KEEYASK TRANSMISSION PROJECT

BIRD-WIRE COLLISION MONITORING 2017

Prepared for

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By

Wildlife Resource Consulting Services MB Inc.

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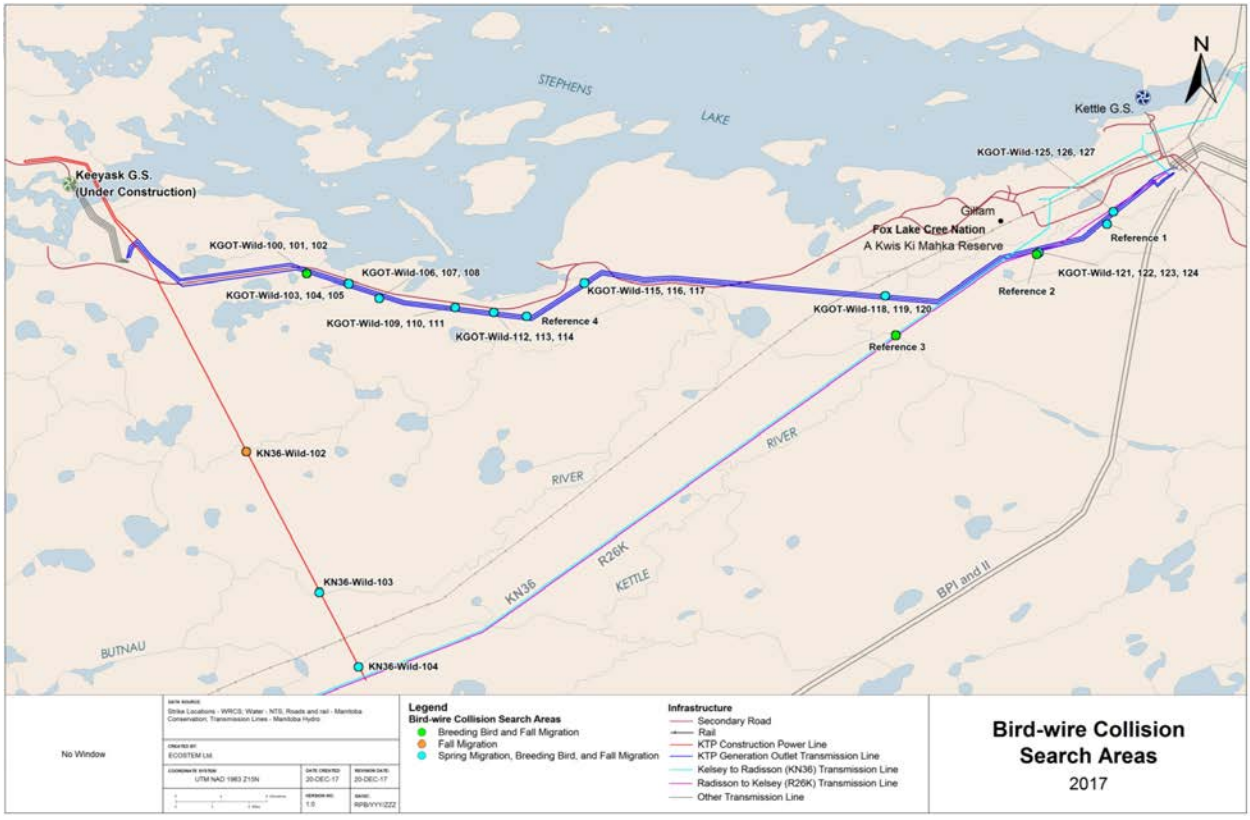
SUMMARY

Background

The Keeyask Transmission Project (the Project) provides generation outlet transmission (GOT) capacity and construction power (CP) and for the Keeyask Generating Station, located in northern Manitoba along the Nelson River at Gull (Keeyask) Rapids upstream of Stephens Lake. The GOT lines extend 38 km from the Keeyask Switching Station to the Radisson Converter Station at Gillam. The CP line extends 21 km from the Keeyask Switching Station to the KN36 transmission line which extends from the Kelsey Generation Station to the Radisson Converter Station. The R26K line runs parallel to KN36. Construction of the Project began in October 2014.



