APPENDIX 4.6-1

GAL 2022 Wind Turbine Wildlife Collision Risk Assessment

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REPORT

Wind Turbine Wildlife Collision Risk Assessment

Horse Heaven Wind Farm

Submitted to:

Horse Heaven Wind Farm, LLC

5775 Flatiron Parkway, Suite 120
Boulder, CO 80301

Submitted by:

Golder Associates Ltd.

Suite 200 - 2920 Virtual Way, Vancouver, British Columbia, V5M 0C4, Canada

+1 604 296 4200

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Executive Summary

Horse Heaven Wind Farm, LLC (the Applicant) is proposing to develop the Horse Heaven Wind Farm (the Project) in Benton County, Washington. The Applicant is considering two general turbine options comprising four different turbine technologies. The four turbine technologies presented in the Application for Site Certification are examples of available technologies and are not prescriptive of what might be available at the time of construction. Under Option 1, turbines would be shorter and have a smaller rotor diameter than under Option 2. Option 2 would involve fewer turbines because each turbine would have a higher energy production capability. This special study report compares the potential bird and bat collision risk associated with each turbine option based on existing information collected during baseline studies conducted for the Project and a review of published scientific literature pertaining to bird and bat interactions with wind turbines.

Baseline studies conducted by the Applicant considered in this special study report are avian use surveys (AUS) and acoustic bat surveys. AUS were conducted for the Project and used to determine a relative index of bird exposure, which is a relative measure of species-specific risk to turbine collisions that considers each species' local abundance, proportion of observations in flight, and observed flight heights. Exposure indices are available for eight special status bird species and were compared between turbine technologies to evaluate relative collision risk.

Acoustic bat surveys were conducted by the Applicant to estimate bat activity levels within the Project area during the known regional period of bat activity. Acoustic detectors were deployed at four sites in and around the Project Lease Boundary with paired microphones placed near ground level and approximately 148 feet (45 m) above ground level on a meteorological tower. Eight bat species were documented during acoustic bat surveys in and around the Lease Boundary. Most recorded bat passes were produced by three low-frequency bat species: silver-haired bat *(Lasionycteris noctivagans)*, hoary bat *(Lasiurus cinereus)*, and big brown bat *(Eptesicus fuscus)*.

The literature review suggests that the effect of turbine height and rotor swept area on bird collision mortalities remains uncertain (AWWI 2021). Some studies did not find a relationship between bird mortality rates and turbine height (Everaert 2014; Barclay et al. 2007; Krijgsveld et al. 2009). Other studies report higher bird mortality rates at taller turbines on a per turbine basis (Loss et al. 2013; De Lucas et al. 2008, Thelander et al. 2003) but lower mortality rates per unit of energy generation (Thaxter et al. 2017), although this is not unequivocal (Huso et al. 2021). Nevertheless, replacing several small turbines with fewer larger turbines has been hypothesized to reduce bird collision risk, particularly for raptors (Arnett and May 2016; Dahl et al. 2015; Thaxter et al. 2017).

Collision with turbines is considered one of the greatest threats to bats in North America (O'Shea et al. 2016). Three species of migratory tree-roosting bats (i.e., eastern red bat *[Lasiurus borealis]*, silver-haired bat, hoary bat) make up most bat mortalities resulting from turbine collision, raising concerns about population-level impacts as the number of wind farms increases (Barclay et al. 2007; Zimmerling and Francis 2016; Hein and Schirmacher 2016). However, there is limited and conflicting information about the effect of turbine height on bat collision mortalities. Some studies report that bat mortality rates increase with turbine size (Baerwald and Barclay 2009), including on a per megawatt (MW) basis (Barclay et al. 2007), while others report no effect (Huso et al. 2021), the opposite effect (Fielder et al. 2007), or that mortality rates increase on either side of an optimum intermediate turbine size (Thaxter et al. 2017).

The following provides a summary of anticipated wildlife collision risk associated with the two turbine options based on information collected during baseline studies and a review of available published scientific literature:

- Based on AUS data:
  - Mean exposure indices for small bird species were highest at the GE 3.03-MW turbines (Option 1) and similar across the three other turbine technologies. Therefore, Option 1 is expected to result in a greater number of small bird mortalities.
  - Among large bird species, exposure indices for raptors were higher for shorter turbines (Option 1), but exposure indices for waterfowl were higher at taller turbines (Option 2). It is expected that the option requiring a greater number of shorter turbines (Option 1) would result in more large bird mortalities because raptors appear more susceptible to turbine collisions than waterfowl (AWWI 2021).
  - Option 1 is expected to result in greater collision risk for six of the eight special status bird species observed during AUS (ferruginous hawk *[Buteo regalis]*, golden eagle *[Aquila chrysaetos]*, prairie falcon *[Falco mexicanus]*, tundra swan *[Cygnus columbianus]*, American white pelican *{Pelecanus erythrorhycnhos]*, great blue heron *[Ardea herodias]*). Exposure indices were highest for Option 2 technologies for two special status bird species (sandhill crane *[Grus canadensis]*, bald eagle *[Haliaeetus leucocephalus]*), but it is uncertain to what degree this may be offset by fewer turbines.
- Based on a literature review, the weight of evidence suggests that per unit of energy output, a wind farm layout with fewer larger turbines (i.e., Option 2) is likely to have fewer total bird mortalities than one with a greater number of smaller turbines (i.e., Option 1).
- The relationship between turbine height and bat collision mortalities is too inconclusive to make confident predictions regarding which turbine option is expected to result in fewer bat mortalities.

It is important to acknowledge that there is uncertainty associated with these conclusions related to conflicting results in available published scientific studies, lack of studies at turbines within the range of heights considered for the Horse Heaven Wind Farm, and potential for substantial variability in wildlife mortality based on local factors (e.g., bird abundance, species composition, topography, habitat, spatial arrangement of turbines). These sources of uncertainty limit the confidence of predicted wildlife mortality risk associated with the two turbine options.

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1.0 INTRODUCTION

Horse Heaven Wind Farm, LLC (the Applicant) is proposing to develop the Horse Heaven Wind Farm (the Project) in Benton County, Washington. The Applicant is considering two general turbine options comprising four different turbine technologies to facilitate flexible turbine siting (Table 1). The turbine technologies are examples of available technologies and are not prescriptive of what might be available at the time of construction. Under Option 1, turbines would be shorter and have a smaller rotor diameter than under Option 2. Option 2 would involve fewer turbines because each turbine would have a higher energy production capability. Golder Associates Ltd. (Golder) was retained to complete this special study report comparing the potential bird and bat collision risk associated with each turbine option.

