Post-Construction Research and Monitoring Protocol
Number Nine Wind Farm
Aroostook County, Maine

Prepared for:

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NATURAL RESOURCES ◆ SCIENTIFIC SOLUTIONS

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INTRODUCTION

Number Nine Wind Farm LLC, a subsidiary of EDP Renewables North America, (EDPR) has proposed a wind energy facility referred to as the Number Nine Wind Farm (Project). The Project is located in Aroostook County, in northeastern Maine, approximately eight miles (13 kilometers [km]) west of the town of Bridgewater (Figure 1). The proposed Project would be 119 2.0 megawatt (MW) and 2.1 MW turbines with a total capacity of approximately 250 MW. Pre-construction survey effort included 175 potential turbine sites to provide flexibility to the Project design to help minimize impacts to resources of concern.

EDPR plans to conduct post-construction (operational) wildlife monitoring studies to determine the direct impacts the Project has on birds and bats and research operational protocols that are designed to reduce direct impacts to bats. This monitoring plan was developed with consideration to the Maine Department of Inland Fisheries and Wildlife (MDIFW) post-construction monitoring recommendations (MDIFW 2014), Tier 4 studies of the U.S. Fish and Wildlife Service (USFWS) Land-based Wind Energy Guidelines (WEG; USFWS 2012), industry standards (Strickland et al 2011), and expertise of Western EcoSystems Technology (WEST) conducting post-construction monitoring studies throughout the eastern and entire U.S. (e.g., Chatfield et al. 2009; Derby et al. 2010; Erickson et al. 2007; Gruver et al. 2008; Tidhar et al. 2010, 2011; Young et al. 2009, 2013).

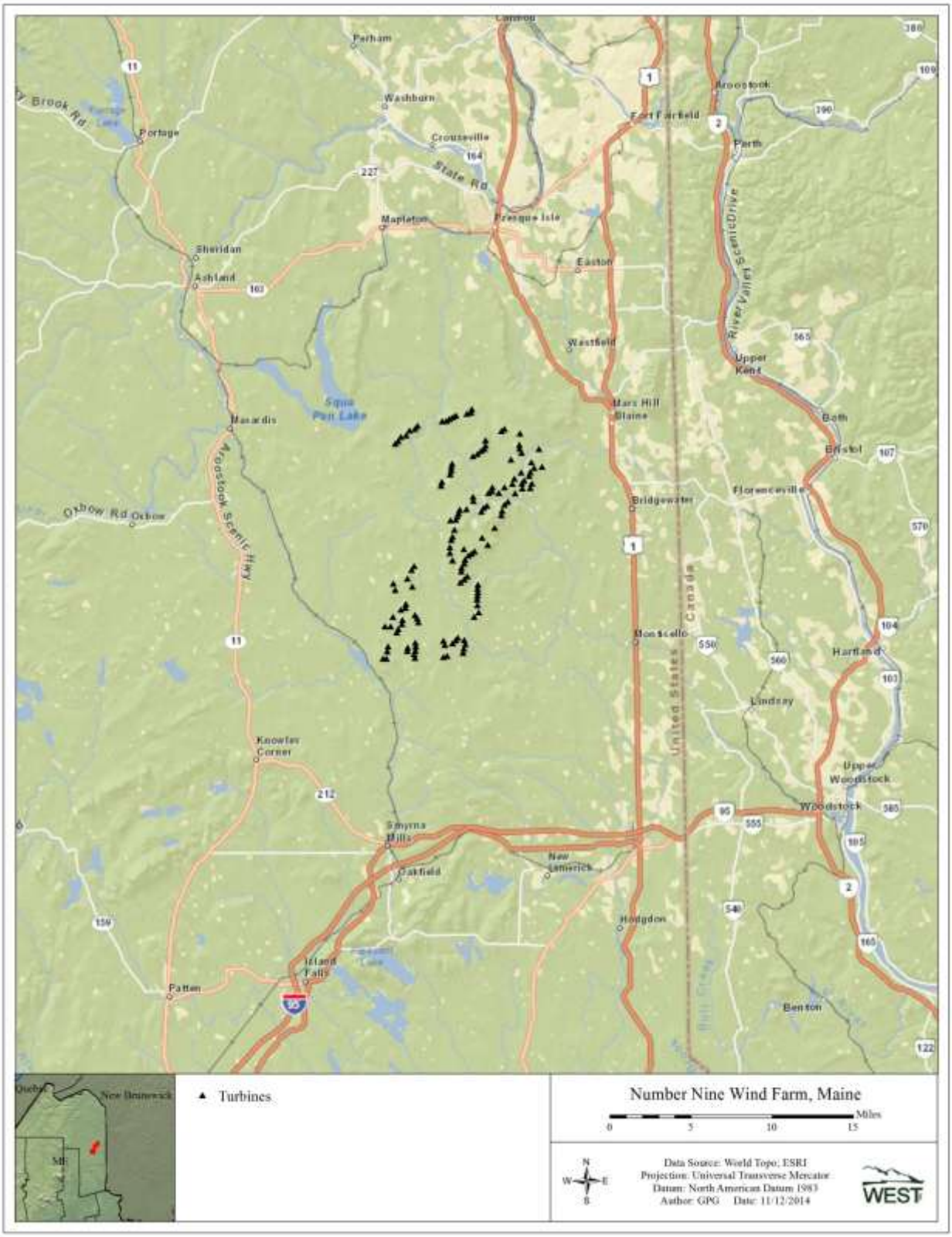

Figure 1. Location of the Number Nine Wind Farm.

Purpose and Objectives

The primary purposes of the Project research and monitoring study are to (1) determine the direct impact of the wind farm on birds and bats (Perry 2014, USFWS 2012), and (2) research the effectiveness of different turbine operational protocols in reducing bat mortality, and potentially bird mortality, at the wind farm.

The primary objectives of the study are to:

1. Provide a scientifically defensible estimate of annual bird and bat mortality due to the Project;
2. Provide an understanding of the timing, number, species composition, distribution, and location of bird and bat casualties found;
3. Compare the overall bird and bat fatality rates to expected rates based on other monitoring studies in Maine and the northeastern US; and
4. Compare bat and bird fatality rates for different turbine operational protocols.

Study Area

The Project is located in Aroostook County, Maine, about eight miles (13 kilometers [km]) west of the town of Bridgewater (Figure 1). The Project Area, defined as the area encompassed by a 2-mile buffer around the proposed turbine layout (Figure 2), is about 132,000 acres (206.7 square miles, 535.3 square km). Elevations in the Project Area range from 500 to 1,700 feet (152. to 518 meters [m]) above sea level. The Project is located in the Laurentian Plains and Hills Ecoregion in northeastern Maine. The dominant vegetation type in the Project Area is mixed spruce-fir and deciduous forest intermixed with patches/tracts of coniferous forest and deciduous forest composed primarily of maple (*Acer* spp), beech (*Fagus* spp), and birch (*Betula* spp) trees (USEPA 2007) (Figure 2). The land in the Project is privately owned and commercial timber harvest is the primary land use. The forests are transitional and in various stages of growth, from regenerating stands to mature trees, due to past and ongoing logging activities. Shrub/scrub habitat is common in areas where the timber has been harvested. Glacial lakes occur throughout the region and Project Area and woody wetlands are common.

