APPENDIX H
WILDLIFE AND WILDLIFE HABITAT

Appendix H WILDLIFE AND WILDLIFE HABITAT

H.1 SPECIES RANKING DEFINITIONS

Table H-1 Species Ranking Definitions

Category	Definition
SKCDC[1]	
S1	Critically Imperiled/Extremely Rare – at very high risk of extinction or extirpation due to extreme rarity, very steep declines, high threat level, or other factors.
S2	Imperiled/Very Rare – at high risk of extinction or extirpation due to a very restricted range, very few populations, steep declines, threats or other factors.
S3	Vulnerable/Rare to Uncommon – at moderate risk of extinction or extirpation due to a restricted range, relatively few populations, recent and widespread declines, threats, or other factors.
S4	Apparently Secure – uncommon, but not rare; some cause for long-term concern due to declines or other factors.
S5	Secure/Common – demonstrably secure under present conditions; widespread and abundant; low threat level.
Modifiers for SKCDC Ranks	
A	Accidental or casual in the province, including species recorded infrequently that are far outside their range (birds or butterflies).
B	For migratory species, rank applies to the breeding population in the province.
N	For migratory species, rank applies to the non-breeding population in the province.
M	For migratory species, rank applies to the transient (migrant) population.
H	Historical occurrence but without recent verification (e.g., within 20 years).
U	Status uncertain and species unrankable due to lack of information.
X	A species that is believed to be extinct or extirpated.
NA	Conservation status is not applicable to this species (e.g., exotic species).
NR	Species is not yet ranked.
?	Can be added to any rank to denote an inexact numeric rank (e.g., S1? = believed to be 5 or fewer occurrences, but some doubt exists concerning status).
SK Wildlife Act[2]	
Extirpated	A species that no longer exists in the wild in Saskatchewan but exists in the wild outside the province.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Vulnerable	A species of special concern because of low or declining numbers due to human activities or natural events but that is not endangered or threatened.

Table H-1 Species Ranking Definitions

Category	Definition
SARA[3]	
Extinct	A wildlife species that no longer exists.
Extirpated	A wildlife species that no longer exists in the wild in Canada, but exists elsewhere in the wild.
Endangered	A wildlife species that is facing imminent extirpation or extinction.
Threatened	A wildlife species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
COSEWIC[4]	
Extinct	A wildlife species that no longer exists.
Extirpated	A wildlife species that no longer exists in the wild in Canada, but exists elsewhere in the wild.
Endangered	A wildlife species facing imminent extirpation or extinction.
Threatened	A wildlife species likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Data Deficient	A wildlife species for which there is insufficient information to resolve a species' suitability for assessment or to permit an assessment of the species' risk of extinction.
Not At Risk	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.

SOURCES:
[1] SKCDC 2017a.
[2] Government of Saskatchewan 1998.
[3] Government of Canada 2002.
[4] COSEWIC 2016.

H.2 WILDLIFE SAR AND SOMC WITH POTENTIAL TO OCCUR IN THE WILDLIFE RAA

Table H-2 SAR and SOMC with the Potential to Occur in the Wildlife RAA

Common Name	Scientific Name	SARA[1]	COSEWIC[1]	SKMOE[2]	SKCDC[3]	SAR	SOMC	SKMOE Activity Restriction Feature (Setback)[4]
INSECTS								
Dusky dune moth	*Copablepharon longipenne*	Endangered	Endangered		S1	Y		None
Pale yellow dune moth	*Copablepharon grandis*	Special Concern	Special Concern		S2	Y		None
Monarch	*Danaus plexippus*	Endangered	Special Concern		S2B	Y		None
Rhesus skipper	*Polites rhesus*				S2		Y	None
Verna's flower moth	*Schinia verna*	Threatened	Threatened		S1	Y		None
Gypsy cuckoo bumble bee	*Bombus bohemicus*	*No Status*	*Endangered*		SH		Y	None
Western bumble bee	*Bombus occidentalis occidentalis*	No Status	Threatened		S4		Y	None
Yellow-banded bumble bee	*Bombus terricola*	No Status	Special Concern		S5		Y	None
Nine-spotted lady beetle	*Coccinella novemnotata*	No Status	Endangered		S4		Y	None

Table H-2 SAR and SOMC with the Potential to Occur in the Wildlife RAA

Common Name	Scientific Name	SARA[1]	COSEWIC[1]	SKMOE[2]	SKCDC[3]	SAR	SOMC	SKMOE Activity Restriction Feature (Setback)[4]
AMPHIBIANS								
Canadian toad	*Anaxyrus hemiophrys*		Not At Risk		S4		Y	Breeding and overwintering habitat (90 m)
Great plains toad	*Anaxyrus cognatus*	Special Concern	Special Concern		S3	Y		Breeding and overwintering habitat (500 m)
Plains spadefoot	*Spea bombifrons*		Not At Risk		S3		Y	Breeding and overwintering habitat (90 m)
Northern leopard frog	*Lithobates pipiens*	Special Concern	Special Concern		S3	Y		Breeding and overwintering habitat (500 m)
Western tiger salamander	*Ambystoma mavortium*	No Status	Special Concern		S4		Y	None
Bullsnake	*Pituophis catenifer sayi*	No Status	Special Concern		S4		Y	None
Plains hog-nosed snake	*Heterodon nasicus*				S3		Y	Hibernacula (200 m)
UPLAND GAME BIRDS								
Sharp-tailed grouse	*Tympanuchus phasianellus*				S5		Y	Lek (400 m)

Table H-2 SAR and SOMC with the Potential to Occur in the Wildlife RAA

Common Name	Scientific Name	SARA[1]	COSEWIC[1]	SKMOE[2]	SKCDC[3]	SAR	SOMC	SKMOE Activity Restriction Feature (Setback)[4]
RAPTORS								
Osprey	*Pandion haliaetus*				S2B, S2M		Y	Nest site (1,000 m)
Bald eagle	*Haliaeetus leucocephalus*		Not At Risk		S5B, S5N, S4M		Y	Nest site (1,000 m)
Golden eagle	*Aquila chrysaetos*		Not At Risk		S3B, S3N, S4M		Y	Nest site (1,000 m)
Ferruginous hawk	*Buteo regalis*	Threatened	Threatened		S3	Y		Nest site (1,000 m)
Peregrine falcon	*Falco peregrinus anatum*	Special Concern	Special Concern		S1B, SNRM	Y		Nest site (1,000 m)
Burrowing owl	*Athene cunicularia*	Endangered	Endangered	Endangered	S2B, S2M	Y		Breeding bird (500 m)
Short-eared owl	*Asio flammeus*	Special Concern	Special Concern		S3B, S2N, S3M	Y		Breeding bird (500 m)
MIGRATORY BIRDS								
Horned grebe	*Podiceps auritus*	Special Concern	Special Concern		S5B, S5M	Y		None
Eared grebe	*Podiceps nigricollis*				S5B, S5M		Y	Breeding grebe colony (200 m)
Western grebe	*Aechmophorus occidentalis*	Special Concern	Special Concern		S3B, S3M	Y		Breeding grebe colony (200 m)
Double-crested cormorant	*Phalacrocorax auritus*		Not At Risk		S5B, S5M		Y	Nesting colony (1,000 m)
American white pelican	*Pelecanus erythrorhynchos*		Not At Risk		S5B, S5M		Y	Nesting colony (1,000 m)

Table H-2 SAR and SOMC with the Potential to Occur in the Wildlife RAA

Common Name	Scientific Name	SARA[1]	COSEWIC[1]	SKMOE[2]	SKCDC[3]	SAR	SOMC	SKMOE Activity Restriction Feature (Setback)[4]
American bittern	*Botaurus lentiginosus*				S5B		Y	Breeding bird (350 m)
Black-crowned night-heron	*Nycticorax nycticorax*				S4B		Y	Nesting colony (1,000 m)
Great blue heron	*Ardea herodias*				S5B		Y	Nesting colony (1,000 m)
Snowy egret	*Egretta thula*				SNA		Y	Nesting colony (1,000 m)
Cattle egret	*Bubulcus ibis*				SNA		Y	Nesting colony (1,000 m)
Great egret	*Ardea alba*				SNA		Y	Nesting colony (1,000 m)
Whooping crane	*Grus americana*	Endangered	Endangered	Endangered	SXB, S1M	Y		Staging area (1,000 m)
Yellow rail	*Coturnicops noveboracensis*	Special Concern	Special Concern		S3B, S3M	Y		Breeding bird (350 m)
Piping plover	*Charadrius melodus circumcinctus*	Endangered	Endangered	Endangered	S3B	Y		High-water mark (600 m)
Snowy plover	*Charadrius nivosus nivosus*				SHB		Y	High-water mark (600 m)
Long-billed curlew	*Numenius americanus*	Special Concern	Special Concern		S3B, S4M	Y		Breeding bird (200 m)
Red knot	*Calidris canutus rufa*	Endangered	Endangered		S2M	Y		Staging area (1,000 m)
Buff-breasted sandpiper	*Calidris subruficollis*	Special Concern	Special Concern		S4M	Y		None

Table H-2 SAR and SOMC with the Potential to Occur in the Wildlife RAA

Common Name	Scientific Name	SARA[1]	COSEWIC[1]	SKMOE[2]	SKCDC[3]	SAR	SOMC	SKMOE Activity Restriction Feature (Setback)[4]
Red-necked phalarope	*Phalaropus lobatus*	No Status	Special Concern		S4B, S3M		Y	None
Bonaparte's gull	*Chroicocephalus philadelphia*				S4B, S4M		Y	Nesting colony (400 m)
Franklin's gull	*Leucophaeus pipixcan*				S4B, S4M		Y	Nesting colony (400 m)
Herring gull	*Larus argentatus*				S5B, S5M		Y	Nesting colony (400 m)
Black tern	*Chlidonias niger*		Not At Risk		S5B, S5M		Y	Nesting colony (400 m)
Common tern	*Sterna hirundo*		Not At Risk		S5B, S5M		Y	Nesting colony (400 m)
Forster's tern	*Sterna forsteri*		Data Deficient		S4B, S4M		Y	Nesting colony (400 m)
Common nighthawk	*Chordeiles minor*	Threatened	Threatened		S4B, S4M	Y		Breeding bird (200 m)
Loggerhead shrike	*Lanius ludovicianus excubitorides*	Threatened	Threatened		S2B, S2M	Y		Breeding bird (400 m)
Bank swallow	*Riparia riparia*	Threatened	Threatened		S4B, S5M	Y		None
Barn swallow	*Hirundo rustica*	Threatened	Threatened		S5B, S5M	Y		None
Sprague's pipit	*Anthus spragueii*	Threatened	Threatened		S3B, S3M	Y		Breeding bird (250 m)
Chestnut-collared longspur	*Calcarius ornatus*	Threatened	Threatened		S3B	Y		Breeding bird (200 m)
McCown's longspur	*Rhynchophanes mccownii*	Special Concern	Threatened		S3B	Y		Breeding bird (200 m)

Table H-2 SAR and SOMC with the Potential to Occur in the Wildlife RAA

Common Name	Scientific Name	SARA[1]	COSEWIC[1]	SKMOE[2]	SKCDC[3]	SAR	SOMC	SKMOE Activity Restriction Feature (Setback)[4]
Baird's sparrow	*Ammodramus bairdii*	Special Concern	Special Concern		S4B	Y		None
Lark bunting	*Calamospiza melanocorys*	No Status	Threatened		S2B, S2M		Y	None
Bobolink	*Dolichonyx oryzivorus*	Threatened	Threatened		S4B, S4M	Y		none
Rusty blackbird	*Euphagus carolinus*	Special Concern	Special Concern		S3B, SUN, S3M	Y		Breeding bird (300 m)
MAMMALS								
American badger	*Taxidea taxus taxus*	No Status	Special Concern		S3		Y	None
Little brown myotis	*Myotis lucifugus*	Endangered	Endangered		S4	Y		Roost/foraging site (500 m)
Long-eared myotis	*Myotis evotis*				S2		Y	Roost/foraging site (500 m)
Western small-footed myotis	*Myotis ciliolabrum*				S2		Y	Roost/foraging site (500 m)
Northern myotis	*Myotis septentrionalis*	Endangered	Endangered		S3	Y		Roost/foraging site (500 m)
Big brown bat	*Eptesicus fuscus*				S5		Y	Roost/foraging site (500 m)
Silver-haired bat	*Lasionycteris noctivagans*				S5B		Y	Roost/foraging site (500 m)

Table H-2 SAR and SOMC with the Potential to Occur in the Wildlife RAA

Common Name	Scientific Name	SARA[1]	COSEWIC[1]	SKMOE[2]	SKCDC[3]	SAR	SOMC	SKMOE Activity Restriction Feature (Setback)[4]
Hoary bat	*Lasiurus cinereus*				S5B		Y	Roost/foraging site (500 m)
Eastern red bat	*Lasiurus borealis*				S4B		Y	Roost/foraging site (500 m)

SOURCES:
[1] Government of Canada 2017b
[2] SKMOE 1999
[3] SKCDC 2017d, 2017e
[4] SKMOE 2017b

H.2.8

H.3 WILDLIFE SAR AND SOMC HABITAT ASSOCIATIONS

Table H-3 Habitat Associations of Potential SAR and SOMC

Common Name	Scientific Name	SAR/ SOMC	Native Prairie	Tame Pasture	Hayland	Cultivated	Shrubland	Developed	Exposed/barren	Water	Wetland
INSECTS[1]											
Dusky dune moth	*Copablepharon longipenne*	SAR							✓		
Pale yellow dune moth	*Copablepharon grandis*	SAR							✓		
Monarch	*Danaus plexippus*	SAR	✓	✓							
Rhesus skipper	*Polites rhesus*	SOMC	✓								
Verna's flower moth	*Schinia verna*	SAR	✓								
Gypsy cuckoo bumble bee	*Bombus bohemicus*	SOMC	✓	✓	✓		✓	✓			
Western bumble bee	*Bombus occidentalis occidentalis*	SOMC	✓	✓	✓	✓	✓	✓			
Yellow-banded bumble bee	*Bombus terricola*	SOMC	✓	✓	✓	✓	✓	✓			
Nine-spotted lady beetle	*Coccinella novemnotata*	SOMC	✓	✓	✓	✓	✓	✓			
AMPHIBIANS[2]											
Canadian toad	*Anaxyrus hemiophrys*	SOMC	✓	✓	✓					✓	✓
Great plains toad	*Anaxyrus cognatus*	SAR	✓	✓	✓					✓	✓
Plains spadefoot	*Spea bombifrons*	SOMC	✓	✓	✓					✓	✓
Northern leopard frog	*Lithobates pipiens*	SAR	✓	✓	✓					✓	✓
Western tiger salamander	*Ambystoma mavortium*	SOMC	✓	✓	✓	✓	✓			✓	✓

Table H-3 Habitat Associations of Potential SAR and SOMC

Common Name	Scientific Name	SAR/ SOMC	Native Prairie	Tame Pasture	Hayland	Cultivated	Shrubland	Developed	Exposed/barren	Water	Wetland
Bullsnake	*Pituophis catenifer sayi*	SOMC	✓	✓	✓				✓		
Plains hog-nosed snake	*Heterodon nasicus*	SOMC	✓	✓	✓		✓				
UPLAND GAME BIRDS[3]											
Sharp-tailed grouse	*Tympanuchus phasianellus*	SOMC	✓	✓	✓		✓				
RAPTORS[3]											
Osprey	*Pandion haliaetus*	SOMC								✓	
Bald eagle	*Haliaeetus leucocephalus*	SOMC								✓	
Golden eagle	*Aquila chrysaetos*	SOMC	✓	✓	✓		✓		✓		
Ferruginous hawk	*Buteo regalis*	SAR	✓	✓	✓		✓		✓		
Peregrine falcon	*Falco peregrinus anatum*	SAR							✓		
Burrowing owl	*Athene cunicularia*	SAR	✓	✓							
Short-eared owl	*Asio flammeus*	SAR	✓	✓							✓
MIGRATORY BIRDS[3]											
Horned grebe	*Podiceps auritus*	SAR									✓
Eared grebe	*Podiceps nigricollis*	SOMC									✓
Western grebe	*Aechmophorus occidentalis*	SAR								✓	
Double-crested cormorant	*Phalacrocorax auritus*	SOMC								✓	
American white pelican	*Pelecanus erythrorhynchos*	SOMC								✓	✓
American bittern	*Botaurus lentiginosus*	SOMC									✓

Table H-3 Habitat Associations of Potential SAR and SOMC

Common Name	Scientific Name	SAR/ SOMC	Native Prairie	Tame Pasture	Hayland	Cultivated	Shrubland	Developed	Exposed/barren	Water	Wetland
Black-crowned night-heron	*Nycticorax nycticorax*	SOMC								✓	✓
Great blue heron	*Ardea herodias*	SOMC								✓	✓
Snowy egret	*Egretta thula*	SOMC								✓	✓
Cattle egret	*Bubulcus ibis*	SOMC								✓	✓
Great egret	*Ardea alba*	SOMC								✓	✓
Whooping crane	*Grus americana*	SAR				✓					✓
Yellow rail	*Coturnicops noveboracensis*	SAR									✓
Piping plover	*Charadrius melodus circumcinctus*	SAR								✓	✓
Snowy plover	*Charadrius nivosus nivosus*	SOMC								✓	✓
Long-billed curlew	*Numenius americanus*	SAR	✓	✓	✓	✓					
Red knot	*Calidris canutus rufa*	SAR								✓	✓
Buff-breasted sandpiper	*Calidris subruficollis*	SAR	✓	✓	✓	✓					
Red-necked phalarope	*Phalaropus lobatus*	SOMC								✓	✓
Bonaparte's gull	*Chroicocephalus philadelphia*	SOMC								✓	✓
Franklin's gull	*Leucophaeus pipixcan*	SOMC								✓	✓
Herring gull	*Larus argentatus*	SOMC						✓		✓	✓
Black tern	*Chlidonias niger*	SOMC								✓	✓

Table H-3 Habitat Associations of Potential SAR and SOMC

Common Name	Scientific Name	SAR/ SOMC	Native Prairie	Tame Pasture	Hayland	Cultivated	Shrubland	Developed	Exposed/barren	Water	Wetland
Common tern	*Sterna hirundo*	SOMC								✓	✓
Forster's tern	*Sterna forsteri*	SOMC								✓	✓
Common nighthawk	*Chordeiles minor*	SAR	✓	✓	✓		✓	✓	✓		
Loggerhead shrike	*Lanius ludovicianus excubitorides*	SAR	✓	✓	✓		✓				
Bank swallow	*Riparia riparia*	SAR							✓	✓	✓
Barn swallow	*Hirundo rustica*	SAR	✓	✓	✓	✓		✓		✓	✓
Sprague's pipit	*Anthus spragueii*	SAR	✓	✓							
Chestnut-collared longspur	*Calcarius ornatus*	SAR	✓	✓							
McCown's longspur	*Rhynchophanes mccownii*	SAR	✓	✓							
Baird's sparrow	*Ammodramus bairdii*	SAR	✓	✓	✓						
Lark bunting	*Calamospiza melanocorys*	SOMC	✓	✓	✓						
Bobolink	*Dolichonyx oryzivorus*	SAR	✓	✓	✓						
Rusty blackbird	*Euphagus carolinus*	SAR				✓	✓				✓
MAMMALS[4]											
American badger	*Taxidea taxus taxus*	SOMC	✓	✓	✓						
Little brown myotis	*Myotis lucifugus*	SAR						✓		✓	✓
Long-eared myotis	*Myotis evotis*	SOMC						✓			✓
Western small-footed myotis	*Myotis ciliolabrum*	SOMC	✓	✓				✓			✓

Table H-3 Habitat Associations of Potential SAR and SOMC

Common Name	Scientific Name	SAR/ SOMC	Native Prairie	Tame Pasture	Hayland	Cultivated	Shrubland	Developed	Exposed/barren	Water	Wetland
Northern myotis	*Myotis septentrionalis*	SAR						✓			✓
Big brown bat	*Eptesicus fuscus*	SOMC	✓	✓	✓	✓	✓	✓		✓	✓
Silver-haired bat	*Lasionycteris noctivagans*	SOMC						✓		✓	✓
Hoary bat	*Lasiurus cinereus*	SOMC						✓		✓	✓
Eastern red bat	*Lasiurus borealis*	SOMC						✓			✓
Total			**33**	**31**	**24**	**10**	**13**	**15**	**8**	**31**	**38**

NOTES:
✓ Habitat type where species may occur

SOURCES:
[1] Government of Canada 2002
[2] Stebbins 2003
[3] Cornell Lab of Ornithology and the American Ornithologist's Union 2017
[4] Reid 2006

H.3.6

H.4 ALL WILDLIFE SPECIES OBSERVED DURING 2017 FIELD STUDIES

Table H-4 All Wildlife Species Observed during 2017 Field Studies

Common Name	Scientific Name	SKCDC[1,2]	SARA[3]	COSEWIC[3]
Amphibians				
Boreal chorus frog	*Pseudacris maculata*	S5		Not at Risk
Northern leopard frog	*Lithobates pipiens*	S3	Special Concern	Special Concern
Birds				
Snow goose	*Anser caerulescens*	S5M		
Greater white-fronted goose	*Anser albifrons*	S5M		
Canada goose	*Branta canadensis*	S5B, S2N, S5M		
Tundra swan	*Cygnus columbianus*	S5M		
Blue-winged teal	*Spatula discors*	S5B, S5M		
Northern shoveler	*Spatula clypeata*	S5B, S5M		
Gadwall	*Mareca strepera*	S5B, S2N, S5M		
American wigeon	*Mareca americana*	S5B, S2N, S5M		
Mallard	*Anas platyrhynchos*	S5B, S5M		
Northern pintail	*Anas acuta*	S5B, S4N, S5M		
Green-winged teal	*Anas crecca*	S5B, S2N, S5M		
Canvasback	*Aythya valisineria*	S5B, S2N, S5M		
Redhead	*Aythya americana*	S5B, S2N, S5M		
Lesser scaup	*Aythya affinis*	S5B, S3N, S5M		
Bufflehead	*Bucephala albeola*	S5B, S1N, S3M		
Common goldeneye	*Bucephala clangula*	S5B, S3N, S3M		
Common merganser	*Mergus merganser*	S5B, S2N, S4M		
Ruddy duck	*Oxyura jamaicensis*	S5B		
Gray partridge	*Perdix perdix*	SNA		
Sharp-tailed grouse	*Tympanuchus phasianellus*	S5		
Horned grebe	*Podiceps auritus*	S5B, S5M	Special Concern	Special Concern
Eared grebe	*Podiceps nigricollis*	S5B, S5M		
Western grebe	*Aechmophorus occidentalis*	S3B, S3M	Special Concern	Special Concern
Rock pigeon	*Columba livia*	SNA		
Mourning dove	*Zenaida macroura*	S5B, S5M		

Table H-4 All Wildlife Species Observed during 2017 Field Studies

Common Name	Scientific Name	SKCDC[1,2]	SARA[3]	COSEWIC[3]
Common nighthawk	*Chordeiles minor*	S4B, S4M	Threatened	Threatened
Sora	*Porzana carolina*	S5B, S5M		
American coot	*Fulica americana*	S5B, S5M		Not at Risk
Sandhill crane	*Grus canadensis*	S5B, S5M		
American avocet	*Recurvirostra americana*	S4B, S4M		
Black-bellied plover	*Pluvialis squatarola*	S4M		
American golden-plover	*Pluvialis dominica*	S5M		
Semipalmated plover	*Charadrius semipalmatus*	SUB, S5M		
Killdeer	*Charadrius vociferus*	S5B, S5M		
Whimbrel	*Numenius phaeopus*	S4M		
Long-billed curlew	*Numenius americanus*	S3B, S4M	Special Concern	Special Concern
Marbled godwit	*Limosa fedoa*	S4B, S4M		
Red knot	*Calidris canutus rufa*	S2M	Endangered	Endangered
Semipalmated sandpiper	*Calidris pusilla*	S4M		
Short-billed dowitcher	*Limnodromus griseus*	SUB, S4M		
Long-billed dowitcher	*Limnodromus scolopaceus*	S5M		
Wilson's snipe	*Gallinago delicata*	S5B, S5M		
Spotted sandpiper	*Actitis macularius*	S4B, S4M		
Solitary sandpiper	*Tringa solitaria*	S5B, S4M		
Lesser yellowlegs	*Tringa flavipes*	S4B, S4M		
Willet	*Catoptrophorus semipalmatus*	S4B, S4M		
Greater yellowlegs	*Tringa melanoleuca*	S5B, S5M		
Wilson's phalarope	*Phalaropus tricolor*	S5B, S5M		
Red-necked phalarope	*Phalaropus lobatus*	S4B, S3M	No Status	Special Concern
Bonaparte's gull	*Chroicocephalus philadelphia*	S4B, S4M		
Franklin's gull	*Leucophaeus pipixcan*	S4B, S4M		
Ring-billed gull	*Larus delawarensis*	S5B, S5M		
Herring gull	*Larus argentatus*	S5B, S5M		
California gull	*Larus californicus*	S4B, S4M		
Caspian tern	*Hydroprogne caspia*	S2B, S2M		Not at Risk
Black tern	*Chlidonias niger*	S5B, S5M		Not at Risk
Common tern	*Sterna hirundo*	S5B, S5M		Not at Risk

Table H-4 All Wildlife Species Observed during 2017 Field Studies

Common Name	Scientific Name	SKCDC[1,2]	SARA[3]	COSEWIC[3]
Forster's tern	*Sterna forsteri*	S4B, S4M		Data Deficient
Double-crested cormorant	*Phalacrocorax auritus*	S5B, S5M		Not at Risk
American white pelican	*Pelecanus erythrorhynchos*	S5B, S5M		Not at Risk
American bittern	*Botaurus lentiginosus*	S5B		
Great blue heron	*Ardea herodias*	S5B		
Black-crowned night-heron	*Nycticorax nycticorax*	S4B		
White-faced ibis	*Plegadis chihi*	S2N, S2M		
Osprey	*Pandion haliaetus*	S2B, S2M		
Bald eagle	*Haliaeetus leucocephalus*	S5B, S5N, S4M		Not at Risk
Northern harrier	*Circus hudsonius*	S4B, S4M		Not at Risk
Swainson's hawk	*Buteo swainsoni*	S4B, S4M		
Red-tailed hawk	*Buteo jamaicensis*	S5B, S1N, S5M		Not at Risk
Rough-legged hawk	*Buteo lagopus*	S4N, S4M		Not at Risk
Ferruginous hawk	*Buteo regalis*	S3	Threatened	Threatened
Great horned owl	*Bubo virginianus*	S4		
Short-eared owl	*Asio flammeus*	S3B, S2N, S3M	Special Concern	Special Concern
American kestrel	*Falco sparverius*	S5B, S1N, S5M		
Merlin	*Falco columbarius*	S5B, S5N, S5M		Not at Risk
Peregrine falcon	*Falco peregrinus anatum*	S1B, SNRM	Special Concern	Special Concern
Prairie falcon	*Falco mexicanus*	S3B, S3N, S3M		Not at Risk
Western kingbird	*Tyrannus verticalis*	S5B, S5M		
Eastern kingbird	*Tyrannus tyrannus*	S5B, S5M		
Loggerhead shrike	*Lanius ludovicianus excubitorides*	S2B, S2M	Threatened	Threatened
Black-billed magpie	*Pica hudsonia*	S5		
American crow	*Corvus brachyrhynchos*	S5B, S4N, S5M		
Common raven	*Corvus corax*	S5		
Horned lark	*Eremophila alpestris*	S4B, S3N, SUM		
Tree swallow	*Tachycineta bicolor*	S5B, S5M		
Bank swallow	*Riparia riparia*	S4B, S5M	Threatened	Threatened
Barn swallow	*Hirundo rustica*	S5B, S5M	Threatened	Threatened
American robin	*Turdus migratorius*	S5B, SUN, S5M		

Table H-4 All Wildlife Species Observed during 2017 Field Studies

Common Name	Scientific Name	SKCDC[1,2]	SARA[3]	COSEWIC[3]
Brown thrasher	*Toxostoma rufum*	S5B, S5M		
European starling	*Sturnus vulgaris*	SNA		
House sparrow	*Passer domesticus*	SNA		
Sprague's pipit	*Anthus spragueii*	S3B, S3M	Threatened	Threatened
Lapland longspur	*Calcarius lapponicus*	S4N, S4M		
Chestnut-collared longspur	*Calcarius ornatus*	S3B	Threatened	Threatened
Snow bunting	*Plectrophenax nivalis*	S5N, S5M		
American tree sparrow	*Spizelloides arborea*	S4B, S5M		
Clay-colored sparrow	*Spizella pallida*	S5B, S5M		
Vesper sparrow	*Pooecetes gramineus*	S5B, S5M		
Lark sparrow	*Chondestes grammacus*	S5B, SNRM		
Savannah sparrow	*Passerculus sandwichensis*	S5B, S5M		
Grasshopper sparrow	*Ammodramus savannarum*	S4B		
Baird's sparrow	*Ammodramus bairdii*	S4B	Special Concern	Special Concern
Le Conte's sparrow	*Ammodramus leconteii*	S5B, S5M		
Lincoln's sparrow	*Melospiza lincolnii*	S5B, S5M		
Dark-eyed junco	*Junco hyemalis*	S5B, S4N, S5M		
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	S5B, S5M		
Bobolink	*Dolichonyx oryzivorus*	S4B, S4M	Threatened	Threatened
Western meadowlark	*Sturnella neglecta*	S4B, S4M		
Red-winged blackbird	*Agelaius phoeniceus*	S5B, SUN, S5M		
Brewer's blackbird	*Euphagus cyanocephalus*	S4B, SUN, S4M		
Brown-headed cowbird	*Molothrus ater*	S5B, SUN, S5M		
Common grackle	*Quiscalus quiscula*	S5B		
Yellow warbler	*Setophaga petechia*	S5B, S5M		
Mammal				
American badger	*Taxidea taxus taxus*	S3		
Pronghorn	*Antilocapra americana*	S3		
White-tailed deer	*Odocoileus virginianus*	S4		
Mule deer	*Odocoileus hemionus*	S4		
Coyote	*Canis latrans*	S5		

Table H-4 All Wildlife Species Observed during 2017 Field Studies

Common Name	Scientific Name	SKCDC[1,2]	SARA[3]	COSEWIC[3]
Big brown bat	*Eptesicus fuscus*	S5		
Silver-haired bat	*Lasionycteris noctivagans*	S5B		
Hoary bat	*Lasiurus cinereus*	S5B		
Eastern red bat	*Lasiurus borealis*	S4B		
Little brown myotis	*Myotis lucifugus*	S4	Endangered	Endangered
Long-eared myotis	*Myotis evotis*	S2		
Western small-footed myotis	*Myotis ciliolabrum*	S2		
NOTES: [1] See Appendix H.1 for provincial and federal ranking definitions.				
SOURCES: [2] SKCDC 2017d, 2017e [3] Government of Canada 2017b				

H.4.6

H.5 BIRD MOVEMENT TECHNICAL REPORT

H.5.2

Blue Hill Wind Energy Project
Bird Movement Technical Report

Prepared for:
Algonquin Power Co.