Areas searched for bird-wire collision evidence under the Keeyask Transmission Project's GOT lines, CP line, and reference sites in 2017.

Monitoring results will help Manitoba Hydro, government regulators, members of local First Nation communities, and the general public understand how construction and operation of the

Project will affect birds, and whether or not more needs to be done to reduce potentially harmful effects. The objective of this study is to:

- Assess the effectiveness of bird diverters placed on sky wires to improve visibility of the wires to birds and to minimize potential bird-wire collisions.

This report describes the results of bird-wire collision mortality monitoring conducted during the spring migration period, the breeding bird season and the fall migration period of 2017, the third year of Project construction.

Canada geese flying above the Keeyask Transmission Project's generation outlet transmission lines. Bird diverters can be seen on the sky wires.

Why is the study being done?

Bird-wire collision monitoring is being done to verify predicted potential effects related to the risk of birds colliding with transmission lines and a construction power line in the near-term Project operation phase. The EIS predicted that operation-related effects to birds were expected to be small, site-specific, long-term and not significant to local populations.

What was done?

Ground surveys for evidence of bird collision mortalities were conducted by a team of searchers at stream crossings under the Keeyask GOT line, the Keeyask CP line, and reference transmission lines during the spring migration period (May), the breeding bird season (June) and the fall migration period (September). Bird diverters were present on the GOT and CP lines where they crossed streams. Sites under nearby transmission lines were searched and used as reference sites as these 20 year old lines did not have bird diverters. Carcass searches alone provide a minimum biased estimate of actual fatalities as searchers may not always find all

carcasses. Collision mortality was estimated by dividing the number of bird-wire collision mortalities found by the search team by common biases (i.e., searcher efficiency, scavenger removal bias and habitat bias). Searcher efficiency and scavenger removal trials were conducted to account for the efficiency of the search team and scavengers removing evidence of bird collision mortalities. Deceased wild birds, sourced from wildlife rehabilitation centres, and juvenile ring-necked pheasant carcasses purchased from a commercial supplier, were planted in the search areas in locations unknown to the search team prior to the search. The proportion of carcasses found by the search team indicated the efficiency of the search team in finding evidence of bird-wire collisions. Planted bird carcasses were similarly used to estimate the proportion of birds not removed by scavengers. Habitat bias was the proportion of formal search areas that were searched; open water, low-lying wet areas and dense forest were not searched.

What was found?

No mortality evidence for provincially or federally listed threatened or endangered bird species was found during the 2017 surveys. During the spring migration period, evidence of 11 collision mortalities were detected under the GOT and CP lines, and evidence of five collision mortalities were detected at reference sites. Collision mortalities in spring were identified as willow ptarmigan, Canada goose, Dark-eyed junco, mallard, spruce grouse, American widgeon, yellow-bellied sapsucker, Swainson's thrush, savannah sparrow, and chipping sparrow. During the breeding bird season, no evidence of collision mortality was detected under the GOT and CP lines, and evidence of one ruffed grouse collision mortality was detected at reference sites. During the fall migration period, evidence of three collision mortalities were detected under the GOT and CP lines, and evidence of two collision mortalities were detected at reference sites. Collision mortalities in fall were identified as Smith's longspur, Swainson's thrush, pine grosbeak, savannah sparrow, and mallard.

After correcting for biases, estimated collision mortality was unreasonably high in the spring migration period at all sites. Highly efficient scavengers (*e.g.*, black bear, red fox, and common raven) at the study sites confounded calculations and exaggerated estimated spring migration collision mortality rates. When GOT and CP lines are considered as a single sampling unit, estimated collision mortality was unreasonably high in the spring migration period, none in the breeding bird season, and 7.27 birds/km in the fall migration period. Estimated collision mortality for reference sites was unreasonably high in the spring migration period, 55 birds/km in the breeding bird season, and 14 birds/km in the fall migration period.