Post-construction Fatality Patterns at Nearby Wind Farms

Results from a number of post-construction fatality monitoring studies conducted at 18 wind farms are publically available for the northeastern US (Table 1). Three of these wind farms are located in Maine: Mars Hill, Stetson Mountain and Kibby (Table 1). Fatality patterns for birds are considered generally average for the state at these three projects on a per megawatt (MW) annualized basis. In general, patterns of bird fatalities have been low and consistent at available studies in the northeast (Table 1). Bat fatality estimates for facilities in Maine and New Hampshire are generally considered low when compared to projects further south such as those on mountain ridge top areas of the mid-Atlantic states of Pennsylvania, Maryland, and West Virginia (see Arnett et al. 2005, 2008).

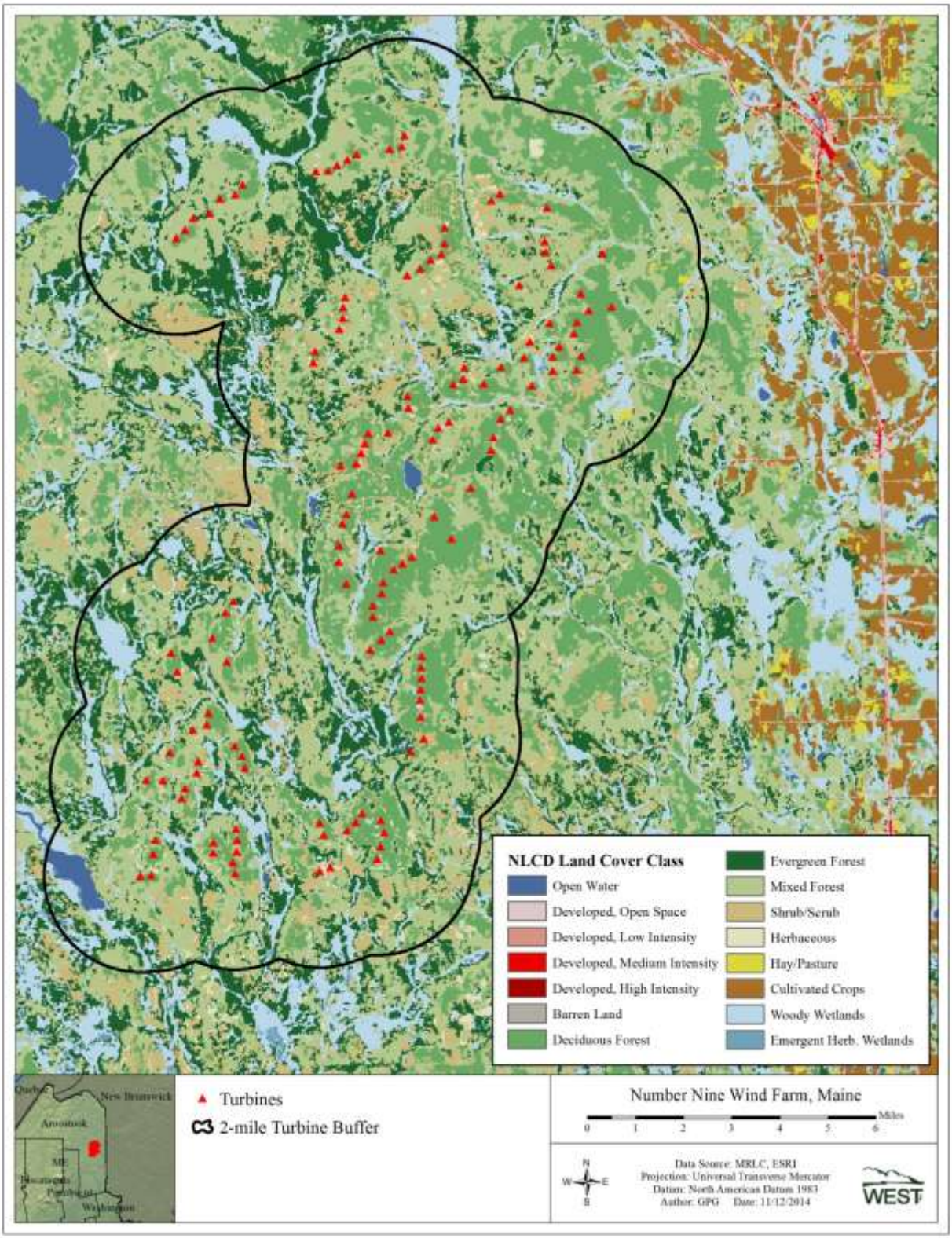

Figure 2. Wind turbines and land cover classes within the Number Nine Wind Farm.

Table 1. Fatality rates at wind farms in the northeast with publically available reports[1].

Project Name	State	Year	Bird Fatality/MW/Year	Bat Fatality/MW/Year	Raptor Fatality/MW/year
Mars Hill	ME	2007	1.67	2.91	0
Mars Hill	ME	2008	1.76	0.45	0
Stetson Mountain I	ME	2009	2.68	1.4	0
Stetson Mountain I	ME	2011	1.18	0.28	0
Stetson Mountain II	ME	2010	1.42	1.65	0
Kibby[14]	ME	2011	0.54	0.12	0
Lempster	NH	2009	3.38	3.11	0
Lempster	NH	2010	2.64	3.57	0
Cohocton/Dutch Hills	NY	2009	1.88[2]	16.02[2]	nr
Cohocton/Dutch Hills	NY	2010	1.37[2]	17.08[2]	nr
Hardscrabble	NY	2011	0.80[5]	0	0
Hardscrabble	NY	2012	3.43	10.67	0
High Sheldon	NY	2010	1.76	2.33	0.06
High Sheldon	NY	2011	1.57	1.78	0
Howard	NY	2012	1.29	10.00	0
Maple Ridge	NY	2006	5.81[2]	14.87[2]	0.04[4]
Maple Ridge[7]	NY	2007	2.34	6.49	nr
Maple Ridge[7]	NY	2008	2.07	4.96	0.03[8]
Maple Ridge[9]	NY	2012	-	7.30	-
Munnsville	NY	2008	1.48[4]	1.93[10]	nr
Noble Altona	NY	2010	1.84[4]	4.34[11]	0
Noble Altona	NY	2011	nr	nr	nr
Noble Bliss	NY	2008	2.86[2]	9.78[3]	nr
Noble Bliss	NY	2009	2.97[2]	5.50[2]	0.18[4,8]
Noble Bliss/Wethersfield	NY	2011	nr	nr	nr
Noble Chateaugay	NY	2010	1.66[12]	2.44	nr
Noble Clinton	NY	2008	2.17[3]	3.63[2]	0.29[3]
Noble Clinton	NY	2009	1.17[4]	6.48[2]	0.24[4,8]
Noble Ellenburg	NY	2008	1.12[2,12]	4.39[2]	0.32[2]
Noble Ellenburg	NY	2009	3.79[2]	5.34[2]	0.49[11]
Noble Wethersfield	NY	2010	1.70	16.30	nr
Steel Winds I & II[13]	NY[15]	2012	3.38	2.75	nr