Prepared by:
Stantec Consulting Ltd.

December 2017

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1.0 INTRODUCTION

One known environmental effect of wind energy facilities is the effect of bird mortality through collision strikes with turbines. This topic has been extensively studied over the past two decades and is relatively well understood.

Mortality rates at wind energy facilities varies from one facility to another across the landscape as a function of the bird species moving through a project area, local movement patterns, the abundance of birds, and other factors, including the proximity to landscape features that may concentrate birds.

Some bird species have been shown to have a higher risk of collision susceptibility (BSC et al. 2017), and understanding the species that inhabit a project area is helpful to better evaluate the potential for an increase in mortality risk from a project. The relative abundance of birds inhabiting or migrating through an area is expected to correlate to some degree with the relative collision risk a project may pose.

Some landscape features, such as watercourses and valleys, may funnel birds along local movement corridors. These local movement corridors differ from large-scale migration corridors, such as the four main flyways in North America. Other features, such as lakes and large wetlands, may concentrate birds of particular species groups at specific locations.

Therefore, understanding the species, their abundance, local movement patterns and the relative influence of concentration sites on the landscape is fundamental to an understanding of potential effects a project may have on increasing bird collision mortality risk. As such, to measure these parameters for the Project, Stantec undertook two field studies: a diurnal bird movement survey and a nocturnal movement survey using marine radar.

1.1 OBJECTIVES

The overall objectives of the bird movement survey program for the Project are:

- to understand the movement rates of birds within the Project and in relation to the landscape outside the Project area,
- to characterize the species composition of the birds inhabiting or migrating through the Project area in relation to the landscape,
- to understand the relative flight altitudes of birds across the Project area and in relation to the landscape,

- to characterize local movement patterns and identify areas of higher movement rates, and
- to compare bird movement within the Project area in relation to features on the landscape that may concentrate birds and bird activity.

The diurnal bird movement surveys are conducted by observers and have limitations on the ability to detect all birds passing through an area and at high altitudes (e.g., >300 m). However, they allow for many individuals to be identified to species or species group.

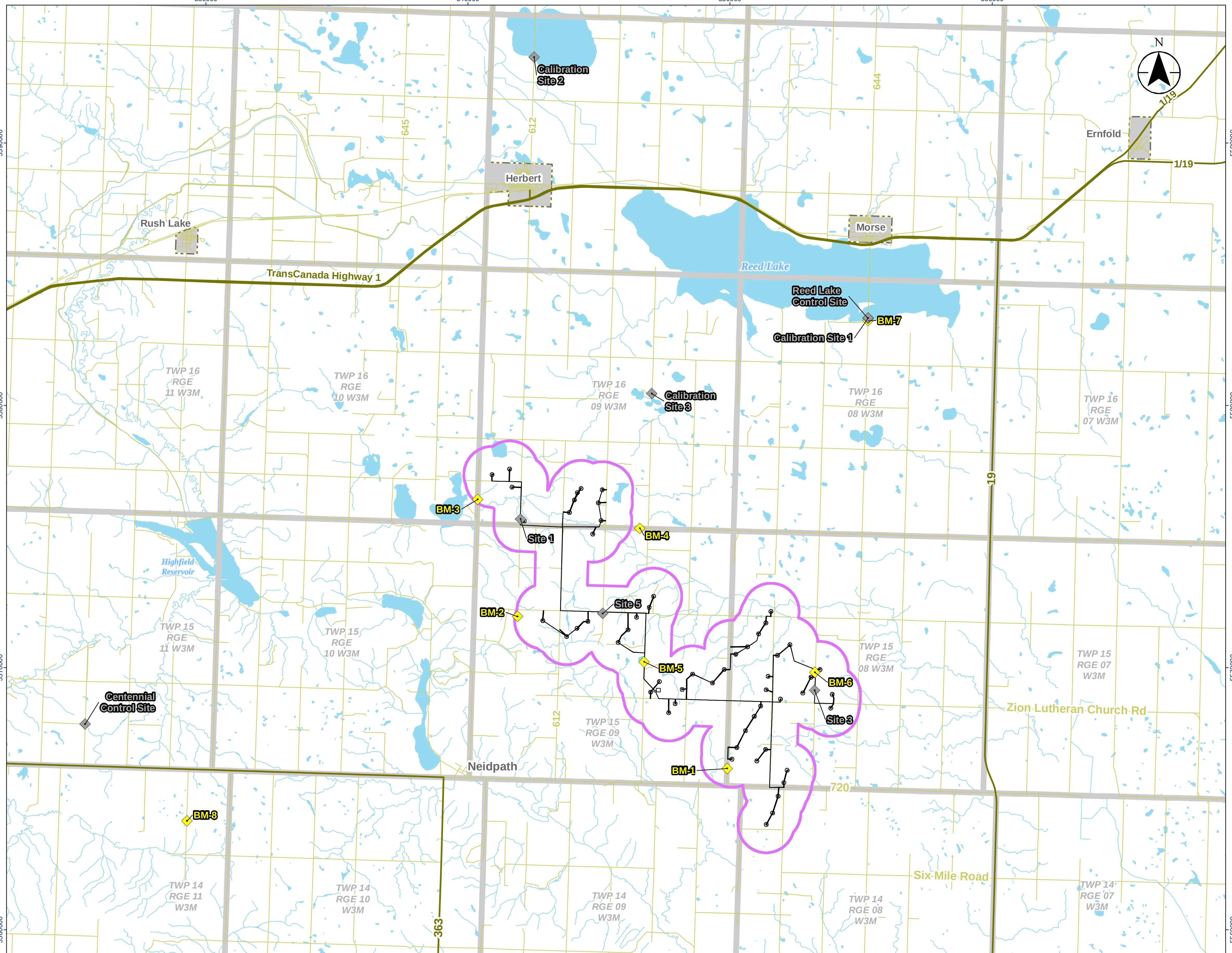
Nocturnal surveys, using marine radar equipment, provide a more precise measure of flight altitude up to 1,500 m, and within a larger surface area (1,500 m radius) but do not allow species to be differentiated.

The Project is located within a landscape that contains the Reed Lake Important Bird Area where large numbers of shorebirds, which are primarily nocturnal migrants, may concentrate. In addition to the standard bird movement survey, Algonquin undertook radar surveys to further investigate bird movement. The combination of these two survey methods provided a more thorough understanding of bird movement in this landscape than if only diurnal surveys had been applied.

1.2 STUDY AREA

The surveys were completed both within the area under consideration for siting of the Project (i.e., the Project area) and at two control sites, one located on the edge of Reed Lake, and the other located directly north of the Centennial Wind Project within an agricultural landscape (Figure H5-1). Once the proposed Project layout was finalized for the purposes of the environmental assessment, one survey site within the Project area was found to be outside the Local Assessment Area (LAA) of the Wildlife and Wildlife Habitat VC. However, as one of the objective of the bird movement surveys is to quantify bird movement within the Project area, all sites initially selected within the Project area were used in evaluating these metrics for the Project compared to the control sites. Therefore, for the purpose of this technical report, sites are discussed in the context of being within the Project area or being one of the two control sites.

The Reed Lake control site was selected as a positive control where activity rates were expected to be relatively high. The control site north of the Centennial Wind Project was located in a terrestrial landscape with no apparent features that would concentrate movements of birds and was considered a negative control where bird movement was assumed representative of the background terrestrial landscape of Saskatchewan. The comparison of each control site against survey sites in the Project area would provide a means of comparing relative movement rates. The negative control site was also located north of the Centennial Wind Project which helped to provide some context of potential fatality rates through a review of the Centennial Wind Project's mortality monitoring report for post-construction monitoring conducted in 2006 and 2007.



Stantec Algonquin

- Bird Movement Survey Site
- Nocturnal Radar Survey Site
- Project Development Area
- Wildlife Local Assessment Area
- Major Road
- Minor Road
- Railway
- Watercourse
- Waterbody
- Town/City
- Township

0 1.5 3 4.5 6 Kilometers

1:150,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 13N
2. Base features produced under license with the Government of Saskatchewan and the Government of Canada
3. Project Development Area based on Algonquin layout Sept 06, 2017, V3

Project Location
Near Herbert, SK

113254088-039 REVD
Prepared by acory on 2017-12-18
Technical Review by ceidem on 2017-12-18

Client/Project
Algonquin Power Co.
Blue Hill Wind Energy Project

Figure No.
H5-1

Title
Diurnal Bird Movement and Nocturnal Radar Survey Locations

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

2.0 METHODS

Wildlife surveys followed SKMOE-approved survey protocols and were conducted under an SKMOE scientific research permit (permit #17FW070) and data reported to the SKMOE in accordance with permit conditions.

2.1 DIURNAL BIRD MOVEMENT SURVEYS

Diurnal bird movement surveys conducted by observers are a useful tool to document the rates of bird movement during the day at set survey locations on the landscape. These surveys allow for the comparison of relative rates of movement to identify patterns and specific locations where projects may result in a higher risk to birds or specific species groups of birds.

These surveys have limitations in the ability to detect birds traveling at all altitudes due to observer limitations, and as such are a more effective tool for measuring relative rates of movement on the landscape, rather than the proportions flying at specific altitudes.

2.1.1 Study Design

Bird movement surveys were conducted to document species, flight path (i.e., height and direction) and habitat use during peak migration in the spring and fall. Surveys were conducted at six sites (Sites 1 through 6) within the Project area (Figure H5-1). Sites 2 and 3 were located between a Migratory Bird Concentration Site to the southwest and Reed Lake to the northeast to document any potential bird movement between two migratory bird stopover sites. Sites 1, 4, 5 and 6 were located in areas representative of the overall landscape in the Project area, predominantly in cultivated fields, to document bird movement through the landscape. An additional two sites were located outside the Project area as control sites (Sites 7 and 8) to determine average bird movement beyond the Project area.

2.1.2 Survey Methods

Each visit targeted waterbirds (e.g., ducks, geese), songbirds (e.g., sparrows, blackbirds), and raptors (e.g., hawks, eagles) with distinct survey intervals (the period in the day when a specific species group was surveyed). Waterbirds were surveyed twice each visit (i.e., 1 hour total), once in the early morning from one half hour before sunrise to one hour after, and once in the evening from one hour before sunset to one half hour after. Songbirds were generally surveyed twice each visit in the morning between sunrise and 1100 (due to an overlap with the waterbird interval in the morning, one survey in the morning was a combined 30-minute waterbird/songbird survey). Raptors were generally surveyed twice each visit in the middle of the day between 1100 and 1800. Only for the first spring visit, songbird and raptor surveys were limited to a single combined 30-minute survey.

Movement surveys consisted of a two-minute waiting period upon arrival to allow disturbance associated with site access to subside followed by a 30-minute observation period. For all birds observed within a 1 km radius during the movement survey, the species, number of individuals, flight path and behavioural data (e.g., flapping, perched, soaring) were recorded. Observations made beyond the 1 km radius were recorded as incidentals. Surveys were conducted when visibility was at least 800 m with a ceiling of 500 m or greater (e.g., precipitation no greater than a light rain, no fog). Wind speed could impede bird activity and surveys were generally discontinued if the wind was consistently above 30 km/h, except if it was a tail wind increasing bird activity.

Three spring bird movement survey visits were conducted between mid-April and mid-May and four fall bird movement survey visits were conducted between early September and late October at each site. In the spring, survey visits were conducted between April 12 and 16, April 28 and May 1, and May 16 and 17, 2017. In the fall, survey visits were conducted between September 5 and 7, September 19 and 21, October 1 and 5, and October 17 and 18, 2017. During the third fall survey visit, Site 4 and Site 5 were not surveyed due to weather restrictions (e.g., three days of rain) and unsafe site access.

2.1.3 Data Analysis

To assess the risk of the Project to migrants that pass through the Project area, analysis of bird movement data focused on flight height and species guild. Data from control sites outside the LAA were analyzed separately and used to compare against movement rates within the Project area.

Diurnal bird movement rates were not analyzed in relation to the tower rotor-swept area (RSA) because of the limited altitude of birds detected using this survey method. A comparison of diurnal bird movement flight altitudes would be biased to birds flying at a maximum of approximately 200-300 m altitude and does not adequately measure movement rates at higher altitudes. The nocturnal radar surveys (see below) provide a more accurate estimate of proportional flight altitudes that can be used for this purpose.

The assessment of potential effects on wildlife (see the Wildlife and Wildlife Habitat section in the Environmental Impact Statement) focuses on representative wildlife species at risk (SAR) and species of management concern (SOMC).

Wildlife SAR are defined as species listed under Schedule 1, Schedule 2, or Schedule 3 of the federal SARA as *endangered, threatened* or *special concern* (Government of Canada 2002).

Wildlife SOMC are defined as provincially legislated SAR and other species identified in federal and provincial tracking lists and activity restriction guidelines, including species:

- Listed in *The Wildlife Act* of Saskatchewan as endangered, threatened or vulnerable (Government of Saskatchewan1998);
- Listed by the COSEWIC as *endangered, threatened* or *special concern* (Government of Canada 2017), but not yet listed under SARA;
- Assigned a ranking of S1 (critically imperiled/extremely rare) or S2 (Imperiled/Very Rare) (or a combination of these rankings) by the SKCDC (SKCDC 2017d, 2017e); and,
- Included in the Saskatchewan Activity Restriction Guidelines for Sensitive Species (SKMOE 2017).

2.2 NOCTURNAL RADAR SURVEYS

Radio detection and ranging (radar) is a useful tool for monitoring nocturnal bird movement patterns. Radar provides continuous and simultaneous sampling of bird movements over a large area day and night during clear or overcast conditions. This technology has been used to monitor migrant bird flight paths (e.g., Cooper et al. 1991, Cooper et al. 2001), assess bird movement relative to airports (e.g., Loots and Otter 2011), assess mortality risk for migratory birds (Desholm and Kahlert 2005, Mabee et al. 2006, Plissner et al. 2006) and examine movements of nocturnal birds around wind energy facilities (e.g., d'Entremont et al. 2017).

Marine (X-band) radar, originally designed for use on water, has several advantages over other radar technology, including portability (easily mounted to a truck or trailer) and its ability to detect small targets at low altitudes. This form of radar has been used extensively to describe nocturnal bird and bat flight paths and altitudinal distribution (Harmata et al. 1999, Mabee and Cooper 2004, Mabee et al. 2006). A combination of horizontal and vertical orientation of the antenna provides data on flight direction and flight height, respectively, though not simultaneously.

While radar can be effective for describing the height and direction of migrating birds, it has limited ability to differentiate objects moving at the same speed in close proximity, and therefore cannot be used for accurate counts of migratory birds travelling in flocks. Detection of small targets is also hampered by ground clutter (i.e., unwanted signals returned from land masses and vegetation). In addition, marine X-band radar cannot perform species-specific identification of birds, and even migratory bats can be indistinguishable from birds (Kunz et al. 2007). However, these shortcomings can be partially overcome by calibrating radar with diurnal visual observations (Plissner et al. 2006, Loots and Otter 2011).

2.2.1 Study Design

Nocturnal radar surveys were conducted between sunset and sunrise (~2100h to 0500h) from May 5-10, 2017 and May 26 -31, 2017 for spring migration and from August 12-17, 2017 and September 6-11, 2017 for fall migration. The timing of radar surveys differed somewhat from diurnal bird movement surveys to focus on shorebird and passerine migration periods, while also capturing some waterfowl movement, particularly in spring migration.

Three radar survey sites were sited within the Project area at locations with road access and minimal interference from ground clutter. There were three sites within the Project area compared to six for the diurnal bird movement surveys because radar has a larger detection area, and because of the much higher effort required to complete radar surveys compared to diurnal bird movement surveys. The combined radar coverage of these sites included 13 of 49 proposed wind turbine sites (Figure 1). Two additional control sites were established outside of the Project area, as described in Section 1.2.

To remove ground clutter, the radar sites were sited in small depressions or close to hedgerows that act to shield radar from ground clutter farther afield (Cooper et al. 1991, Larkin 2005).

To relate radar target data to migrants potentially flying over the Project area, target calibration (based on visual observation of bird species) was conducted in the evening at nearby wetlands immediately prior to nocturnal radar surveys. Target calibration involves the comparison of bird observations prior to sunset by one observer against what is observed by the radar. These comparisons allow for the validation of target size against number of birds in a group and species groups.

2.2.2 Survey Methods

2.2.2.1 Radar Equipment

Nocturnal migrant flight data were obtained using a Furuno X-band marine radar unit (model 2117BB/DC, 12 kW, 9,410 MHz, 1.98 m open array antenna with a beam width of 1.23° horizontal and 20° vertical - Furuno Electric Company Ltd. Miki Japan). The antenna was mounted on a hinged wooden frame attached to a pickup truck bed (Photo 1). This setup was based, in part, on that described by Harmata et al. (2003). The antenna was manually alternated between vertical and horizontal position every 30 minutes to obtain data on flight height and direction (i.e., bearing), respectively. In horizontal position, the radar was mounted approximately 2.5 m above ground, and in vertical position the radar was mounted approximately 3 m above ground. Radar range was set to 1.5 km on short pulse length in both the horizontal and vertical configurations to simultaneously optimize detection of small targets (i.e., individual birds) close to the radar, and the area sampled. The radar unit was oriented to true north in both horizontal and vertical configurations. Gain was set at 100% and sea clutter and rain clutter were set to 0% to maximize sensitivity for small bodied targets such as shorebirds. Because species identification and confirmation of size of biological targets observed with radar is generally not possible, the term target is used rather than individual or flock due to the lack of visual confirmation. To aid target identification and to minimize on-screen clutter, target trails were set to display for 30 to 60 seconds depending on the number of targets. Target data from insects and bats were reduced by excluding all small targets that appeared within 500 m of the radar as small, slow moving targets with weak reflectivity (after Kuntz et al. 2007).

Radar target (a single or group of birds in flight) data were collected with the radar in horizontal and vertical orientation. For horizontal target data, the radar operator managed the radar display and the data recorder plotted the flight path on a Trimble Navigation Ltd. Geo7X datalogger with a display that mirrored the radar display. For vertical target data, the radar operator measured the height based on altitude displayed on the monitor when a target was first observed entering the detection cone and where it disappeared. The resulting minimum and maximum flight heights were recorded using the datalogger. Target size (small, medium, or large or very large; see Appendix A for a description of target sizes) was also recorded for each target observed. Weather data were recorded every 30 minutes using a Kestrel™ 2000 Wind Meter.

Photo 1 Truck-mounted marine radar unit used for nocturnal radar surveys

2.2.2.2 Target Calibration

Diurnal target calibration was used to:

1. record visual observations of bird flight paths and flock size at local wetlands as a reference for nocturnal radar data targets (i.e., to correlate flock size and composition with target size, speed and trajectory).
2. ensure proper functioning of the radar unit (i.e., that targets observed at various distances and direction were observed on the radar screen), and
3. confirm differences in flight observed patterns on the radar screen of bird species from those of foraging bats and insects.

Calibration consisted of simultaneous radar and visual surveys, where the radar recorder and visual observer identified the same target. Both observers were positioned such that a 360-degree view of the wetland could be monitored. Target calibration was carried out at three locations: Reed Lake, Francis Lake (north of the town of Herbert) and an unnamed wetland near site 1 (Figure H5-1). Wetland locations are selected for target calibration for increased efficiency as they tend to have higher bird activity, but are also selected near the survey area to capture similar species and flock sizes. Additional targets identified to species during the nocturnal radar survey (i.e., a low light levels, using binoculars) were also used for target calibration. Calibration took place1-2 hours before sunset (i.e., immediately prior to nocturnal radar surveys) between May 6-9, 2017 and May 26-31, 2017 during spring migration and August 12 -16, 2017 and September 7-9, 2017 during fall migration. Data recorded for each target included: target size (small, medium, large, or very large), number of individuals per target, guild (see Table A-1 in Appendix A for a breakdown of guilds) and, where possible, species identification.

The calibration period also provided an opportunity to identify bird migrants arriving at Reed Lake and other nearby wetlands prior to nocturnal radar surveys. Calibration was not performed with the radar in vertical orientation as high altitude targets are extremely difficult to identify visually by the observers, particularly at Reed Lake where up to 100 targets were within radar range at a given time.

2.2.3 Data Analysis

To assess the risk of the Project to nocturnal migrants, analysis of radar targets focused on quantifying flight heights (vertical radar data) and flight path direction (horizontal radar data) relative to proposed infrastructure (turbines) within the Project area. Data from control sites outside the Project area were analyzed separately for comparison of Project migrant activity with activity at Reed Lake (suspected high activity site) and west of the Project (suspected low activity site).

The number of targets below, within and above the RSA was calculated for turbine hub heights ranging from a minimum of 80 m (with a 40 m blade and an RSA of 40-120 m) and a maximum of 105 m (with a 68 m blade and RSA of 37-173 m). The survey detection area is increasingly smaller at higher altitudes because of the dome shape of the radar beam in vertical orientation (up until the set detection limit of 1500 m); to account for the smaller detection area, and subsequent reduced probability of detection at higher altitudes, target counts were multiplied by an area-based correction factor. This correction factor accounts for the smaller area sampled by the radar as altitude increases. Therefore, hereafter results of vertical surveys are referred to as corrected vertical targets. Also, a limitation of radar data is that clutter and surface obstructions can sometimes cause targets flying at low altitudes to be missed; as such, it is likely that the proportion of movements below the RSA are also biased low, which would indicate that overall the proportion of movements within the RSA is conservatively high.

Flight height and flight path direction were assessed for seasonal (i.e., spring vs. fall migration) patterns and site-specific patterns (i.e. for each site). To help differentiate local flights from those of nocturnal migrants, flight altitude and directional data were separated into crepuscular activity (dawn and dusk) and nocturnal activity (night, defined as the period between nautical dusk and dawn). Flight path direction was also assessed in relation to fight path distance to help distinguish between local flights and migrants. Target flight path direction was summarized using circular histograms with direction split into 45 degree quadrants. Figures were generated in the statistical program R (R Development Core Team 2017).

3.0 RESULTS

3.1 DIURNAL BIRD MOVEMENT

3.1.1 Environmental Conditions

Surveys were conducted when visibility was at least 800 m with a ceiling of 500 m or greater (e.g., precipitation no greater than a light rain, no fog). Wind speed may impede bird activity and were generally discontinued if the wind was consistently above 30 km/h, except if it was a tail wind increasing bird activity. Surveys were suspended when weather conditions hindered the ability to accurately observe and identify species within the target radius and/or if weather was hindering bird movement.

Larger, heavier species (i.e., raptors, ducks, geese) are less affected by stronger winds and precipitation and may continue migration in conditions that smaller, lighter migrants (i.e., songbirds) may find unsuitable. Wind direction may be more important for predicting bird movement than overall speed as a strong tailwind may increase overall migration activities above those observed on a calm day as birds take advantage of the ability to cover more ground using less energy. Large weather systems can concentrate bird movement with increased migration activity before and after the system and minimal movement during as birds seek shelter.

3.1.2 Movement Rates by Season and Survey Visit

3.1.2.1 Spring Bird Movement Surveys

Within the Project area, a total of 2,096 individuals from 61 species of birds were recorded during spring bird movement surveys, including two SAR (ferruginous hawk [*Buteo regalis*] and Sprague's pipit [*Anthus spragueii*]), and one SOMC (red-necked phalarope [*Phalaropus lobatus*]) (Table 3-1). The five most abundant species observed in the Project area during spring movement surveys were horned lark (*Eremophila alpestris*; 251 individuals), red-winged blackbird (*Agelaius phoeniceus*; 186 individuals), mallard (*Anas platyrhynchos*; 171 individuals), Lapland longspur (*Calcarius lapponicus*; 82 individuals), and semipalmated plover (*Charadrius semipalmatus*; 75 individuals).

Within the Project area, Sites 1 and 3 had the most observations with 480 (22.9%) and 778 (37.1%) individuals, respectively; conversely, Sites 2 and 4 had the fewest observations with 129 (6.2%) and 158 (7.5%) observations, respectively. In the Project area, a total of 1,062 (50.7%) observations were recorded during the waterbird survey interval, 989 (47.2%) during the songbird interval, and 45 (2.1%) during the raptor interval (see Table 3-1). The average number of observations at the six sites in the Project area was 349 birds.

Table 3-1 Avian Species Observed during the 2017 Spring Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
WATERBIRD SURVEY INTERVAL[3]									
Waterfowl									
Snow goose	*Anser caerulescens*	0	0	60	0	0	0	0	0
Canada goose	*Branta canadensis*	0	8	26	9	4	6	24	2
Tundra swan	*Cygnus columbianus*	0	0	0	0	0	0	9	0
Blue-winged teal	*Spatula discors*	3	2	1	0	11	0	47	4
Northern shoveler	*Spatula clypeata*	2	0	4	0	1	0	78	6
Gadwall	*Mareca strepera*	3	3	29	0	19	7	11	2
American wigeon	*Mareca americana*	0	0	6	0	6	1	0	0
Mallard	*Anas platyrhynchos*	22	12	39	7	76	15	19	19
Northern pintail	*Anas acuta*	0	2	3	6	25	0	4	2
Green-winged teal	*Anas crecca*	0	0	0	0	0	0	9	2
Canvasback	*Aythya valisineria*	0	0	69	0	0	0	13	0
Redhead	*Aythya americana*	0	0	0	0	0	0	4	0
Lesser scaup	*Aythya affinis*	0	0	6	5	22	0	314	0
Common goldeneye	*Bucephala clangula*	0	0	0	0	0	0	11	0
Common merganser	*Mergus merganser*	0	0	0	0	0	0	1	0
Duck spp.	*n/a*	11	0	31	0	0	0	420	0
Waterfowl Total		**41**	**27**	**274**	**27**	**164**	**29**	**964**	**37**
Waterbird									
Eared grebe	*Podiceps nigricollis*	0	0	0	0	8	0	8	0
Western grebe	***Aechmophorus occidentalis***	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**

Table 3-1 Avian Species Observed during the 2017 Spring Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
American white pelican	*Pelecanus erythrorhynchos*	0	0	0	0	0	0	11	0
Double-crested cormorant	*Phalacrocorax auritus*	0	0	3	0	0	8	58	0
American coot	*Fulica americana*	0	0	0	0	6	0	0	2
Sandhill crane	*Antigone canadensis*	0	0	40	0	0	0	14	0
Franklin's gull	*Leucophaeus pipixcan*	19	1	11	0	2	13	1,505	0
Ring-billed gull	*Larus delawarensis*	2	0	2	0	0	9	805	0
California gull	*Larus californicus*	0	0	0	0	0	0	80	0
Herring gull	*Larus argentatus*	0	0	0	0	0	1	1,182	0
Gull spp.	*n/a*	50	0	1	0	0	0	310	0
Forster's tern	*Sterna forsteri*	6	0	0	0	25	0	28	0
Common tern	*Sterna hirundo*	0	0	0	0	3	0	0	0
Waterbird Total		**77**	**1**	**57**	**0**	**44**	**31**	**4,002**	**2**
Shorebird									
American avocet	*Recurvirostra americana*	0	0	0	0	0	0	4	0
Semipalmated plover	*Charadrius semipalmatus*	0	0	75	0	0	0	0	0
Killdeer	*Charadrius vociferus*	0	0	0	0	1	0	4	1
Whimbrel	*Numenius phaeopus*	0	0	0	0	0	0	10	0
Long-billed curlew	***Numenius americanus***	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**
Marbled godwit	*Limosa fedoa*	0	0	4	0	0	7	0	0
Red knot	***Calidris canutus rufa***	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Short-billed dowitcher	*Limnodromus griseus*	0	0	0	0	0	0	8	0

Table 3-1 Avian Species Observed during the 2017 Spring Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
Long-billed dowitcher	*Limnodromus scolopaceus*	0	0	25	0	0	0	0	0
Wilson's snipe	*Gallinago delicata*	1	3	14	2	0	0	0	0
Spotted sandpiper	*Actitis macularius*	0	0	50	0	0	0	0	0
Solitary sandpiper	*Tringa solitaria*	0	15	39	0	0	0	0	0
Lesser yellowlegs	*Tringa flavipes*	0	0	0	0	0	0	13	0
Willet	*Tringa semipalmata*	0	1	1	0	0	0	6	4
Greater yellowlegs	*Tringa melanoleuca*	0	0	0	0	0	0	0	2
Wilson's phalarope	*Phalaropus tricolor*	0	0	1	0	0	1	6	0
Red-necked phalarope	***Phalaropus lobatus***	**0**	**0**	**0**	**0**	**1**	**0**	**22**	**0**
Sandpiper spp.	*n/a*	0	0	3	0	1	0	0	0
Shorebird spp.	*n/a*	24	0	0	21	0	0	354	0
Shorebird Total		**25**	**19**	**212**	**23**	**3**	**8**	**433**	**7**
RAPTOR SURVEY INTERVAL									
Osprey	*Pandion haliaetus*	0	0	0	0	1	0	0	0
Northern harrier	*Circus hudsonius*	4	1	1	1	1	4	1	4
Red-tailed hawk	*Buteo jamaicensis*	2	1	2	1	0	2	0	3
Swainson's hawk	*Buteo swainsoni*	1	6	5	2	2	0	1	0
Ferruginous hawk	***Buteo regalis***	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Hawk spp.	*n/a*	0	0	0	1	0	0	0	4
American kestrel	*Falco sparverius*	1	0	1	0	0	0	0	0
Merlin	*Falco columbarius*	1	0	0	1	0	0	1	0
Raptor spp.	*n/a*	1	0	0	1	0	0	0	0

Table 3-1 Avian Species Observed during the 2017 Spring Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
Raptor Total		**10**	**8**	**10**	**7**	**4**	**6**	**3**	**11**
SONGBIRD SURVEY INTERVAL[4]									
Sharp-tailed grouse	*Tympanuchus phasianellus*	0	11	1	1	0	29	0	0
Gray partridge	*Perdix perdix*	0	0	0	2	0	0	0	0
Rock pigeon	*Columba livia*	5	0	3	0	0	0	0	0
Mourning dove	*Zenaida macroura*	2	0	3	1	0	0	0	0
Black-billed magpie	*Pica hudsonia*	0	0	1	1	0	0	0	0
Common raven	*Corvus corax*	0	0	0	1	0	0	1	0
American crow	*Corvus brachyrhynchos*	1	4	1	0	0	0	0	3
Horned lark	*Eremophila alpestris*	201	8	8	18	10	6	22	86
Barn swallow	***Hirundo rustica***	**0**	**0**	**0**	**0**	**0**	**0**	**7**	**0**
Tree swallow	*Tachycineta bicolor*	0	0	25	0	0	0	0	0
American robin	*Turdus migratorius*	0	0	4	0	0	0	4	2
European starling	*Sturnus vulgaris*	0	0	3	0	0	1	0	4
Sprague's pipit	***Anthus spragueii***	**0**	**4**	**0**	**0**	**0**	**0**	**2**	**0**
Lapland longspur	*Calcarius lapponicus*	45	0	0	37	0	0	0	65
Snow bunting	*Plectrophenax nivalis*	0	0	0	0	0	0	0	1
Grasshopper sparrow	*Ammodramus savannarum*	0	0	3	0	0	0	0	0
Clay-colored sparrow	*Spizella pallida*	2	1	0	5	1	1	0	2
Lincoln's sparrow	*Melospiza lincolnii*	0	3	1	0	0	0	0	0
Vesper sparrow	*Pooecetes gramineus*	0	0	1	1	0	1	2	0

Table 3-1 Avian Species Observed during the 2017 Spring Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
Savannah sparrow	*Passerculus sandwichensis*	0	3	2	0	7	3	0	1
Lark sparrow	*Chondestes grammacus*	0	0	8	0	0	0	0	0
Dark-eyed junco	*Junco hyemalis*	0	0	0	0	0	0	1	0
Western meadowlark	*Sturnella neglecta*	4	13	14	6	3	2	4	5
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	0	1	28	0	5	0	7	0
Red-winged blackbird	*Agelaius phoeniceus*	42	2	73	1	40	28	28	51
Brewer's blackbird	*Euphagus cyanocephalus*	0	15	25	4	0	6	129	11
Brown-headed cowbird	*Molothrus ater*	14	8	15	9	8	19	12	0
Common grackle	*Quiscalus quiscula*	3	1	6	14	0	12	21	0
Blackbird spp.	*n/a*	8	0	0	0	0	80	0	88
Songbird Total		**327**	**74**	**225**	**101**	**74**	**188**	**240**	**319**
Grand Total		**480**	**129**	**778**	**158**	**289**	**262**	**5,642**	**376**

NOTES:
1 Only targeted species observed during the appropriate timing interval are included (i.e., ducks are only counted if observed during the waterbird survey interval).
2 Bold names indicate a SAR or an SOMC.
3 Waterbird survey interval subdivided into waterfowl (i.e., ducks, geese and swans), waterbird (i.e., grebes, loons, gulls, terns, herons, and pelicans), and shorebird (i.e., wading species such as curlews, plovers, and sandpipers) species.
4 Songbird survey interval includes all landbirds such as passerines, corvids, and gamebirds.
5 Control sites which are outside of the Project area.

