the site location and radar visibility while in horizontal and vertical modes of operation.

The radar screen pictures show the ground clutter that was observed at each site. Ground clutter is yellow and may be very limited to the center of the screen or may be widespread across the screen, depending on the complexity of the vegetation and landscape at each site. Figure 4 of the report, above, provides an example of how nearby vegetation was used to try to mask out large areas of ground clutter and should be referred to when interpreting the site descriptions, below.

All radar sites were established with true north oriented to the top of the radar screen. The exception to this was Kibby Mountain (because of the use of the existing lookout tower structure at that site). At this site, the radar antenna was oriented northwest. Consequently, on the radar screen picture for that site the top of the screen is oriented northwest and true north occurs approximately 40º (clockwise) from this.

Kibby Mountain Road – Mobile Site

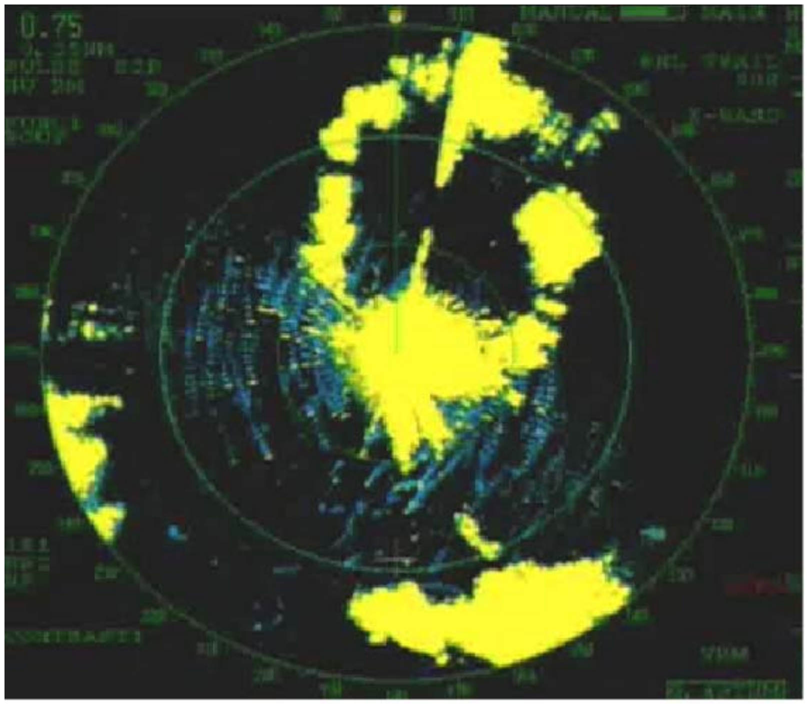


The Kibby Mountain Road mobile radar site was located in a clearcut on the edge of the road approximately 200 m beyond the Kibby Mountain access trail. The clearcut appeared to be approximately 5 years old, based on softwood regeneration. Some small mixed stands of mature trees were also within the cut and acted as ground clutter screens to the west and northwest while still providing clear views of targets flying above those areas.

During horizontal operation the open slope of the ridgeline to the southeast, which was included in the area of recent harvesting, was visible to the radar and caused ground clutter. Gaps in the tree line to the east and northeast provided radar views up the slope in those directions, causing the streaks of ground clutter in the above picture. Clear views to the north, west, and southwest were provided over the low trees in those directions at this site.

With the radar beam extending in an east-west alignment in vertical mode the western slope of the ridgeline to the east was detected. This slope was rather gradual, however, and had little impact on detecting target flight heights over that slope.

Spencer Bale Road – Mobile Site

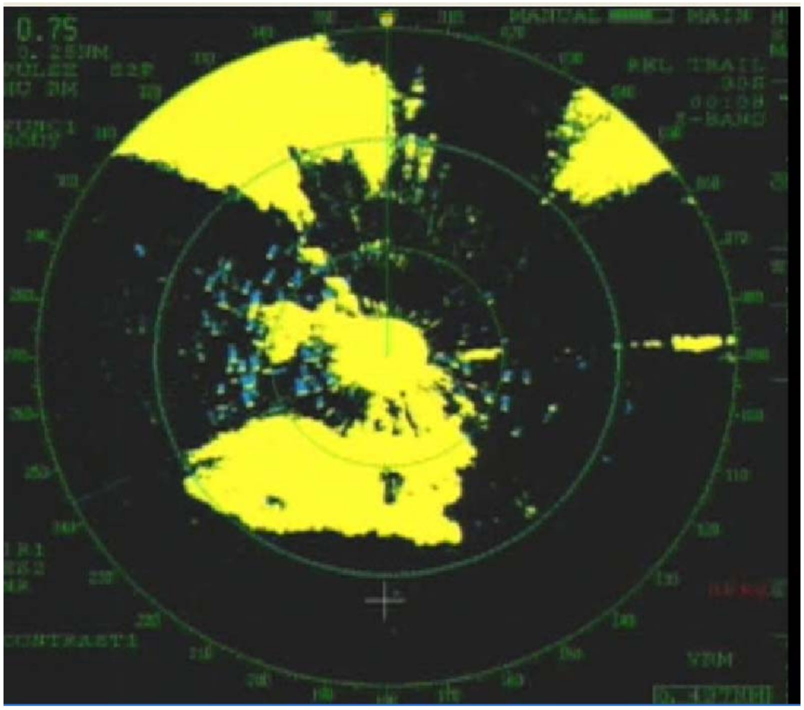


This survey site was located on a small spur road that extends off of Spencer Bale Road. The radar site was located within a large clearcut approximately 12 years old. Tree height surrounding the radar was uniform and provided a relatively level canopy nearly equal in elevation to the radar antenna. One small grove of more mature trees occurred approximately 200 m north of the site.

During horizontal operation the surrounding topography created some areas of ground clutter. Parts of a ridgeline extending down from the Kibby Mountain ridge were visible to the north. The crest of another ridge to the northeast of the site, which is included within the one of the potential turbine development areas, was also visible as a fairly small area of ground clutter. The very southern end of the Kibby Mountain project area was visible southeast of the site, near the outer edge of the radar range setting and a small part of one hillside west of Kibby Stream was visible at the western edge of the radar screen. Clear views over Kibby Stream to the west and over the clearcut areas to the southeast were available at this site.

While in vertical mode, a clear view of the airspace over Kibby Stream was available. The ridgeline to the east created a gradual slope detected by the radar. Due to the nearly level height of the surrounding regeneration with the antenna, that ridge did not cause ground clutter until approximately 0.75 km away from the radar and targets were visible passing over that slope.

Wahl Road – Mobile Site

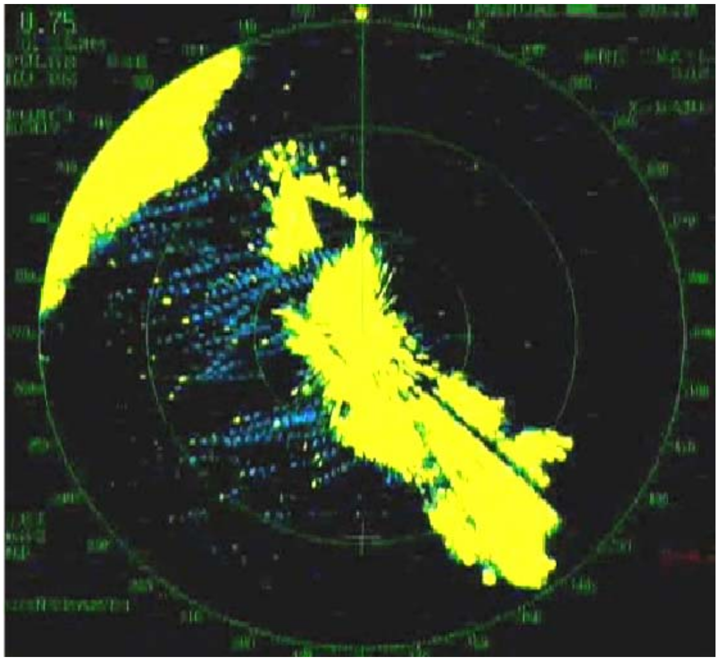


The Wahl Road mobile radar site was located at the junction of three valleys. It was located approximately 50 m down Wahl Road (also called Kibby Stream Road), off of Beaudry Road. The difficulty at this site was in its presence at the base of several different slopes and some relatively tall trees in the area. Although the radar was placed so that surrounding vegetation did not impair the radar's ability to see targets in the area, the high elevations to the north and south did.

During horizontal operation, the steep slopes on either side of Beaudry Road were detected and created areas of ground clutter. The northern slope of Kibby Range created a large area of ground clutter immediately south of the radar that extended upward, through the full radar beam. Consequently, the airspace south of that ground clutter was not surveyed by the radar. North of Beaudry Road, a steep slope created clutter, as did the slope just southwest of the Kibby Mountain project area that was visible at the northeast edge of the radar screen. The clear view to the west was approximately 70 degrees wide, while the view to the north and east was clear.

In vertical operation, the radar antenna was again positioned east to west. A clear view nearly to the horizontal was observed without any ground clutter disturbance because of the Kibby Stream valley.