nr=did not report a fatality estimate; 0 = none were found

[1]Highest estimates presented in reports are included in the table.
[2] Estimates based on daily search intervals.
[3] Estimates based on 3-day search intervals.
[4] Estimates based on weekly search intervals.
[5]Hardscrabble (2011): report only includes October 16-December 30, 2011. No bats were found. No raptors were found.
[6]Adjusted fatality estimate was presented per turbine only. Turbines are 2MW, divide the per turbine estimate by 2; 1.60/2=0.80.
[7]Estimates do not include incidental finds. Estimates including incidental finds are also in the report.
[8]Added raptor species estimates to get overall raptor estimate.
[9]Bat specific study. Bird/raptor estimates were not presented
[10]Estimates based on surveyor with a dog.
[11]Estimates based on daily and weekly search intervals.
[12]Added small and large bird estimates to get overall bird estimate.
[13]Jain estimate presented in this table. Huso estimates are also available in the report.
[14] Estimate based on study dates 5/2/11-6/20/11 and 7/11/11-10/14/11
[15] Fatality monitoring studies in New York have generally followed similar field protocols and been conducted over similar annual study periods, but have differed in the type of statistical estimators used.

FATALITY MONITORING STUDY

The bird and bat fatality monitoring will occur during the spring, summer and fall seasons (April 15 to October 15) for years one and two of Project operation. The following protocol is proposed for the first year of operation and to facilitate the proposed research study (see below). Following the first year of monitoring, the protocol will be evaluated for meeting the monitoring and research study objectives and may be adjusted as needed.

Study Components

The field study will include the following components:

1. Standardized carcass searches of plots around turbines defined as the area on roads and pads within 60 m (~197 ft) of all turbines in the Project;
2. Searcher efficiency trials to estimate the percentage of carcasses found by searchers; and
3. Carcass removal trials to estimate the length of time that a carcass remains in the field for possible detection.

Permits

Prior to starting studies, appropriate MDIFW and USFWS salvage permits will be obtained, allowing collection and storage of non-federally-listed bird and bat carcasses found. In the event an eagle or federally or state listed bird or bat carcass is discovered, the USFWS and MDIFW will be informed within 24 hours of preliminary identification via phone and/or email. Any injured animals will be euthanized if allowed by permit and recorded as a casualty. If euthanization is not allowed, injured wildlife will be brought to a nearby wildlife rehabilitation center, if available, and if allowed by permitted. Otherwise, any injured wildlife will be left in place and will be recorded as a casualty with as much information as possible. Final disposition of all carcasses collected will be according to permit conditions.

Standardized Carcass Searches

Standardized carcasses searches will be completed to survey the delineated search plots (see below) for bird and bat casualties[1]. All casualties found during searches will be recorded independent of cause of death.

Turbine Selection

All turbines in the Project will be monitored to provide complete spatial coverage which is greater that the recommendations of the MDIFW (2014) and USFWS (2012).

Search Plot

The search plot for each turbine will be defined as the area on roads and pads within 60 m of the turbine. The boundary of all plots will be mapped by GPS by walking the plot perimeter in the field.

[1] Casualty is defined as an injured or dead bird or bat.

Studies at other wind farms with large turbines (>300 feet tall) have shown that close to 90% of bat fatalities are found within 40 m distance measured along the ground from the base of the turbines (Figure 3; and see Erickson *et al.* 2000, Johnson *et al.* 2002, Higgins *et al.* 1996, Young *et al.* 2007, Erickson *et al.* 2003b, Jain *et al.* 2007). The proposed search plot radius is greater than the blade length of the proposed turbines to ensure that most bat and bird fatalities likely would land within the area equal to the search plot distance.

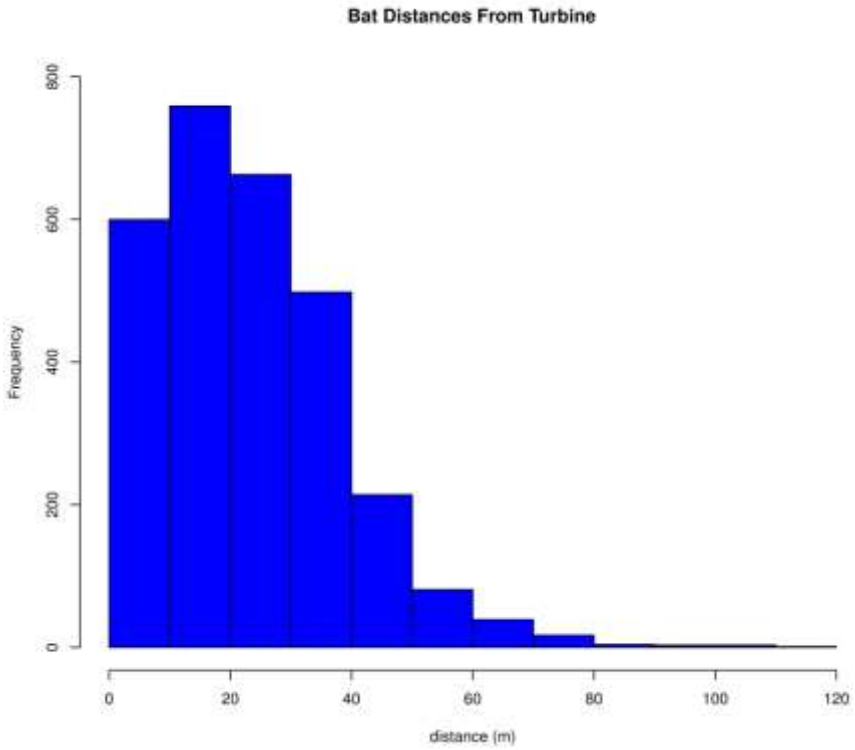

Figure 3. Distribution of bat carcasses found in relation to the turbine tower from post-construction monitoring studies at wind farms throughout the U.S.

Search Methods

Observers trained in proper search techniques will conduct the carcass searches. The search pattern around the turbine may vary depending on the configuration of the road and pad plot but in general observers will walk along the road approximately 2-3 m from the edge of the road nearest the turbine, then circle the turbine while walking in roughly the center of the pad around the turbine, and then walk parallel to the outer edge of the road back to the starting location. Searchers will walk at a rate of approximately 45-60 meters per minute (148-197 ft/min). Observers will scan the area on both sides out to approximately 2-3 m (~8-9 ft) for casualties as they walk, thereby surveying the entire road and pad area within 60 m of the turbine and providing some visual overlap between transects to improve searcher efficiency.