2.0 METHODS

Each turbine option has two possible turbine technologies (see Table 1). The specifications for each type served as the basis for evaluating bird and bat collision risk associated with Option 1 and Option 2.

Table 1: Potential Turbine Specifications

Turbine Parameters/Features	Turbine Option 1		Turbine Option 2	
	GE 2.82 MW Turbine	GE 3.03 MW Turbine	GE 5.5 MW Turbine	SG 6.0 MW Turbine
Tower Type	Tubular	Tubular	Tubular	Tubular steel / hybrid
Maximum Number of Turbines Considered	244	244	150	150
Turbine Rotor Diameter	127 m / 417 ft	140 m / 459 ft	158 m / 518 ft	170 m /557 ft
Turbine Hub Height (ground to nacelle)	89 m / 292 ft	81 m / 266 ft	125 m / 411 ft	113 m / 377 ft
Maximum Total Height (ground to blade tip)	152 m / 499 ft	151 m / 496 ft	204 m / 671 ft	200 m / 657 ft
Tower Base Diameter	4.6 m / 15.1 ft	4.6 m / 15.1 ft	4.6 m / 15.1 ft	4.7 m / 15.5 ft

Source: Table 2.3-1 of the Application for Site Certification (Horse Heaven Wind Farm, LLC 2021)

ft = feet; GE = General Electric; MW = megawatts; m = meters; SG = Siemens Gamesa

Bird and bat collision risk associated with the two general turbine options was evaluated based on site-specific information collected during baseline studies conducted for the Project and presented in the Application for Site Certification (ASC) to the Washington Energy Facility Site Evaluation Council (Horse Heaven Wind Farm LLC, 2021), in combination with a review of published scientific literature pertaining to bird and bat interactions with wind turbines.

2.1 Baseline Studies

The following sections provide an overview of baseline studies conducted for the Project and how those data were used in this special study report. For detailed information related to baseline wildlife studies, refer to Section 3.4.1.3 of the ASC and Appendices K and M to the ASC (Horse Heaven Wind Farm, LLC 2021).

2.1.1 Avian Use Surveys

Avian use surveys (AUS) were conducted for the Project from 2017 to 2020 to document temporal and spatial use of the Lease Area by small and large bird species. AUS consisted of 10-minute, 100-meter (m) circular plot point counts for small birds and 60-minute, 800-m circular plot point counts for large birds. During both survey methodologies, biologists recorded the bird species observed, number of individuals, distance, flight height and direction, and habitat types.

Data from AUS conducted during all years, survey areas, and seasons were aggregated to calculate a relative index of bird exposure, *R*, which is a relative measure of species-specific risk of turbine collision, using the following formula:

$$R = A \times P_f \times P_t$$

- *A* equals the mean relative use (i.e., average number of observations per survey plot) for a particular species (i.e., species *i*). Mean relative use was calculated by summing the total number of observations within each plot during a visit, then averaging across all survey plots within each visit, followed by averaging across visits within each season, and finally averaging seasonal values weighted by the number of days in each season;
- P_f equals the proportion of all observations of species *i* where activity was recorded as flying; and
- P_t equals the proportion of all initial flight height observations of species *i* within the rotor swept height for the proposed turbine.

The exposure index provides a relative measure of species-specific collision risk with a wind turbine at the Project based on their local abundance, proportion of flying observations, and flight heights. The exposure index can also be used to compare relative collision risk for a particular species between turbines with different rotor swept zones. A greater exposure index value represents higher collision risk. For example, a species with an exposure index of 0.20 is ten times more likely to be exposed to collision with a wind turbine than a species with an exposure index of 0.02. However, the exposure index is not directly translatable to the number of bird mortalities. This is partly because it does not take into consideration habitat selection, flight movements relative to proposed turbine siting, or species-specific ability to detect and avoid turbines.

Exposure indices for Option 1 and Option 2 turbine technologies were compared to evaluate bird collision risk. However, the relative index of exposure does not consider the number of turbines required for each option. If the exposure index for Option 1 technologies is greater than for Option 2 technologies, it was assumed that the overall collision risk for Option 1 is also greater because it consists of a larger number of turbines. However, the opposite does not necessarily hold true. If the exposure index for Option 2 technologies is greater than Option 1 technologies, collision risk could still be offset by fewer turbines, depending on the magnitude of the differences in the exposure indices and the number of turbines. Unfortunately, there is no clear mathematical relationship between the exposure index and number of turbines. Therefore, assessment of mortality risk based on exposure indices was evaluated qualitatively.

2.1.2 Acoustic Bat Surveys

The objective of acoustic bat surveys was to estimate bat activity levels within the Project area during the known regional period of bat activity. Acoustic surveys were conducted at four sites in and around the Project Lease Boundary from August through October in 2017 and from May through October in 2018 using a combination of Anabat SD2 Active Bat Detector and Wildlife Acoustic Song Meter SM3 full-spectrum acoustic detectors. At each site, one microphone was deployed near ground level, at approximately 5 feet (1.5 m) above ground level, and another was raised on the same meteorological tower to approximately 148 feet (45 m) above ground level. Three detector sites were in grassland habitat and one detector site was in shrub-steppe habitat. Bat activity recorded at detectors was summarized as the number of total passes, as well as passes by high-frequency (>30 kilohertz [kHz]) and low-frequency (<30 kHz) bat groups.

The relationship between pre-construction bat acoustic activity and post-construction bat mortality rates at wind farms has been debated in scientific literature (Hein et al. 2013). Based on an analysis of paired pre- and post-construction studies from 49 wind farms in the United States and Canada, Solick et al. (2020) found that pre-development bat activity rates did not predict bat mortality rates during operation. A possible explanation for the lack of a predictive relationship is that some bat species may be attracted to wind turbines as hypothesized by several studies (AWWI 2021; Arnett and May 2016; Guest et al. 2022). There is uncertainty around the causes of attraction and information at the species-level is limited (Guest et al. 2022). Therefore, information from acoustic bat surveys was primarily used to focus the literature review on bat species present within the Project Lease Boundary instead of attempting to use pre-construction bat activity as a predictor of bat mortality.

3.0 RESULTS

3.1 Birds

3.1.1 Avian Use Studies

Species-specific exposure indices derived from AUS are presented in Appendix A. The exposure indices represent relative collision risk but are not directly translatable to the number of bird mortalities due to factors such as species-specific collision avoidance.