Mile 4 Road – Mobile Site

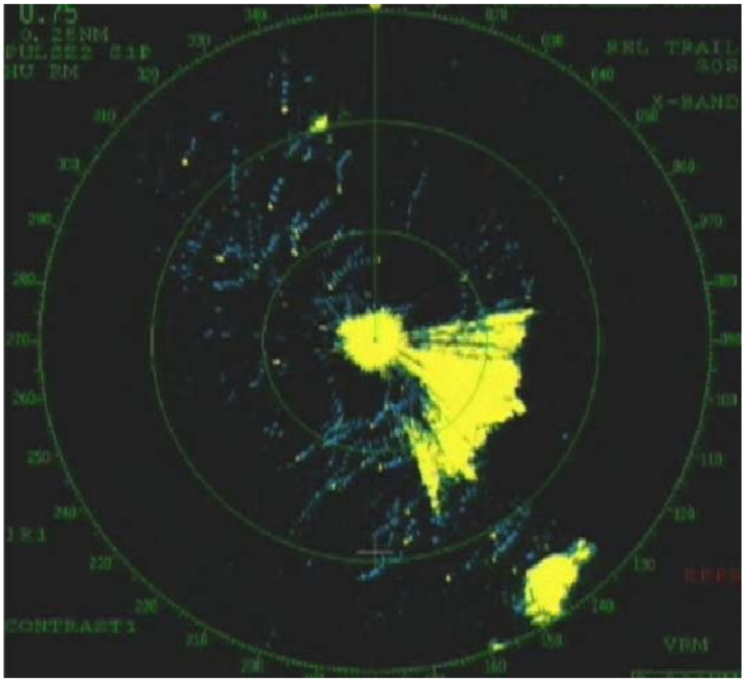


The Mile 4 Road mobile radar site was located within a large, approximately 15-year old clearcut. Tree height was uniform throughout the cut. Since tree height was optimal, vegetation did not impact the radar's ability to see the surrounding airspace. However, the slope to the east did impair the radar detection area.

During horizontal operation the surrounding topography ground clutter to the northwest of the radar was caused by a steep slope west of Beaudry Road that eventually leads to the northern end of Sisk Mountain. To the east and southeast, the slope of Kibby Range rose just enough to increase the canopy height of the regeneration and limit the view of the radar. To the northeast and east-northeast, the radar did still detect targets but they were limited to higher flying targets. The slope was steep enough to the east and southeast to eliminate the detection of targets in those directions.

With the radar in vertical mode, the targets were visible east and west of the radar. The view to the west was downward, over Gold Brook. To the west, the tree canopy did raise the view to approximately 6 degrees above the horizontal. Beyond this, however, the slope of Kibby Range was only detected at a distance of approximately 1 km.

Kibby Range – Stationary Site

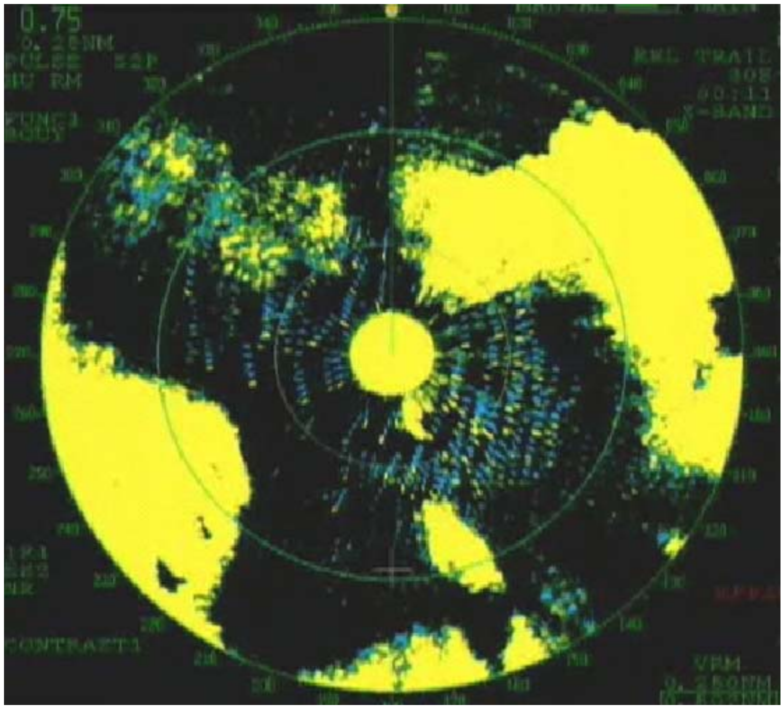


Kibby Range, a stationary radar site, was located within a small opening created around 1994 intended for a meteorological measurement tower. Trees in this area were generally low, as is common in areas along high ridges in western Maine. However, the trees were high enough to limit the view of the radar, so a temporary 6-m (20-ft) tower for the radar antenna was constructed to raise it to near-canopy height and the front edge of the antenna was inclined approximately 5 degrees to maximize the airspace sampled by the radar.

During horizontal operation, the surrounding tree line created a mask for ground clutter, limiting the clutter to the center of the radar screen. A small, triangular area of ground clutter occurred to the southeast and was caused by the radar's view of the forest canopy leading to the adjacent peak (941 m, or 3,086 ft) in that direction. Another small area of ground clutter caused by a slope further to the southeast was detected. A third, very small area of ground clutter was also present north-northeast of the radar and was caused by a small prominence on the Kibby Range ridgeline. This area is marked on USGS topographic maps as being at an elevation of 866 m (2,841 ft).

In vertical mode, the radar had a clear view of the airspace above the radar and to the east and west. In both directions, the view was to just below the horizontal, as some targets at this site were observed flying below the height of the radar.

Kibby Mountain – Stationary Site



The Kibby Mountain radar site was positioned on top of the existing lookout tower at an elevation of 1,114 m (3,654 ft). Tree height at the top of this mountain did not significantly block the view that the radar had of the surrounding airspace. The radar antenna was above tree level, allowing the radar to see down onto the surrounding valleys and ridgelines, which caused ground clutter. Because of the alignment of the lookout tower used for the antenna placement, the radar was not oriented to the north as it was at the other survey sites. Instead, it was oriented approximately 40 degrees west of north. The directional data from the radar was corrected to account for this, but the illustration above was not (i.e., north is oriented at approximately 40º, clockwise, from the center of the image).

During horizontal operation, the radar detected the high ridgeline of Kibby Mountain that extends northward from the peak and eventually curves eastward. Also detected was a low, rounded ridge to the south-southwest of the radar (lower left on the image above), the top of the sharp ridge extending southeast from the radar (the two small to medium concentrated areas of clutter below the center of the image), and the lower portions of the project area further southward. The trees west of the radar were so low that inconsistent views down the western slope of the mountain occurred. These views manifested as faint ground clutter depicted by the diffuse echoes above and to the left of the center of the radar screen.

In vertical mode, this clear, high, open radar site provided excellent views down into the valleys to the northeast and southwest of the radar (as indicated above, the antenna was pointed to the northwest). In fact, many targets at this site were observed flying below the height of the radar, indicating that the radar was able to see down into the valleys.

Appendix B

Radar Survey Data Tables

Appendix B Table 1. Summary of radar surveys conducted at the Kibby Wind Power Project by night and by site - Fall 2005.

Night Of	Passage Rate (t/km/hr)			Flight Height (m)			% of Targets < 125 m	Flight Direction (compass degrees)		
	Kibby Mountain	Kibby Range	Mobile	Kibby Mountain	Kibby Range	Mobile	*	Kibby Mountain	Kibby Range	Mobile
22-Aug	--	--	599 ± 24	--	--	203 ± 15	10%	--	--	177 ± 43
23-Aug	--	--	620 ± 136	--	--	459 ± 30	3%	--	--	178 ± 34
24-Aug	--	--	372 ± 89	--	--	501 ± 41	2%	--	--	179 ± 34
2-Sep	1054 ± 67	--	--	394 ± 16	--	--	8%	144 ± 37	--	--
3-Sep	1054 ± 56	--	--	421 ± 16	--	--	12%	175 ± 27	--	--
4-Sep	1107 ± 77	--	--	431 ± 21	--	--	9%	182 ± 20	--	--
5-Sep	797 ± 119	--	--	472 ± 11	--	--	5%	204 ± 68	--	--
6-Sep	518 ± 27	--	--	390 ± 17	--	--	10%	114 ± 55	--	--
7-Sep	475 ± 51	--	--	326 ± 5	--	--	13%	135 ± 47	--	--
14-Sep	--	83 ± 16	--	--	492 ± 35	--	3%	--	59 ± 71	--
15-Sep	--	277 ± 41	--	--	374 ± 22	--	13%	--	224 ± 25	--
16-Sep	--	127 ± 26	--	--	333 ± 29	--	16%	--	301 ± 33	--
19-Sep	--	398 ± 25	--	--	414 ± 14	--	5%	--	192 ± 53	--
20-Sep	--	299 ± 26	--	--	331 ± 9	--	3%	--	136 ± 30	--
21-Sep	--	783 ± 67	--	--	354 ± 13	--	4%	--	192 ± 27	--
24-Sep	618 ± 65	--	--	425 ± 29	--	--	21%	283 ± 71	--	--
25-Sep	122 ± 18	--	--	313 ± 19	--	--	21%	71 ± 36	--	--
27-Sep	457 ± 80	--	--	386 ± 13	--	--	15%	173 ± 25	--	--
29-Sep	109 ± 28	--	--	205 ± 38	--	--	56%	152 ± 33	--	--
30-Sep	200 ± 35	--	--	391 ± 64	--	--	3%	157 ± 49	--	--
1-Oct	267 ± 23	--	--	291 ± 11	--	--	22%	139 ± 27	--	--
3-Oct	--	7 ± 3	--	--	173 ± 20	--	34%	--	255 ± 33	--
4-Oct	--	126 ± 12	--	--	442 ± 24	--	6%	--	216 ± 43	--
5-Oct	--	80 ± 15	--	--	490 ± 34	--	5%	--	222 ± 55	--
6-Oct	--	53 ± 8	--	--	341 ± 32	--	12%	--	304 ± 91	--
7-Oct	--	12 ± 1	--	--	134 ± 44	--	35%	--	109 ± 68	--
10-Oct	--	161 ± 38	--	--	350 ± 32	--	9%	--	240 ± 63	--
11-Oct	--	--	316 ± 64	--	--	483 ± 34	1%	--	--	229 ± 37
12-Oct	--	--	351 ± 70	--	--	310 ± 52	8%	--	--	268 ± 34
Entire Season	565 ± 54	201 ± 23	452 ± 77	370 ± 22	352 ± 26	391 ± 34	13%	167 ± 53	196 ± 56	193 ± 47

* The average percent of targets observed flying below 125 m (approximate maximum height of proposed turbines) is presented for each night based on the corresponding site surveyed.