The control site at Reed Lake (Site 7) had the most observations with 5,642 individuals recorded. This was more than seven times the number of birds observed at Site 3, which had the highest abundances recorded within the Project area, and more than all sites in the Project area combined. Five SAR (ferruginous hawk, long-billed curlew, red knot [*Calidris canutus*], western grebe [*Aechmophorus occidentalis*] and Sprague's pipit) and one SOMC (red-necked phalarope) were recorded at the Reed lake control site. The most abundant species observed at Site 7 were Franklin's gull (*Leucophaeus pipixcan,* 1,505 individuals), herring gull (*Larus argentatus,* 1,182 individuals), and ring-billed gull (*Larus delawarensis*, 805 individuals). Site 8, the control site north of the Centennial Wind Project, had 376 recorded observations, with species abundances being similar to sites within the Project Area with horned lark (86 individuals), Lapland longspur (65 individuals), and red-winged blackbird (51 individuals) as the most abundant (see Table 3-1).

3.1.2.2 Fall Bird Movement Surveys

A total of 85,867 individuals from 30 species of birds were observed in the Project area, with no SAR or SOMC recorded (Table 3-2). The five most abundant species observed in the Project area during fall movement surveys were snow goose (*Anser caerulescens*; 73,700 individuals), mallard (464 individuals), Canada goose (*Branta canadensis*; 451 individuals), horned lark (421 individuals), and greater white-fronted goose (*Anser albifrons*; 387 individuals).

Within the Project area, 97.5% of fall bird movement observations were waterfowl (i.e., ducks and geese). Snow goose accounted for most (84,160) observations during fall movement surveys with 73,700 individuals in the Project area (85.8% of total bird observations). Several of these observations were due to large flocks with over 2,000 individuals (see footnotes in Table 3-2 for specific observations). Both Sites 4 and 5 had flocks with more than 10,000 individual snow geese.

Overall, within the Project area, Sites 4 and 5 had the most observations with 39,387 (45.9%) and 24,268 (28.3%) observations, respectively; conversely, Sites 1 and 6 had the fewest observations with 734 (0.9%) and 3,845 (4.5%) observations, respectively (see Table 3-2). When the snow goose observations are removed, Sites 4 and 5 still had the highest number of observations (3,290 and 3,395 individuals, respectively), but were much closer to the numbers recorded at Sites 2 and 3 (1,807 and 2,659 individuals, respectively, excluding snow geese). Sites 1 and 6, both sites in the southeast portion of the Project area, continued to have the lowest number of observations, even after the snow geese were removed, with 659 and 357 individuals, respectively.

The control site near Reed Lake (Site 7) had 22,846 observations, similar to the number recorded at Site 5. The most abundant species observed at Site 7 were snow goose (10,460 individuals), American coot (*Fulica americana*, 2,075 individuals), and lesser scaup (*Aythya affinis*; 1,560 individuals). Additionally, three SAR (horned grebe, western grebe, and barn swallow) were recorded at the site (Table 3-2). Control Site 8 had 305 recorded observations with Canada goose (152 individuals), Lapland longspur (41 individuals), and horned lark (34 individuals) being the most abundant species (Table 3-2).

Table 3-2 Avian Species Observed during the 2017 Fall Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
WATERBIRD SURVEY INTERVAL[3]									
Waterfowl									
Snow goose	*Anser caerulescens*	75	6,582	6,585	36,097**	20,873**	3,488*	10,460*	0
Greater white-fronted goose	*Anser albifrons*	0	232	155	0	0	0	52	0
Canada goose	*Branta canadensis*	33	13	133	9	173	90	441	152
Goose spp.	*n/a*	340	1,350	1,003	3,100*	1,400	0	0	0
Tundra swan	*Cygnus columbianus*	0	0	3	0	0	0	96	0
Swan spp.	*n/a*	0	50	25	0	0	9	16	0
Blue-winged teal	*Spatula discors*	0	0	0	0	2	0	875	3
Northern shoveler	*Spatula clypeata*	0	0	0	0	0	0	492	0
Gadwall	*Mareca strepera*	0	0	0	0	0	0	300	0
American wigeon	*Mareca americana*	0	0	0	0	0	0	80	0
Mallard	*Anas platyrhynchos*	0	0	6	0	458	0	1,323	9
Northern pintail	*Anas acuta*	0	0	0	0	0	0	8	0
Canvasback	*Aythya valisineria*	0	0	0	0	0	0	992	0
Redhead	*Aythya americana*	0	0	0	0	40	0	183	0
Lesser scaup	*Aythya affinis*	0	0	0	0	0	0	1,560	0
Bufflehead	*Bucephala albeola*	0	0	0	0	0	0	2	0
Ruddy duck	*Oxyura jamaicensis*	0	0	0	0	0	0	36	0
Duck spp.	*n/a*	22	0	911	20	192	25	3,380	13
Waterfowl spp.	*n/a*	0	0	16	0	239	0	0	0
Waterfowl Total		**470**	**8,227**	**8,837**	**39,226**	**23,377**	**3,612**	**20,296**	**177**

Table 3-2 Avian Species Observed during the 2017 Fall Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
Waterfowl Total without Snow Goose		**395**	**1,645**	**2,252**	**3,129**	**2,504**	**124**	**9,836**	**177**
Waterbird									
Horned grebe	***Podiceps auritus***	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**
Eared grebe	*Podiceps nigricollis*	0	0	0	0	0	0	30	0
Western grebe	***Aechmophorus occidentalis***	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**0**
American white pelican	*Pelecanus erythrorhynchos*	0	0	0	0	0	0	8	0
Double-crested cormorant	*Phalacrocorax auritus*	0	0	0	0	0	0	33	0
American coot	*Fulica americana*	0	0	0	0	0	0	2,075	0
Sandhill crane	*Antigone canadensis*	0	0	1	0	0	0	24	0
Gull spp.	*n/a*	0	0	0	0	0	0	1	0
Waterbird Total		**0**	**0**	**1**	**0**	**0**	**0**	**2,184**	**0**
Shorebird									
Killdeer	*Charadrius vociferus*	0	0	0	0	0	1	7	0
Lesser yellowlegs	*Tringa flavipes*	0	0	0	0	0	0	4	0
Greater yellowlegs	*Tringa melanoleuca*	0	0	0	0	0	0	22	0
Wilson's phalarope	*Phalaropus tricolor*	0	0	0	0	0	0	82	0
Shorebird spp.	*n/a*	0	0	0	0	0	0	15	0
Shorebird Total		**0**	**0**	**0**	**0**	**0**	**1**	**130**	**0**
RAPTOR SURVEY INTERVAL									
Northern harrier	*Circus hudsonius*	0	1	1	0	0	1	1	2
Red-tailed hawk	*Buteo jamaicensis*	0	0	3	1	0	0	0	1
Swainson's hawk	*Buteo swainsoni*	0	0	1	0	0	0	1	0
Rough-legged hawk	*Buteo lagopus*	0	0	0	0	0	1	0	0

Table 3-2 Avian Species Observed during the 2017 Fall Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
Hawk spp.	*n/a*	0	0	2	3	0	0	2	0
American kestrel	*Falco sparverius*	1	0	0	0	1	0	0	1
Merlin	*Falco columbarius*	1	0	1	0	0	0	0	0
Great horned owl	*Bubo virginianus*	0	0	0	0	1	0	0	0
Raptor spp.	*n/a*	0	0	0	0	0	1	0	1
Raptor Total		**2**	**1**	**8**	**4**	**2**	**3**	**4**	**5**
SONGBIRD SURVEY INTERVAL[4]									
Sharp-tailed grouse	*Tympanuchus phasianellus*	0	1	0	0	0	32	0	0
Gray partridge	*Perdix perdix*	0	0	0	0	0	0	0	20
Rock pigeon	*Columba livia*	0	0	15	0	2	0	5	0
Mourning dove	*Zenaida macroura*	5	0	0	0	0	1	0	0
Black-billed magpie	*Pica hudsonia*	14	0	1	0	0	0	0	0
Common raven	*Corvus corax*	0	0	1	0	1	1	2	0
American crow	*Corvus brachyrhynchos*	0	0	0	0	0	0	1	0
Horned lark	*Eremophila alpestris*	96	68	14	111	71	61	47	34
Barn swallow	***Hirundo rustica***	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**0**
American robin	*Turdus migratorius*	0	8	0	0	0	0	0	0
Brown thrasher	*Toxostoma rufum*	0	1	0	0	0	0	0	0
House sparrow	*Passer domesticus*	0	0	0	0	0	0	10	8
Lapland longspur	*Calcarius lapponicus*	15	39	5	0	0	34	103	41
American tree sparrow	*Spizelloides arborea*	0	0	4	0	0	0	0	0
Clay-colored sparrow	*Spizella pallida*	32	0	0	0	0	0	3	6
Vesper sparrow	*Pooecetes gramineus*	24	1	0	14	0	0	20	0

Table 3-2 Avian Species Observed during the 2017 Fall Bird Movement Surveys

Common Name[1,2]	Scientific Name	No. of Individuals Observed							
		Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7[5]	Site 8[5]
Savannah sparrow	*Passerculus sandwichensis*	1	0	0	11	3	0	0	1
Western meadowlark	*Sturnella neglecta*	39	15	12	4	8	13	8	9
Red-winged blackbird	*Agelaius phoeniceus*	0	0	8	0	0	0	4	0
Brown-headed cowbird	*Molothrus ater*	2	0	0	0	0	0	0	1
Brewer's blackbird	*Euphagus cyanocephalus*	0	0	0	0	0	0	6	0
Blackbird spp.	*n/a*	0	0	168	0	0	32	0	0
Songbird spp.	*n/a*	34	28	170	17	804	55	15	3
Songbird Total		**262**	**161**	**398**	**157**	**889**	**229**	**232**	**123**
Grand Total		**734**	**8,389**	**9,244**	**39,387**	**24,268**	**3,845**	**22,846**	**305**
Grand Total without Snow Goose		**659**	**1,807**	**2,659**	**3,290**	**3,395**	**357**	**12,386**	**305**

NOTES:

[1] Only targeted species observed during the appropriate timing interval are included (i.e., ducks are only counted if observed during the waterbird survey interval).

[2] Bold names indicate a SAR or an SOMC.

[3] Waterbird survey interval subdivided into waterfowl (i.e., ducks, geese and swans), waterbird (i.e., grebes, loons, gulls, terns, herons, and pelicans), and shorebird (i.e., wading species such as curlews, plovers, and sandpipers) species.

[4] Songbird survey interval includes all landbirds such as passerines, corvids, and gamebirds.

[5] Control sites which are outside of the Project area.

* Observation of at least 1 flock with 2,000 individuals or more.

** Observation of at least 1 flock with 10,000 individuals or more.

3.1.3 Species of Management Concern

During the spring bird movement surveys, five SAR (long-billed curlew, western grebe, ferruginous hawk, barn swallow, and Sprague's pipit) and one SOMC (red-necked phalarope) were recorded. Sprague's pipit and red-necked phalarope were both recorded in the Project area and at Site 7, and ferruginous hawk was only observed within the Project area. The remaining SAR and SOMC were only observed at the Reed Lake control site (Site 7).

During the fall bird movement surveys, three SAR (horned grebe, western grebe, and barn swallow) were recorded at Site 7, but no SAR or SOMC were observed within the Project area.

3.1.4 Movement Patterns on the Landscape

Within the Project area there were 2,096 observations in spring and 85,867 observations in fall. Waterfowl accounted for 97.5% (83,749 individuals) of the observations recorded during fall, of which 73,700 individuals were snow geese. Conversely, 47.2% (989 individuals) of the observations recorded during spring movement were landbirds, of which 251 were horned lark and 186 were red-winged blackbird. While absolute numbers observed do not indicate the actual number of birds using the region, these data suggest a greater number of individuals use the area in the fall for migration staging than in the spring.

As expected, Site 7 had the highest number of observations of all sites in the spring (5,638 individuals), and was an order of magnitude higher than the Project area sites; Site 8 had a similar number of observations (376) to the average (349) of the Project area sites.

Within the Project area, Site 3 had the most observations (778 individuals), likely due to the proximity of a large wetland west of the survey location.

Patterns differed in the fall where Site 4 had the most observations (39,387 individuals). However, when snow geese are removed as a few large flocks can greatly influence overall bird numbers, Site 7 again had the highest number of observations by an order of magnitude (Table 3-2). This is notable as most snow geese were not observed roosting on Reed Lake near Site 7, but tended to be at the east or west ends of the lake. Site 8 had the fewest observation in the fall with 305 individuals, which was similar to Site 6 in the Project area (357 individuals).

Overall, beyond Reed Lake having consistently higher numbers of birds, there were no clear patterns in bird movement rates when considering the spring and fall.

3.2 NOCTURNAL RADAR SURVEYS

3.2.1 Environmental Conditions

There were no precipitation events during the spring and fall surveys that prevented data collection; however, approximately 180 minutes of survey time was lost due to safety considerations (e.g., avoidance of lightning storms). During spring, five survey nights were clear with visible stars and five nights were partially cloudy or overcast (i.e., ≥ 50% cloud cover). During fall, six nights were clear and four nights were partially cloudy or overcast. The moon phase ranged from waxing crescent to full during spring surveys and from full to waning crescent during the fall surveys. Aurora Borealis occurred on May 27, 2017 during the spring and September 6 and 7, 2017 during fall surveys. Temperature ranged from 0°C to 29°C in spring and 4°C to 28°C in fall. Winds were generally calm to light during both seasons with the majority of winds ≤11 km/h; wind speed ranged from Beaufort 0 to 4 (0 to 28 km/h) during spring surveys and from Beaufort 0 to 5 (0 to 38 km/h) during fall surveys. Wind direction was highly variable and changed hourly some nights; in spring, winds were predominantly from the south and west, whereas in fall, winds were typically from the south and east. Cloud cover and wind direction were not linked to patterns in target height or flight path direction. Some evidence suggests targets were flying at lower altitude when wind speeds at ground level were ≥ 11 km/h (see Section 3.2.3.2).

3.2.2 Target Calibration

A summary of flock size and associated radar target size is provided for observed waterbird guilds in Table 3-5 and Table 3-6 (see species composition of each guild in Table A-1 in Appendix A). Data for small shorebirds indicate that small, medium, large, and very large targets comprised an average of 6, 15, 79, and 180 individuals (primarily unidentified shorebirds) during spring (Table 3-5). For medium-size waterfowl recorded during fall calibration, small, medium, and large targets represent and average of 4, 7, and 17 individuals (Table 3-6). Overall, 34 species were identified during calibration field work, including eight shorebird species. A breakdown of calibration for each species observed in spring and fall is provided in Table A-2 and Table A-3 in Appendix A.

Table 3-3 Summary of Target Calibration Data Collected during Spring 2017

Guild (size)	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Shorebird (small)	Small	6	1	40	65	13
	Medium	15	10	22	75	5
	Large	79	10	160	555	7
	Very large	180	180	180	180	1
	Total				**875**	**26**
Shorebird (medium)	Small	2	1	3	19	13
	Total				**19**	**13**
Wading bird (medium)	Small	3	3	3	3	1
	Medium	2	1	4	11	5
	Total				**14**	**6**
Wading bird (large)	Medium	1	1	1	1	1
	Total				**1**	**1**
Waterfowl (small)	Small	2	1	4	14	7
	Medium	2	1	3	19	10
	Large	11	6	15	21	2
	Total				**54**	**19**
Waterfowl (medium)	Small	2	1	8	96	61
	Medium	4	1	18	139	35
	Large	14	8	22	109	8
	Total				**344**	**104**
Waterfowl (large)	Small	2	1	4	19	13
	Medium	4	1	6	39	9
	Large	9	2	20	47	5
	Total				**105**	**27**
Waterbird (large)	Small	1	1	1	8	8
	Medium	2	1	6	13	6
	Large	4	4	4	4	1
	Total				**25**	**15**
Gull (medium)	Small	1	1	6	220	160
	Medium	4	1	16	125	36
	Large	16	9	28	64	4
	Total				**409**	**200**

Table 3-3 Summary of Target Calibration Data Collected during Spring 2017

Guild (size)	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Tern (medium)	Small	1	1	1	10	10
	Total				**10**	**10**
Passerine (small)	Small	3	1	16	27	9
	Medium	6	5	6	11	2
	Large	55	55	55	55	1
	Total				**93**	**12**
Passerine (medium)	Small	1	1	1	1	1
	Total				**1**	**1**
Grand Total					**1,950**	**434**

Table 3-4 Summary of Target Calibration Data Collected during Fall 2017

Guild (size)	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Shorebird (small)	Small	10	1	20	58	6
	Medium	17	15	19	34	2
	Total				**92**	**8**
Shorebird (medium)	Small	5	3	6	9	2
	Total				**9**	**2**
Waterfowl (small)	Small	2	2	2	2	1
	Total				**2**	**1**
Waterfowl (medium)	Small	4	1	21	127	36
	Medium	7	2	13	163	23
	Large	17	8	40	204	12
	Total				**494**	**71**
Waterfowl (large)	Medium	4	3	6	12	3
	Large	14	4	26	99	7
	Total				**111**	**10**
Waterbird (small)	Small	1	1	1	2	2
	Total				**2**	**2**
Waterbird (large)	Small	1	1	1	3	3
	Total				**3**	**3**

Table 3-4 Summary of Target Calibration Data Collected during Fall 2017

Guild (size)	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Raptor (large)	Small	1	1	1	1	1
	Total				**1**	**1**
Gull (medium)	Small	1	1	4	37	34
	Medium	7	4	10	29	11
	Total				**66**	**45**
Tern (medium)	Small	1	1	1	3	3
	Medium	15	15	15	15	1
	Total				**18**	**4**
Tern (large)	Small	1	1	1	1	1
	Total				**1**	**1**
Grand Total					**799**	**148**

3.2.3 Nocturnal Movements

3.2.3.1 All Targets Combined

3.2.3.1.1 Project Area Sites

Within the Project area, a total of 6,498 targets (i.e., horizontal and corrected vertical targets combined) were observed during both migratory seasons. Approximately 65% more targets were recorded during spring (4,042) compared to fall (2,454) and approximately 40% more vertical targets (3,804) were recorded compared to horizontal targets (2,694) (Table 3-5). The majority of targets were observed at night (vs. dusk and dawn) in fall (89%), while a lower proportion of targets were observed at night during spring (69%) (Table 3-7). The distribution of targets varied seasonally among the three sites, with the highest number of targets in the spring recorded at site 3 (1,880) and the highest number of targets in the fall recorded at site 5 (1,282). Site 1 had the highest number of targets combined for both seasons (2,328 total; spring – 1,469, fall – 859; Table 3-5).

Approximately 90% of targets recorded in the Project area were small (Table 3-6). Super large targets, observed for large flocks of waterfowl during target calibration (see Section 3.2.2, Table 3-1 and Table 3-2), were not observed during nocturnal radar surveys. The number of medium and large-sized targets was similar during spring (368) and fall (317) surveys (Table 3-6). The highest number of medium and large-sized targets was recorded at site 3 during spring and site 1 during fall (Table 3-6). During spring, large and medium-sized targets were recorded more often at dusk, while during fall, large and medium-sized target were recorded more often at night (Table 3-7). Large and medium-sized targets were recorded less often at dawn than during other time categories, particularly in fall (Table 3-7).

3.2.3.1.2 Control Sites

More targets were recorded at both control sites compared to sites within the Project area (Table 3-7). The highest number of targets was recorded at the control site near the Centennial WEP west of the Project area (3,893 total; spring – 1,821; fall – 2,072; Table 3-5); approximately 40% fewer targets were recorded at the Reed Lake site (2,836 total; spring – 1,609; fall – 1,227; Table 3-5). As with sites in the Project area, more targets were recorded at control sites during spring and more vertical targets were recorded compared to horizontal targets (Table 3-5). At both control sites, a higher proportion of targets were recorded at night (vs. dusk and dawn) during fall compared to spring (Table 3-7).

The number of medium and large-sized targets was greater at the Reed Lake site (483 medium, 47 large) compared to the Centennial site (137 medium, 9 large) in both spring and fall (Table 3-6). In addition, more medium and large-sized targets were recorded at Reed Lake compared to any one site within the Project area (Table 3-6). Large and medium-sized targets were recorded more often at night (vs. dusk and dawn) at both control sites (Table 3-7). Large and medium-sized targets were recorded less often at dawn than during other time categories, particularly in fall (Table 3-7).

Table 3-5 Number of Targets Recorded during 2017 Nocturnal Radar Survey

Site ID	Spring		Fall		Combined Seasons		
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Total
Project Area							
Site 1	639	830	475	384	1,114	1,214	2,328
Site 3	644	1,236	186	128	830	1,364	2,194
Site 5	376	318	374	908	750	1,226	1,975
Total	**1,659**	**2,383**	**1,035**	**1,419**	**2,694**	**3,804**	**6,498**
Control Sites							
Centennial	617	1,204	576	1,496	1,193	2,700	3,893
Reed Lake	960	649	664	563	1,624	1,212	2,836
Total	**1,577**	**1,853**	**1,240**	**2,059**	**2,817**	**3,912**	**6,729**

Table 3-6 Size of Targets Recorded during 2017 Nocturnal Radar Survey

Target Size	Project Area							Control Sites				
	Site 1		Site 3		Site 5		Total	Centennial		Reed Lake		Total
	Spring	Fall	Spring	Fall	Spring	Fall		Spring	Fall	Spring	Fall	
Large	5	17	12	3	0	10	**47**	3	6	27	20	**56**
Medium	135	205	159	31	57	51	**638**	72	65	246	237	**620**
Small	1,329	637	1,709	280	637	1,221	**5,813**	1,746	2,001	1,336	970	**6,053**
Total	**1,469**	**859**	**1,880**	**314**	**694**	**1,282**	**6,498**	**1,821**	**2,072**	**1,609**	**1,227**	**6,729**

Table 3-7 Size of Targets Recorded at Dawn, Night and Dusk during 2017 Nocturnal Radar Survey

Target Size	Spring				Fall			Total
	Dawn	Night	Dusk	Total	Dawn	Night	Dusk	
Project Area								
Large	4	3	10	17	0	20	10	30
Medium	52	149	150	352	0	209	77	286
Small	246	2,674	754	3,674	37	1,950	152	2,138
Total	**302**	**2,826**	**914**	**4,042**	**37**	**2,179**	**239**	**2,454**
Centennial Control Site								
Large	0	1	2	3	0	5	1	6
Medium	3	53	17	72	3	54	8	65
Small	152	1,152	441	1,746	30	1,874	97	2,001
Total	**155**	**1,206**	**460**	**1,821**	**33**	**1,933**	**106**	**2,072**
Reed Lake Control Site								
Large	5	10	12	28	0	5	15	20
Medium	26	125	94	246	0	176	61	237
Small	159	764	413	1,336	82	760	128	970
Total	**191**	**899**	**519**	**1,609**	**82**	**941**	**203**	**1227**

3.2.3.2 Flight Altitudes (Vertical Targets)

Within the Project area, recorded flight altitudes averaged 275 m across both migratory seasons and were similar to those at the Centennial control site (293 m), and both lower than the Reed Lake control site (371 m) (Table 3-8). At sites within the Project area, the majority of vertical targets recorded during spring and fall surveys (corrected to account for the radar detection area) were above the RSAs for tower hub heights of 80 m (spring, 80%; fall, 83%) and 105 m (spring, 72%; fall, 76%) (Table 3-9).

Large-sized targets, though rarely encountered within the Project area, were relatively more common below and above the RSA compared to smaller sized targets (Table 3-9; Figure H5-2). The altitude of targets recorded in the Project area was similar during dusk and night in spring and fall, whereas altitudes at dawn tended to be lower, particularly during fall (Figure H5-3). At higher wind speeds (i.e., between 11-38 km/h) relatively more targets in the Project area were within the RSAs (17-27%, for 80 and 105 m hub heights, respectively) compared to lower wind speeds (13-21%).

The majority of flights recorded at the Centennial control site were above the RSAs for turbine hub heights of 80 m (spring, 77%; fall, 89%) and 105 m (spring, 67%; fall, 82%), as were those for the Reed Lake control site for 80 m (spring, 85%; fall, 68%) and 105 m (spring, 80%; fall, 64%) hub heights (Table 3-9). The percentage of targets in spring and fall within the RSA varied from 11 to 25% for the Project area compared to 9 to 31% for the Centennial control site and 10 to 26% for the Reed Lake control site. (Table 3-9). Large and medium-sized targets were recorded at higher elevations at the Reed Lake control site than records for the Project area (Table 3-9; Figure H5-4), whereas all large-sized targets recorded at the Centennial control site were within the RSA during both seasons (Figure H5-5). No distinct pattern was observed for flight altitudes and time of night at the control sites (Figures H5-6 and H5-7), nor between wind speed and target altitude.

Table 3-8 Mean Target Altitude Below, Within, and Above the Rotor Swept Area (RSA) for Turbines with 80 m and 105 m Hub Heights

Height Relative to the RSA	Mean Recorded Heights (m ± 1 S.D.)[1]	
	80 m Hub Height (RSA = 40-120 m)	**105 m Hub Height (RSA = 37-173 m)**
Project Area		
Below	9 ± 12	8 ± 10
Within	77 ± 25	109 ± 43
Above	345 ± 163	367 ± 157
Total	**275 ± 194**	**275 ± 194**
Centennial Control Site		
Below	12 ± 13	11 ± 12
Within	80 ± 23	109 ± 40
Above	341 ± 157	363 ± 150
Total	**293 ± 179**	**293 ± 179**
Reed Lake Control Site		
Below	26 ± 8	25 ± 7
Within	78 ± 24	94 ± 39
Above	472 ± 265	496 ± 258
Total	**371 ± 291**	**371 ± 291**

NOTE:
[1] Mean plus or minus one standard deviation.