3.1.1.1 Small Bird Species

The number of small bird species with non-zero exposure indices for each turbine technology was nine species for the GE 2.82-megawatt (MW) turbine (Option 1), 16 species for the General Electric (GE) 3.03-MW turbine (Option 1), two species at the GE 5.5-MW turbine (Option 2), and six species at the Siemens Gamesa (SG) 6.0-MW turbine (Option 2). Non-zero species-specific mean exposure indices were highest for all small bird species at the GE 3.03-MW turbines (Option 1) and similar across the three other turbine technologies. Exposure indices were generally low, ranging from 0.001 to 0.312 for all species and turbine technologies, except for horned lark (*Eremophila alpestris*) at the Option 1, GE 3.03 MW turbines (exposure index of 1.275). Based on these exposure indices, it is expected that collision risk for small bird species would be greater for Option 1 technologies, especially the GE 3.03-MW turbine, than Option 2 technologies. Because Option 1 would require a greater number of turbines than Option 2, it is also expected that small bird mortalities would be greater under Option 1 than Option 2. Studies show that, for small passerine (i.e., songbird) species, turbine-related mortalities resulting from currently developed wind farms constitute a small percentage of their total population size (<0.045%) (Erickson et al. 2014) and do not appear likely to lead to population-level impacts (AWWI 2021).

3.1.1.2 Large Bird Species

The number of large bird species with non-zero exposure indices was similar for all turbine technologies, ranging from 34 species for the GE 3.03-MW turbine (Option 1) to 29 species for the GE 5.5-MW turbine (Option 2). In general, exposure indices for raptors were higher for shorter turbines than taller turbines. Conversely, exposure indices for waterfowl (i.e., ducks, geese, and swans) were higher at taller turbines. However, mortalities of waterbirds and waterfowl are relatively infrequent at land-based wind farms, whereas diurnal raptors appear more susceptible (AWWI 2021). Therefore, it is expected that the option requiring a greater number of shorter turbines (Option 1) would result in a greater number of large bird mortalities. Large bird species that are slow to mature and have a low reproductive rate may be more susceptible to population-level impacts from collision mortality (Watson et al. 2018). Demographic modeling suggests potential for population-level impacts for some raptor species, including ferruginous hawk *(Buteo regalis)* and golden eagle *(Aquila chrysaetos)*, based on future wind energy projections (Diffendorfer et al. 2021).

3.1.1.3 Special Status Bird Species

Conservation status of wildlife species reflects their existing population size and trends. Special status bird species are likely less resilient to population declines, and it is prudent to consider their species-specific potential for collision mortality associated with the two turbine options. For the purposes of the ASC, special status bird species were defined as species listed under the U.S. Endangered Species Act, state-listed endangered species, state-listed threatened species, state-listed sensitive species, state-listed candidate species, Washington Department of Fish and Wildlife priority species, and eagles (Horse Heaven Wind Farm LLC, 2021). Fourteen special status bird species have potential to occur within the Project Lease Boundary, with 13 species documented in the Project Lease Boundary (Horse Heaven Wind Farm LLC, 2021). Mean exposure indices from AUS conducted for the Project are available for eight special status bird species. Mean exposure indices are not available for the following six special status bird species: burrowing owl *(Athene cunicularia)*, loggerhead shrike *(Lanius ludovicianus)*, ring-necked pheasant *(Phasianus colchicus)*, sagebrush sparrow *(Artemisiospiza nevadensis)*, sage thrasher *(Oreoscoptes montanus)*, and Vaux's swift *(Chaetura vauxi).* For the eight species with data, the exposure indices for the different turbine technologies under consideration for the Project are discussed below and summarized in Table 2.

- American white pelican *(Pelecanus erythrorhycnhos)*: Exposure indices for American white pelican are similar for all turbine technologies, ranging from 0.289 for Option 1 technologies to 0.303 for Option 2 technologies (Table 2). However, the Applicant has excluded areas of the highest observed use by American white pelican from the Project Lease Boundary, which reduces the turbine collision exposure for this species. Based on the observed similarities in exposure indices across all turbine technologies, it is expected that the option requiring more turbines (Option 1) would result in greater collision risk for American white pelicans.
- Sandhill crane *(Grus canadensis)*: The exposure index for sandhill cranes for Option 1 technologies is approximately eight times less than Option 2 technologies (Table 2). Sandhill cranes have the highest mean use of the special status bird species observed during AUS. However, sandhill cranes may not be particularly susceptible to collision risk with turbines. Studies at wind facilities in other parts of the United States have shown that sandhill cranes are likely to avoid turbines despite relatively high numbers of sandhill cranes observed within and surrounding wind facilities (Nagy et al. 2012; Pearse et al. 2016).
- Ferruginous hawk: The exposure index for ferruginous hawks is approximately 1.3 times greater for the GE 3.03-MW turbine (Option 1) than for the other three turbine technologies (Table 2). AUS indicated very low mean use of the Project area by ferruginous hawks; however, breeding has been observed within 2 miles of the Lease Boundary. Because Option 1 also requires a larger number of turbines, it is expected that this option would result in greater collision risk for ferruginous hawks.
- Bald eagle *(Haliaeetus leucocephalus)*: The exposure index for bald eagles is approximately 1.1 to 1.3 times greater for Option 2 technologies than Option 1 technologies (Table 2). It is uncertain if the smaller exposure indices for Option 1 technologies would offset the larger number of turbines required.

- Golden eagle: The exposure index for golden eagles for Option 1 technologies is approximately 1.2 times greater than the GE 5.5-MW turbine (Option 2), but the same as for the SG 6.0-MW turbine (Option 2) (Table 2). Because Option 1 would also require a greater number of turbines than Option 2, it is expected to result in greater collision risk for golden eagles.
- Great blue heron *(Ardea herodias)*: Exposure indices are less than 0.001 for all turbine technologies (Table 2); therefore, the option requiring more turbines (Option 1) is expected to result in greater collision risk for great blue herons.
- Prairie falcon *(Falco mexicanus)*: Exposure indices for prairie falcons are 1.2 to 3.3 times greater for Option 1 technologies than Option 2 technologies (Table 2). Because Option 1 would also require a greater number of turbines than Option 2, it is expected to result in greater collision risk for prairie falcons.
- Tundra swan *(Cygnus columbianus)*: Exposure indices for tundra swans are 0.011 for the GE 3.03-MW turbine (Option 1) and zero at all other turbine technologies (Table 2). Because Option 1 would also require a greater number of turbines than Option 2, it is expected to result in greater collision risk for tundra swans.