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

Night of	Passage Rate (targets/km/hr) by hour after sunset												Entire Night	
	1	2	3	4	5	6	7	8	9	10	11	12	Mean	SE
Sep 2	884	854	1315	1259	1086	975	1007	--	--	--	--	--	1054	67
Sep 3	826	994	884	1013	917	1000	1329	1432	1184	1013	1007	--	1054	56
Sep 4	377	1156	1122	1098	1101	1143	1361	1279	1203	1219	1116	--	1107	77
Sep 5	764	1295	1348	884	973	861	991	912	339	175	228	--	797	119
Sep 6	453	431	526	718	543	603	551	546	456	411	459	--	518	27
Sep 7	298	502	423	440	674	510	--	--	--	--	--	--	475	51
Sep 24	645	443	489	431	652	867	798	--	--	--	--	--	618	65
Sep 25	134	67	71	31	51	194	171	195	190	136	102	--	122	18
Sep 27	86	411	485	432	554	787	891	796	554	246	110	129	457	80
Sep 29	--	--	86	64	74	220	241	226	100	14	64	4	109	28
Sep 30	379	300	350	263	115	122	148	106	89	67	98	364	200	35
Oct 1	321	191	267	309	360	377	300	256	279	294	206	257	267	23
Entire Season	470	604	614	579	592	638	708	639	488	397	377	188	565	54

-- indicates no data for that hour

Appendix B Table 3. Summary of passage rates by hour, night, and for entire season for Kibby Range.

Night of	**Passage Rate (targets/km/hr) by hour after sunset**												**Entire Night**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Mean**	**SE**
Sep 14	64	59	60	70	--	137	107	--	--	--	--	--	83	16
Sep 15	21	305	376	376	356	407	448	370	276	200	77	117	277	41
Sep 16	179	129	144	55	--	--	--	--	--	--	--	--	127	26
Sep 19	421	484	362	304	400	505	372	332	--	--	--	--	398	25
Sep 20	159	289	347	352	334	473	429	271	245	223	230	240	299	26
Sep 21	624	948	905	933	907	603	563	--	--	--	--	--	783	67
Oct 3	6	18	3	6	4	--	--	--	--	--	--	--	7	3
Oct 4	43	101	121	173	165	130	117	116	98	122	194	--	126	12
Oct 5	6	40	52	61	58	56	70	--	157	109	116	161	80	15
Oct 6	16	70	57	120	64	63	30	68	37	41	29	45	53	8
Oct 7	14	11	12	13	--	--	--	--	--	--	--	--	12	1
Oct 10	38	81	216	261	314	264	191	84	0	--	--	--	161	38
Entire Season	133	211	221	227	289	293	259	207	135	139	129	141	201	23

-- indicates no data for that hour

Appendix B Table 4. Summary of flight patterns observed at mobile sampling sites by night.

Passage Rate (targets/kilometer/hour)				
Night of	**Kibby Mtn Road**	**Spencer Bale Road**	**Wahl Road**	**Mile 4 Road**
Aug 22	--	--	--	599 ± 24
Aug 23	395 ± 99	995 ± 202	471 ± 108	--
Aug 24	238 ± 67	513 ± 126	364 ± 75	--
Oct 11	320 ± 72	241 ± 53	56 ± 9	647 ± 122
Oct 12	68 ± 16	100 ± 23	52 ± 11	107 ± 40
Entire Season	***255 ± 64***	***462 ± 101***	***236 ± 51***	***451 ± 62***
Flight Height (in meters)				
Night of	**Kibby Mtn Road**	**Spencer Bale Road**	**Wahl Road**	**Mile 4 Road**
Aug 22	--	--	--	203 ± 15
Aug 23	432 ± 46	474 ± 28	468 ± 15	--
Aug 24	440 ± 54	519 ± 39	544 ± 31	--
Oct 11	582 ± 20	581 ± 17	610 ± 41	157 ± 59
Oct 12	470 ± 120	302 ± 22	356 ± 32	113 ± 35
Entire Season	***481 ± 60***	***469 ± 27***	***495 ± 30***	***158 ± 36***
Flight Direction (compass degrees)				
Night of	**Kibby Mtn Road**	**Spencer Bale Road**	**Wahl Road**	**Mile 4 Road**
Aug 22	--	--	--	177 ± 43
Aug 23	176 ± 39	176 ± 27	183 ± 44	--
Aug 24	165 ± 28	184 ± 32	176 ± 39	--
Oct 11	203 ± 21	206 ± 35	197 ± 61	253 ± 21
Oct 12	249 ± 36	264 ± 27	292 ± 34	270 ± 32
Entire Season	***190 ± 38***	***185 ± 35***	***187 ± 52***	***203 ± 54***

Appendix B Table 5. Summary of mean flight heights by hour, night, and for entire season for Kibby Mountain.

Night of	Mean Flight Height (altitude in meters) by hour after sunset												Entire Night		% of targets < 100 m	% of targets < 125 m
	1	2	3	4	5	6	7	8	9	10	11	12	Mean	SE		
Sep 2	--	338	363	389	441	419	415	--	--	--	--	--	394	16	6%	8%
Sep 3	417	496	464	446	435	367	359	355	368	441	486	--	421	16	10%	12%
Sep 4	--	281	390	411	479	501	491	450	448	467	395	--	431	21	7%	9%
Sep 5	438	441	452	436	446	461	463	502	525	530	493	--	472	11	5%	5%
Sep 6	242	352	403	362	405	374	383	393	434	449	491	--	390	19	8%	10%
Sep 7	321	343	305	336	321	331	--	--	--	--	--	--	326	5	9%	13%
Sep 24	363	527	473	475	456	354	328	--	--	--	--	--	425	29	19%	21%
Sep 25	249	282	409	413	368	253	289	250	303	279	344	--	313	19	15%	21%
Sep 27	--	450	383	403	389	453	388	365	336	375	397	312	386	13	12%	15%
Sep 29	--	--	--	299	204	241	145	155	431	183	165	19	205	38	48%	56%
Sep 30	--	714	590	614	580	485	315	176	251	120	283	169	391	64	7%	3%
Oct 1	--	236	296	295	277	325	320	360	304	244	276	264	291	11	17%	22%
Entire Season	338	405	412	407	400	380	354	334	378	343	370	191	370	22	13%	16%

-- indicates no data for that hour

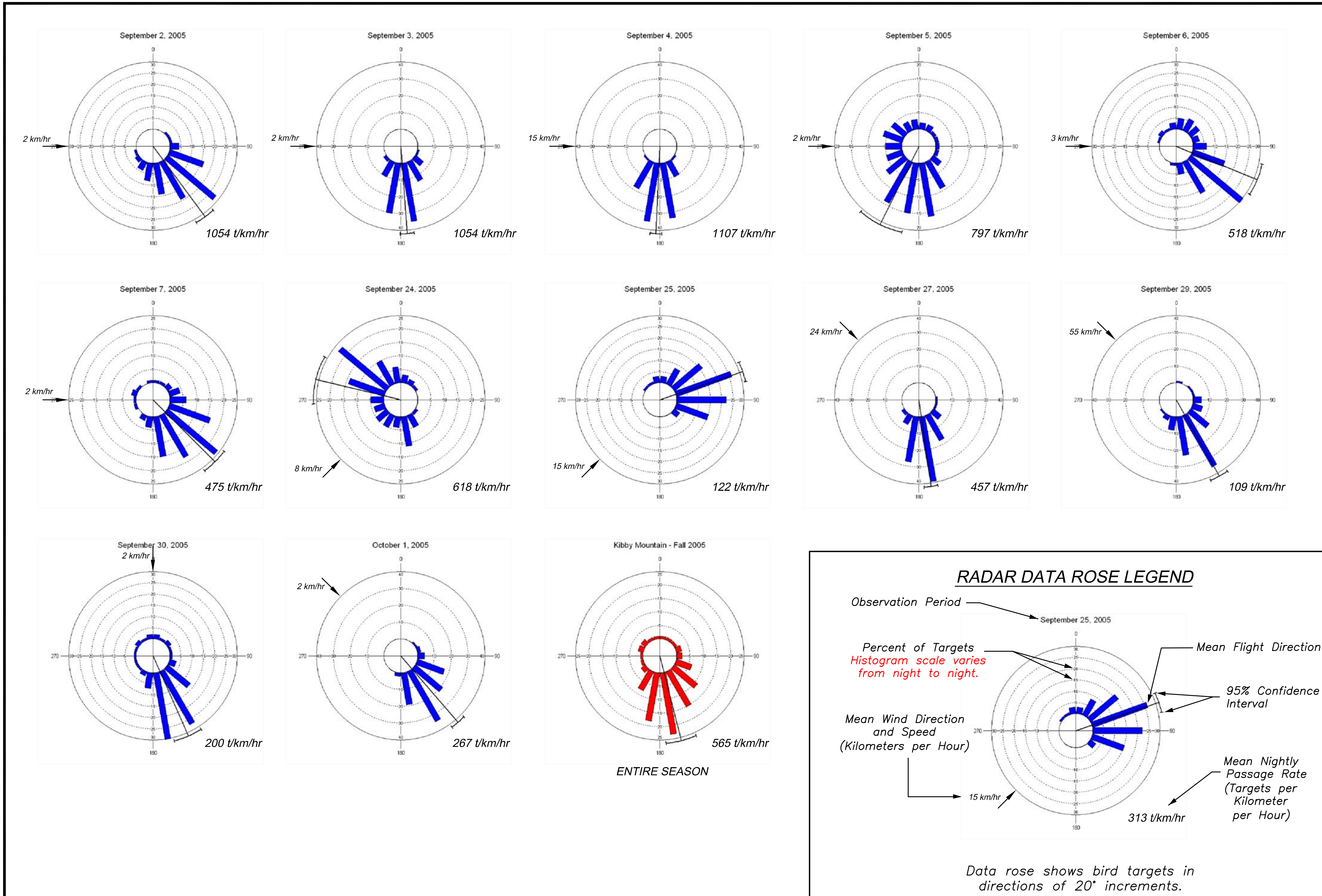
Appendix B Table 6. Summary of mean flight heights by hour, night, and for entire season for Kibby Range.