Data Collection

Casualties found during the study could be found by: 1) searchers during scheduled searches; 2) searchers outside of search plots; 3) searchers within search plots outside of scheduled searches; or 4) facility personnel or others on site for other purposes, such as turbine maintenance. All casualties found within a search plot during or outside of a scheduled search within the study period will be included in the analysis of the fatality estimates. For those casualties found outside scheduled searches but within a search plot it is assumed that they would have been found during the next scheduled survey. Casualties found outside of search plots (e.g., off the roads and pads plot) or outside of the study period will be documented as incidentals but not included in analysis of the fatality estimates (see Statistical Methods below).

All casualties found will be recorded. Cause of death will be determined, if possible, based on field inspection; however, due to the difficulty associated with obtaining accurate estimates of natural or reference mortality (Johnson et al. 2000), the assumption[2] will be made that all casualties found are attributable to turbine collision or barotrauma.

Date, start time, end time, observer, turbine number, and weather data will be recorded for each search (see Appendix A). When a bat or bird casualty is found, the observer will record the distance the observer is from the carcass when first observed. Observers will place a flag near the carcass and continue the search. After searching the entire plot, the observer will return to each carcass and record information on a fatality data sheet, including the date, observer, turbine number, species, sex and age (when possible), distance and direction from turbine, UTM coordinates, condition (e.g., intact, scavenged, feather spot, partial carcass), and estimated time of death (e.g., less than one day, two days, etc.). Digital photographs will be taken of the carcass, any visible injuries, and surrounding habitat. Rubber gloves will be used to handle all carcasses to eliminate possible transmission of diseases and to reduce any possible human scent bias for carcasses later used in carcass removal trials. All carcasses found will be placed in a plastic bag and labeled with a unique number, and stored in a freezer on site for future reference and possible further study. A copy of the data sheet will be maintained with the carcass at all times. In addition to carcasses, all injured bats and birds observed in search plots will be recorded and considered as a fatality for analysis purposes. All *Myotis* bat fatalities found will be retained and not used in bias trials (see below) for species verification either by another expert or through genetic analysis.

Casualties found in non-search area, or outside of the scheduled search time, will be coded as incidental discoveries and will be documented in a similar fashion as those found during standard searches. Incidental discoveries found outside of delineated search plots will not be included in the calculation of fatality estimates, but will be included in reporting on appropriate topics such as species composition and distance of fatalities from turbines.

[2] This assumption likely leads to an over-estimation for bird and bat fatalities attributable to the facility. Most wind energy facility monitoring studies have used this conservative approach because of the added costs associated with obtaining accurate estimates of natural or reference mortality (Strickland et al. 2011).

Timing and Search Interval

Carcass searches will be conducted over a 27 week period from April 15 through October 15 during the first two years of Project operation. The study period generally encompasses the spring (approximately April 15 – May 31) and fall migration periods (approximately August 1 – October 15) each calendar year as well as the summer breeding seasons (approximately June 1 – July 31) for birds and bats.

The search effort will follow a predefined schedule as closely as possible to ensure that observers are on site every day but will remain flexible to adapt to unsafe field conditions (e.g., lightning). For the first year of study, the search interval will be every four days. Either 40 or 39 turbines will be searches each day so that all 119 turbines are searched over a 3-day period[3]. Carcass removal times at a project should be considered with an average search interval not longer than twice the average removal time. Carcass removal times recorded in the eastern U.S. indicate that a search interval greater than one week (7 days) would be sufficient at the Project (Table 2) with the current estimators used for determining overall mortality (see Huso 2010, Shoenfeld 2004).

[3] A weekly search interval is sufficient for determining overall fatality rates and making between-project comparisons (Strickland et al, 2011); however, a more frequent search interval may be needed if other objectives such as determining differences among treatment groups is included in the study.

Table 2. Average removal times in days for wind farms in the Northeast.

Project	State	Year	Average Bat Removal Time	Average Small Bird Removal Time	Average Large Bird Removal Time
Mars Hill	ME	2008	6		
Stetson Mountain I	ME	2009	2		
Stetson Mountain I	ME	2011	9.0		
Stetson Mountain II	ME	2010	9.5		
Kibby[7]	ME	2011	21[5]		
Lempster	NH	2009	6.61	6.23	8.61
Lempster	NH	2010	nr	5	8.63
Cohocton/Dutch Hills[1]	NY	2009	5.00	4.00	4.00
Cohocton/Dutch Hills[1]	NY	2010	4.00	8.00	8.00
Hardscrabble[2]	NY	2011	-	24.38	19.38
Hardscrabble[3]	NY	2012	3.20, 4.00	7.40, 4.40	11.80, 17.80
High Sheldon	NY	2010	nr	3.65	4.05
High Sheldon	NY	2011	3.36	3.75	3.44
Howard	NY	2012	8.80	7.66	20.80, 7.31
Maple Ridge	NY	2006	nr	nr	nr
Maple Ridge	NY	2007	nr	nr	nr
Maple Ridge	NY	2008	nr	nr	nr
Maple Ridge	NY	2012	nr	4.49	nr
Munnsville[1]	NY	2008	5.00	4.80	4.80
Noble Altona	NY	2010	nr	nr	nr
Noble Altona	NY	2011	nr	nr	nr
Noble Bliss	NY	2008	nr	nr	nr
Noble Bliss	NY	2009	nr	nr	nr
Noble Bliss/Wethersfield	NY	2011	nr	nr	nr
Noble Chateaugay	NY	2010	nr	nr	nr
Noble Clinton	NY	2008	nr	nr	nr
Noble Clinton	NY	2009	nr	nr	nr
Noble Ellenburg	NY	2008	nr	nr	nr
Noble Ellenburg	NY	2009	nr	nr	nr
Noble Wethersfield	NY	2010	nr	nr	nr
Steel Winds I & II[1]	NY	2012	6.79	2.40	2.40
Overall Average[4]			5.22	6.90	8.33

nr=average removal times were not presented in the report.
[1]Removal time for birds was given for all birds, not by bird size.
[2]Only birds were used for carcass removal trials.
[3]Removal days were presented by season; spring, fall.
[4] The overall average was calculated by averaging across projects. Projects with multiple estimates were averaged first.