Of the eight special status bird species for which exposure indices are available, exposure indices are highest for Option 1 technologies for four species (ferruginous hawk, golden eagle, prairie falcon, and tundra swan) and similar across all technologies for two species (American white pelican and great blue heron). Option 1 is expected to result in greater collision risk for these six special status species based on the combination of higher exposure indices and greater number of turbines than Option 2. Exposure indices are highest for Option 2 technologies for two special status bird species (sandhill crane and bald eagle), but it is uncertain to what degree this may be offset by fewer turbines. When interpreting these conclusions, it should be noted that exposure indices do not consider species-specific collision avoidance behavior around wind turbines.

Table 2: Exposure Indices for Special Status Bird Species

Common Name	Overall Mean Use[1]	Exposure Index			
		Option 1 (GE 2.82 MW Turbine)	Option 1 (GE 3.03 MW Turbine)	Option 2 (GE 5.5 MW Turbine)	Option 2 (SG 6.0 MW Turbine)
American white pelican	0.35	0.289	0.290	0.303	0.303
Sandhill crane	1.60	0.042	0.042	0.332	0.332
Bald eagle	0.02	0.009	0.011	0.012	0.012
Tundra swan	0.01	0	0.011	0	0
Prairie falcon	0.02	0.007	0.010	0.003	0.006
Golden eagle	0.01	0.007	0.007	0.006	0.007
Ferruginous hawk	0.01	0.003	0.004	0.003	0.003
Great blue heron	<0.01	<0.001	<0.001	<0.001	<0.001

[1] Overall mean use is the average number of observed individuals per survey plot.

GE = General Electric; MW = megawatts; SG = Siemens Gamesa

3.1.2 Literature Review

The effect of turbine height and rotor swept area on bird collision mortalities remains uncertain (AWWI 2021). It is possible that local factors at wind farms (e.g., bird abundance, species composition, topography, habitat, spatial arrangement of turbines) can lead to strong variation in bird mortality rates that confound possible effects of turbine size (Marques et al. 2014; Everaert 2014). Turbine size has been suggested as an important factor for collision risk because higher turbines may extend into the airspace traveled by migrating birds and higher turbines typically have a larger rotor swept zone and consequently a larger collision risk area. However, the relationship between turbine heights and bird mortality rates is not consistent among studies.

Some studies report higher bird mortality rates per turbine at taller turbines. Bird collision mortality modeled by Loss et al. (2013) predicted that mortality rates would increase nearly tenfold from 0.64 to 6.20 birds per turbine across the range of turbine heights included in their study, which was 118 to 262 feet (36 to 80 m). De Lucas et al. (2008) found a positive relationship between turbine height and mortality rate of raptors (i.e., more fatalities at taller turbines) at two wind farms in Spain where turbine heights ranged from 59 to 118 feet (18 to 36 m). A similar positive relationship was observed at Altamont Pass, California, where the number of bird mortalities at turbines with larger rotor diameters and rotors 79 feet (24 m) above ground was more than expected based on the number of turbines alone (Thelander et al. 2003). Thaxter et al. (2017) noted that bird mortality rates increased with larger turbine capacity (megawatts).

Other studies did not find a relationship between bird mortality rates and turbine height. Bird mortality rate and collision risk were not significantly related to turbine size at eight wind farms in Belgium, where turbine characteristics ranged from 75 to 322 feet (23 to 98 m) hub height and 112 to 456 feet (34 to 139 m) maximum total height (i.e., blade tip) (Everaert 2014). Barclay et al. (2007) compiled wind turbine and bird and bat mortality data from 33 wind farms in North America to assess the influence of turbine characteristics on collision risk. Turbine characteristics varied among sites, with rotor diameters ranging from 59 to 295 feet (18 to 90 m) and turbine hub heights ranging from 78 to 308 feet (24 to 94 m). They found that turbine height and rotor diameter did not influence bird mortality rate. The authors suggested that because a significant proportion of bird mortalities at wind farms occur during the day, the ability of birds to detect and avoid turbines may not vary with turbine size (Barclay et al. 2007). Krijgsveld et al. (2009) found that bird collision risk with larger multi-MW turbines (hub height 220 to 256 feet [67 to 78 m]; rotor diameter 217 feet [66 m]) was similar to earlier generation turbines and suggested that the increased altitude of turbine blades may allow more local birds (i.e., birds not undertaking migratory flight) to pass underneath the rotor area, while greater spacing between larger turbines may allow birds to pass between turbines. Further, mortality rates could also be related to rotation speed of the rotors (Krigjsveld et al. 2009). Large rotors rotate at lower speeds than small ones, which reduces the probability that birds flying through the rotor swept area will be hit (Orfloff and Flannery 1996). Tucker (1996) demonstrated mathematically that collision risk is higher closer to the hub than at the rotor tip and does not increase linearly with the surface area of the rotor swept zone.

Bird mortality rates may be lower at taller turbines per unit of energy generation, however results are not unequivocal. Although Thaxter et al. (2017) noted a strong positive relationship between wind turbine capacity (i.e., MW) and bird collision rate per turbine, the strength of this relationship was offset by the reduced number of turbines required per unit of energy generation. A greater number of small turbines resulted in higher predicted bird mortality rates than a smaller number of large turbines per unit energy output (Thaxter et al. 2017). Thaxter et al. (2017) concluded that wind farm generation capacity should be met by deploying fewer large turbines, rather than many smaller ones. However, they modeled turbines with a capacity range of 0.1 to 2.5 MW, which is lower than those considered for the Horse Heaven Wind Farm, and the number of estimated bird mortalities decreased exponentially up to 1.2 MW, but only slightly thereafter to 2.5 MW (Thaxter et al. 2017). Further, such results are not unequivocal. Huso et al. (2021) found that bird mortality rate was constant per unit of energy produced, a metric that accounts for turbine operating time, across all sizes and spacing of turbines at a repowered wind farm in California.