What does it mean?

The presence of bird diverters on the Keeyask Transmission Project transmission lines where streams were crossed appears to have been successful at protecting birds from collisions with the Keeyask Transmission Project transmission lines.

What will be done next?

Bird-wire collision mortality surveys for the Keeyask Transmission Project are now concluded. No additional bird-wire collision mortality surveys are scheduled.

STUDY TEAM

This study was conducted under the auspices of Manitoba Hydro to meet the requirements of Environment Act Licence No. 3106. Thanks are extended to Jonathan Wiens, James Matthewson, and Sherrie Mason of Manitoba Hydro for reviewing this report. Kim Bryson and Megan Anger of Manitoba Hydro, Ben Hofer of Custom Helicopters, and Ron Bretecher of North/South Consultants Inc. are acknowledged for logistical assistance in the field. Thanks are also extended to Dr. James Ehnes, ECOSTEM Ltd., for providing cartography services for this report.

Biologists, technicians and additional personnel who designed, participated in, and drafted the study results included:

- Robert Berger, M.N.R.M.; Design, analysis, reporting, and survey personnel
- Nicholas LaPorte, M.N.R.M.; Analysis and reporting
- Kate McCormack, B.Sc. (honours); Survey personnel
- Morgan Zaretski, B.Env.St (honours); Survey personnel
- Jacqueline Verstege, M.Sc.; Survey personnel
- Kelsey O'Brien, M.Sc.; Survey personnel
- Riley Bartel, B.Env.St (honours); Survey personnel
- Kevin McRae, B.Env.St.; Survey personnel
- Nathaniel Beardy (YFN); Survey personnel
- Donald Flett (TCN); Survey personnel
- Aaron Chornoby (WLFN); Survey personnel
- Gary Flett (TCN); Survey personnel
- Nicholas Beardy (WLFN); Survey personnel
- Colin Brightnose (YFFN); Survey personnel
- Payton Flett (TCN); Survey personnel
- Chad Kirkness (TCN); Survey personnel
- Kenneth Ouskan (TCN); Survey personnel
- Leonard Chornoby (TCN); Survey personnel
- Martina Harvey (TCN); Survey personnel
- John Laliberty (WLFN); Survey personnel
- Justin Spence (WLFN); Survey personnel

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1.0 INTRODUCTION

The Keeyask Transmission Project (the Project) includes the generation outlet transmission lines and the construction power line. The primary function of the Project is to provide construction power and generation outlet transmission capacity for the Keeyask Generating Station being constructed in northern Manitoba along the Nelson River at Gull (Keeyask) Rapids upstream of Stephens Lake. The Project is located approximately 300 km northeast of Thompson (Manitoba) within the Split Lake Resource Management Area.

The generation outlet transmission lines (GOT) transmit electricity from the 138 kV ac switchyard at the Keeyask Switching Station to the 138 kV ac Switchyard at the existing Radisson Converter Station. The three lines are typically located in a single 275 m wide corridor approximately 38 km long, however, the width and configuration of the three lines in the corridor varies. As of 2017, only one transmission line has been constructed; two additional lines will be completed in winter 2017/18.

The construction power line (CP) is a 21 km 138 kV transmission line that taps the Kelsey to Radisson 138 kv transmission line (KN36) between the Ilford Station and the tap to Gillam Station. The tap point along KN36 is approximately 33 km from Ilford Station and 29 km from the Gillam Station tap. The R26K line runs parallel to KN36. The width of the R26K right-of-way is 60 m for most of its length, except for the locations where the line shares a right-of-way with GOT lines.

The Project Avian Technical Report (Stantec 2012) provides a summary of predicted effects and planned mitigation for the Project including increased bird mortality from collisions with transmission lines. This monitoring study focused on evaluating/verifying predicted potential effects related to the risk of birds colliding with transmission lines and a construction power line in the Project operation phase. These permanent structures pose a risk to birds and are an issue of concern to utilities, regulators, and the general public. Birds are known to occasionally collide with wires associated with transmission lines and communications towers, resulting in fatalities or injuries to collision victims (CEC 2003, APLIC 2012). Collision fatalities are a major source of non-hunter related bird mortalities, and mainly affect long-distance or nocturnal migrants (Brown and Drewien 1995, Bevanger 1998, Morkill and Anderson 1991, Longcore *et al*. 2012, APLIC 2012, Calvert *et al*. 2013).