Data from the following sources:

Project Name	Reference	Project Name	Reference
Lempster 2009	Tidhar et al. 2010	Stetson Mountain I (2009)	Stantec 2009
Lempster 2010	Tidhar et al. 2011	Stetson Mountain I (2011)	Normandeau Associates 2011
Mars Hill (2007)	Stantec 2008b	Stetson Mountain II (2010)	Normandeau Associates 2010
Mars Hill (2008)	Stantec 2009	Kibby (2011)	Stantec 2012
Cohocton/Dutch Hill (2009)	Stantec 2010	Noble Altona (2010)	
Cohocton/Dutch Hills (2010)	Stantec 2011	Noble Altona (2011)	
Hardscrabble (2011)		Noble Bliss (2008)	
Hardscrabble (2012)		Noble Bliss (2009)	
High Sheldon (2010)	Tidhar et al. 2011b	Noble Bliss/Wethersfield (2011)	
High Sheldon (2011)	Tidhar et al. 2011c	Noble Chateaugay (2010)	
Howard (2012)		Noble Clinton (2008)	
Maple Ridge (2006)		Noble Clinton (2009)	
Maple Ridge (2007)		Noble Ellenburg (2008)	
Maple Ridge (2008)		Noble Ellenburg (2009)	
Maple Ridge (2012)		Noble Wethersfield (2010)	
Munnsville 2008	Stantec 2009b	Steel Winds I & II (2012)	

Bias Trials

Searcher Efficiency Trials

The objective of the searcher efficiency trials is to estimate the percentage of casualties that are found by searchers. Searcher efficiency trials will be conducted throughout the study period (April 15 – October 15). During each 9 week period of the study (which approximates the spring, summer, and fall periods) a minimum of 15 carcasses each of small birds, bats (if available), and medium to large sized birds will be placed in the search area of plots, for a minimum total of 135 searcher efficiency trial carcasses for the study period. If allowed by permit, carcasses found during the study will be used as trial carcasses. In addition, these will be supplemented with non-protected species such as house sparrows, European starlings, rock doves, and pen raised game species (e.g., quail, pheasants, mallards). If bat carcasses are not available, or are available only in very small quantities, brown house mice (*Mus musculus*) will be used as a substitute for bats in searcher efficiency trials. Each trial carcass will be discreetly marked with a small black zip-tie around the leg for birds and mice or around the upper forearm for bats so that it can be identified as a study carcass after it is found.

Searcher efficiency trials will be spread over the entire study period, but at a minimum, carcasses will be placed on six dates each season for a total of at least 18 trial dates over the study period. All carcasses will be placed at random locations within areas being searched prior to the carcass search on the same day. If avian scavengers appear attracted by placement of carcasses, the carcasses will be distributed before dawn. Trial carcasses will be dropped from shoulder or waist height to simulate falling. During each trial approximately 2-6 carcasses of each type will be placed randomly throughout the search areas.

The number and location of carcasses found during the subsequent carcass search will be recorded, and the number of carcasses available for detection during each trial will be determined immediately after each trial by the person responsible for distributing the carcasses. Carcasses scavenged before the casualty search will be marked as unavailable on the data sheet and will be excluded from the estimation of searcher efficiency.

Carcass Removal Trials

The objective of carcass removal trials is to estimate the average length of time (in days) a carcass persists and is available for detection. Carcass removal trials will be conducted throughout the study period. Carcass removal includes removal by scavenging, predation, or removal by other unknown means.

Within each 9 week period of the study (approximation of seasons), a minimum of 15 carcasses each of small birds, bats, and medium to large sized birds will be placed in the study area, for a minimum total of 135 removal trial carcasses for the study period. If allowed by permit, carcasses found during the searches will be used as trial carcasses. In addition, these will be supplemented with non-protected species as with the searcher efficiency trials (see above). If bat carcasses are limited in availability, they will be used for carcass removal trials first and searcher efficiency second. Brown house mice will serve as a surrogate for bats in carcass

removal trials only if necessary to achieve an adequate sample size. Carcass removal trials will begin when carcass search studies begin. Placement will be spread throughout the study period and Project Area to minimize potential for attracting scavengers by placing too many carcasses at one time in one area. Carcasses will be checked for a minimum period of 14 days to determine removal rates. Carcasses will be checked every day for the first 5 days, and then approximately every two days through day 14. This schedule may vary depending on weather and coordination with the other survey work. Experimental carcasses will be marked discreetly (e.g., tape or zip-tie on leg) so that they can be recognized as trial carcasses. Trial carcasses will be left at the location until the end of the carcass removal trial. Any remaining trial carcasses or evidence of the carcass will be removed at the end of the 14-day period.

Statistical Methods

To determine the rate at which bird and bat fatalities occur, the average number of carcasses found in each search plot is adjusted for biases that influence the number of fatalities that are counted. Carcasses persist for variable amounts of time and can be detected with varying levels of success based on carcass characteristics and ground cover. To account for these variables, statistical analyses have been developed to adjust the observed count of carcasses based on the project-specific rate of carcass persistence, the ability of searchers to detect carcasses, and the proportion of carcasses likely to have fallen in non-searched areas.

Analyses will include estimates of fatality rates for bats and birds calculated using both the Schoenfeld estimator and the best estimator that is available at the time of the analysis, if needed (Strickland et al 2011)[4]. The Schoenfeld estimator will be used to provide comparable results with most of the other monitoring studies conducted at wind projects in the eastern U.S. that have used that method for estimating the total bird and bat fatality rates. Fatality estimates and 90% confidence intervals will be calculated for five categories: 1) all birds, 2) small birds, 3) large birds, 4) raptors[5], and 5) bats. Annual and, if necessary, seasonal fatality estimates will be calculated on a per turbine and per megawatt (MW) basis. Seasonal periods will be defined as spring (April 15 – May 31), summer (June 1 – July 31), and fall (August 1 – October 15).

[4] Methods for fatality estimation are evolving (Strickland et al 2011). Should new statistical methods be developed prior to implementation of this study, EDPR and its consultant will consider those methods for use in the study and discuss changes in statistical methods with the USFWS and MDIFW.

[5] Raptors are defined here as eagles, owls, accipiters, buteos, harriers, and ospreys.

Estimates of Project-related fatalities will be based on:

(1) Observed number of carcasses found during standardized searches during the monitoring year for which the cause of death is either unknown or attributed to the facility;

(2) Searcher efficiency, expressed as the proportion of trial carcasses found by searchers during searcher efficiency trials.

(3) Carcass persistence rates, expressed as the estimated average probability a carcass is expected to remain in the study area and be available for detection based on carcass removal trials; and

(4) Search area adjustment based on the plot size and carcass distribution.

Except when obvious evidence to the contrary is present, all fatalities will be assumed to be attributable to wind facility operations.

Observed Number of Carcasses

The estimated average number of carcasses ($\bar{c}$) observed per turbine per monitoring year is:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k \cdot A}$$

where c_i is the number of carcasses detected at turbine *i* for the period of study, and *k* is the number of turbines searched, and *A* is an adjustment for carcasses falling in non-searched areas of the plot.

Estimation of Carcass Non-Removal Rates

Estimates of carcass non-removal rates are used to adjust carcass counts for removal bias. Mean carcass removal time ($\bar{t}$) is the average length of time a carcass remains in the study area before it is removed:

$$\bar{t} = \frac{\sum_{j=1}^{s} t_j}{s - s_c}$$

where *s* is the number of carcasses used in the scavenging trials and i denotes each carcass. Modifications to the estimator, S_c, will be made if there are trial carcasses that remain at the end of the 14-day trial period (Barnard 2000; Erickson et al. 2003a; Shumway et al. 1989).