Night of	Mean Flight Height (altitude in meters) by hour after sunset												Entire Night		% of targets < 100 m	% of targets < 125 m
	1	2	3	4	5	6	7	8	9	10	11	12	Mean	SE		
Sep 14	--	515	577	503	576	--	392	388	--	--	--	--	492	35	2%	3%
Sep 15	346	456	478	421	340	265	303	361	319	468	353	--	374	22	7%	13%
Sep 16	266	305	363	398	--	--	--	--	--	--	--	--	333	29	9%	16%
Sep 19	--	398	403	415	386	497	407	394	--	--	--	--	414	14	3%	5%
Sep 20	334	345	324	321	340	353	347	336	357	350	325	236	331	9	1%	3%
Sep 21	339	426	351	314	351	352	348	--	--	--	--	--	354	13	1%	4%
Oct 3	--	--	--	169	110	226	188	--	--	--	--	--	173	20	27%	34%
Oct 4	370	520	544	452	510	468	497	498	427	410	357	251	442	24	3%	6%
Oct 5	310	432	478	599	641	618	626	534	503	438	382	315	490	34	2%	5%
Oct 6	36	256	469	389	430	363	351	384	410	339	327	335	341	32	7%	12%
Oct 7	249	137	37	113	--	--	--	--	--	--	--	--	134	44	31%	35%
Oct 10	172	269	365	327	413	409	395	446	--	--	--	--	350	32	5%	9%
Entire Season	269	369	399	368	410	395	385	418	403	401	349	284	352	26	8%	12%

-- indicates no data for that hour

Appendix C

Nightly Flight Direction Histograms



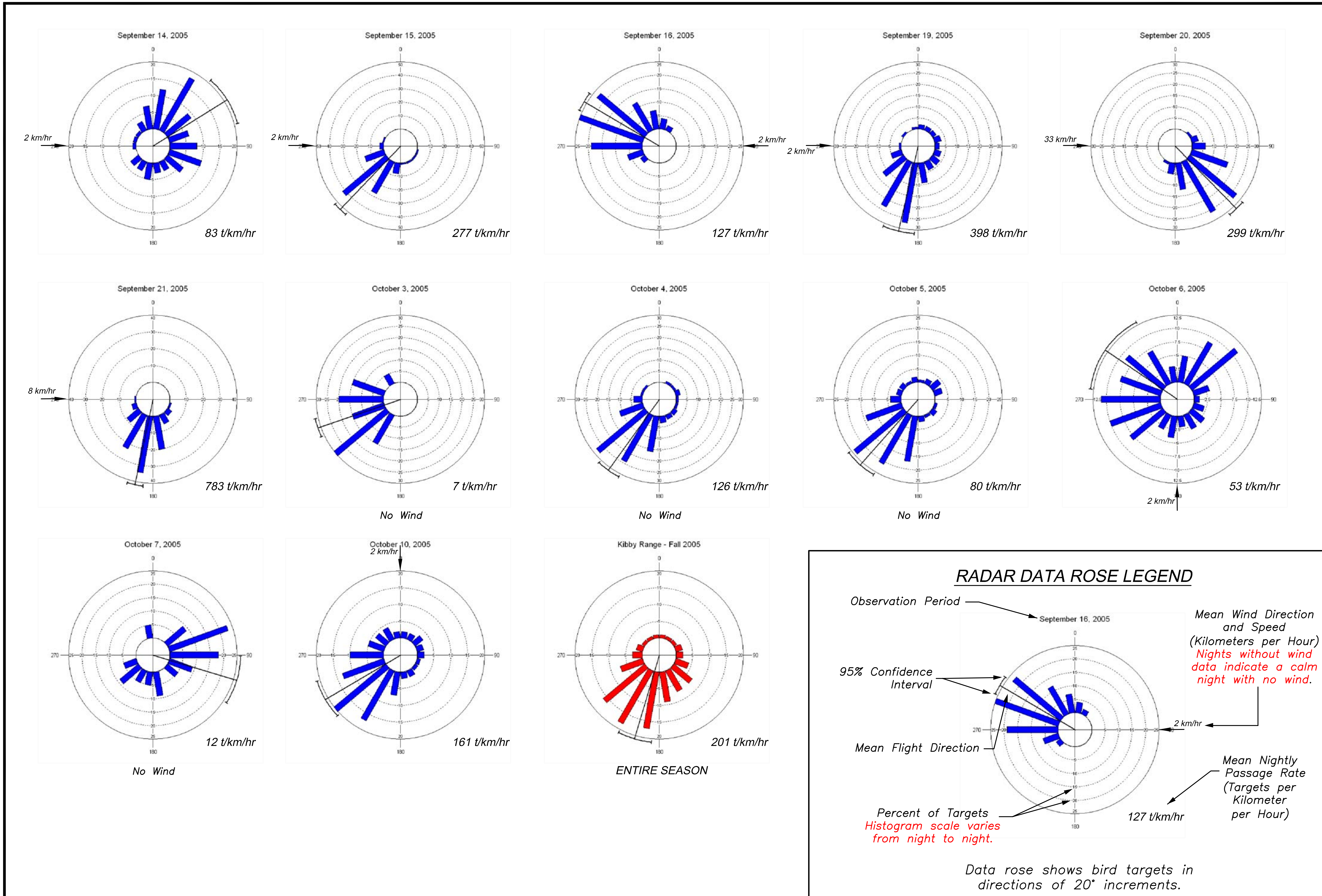
NO. | REVISIONS | DATE

SHEET TITLE:
Appendix C
Fall 2005 Kibby Mountain
Nightly Mean Flight Direction

PROJECT:
Kibby Wind Power Project
TransCanada Energy, Ltd.

PREPARED BY:
WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS
105112-00-KibMtnTraffic.dwg

DATE: January 2006
SCALE: n/a
PROJ. NO. 105112
FIGURE: 1



NO. | DATE | REVISIONS

SHEET TITLE: Appendix C Fall 2005 Kibby Range Nightly Mean Flight Direction

PROJECT: Kibby Wind Power Project TransCanada Energy, Ltd.

PREPARED BY: WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS

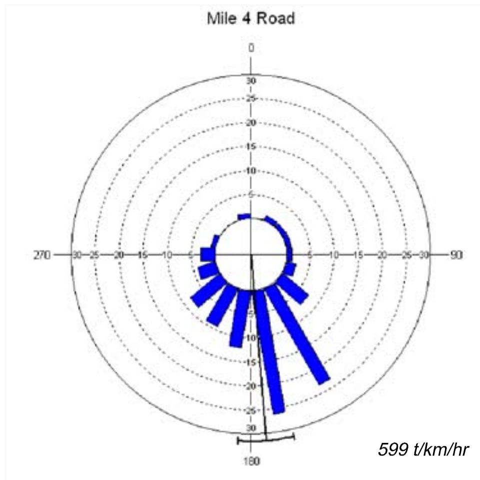
105112-00-KibRangeTraffic.dwg

DATE: January 2006

SCALE: n/a

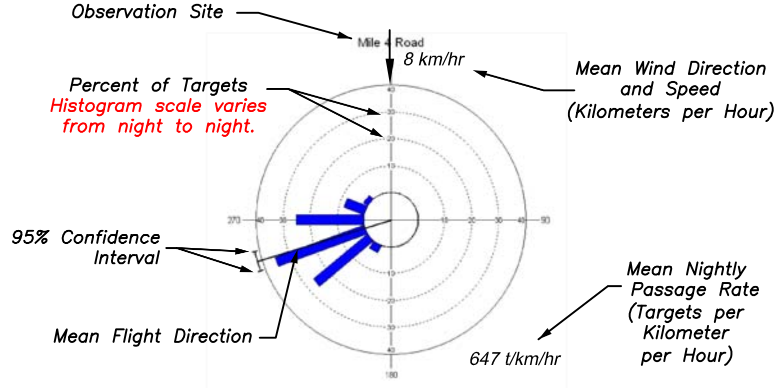
PROJ. NO. 105112

FIGURE: 2



No Wind

RADAR DATA ROSE LEGEND



Data rose shows bird targets in directions of 20° increments.