Birds are capable of avoiding collisions with transmission lines if they are able to see the obstacle early enough (APLIC 2012). Several devices that improve the sightability of transmission lines to birds, including Swan-Flight™ Diverters, have been developed and tested though none have yet been found to outperform the others (APLIC 2012). Sites such as riparian areas typically support higher-quality habitat for birds and are therefore sites where there is an increased risk of bird-wire collisions. Manitoba Hydro installed Swan-Flight™ Diverters and other diverters (Photo 1) at streams crossed by the Project (Figure 1).

The operation monitoring program tests the EIS predictions that operation-related effects to birds were expected to be small, site-specific, long-term and not significant to local populations. Bird-wire collision monitoring was recommended as part of the conclusions of the Project's Environmental Impact Assessment. Parameters that were measured during operation-phase bird monitoring included the frequency and types of birds colliding with the Keeyask outlet transmission lines and the construction power line.

This report presents the results of May, June and September 2017 bird-wire collision monitoring at the Project's generation outlet transmission lines and the construction power line.

Photo 1. Canada geese flying over Swan-Flight™ Diverters and other diverters installed on the Keeyask Transmission Project's generation outlet transmission line sky wires.

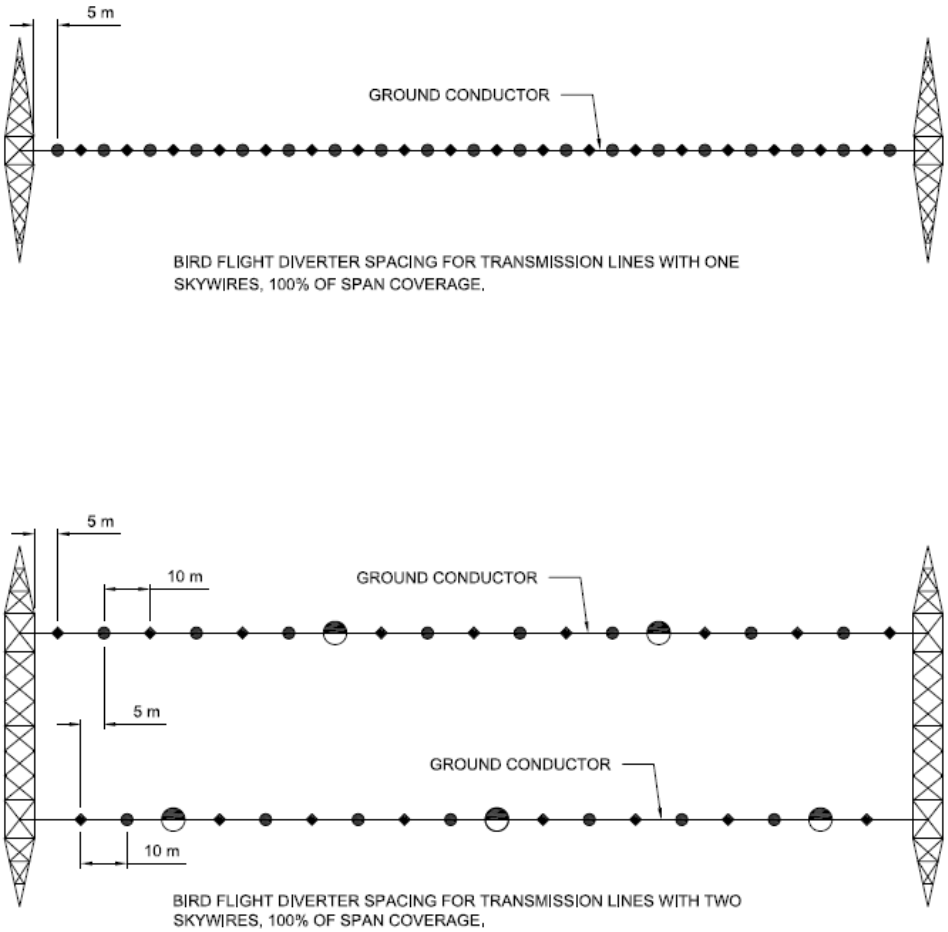


Figure 1: Manitoba Hydro installation protocol for spiral flight diverters and bird flight diverters, with and without aerial marker cones