Table 3-9 Count of Targets Observed Above, Within, and Below the Rotor Swept Area (RSA) for Turbines with 80 m and 105 m Hub Heights

Height Relative to the RSA	80 m hub height (RSA = 40-120 m)								105 m hub height (RSA = 37-173 m)							
	Spring				Fall				Spring				Fall			
	S[1]	M[2]	L[3]	Total (%)	S[1]	M[2]	L[3]	Total (%)	S[1]	M[2]	L[3]	Total (%)	S[1]	M[2]	L[3]	Total (%)
Project Area																
Above	1,807	100	3	**1,910 (80)**	1,137	41	4	**1,183 (83)**	1,623	91	3	**1,717 (72)**	1,045	31	2	**1,079 (76)**
Within	343	45	5	**393 (16)**	141	12	2	**155 (11)**	535	55	5	**595 (25)**	241	25	4	**270 (19)**
Below	69	8	3	**80 (4)**	63	14	4	**81 (6)**	61	7	3	**71 (3)**	55	11	4	**70 (5)**
Total	**2,219**	**153**	**11**	**2,383**	**1,341**	**67**	**11**	**1,419**	**2,219**	**153**	**11**	**2,383**	**1,341**	**67**	**11**	**1,419**
Centennial Control Site																
Above	892	29	0	**921 (77)**	1,302	36	0	**1,338 (89)**	782	28	0	**811 (67)**	1,193	32	0	**1,225 (82)**
Within	249	5	2	**256 (21)**	127	4	1	**132 (9)**	361	6	2	**369 (31)**	240	8	1	**249 (17)**
Below	27	0	0	**27 (2)**	25	1	0	**26 (2)**	24	0	0	**24 (2)**	21	1	0	**22 (1)**
Total	**1,168**	**34**	**2**	**1,204**	**1,454**	**41**	**1**	**1,496**	**1,168**	**34**	**2**	**1,204**	**1,454**	**41**	**1**	**1,496**
Reed Lake Control Site																
Above	488	57	7	**551 (85)**	327	55	3	**385 (68)**	457	55	7	**519 (80)**	306	51	3	**359 (64)**
Within	52	12	1	**65 (10)**	110	2	0	**112 (20)**	84	14	1	**99 (15)**	138	6	**0**	**144 (26)**
Below	30	2	1	**33 (5)**	63	3	0	**66 (12)**	28	2	1	**31 (5)**	56	3	**0**	**59 (10)**
Total	**569**	**71**	**9**	**649**	**500**	**60**	**3**	**563**	**570**	**71**	**9**	**649**	**500**	**60**	**3**	**563**

NOTES:
[1] Small target size
[2] Medium target size
[3] Large target size

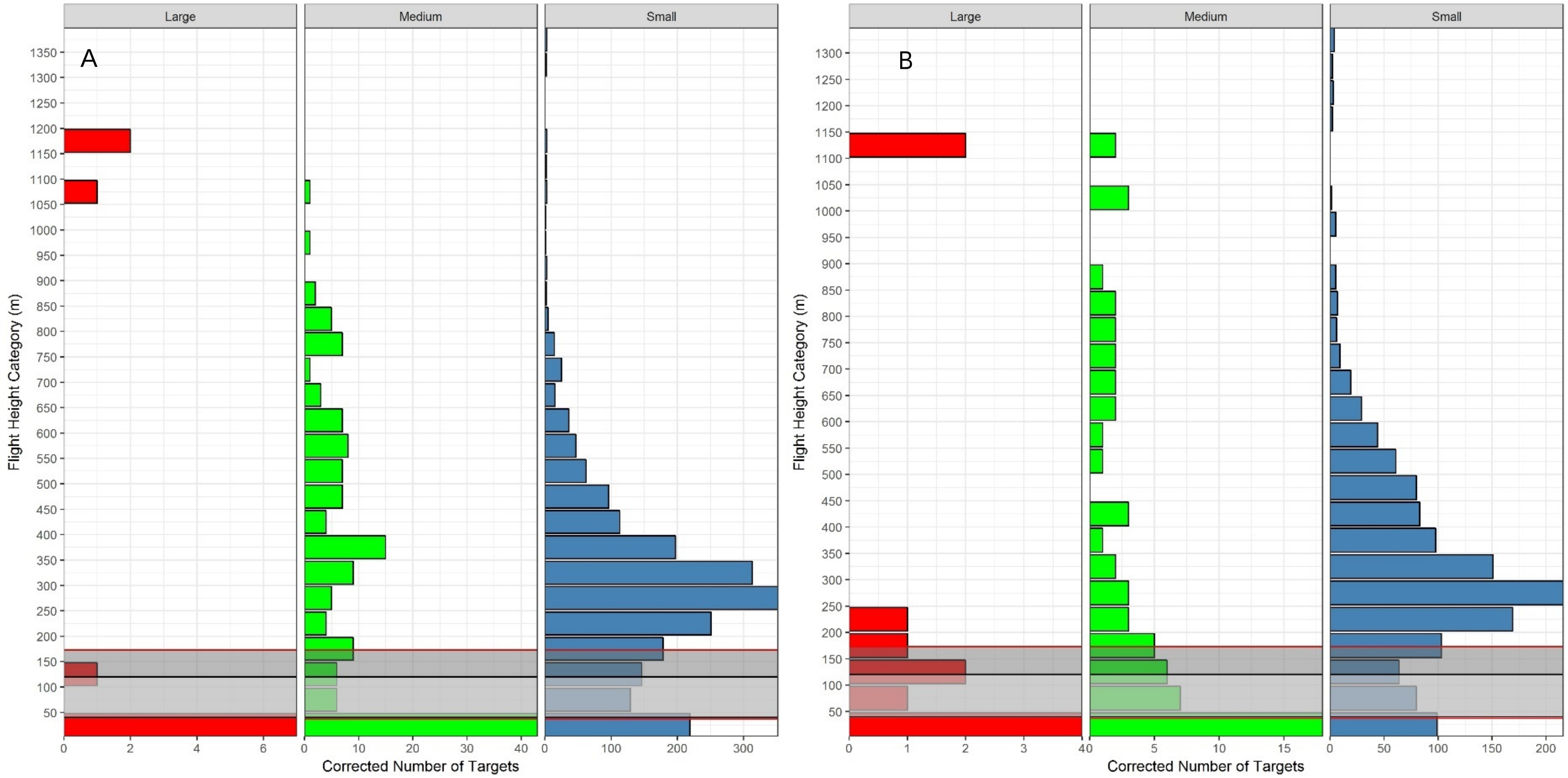


Figure H5-2 Flight Altitudes and Target Size Recorded at Radar Sites within the Project Area during Spring (A) and Fall (B) 2017. Light grey band represents 40-120 m RSA superimposed on 37-173 m RSA (dark grey).

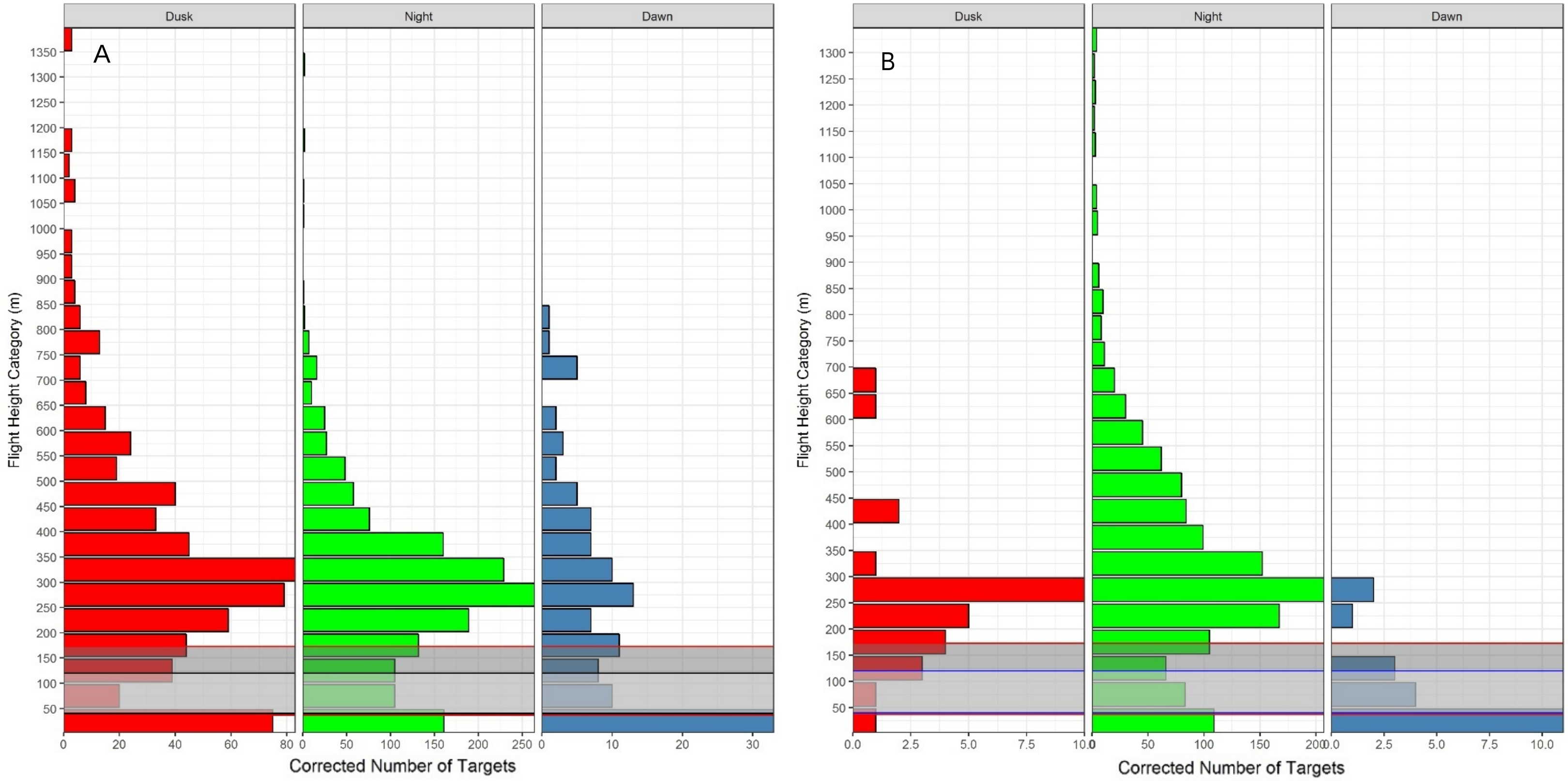


Figure H5-3 Flight Altitudes and Time of Night Recorded at Radar Sites within the Project Area during Spring (A) and Fall (B) 2017. Light grey band represents 40-120 m RSA superimposed on 37-173 m RSA (dark grey).

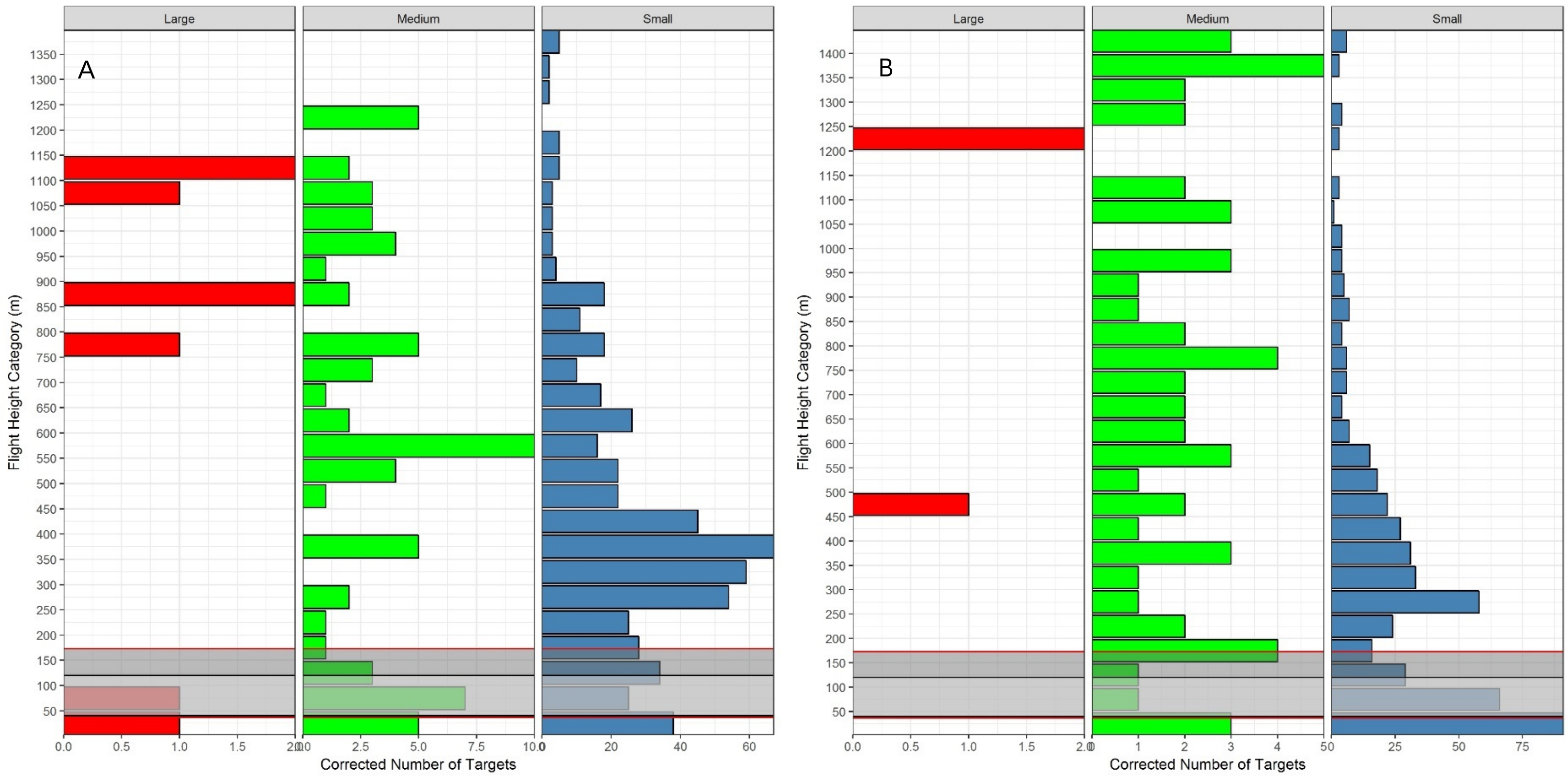


Figure H5-4 Flight Altitudes and Target Size Recorded at the Reed Lake Control Site during Spring (A) and Fall (B) 2017. Light grey band represents 40-120 m RSA superimposed on 37-173 m RSA (dark grey).

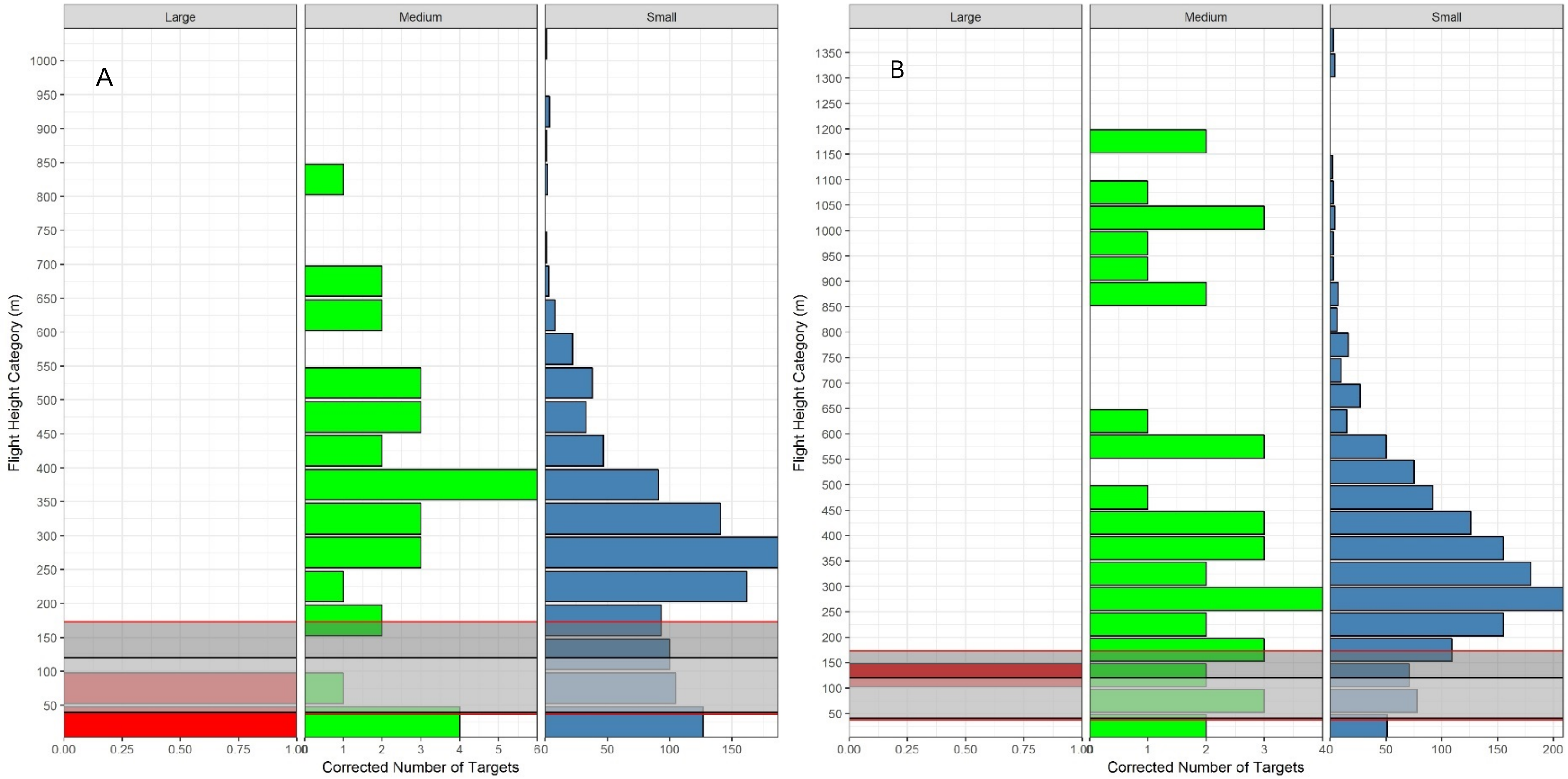


Figure H5-5 Flight Altitudes and Target Size Recorded at the Centennial Control Site during Spring (A) and Fall (B) 2017. Light grey band represents 40-120 m RSA superimposed on 37-173 m RSA (dark grey).

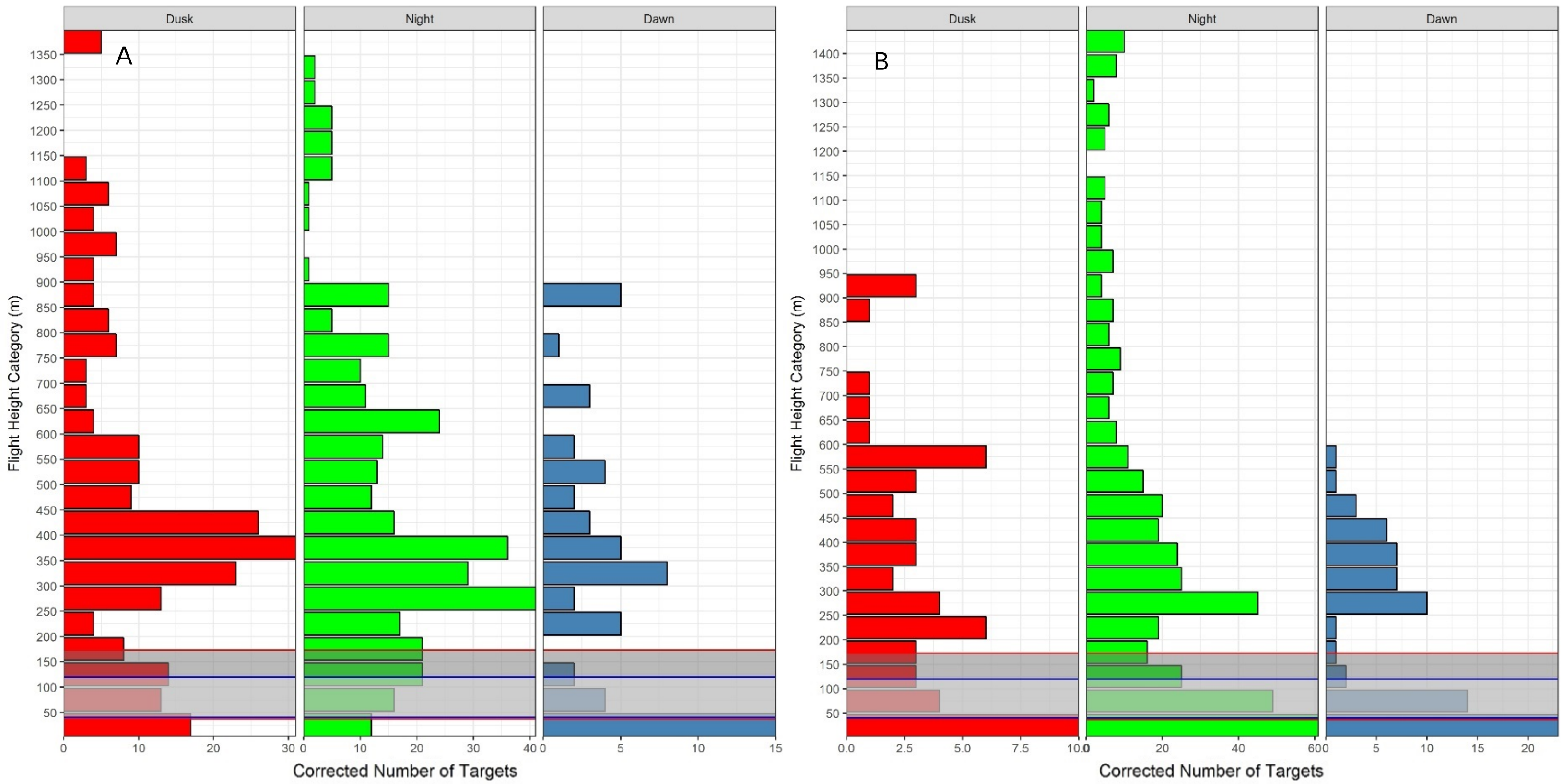


Figure H5-6 Flight Altitudes and Time of Night Recorded at the Reed Lake Control Site during Spring (A) and Fall (B) 2017. Light grey band represents 40-120 m RSA superimposed on 37-173 m RSA (dark grey).

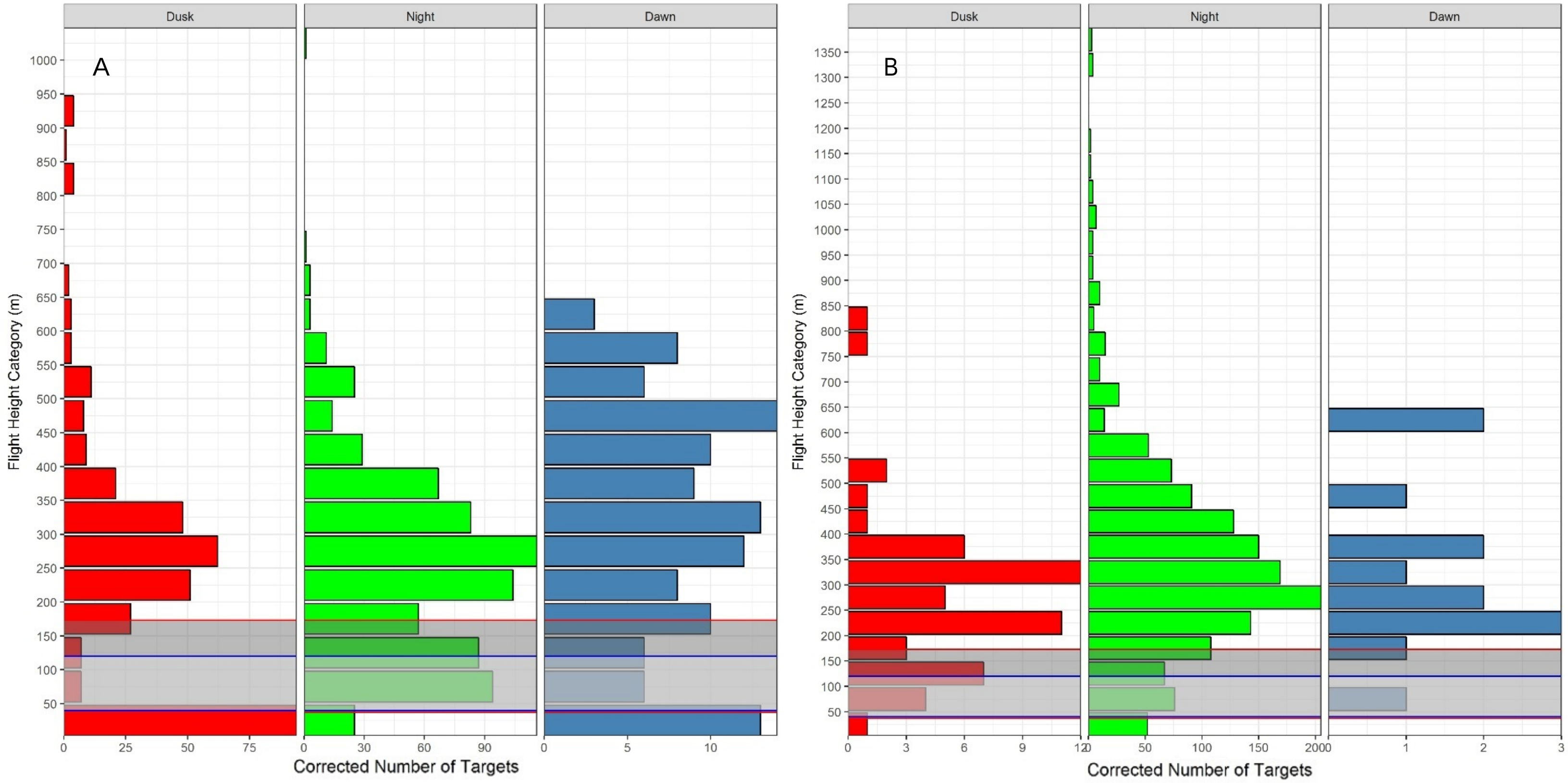


Figure H5-7 Flight Altitudes and Time of Night Recorded at the Centennial Control Site during Spring (A) and Fall (B) 2017. Light grey band represents 40-120 m RSA superimposed on 37-173 m RSA (dark grey).

3.2.3.3 Flight Direction (Horizontal Targets)

Direction of flight paths varied between seasons; within the Project area, the majority of spring flight paths for all target sizes were to the north and northwest, whereas flight paths recorded during the fall were multidirectional (Figure H5-8). Long distance flights (considered anything greater than 1.5 km radar range) were more common to the north and northwest in spring and to the west and southwest during fall (Figure H5-9).

At the Reed Lake control site, spring and fall flight paths were multidirectional for all target sizes; however, spring data had a stronger northward signal and fall data had a stronger signal to the south (Figure H5-10). Medium and large targets recorded at Reed Lake did not exhibit a strong directional pattern in either season. Long distance flights were more common during spring compared to fall (Figure H5-11). During spring, long distance flights were largely to the north and east, whereas during fall, long distance flights were multidirectional (Figure H5-11).

At the Centennial control site, spring flights were predominantly to the northwest and fall flights were predominantly to the southeast for all target sizes (Figure H5-12). Long distance flights were more common during spring compared to fall (Figure H5-13). During spring, long distance flights were largely to the north and northwest, whereas during fall, long distance flights were from the east, south or southeast (Figure H5-13).

3.2.4 Species of Management Concern

No SAR or SOMC were observed within the Project area during the nocturnal radar movement surveys. One SOMC (red-necked phalarope) was observed during target calibration outside the Project area (see Appendix A).