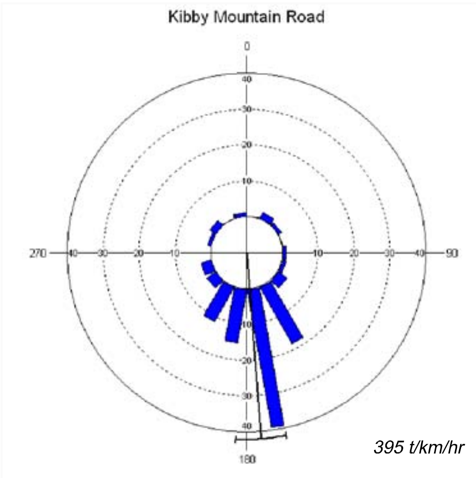
PREPARED BY: WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS

DESIGN:	DATE: January 2006
DRAFT:	PROJ. NO.: 105112
CHECKED:	SCALE: n/a
FILE: 105112-00-MobileTraffic.dwg	

SHEET TITLE: August 22, 2005 Nightly Mean Flight Direction

PROJECT: Kibby Wind Power Project TransCanada Energy, Ltd.

FIGURE: 3



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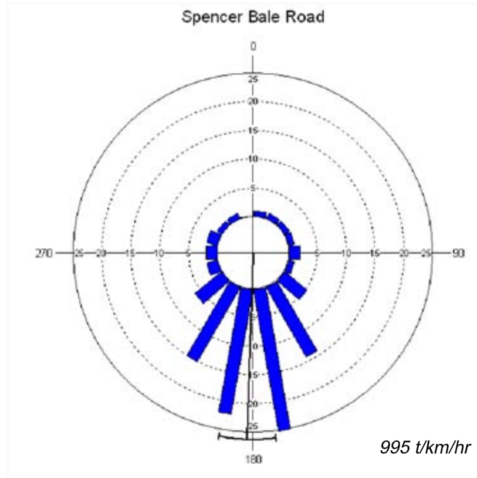
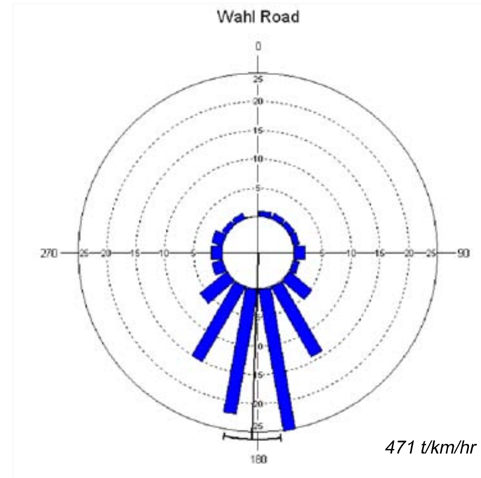
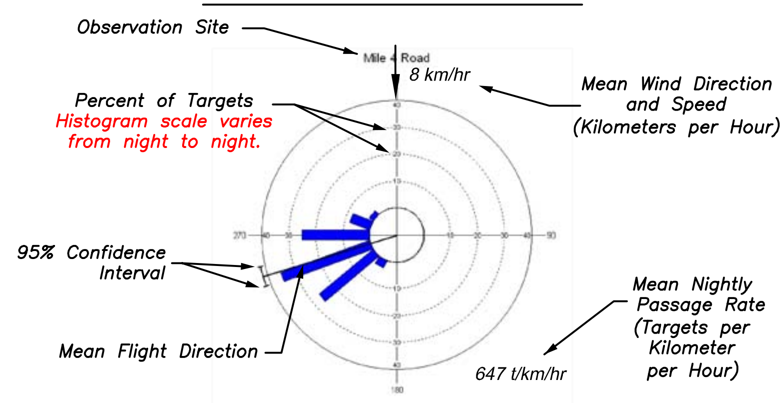


No Wind



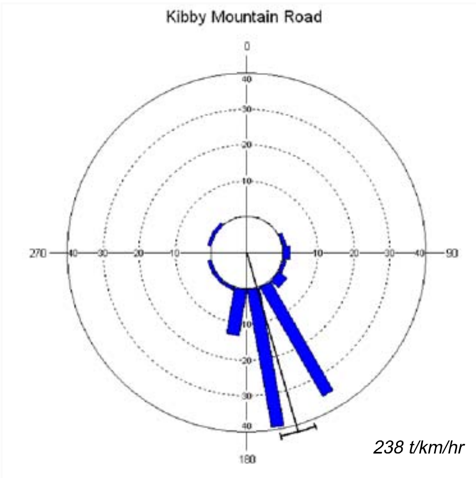
No Wind

RADAR DATA ROSE LEGEND

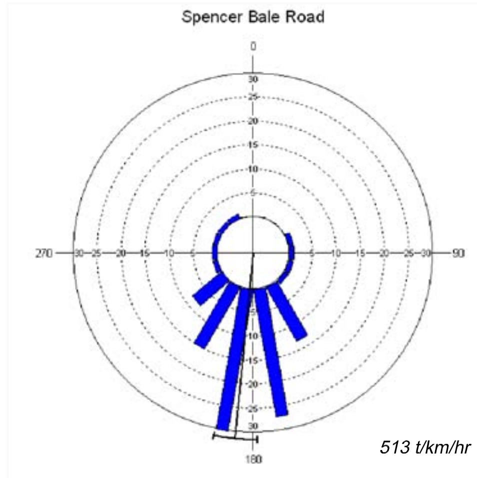


Data rose shows bird targets in directions of 20° increments.

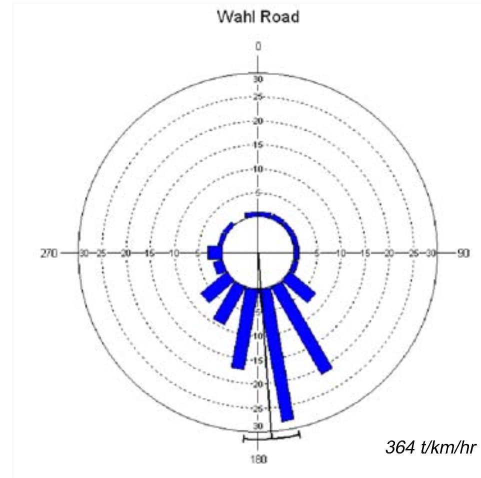
PREPARED BY: WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS	DESIGN:	DATE: January 2006	SHEET TITLE: August 23, 2005 Nightly Mean Flight Direction
	DRAFT:	PROJ. NO.: 105112	PROJECT: Kibby Wind Power Project TransCanada Energy, Ltd.
	CHECKED:	SCALE: n/a	FIGURE: 4
	FILE: 105112-00-MobileTraffic.dwg		



No Wind

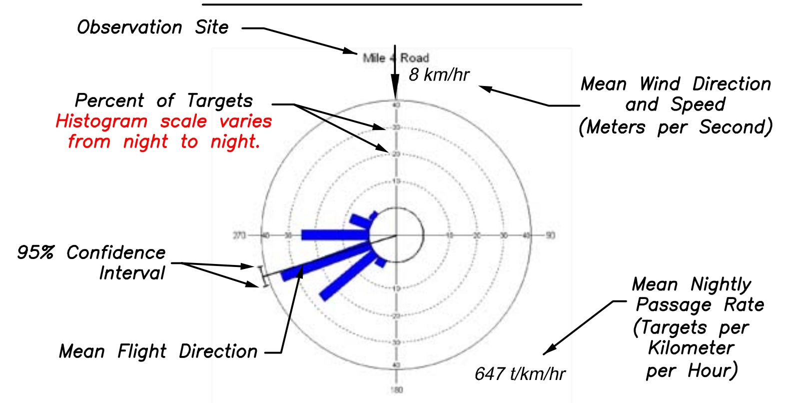


No Wind



No Wind

RADAR DATA ROSE LEGEND



Data rose shows bird targets in directions of 20° increments.

PREPARED BY:

WOODLOT ALTERNATIVES, INC.
ENVIRONMENTAL CONSULTANTS

DESIGN:	DATE: January 2006
DRAFT:	PROJ. NO.: 105112
CHECKED:	SCALE: n/a
FILE: 105112-00-MobileTraffic.dwg	

SHEET TITLE:

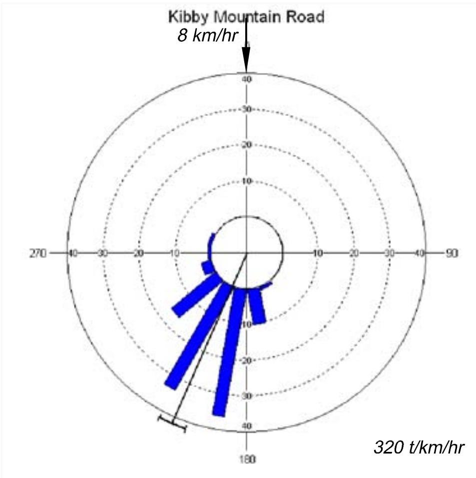
August 24, 2005
Nightly Mean Flight Direction

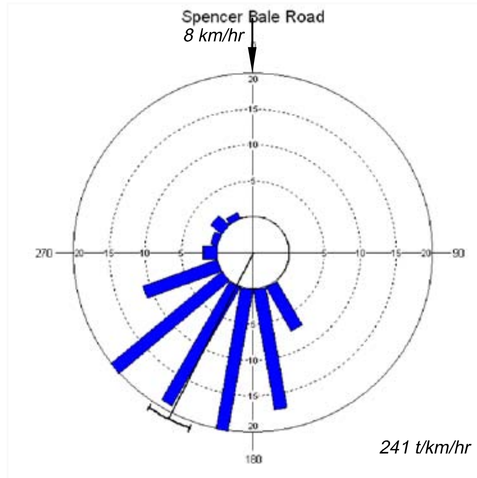
PROJECT:

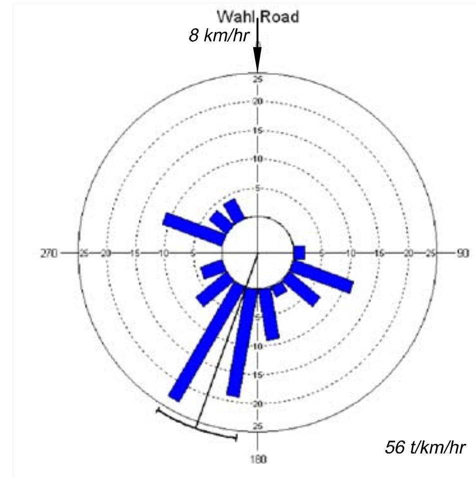
Kibby Wind Power Project
TransCanada Energy, Ltd.