2.0 METHODS

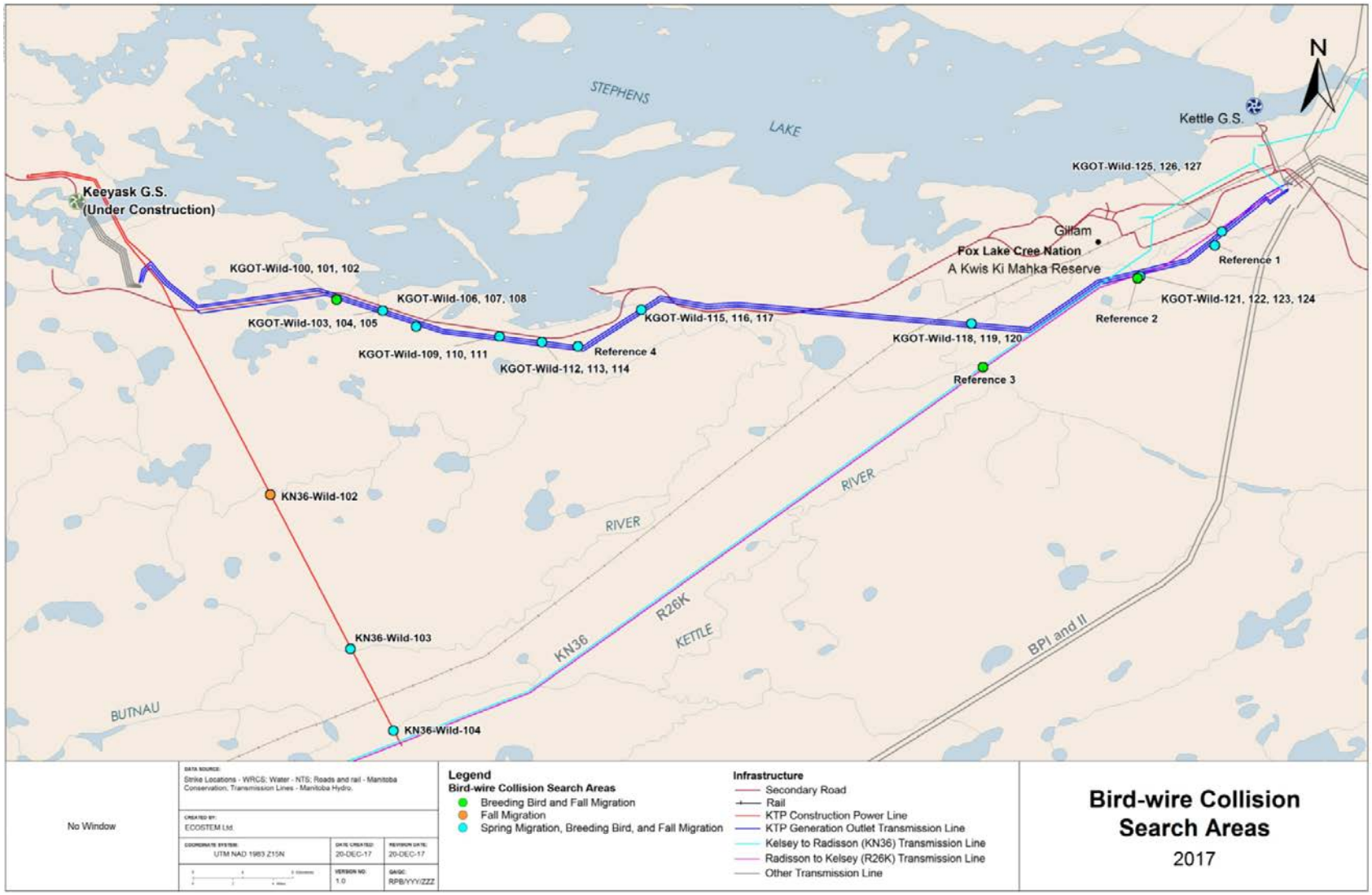
2.1 STUDY SITE

Monitoring of potential bird-wire collisions was conducted at stream crossings under the Keeyask GOT lines, the Keeyask CP line, and at four reference sites. The GOT lines extend 38 km from the Keeyask Switching Station to the Radisson Converter Station at Gillam (Map 1). The CP line extends 21 km from the Keeyask Switching Station to the KN36 transmission line (Map 1). One reference site was under the GOT lines, two reference sites were under the R26K transmission line, 150 m southeast of and parallel to two GOT sites, and another was under the KN36 line, about 1.1 km south of a GOT site (Map 1). Reference sites were chosen for comparison because they were the only four sites on transmission lines without bird diverters that crossed or paralleled streams or creeks in the regional study area.

In May, eight GOT, two CP sites, and two reference sites were searched (Map 1). In June, nine GOT sites, two CP sites, and four reference sites were searched (Map 1). In September, nine GOT sites, three CP sites, and four reference sites were visited (Map 1).

All but one of the monitoring sites consisted of the area under one span of towers to the 60 m width of the Right of Way (ROW). One monitoring site was located where two bends in a stream were crossed by the GOT lines and consisted of two spans. Spans are defined as the length of the ROW between two transmission towers. The lengths of the surveyed areas ranged from 300 m to 880 m. The total length of all surveyed areas in May was 3.48 km under GOT lines (20.9 ha), 0.70 km under the CP line (5.8 ha), and 0.77 km under reference lines (3.1 ha). In June, the total length of all surveyed areas was 3.78 km under the GOT lines (22.7 ha), 0.70 km under the CP line (5.8 ha), and 1.57 km under reference lines (5.6 ha). In September, the total length of all surveyed areas was 3.78 km under the GOT lines (22.7 ha), 1.10 km under the CP line (8.2 ha), and 1.57 km under reference lines (5.6 ha).