Estimation of Searcher Efficiency Rates

Searcher efficiency rates are expressed as *p,* the proportion of trial carcasses that are found by searchers in the searcher efficiency trials. These rates will be estimated by carcass size and season.

Estimation of Facility-Related Fatality Rates

The estimated per turbine annual fatality rate (*m*) is calculated by:

$$m = \frac{\bar{c}}{\hat{\pi}} \qquad (3)$$

where $\hat{\pi}$ is the probability a carcass is not removed and is detected (adjustments for both carcass removal and searcher efficiency biases). If not statistically different across seasons , data for carcass removal and searcher efficiency bias will be pooled across the study to estimate $\hat{\pi}$.

$\hat{\pi}$ is calculated as follows:

$$\hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{\exp\left(I / \bar{t} \right) - 1}{\exp\left(I / \bar{t} \right) - 1 + p} \right]$$

where *I* is the interval between searches and *p* and *t* are as defined previously. This formula has been independently verified by Shoenfeld (2004). The reported estimates standard errors and 90% confidence intervals will be calculated using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances, and confidence intervals for complicated test statistics. For each bootstrap sample, $\bar{c}$, $\bar{t}$, p, $\hat{\pi}$, and m are calculated. A total of 1,000 bootstrap samples will be used. The standard deviation of the bootstrap estimates is the estimated standard error. The lower 5th and upper 95th percentiles of the 1,000 bootstrap estimates are estimates of the lower limit and upper limit of 90% confidence intervals.

Density-weighted Area Correction

The carcass density-weighted proportion (DWP) of area searched will be modeled to account for unsearched area; separate estimates will be calculated for small birds, large birds, and bats. Searched area is weighted as a function of distance from the turbine, because the areas near the turbine tend to have a higher density of carcasses than areas farther from the turbine (Huso 2014). The result is an estimate of the proportion of fatalities expected to land within searched and unsearched areas around a turbine. If carcass counts are low, the carcass density distribution will be estimated using a Bayesian approach (Gelman et al. 2013), and publicly-

available data regarding carcass distance from turbines from other studies in North America will be incorporated into the model prior distribution. Data from historical studies are only included in the prior distribution if the plots were completely searched (i.e., 100% of the plot area was searchable). If carcass counts are high, no historical data are used and the carcass density model is fit using standard maximum likelihood methods.

The observed distances of carcasses from turbines will be used to calculate a Bayesian posterior distribution of bat and bird distances from the turbine. The package BRugs in R is used to fit the parameters of the posterior distribution using the Gibbs sampler (Gelman 1984). The proportion of searchable area within each 1-m band is determined based on digitized maps of each turbine plot searched. The proportion of searchable area is multiplied by the proportion of fatalities expected to fall within each 1-m band yields a density-weighted area correction factor (a_i).

RESEARCH STUDY

Background

Bat mortality at the Project is expected to be similar to other regional wind projects and likely in the range of 1-2 bat fatalities per MW (see Table 1). EDPR is committed to minimizing the impact the Project may have on bats by implementing turbine operational adjustments to insure that bat mortality at the Project is reduced by 50% when compared to normally operating turbines. To achieve this goal, the Project will study the effects of feathering the turbine blades under varying wind speeds during the entire study period, and chose which wind speed best meets the goal while maximizing energy production. Numerous studies have shown that increasing turbine cut-in speed (the wind speed at which the turbine begins producing electricity) and feathering turbine blades under the cut-in speed have a dramatic effect on reducing bat mortality caused by turbines (Table 3). Results of these studies provide the basis for the research study at the Project.

Table 3. Results from publicly-available curtailment effectiveness studies.

Study Name	Normal Cut-in Speed (m/s)	Treatment Cut-in Speed (m/s)	Mean Percent Reduction in Mortality	Mean Percent Reduction in Bat Mortality Per Cut-in Speed	Source
Fowler Ridge, IN 2011	3.5	3.5	36	36	Good et al. 2012
Mount Storm, WV 2010[a]	4.0	4.0	35	46	Young et al. 2011
Summerview, Alberta	4.0	4.0	57.5		Baerwald et al. 2009
Fowler Ridge, IN 2011	3.5	4.5	57	51	Good et al. 2012
Anonymous Project (AN01), USFWS R3	3.5	4.5	47		Arnett et al. 2013
Wolfe Island, Ontario	4.0	4.5	48		Stantec 2011
Casselman, PA 2008	3.5	5.0	82	58	Arnett et al. 2010
Casselman, PA 2009	3.5	5.0	72		Arnett et al. 2010
Fowler Ridge, IN 2010[b]	3.5	5.0	50		Good et al. 2011
Criterion, MD 2012[c]	4.0	5.0	61		Young et al. 2013
Criterion, MD 2013[c]	4.0	5.0	57		Young et al. 2104
Pinnacle, WV 2013	3.0	5.0	54		Hein et al. 2014
Bull Hill, ME 2013	3.0	5.0	33		Stantec 2014
Summerview, AB	3.5	5.5	60	66	Baerwald et al. 2009
Fowler Ridge, IN 2011	4.0	5.5	73		Good et al. 2012
Anonymous Project (AN01), USFWS R3	3.5	5.5	72		Arnett et al. 2013
Wolfe Island, Ontario	4.0	5.5	60		Stantec 2011
Sheffield, VT[d]	4.0	6.0	60	60	Arnett et al. 2013
Casselman, PA 2008	3.5	6.5	82	77	Arnett et al. 2010
Casselman, PA 2009	3.5	6.5	72		Arnett et al. 2010
Fowler Ridge, IN 2010[b]	3.5	6.5	78		Good et al. 2011
Pinnacle, WV 2013	3.0	6.5	76		Hein et al. 2014
Beech Ridge, WV 2012	3.5	6.9	89[f]	91	Tidhar et al. 2013
Beech Ridge, WV 2013	3.5	6.9	93[f]		Young et al. 2014

[a] Based on the average reduction of 47% and 22% from first and second halves of the night; note that an average reduction of 61% (72% and 50% from first and second halves of the night) was realized when comparing only nights when treatments were in place (32% and 40% of the time for the first and second halves of the night) to nights when treatments were not in place

[b] Study did not include feathering below cut-in speed

[c] Percent reduction is based on comparison to the previous year's results from mortality monitoring, since there were no control turbines during the year the curtailment was implemented

[d] Raised cut-in speeds were applied only when temperatures were above 49° F (9.5° C)

[e] Percent reduction based on comparison to the Eastern North America regional average of bat mortality

[f] There were no control turbines at the Beech Ridge project – all turbines were feathered below 6.9 m/s wind speeds. Percent reduction based on comparison to average bat mortality at two other West Virginia projects, likely most relevant to what impacts could have been at the site in the absence of feathering.