Replacing several small turbines with fewer larger turbines (i.e., repowering) has been hypothesized to reduce bird collision risk, particularly for raptors (Arnett and May 2016; Dahl et al. 2015; Thaxter et al. 2017). For example, repowering of the 20.5 MW Diablo Winds Energy Project in California from 105 150-kilowatt (kW) and 25 250-kW turbines to 38 of the larger 660-kW turbines decreased raptor mortalities per MW per year by 54% (Smallwood et al. 2009). When a wind farm in Sweden was repowered from 58 to 28 turbines that produced four times the amount of energy, the number of bird mortalities per turbine per year was 1.77 times greater, but this was offset by the reduced number of turbines and the total bird mortalities decreased by 19%, while the bird mortality rate per MW decreased by 80% (Hjernquist 2014 as cited in Dahl et al. 2015). Dahl et al. (2015) predicted a reduction in collision risk of 29% and 68% for white-tailed eagles at a wind farm in Norway if 68 2-MW turbines were repowered to 50 3-MW or 30 5-MW turbines, respectively. The reduced risk was attributed to fewer turbines and better individual siting (Dahl et al. 2015).

In summary, there is conflicting research regarding whether turbine size influences bird mortality rates, but the weight of evidence suggests that per unit of energy output, a wind farm layout with fewer larger turbines (i.e., Option 2) may have fewer total bird mortalities than one with a greater number of smaller turbines (i.e., Option 1). Some studies report no significant relationship between bird mortality rates and turbine size (Everaert 2014; Barclay et al. 2007; Krijsveld et al. 2009), while others report higher mortality rates with larger turbines (Loss et al. 2013; Dahl et al. 2015; De Lucas et al. 2008; Thelander et al. 2003; Thaxter et al. 2017). Even with a positive relationship between turbine size and mortality rates, it appears that the increased number of mortalities per turbine may be offset by fewer mortalities as a result of fewer turbines (e.g., Thaxter et al. 2017; Hjernquist 2014 as cited in Dahl et al. 2015).

There are several important limitations and sources of uncertainty related to this conclusion. Existing available information is derived from studies at wind farms with shorter turbines than those considered for the Project under either option. Notably, none of the studies reviewed during this literature review included turbines as tall as those considered under Option 2 (i.e., 410 feet [125 m] hub height). It is possible that a different relationship between turbine height and bird mortality rate may exist at turbine heights beyond the range considered in published literature. Additionally, relatively few studies have been completed at repowered wind farms; those that have been completed examined changes in bird mortality rates from replacing smaller old-generation turbines with fewer, larger, newer turbines (e.g., Smallwood et al. 2010). It is uncertain if similar differences in bird mortality rates would exist between two wind farm layouts with substantially larger turbines such as those considered under the two options for the Project. Finally, measuring impacts of repowering can be confounded by variability in space, time, and operational constraints (Huso et al. 2021), making it difficult to extrapolate results from one wind farm to another.

3.2 Bats

3.2.1 Acoustic Bat Surveys

The average number of bat passes per night recorded during acoustic bat surveys ranged from 0.27 to 1.12 among the study areas and survey years for which bat surveys were conducted for the Project (Table 3). Eight bat species were documented during acoustic bat surveys in and around the Lease Boundary (Table 3). No federal or state-listed bat species were detected. Most recorded bat passes were produced by three low-frequency bat species: silver-haired bat *(Lasionycteris noctivagans)*, hoary bat *(Lasiurus cinereus)*, and big brown bat *(Eptesicus fuscus)* (Table 4). The documented period of peak bat activity in and around the Lease Boundary occurred during September at all stations.

Table 3: Summary of Acoustic Bat Survey Results

Survey Year / Type	Horse Heaven West 2017	Horse Heaven West 2018	Horse Heaven West 2018[(a)]	Horse Heaven East 2018[(b)]
Survey Dates	19 Aug–30 Oct	14 May–29 Oct	14 May–29 Oct	11 May–29 Oct
No. of Stations	1	1	1	2
No. of Detectors	1	2	2	4
Detector Nights	72	303	344	670
Total Bat Passes	24	82	384	734
Number of High-Frequency (>30 kHz) Bat Passes	2	1	24	55
Number of Low-Frequency (<30 kHz) Bat Passes	22	81	360	679
Average Number of Bat Passes per Night	0.33 ± 0.08	0.27 ± 0.05	1.12 ± 0.13	1.09 ± 0.11

(a) Formerly Badger Canyon Wind Project

(b) Formerly Four Mile Wind Project

Source: Table 3.4-6 of the Application for Site Certification (Horse Heaven Wind Farm, LLC 2021)

Table 4: Bat Species Present by Study Phase

Common Name	Scientific Name	Number of Nights Present (Percentage of Nights Present)		
		Horse Heaven West 2017 & 2018	Horse Heaven West 2018[(a)]	Horse Heaven East 2018[(b)]
High-Frequency Group (>30 kHz)				
California bat	*Myotis californicus*	0 (0%)	0 (0%)	1 (<1%)
Canyon bat	*Parastrellus hesperus*	3 (<1%)	9 (3%)	11 (2%)
Little brown bat	*Myotis lucifugus*	0 (0%)	2 (1%)	8 (1%)
Long-legged bat	*Myotis volans*	0 (0%)	0 (0%)	2 (<1%)
Western long-eared bat	*Myotis evotis*	0 (0%)	0 (0%)	1 (<1%)

Common Name	Scientific Name	Number of Nights Present (Percentage of Nights Present)		
		Horse Heaven West 2017 & 2018	Horse Heaven West 2018(a)	Horse Heaven East 2018(b)
Low-Frequency Group (<30 kHz)				
Big brown bat	*Eptesicus fuscus*	8 (2%)	19 (6%)	31 (5%)
Hoary bat	*Lasiurus cinereus*	13 (3%)	47 (14%)	91 (14%)
Silver-haired bat	*Lasionycteris noctivagans*	55 (15%)	81 (24%)	169 (25%)
Total Number of Detector Nights		**375**	**344**	**670**

(a) Formerly Badger Canyon Wind Project

(b) Formerly Four Mile Wind Project

Source: Table 3.4-7 of the Application for Site Certification (Horse Heaven Wind Farm, LLC 2021)

kHz = kilohertz

3.2.2 Literature Review

Collision with turbines is considered one of the greatest threats to bats in North America (O'Shea et al. 2016). Post-construction monitoring studies at wind farms show that migratory tree-roosting bat species (e.g., eastern red bat *[Lasiurus borealis]*, hoary bat, and silver-haired bat) compose approximately 72% of reported bat fatalities and occur mostly during fall migration (August to September) (AWWI 2018). Based on data from 52 wind farms in Washington, hoary and silver-haired bats made up 52% and 44% of reported bat mortalities (WEST 2019). In Washington, mortality estimates from 13 wind farms had a median adjusted mortality rate of 1.4 bats/MW/year (range 0.4 to 2.5 bats per MW per year) (WEST 2019). The bat fatality rate at the nearby Nine Canyon Wind Project was 2.47 bats per MW per year and consisted entirely of hoary and silver-haired bats (Horse Heaven Wind Farm, LLC 2021). The ASC predicted that bat mortalities during operation of the Project (Horse Heaven Wind Farm, LLC 2021) would:

- be within the range of other facilities in Washington
- consist primarily of migratory, tree-roosting species (e.g., silver-haired bat, hoary bat)
- occur mainly in the fall

Considering that only three species make up most bat mortalities resulting from turbine collision, population-level impacts to these species may become an issue as the number of wind farms increases (Barclay et al. 2007; Zimmerling and Francis 2016; Hein and Schirmacher 2016). Demographic modeling suggests that mortality from wind turbines may drastically reduce population size of the hoary bat and increase its risk of extinction (Frick et al. 2017). The qualitative conclusions are likely broadly informative about the relative risk to other migratory bat species that share similar life histories and high fatality rates at wind turbines, such as silver-haired bat (Frick et al. 2017). The potential for population-level consequences for some bat species from wind farm development across North America highlights the importance of considering them as priority species for mitigation measures. However, the effect of turbine height and rotor swept area on bat collision mortalities remains uncertain (AWWI 2021).

Some studies report that bat mortality rates increase with turbine size (Baerwald and Barclay 2009), including on a per MW basis (Barclay et al. 2007). A study conducted at nine wind farms in southern Alberta, where turbine heights ranged from 164 to 276 feet (50 to 84 m), found that bat mortality rates increase with turbine height (Baerwald and Barclay 2009). That study also found that the interaction between migratory bat activity at 98 feet (30 m) above ground level and turbine height was an important predictor of bat mortality rates (Baerwald and Barclay 2009). Modeling predicted that sites with high activity but relatively short turbines had low mortality rates, as did sites with low activity but tall turbines. At sites with little migratory bat activity, mortality rates were predicted to be low regardless of turbine height. However, at sites with high bat activity, an increase in turbine height also increases the mortality rate (Baerwald and Barclay 2009). Barclay et al. (2007) compiled wind turbine and bat mortality data from 33 wind farms in North America to assess the influence of turbine characteristics on collision risk. Turbine characteristics varied across sites, with rotor diameters ranging from 59 to 295 feet (18 to 90 m) and turbine hub height ranging from 78 to 308 feet (24 to 94 m). They found that rotor diameter did not influence bat mortality rate, but turbine (i.e., hub) height did. Fatality rates of bats were relatively low at short turbines (< 213 feet [65 m] high) but increased exponentially with turbine height. The highest bat fatality rates occurred at turbines with towers 213 feet (65 m) or taller and increased with MW capacity per turbine (Barclay et al. 2007). Barclay et al. (2007) concluded that replacing several small turbines (each with low power output) with one large one (with higher power output) may help reduce bird fatalities but is likely to increase the number of bats killed per megawatt of installed capacity. They also suggested that taller turbines reach the airspace used by migrating bats and that minimizing turbine height may help minimize bat fatalities (Barclay et al. 2007). Radar studies indicate that nocturnal migrants fly at heights ranging from <328 feet (100 m) to >0.61 miles (1 kilometer) (Barclay et al. 2007), noting that radar cannot distinguish between bats and birds.

Some studies report lower bat mortality rates at taller turbines on a per MW basis (Fielder et al. 2007) or suggest that bat mortality rates increase on either side of an optimum intermediate turbine size (Thaxter et al. 2017). Although bat mortality estimates at a wind farm in Tennessee were greater on a per turbine basis at larger 1.8-MW turbines (V80 turbine with a height of 256 feet [78 m] and rotor diameter of 276 feet [84 m]) than at smaller 0.66-MW turbines (V47 turbine with a height of 213 feet [65 m] and rotor diameter of 151 feet [46 m]), when mortality was measured per MW, the smaller V47 turbines had a greater mortality rate (53.3 bats/MW/year) than the larger V80 turbines (38.7 bats per MW per year) (Fiedler et al. 2007). Thaxter et al. (2017) suggest that for bats, an optimum turbine size of approximately 1.25 MW may minimize collision risk. Their models indicated that per unit of energy output at a hypothetical 10-MW wind farm, using one thousand 0.01-MW turbines resulted in the largest estimated number of bat mortalities. Thereafter, the numbers decreased exponentially up to approximately 1.2 MW, but then increased again from 14 bats with 1.2-MW turbines, to 24 bats with 2.5-MW turbines. However, the authors cautioned that model certainty was low and more research was required to understand the relationship between collision risk and turbine size for larger turbines (Thaxter et al. 2017).

Overall, the relationship between turbine height and bat collision mortalities is too inconclusive to make confident predictions regarding which turbine option is expected to result in fewer bat mortalities. There is limited and conflicting information about the effect of turbine height on bat collision mortalities. Some studies report that bat mortality rates increase with turbine size (Baerwald and Barclay 2009), including on a per MW basis (Barclay et al. 2007), while others report no effect (Huso et al. 2021), the opposite effect (Fielder et al. 2007), or that mortality rates increase on either side of an optimum intermediate turbine size (Thaxter et al. 2017). Extrapolating results from these studies to the Horse Heaven Wind Farm is further limited by the range of turbine heights analyzed, which are shorter than those under consideration for the Project under either option. It is possible that a different relationship between turbine height and bat mortality rate may exist at turbine heights beyond the range considered in available published literature.

4.0 CONCLUSION

This special study report contains supplemental information regarding potential bird and bat collision risk between the two turbine options considered for the Project for use in the Energy Facility Site Evaluation Council's evaluation of impacts within the Environmental Impact Statement. The following provides a summary of anticipated wildlife collision risk associated with the two turbine options based on information collected during baseline studies and a review of available published scientific literature:

- Based on AUS data:
    - Mean exposure indices for small bird species were highest at the GE 3.03-MW turbines (Option 1) and similar across the three other turbine technologies. Therefore, Option 1 is expected to result in a greater number of small bird mortalities.
    - Among large bird species, exposure indices for raptors were higher for shorter turbines (Option 1), but exposure indices for waterfowl were higher at taller turbines (Option 2). It is expected that the option requiring a greater number of shorter turbines (Option 1) would result in more large bird mortalities because raptors appear more susceptible to turbine collisions than waterfowl (AWWI 2021).
    - Option 1 is expected to result in greater collision risk for six of the eight special status bird species observed during AUS (ferruginous hawk, golden eagle, prairie falcon, tundra swan, American white pelican, great blue heron). Exposure indices were highest for Option 2 technologies for two special status bird species (sandhill crane, bald eagle), but it is uncertain to what degree this may be offset by fewer turbines.
- Based on a literature review, the weight of evidence suggests that per unit of energy output, a wind farm layout with fewer larger turbines (i.e., Option 2) is likely to have fewer total bird mortalities than one with a greater number of smaller turbines (i.e., Option 1).
- The relationship between turbine height and bat collision mortalities is too inconclusive to make confident predictions regarding which turbine option is expected to result in fewer bat mortalities.