All GOT and CP sites were mechanically cleared between 2014 and 2016 and were characterized as open mossy areas with riparian portions characterized by thick shrubs. The area under the R26K and KN36 lines was characterized by low to moderate density tree and shrub regrowth.



Map 1: Areas searched for bird-wire collision evidence under the Keeyask Transmission Project's generation outlet transmission lines (GOT), construction power line (CP), and reference lines in the 2017 spring migration period, breeding bird season, and the fall migration period.

2.2 DATA COLLECTION

To monitor avian mortality resulting from collisions with GOT lines and CP lines, searches for evidence of bird-wire collisions were completed in 2017. Searches for potential bird-wire collisions were conducted during the spring migration period (May 17, 18, 19, 23, 24, 25), the breeding bird season in June (1, 2, 8, 9), and during two weeks in the fall migration period in September (6, 7, 8, 9, 10, 12, 13, 14, 15, and 17, 18, 19, 20, 22, 23, 24, 25). During each period, an initial site visit was conducted to remove evidence of bird-wire collisions that occurred prior to the standard one-week sample period, which begins the day of the initial visit. Due to logistical constraints and meteorological factors, sites were revisited between five and eight days after the initial visit.

Surveys were conducted on foot and documented the date, time, species, location, and the state of encountered bird remains. During each survey, the searchers walked in a survey grid with parallel survey lines close to one another (Photo 2) to assure complete coverage of the ground. Spacing between searchers varied between 3 m and 7 m depending on the relative density of vegetation within the search areas. In areas with shrub and tree growth, that required closer scrutiny, 3 m spacing was used, whereas 7 m spacing was used in open areas.