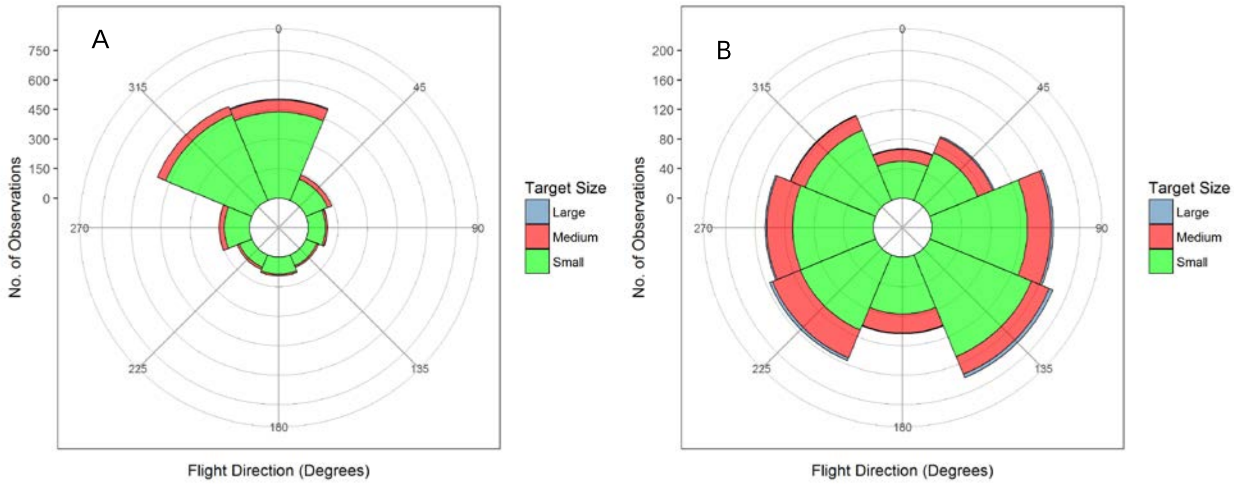


Figure H5-8 Flight Direction and Target Size Recorded within the Project Area during Spring (A) and Fall (B) 2017

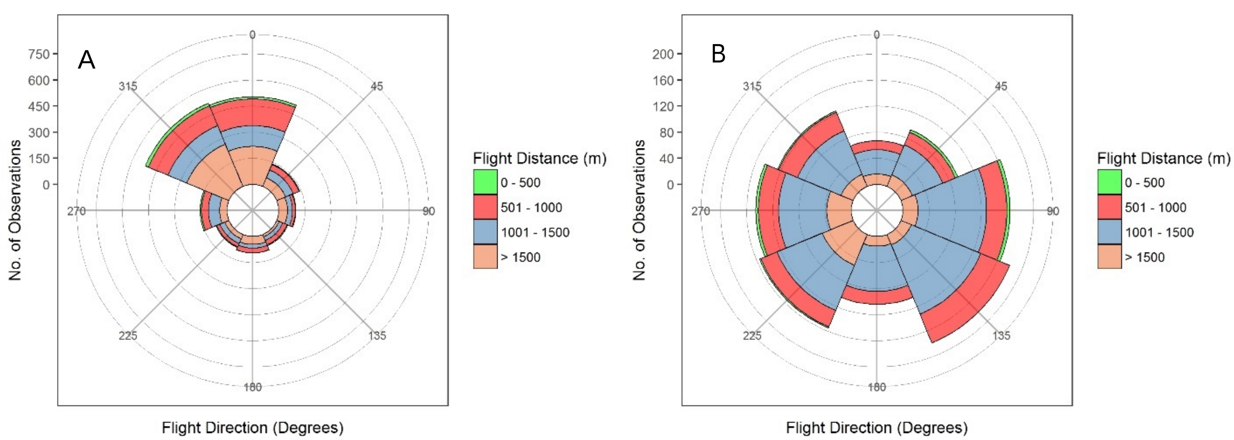


Figure H5-9 Flight Distance and Direction of Targets Recorded within the Project Area during Spring (A) and Fall (B) 2017

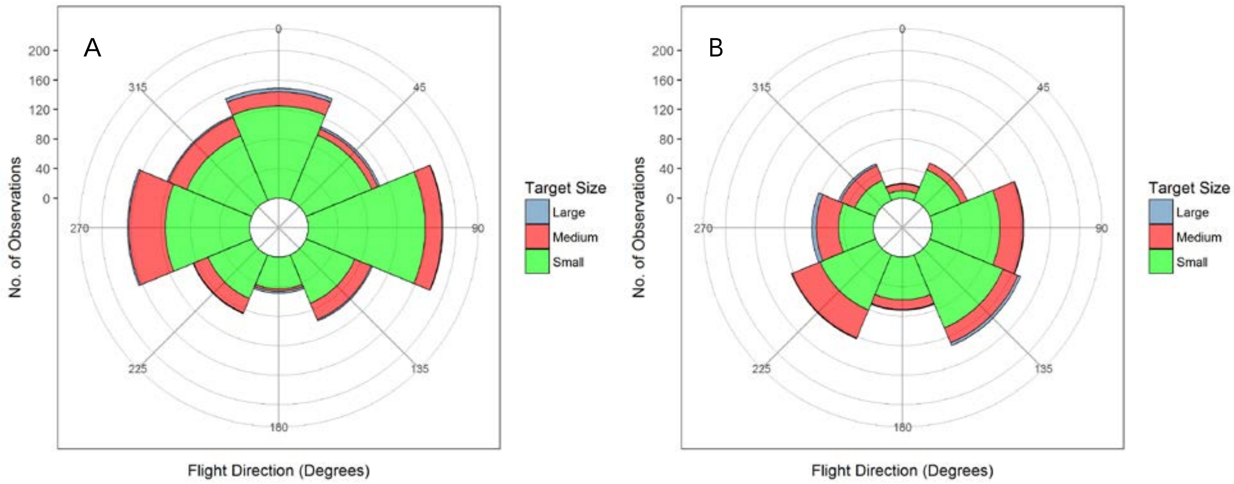


Figure H5-10 Flight Direction and Target Size Recorded at the Reed Lake Control Site during Spring (A) and Fall (B) 2017

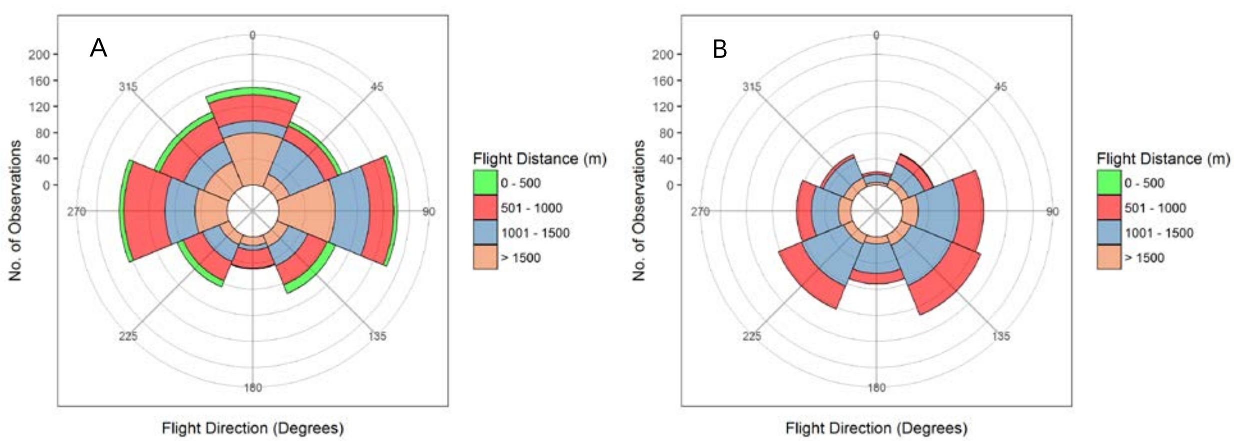


Figure H5-11 Flight Distance and Direction of Targets Recorded at the Reed Lake Control Site during Spring (A) and Fall (B) 2017

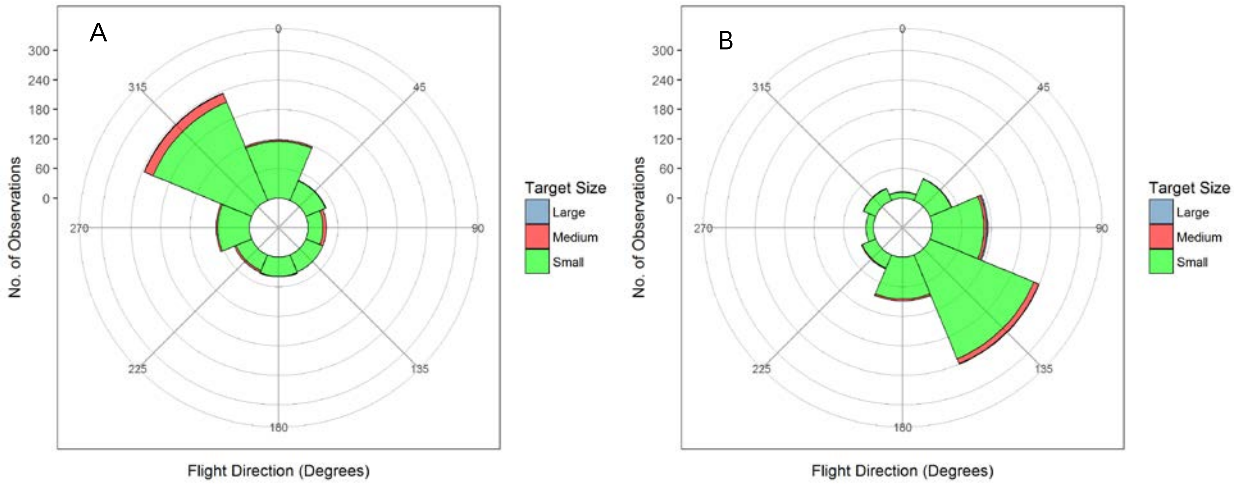


Figure H5-12 Flight Direction and Target Size Recorded at the Centennial Control Site during Spring (A) and Fall (B) 2017

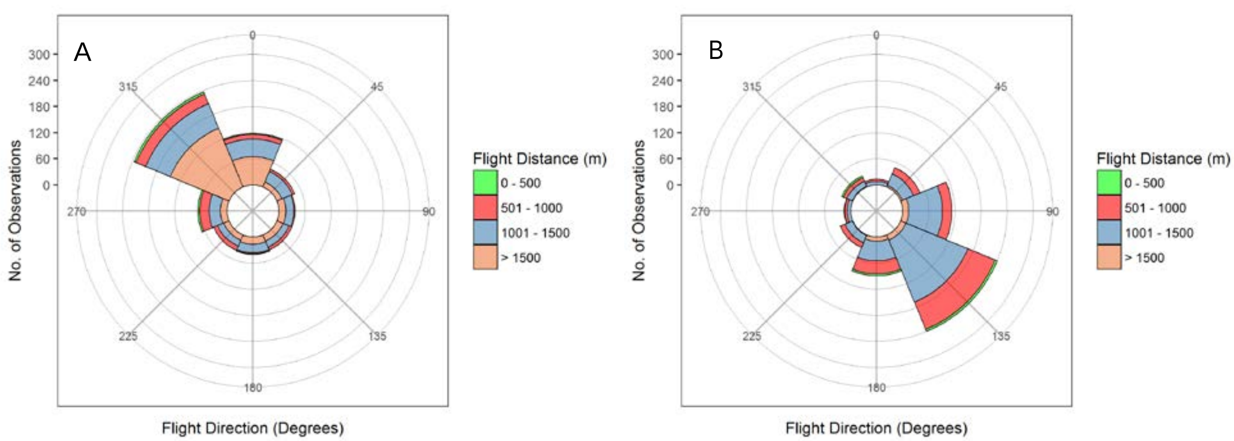


Figure H5-13 Flight Distance and Direction of Targets Recorded at the Centennial Control Site during Spring (A) and Fall (B) 2017

4.0 DISCUSSION

4.1 DIURNAL BIRD MOVEMENT SURVEYS

During the spring bird movement surveys, the number of birds passing through the sites within the Project area did not suggest there was a specific flight corridor across the landscape. Within the Project area, almost half (47.2%) of all birds observed were landbirds, while 26.8% were waterfowl, 13.8% shorebirds, 10.0% waterbirds, and 2.1% raptors. As expected, the control site near Reed Lake (Site 7) had a higher number of observations (5,642 individuals) than any site within the Project area, which averaged 349 individuals (ranged from 129 to 778 individuals). This was comparable to the control site near Centennial Wind Project (Site 8), which recorded 376 individuals.

During the fall bird movement surveys, there were several large flocks of snow geese (e.g., a single flock with more than 10,000 individuals) recorded. The large number of snow geese inflated the overall activity at certain sites (e.g., Sites 4 and 5) and created the appearance of major flight corridors in the Project area. When the snow goose observations are removed, sites within the Project area averaged 2,208 individuals compared to 14,311 individuals when snow goose observations were included. Even accounting for the fourth survey visit (i.e., an extra survey visit in the fall) and removing the snow goose observations, there appears to have been more activity in the Project area in the fall than during the spring (12,167 and 2,096 individuals, respectively). Sites 1 and 6 had the lowest number of observations in the fall (659 and 357 individuals, respectively) suggesting that the southeast portion of the Project area may be an area of low bird movement.

During the spring bird movement surveys, two SAR were recorded in the Project area (ferruginous hawk and Sprague’s pipit), and one SOMC (red-necked phalarope). No SAR or SOMC were recorded within the Project area during the fall bird movement surveys.

4.2 NOCTURNAL RADAR MOVEMENT SURVEYS

Although data collected during the nocturnal radar survey represents a snapshot of total avian activity during a much broader migratory period, the large number of targets recorded (over 13,000) provides sufficient data from which baseline avian movement patterns can begin to be understood in and around the Project area. Calibration data along with target size, direction, distance, and height suggest that much of the nocturnal activity recorded is that of waterfowl, shorebirds and gulls; however, it is likely that some activity is associated with other avian species (e.g., passerines) and other nocturnal fliers (e.g., bats).

The spatial distribution of radar data suggests there isn’t a portion of the Project area (east, center or middle) that has a notably higher activity level during spring and fall. Furthermore, the data suggest that nocturnal flight activity is greater in the control areas west and northeast of the Project area compared to within the Project area. The majority of flights recorded both in and outside of the Project Area were above the RSAs for proposed turbines during both seasons. It is likely that the number of birds flying above the RSA is underrepresented in the data as radar sensitivity, particularly for small targets, is skewed towards the radar unit (i.e., closer to ground level) (d'Entremont et al. 2017). It is also possible that waterbirds may be travelling above the 1.5 km detection altitude for the radar as observed elsewhere (e.g., Richardson 1979).

Within the Project area, more targets were recorded during spring compared to fall, and flight altitudes overlapped the RSA more often in the spring than during fall. This may be a reflection of seasonal differences, such as species composition and weather effects (Richardson 2000). Large targets were also uncommon at sites within the Project area, indicating that birds travelled above the Project area as individuals or in small groups.

Unexpectedly, the number of targets recorded at the Reed Lake site was lower than that recorded at the Centennial site west of the Project area, though it is unclear whether activity at the Centennial site is that of migrants or local birds. The overall pattern of long distance north-south flight paths suggests that many flights at the Centennial site were migratory, particularly during spring. The majority of these observations were small targets, which suggests these were individual birds rather than large, cohesive, flocks. A higher number of medium and large-sized targets recorded at Reed Lake indicates large cohesive flocks are more common at this site.

5.0 REFERENCES

BSC (Bird Studies Canada), Canadian Wind Energy Association, Environment Canada and Ontario Ministry of Natural Resources. 2017. Wind Energy Bird and Bat Monitoring Database Summary of the Findings from Post-construction Monitoring Reports. Canadian Wind Energy Association, Environment Canada and Ontario Ministry of Natural Resources. Available at: https://www.bsc-eoc.org/resources/wind/Jul2017_Wind_Database_Summary.pdf. Accessed November 2017.

Cooper, B.A., R.H. Day, R.J. Ritchie, and C.L. Cranor. 1991. An improved marine radar system for studies of bird migration. Journal of Field Ornithology 62:367–377.

Cooper, B.A., M.G. Raphael, and D.E. Mack. 2001. Radar-based monitoring of marbled murrelets. Condor 103:219-229.

d'Entremont, M. V., I. Hartley, and K. A. Otter. 2017. Comparing pre- versus post-operational movement of nocturnal migrants around a wind energy facility in northeast British Columbia, Canada. Avian Conservation and Ecology 12:3.

Desholm, M. and J. Kahlert. 2005. Avian collision risk at an offshore wind farm. Biology Letters 1:296-298.

Government of Canada. 2002. *Species at Risk Act* (S.C. 2002, c.29). Last amended: June 20, 2017. Government of Canada, Environment Canada. Available at: http://laws-lois.justice.gc.ca/eng/acts/S-15.3/. Accessed: September 2017.

Government of Canada. 2017. Species at Risk Public Registry. Available at: http://www.sararegistry.gc.ca/search/advSearchResults_e.cfm?stype=species&lng=e&advkeywords=&op=2&locid=3&. Accessed: September 2017.

Government of Saskatchewan. 1998. *The Wildlife Act, 1998*. Last amended 2015-05-14. Available at: http://www.qp.gov.sk.ca/documents/English/Statutes/Statutes/W13-12.pdf. Accessed: September 2017.

Harmata, A.R., K.M. Podruzny, J.R. Zelenak, and M.L. Morrison. 1999. Using marine surveillance radar to study bird movements and impact assessment. Wildlife Society Bulletin 27:44–52.

Harmata, A.R., G. Leighty and E.L. O'Neil 2003. A vehicle-mounted radar for dual purpose monitoring of birds. Wildlife Society Bulletin 31:882-886.

Kunz, T.H., E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. Journal of Wildlife Management 71:2449–4486.

Larkin, R. P. 2005. Radar techniques for wildlife biology. Pages 448–464 in C.E. Braun, editor. Techniques for wildlife investigations and management. The Wildlife Society, Bethesda, Maryland, USA.

Loots, S. and K.A. Otter. 2011. Fall 2010 Avian Movement Patterns at the Prince George Airport Monitored with Remote Radar. Technical Report to the Prince George Airport Authority. 14pp.

Mabee, T.J., and B.A. Cooper. 2004. Nocturnal bird migration in northeastern Oregon and southeastern Washington. Northwestern Naturalist 85:39–47.

Mabee, T.J., B.A. Cooper, J.H. Plissner, and D.P. Young. 2006. Nocturnal bird migration over an Appalachian Ridge at a proposed wind power project. Wildlife Society Bulletin 34:682-690.

Plissner, J.H., T.J. Mabee, and B.A. Cooper. 2006. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Highland Wind Development Project. Virginia, Fall 2005. Prepared by ABR, Inc. – Environmental Research Services. 32pp.

Richardson, J.W. 1979. Southeastward shorebird migration over Nova Scotia and New Brunswick in autumn: a radar study. Canadian Journal of Zoology 57:107-124.

Richardson, J.W. 2000. Bird Migration and Wind Turbines: Migration, Timing, Flight Behaviour, and Collision Risk. Pages 132-140 in Proceedings of National Avian - Wind Power Planning Meeting III, Sand Diego, California, May 1998. Prepared for the Avian Subcommittee of the National Wind Coordinating Committee by LGL Ltd., King City, Ontario.

SKCDC (Saskatchewan Conservation Data Centre). 2017d. Taxa List: Vertebrates. Last updated: May 15, 2017. Available at: http://www.biodiversity.sk.ca/SppList/verts.pdf. Accessed: September 2017.

SKCDC. 2017e. Taxa List: Invertebrates. Last updated: May 15, 2017. Available at: http://www.biodiversity.sk.ca/SppList/invert.pdf. Accessed: September 2017.

SKMOE (Saskatchewan Ministry of Environment). 2017. Saskatchewan Activity Restriction Guidelines for Sensitive Species. April 2017 Update. Available at: http://publications.gov.sk.ca/documents/66/89554-Saskatchewan%20Activity%20Restriction%20Guidelines%20for%20Sensitive%20Species%20-%20April%202017.pdf. Accessed: May 2017.

Appendix A TARGET CALIBRATION OBSERVATIONS

Table A-1 Species Groupings for Avian Guilds Observed during 2017 Spring and Fall Radar Target Calibration

Guild (size)	Representative Species
Shorebird (small)	Semipalmated sandpiper (*Calidris pusilla*), red-neck phalarope (*Phalaropus lobatus*), Wilson's phalarope (*Phalaropus tricolor*), killdeer (*Charadrius vociferus*), unknown phalarope, unknown shorebird
Shorebird (medium)	American avocet (*Recurvirostra americana*), marbled godwit (*Limosa fedoa*), willet (*Tringa semipalmata*), greater yellowlegs (*Tringa melanoleuca*), unknown yellowlegs
Wading bird (medium))	White-faced ibis (*Plegadis chihi*), black-crowned night heron (*Nycticorax nycticorax*)
Wading bird (large)	Great blue heron (*Ardea herodias*)
Waterfowl (small)	Green-winged teal (*Anas crecca*), blue-winged teal (*Spatula discors*), bufflehead (*Bucephala albeola*)
Waterfowl (medium)	Gadwall (*Mareca strepera*), American wigeon (*Mareca americana*), northern pintail (*Anas acuta*), mallard (*Anas platyrhynchos*), northern shoveler (*Spatula clypeata*), lesser scaup (*Aythya affinis*), unknown duck
Waterfowl (large)	Canada goose (*Branta canadensis*)
Waterbird (small)	American coot (*Fulica americana*)
Waterbird (large)	Double-crested cormorant (*Phalacrocorax auritus*), American white pelican (*Pelecanus erythrorhynchos*)
Gull (medium)	Franklin's gull (*Leucophaeus pipixcan*), Bonaparte's gull (*Chroicocephalus philadelphia*), California gull (*Larus californicus*), unknown gull
Tern (medium)	Common tern (*Sterna hirundo*), black tern (*Chlidonias niger*), unknown medium tern
Tern (large)	Caspian tern (*Hydroprogne caspia*)
Raptor (large)	Northern harrier (*Circus hudsonius*)
Passerine (small)	Red-winged blackbird (*Agelaius phoeniceus*), unknown blackbird, unknown swallow
Passerine (medium)	Black-billed magpie (*Pica hudsonia*)

Table A-2 Species-Specific Target Calibration Data Spring 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Canada goose	*Branta canadensis*	Small	2	1	4	12	6
		Medium	4	1	6	39	9
		Large	9	2	20	47	5
						98	**20**
Blue-winged teal	*Spatula discors*	Small	2	1	4	12	6
		Medium	2	2	3	13	6
		Large	11	6	15	21	2
						46	**14**
Northern shoveler	*Spatula clypeata*	Small	1	1	2	8	7
		Medium	2	1	4	6	3
						14	**10**
Gadwall	*Mareca strepera*	Small	1	1	1	8	8
		Medium	4	1	15	51	14
						59	**22**
American wigeon	*Mareca americana*	Small	3	3	3	3	1
						3	**1**
Mallard	*Anas platyrhynchos*	Small	2	1	3	23	15
		Medium	2	1	7	17	8
						40	**23**
Northern pintail	*Anas acuta*	Small	1	1	2	7	6
						7	**6**

Table A-2 Species-Specific Target Calibration Data Spring 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Green-winged teal	*Anas crecca*	Medium	3	3	3	3	1
						3	**1**
Lesser scaup	*Aythya affinis*	Small	3	2	3	5	2
		Large	10	8	12	30	3
						35	**5**
Bufflehead	*Bucephala albeola*	Small	2	2	2	2	1
		Medium	1	1	1	3	3
						5	**4**
Unknown duck	n/a	Small	2	1	8	42	22
		Medium	7	1	18	65	10
		Large	16	9	22	79	5
						186	**37**
American avocet	*Recurvirostra americana*	Small	2	1	3	7	4
						7	**4**
Killdeer	*Charadrius vociferus*	Small	1	1	1	6	6
						6	**6**
Semipalmated sandpiper	*Calidris pusilla*	Medium	13	10	15	25	2
						25	**2**
Marbled godwit	*Limosa fedoa*	Small	1	1	2	8	6
						8	**6**
Willet	*Catoptrophorus semipalmatus*	Small	1	1	3	4	3
						4	**3**

Table A-2 Species-Specific Target Calibration Data Spring 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Wilson's phalarope	*Phalaropus tricolor*	Small	4	1	7	8	2
		Large	33	10	55	65	2
						73	**4**
Red-necked phalarope	***Phalaropus lobatus***	Large	60	60	60	60	1
						60	**1**
Unknown shorebird	n/a	Small	26	3	40	51	5
		Medium	17	13	22	50	3
		Large	108	80	160	430	4
		Very large	180	180	180	180	1
						711	**13**
Bonaparte's gull	*Chroicocephalus philadelphia*	Small	1	1	1	5	5
		Medium	1	1	1	8	8
						13	**13**
Franklin's gull	*Leucophaeus pipixcan*	Small	1	1	3	29	20
		Medium	5	4	6	23	5
		Large	28	28	28	28	1
						80	**26**
Ring-billed gull	*Larus delawarensis*	Small	1	1	3	112	107
		Medium	3	1	16	30	12
		Large	14	9	18	27	2
						169	**121**

Table A-2 Species-Specific Target Calibration Data Spring 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
California gull	*Larus californicus*	Small	1	1	1	7	7
						7	**7**
Unknown gull	n/a	Small	3	1	6	74	28
		Medium	6	1	12	64	11
		Large	9	9	9	9	1
						147	**40**
Black tern	*Chlidonias niger*	Small	1	1	1	1	1
						1	**1**
Common tern	*Sterna hirundo*	Small	1	1	1	9	9
						9	**9**
Double-crested cormorant	*Phalacrocorax auritus*	Small	1	1	1	8	8
		Medium	2	1	6	13	6
						21	**14**
American white pelican	*Pelecanus erythrorhynchos*	Large	4	4	4	4	1
						4	**1**
Great blue heron	*Ardea herodias*	Medium	1	1	1	1	1
						1	**1**
Black-crowned night heron	*Nycticorax nycticorax*	Small	3	3	3	3	1
						3	**1**
White-faced ibis	***Plegadis chihi***	Medium	2	1	4	11	5
						11	**5**

Table A-2 Species-Specific Target Calibration Data Spring 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Black-billed magpie	*Pica hudsonia*	Small	1	1	1	1	1
						1	**1**
Unknown swallow	n/a	Small	1	1	2	**8**	**7**
						8	**7**
Red-winged blackbird	*Agelaius phoeniceus*	Small	12	16	16	16	1
						16	**1**
Unknown blackbird	n/a	Small	3	3	3	3	1
		Medium	6	5	6	11	2
		Large	55	55	55	55	1
						69	**4**
Total						**1,950**	**434**

NOTE:
[1] Bold indicates a SOMC

Table A-3 Species-Specific Target Calibration Data Fall 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Canada goose	*Branta canadensis*	Medium	4	3	6	12	3
		Large	14	4	26	99	7
						111	**10**
Blue-winged teal	*Spatula discors*	Small	2	2	2	2	1
						2	**1**
Northern shoveler	*Spatula clypeata*	Medium	10	10	10	10	1
						10	**1**
Gadwall	*Mareca strepera*	Small	4	2	5	7	2
						7	**2**
American wigeon	*Mareca americana*	Medium	5	5	5	5	1
						5	**1**
Mallard	*Anas platyrhynchos*	Small	2	1	3	5	3
		Medium	13	13	13	13	1
						18	**4**
Unknown duck	n/a	Small	4	1	21	115	31
		Medium	7	2	12	135	20
		Large	17	8	40	204	12
						454	**63**
American coot	*Fulica americana*	Small	1	1	1	2	2
						2	**2**
Greater yellowlegs	*Tringa melanoleuca*	Small	5	3	6	9	2
						9	**2**

Table A-3 Species-Specific Target Calibration Data Fall 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Unknown yellowlegs	n/a	Small	1	1	1	1	1
		Medium	15	15	15	15	1
						16	**2**
Unknown phalarope	n/a	Small	13	13	13	13	1
		Medium	19	19	19	19	1
						32	**2**
Unknown shorebird	n/a	Small	11	5	20	44	4
						44	**4**
Franklin's gull	*Leucophaeus pipixcan*	Small	1	1	4	34	31
		Medium	4	4	4	4	1
						38	**32**
Ring-billed gull	*Larus delawarensis*	Medium	8	6	10	25	10
						25	**10**
Unknown gull	n/a	Small	1	1	1	3	3
						3	**3**
Caspian tern	***Hydroprogne caspia***	Small	1	1	1	1	1
						1	**1**
Common tern	*Sterna hirundo*	Small	1	1	1	3	3
						3	**3**
Unknown tern	n/a	Medium	15	15	15	15	1
						15	**1**

Table A-3 Species-Specific Target Calibration Data Fall 2017

Species[1]	Scientific Name	Target Size	Average Count	Minimum Count	Maximum Count	Total Count	Total Targets
Double-crested cormorant	*Phalacrocorax auritus*	Small	1	1	1	3	3
						3	**3**
Northern harrier	*Circus hudsonius*	Small	1	1	1	1	1
						1	**1**
Total						**799**	**148**

NOTE:
[1] Bold indicates a SOMC

H.6 BAT ACTIVITY TECHNICAL REPORT

H.6.2

Blue Hill Wind Energy Project
2017 Pre-Construction
Bat Monitoring Report

Prepared for:
Algonquin Power Co.

Prepared by:
Stantec Consulting Ltd.

December 2017

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Abbreviations

ABAT	Alberta Bat Action Team
CF	Compact Flash
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
ECCC	Environment and Climate Change Canada
ESRD	Alberta Environment and Sustainable Resource Development
GOA	Government of Alberta
LLD	Legal Land Description
km	Kilometres
km/h	Kilometres per hour
m	Metres
ms	Millisecond
m/s	Metres per second
MET	Meteorological
PVC	Polyvinyl chloride
SKMOE	Saskatchewan Ministry of Environment
SARA	*Species at Risk Act*
SK	Saskatchewan
Stantec	Stantec Consulting Ltd.
UTM	Universal Transverse Mercator

1.0 INTRODUCTION

Algonquin Power is proposing to develop the Blue Hill Wind Energy Project (the Project). The Project will consist of 49 to 56 WTGs, each with a capacity between 3.2 and 3.7 MW, for a total capacity of 177 MW. Each WTG consists of the following components: tower, nacelle, hub, rotor blades, controller and transformer. The height of each WTG tower will be between 80 to 105 m from the foundation to the hub depending on final equipment selection. Each WTG consists of three blades (each approximately 40 to 68 m long) with a rotor diameter of approximately 80 to 136 m. The Project is located approximately 10 km south of the town of Herbert, Saskatchewan (SK) (Figure H6-1). Reed Lake is located approximately 8 km northeast of the Project (Figure H6-1). The proposed Project footprint is 158.2 ha in total located on 62 quarter sections of private land consisting predominately of cultivated lands and agricultural lands (i.e., hayland and tame pasture), with some native prairie (Figure H6-1).

Bat fatalities at wind energy facilities have become an increasing concern, particularly for migratory bats (Arnett et al. 2008, Arnett and Baerwald 2013, ESRD 2013, Bird Studies Canada [BSC] et al. 2017, Zimmerling and Francis 2016, AWWI 2017). Though information is available on direct impacts to bats, population sizes for migratory bats are unknown and therefore there is uncertainty regarding whether current or future collision fatality levels represent a significant threat to overall migratory bat population levels (AWWI 2017).

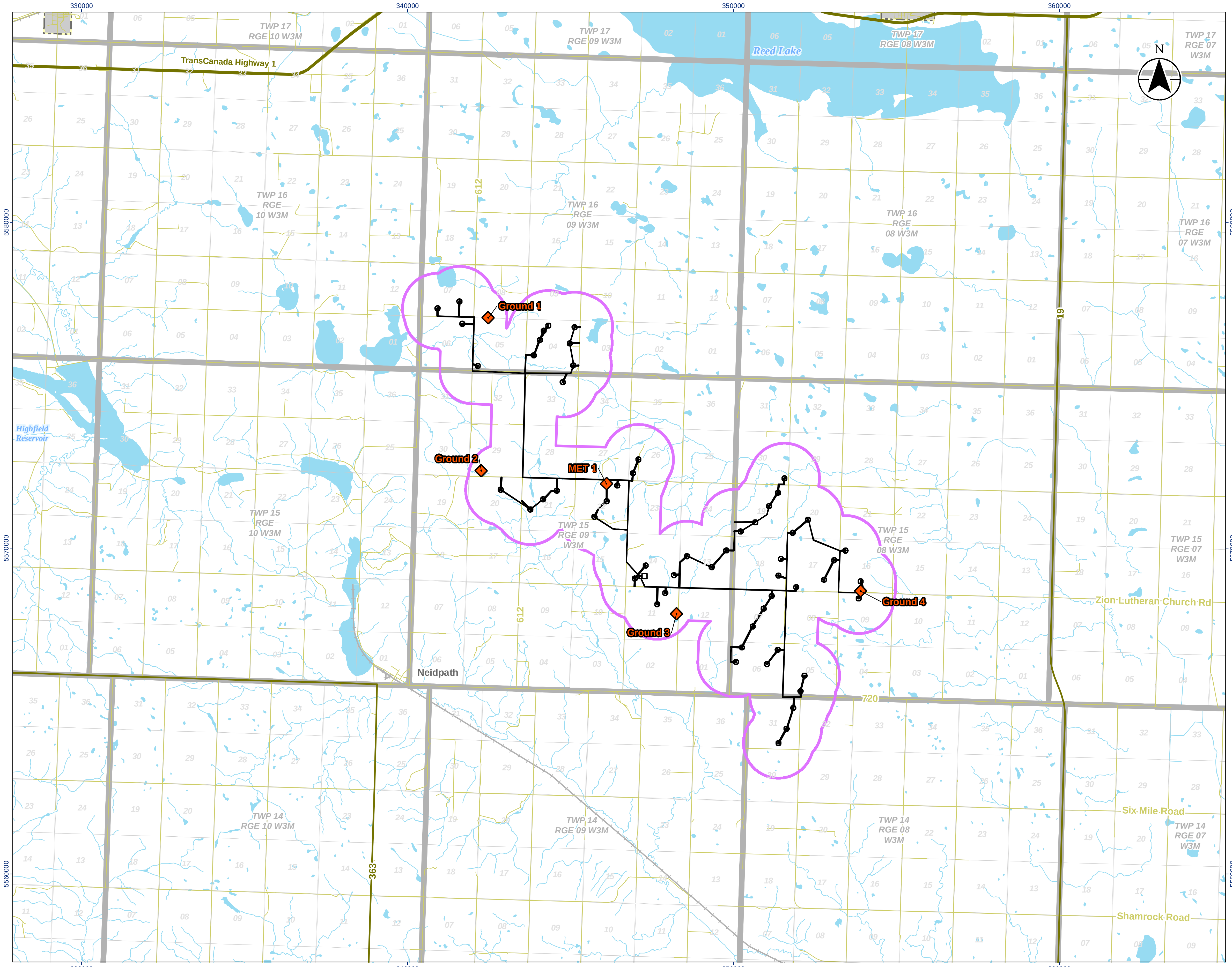
To identify the baseline level of migratory and total (migratory and non-migratory) bats in the Project area, Stantec Consulting Ltd. (Stantec) conducted acoustic bat activity surveys in 2017. This report summarizes the results of the spring and fall 2017 bat acoustic surveys, and will contribute to the assessment of potential mortality risk to bats in the Project area.