The mortality risk for different taxa should be weighed against the potential for population-level impacts. For example, collisions with turbines do not appear likely to lead to population-level impacts for small passerine (i.e., songbird) species (AWWI 2021), but may have population-level impacts for some diurnal raptor species based on future wind energy projections (Diffendorfer et al. 2021). Considering that only three bat species (hoary, silver-haired, and eastern red bat) make up most bat mortalities at turbines, population-level impacts may become an issue as the number of wind farms increase (Barclay et al. 2007; Hein and Schirmacher 2016; Zimmerling and Francis 2016; Frick et al. 2017).

It is important to acknowledge that there is uncertainty associated with these conclusions related to conflicting results in available published scientific studies, lack of studies at turbines within the range of heights considered for the Horse Heaven Wind Farm, and potential for substantial variability in wildlife mortality based on local factors (e.g., bird abundance, species composition, topography, habitat, spatial arrangement of turbines). These sources of uncertainty limit the confidence of predicted wildlife mortality risk associated with the two turbine options.

5.0 CLOSURE

We trust that the information contained in this report is sufficient for your present needs. Should you have any questions regarding the Project or this report, please do not hesitate to contact the undersigned.

The material in this report reflects Golder's best judgment based on information available at the time of preparation and has been produced in a manner consistent with the level of care and skill normally exercised by environmental professionals currently practicing under similar conditions in the jurisdiction in which the services are provided. If the report is edited, revised, altered, or added to in any way, all references to Golder and Golder's employees must be removed unless changes are agreed to by Golder. Any use which a third party makes of this report or any reliance on or decisions to be made based on it are the responsibility of such third party. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or action based on this report.

Golder Associates Ltd.

Ilya Povalyaev, RPBio
Wildlife Biologist

Kate Moss, RPBio
Senior Biologist

Don Gamble, RPP, MCIP, RPBio
Principal, Senior Environmental Planner

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APPENDIX A

Species-specific Exposure Indices from Avian Use Studies

Table A-1: Exposure Indices Calculated for Small Bird Species Observed During Avian Use Studies, 2017-2020

Common Name	Overall Mean Use	Percentage Flying	Option 1				Option 2			
			GE 2.82 MW Turbine (25 to 155 m RSH)		GE 3.03 MW Turbine (10 to 155 m RSH)		GE 5.5 MW Turbine (45 to 205 m RSH)		SG 6.0 MW Turbine (30 to 200 m RSH)	
			Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index
Horned lark	5.30	69.0	8.5	0.312	34.9	1.275	0	0	5.1	0.187
Unidentified small bird	0.15	96.1	21.6	0.032	95.9	0.149	21.6	0.032	21.6	0.032
Bank swallow	0.14	100.0	0	0	50.0	0.072	0	0	0	0
White-crowned sparrow	0.14	70.0	0	0	62.5	0.063	0	0	0	0
European starling	0.10	69.6	79.8	0.057	81.9	0.059	2.1	0.002	78.7	0.057
Barn swallow	0.09	100.0	10.3	0.010	41.4	0.039	0	0	10.3	0.010
Brewer's blackbird	0.03	100.0	0	0	50.0	0.014	0	0	0	0
Western meadowlark	0.28	31.8	0	0	11.7	0.011	0	0	0	0
Western kingbird	0.03	31.3	20.0	0.002	80.0	0.008	0	0	20.0	0.002
Unidentified swallow	0.02	100.0	0	0	28.6	0.007	0	0	0	0
Savannah sparrow	0.06	76.9	0	0	12.0	0.006	0	0	0	0
Cliff swallow	0.04	100.0	0	0	10.0	0.004	0	0	0	0
American goldfinch	0.02	14.9	71.4	0.002	71.4	0.002	0	0	0	0
Red-winged blackbird	<0.01	100.0	66.7	0.001	100.0	0.002	0	0	66.7	0.001

Common Name	Overall Mean Use	Percentage Flying	Option 1				Option 2			
			GE 2.82 MW Turbine (25 to 155 m RSH)		GE 3.03 MW Turbine (10 to 155 m RSH)		GE 5.5 MW Turbine (45 to 205 m RSH)		SG 6.0 MW Turbine (30 to 200 m RSH)	
			Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index
American pipit	<0.01	50.0	50.0	0.001	50.0	0.001	0	0	0	0
Vesper sparrow	<0.01	85.7	16.7	0.001	16.7	0.001	0	0	0	0
American robin	<0.01	100.0	0	0	0	0	0	0	0	0
Chipping sparrow	<0.01	50.0	0	0	0	0	0	0	0	0
Golden-crowned sparrow	<0.01	100.0	0	0	0	0	0	0	0	0
Grasshopper sparrow	0.02	16.7	0	0	0	0	0	0	0	0
House finch	0.01	100.0	0	0	0	0	0	0	0	0
Lark sparrow	0.01	50.0	0	0	0	0	0	0	0	0
Northern flicker	0.01	25.0	0	0	0	0	0	0	0	0
Say’s phoebe	<0.01	100.0	0	0	0	0	0	0	0	0
Song sparrow	0.01	100.0	0	0	0	0	0	0	0	0
Unidentified passerine	<0.01	100.0	0	0	0	0	0	0	0	0
Unidentified sparrow	<0.01	50.0	0	0	0	0	0	0	0	0

Source: Table 3.4-9 of the ASC (Horse Heaven Wind Farm, LLC 2021).