While surveying, personnel visually inspected the area for signs of bird collisions, including carcasses and clusters of feathers. Collision mortalities were recorded when the remains found consisted of more than five feathers in a square meter (Barrientos et al. 2012), as a smaller number of feathers cannot safely be interpreted as a collision mortality, and feathers may have been lost by a bird during preening, moulting or fighting (Bevanger 1999). Because it is not possible to accurately determine when potential mortalities occurred before the initial search, evidence of bird-wire collisions found during initial searches were excluded in calculations of estimated collision mortality, but are listed in Appendix 1. Bird remains were collected under scientific permits (CWS 16-AB-SC005 and 17-MB-SC001) for species verification purposes. Specimens were photographed prior to removal, then bagged, labelled, and stored in a freezer. Bird remains were transported to Winnipeg at the end of each survey period, where the species of each specimen was verified by a qualified biologist.

To account for the efficiency of the search team and scavengers removing evidence of bird collision mortalities, a variety of dead birds were planted throughout the search areas in the morning of the initial site visit. Planting bird carcasses in blind trials is a commonly used technique to estimate searcher efficiency and scavenger removal bias (CEC 2003, CWS 2007, APLIC 2012). Carcasses of boreal bird species sourced from wildlife rehabilitation centres and Oak Hammock Marsh Interpretive Centre, and ring-necked pheasants (*Phasianus colchicus*)

Photo 2: Survey personnel searching for evidence of bird-wire collisions under the Keeyask generation outlet transmission lines on May 18, 2017.

(Photo 3) purchased from a commercial supplier, were used to conduct scavenger/searcher trials. Ring-necked pheasants were selected for their moderate size and because their cryptic plumage makes them reasonably challenging to find. Wild bird species used for searcher efficiency and scavenger removal trials included pine siskin (*Spinus pinus*), Swainson's thrush (*Catharus ustulatus*), common grackle (*Quiscalus quiscula*), American robin (*Turdus migratorius*), purple finch (*Haemorhous purpureus*), white-throated sparrow (*Zonotrichia albicollis*), yellow-bellied sapsucker (*Sphyrapicus varius*), yellow-rumped warbler (*Setophaga coronata*), song sparrow (*Melospiza melodia*), red-winged blackbird (*Agelaius phoeniceus*), dark-eyed junco (*Junco hyemalis*), and merlin (*Falco columbarius*). Searcher efficiency was a measure of the ability of the search team, not individual searchers, to find evidence of bird collision mortality occurring within the search area. The search team was tested during each site visit where carcasses were planted. In knowing that planted carcasses are in the search area, searcher efficiency can be high as the searchers are "*on guard*" during the search (CWS 2007).

Photo 3. Juvenile ring-necked pheasant (*Phasianus colchicus*) planted for searcher efficiency and scavenger removal trials.

Dead birds were thawed before being planted within search areas at locations unknown to the searcher team. Following each search, the proportion of planted carcasses found by the search team was recorded. In each of the three survey periods, searcher efficiency was assessed by pooling the results of all searcher efficiency trials under all sites. Planted carcasses were similarly used to estimate the proportion of birds not removed by scavengers.

A limited number of bird carcasses were planted in May (*n* = 11), June (*n* = 13), and September (*n* = 28) to avoid creating an excessive attraction to scavengers (NYSDEC 2007) and to not make carcasses unattractive by providing more carcasses than scavengers can consume/remove (Smallwood 2007). At sites under the GOT lines, nine carcasses were planted in May, 10 were planted in June, 10 were planted in early September, and eight were planted in mid-September. At sites under the CP line, two carcasses were planted in May, two were planted in June, two were planted in early September, and two were planted in mid-September. At the three reference sites, no carcases were planted in May, two were planted in June, three were planted in early September, and three were planted in mid-September.