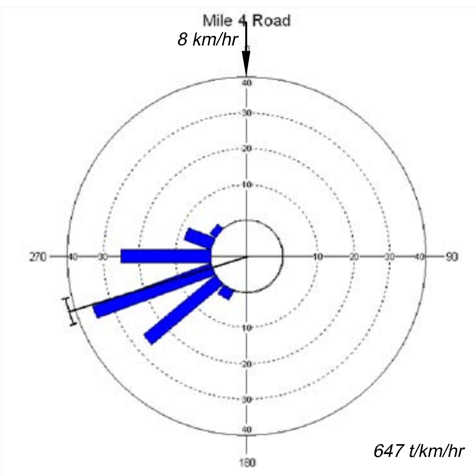
FIGURE:

5

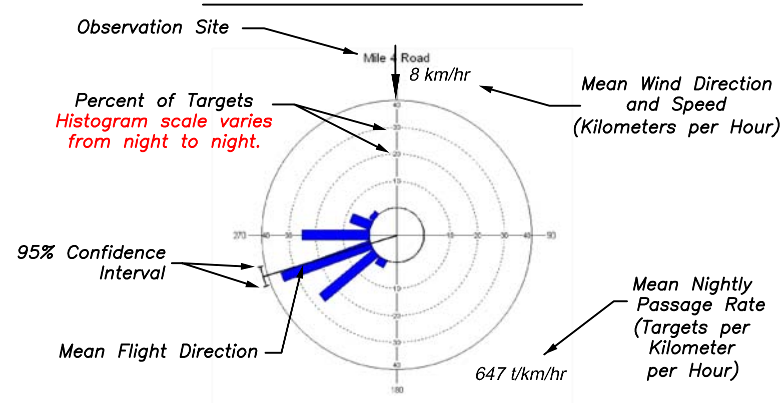








RADAR DATA ROSE LEGEND



Data rose shows bird targets in directions of 20° increments.

PREPARED BY: WOODLOT ALTERNATIVES, INC. ENVIRONMENTAL CONSULTANTS	DESIGN:	DATE: January 2006	SHEET TITLE: October 11, 2005 Nightly Mean Flight Direction
	DRAFT:	PROJ. NO.: 105112	PROJECT: Kibby Wind Power Project TransCanada Energy, Ltd.
	CHECKED:	SCALE: n/a	FIGURE: 6
	FILE: 105112-00-MobileTraffic.dwg		

Appendix D

Direction Data Statistics Summaries by Site

Appendix D Table 1. Nightly Circular Statistics for Kibby Mountain - Fall 2005

Variable	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**
Night Of	**2-Sep**	**3-Sep**	**4-Sep**	**5-Sep**	**6-Sep**	**7-Sep**	**24-Sep**	**25-Sep**	**27-Sep**	**29-Sep**	**30-Sep**	**1-Oct**	**Entire Season**
Data Type	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles
Number of Observations	4010	6451	7422	4833	3319	1557	2678	800	3447	735	1359	2225	38836
Data Grouped?	No	No	No	No	No	No	No	No	No	No	No	No	No
Group Width (& Number of Groups)													
Mean Vector (µ)	143.708°	175.242°	182.393°	203.58°	113.716°	134.593°	282.867°	70.912°	172.535°	151.568°	156.808°	139.077°	167.07°
Length of Mean Vector (r)	0.813	0.895	0.938	0.493	0.634	0.711	0.467	0.824	0.908	0.851	0.694	0.897	0.652
Concentration	3.032	5.034	8.373	1.131	1.657	2.074	1.055	3.186	5.745	3.673	1.967	5.158	1.742
Circular Variance	0.187	0.105	0.062	0.507	0.366	0.289	0.533	0.176	0.092	0.149	0.306	0.103	0.348
Circular Standard Deviation	36.848°	27.053°	20.455°	68.127°	54.684°	47.353°	70.687°	35.668°	25.116°	32.53°	49.011°	26.681°	52.99°
Standard Error of Mean	0.576°	0.336°	0.237°	1.104°	0.97°	1.196°	1.577°	1.25°	0.427°	1.195°	1.33°	0.565°	0.273°
Rayleigh Test (Z)	2651.672	5161.868	6533.849	1175.458	1334.747	786.415	584.51	542.979	2844.4	532.465	653.787	1791.244	16510.802
Rayleigh Test (p)	0	0	0	0	0	0	0	0	0	0	0	0	0
Rao's Spacing Test (U)	242.455	264.23	279.553	197.665	209.199	214.471	191.937	237.799	261.103	236.942	220.226	259.468	218.464
Rao's Spacing Test (p)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Appendix D Table 2. Nightly Circular Statistics for Kibby Range - Fall 2005

Variable	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**
Night of	**14-Sep**	**15-Sep**	**16-Sep**	**19-Sep**	**20-Sep**	**21-Sep**	**3-Oct**	**4-Oct**	**5-Oct**	**6-Oct**	**7-Oct**	**10-Oct**	**Entire Season**
Data Type	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles	Angles
Number of Observations	154	2148	295	1728	2231	3106	20	872	585	384	22	894	12439
Data Grouped?	No	No	No	No	No	No	No	No	No	No	No	No	No
Group Width (& Number of Groups)													
Mean Vector (μ)	58.945°	224.241°	300.892°	192.293°	136.385°	191.674°	255.17°	215.851°	221.744°	303.669°	109.381°	239.658°	195.892°
Length of Mean Vector (r)	0.463	0.907	0.849	0.652	0.873	0.892	0.851	0.755	0.635	0.283	0.49	0.548	0.624
Concentration	1.043	5.693	3.631	1.742	4.225	4.919	3.676	2.402	1.659	0.59	1.121	1.314	1.609
Circular Variance	0.537	0.093	0.151	0.348	0.127	0.108	0.149	0.245	0.365	0.717	0.51	0.452	0.376
Circular Standard Deviation	71.092°	25.245°	32.764°	52.983°	29.924°	27.41°	32.515°	42.991°	54.645°	91.053°	68.453°	62.805°	55.687°
Standard Error of Mean	6.642°	0.544°	1.9°	1.293°	0.632°	0.491°	7.243°	1.441°	2.309°	7.158°	16.487°	2.257°	0.513°
Rayleigh Test (Z)	33.029	1768.984	212.718	734.795	1698.379	2470.646	14.493	496.604	235.565	30.727	5.279	268.854	4836.564
Rayleigh Test (p)	0	0	0	0	0	0	2.10E-07	0	0	0	0.004	0	0
Rao's Spacing Test (U)	170.432	265.874	233.368	208.41	247.219	251.08	234.793	224.468	208.018	158.901	160.888	187.037	198.595
Rao's Spacing Test (p)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05	< 0.01	< 0.01

Appendix D Table 3. Nightly Circular Statistics for Kibby Mountain Road - Fall 2005

Variable	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**
Night of	**23-Aug**	**24-Aug**	**11-Oct**	**12-Oct**	**Entire Season**
Data Type	Angles	Angles	Angles	Angles	Angles
Number of Observations	383	136	358	76	953
Data Grouped?	No	No	No	No	No
Group Width (& Number of Groups)					
Mean Vector (µ)	176.07°	164.72°	202.883°	248.813°	190.196°
Length of Mean Vector (r)	0.797	0.886	0.934	0.816	0.801
Concentration	2.83	4.692	7.806	3.077	2.874
Circular Variance	0.203	0.114	0.066	0.184	0.199
Circular Standard Deviation	38.561°	28.161°	21.239°	36.495°	38.171°
Standard Error of Mean	1.949°	2.409°	1.122°	4.147°	1.223°
Rayleigh Test (Z)	243.494	106.813	312.035	50.654	611.416
Rayleigh Test (p)	0	0	0	0	0
Rao's Spacing Test (U)	237.698	264.742	269.849	226.759	232.552
Rao's Spacing Test (p)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Appendix D Table 4. Nightly Circular Statistics for Spencer Bale Road - Fall 2005					
Variable	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**
Night Of	**23-Aug**	**24-Aug**	**11-Oct**	**12-Oct**	**Entire Season**
Data Type	Angles	Angles	Angles	Angles	Angles
Number of Observations	1199	393	245	107	1944
Data Grouped?	No	No	No	No	No
Group Width (& Number of Groups)					
Mean Vector (µ)	176.098°	184.454°	206.347°	263.844°	184.943°
Length of Mean Vector (r)	0.897	0.855	0.828	0.897	0.826
Concentration	5.151	3.759	3.252	5.16	3.223
Circular Variance	0.103	0.145	0.172	0.103	0.174
Circular Standard Deviation	26.703°	32.079°	35.193°	26.675°	35.403°
Standard Error of Mean	0.77°	1.612°	2.231°	2.574°	0.796°
Rayleigh Test (Z)	964.908	287.246	168.001	86.149	1327.027
Rayleigh Test (p)	0	0	0	0	0
Rao's Spacing Test (U)	258.778	243.621	231.531	254.366	236.496
Rao's Spacing Test (p)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