MW = megawatt; RSH = rotor swept height

Table A-2: Exposure Indices Calculated for Large Bird Species Observed during Avian Use Studies, 2017–2020

Common Name	Overall Mean Use	Percentage Flying	Option 1				Option 2			
			GE 2.82 MW Turbine (25 to 155 m RSH)		GE 3.03 MW Turbine (10 to 155 m RSH)		GE 5.5 MW Turbine (45 to 205 m RSH)		SG 6.0 MW Turbine (30 to 200 m RSH)	
			Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percent Flying within RSH	Exposure Index
Corvids										
American crow	<0.01	100.0	0	0	0	0	0	0	0	0
Black-billed magpie	0.02	93.3	10.7	0.002	21.4	0.004	0	0	10.7	0.002
Common raven	1.54	93.8	53.2	0.77	82.2	1.19	25.1	0.363	47.2	0.684
Diurnal Raptors										
American kestrel	0.18	52.6	22.1	0.021	72.6	0.07	4.4	0.004	15.0	0.014
Bald eagle	**0.02**	**100.0**	**60.0**	**0.009**	**73.3**	**0.011**	**80.0**	**0.012**	**80.0**	**0.012**
Cooper's hawk	0.01	100.0	66.7	0.007	66.7	0.007	33.3	0.003	66.7	0.007
Ferruginous hawk	**0.01**	**100.0**	**50.0**	**0.003**	**75.0**	**0.004**	**50.0**	**0.003**	**50.0**	**0.003**
Golden eagle	**0.01**	**85.7**	**100.0**	**0.007**	**100.0**	**0.007**	**83.3**	**0.006**	**100.0**	**0.007**
Merlin	<0.01	100.0	0	0	0	0	0	0	0	0
Northern harrier	0.56	98.4	10.6	0.058	24.7	0.136	5.9	0.032	8.9	0.049
Osprey	<0.01	100.0	100.0	0.002	100.0	0.002	100.0	0.002	100.0	0.002
Prairie falcon	**0.02**	**57.6**	**63.2**	**0.007**	**89.5**	**0.01**	**26.3**	**0.003**	**52.6**	**0.006**
Red-tailed hawk	0.32	78.7	75.7	0.188	91.7	0.228	60.3	0.15	72.6	0.181

Common Name	Overall Mean Use	Percentage Flying	Option 1				Option 2			
			GE 2.82 MW Turbine (25 to 155 m RSH)		GE 3.03 MW Turbine (10 to 155 m RSH)		GE 5.5 MW Turbine (45 to 205 m RSH)		SG 6.0 MW Turbine (30 to 200 m RSH)	
			Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percent Flying within RSH	Exposure Index
Rough-legged hawk	0.26	88.7	75.9	0.172	93.8	0.213	49.5	0.112	71.0	0.161
Sharp-shinned hawk	0.01	100.0	42.9	0.002	71.4	0.004	28.6	0.002	42.9	0.002
Swainson's hawk	0.24	83.4	83.7	0.164	97.2	0.19	62.6	0.123	79.3	0.155
Unidentified accipiter	<0.01	100.0	75.0	0.003	75.0	0.003	75.0	0.003	100.0	0.003
Unidentified buteo	0.03	75.0	70.0	0.013	70.0	0.013	63.3	0.012	73.3	0.014
Unidentified falcon	0.01	70.0	28.6	0.001	42.9	0.002	14.3	0.001	14.3	0.001
Unidentified raptor	0.02	100.0	54.5	0.009	90.9	0.015	36.4	0.006	63.3	0.011
Doves/Pigeons										
Mourning dove	0.01	65.4	0	0	52.9	0.005	0	0	0	0
Rock pigeon	1.01	80.2	47.8	0.388	78.2	0.634	8.8	0.071	37.5	0.304
Gulls/Terns										
California gull	0.23	100.0	70.2	0.159	91.1	0.206	28.6	0.065	78.0	0.176
Ring-billed gull	0.02	100.0	30.8	0.005	30.8	0.005	3.8	0.001	28.8	0.005
Unidentified gull	0.09	100.0	94.2	0.087	97.1	0.09	89.4	0.082	93.3	0.086

Common Name	Overall Mean Use	Percentage Flying	Option 1				Option 2			
			GE 2.82 MW Turbine (25 to 155 m RSH)		GE 3.03 MW Turbine (10 to 155 m RSH)		GE 5.5 MW Turbine (45 to 205 m RSH)		SG 6.0 MW Turbine (30 to 200 m RSH)	
			Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percent Flying within RSH	Exposure Index
Owls										
Short-eared owl	<0.01	66.7	0	0	0	0	0	0	0	0
Shorebirds										
Killdeer	0.01	96.0	16.7	0.001	83.3	0.007	0	0	0	0
Long-billed curlew	0.01	60.0	16.7	0.001	100.0	0.003	0	0	16.7	0.001
Upland Game Birds										
California quail	0.01	13.3	0	0	0	0	0	0	0	0
Gray partridge	0.01	11.1	0	0	0	0	0	0	0	0
Vultures										
Turkey vulture	0.01	100.0	100.0	0.008	100.0	0.008	100.0	0.008	100.0	0.008
Waterbirds										
American white pelican	**0.35**	**100.0**	**81.5**	**0.289**	**81.9**	**0.29**	**85.6**	**0.303**	**85.6**	**0.303**
Great blue heron	**<0.01**	**100.0**	**100.0**	**<0.001**	**100.0**	**<0.001**	**100.0**	**<0.001**	**100.0**	**<0.001**
Sandhill crane	**1.60**	**98.4**	**2.6**	**0.042**	**2.6**	**0.042**	**21.1**	**0.332**	**21.1**	**0.332**

Common Name	Overall Mean Use	Percentage Flying	Option 1				Option 2			
			GE 2.82 MW Turbine (25 to 155 m RSH)		GE 3.03 MW Turbine (10 to 155 m RSH)		GE 5.5 MW Turbine (45 to 205 m RSH)		SG 6.0 MW Turbine (30 to 200 m RSH)	
			Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percentage Flying within RSH	Exposure Index	Percent Flying within RSH	Exposure Index
Waterfowl										
Canada goose	1.87	78.5	85.3	1.25	85.6	1.254	94.9	1.39	97.5	1.428
Greater white-fronted goose	0.01	100.0	100.0	0.011	100.0	0.011	57.1	0.006	100.0	0.011
Snow goose	12.96	98.0	75.5	9.579	76.3	9.681	81.7	10.372	98.3	12.479
Tundra swan	**0.01**	**100.0**	**0**	**0**	**100.0**	**0.011**	**0**	**0**	**0**	**0**
Unidentified goose	0.04	100.0	100.0	0.037	100.0	0.037	100.0	0.037	100.0	0.037

Source: Table 3.4-10 of the ASC (Horse Heaven Wind Farm 2021).

GE = General Electric; MW = megawatt; RSH = rotor swept height; SG = Siemens Gamesa

Bold text indicates special status bird species.