1.1 REGULATORY CONTEXT

Bats are protected under the *Wildlife Act* of Saskatchewan (SKMOE 1998), and under the federal *Species at Risk Act* for those bat species listed as *endangered* in Canada (Environment and Climate Change Canada [ECCC] 2017). As no Saskatchewan guidelines on thresholds for pre-construction bat activity rates pertaining to wind developments exist, Alberta guidelines were used as context for the potential magnitude of effects. The Saskatchewan Ministry of Environment (SKMOE) regularly directs proponents to Alberta Environment and Parks (AEP) guidance and survey protocols where none have been published in Saskatchewan, and previous experience with the SKMOE pertaining to assessment of effects to bats from wind developments in Saskatchewan confirms their reliance on the AEP guidance.

The *Wildlife Directive for Alberta Wind Energy Projects* (Government of Alberta [GOA] 2017) states that bat acoustic surveys must be conducted during the spring (May 1 to May 31) and fall (July 15 to October 15) bat migration periods (GOA 2017). Within the Directive, proponents are required to analyse their data and bat mortality esimates in comparison to The *Bat Mitigation Framework for Wind Power Development* (Alberta Environment and Sustainable Resource Development [ESRD] 2013; the "Framework"). The Framework establishes guidelines for interpreting pre-construction acoustic bat monitoring data for potential mitigation. This guidance document indicates potential fatality rates and acceptable activity levels based on bat passes per elevated (> 30 m height) detector night during the period identified in Lausen et al. (2010) for use in evaluating sites and applying mitigation. The thresholds of bat activity identified in ESRD (2013) are:

- Less than 1 migratory bat pass per detector night as potentially acceptable.
- 1 to 2 migratory bat passes per detector night as potentially requiring mitigation such as alternative siting locations and reduced turbine height or rotor length.
- Greater than 2 migratory bat passes per detector as likely requiring mitigation such as alternative turbine locations and changing cut-in speeds to reduce bat fatality.



Stantec Algonquin

- Bat Acoustic Monitoring Site
- Project Development Area
- Wildlife Local Assessment Area
- Major Road
- Minor Road
- Railway
- Town/City
- Township
- Section

0 1 2 3 4 Kilometers
1:120,000 (At original document size of 11x17)

Notes
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Base features produced under license with the Government of Saskatchewan and the Government of Canada
3. Layout: Algonquin, Sept 06, 2017, V3

Project Location
Near Herbert, SK

113254088-042 REVD
Prepared by acory on 2017-12-18
Technical Review by kgibson on 2017-12-18

Client/Project
Algonquin Power Co.
Blue Hill Wind Energy Project

Figure No.
H6-1

Title
2017 Bat Acoustic Monitoring Site Locations for the Blue Hill Wind Energy Project

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

2.0 METHODS

The bat activity studies for the Project followed methods provided in the *Wildlife Directive for Alberta Wind Energy Projects* (GOA 2017), the *Bat Mitigation Framework for Wind Energy Development* (ESRD 2013), and Lausen et al. (2010). The *Wildlife Directive for Alberta Wind Energy Projects* requires one year of spring and fall bat surveys. Therefore, acoustic surveys were conducted during the spring monitoring period (May) and fall monitoring period (July 15 to October 15) to determine whether activity rates vary by season, as higher levels of bat activity are expected in the fall than in the spring. Within the Directive (GOA 2017), proponents are required to report on data and bat mortality estimates in comparison to the Framework (ESRD 2013), which states a fall monitoring period of August 1 to September 10. For this report, data was analysed for both the full fall monitoring period and the period stated in the Framework.

This document provides methods for acoustic bat surveys for consistent sampling, including survey periods, survey timing, and detector placement based on project scale and landscape.

2.1 EQUIPMENT

A total of six AnaBat SD1 CF Bat Detectors (Titley Electronics) were installed at five sites within the Project area. All detectors were powered by two HAZE or PowerKing (12 Volt 18 Ah) sealed lead acid batteries connected in parallel. To prevent exposure to the elements, each detector was housed in an 8x8x4 cm PVC junction box enclosure, with an accompanying microphone pointing out of the junction box enclosure through a PVC elbow. To optimize data collection quantity, division ratios were set to 8. Sensitivity was adjusted to the highest level, which did not produce ambient static during set up (below the squelch zone). Data were recorded and stored on compact flash (CF) cards. The acoustic data is based on detectors operating one half hour after sunset to one half hour before sunrise (ESRD 2013). Therefore, the detectors were adjusted during each maintenance visit to account for the change in sunset and sunrise periods, and were programed to start data collection before and after the targeted time period in order that bat passes were recorded. Data collection started before and ended after the target monitoring periods (i.e., May 1 to May 31, and July 15 to October 15) such that activity rates throughout both periods were collected.

The bat call data were downloaded from the CF cards using CFC read storage ZCAIM interface (version 4.4.21u). The data collected were transcribed using the latest available software (AnalookW Version 4.2n).

2.2 MONITORING SITES

Two detectors were installed on the Project's meteorological (MET) tower ; one at a low elevation (2 m; MET 1 Low detector) and one at a high elevation (approximately 43 m; MET 1 High detector) as listed in Table 2-1 and shown on Figure H6-1. The elevated detector was installed with a pulley system developed by Stantec; heights were verified using a range finder. The power cable connecting elevated detectors to the battery source was secured to rope using zip ties and attached at the tower's base near the weather-proof battery container. The elevated detector was installed to provide information on bat activity within the turbine rotor-swept altitude, as ground (i.e., Low) detectors only reliably collect data on bats travelling from ground level up to approximately 30 m height (Titley Scientific 2015).

Ground level detectors (Ground 1, 2, 3 and 4) were installed at four additional ground sites (see Figure H6-1 and Table 2-1) to better understand the spatial distribution of bat activity in the Project area. To maintain consistency in data collection and allow data comparison, the four ground detectors were installed using the same parameters (i.e., height, orientation and detector settings) as the MET 1 Low detector. The ground sites were sited throughout the Project area to provide coverage of the Project area in locations similar to where turbines might be constructed (see Figure H6-1). All detectors were placed in the same locations during the spring and fall survey periods.

Based on data from the Swift Current airport, prevailing winds in the region originate from the northwest (Aviador 2017). In the spring, bats are expected to migrate from the south, and in the fall, from the north, but taking into account the prevailing wind direction, and for consistency, all detectors were oriented to the southeast in the spring and northeast in the fall. Orienting the microphones perpendicular to the prevailing wind direction provides a balance that increases potential bat detections while reducing interfering noise caused by prevailing winds.

Table 2-1 Site Information and Photos of the Blue Hill Bat Monitoring Sites

Monitoring Site	Location (LLD, UTM)	Site / Setup Description	Land Cover	Photo
Ground 1	NW-5-16-9-W3M; NAD 83, 13U, 342482, 5577064	Attached to a fence line with temporary PVC pipe at a height of approximately 2 m. Located ~400 m east of road	Cultivation to the north; tame pasture to the south. Treed shelterbelts ~150 m northwest and southeast	Photo orientation: facing north 

Table 2-1 Site Information and Photos of the Blue Hill Bat Monitoring Sites

Monitoring Site	Location (LLD, UTM)	Site / Setup Description	Land Cover	Photo
Ground 2	SW-29-15-09-W3M; NAD 83, 13U, 342262, 5572367	Attached to a fence line with temporary PVC pipe at a height of approximately 2 m. Located ~150 m north of road.	Cultivation to the east; tame pasture to the west Dugout and shrubby wetland ~200 m west.	Photo Orientation: facing west 
Ground 3	NE-11-15-09-W3M; NAD 83, 13U, 348249, 5567977	Attached to a fence line with temporary PVC pipe at a height of approximately 2 m. Located ~30 m west of road.	Surrounded by cultivation. Small wetland ~100 m south.	Photo Orientation: facing south 
Ground 4	SW-16-15-08-W3M; NAD 83, 13U, 353903, 5568679	Attached to a fence line with temporary PVC pipe at a height of approximately 2 m. Located 20 m west of road.	Tame pasture to the west; cultivation to the east and south. Old farmyard (treed) located ~600 m west.	Photo Orientation: facing west 

Table 2-1 Site Information and Photos of the Blue Hill Bat Monitoring Sites

Monitoring Site	Location (LLD, UTM)	Site / Setup Description	Land Cover	Photo
MET 1 (MET 1 High and MET 1 Low)	NE-22-15-09-W3M; NAD 83, 13U, 346107, 5571972	2 detectors were attached to the MET Tower: approximately 2 m and 43 m above ground. Located ~50 m south of road.	Located within tame pasture; surrounded by cultivation. Treed patch ~800 m west; small wetlands within 300 m east.	Photo Orientation: facing east 

2.2.1 Equipment Status Visits and Monitoring Issues

Spring 2017

All five sites (six detectors) began collecting data on April 28, 2017 at 19:00 hours. Equipment status checks were performed on May 12, 2017, during which the CF cards and HAZE batteries were exchanged for empty cards and charged batteries. Data were retrieved from the cards and stored for interpretation at a future date. All detectors were removed on June 1, 2017, at which time data were again retrieved and stored.

Detectors Ground 1, Ground 2, Ground 3, Ground 4 and MET 1 Low were in operation for the entire monitoring period and complete datasets were collected. The MET 1 High detector had a malfunction and did not collect data during the first round (April 28 through May 11, 2017), but was operational for the remainder of spring.

It is unknown why this detector malfunctioned, but is likely due to power failure. The malfunction at MET 1 High occurred during a portion of the peak spring activity period; however, the overall bat activity is calculated as bat passes per detector night, based on the number of operational nights during the monitoring period. Therefore, the average activity rate of the period when data were collected was assumed representative of the monitoring period. Though this resulted in reduced sample size, with five sites, ample data were collected for the Project area despite the malfunction.

Fall 2017

All five sites (six detectors) began collecting data on July 13, 2017 at 19:00 hours. Equipment status checks were performed on August 4, August 17, September 8, and September 30, 2017. During these visits the CF cards and HAZE batteries were exchanged for empty cards and charged batteries. Data were retrieved from the cards and stored for interpretation at a future date. All detectors were removed on October 17, 2017.

Detectors Ground 1, Ground 2, Ground 3 and Ground 4 were in operation for the entire monitoring period and complete datasets were collected. Two detectors had malfuncations during the fall 2017 monitoring period, accounting for 5% of the total dataset. MET 1 Low had an internal battery failture and did not collect data for 11 nights from July 24 through August 3, 2017. MET 1 High had a power failure and did not collect data for 19 nights between July 15 through August 3, 2017. Both detectors were replaced during the first maintenance visit and no other malfunctions occurred.

Though these two malfunctions resulted in reduced sample size at two locations, with six detectors, ample data were collected for the Project area despite the malfunctions.

2.3 ANALYSIS

2.3.1 Bat Echolocation Analysis

The unit of measure selected for analysis is a bat call sequence, which is expressed as a bat pass and can be used as a relative measure of bat activity. Bat passes per detector night is used as the relative measure of bat activity and is the primary measurement for reporting activity rates. A limitation to using bat passes as a metric is that it is unknown whether multiple passes represent one or several active bats in the area (i.e., one individual making multiple passes near the detector vs. multiple individuals passing by once each). Standard practice is to use ≥ 2 seconds between call sequences to define a bat pass (Loeb et al. 2015). Echolocation analysis to determine the number of bat passes and identify passes to species was conducted using AnalookW (version 4.2n). Data were compiled using Microsoft Excel and outputs modeled using R (version 3.2.2). Site-specific data for sunrise and sunset were generated using Anasun (version 1.0a). Bat calls and passes were visually distinguished using reference data from:

- Acoustics Workshop: Analysis of AnaBat files (Lausen 2008, pers. comm.)
- Acoustics Techniques Course: Reference Bat Calls (Lausen 2011, pers. comm.)
- Published literature
- Stantec bat call identification key

While automatic bat identification algorithms (e.g., Kaleidoscope Pro) exist and, in some cases, provide a more rapid and objective identification than manual identification, previous experience has indicated that these types of software do not completely analyze an entire dataset, and have a tendency to not recognize low quality calls and duplicate bat passes. Manual identification using AnalookW was therefore used to undertake a complete analysis of the dataset.

Where possible, bats were identified to species or grouping based on several parameters of their calls: frequency (minimum), duration, slope, and shape. Considerable regional variation can occur with the calls of a species based on habitat and other bat species in the area (Lausen, 2008, pers. comm.); therefore, parameters from western Canada records were relied upon more heavily.

Though detector setup methods such as microphone orientation and sensitivity reduce extraneous noise collected (see Section 2.1), large quantities of unwanted noise data can be collected by the detectors. Due to similarities between species echolocation parameters and/or degraded call quality from extraneous noise, some bats cannot be conclusively identified to species and were therefore grouped together. Due to the potential for call similarities, there is some uncertainty in differentiating calls of big brown bats (*Eptesicus fuscus*) and silver-haired bats (*Lasionycteris noctivagans*), eastern red bats (*Lasiurus borealis*) and little brown myotis (*Myotis lucifugus*), and bat species in the *Myotis* genus. In most cases, these groupings were not identified to species conclusively.

Considering the bat species in Saskatchewan (see Section 3.1) and the inability to identify all bat passes to species due to call quality and overlapping call parameters between species, the following five groupings were used for species classification in this study when individual species classification was not possible:

- **Low frequency bat**: includes big brown bat, silver-haired bat and hoary bat (*Lasiurus cinereus*)
- **High frequency bat**: includes eastern red bat, long-eared bat (*Myotis evotis*), little brown myotis and western small-footed bat (*Myotis ciliolabrum*)
- **Big brown bat or silver-haired bat**
- **Eastern red bat or little brown myotis**
- ***Myotis* species**: includes long-eared bat, little brown myotis, and western small-footed bat

Based on comparisons of echolocation results and fatality search results at a number of wind development projects in southern Alberta by Baerwald et al. (2008) and Baerwald and Barclay (2009), bat passes identified into the big brown/silver-haired grouping are likely to be mainly silver-haired bats. Likewise, the low frequency bat grouping is expected to be predominantly silver-haired and hoary bats.

The majority of bat fatalities at wind energy development sites in North America involve migratory species (ESRD 2013, Arnett and Baerwald 2013, Zimmerling and Francis 2016, AWWI 2017); therefore, migratory bats were considered as an additional grouping for this assessment. Three bat species known to occur within the Project area are considered migratory: hoary, eastern red, and silver-haired bats. As such, the migratory bat grouping includes the three migratory bat species and all individuals within the low frequency bat, big brown/silver-haired bat, and eastern red/little brown myotis groupings. Grouping migratory bats in this manner provides the most conservative estimate of the maximum potential migratory bat activity within the Project area.

3.0 RESULTS AND DISCUSSION

3.1 BAT SPECIES IN THE PROJECT AREA

Eight species of bat are known to occur in Saskatchewan, seven of which have the potential to occur within the Project area (Table 3-1). The distribution data for Saskatchewan's bats indicate that the northern myotis (*Myotis septentrionalis*), a non-migratory species of bat, is not expected to occur in the Project area (Caceres and Barclay 2000, Bat Conservation International 2012). The remaining seven bat species may potentially breed within the Project area, as suitable terrain and vegetation is present.

All seven bat species potentially occurring in the Project area were identified by call, and therefore confirmed as occurring in the Project area, which included: eastern red bat, hoary bat, silver-haired bat, big brown bat, little brown myotis, long-eared myotis, western small footed myotis.

Little brown myotis has been considered the most abundant and widespread bat species in North America (COSEWIC 2013), though this may change due to population changes as a result of white-nose syndrome. While little brown myotis are currently abundant in Saskatchewan, the species is listed as *endangered* under SARA (ECCC 2017) due to white-nose syndrome, which is currently decimating populations in eastern North America (USGS 2017).

Table 3-1 Bat Species With Potential to Occur in the Project Area

Common Name	Scientific Name	SRank[1]	Wildlife Act[2]	COSEWIC Status[3]	SARA Status[4]	Expected to Breed in the Project Area	Migratory Bat
Big brown bat	*Eptesicus fuscus*	**S5**	N/A	N/A	N/A	Yes (roosts in buildings, tree cavities, rock crevices)	No
Silver-haired bat	*Lasionycteris noctivagans*	**S5B**	N/A	N/A	N/A	Yes (roosts in foliage)	Yes
Eastern red bat	*Lasiurus borealis*	**S4B**	N/A	N/A	N/A	Yes (roosts in foliage)	Yes
Hoary bat	*Lasiurus cinereus*	**S5B**	N/A	N/A	N/A	Yes (roosts in tree cavities)	Yes
Western small-footed bat	*Myotis ciliolabrum*	**S2**	N/A	N/A	N/A	Yes (roosts in rock crevices; associated with badlands along river valleys)	No
Little brown myotis	*Myotis lucifugus*	**S4**	N/A	Endangered	Endangered (Schedule1)	Yes (roosts in buildings, tree cavities, rock crevices)	No
Long-eared bat	*Myotis evotis*	**S2**	N/A	N/A	N/A	Yes (roosts in buildings, tree cavities, rock crevices)	No

SOURCES:

[1] SKCDC (2017), [2] SKMOE (1998), [3] COSEWIC (2016), [4] ECCC (2017)

S Rank identifies subnational conservation rank (for Saskatchewan): S1: critically imperiled, S2: imperiled, S3: vulnerable, S4: Apparently Secure; S5: Secure; B refers to the Saskatchewan breeding population only.

3.2 BAT ACTIVITY LEVELS

This study uses Alberta's guidelines (ESRD 2013), which states that pre-construction migratory bat activity, based on elevated detectors (>30 m), can be correlated to post-construction mortality rate. While the correlation is based on elevated detectors, a limited number of MET towers requires that detectors be also placed near ground level throughout the Project area to increase spatial coverage. An average of 1 bat pass per detector night equates to 4 bat fatalities per turbine per year (Baerwald and Barcay 2009); therefore, this study provides bat activity levels in bat passes per detector night to allow for comparison to the Alberta risk asssessment guidelines (ESRD 2013).

3.2.1 Monitoring Summary

Spring 2017

During the 2017 spring monitoring period, migratory bat activity rates for all detectors during the full monitoring period (May 1 to May 31) ranged from 0 to 0.2 migratory bat passes per detector night, with an average of 0.1 migratory bat passes per detector night. During this same monitoring period, total bat activity rates for all bats in the Project area from all detectors combined ranged from 0 to 0.3 total bat passes per detector night, with an average of 0.1 total bat passes per detector night (Table 3-2).

Overall, Ground 1 recorded the highest levels of both total and migratory bat activity in the Project area, with 0.3 total and 0.2 migratory bat passes per detector night, respectively. This was likely due to the proximity of the detector to the treed shelterbelts. MET 1 High recorded no bat passes, and Ground 2 recorded only one bat pass during the spring monitoring period. Migratory bat activity was highest in mid-May (Figure H6-2), with the highest level of activity recorded on May 13, 2017, with an average of 0.67 migratory (and total) bat passes recorded among detectors (Figure H6-2).

Table 3-2 Summary of Bat Activity at Each Monitoring Site During the Spring 2017 Monitoring Period

	Ground 1	Ground 2	Ground 3	Ground 4	MET 1 High	MET 1 Low	Total
Number of Detectors	1	1	1	1	1	1	6
Detector Height Above Ground (m)	2	2	2	2	43	2	N/A
Number of Nights of Operation	31	31	31	31	20	31	175
Number of Detector Hours	372	372	372	372	240	372	2,100
Number of Raw Data Files	1,163	310	9,880	1,617	7,648	9,416	30,034
Number of Recorded Total Bat Passes from May 1 to May 31	10	1	4	4	0	2	21
Number of Recorded Migratory Bat Passes from May 1 to May 31	7	1	4	4	0	2	18
Total Bat Passes Per Detector Night	0.3	0	0.1	0.1	0	0.1	0.1*
Migratory Bat Passes Per Detector Night	0.2	0	0.1	0.1	0	0.1	0.1*

NOTES:
* Average bat pass per detector night for all detectors, based on total bat passes per night divided by number of functioning detectors.

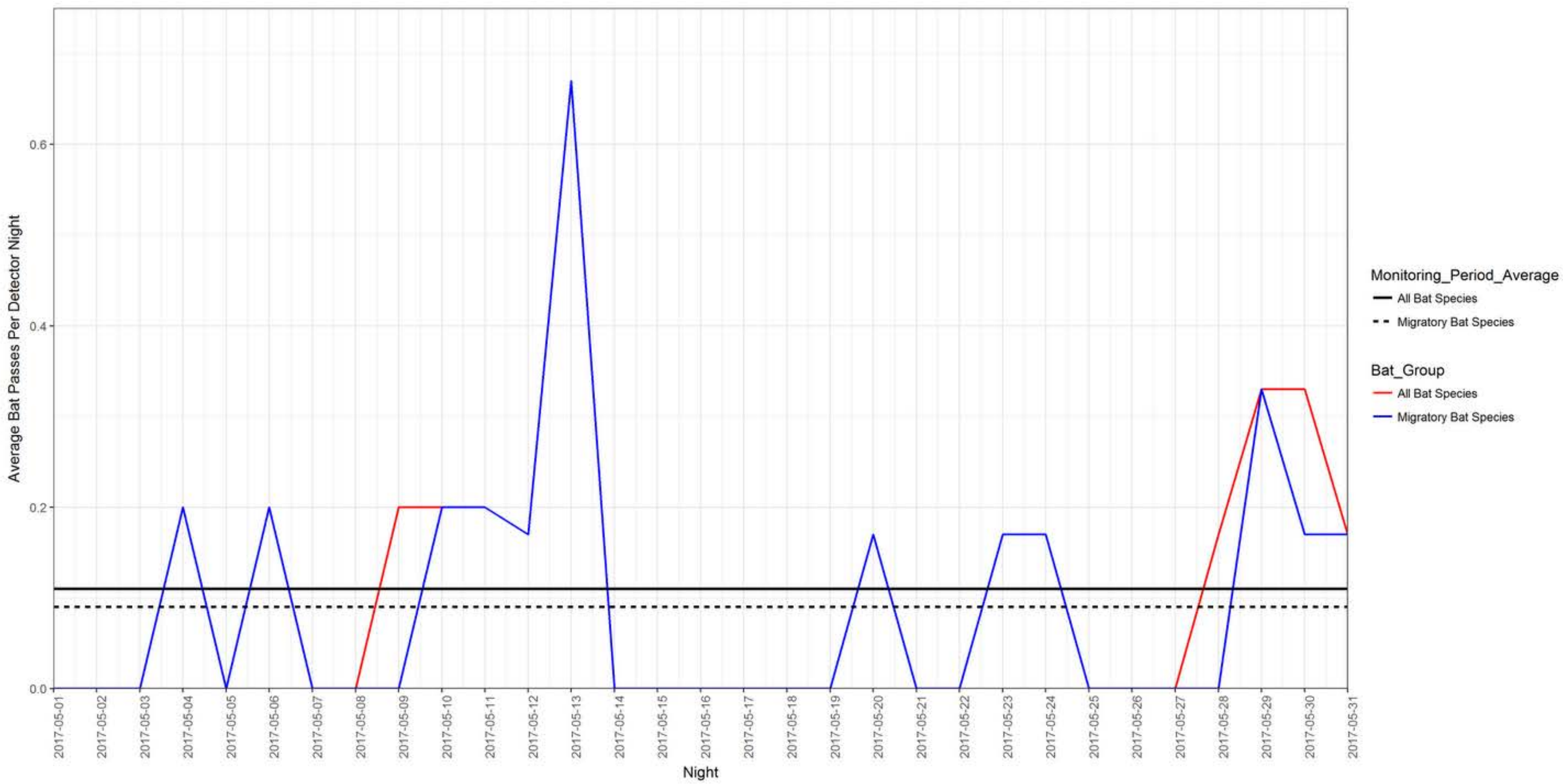


Figure H6-2 Bat Passes per Detector Night (Migratory and Total) During the 2017 Spring Monitoring Period

Fall 2017

During the 2017 fall monitoring period, migratory bat activity rates for all detectors during the full monitoring period (July 15 to October 15) ranged from 0.3 to 0.9 migratory bat passes per detector night, with an average of 0.5 migratory bat passes per detector night. Total bat activity rates for fall 2017 ranged from 0.4 to 1.4 total bat passes per detector night, with an average of 0.7 total bat passes per detector night (Table 3-3). Migratory bat activity peaked in early August with a range of 1.17 to 2.17 migratory bat passes recorded between August 5 and August 12, 2017, and again in late August, with a range of 2.5 to 4.0 migratory bat passes recorded between August 23 and August 26, 2017 (Figure H6-3).

During the monitoring period with the Framework (ESRD 2013; August 1 to September 10) the migratory bat activity rate ranged from 0.4 to 1.7 migratory bat passes per detector, with an average of 1.0 migratory bat passes per detector night. The migratory bat activity rate was recorded as 1.5 migratory bat passes per detector night at the elevated detector (Table 3-3). Total bat activity rates for this reduced period ranged from 0.6 to 2.5 total bat passes per detector night, with an average of 1.3 total bat passes per detector night. Peak activity was recorded in early and late-August (Figure H6-4).

The majority (98%; n=58) of bat passes at the MET 1 High detector were migratory (Table 3-3), consistent with observations that most bat fatalities at wind projects are migratory bats, as non-migratory bats are more active at a lower altitude (Arnett et al. 2008).

Table 3-3 Summary of Bat Activity at Each Monitoring Site During the Fall 2017 Monitoring Period

	Ground 1	Ground 2	Ground 3	Ground 4	MET 1 High	MET 1 Low	Total
Number of Detectors	1	1	1	1	1	1	6
Detector Height Above Ground (m)	2	2	2	2	43	2	N/A
Number of Nights of Operation	94	94	94	94	83	75	551
Number of Detector Hours	1,128	1,128	1,128	1,128	900	996	6,408
Number of Raw Data Files	3,479	122,221	55,720	5,572	13,528	9,975	210,495
Number of Recorded Total Bat Passes from July 15 to October 15	130	46	37	63	59	54	389
Number of Recorded Migratory Bat Passes from July 15 to October 15	86	31	24	47	58	47	293

Table 3-3 Summary of Bat Activity at Each Monitoring Site During the Fall 2017 Monitoring Period

	Ground 1	Ground 2	Ground 3	Ground 4	MET 1 High	MET 1 Low	Total
Total Bat Passes Per Detector Night from July 15 to October 15	1.4	0.5	0.4	0.7	0.8	0.7	0.7*
Migratory Bat Passes Per Detector Night from July 15 to October 15	0.9	0.3	0.3	0.5	0.8	0.6	0.5*
Nights of operaton during Alberta guideline period of August 1 to September 10	40	40	40	40	38	38	236
Number of Recorded Total Bat Passes from August 1 to September 10	98	27	25	51	59	50	310
Number of Recorded Migratory Bat Passes from August 1 to September 10	69	15	16	38	58	43	239
Total Bat Passes Per Detector Night from August 1 to September 10	2.5	0.7	0.6	1.3	1.6	1.3	1.3*
Migratory Bat Passes Per Detector Night from August 1 to September 10	1.7	0.4	0.4	1.0	1.5	1.1	1.0*

NOTES:
* Average bat pass per detector night for all detectors, based on total bat passes per night divided by number of functioning detectors.