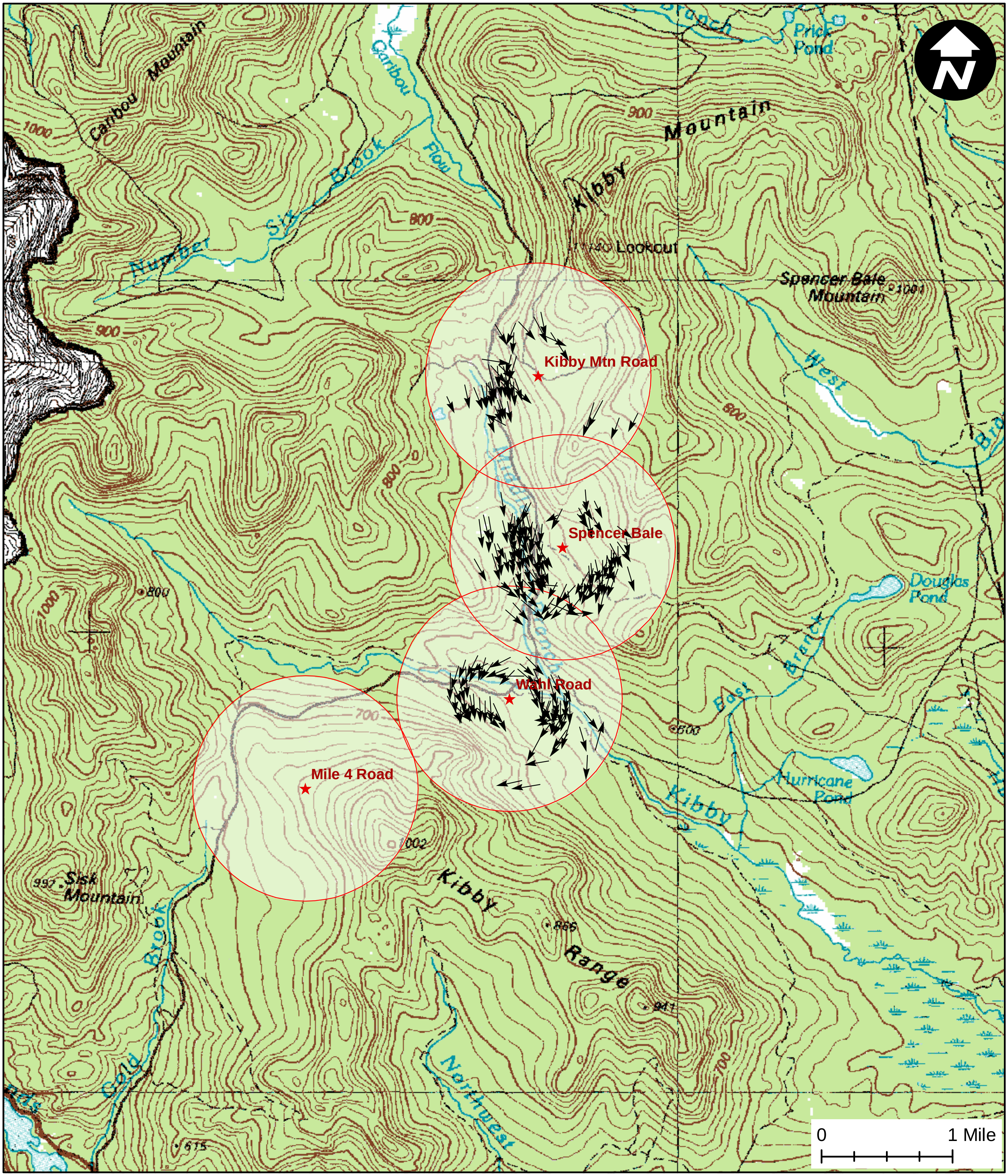
Appendix D Table 5. Nightly Circular Statistics for Wahl Road - Fall 2005

Variable	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**
Night of	**23-Aug**	**24-Aug**	**11-Oct**	**12-Oct**	**Entire Season**
Data Type	Angles	Angles	Angles	Angles	Angles
Number of Observations	599	150	57	63	869
Data Grouped?	No	No	No	No	No
Group Width (& Number of Groups)					
Mean Vector (µ)	183.083°	176.101°	197.48°	292.323°	187.408°
Length of Mean Vector (r)	0.742	0.789	0.57	0.838	0.664
Concentration	2.295	2.732	1.394	3.418	1.805
Circular Variance	0.258	0.211	0.43	0.162	0.336
Circular Standard Deviation	44.305°	39.47°	60.703°	34.072°	51.809°
Standard Error of Mean	1.795°	3.187°	8.509°	4.265°	1.775°
Rayleigh Test (Z)	329.414	93.325	18.552	44.235	383.637
Rayleigh Test (p)	0	0	8.77E-09	0	0
Rao's Spacing Test (U)	216.545	223.664	191.454	232.157	203.923
Rao's Spacing Test (p)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Appendix D Table 6. Nightly Circular Statistics for Mile 4 Road - Fall 2005				
Variable	**Flight Direction**	**Flight Direction**	**Flight Direction**	**Flight Direction**
Night of	**22-Aug**	**11-Oct**	**12-Oct**	**Entire Season**
Data Type	Angles	Angles	Angles	Angles
Number of Observations	1798	648	157	2603
Data Grouped?	No	No	No	No
Group Width (& Number of Groups)				
Mean Vector (µ)	177.091°	253.103°	269.812°	202.872°
Length of Mean Vector (r)	0.752	0.934	0.853	0.637
Concentration	2.382	7.842	3.709	1.669
Circular Variance	0.248	0.066	0.147	0.363
Circular Standard Deviation	43.225°	21.188°	32.34°	54.433°
Standard Error of Mean	1.009°	0.832°	2.571°	1.089°
Rayleigh Test (Z)	1017.69	565.18	114.166	1055.597
Rayleigh Test (p)	0	0	0	0
Rao's Spacing Test (U)	223.358	272.932	244.66	209.123
Rao's Spacing Test (p)	< 0.01	< 0.01	< 0.01	< 0.01

Appendix E

Radar Survey Sample Data Plots



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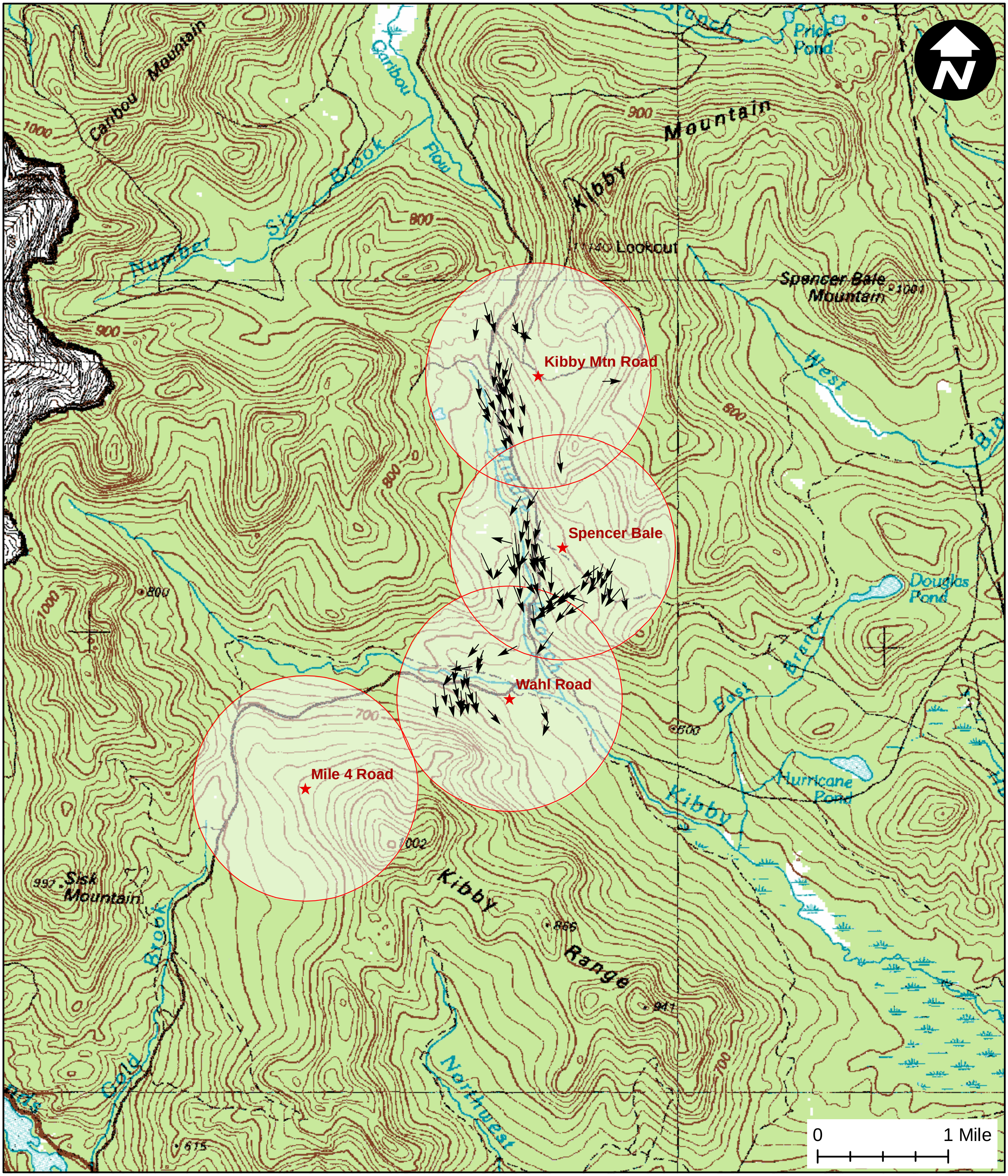
DATE: December 2005	*Appendix E - Figure 1*
SCALE: 1" = 1 Mile	*Target Skyplots for 08/23/05*
JOB NO. 105112	*Kibby Wind Power Project*
FILE: 105112-00-skyplot.mxd	*TransCanada Energy, Ltd.*