Experimental Design

All 119 turbines will be included in the research study. Each turbine will be systematically assigned to one of three treatments for the duration of the study period:

1. turbines allowed to run normally (cut-in speed 3.0 m/s) from one-half hour before sunset to one-half hour after sunrise.
2. turbine blades feathered below a cut-in speed of 4.0 m/s from one-half hour before sunset to one-half hour after sunrise.
3. turbine blades feathered below a cut-in speed of 5.0 m/s from one-half hour before sunset to one-half hour after sunrise.

Feathering the turbine blades will cause the rotors to move less than 1-2 rotations per minute (rpm). As wind speed increase and the 10 minute average wind speeds reaches either the 4.0 m/s or 5.0 m/s threshold, the turbine will be released to run and the blades will pitch into the wind and the rotor speed will increase. As wind speed decreases and the 10 minute average wind speed reaches either the 4.0 or 5.0 m/s threshold, a pause command will be sent to the turbine and the blades actively feathered so the rotor speed decreases to below 1-2 rpm.

The turbines will be systematically assigned to a treatment so as to achieve approximately equal spatial coverage by treatment across the Project Area. Each treatment will be left in place for the entire study period. The research study will be conducted for entire monitoring period; from April 15 to the end of the monitoring October 15. This encompasses the migration periods for bats, the summer maternity season, and the period when bat mortality is expected to be the highest which is generally during the late summer and fall migration (Johnson 2005; Arnett et al. 2008).

The power to detect effects is related to a number of factors and the study is designed to increase the sample size of these factors as much as possible. Because bat mortality in Maine has been low (see Table 1; average approximately 1.135 bat per MW) few bat fatalities are expected per turbine for the entire study period which will compromise the ability to measure a significant effect. To maximize the number of bats found, all turbines will be search on a four-day rotation. The average bat carcass removal time for studies in the northeast has been approximately 5 days. The search interval will be less than this so on average fatalities will be available to be found on any given search, given a 4-day search interval. The number of nights a treatment is in effect at each turbine, in this case 184 nights, will be higher than many other studies to maximize the sample size per treatment. In addition, treatments for each turbine will be fixed for the entire research study period so that any bat recovered (no matter what the estimated time of death was) can be attributed to a treatment which minimizes the number of bat fatalities that may need to be excluded because date (night) of death is unknown.

Study Methods

The field study methods for the research study will be identical to those for the general monitoring study described above. Participants in the field study will not know which turbines are subject to which cut-in speed treatment at any given time. Standardized carcass searches

will continued under the normal schedule (4-day search interval). Carcass removal and searcher efficiency trials will continue according the normal schedule, as well.

Estimation of the Curtailment Reduction in Bat Carcasses

The effects of feathering blades below the raised cut-in speeds will be examined using two statistical approaches. The first approach involves calculation of estimated bat fatality rates and associated confidence intervals for each treatment. Point estimates of bat fatality rates and confidence intervals will be compared and overlapping confidence intervals will be interpreted as lack of evidence of significant differences between the point estimates (treatments).

The second approach will involve calculating the reduction in the bat fatality rates for the 4.0 m/s and 5.0 m/s turbines relative to the fatality estimates for the 3.0 m/s control turbines. Fatality rates will be calculated using all bat fatalities found at a turbine within the study period and for the morning following the last night of treatments.

Percent reduction estimates that are not different from 0 (i.e., confidence interval includes 0) will indicate no significant differences in bat fatality rates between treatment types. Reductions that are significantly greater than 0 indicate significant decreases in relative fatality rates relative to the 3.0 m/s control treatment. Bootstrap simulations, as described above, will be used to estimate confidence intervals on the reductions.

REPORTING

Reporting will be comprised of an annual study year report disseminated to the MDIFW and USFWS for review and comments.

Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures will be implemented at all stages of the study, including in the field, during data entry and analysis, and during report writing. Following field surveys, observers are responsible for inspecting data forms for completeness, accuracy, and legibility. A sample of records from an electronic database will be compared to the raw data forms and any errors detected will be corrected. Irregular codes or data suspected as questionable will be discussed with the observer and/or project manager. Errors, omissions, or problems identified in later stages of analysis will be traced back to the raw data forms, and appropriate changes in all steps will be made.

Data Compilation and Storage

A Microsoft® SQL Server database will be developed to store, organize, and retrieve data. Data will be keyed into the electronic database using a pre-defined format to facilitate subsequent QA/QC and data analysis. All data forms, field notebooks, and electronic data files will be retained for reference.

An annual report will be prepared following completion of field surveys. The report will be completed and submitted to the MDIFW and USFWS by January 31 of the year following the year of monitoring. The final report will include details of the post construction mortality studies consistent with the request of the MDIFW (2014), and will include a description of the study methods and Project Area; results of the avian and bat mortality study including details of the numbers and locations of casualties found, searcher efficiency and carcass removal trails, and analysis, including estimates of mortality, and results of the research study showing comparisons of bat fatality rates among the treatments.

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APPENDIX A

EXAMPLE DATA FORMS

Number Nine Wind Farm
Post Construction Avian and Bat Monitoring Study

Casualty Information Form Project: Number Nine Wind Farm

Temperature (F) _____ Precipitation: **none light rain rain light snow other**
TURBINE BEING SEARCHED**:** _____**(INC – for incidental find)** Searcher: _____
Casualty ID # **(example ID: 010109-BARS-1-1)** : _____
Date Found: _____ Time Found: _____
Found During (circle one): Scheduled Carcass Search Incidental Find
CASUALTY **(circle one)**: **Bird / Bat** On road/pad **(circle one): Yes / No**

Species Name: _____ Species Code: _____
Collected **(circle one)**: **Yes No**
Age **(circle one)**: **A J U** Sex **(circle one)**: **M F U**
Physical Condition at time of find **(circle one)**: **Intact / Feather Spot / Scavenged / Dismembered / Injured**
If Injured (circle one): **Euthanized / Released / Transported to rehab. facility**
Position (circle one): **Face Up Face Down**
Describe injuries: _____
_____
Scavenging: **Yes No** Possible Scavengers: **(circle the most prevalent)**
small carnivores large carnivores
rodents corvids or other birds unknown
insects (external scavenging)
other: _____
Scavenging Notes:_____
_____

Carcass Condition:
_____ **No Decomposition (no visible signs of decomp.)**
_____ **Decomposing – early (flesh mostly present)**
_____ **Decomposing – late (flesh mostly absent)**
_____ **Desiccated**
_____ **N/A (e.g., feathers only)**

Infestation:
_____ **None** _____ **Flies**
_____ **Ants** _____ **Maggots**
_____ **Bees/Wasps** _____ **Beetles**
_____ **Grasshoppers** _____ **Other**

Eyes:
_____ **Round/fluid filled**
_____ **Dehydrated**
_____ **Sunken**
_____ **Absent (empty skull)**
_____ **N/A (e.g., head missing)**

Estimated time of death (mark only one):
_____ **Last night** _____ **> 2 weeks**
_____ **2 – 3 days** _____ **> 1 Month**
_____ **4 – 7 days** _____ **Unknown/Undetermined**
_____ **7 – 14 days**