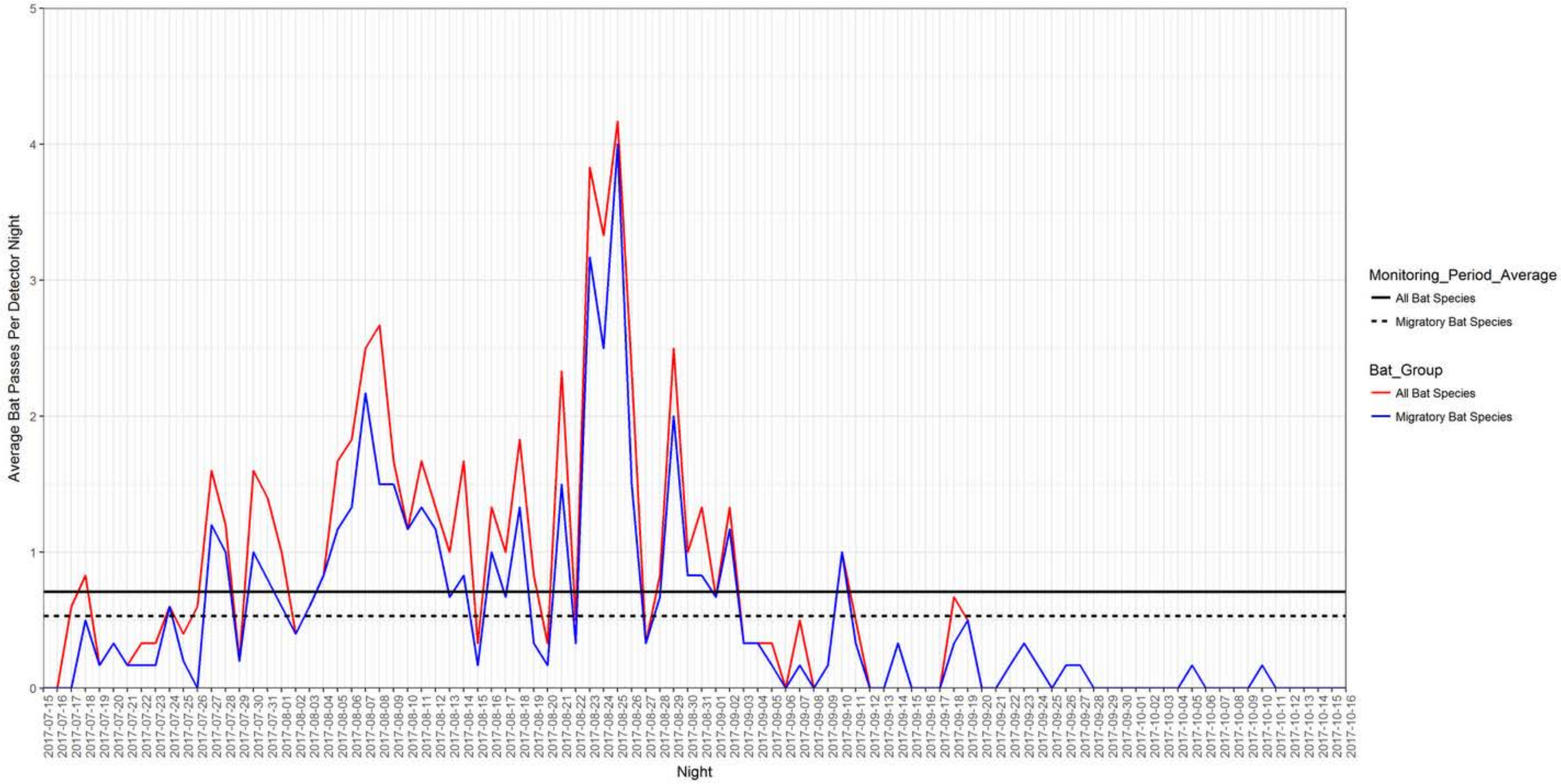


Figure H6-3 Bat Passes per Detector Night (Migratory and Total) During the 2017 Fall Monitoring Period (July 15 – October 15)

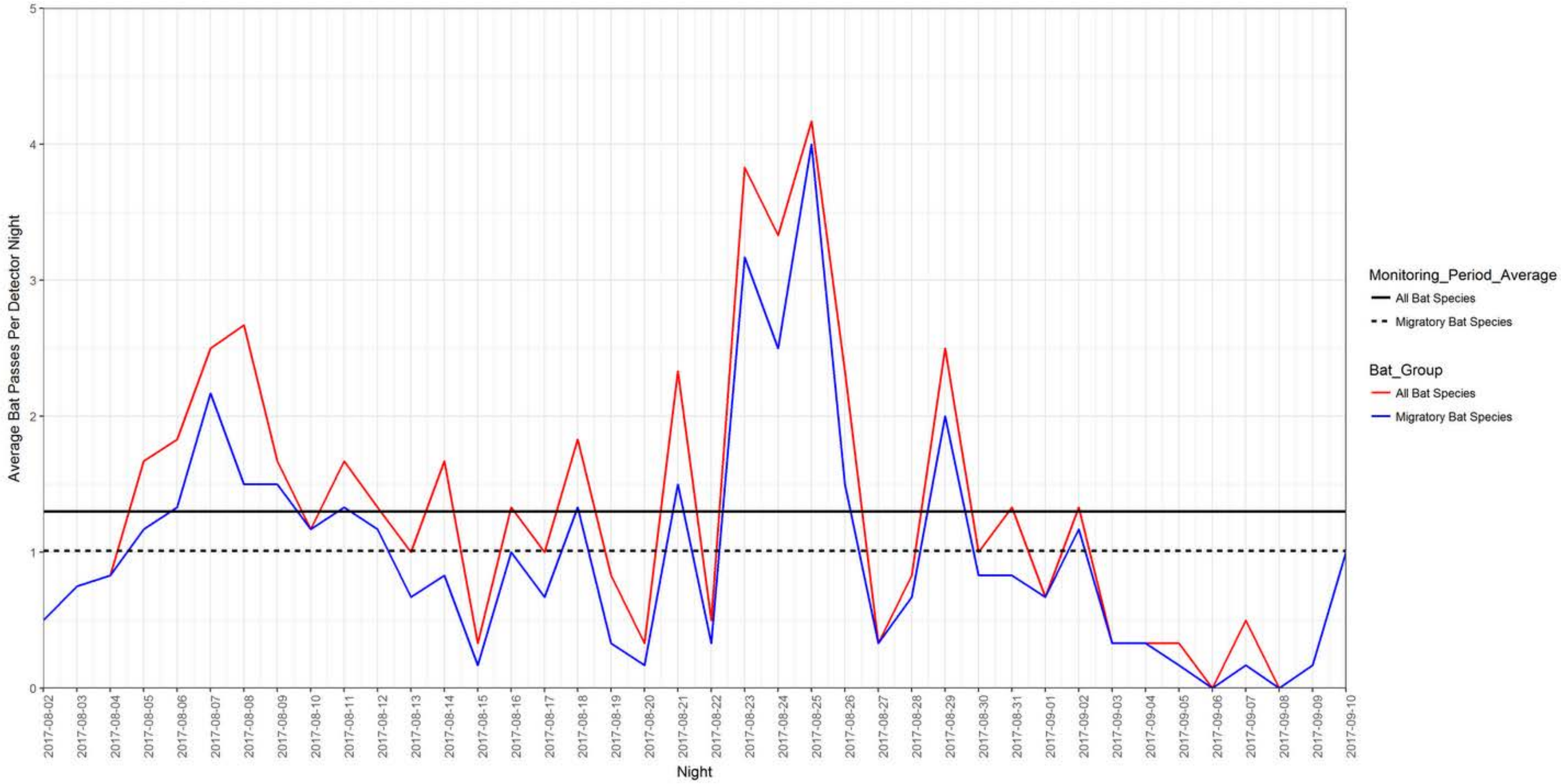


Figure H6-4 Bat Passes per Detector Night (Migratory and Total) During the 2017 Framework Recommended Fall Monitoring Period (August 1 – September 10)

3.2.2 Nightly Bat Activity Levels

Spring 2017

The highest levels of bat activity were recorded between 22:00 and 22:59 hours, with a total of 5 bat passes recorded. Bat activity was relatively even over the evenings between 21:00 and 04:59 hours (Figure H6-5). Non-migratory bats were only recorded between 23:00 – 02:00 hours (Figure H6-5).

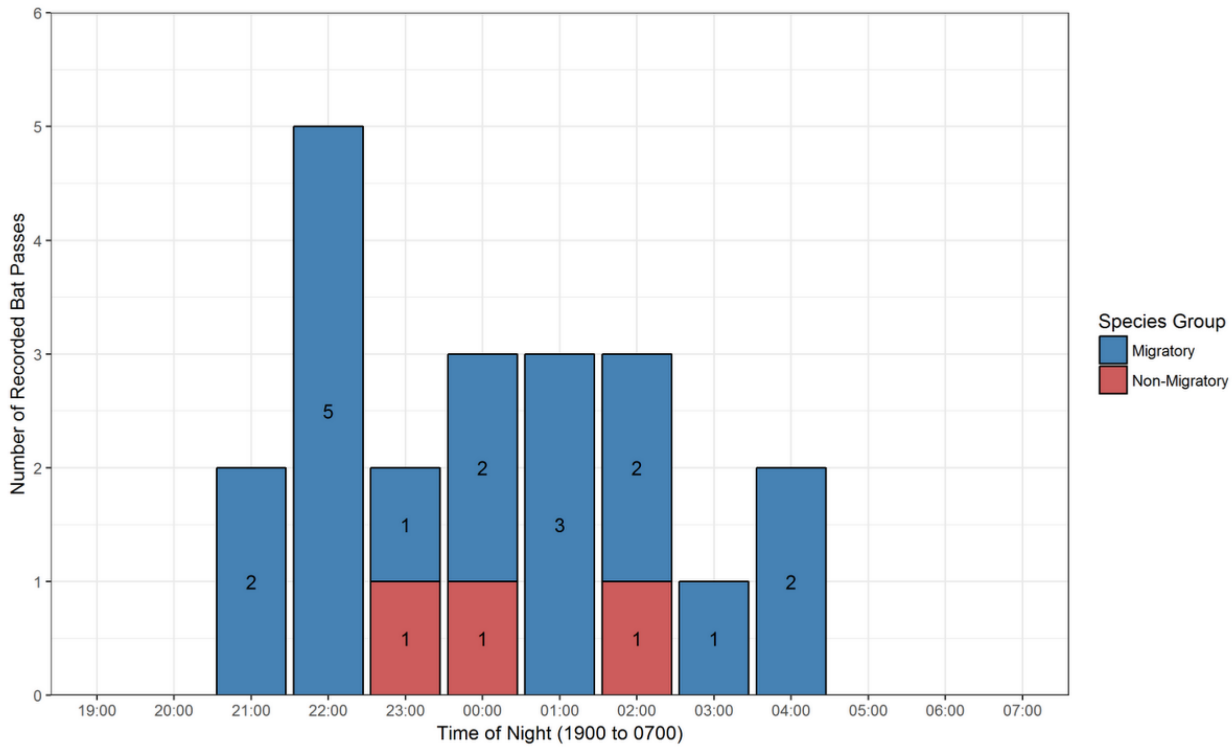


Figure H6-5 Distribution of Hourly Bat Activity for Migratory and Non-migratory Bats During the Spring 2017 Monitoring Period

Fall 2017

The highest levels of bat activity were recorded between 01:00 and 01:59 hours, with a total of 50 bat passes recorded. Most activity occurred between 22:00 and 03:59 hours (Figure H6-6).

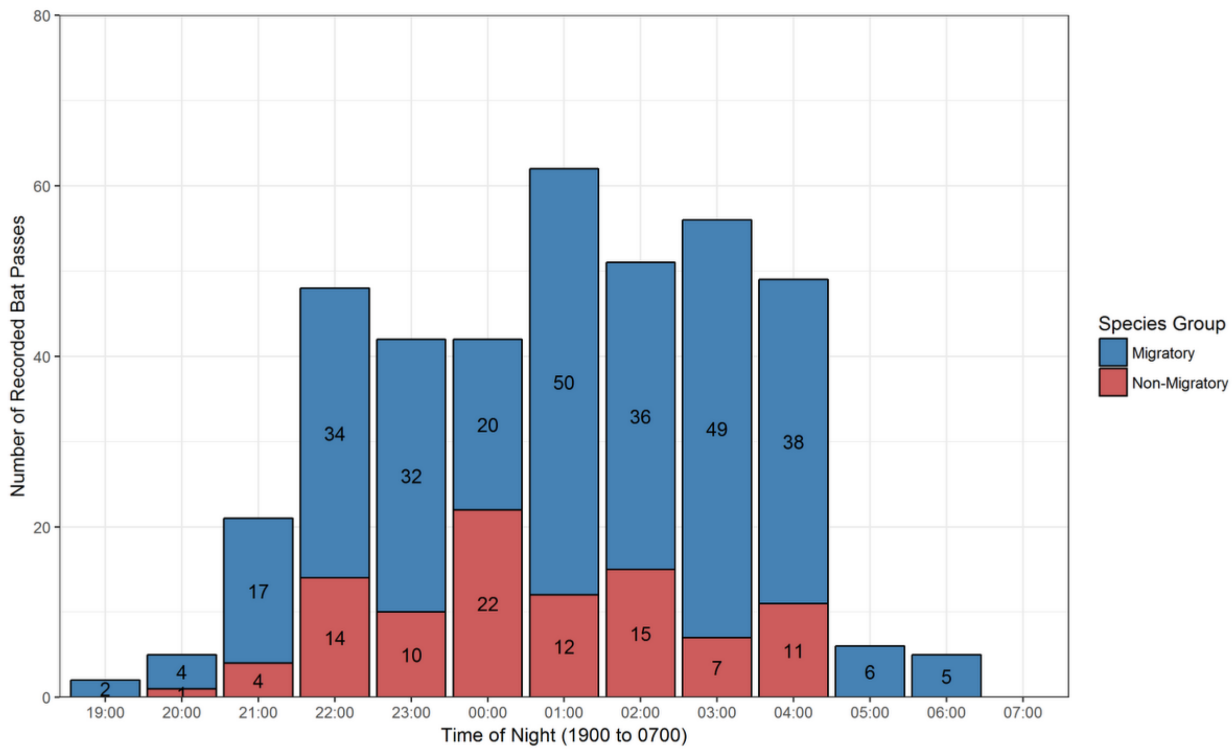


Figure H6-6 Distribution of Hourly Bat Activity for Migratory and Non-migratory Bats During the Fall 2017 Monitoring Period (July 15 to October 15)

3.3 BAT ACTIVITY BY SPECIES OR SPECIES GROUPING

The most common species or species grouping in the Project area during the spring and fall monitoring periods was the big brown/silver-haired grouping, followed by *Myotis* species (Figure H6-7 and H6-8). The big brown/silver-haired group was recorded consistently throughout both the spring and fall monitoring periods. In the spring, the *Myotis* species were recorded at the beginning and end of the monitoring period (i.e., in early and late-May), and in the fall they were observed mainly in the first portion (late July to early September) of the monitoring period.

The most common migratory species or species grouping was the big brown/silver-haired bat species grouping. During the spring monitoring period, bat observations were relatively sparse but consistent throughout May. During the fall monitoring period, the big brown/silver-haired group began increasing in mid-August, peaking in late August, and decreased to very little activity by mid-September.

Other migratory bat species and species groupings, including silver-haired bat, eastern red bat, hoary bat, and low frequency bats, displayed similar patterns of activity to the big brown/silver-haired bat species grouping during both the fall monitoring period, with most activity recorded in mid to late-August and decreasing to very little activity by September. Aside from the big brown/silver-haired grouping, very few observations of migratory bats were identified to species in the spring monitoring period.

The highest levels of bat activity during both the spring and fall monitoring periods were observed at Ground 1, which was located approximately 150 m south of treed shelterbelts, which could potentially provide roosting habitat, followed by Ground 4, which was located approximately 600 m east of an abandoned farmstead, which could also provide roosting habitat. Ground 1 also had the highest observations of *Myotis* species in the spring and fall monitoring period.

Terminal phase calls (i.e., a feeding buzz) within a bat call sequence is indicative of feeding activity and a high number of feeding buzzes could indicate a foraging area or nearby roost areas where higher levels of foraging take place. Foraging areas may have greater potential for fatalities from turbine operation. Very few terminal phase calls were recorded in the spring monitoring period. In the fall monitoring period, MET 1 High and MET 1 Low recorded the highest percentage of migratory bat passes with feeding buzzes. MET 1 High and Ground 2 recorded the highest percentage of non-migratory bat passes with feeding buzzes; however, Ground 2, Ground 3, Ground 4 and MET 1 Low had similar percentages of feeding buzzes. Migratory bats typically forage at high altitudes (above tree tops) which is consistent with greater feeding activity at the MET 1 High detector, which had small wetlands present within 300 m of the site. *Myotis* bats tend to forage close to the ground, therefore ground detectors are more likely to record feeding activity.

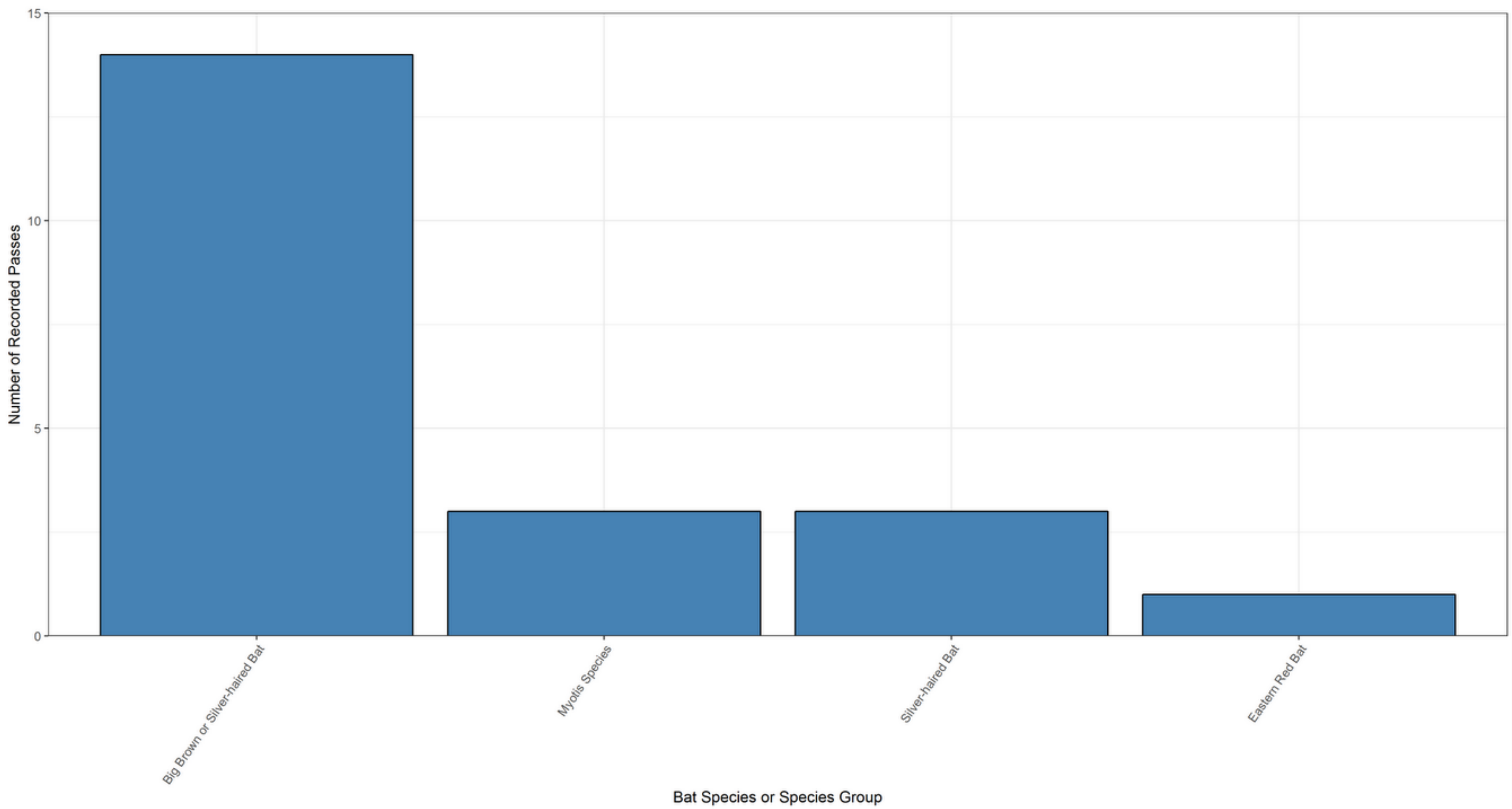


Figure H6-7 Total Bat Passes per Species or Species Grouping During the Spring 2017 Monitoring Period

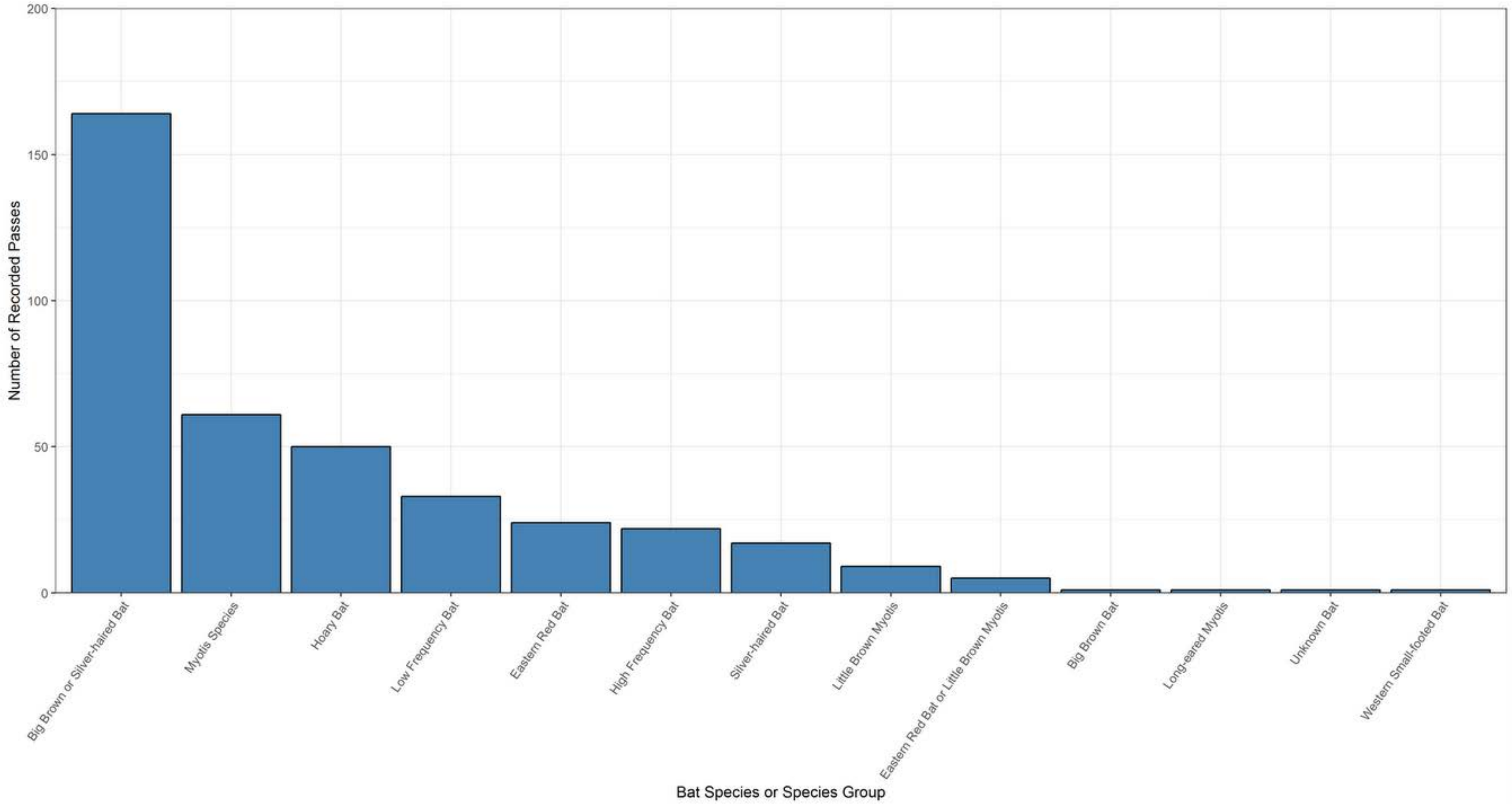


Figure H6-8 Total Bat Passes per Species or Species Grouping During the Fall 2017 Monitoring Period

4.0 SUMMARY

The average activity rate for bats during the spring monitoring period was 0.1 total bat passes per detector night for both migratory and non-migratory bats. There were no bat passes recorded at the elevated detector (MET 1 High) during the spring monitoring period, though this detector only recorded for half the monitoring period due to a malfunction. Nonetheless, no detections during the period monitored is not common and suggests low activity rates for the Project area.

The average activity rate for migratory bats during the full fall monitoring period (July 15 to October 15) was 0.5 migratory bat passes per detector night (0.8 migratory bat passes per detector night at the elevated detector). For the Framework fall monitoring period (August 1 to September 10), the average activity rate for migratory bats was 1.0 migratory bat passes per detector night (1.5 migratory bat passes per detector night at the elevated detector).

Bat activity rates were low in both the spring and fall monitoring periods; however, there were approximately 18 times as many total bat passes recorded during the fall monitoring periods as during the spring monitoring period, and 7 times as many migratory bat passes per detector night. This is consistent with results of previous studies where the highest rates of bat mortality at wind projects in North America were consistently found during August and September (Arnett et al. 2008).

The higher proportion of migratory bat activity at the elevated detector is consistent with observations that most bat fatalities at wind projects are migratory bats (94.9% in Alberta, 71.3 to 74% in Canada), as non-migratory bats are more active at lower altitude (BSC et al. 2017, Zimmerling and Francis 2016). The potential for fatality of non-migratory bats is expected to be low as *Myotis* species tend to travel and forage below the rotor swept area (Arnett et al. 2008).

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December 2017

5.0 REFERENCES

5.1 LITERATURE CITED

Arnett, E.B., K. Brown, W.P. Erickson, J.Fiedler, B.L. Hamilton, T.H. Henry, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T. O'Connell, M. Piorkowski and J.R. Tankersley. 2008. Patterns of fatality of bats at wind energy facilities in North America. Journal of Wildlife Management 72: 61-78.

Arnett, E.B., and E.F. Baerwald. 2013. Chapter 21 Impacts of Wind Energy on Bats: Implications for Conservation. In R. Adams, S. Pedersen. *Bat Evolution, Ecology, & Conservation* (pp. 435-456). New York, NY: Springer Science Press. New York.

AWWI (American Wind Wildlife Institute). 2017. Wind Turbine Interactions with Wildlife and Their Habitats. 12 pp.

Baerwald, E.F., J. Edworthy, M. Holder and R.M.R. Barclay. 2008. A Large-scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities. Journal of Wildlife Management 73: 1077-1081.

Baerwald, E.F., and R.M.R. Barclay. 2009. Geographic Variation in Activity and Fatality of Migratory Bats at Wind Energy Facilities. Journal of Mammalogy 90: 1341-1349.

Bird Studies Canada (BSC), Canadian Wind Energy Association, Environment Canada and Ontario Ministry of Natural Resources. 2016. Wind energy bird and bat monitoring database summary of the findings from post-construction monitoring reports. Available at: https://www.bsc-eoc.org/resources/wind/Jul2016_Wind_Database_Summary.pdf. Accessed September 2017.

Caceres, M.C., and R.M.R. Barclay. 2000. *Myotis septentrionalis.* Mammalian Species Account No. 634: 1-4.

ESRD (Alberta Environment and Sustainable Resource Development). 2013. Bat Mitigation Framework for Wind Power Developments. Environment and Sustainable Resource Development, Fish and Wildlife Division. 8pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2013. COSEWIC assessment and status report on the Little Brown Myotis *Myotis lucifugus*, Northern Myotis *Myotis septentrionalis* and Tri-colored Bat *Perimyotis subflavus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. xxiv + 93 pp.

GOA (Government of Alberta). 2017. Wildlife Directive for Alberta Wind Energy Projects. AEP Fish and Wildife 2016. No.6, Fish and Wildlife Policy, Alberta Environment and Parks. 30 pp.

Lausen, C., E. Baerwald, J. Gruver, and R. Barclay. 2010. Appendix 5 - Bats and Wind Turbines: Pre-siting and Pre-construction Survey Protocols. Alberta Sustainable Resource Development, Fish and Wildlife Division. Edmonton, Alberta.

Loeb, S.C., T.J. Rodhouse, L.E. Ellison, C.L. Lausen, J.D. Reichard, K.M. Irvine, T.E. Ingersoll, J.T.H. Coleman, W.E. Thogmartin, J.R. Sauer, C.M. Francis. M.L. Bayless, T.R. Stanely and D.H. Johnson. 2015. A plan for the North American bat monitoring program (NABat). United States Department of Agriculture. Available at: https://www.researchgate.net/profile/Thomas_Rodhouse/publication/277598072_A_plan_for_the_North_American_Bat_Monitoring_Program_NABat/links/556e414908aeccd7773f6c8c/A-plan-for-the-North-American-Bat-Monitoring-Program-NABat.pdf Accessed: September 2017.

Saskatchewan Conservation Data Centre (SKCDC). 2017. Taxa List: Vertebrates. Last updated: May 15, 2017. Available at: http://www.biodiversity.sk.ca/SppList/verts.pdf. Accessed: September 2017.

Saskatchewan Ministry of Environment (SKMOE). 1998. The Wildlife Act, 1998, Chapter W-13.12 of the Statutes of Saskatchewan. Last amended: May 14, 2015. Available at: http://www.qp.gov.sk.ca/documents/English/Statutes/Statutes/W13-12.pdf. Accessed: September 2017.

Zimmerling, J.R. and C.M. Francis. 2016. Bat mortality due to wind turbines in Canada. Journal of Wildlife Management 80: 1360–1369.

5.2 PERSONAL COMMUNICATIONS

Lausen, Cori. 2008. Bat Biologist, Bats-R-Us.

Lausen, Cori. 2011. Bat Biologist, Bats-R-Us.

5.3 INTERNET SITES

Aviador. 2017. Wind Overlay for CYYM. Accessed October 2017. Available at: http://www.aviador.es/Statistics/Wind/CYYN-1.

Bat Conservation International . 2012. Species Profiles. Accessed: November 2017. Available at: http://www.batcon.org/resources/media-education/species-profiles.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2016. Database of Wildlife Species Assessed by COSEWIC. Accessed: November 2016. Available at: http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_e.pdf.

ECCC (Environment and Climate Change Canada). 2017. Species at Risk Public Registry: A to Z Species Index. Modified October 31, 2017. Accessed: November 2017. Available at: https://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1.

NatureServe. 2017. NatureServe Explorer; Species Quick Search. Accessed: November 2017. Available at: http://www.natureserve.org.

SKMOE (Saskatchewan Ministry of Environment). 2017. Species at Risk under the Wildlife Act 1998. Accessed November 2017. Available at: http://www.environment.gov.sk.ca/Default.aspx?DN=c2e39ae8-cbf1-4f07-8d9a-b50ce3f4fd01.

United States Geological Survey (USGS). 2017. White-nose Syndrome. Accessed November, 2017. Available at: https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/.

H.7 REVIEW OF MORTALITY RISK RELATED TO OPERATION OF WIND PROJECTS

H.7.1 Direct Mortality

During operation of wind turbine projects, direct mortality may occur to birds or bats colliding with rotor blades, towers, or nacelles, or generally to a much lesser extent, to a wide variety of wildlife that may be struck by project-related traffic.

H.7.1.1 Collisions with Wind Turbines

The primary mechanism for direct wildlife mortality is collision of birds and bats with towers, nacelles, and revolving blades of wind turbines. The effects of wind turbines on bird and bat mortality rates and risk have been increasingly studied over the past thirty years, and are now considered to be relatively well understood.

The Swedish Environmental Protection Agency reviewed reported bird mortality at 31 wind energy facilities in Europe, 23 in the United States, and 5 in Canada, finding an overall average of 2.3 bird deaths per turbine per year, and a median of 1.6 within North America (Rydell et al. 2012). The results are comparable to previous reviews from North America which identified mean annual mortalities per turbine per year of 2.2 birds (Erickson et al. 2001). Another recent review of 43 wind facilities in Canada that corrected for detection bias reported a higher mean of 8.2 ± 1.4 (95% CI; range 0 to 26.9) bird deaths per turbine per year (Zimmerling et al. 2013). This study included five facilities in Saskatchewan (mean of 10.1 mortalities per turbine per year) and 26 facilities in Alberta (mean of 4.5 mortalities per turbine per year). While relatively few studies have examined mortality rates over the entire annual cycle, most focus on the period from April to November, when 95% of collisions occur (Zimmerling et al. 2013).