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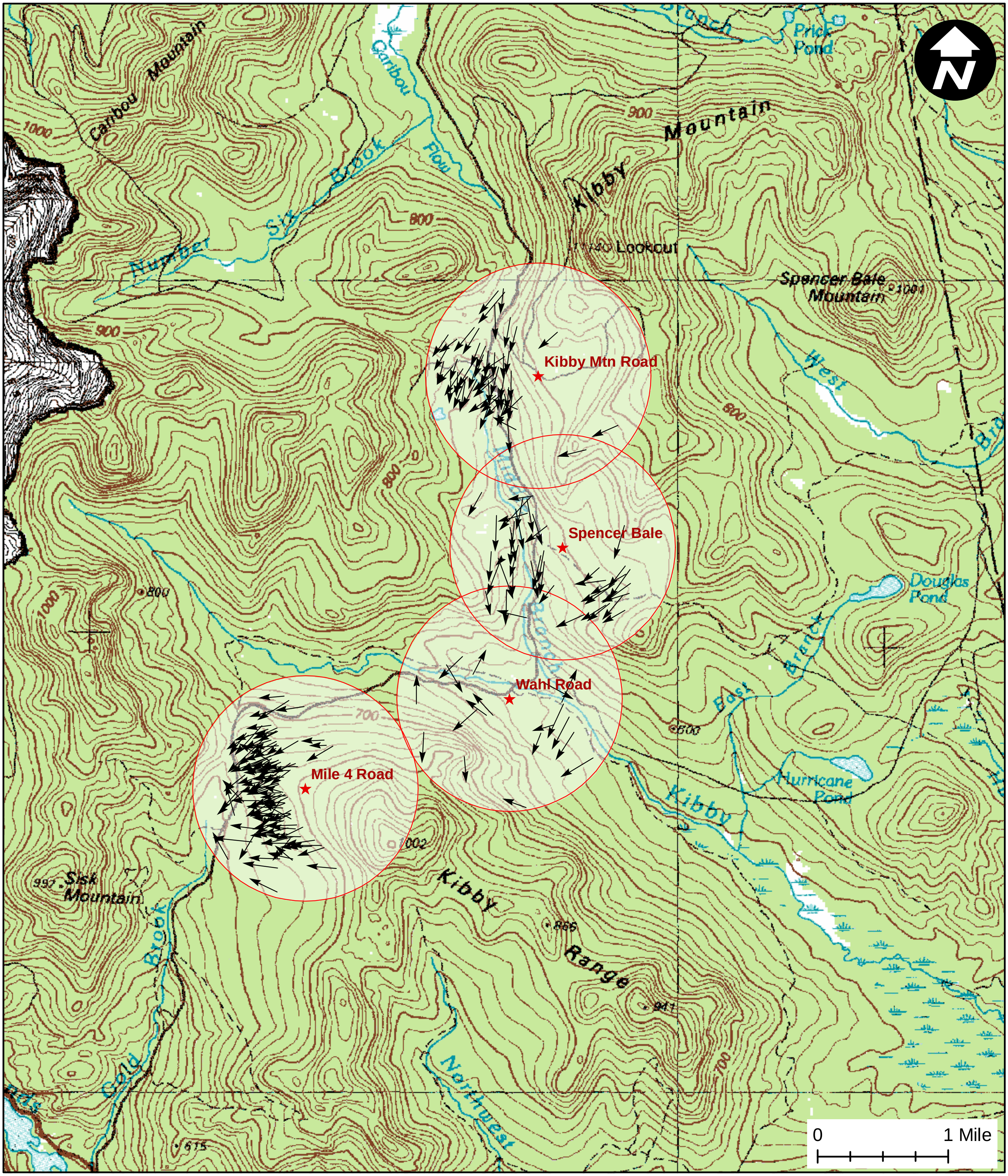
ENVIRONMENTAL CONSULTANTS

DATE: December 2005	
SCALE: 1" = 1 Mile	
JOB NO. 105112	
FILE: 105112-00-skyplot.mxd	

Appendix E - Figure 2
Target Skyplots for 08/24/05
Kibby Wind Power Project
TransCanada Energy, Ltd.



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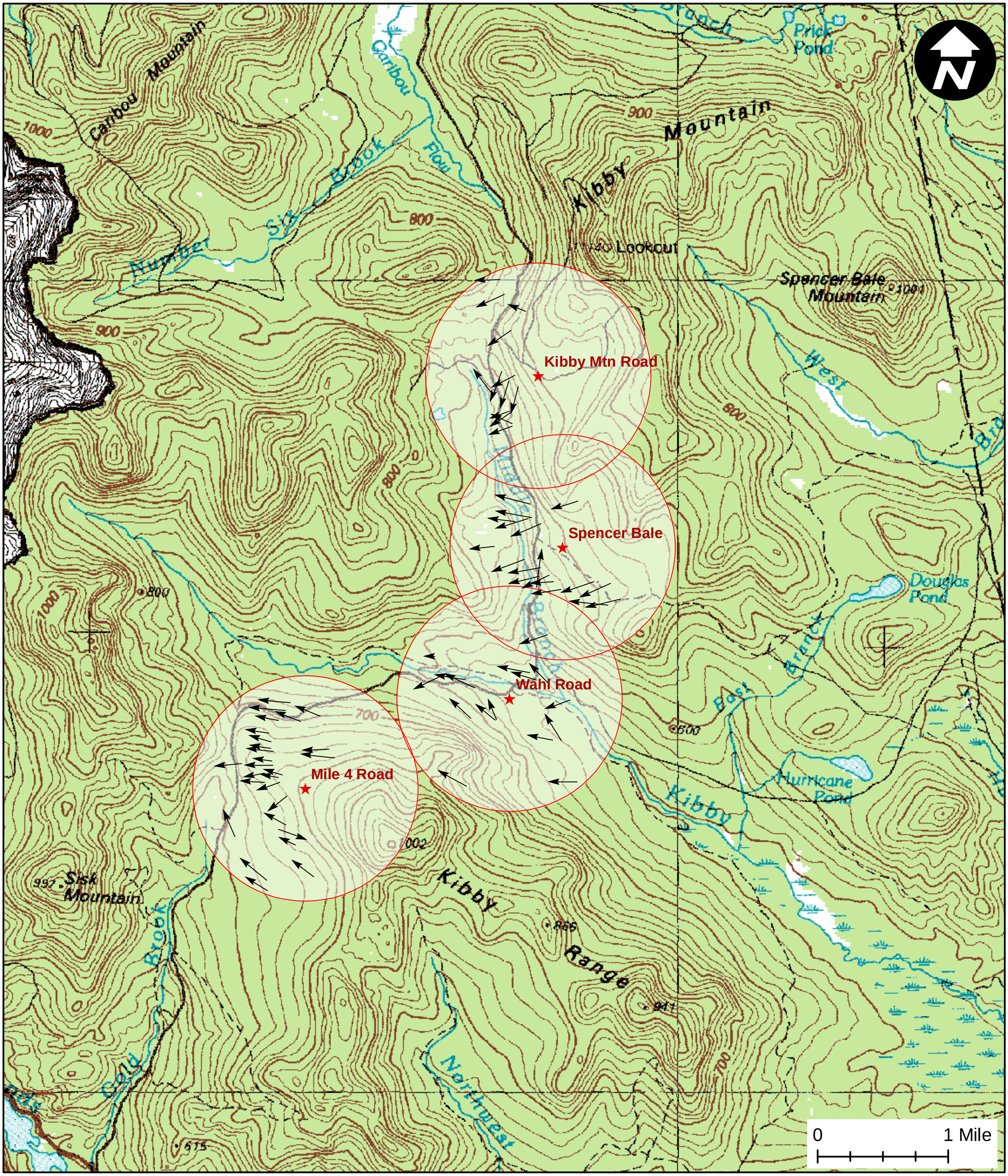
ENVIRONMENTAL CONSULTANTS

DATE: December 2005	
SCALE: 1" = 1 Mile	
JOB NO. 105112	
FILE: 105112-00-skyplot.mxd	

Appendix E - Figure 3
Target Skyplots for 10/11/05
Kibby Wind Power Project
TransCanada Energy, Ltd.



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DATE: December 2005	
SCALE: 1" = 1 Mile	
JOB NO. 105112	
FILE: 105112-00-skyplot.mxd	

Appendix E - Figure 4
Target Skyplots for 10/12/05
Kibby Wind Power Project
TransCanada Energy, Ltd.