Photo Numbers **(at least 4 photos of fatality and surrounding landscape):**_____
Additional Notes: _____
_____

LOCATION (Part # 1)
Nearest turbine **(number):** _____
Quadrant: **NE SE NW SW** Bearing from turbine: _____ Distance from turbine (m): _____
Transect #:_____ Perpendicular Distance to Transect (m):_____
UTM: Datum: _____ (i.e. NAD 83) Easting:_____ Northing:_____
Found Outside of plot? Yes No
LOCATION (Part # 2)

Nearest turbine **(number):** _____

Quadrant: **NE SE NW SW** Bearing from turbine: _____ Distance from turbine (m):_____

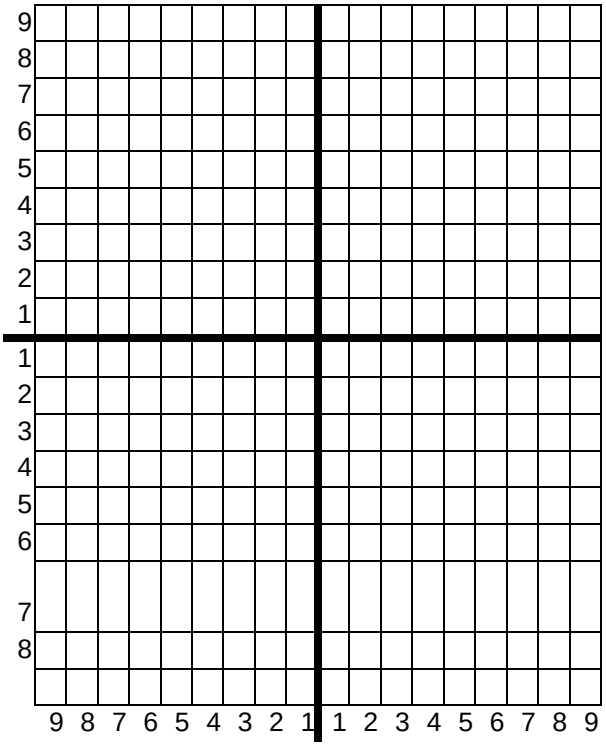
Transect #:_____ Perpendicular Distance to Transect:_____

UTM: Datum: _____ (i.e. NAD 83) Easting:_____ Northing:_____

Found Outside of plot? Yes No

Map Approx. Location on diagram: (label with part number)

N
↑



VEGETATION (w/in 1 m² of carcass)

Dominant Cover (choose only one):

_____ **Bare Dirt (0% veg; dirt)**

_____ **Gravel (0% veg; access road or pad)**

_____ **Grassy area**

_____ **Other:** _____

% Veg cover w/in 1 m radius of carcass **(circle one):**

<10 11-25 26-50 50-75 75-99 100

Slope >25%: **Yes No**

Veg. Height: **Max**_____ **Avg.**_____

Visibility Index:

_____ **Easy (e.g. ≥ 90% bare ground; vegetation <6" tall)**

_____ **Moderate (e.g.,26-89 % BG; vegetation < 6" tall)**

_____ **Difficult (e.g. ≤ 25% BG; ≤ 25% ground cover ≥ 12" tall vegetation or rock/scrub)**

_____ **Very Difficult (e.g., ≤ 25% BG; > 25% of ground cover ≥ 12" tall vegetation or rock/scrub)**

_____ **Not searched (dense shrub/tree cover)**

White Nose Syndrome Score: _____

Additional Notes: _____

CASUALTY SEARCH FORM

Project: Number Nine Wind Farm

DATE:_____ OBSERVER(s):_____ TURBINE NO.: _____
TIME BEGIN:_____ TIME END:_____ GROUND COVER
_____

CASUALTIES FOUND:

SPECIES	SAMPLE NO.	HABITAT

SEARCHER EFFICIENCY CARCASSES FOUND:

SPECIES	ID TAG	HABITAT

DATE:_____ OBSERVER(s):_____ TURBINE NO.: _____
TIME BEGIN:_____ TIME END:_____ GROUND COVER
_____

CASUALTIES FOUND:

SPECIES	SAMPLE NO.	HABITAT

SEARCHER EFFICIENCY CARCASSES FOUND:

SPECIES	ID TAG	HABITAT

DATE:_____ OBSERVER(s):_____ TURBINE NO.: _____
TIME BEGIN:_____ TIME END:_____ GROUND COVER
_____

CASUALTIES FOUND:

SPECIES	SAMPLE NO.	HABITAT

SEARCHER EFFICIENCY CARCASSES FOUND:

SPECIES ID TAG HABITAT

_____ _____ _____

_____ _____ _____

SEARCHER EFFICIENCY TRIALS: CARCASS PLACEMENT LOG ***Number Nine Wind Project***

General Information: Season_____ Month_____ Other_____

No.	Species/Age	Placed By	Date	Time	Plot: Location	Found? (yes/no)	Retrieved? (yes/no)	Available?	Notes
1									
2									
3									
4									
5									
6									
7									
8									
9									
dfs 10									
11									
12									
13									
14									
15									

Weather notes for days that carcasses are placed:

Date_____ Time_____ Temp_____ Wind Dir._____ Wind Speed_____ Precip_____
Date_____ Time_____ Temp_____ Wind Dir._____ Wind Speed_____ Precip_____
Date_____ Time_____ Temp_____ Wind Dir._____ Wind Speed_____ Precip_____
Date_____ Time_____ Temp_____ Wind Dir._____ Wind Speed_____ Precip_____
Date_____ Time_____ Temp_____ Wind Dir._____ Wind Speed_____ Precip_____
Date_____ Time_____ Temp_____ Wind Dir._____ Wind Speed_____ Precip_____

CARCASS REMOVAL TRIAL FORM Project: Number Nine Wind Farm

General Information: Season_____ Month_____
Other_____

	Information Regarding Carcass When Placed							Condition[1] of Carcass on Day Checked										
No.	Species	Age	Plot & Location	Expos.[2]	Placed By	Date	Time	Day 1	Day 2	Day 3	Day 4	Day __	Day __	Day __	Day __	Day __	Day __	Notes
1																		(1)
2																		(2)
3																		(3)
4																		(4)
5																		(5)
6																		(6)
7																		(7)
8																		(8)
9																		(9)
10																		(10)
11																		(11)
12																		(12)

[1] Condition: **I** = intact, no evidence of scavenging, **S** = evidence of scavenging, **FS** = feather spot, **P** = partial carcass, **NF** = insect infestation, **0** = carcass not present or <10 feathers

[2] Exposure: **1** = exposed position, **2** = hidden, **3** = partially hidden

General Comments / Notes about location of each carcass, possible scavengers, other carcass specific comments:

(1)_____
(2)_____
(3)_____
(4)_____
(5)_____
(6)_____
(7)_____
(8)_____
(9)_____
(10)_____