Risk of mortality is often a function of landscape features and bird species present at a particular site (Kingsley and Whittam 2005). Certain landforms (e.g., ridges, steep slopes, valleys, shorelines) can funnel bird movements, especially during migration, such that turbines in these areas might pose a higher level of risk to birds. Topographic features are also one of the most important factors influencing raptor collisions with turbines (Kingsley and Whittam 2005). Wind-energy facilities located within prairie landscapes typically have a relatively lower bird and bat mortality rate than those in landscapes with features such as forested ridges and large rivers (Arnett et al. 2007, Arnett et al. 2008, Baerwald and Barclay 2009). However, factors may differ less predictably at a local scale or among land cover types. For example, there was generally little effect of land cover types or local features, such as coulees and trees, on fatality rates at the Centennial wind energy project (WEP) (Golder Associates 2008).

An analysis of mortality monitoring results from 116 studies at more than 70 wind-energy facilities in North America identified that small passerines accounted for 62.5% of all bird fatalities, upland game birds for 8.2%, diurnal raptors for 7.8%, unidentified birds for 5.2%, doves and pigeons for 3.9%, and the other 14 bird groups accounting for less than 3% each (Erickson et al. 2014). Data from Canadian WEPs show similar proportions of fatalities by bird species groups (BSC et al. 2017). Waterfowl generally represent a small proportion of birds struck by wind turbines across Canada (3.3%), though this number is substantially higher for Alberta WEPs (13.5% of fatalities; BSC et al. 2017). This difference may be a function of the high abundance of nesting waterfowl in Bird Conservation Region 11 – Prairie Pothole Region (EC 2013), and siting of a WEP in a landscape of high nesting waterfowl density may result in a higher risk for duck collisions with WEPs. At five wind facilities in the United Kingdom, collisions of medium to large goose species was a rare event, suggesting that they may avoid wind turbines, or wind farms altogether (Pendlebury 2006, Arnett et al. 2007). Behavioural avoidance of wind turbines by birds in general has been well documented; for example, Rydell et al. (2012) noted that 62% of individuals encountering wind turbines changed their flight direction or altitude. Moreover, after the installation of a wind energy facility, birds tend to fly, on average, at higher altitudes during nocturnal flights than before construction based on radar estimates (d'Entremont et al. 2017), suggesting that birds adapt flight patterns and behaviour in response to changes on the landscape.

Landbirds

Migratory songbirds account for the majority of bird fatalities at wind facilities throughout North America (62.5%, Erickson et al. 2014; 69.4%, BSC et al. 2017). This is largely due to the relative abundance of songbirds, but likely also a function of many species migrating nocturnally, sometimes at altitudes within the rotor swept area of wind turbines. Overall, most of the migratory passerines are neotropical migrants that breed in temperate and boreal regions, and overwinter in tropical areas. However, in Alberta, horned larks accounted for 28% of avian fatalities at WEPs, an order of magnitude more than any other species; this is likely due to their abundance in agricultural landscapes over the majority of their annual cycle, compared to other species only passing through over brief periods in spring and fall (BSC et al. 2017). These results are also consistent with the fatality results from the Morse WEP where horned larks were 10 of 28 fatalities (36%) (Golder Associates 2017). However, even for species such as horned lark that are most commonly struck, the estimated mortality from wind turbines throughout North America ranges from 0.03 to 0.04% of the population (Erickson et al. 2014). Zimmerling et al. (2013) found similar rates at wind farms in Canada and concluded they were not sufficient to cause population-level effects.

The implications of mortality can be greater for species at risk (SAR), which typically have smaller populations and can be more vulnerable to the loss of individuals. No studies have specifically examined mortality risk of loggerhead shrikes, Sprague's pipits, or chestnut-collared longspurs, but these species are all absent from the mortality reports for Canada reviewed by BSC et al. (2017), and only one chestnut-collared longspur mortality has been reported at the Centennial

WEP (Golder Associates Ltd. 2008). There is also evidence of some species at risk co-existing safely with WEPs. For example, at the Judith Gap WEP in 2006 and 2007, 41 Sprague's pipits were detected within the project lands during the post-construction breeding bird surveys, but there were none among the 406 fatalities recorded during the monitoring program (TRC 2008).

Waterbirds

Waterbirds broadly refer to waterfowl (e.g., swans, geese, and ducks), shorebirds (e.g., avocets, stilts, plovers, sandpipers, and phalaropes), and a wide variety of other species (e.g., rails, coots, cranes, herons, pelicans, cormorants, loons, grebes, gulls, and terns). Overall, the group accounts for a relatively small proportion of fatalities at wind energy facilities in North America (6%, Erickson et al. 2014).

Waterfowl account for a small proportion of fatalities at wind energy facilities in Canada (3.3%, BSC et al. 2017) and North America overall (2.7%, Erickson et al. 2014). However, higher rates were noted in Alberta, where mallards alone accounted for 11.7% of fatalities, driving waterfowl fatalities overall to 13.5% (BSC et al. 2017). This higher rate in Alberta may be a function of a specific project that was sited near a wetland heavily used by ducks; for comparison, the Centennial WEP, sited in a terrestrial landscape with few wetlands, reported that 3 of 90 (3.3%) bird fatalities were ducks (2 mallards and 1 northern pintail; no goose carcasses were detected) (Golder Associates Ltd. 2008). At the Morse WEP, out of 28 bird fatalities there were no ducks and only one unidentified goose species reported during the 2015 to 2017 monitoring programs (Golder Associates 2017). Although not specifically assessed, waterfowl collision rates in grassland regions of Saskatchewan are expected to be comparable to those for Canada, with the potential to have higher waterfowl collision rates where WEPs are sited near important staging wetlands. Mallard is the most abundant duck species in North America and frequently feeds in fields, which may in some case be near wind turbines. This species and other dabbling ducks undertake erratic spring courtship flights in which a female is pursued by two or more males, which can result in higher collision susceptibility. However, waterfowl are known to generally avoid wind turbines during flight (Whitfield 2010, Sugimoto and Matsuda 2011), accounting for their typically low collision rates. Geese in particular are known to have low mortality rates because of their turbine avoidance behaviour (Sugimoto and Matsuda 2011). This is consistent with the proportion of fatalities observed at the Centennial Wind Energy project near Swift Current, Saskatchewan, where out of 90 carcasses detected over a two-year period, waterfowl fatalities were limited to three ducks and no geese.

There are no waterfowl in Saskatchewan that are considered SAR or species of management concern (SOMC). While breeding waterfowl densities vary annually in the prairies in relation to environmental conditions and population fluctuations, North American waterfowl abundance in 2014 was the highest on record since standardized waterfowl breeding surveys began in 1955, with 47.3 million breeding pairs of ducks in the traditional survey area, 34% above the long-term mean (USFWS 2017). An extensive study on waterfowl mortality from wind developments in the prairie pothole region supported the expectation that wind turbines had no direct effect on breeding female survival in mallards and blue-winged teal (Gue et al. 2013).

Shorebirds account for an even smaller proportion of bird fatalities at wind energy facilities in North America (1%, Erickson et al. 2014). This is consistent with results from Alberta, where there were three shorebird mortalities (one each killdeer, marbled godwit, and upland sandpiper) out of a total of 355 birds reported (BSC et al. 2017). Project-specific information within Saskatchewan is also consistent with this observation. The Centennial WEP had two shorebird fatalities (a killdeer and an unknown species) out of 100 total (Golder Associated Ltd. 2008), while the Morse WEP reported one shorebird (an upland sandpiper) fatality out of 28 total bird fatalities detected, despite being located approximately 4.5 km southeast of Reed Lake. Notably, all the mortalities identified in Alberta and at the Centennial WEP and Morse WEP involved locally breeding species rather than arctic migrants, and none were SOMC.

In a review of migration height, most arctic-nesting shorebirds traveled at 1,726 m to 2,865 m above ground to make use of strong, cool and more laminar (i.e., less turbulent) wind currents for their long-distance migration movements (Green 2004). Only knots migrated at an average of about 400 m altitude (Green 2004), but even this is above the rotor swept area of wind turbines. Dokter et al. (2010) also reported results from a weather radar migration study that showed many birds ascend quickly to high altitude (above 2,000 m) for long-distance migration. These data are also supported by results about migration altitude of shorebirds in the Canadian Maritimes from Richardson (1979). The high migration altitude and steep rate of climb of shorebirds likely explains the very low proportion of shorebirds found in mortality monitoring studies (AB ESRD 2001).

Projects located in areas of high shorebird abundance would be expected to have relatively higher rates of fatalities. However, even in areas supporting large concentrations of shorebirds, evidence indicates that mortality rates remain low. For example, the Gulf Winds project is a 118 turbine (283 MW) facility within a wetland complex of the Laguna Madre, recognized as a Ramsar wetland of international importance, and the most critical part of the coast of the Gulf of Mexico for shorebirds, supporting 20% of the overwintering piping plover population (Withers 2002). Yet mortality monitoring identified only 53 shorebird mortalities per year (0.19 shorebirds/MW/year), accounting for 5.5% of the total mortality rate of 3.4 birds/MW/year for the project (Confidential Monitoring Report). Similarly, three years of mortality monitoring at the neighbouring Penascal wind facility yielded results below the North American average, with an even lower proportion of shorebirds (Jerry A. Roppe, pers.comm.; Wally Erickson, pers.comm.).

In the prairie pothole region, the 354-turbine Buffalo Ridge project on the border of Minnesota and South Dakota offers the best insights into shorebird collision rates. A four-year monitoring study revealed an overall mortality rate of 3.8 birds/MW/year, with no shorebird fatalities attributable to collisions, despite three shorebirds among the ten species observed as having greatest exposure to collision risk (Johnson et al. 2000a). During various behavioural surveys, 8 to

81% of shorebirds flew within the rotor swept area, suggesting that the absence of documented collisions reflects a high propensity for turbine avoidance (Johnson et al. 2000a).

Reed Lake is located approximately 7 km from the closest proposed Project turbine, and is part of the Chaplin-Old Wives-Reed Lakes (C-OW-RL) Western Hemisphere Shorebird Reserve Network Site, an internationally recognized staging area for migrating shorebirds. The majority of shorebirds staging at C-OW-RL use the aquatic or shoreline habitat for feeding to acquire nutrient stores for migration. Shorebirds in general are an order of magnitude lower at Reed Lake than they are at Chaplin or Old Wives (CWS 2007). The most common shorebirds at Reed Lake are stilt sandpipers, red-necked phalaropes and semipalmated sandpipers; the red knot, a species listed under SARA as *endangered*, is also known to stage at this lake. While some piping plovers also stage at the C-OW-RL complex, they tend to be scarcer at Reed Lake due to limited availability of mud flats (CWS 2007). The Montana Nature Conservancy (Martin et al. 2009) identified 1.6 km as an appropriate setback from piping plover nesting habitat in their ecological risk assessment of wind energy development. The Project is over four times this distance from Reed Lake.

Other waterbirds (e.g., rails, coots, cranes, herons, pelicans, cormorants, loons, grebes, gulls, and terns) collectively account for 3.7% of bird mortalities documented at Canadian wind energy facilities (BSC et al. 2017), and 2.2% for North America overall (Erickson et al. 2014). The percentage is somewhat higher in Alberta (7.6%), reflecting the abundance of species in prairie potholes such as grebes, coots, pelicans, and gulls (BSC et al. 2017). Inland wind energy facilities generally pose a low risk to waterbirds, unless located directly adjacent to waterbird colonies, or in areas of high wetland abundance where waterbirds may nest and move regularly between wetlands. The proximity of wind energy facilities to large roosting or breeding wetlands likely increases collision risk.

At the Buffalo Ridge wind facility, waterbirds accounted for 9% of fatalities, and included American coot, pied-billed grebe and herring gull, all common species found in the prairie pothole region. Similar fatality rates of waterbirds were observed at the Centennial WEP, involving primarily horned grebe, eared grebe, sora, American coot, and Franklin's gull. The Morse WEP had 5 waterbird fatalities out of the 28 bird carcasses detected, and included American coots, American white pelicans and a sora (Golder Associates 2017). Cranes sometimes flew within the rotor swept area at Buffalo Ridge, but no mortalities were detected; this is consistent with results from the Centennial Wind Energy Project (Golder Associates Ltd. 2008) and the lack of any crane mortality in the review by Erickson et al. (2014), and a single sandhill crane fatality in Canada (BSC et al. 2017).

Raptors

Diurnal raptors (e.g., hawks, falcons, eagles) have been identified as species of concern for a number of wind developments. In Canada, raptors account for 7.7% of bird fatalities at WEPs; the proportion was somewhat lower in Alberta at 5.1% (BSC et al. 2017), and similar for North America as a whole (7.8%, Erickson et al. 2014). Red-tailed hawk and turkey vulture are the two most commonly affected raptor species.

The vulnerability of raptors to wind turbine collisions achieved a high profile due to elevated collision rates at the Altamont Pass Wind Resource Area, where establishment of nearly 5,000 turbines began in 1982, when there was little understanding of mortality risk (Zimmerling et al. 2013). The rotor swept area of early turbines extended to as little as 9 m above ground, and sometimes with only 10 m separation from the rotor swept area of adjacent turbines. The limited options for avoidance contributed to high levels of mortality for golden eagles, burrowing owls, and other raptors (Erickson et al. 2001). Smallwood et al. (2009) showed that repowering the Altamont Pass Wind Resource Area to larger modern turbines would significantly reduce mortality risk.

With changes to turbine design, improved understanding of risk factors, and proactive mitigation, mortality risk for raptors has declined considerably at newer projects. For example, at the 105-turbine Seawest wind energy facility in Wyoming, Johnson et al. (2000b) reported no effect over four years on density or reproductive success of raptors at 134 nests among and within 16 km of the facility, compared to a reference area with 44 additional nests. There was a single raptor fatality (a red-tailed hawk) reported during monitoring at the Buffalo Ridge energy project, and this is at least in part attributed to the rotor swept area being above the mean flight height of raptors on site (Johnson et al. 2000a). Similarly, although at least two active great horned owl nests at Centennial WEP successfully hatched young, no owl collision fatalities were detected. No raptor fatalities were detected at the Morse WEP during monitoring conducted in 2015 to 2017 (Golder Associates 2017).

In general, nocturnal owls appear to be at low risk of collision, accounting for only 0.1% of mortalities recorded at wind energy facilities in Canada (BSC et al. 2017). While studies have not specifically addressed the vulnerability of owls to turbines, the low collision rates may be a function of most nocturnal species favouring forested habitat where turbines are uncommon, whereas owls that hunt in open country are mostly diurnal, and may reduce their risk by actively avoiding turbines. This is consistent with the general observation that raptors appear largely capable of avoiding turbines when they are adequately spaced to allow birds to hunt in between them. For example, Garvin et al. (2011) studied effects on raptors of the Forward Energy wind project in Wisconsin, and found that while there was some displacement of raptors from the area post-construction, others remained present, and only 6.4% of 1455 raptor observations were within 100 m of turbines, and active avoidance was documented. These results are consistent with results from Johnson et al. (2000a) who found small scale (<100 m from turbine) avoidance by northern harriers at the Buffalo Ridge Wind Resource Area in Minnesota.

There has been little study of the effects of wind energy developments specifically on ferruginous hawk, a SARA-listed *threatened* species in Canada. Kolar and Bechard (2016) found that in the Columbia Plateau Ecoregion of Oregon, red-tailed hawks, Swainson's hawks, and ferruginous hawks did not select nesting locations in relation to density of wind turbines on the landscape, but instead appeared to stagger their distribution in relation to nesting substrate and to reduce competition (Kolar 2013). At a finer scale, Kolar (2013) reported that there was a significant negative relationship between turbine density and daily nest survival of ferruginous hawks (b = -0.89, SE = 0.39, 85% CI = -1.47 to -0.30), with mortality of chicks arising from starvation or depredation. However, none of the 60 fledgling hawks in the study area were struck by turbines (Kolar and Bechard 2016). At the Centennial WEP, Golder Associates Ltd. (2008) reported that two ferruginous hawk nests were identified within the mortality monitoring area in 2006. One nest was approximately 350 m from a turbine while the second was approximately 470 m away. The first nest successfully hatched young, but the second was not confirmed. Neither nest was monitored to determine fledging success. In 2007, two ferruginous hawk nests were again detected at the same locations. One nest was destroyed when the hedgerow was cleared for agricultural activities and the pair re-nested nearby at approximately 450 m from a turbine. Both nests successfully fledged 4 young in 2007, well above the average of the species (e.g., 2.8 young per occupied nest, based on 629 nests in North Dakota, Gilmer and Stewart 1983). These two nests were within the Saskatchewan Ministry of Environment (SKMOE) activity restriction guidelines of 1,000 m (SKMOE 2017) and the high reproductive output of these two pairs indicates that the adults were not impeded from adequately foraging to feed young.

Bats

Mortality risk to bats has been studied extensively at wind facilities and forms part of many standard assessments and mortality monitoring programs. Baerwald (2008) suggested that barotrauma (i.e., decreased pressure causing hemorrhaging of internal tissues) was a major cause of mortality of bats, but more recent studies have indicated that the majority of bat fatalities are caused by direct strikes of turbines blades with bats (Grodsky et al. 2011, Capparella et al. 2012, Rollins et al. 2012).

The average bat mortality rate varies greatly within Canada. Zimmerling and Francis (2016) analyzed data from across Canada and reported an average annual fatality rate of 15.5 bats/turbine. BSC et al. (2017) reported that from 66 projects reporting mortality data in the period from 2007 to 2014, corrected annual mortality rates for bats ranged from 0.26 bats/turbine in Atlantic Canada to 18.52 bats/turbine in Ontario, with an intermediate level of 8.34 bats/turbine in Alberta. The differences reflect variability in land cover (e.g., prairie vs. forested landscapes), as well as in abundance of bats, most notably the dramatic decline in eastern bat populations due to white nose syndrome in the maritime provinces where the disease has been detected in nearly all counties (https://www.whitenosesyndrome.org/resources/map).

Across Canada, migratory bats (hoary bat, eastern red bat, silver-haired bat) accounted for 68.5% of mortalities in the review by BSC et al. (2017), while resident species (little brown myotis, big brown bat, northern long-eared myotis, eastern small-footed bat, and tri-colored bat) comprise the remainder (31.5%). In Alberta, resident bats accounted for a much smaller proportion of mortalities (5.6%), similar to the 7% rate over four years of mortality monitoring at the Buffalo Ridge wind energy facility in Minnesota (Johnson et al. 2000a). At the Judith Gap WEP in Montana, all fatalities recorded were either hoary bats or silver-haired bats (TRC 2008). Resident bat fatality rates are even lower within Saskatchewan. The Centennial WEP reported that resident bats accounted for only 2.3% of fatalities during 2006 and 2007 monitoring, both of which were big brown bats (Golder Associates 2008). Migratory bats accounted for 97.3 percent of fatalities; overall, the fatality rate at Centennial was 7.9 bats/turbine/year (4.4 bats/MW/year). The Morse WEP did not report any resident bats out of the 43 observed fatalities in 2015 to 2017, and corrected fatality rates were estimated at 13.3 bats/turbine/year (5.77 bats/MW/year) (Golder Associates 2017).

Patterns of elevated bat fatalities have been documented at wind facilities on nights with wind speed less than 6 metres per second (m/s) (Arnett et al. 2008), corresponding to when aerial insects are most active (Kunz et al. 2007). Horn et al. (2008) also indicated that blade rotational speed, which correlates to wind speed, was a significant predictor of collisions with turbines where higher wind speeds were correlated with lower bat fatality rates when turbines were active. This also suggests that bats may be more active on nights with lower wind speeds when turbines are typically not operating. Across Canada, most bat fatalities at WEPs occur between July and September, with a peak in mid-August to early-September (BSC et al. 2017). At the Centennial WEP 85% of bat fatalities occurred between August 1st and September 3rd (Golder Associates Ltd. 2008).

H.7.1.2 Vehicle Collisions

Slow-moving terrestrial animals such as reptiles and amphibians are particularly vulnerable to vehicle collisions, although all wildlife are potentially at risk if they cross roads at or near ground level. However, project-related vehicle traffic during operation is typically limited to occasional monitoring and maintenance visits. In almost all landscapes, this represents a very small increase over background traffic levels, and therefore only a minor incremental increase in mortality risk.

H.7.2 Indirect Mortality

The introduction of wind turbine infrastructure to a landscape may result in changes in behaviour for some wildlife species that have implications for mortality, including facilitation of predator abundance affecting prey species, and avoidance responses that may reduce fitness or abandonment of nests and young.

In grassland areas where natural perches are not common, the addition of infrastructure such as WTGs and collector line poles can facilitate hunting and sometimes even nesting by corvids and raptors that would otherwise be absent or in low densities (Slater and Smith 2010). An increase in the local populations or redistribution of these predatory species can in turn lead to declines in prey, including smaller birds as well as mammals, amphibians, and reptiles (Richardson et al. 2017). Conversely, in areas where the availability of existing perches is not a limiting factor for corvids or raptors (i.e., such perches are common), the introduction of additional infrastructure and associated sensory disturbance may result in displacement of some of these predators, and a concurrent reduction in predation pressure for their prey (Francis et al. 2009).

For most projects, indirect effects pose a lesser mortality risk than direct effects.

H.7.3 References

Arnett, E.B., D.B. Inkley, D.H. Johnson, R.P. Larkin, S. Manes, A.M. Manville, R. Mason, M. Morrison, M.D. Strickland, and R. Thresher. 2007. Impacts of Wind Energy Facilities on Wildlife and Wildlife Habitat. Issue 2007-2. The Wildlife Society, Bethesda, Maryland.

Arnett, E.B., K. Brown, W.P. Erickson, J. Fiedler, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Kolford, C.P. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersley, Jr. 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. Journal of Wildlife Management 72:61–78.

Baerwald, E. F. 2008. Variation in the activity and fatality of migratory bats at wind energy facilities in southern Alberta: causes and consequences. Thesis, University of Calgary, Alberta, Canada.

Baerwald, E. and R. M. R. Barclay. 2009. Geographic variation in activity and fatality of migratory bats at wind energy facilities. Journal of Mammology 90: 1341-1349.

Bird Studies Canada (BSC), Canadian Wind Energy Association, Environment Canada, and Ontario Ministry of Natural Resources. 2017. Wind Energy Bird and Bat Monitoring Database Summary of the Findings from Post-Construction Monitoring Reports. Available at https://www.bsc-eoc.org/resources/wind/Jul2017_Wind_Database_Summary.pdf. Accessed: December 7, 2017

Canadian Wildlife Service (CWS). 2007. Wind turbines and birds: a guidance document for environmental assessment. 52 pp. Available at: http://publications.gc.ca/collections/collection_2013/ec/CW66-363-2007-eng.pdf Accessed May 15, 2015

Capparella, A., S. Loew, and D. K. Meyerholz. 2012. Bat deaths from wind turbine blades. Nature 488:32

d'Entremont, M. V., M. I. Hartley, and K. A. Otter. 2017. Comparing pre- versus postoperational movement of nocturnal migrants around a wind energy facility in northeast British Columbia, Canada. Avian Conservation and Ecology 12(2):3. https://doi.org/10.5751/ACE-01046-120203

Dokter, A.M., F. Liechti, H. Stark, L. Delobb, P. Tabary, and I. Holleman. 2010. Bird migration flight altitudes studied by a network of operational weather radars. Interface 107. http://rsif.royalsocietypublishing.org/content/early/2010/05/29/rsif.2010.0116

Environment Canada. 2013. Bird Conservation Strategy for Bird Conservation Region 11 in the Prairie and Northern Region CWS region: Prairie Potholes. Canadian Wildlife Service, Environment Canada. Saskatoon, Saskatchewan. 107 pp. + appendices.

Erickson, W.P., G. Johnson, D. Young, D. Strickland, K.J. Sernka, and R.E. Good. 2001. Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States. National Wind Coordinating Committee Resource Report. 124 pp.

Erickson, W. P., M. M. Wolfe, K. J. Bay, D. H. Johnson, and J. L. Gehring. 2014. A comprehensive analysis of small-passerine fatalities from collision with turbines at wind energy facilities. PLoS ONE 9:e107491

Francis, C. D., C. P. Ortega and A. Cruz. 2009. Noise pollution changes avian communities and species interactions. Current Biology 19: 1415-1419.

Garvin, J. C., C. S. Jennelle, D. Drake, and S. M. Grodsky. 2011. Response of Raptors to a windfarm. Journal of Applied Ecology. 48:199-209

Gilmer, D. S., and R. E. Stewart. 1983. Ferruginous hawk populations and habitat use in North Dakota. The Journal of Wildlife Management 47: 146-157

Golder Associates Ltd. 2008. SaskPower international centennial wind power facility bird and bat monitoring project. Final Report.

Golder Associates Ltd. 2017. Algonquin Morse Wind Energy Project Post-construction Monitoring Program – 2015-2017. Report Number 1414218. July, 2017.

Green, M. 2004. Flying with the wind – spring migration of arctic-breeding waders and geese over South Sweden. Ardea 92: 145-160

Grodsky, S. M., and D. Drake. 2011. Assessing Bird and Bat Mortality at the Forward Energy Center. Final Report. Report No. 06-1361-276

Gue, C. T., J. A. Walker, K. R. Mehl, J. S. Gleason, S. E. Stephens, C. R. Loesch, R. E. Reynolds, and B. J. Goodwin. 2013. The effects of a large-scale wind farm on breeding season survival of female mallards and blue-winged teal in the Prairie Pothole Region. The Journal of Wildlife Management 77: 1360-1371

Horn, J. W., E. B. Arnett, and T. H. Kunz. 2006. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management 72: 123-132

Johnson, G.D., W.P. Erickson, M. D. Strickland, M.F. Shepherd, D.A. Shepherd. 2000a. Avian Monitoring Studies at the Buffalo Ridge Wind Resource Area, Minnesota: Results of a 4-Year Study. Technical report by WEST Inc. prepared for Northern States Power Co., Minneapolis, Minnesota.

Johnson, G. D., D. P. Young, W.P. Erickson, C.E. Derby, M.D. Strickland, and R.E. Good. 2000b. Wildlife Monitoring Studies. SeaWest windpower project, Carbon County, Wyoming: 1995-1999. Final Report. 207 pp.

Kingsley, A. and B. Whittam. 2005. Wind Turbines and Birds: A Background Review for Environmental Assessment. Draft report for Environment Canada, Canadian Wildlife Service, Quebec. 81 pp. Available at: http://www.energy.ca.gov/windguidelines/documents/other_guidelines/2006-05-12_BCKGRD_ENVIRMTL_ASSMNT.PDF. Accessed: November 2014.

Kolar, P. S., and M. J. Bechard. 2016. Wind energy, nest success, and post-fledging survival of *Buteo* hawks. The Journal of Wildlife Management 80: 1242-1255

Kolar, P.S. 2013. Impacts of wind energy developments on breeding *Buteo* hawks in the Columbia plateau ecoregion. MSc thesis. Boise State University. 137 pp.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A. R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy developments on bats: questions, research, needs, and hypotheses. Frontiers in Ecology and Evolution 5: 315-324

Martin, B. A. Pearson, and B. Bauer. 2009. An ecological risk assessment of wind energy developments in Montana. Nature Conservancy of Montana. 57 pp.

Pendlebury, C. 2006. An appraisal of "A review of goose collisions at operating wind farms and estimation of the goose avoidance rate" by Fernley, J., Lowther, S. and Whitfield, P. British Trust for Ornitology (BTO) Research Report No. 455. pp. 33.Percival, S. 2005. Birds and Wind Farms, What are the Real Issues? British Birds 98: 194-204.

Richardson, W.J. 1979. Southeastward shorebird migration over Nova Scotia and New Brunswick in autumn: a radar study. Canadian Journal of Zoology 57: 107-124.

Rollins, K. E., D. K. Meyerholz, G. D. Johnson, A. P. Capparella, and S. S. Loew. 2012. A forensic investigation into the etiology of bat mortality at a wind farm: barotrauma or traumatic injury. Environmental Pathobiology 49: 362-371

Rydell, J., H. Engstrom, A. Hedenstrom, J. K. Larsen, J. Pettersson, and M. Green. 2012. The effects of wind power on birds and bats: a synthesis. Swedish EPA Report No. 6511. 152 pp.

Saskatchewan Ministry of Environment (SKMOE). 2017. Saskatchewan Activity Restriction Guidelines for Sensitive Species. Fish and Wildlife Branch, Regina, Saskatchewan. Last updated: April 2017.

Slater, S. J., and J. P. Smith. 2010. Effectiveness of raptor perch deterrents on an electrical transmission line in southwestern Wyoming. The Journal of Wildlife Management 74: 1080-1088

Smallwood, K. S., L. Neher, and D. A. Bell. 2009. Map-based repowering and reorganization of a wind resource area to minimize burrowing owl and other bird fatalities. Energies 2: 915-943.

Sugimoto, H. and H. Matsuda. 2011. Collision risk of white-fronted geese with wind turbines. Ornithological Science 10: 61-71.

TRC Environmental Corporation (TRC). 2008. Post-construction avian and bat fatality monitoring and grassland bird displacement surveys at the Judith Gap wind energy project, Wheatland County, Montana.

U.S. Fish and Wildlife Service. 2017. Waterfowl population status, 2017. U.S. Department of the Interior, Washington, D.C. USA. Available at: https://www.fws.gov/migratorybirds/pdf/surveys-and-data/Population-status/Waterfowl/WaterfowlPopulationStatusReport17.pdf

Whitfield, D.P. 2010. Avoidance rates of swans under the 'Band' collision risk model. Natural Research Information Note 5. Natural Research Ltd, Banchory, UK.

Withers, K. 2002. Shorebird use of coastal wetland and barrier island habitat in the Gulf of Mexico. TheScientificWorldJournal 2:514-536

Zimmerling, J. R., A. C. Pomeroy, M. V. d'Entremont, and C. M. Francis. 2013. Canadian estimate of bird mortality due to collisions and direct habitat loss associated with wind turbine development. Ace-Eco 8:10 http://dx.doi.org/10.5751/ACE-00609-080210

Zimmerling, J. R., and C. M. Francis. 2016. Bat mortality due to wind turbines in Canada. The Journal of Wildlife Management 80: 1360-1369