Estimating the number of birds that collide with structures but fall out of the search area, or injured birds that move out of the search area before succumbing to their injuries, is extremely difficult to quantify (Bevanger 1999, APLIC 2012) and rarely incorporated into estimates (Rioux et al. 2013). Estimating crippling loss bias requires a great deal of time and effort to monitor flights near hazards, record collisions, locate injured or dead birds (CEC 2003, APLIC 2012), and importantly, results in small sample sizes (Paddington 1993, Savereno *et al* 1996, Crowder 2000). Some studies suggest that to provide more accurate estimates, it may be reasonable to apply crippling loss bias estimates from other studies (Beaulaurier 1981, Bevanger 1995, Janns and Ferrer 2000, CEC 2003, Sundar and Choudhury 2005). However, the application of estimates from other studies is inappropriate and very misleading due to the effects of bird size and weight on crippling loss bias (APLIC 2012, Rioux et al. 2013). Crippling bias was not quantified in this study or included in estimates of total collision mortality.

2.3 DATA ANALYSIS

Searches for evidence of collision mortalities alone provide a minimum biased estimate of actual fatalities as searchers may not always find all collision mortalities. Searcher efficiency, scavenger removal, habitat type, and crippling can all affect detection (APLIC 2006). Preferably, bias should be determined to accurately estimate mortality rates. However, estimating bias is not always possible due to limited observations, difficulties in sourcing carcasses for searcher and scavenger trials (Yee 2008), and limited observations of rare crippling events (Brown and Drewien 1995). Searcher efficiency (*Se*), scavenger removal bias (*SBi*), and habitat bias (*HBi*) were quantified for this study (Bevanger 1999, APLIC 1994).

Searcher bias was calculated by pooling the results off all searcher efficiency trials under all sites for each survey period. Searcher efficiency (*Se*) was calculated as:

$$Se = \frac{Number\ of\ planted\ carcasses\ found}{Number\ of\ planted\ carcasses\ -number\ of\ planted\ carcasses\ removed\ by\ scavengers}$$

Because all sites neighbour each other, and are highly likely to share the same scavenger community (*e.g.*, red fox (*Vulpes vulpes*), black bear (*Ursus americanus*), common raven (*Corvus corax*)), it is reasonable to assume that scavenger activity and removal bias, are the same for all sites. Weekly scavenger removal bias was calculated for May and June by pooling results of scavenger removal trials from all sites in May and in June, separately. In September, scavenger removal bias was calculated by averaging weekly scavenging bias results from all sites from the two September searches. Scavenger bias (*Sbi*) was calculated as:

$$Sbi = \frac{Number\ of\ planted\ carcasses\ not\ removed\ by\ scavengers\ in\ a\ week}{Number\ of\ planted\ carcasses}$$

To account for unsearchable portions of formal search areas, sections that were not searched were measured by examining search team GPS track logs in Google Earth Pro and were subtracted from formal search areas. Habitat bias (*Hbi*) was calculated as:

$$Hbi = \frac{Actual\ area\ searched}{Formal\ search\ area}$$

Using the results of the dead bird searches, searcher efficiency/scavenger trials and habitat bias, both the generation outlet lines and construction power line were treated as a single sample unit by combining results from both transmission lines. Separate analyses were conducted for the spring migration period (April 15 - May 31), the breeding bird period (June 1 - July 15) when adults are feeding nestlings, and the fall migration period (Sep 1 - Oct 15). Similar to how scavenger removal bias was calculated for September, the weekly collision mortality rate was calculated by pooling the number of collision mortalities found during the second visits from the two September searches. Estimated collision mortality (ECM) was calculated as follows:

$$ECM = \frac{Number\ of\ collision\ mortalies\ found}{Se * Sbi * Hbi}$$

To standardize estimated collision mortality, estimated collision mortality was divided by the total surveyed length of the transmission lines. To estimate seasonal collision mortality, weekly estimated collision mortality rates were multiplied by a factor of six weeks for May and June. Because two weeks were sampled in September, weekly estimated collision mortality rates were multiplied by a factor of three weeks.

3.0 RESULTS

3.1 COLLISION MORTALITY EVIDENCE

In 2017, no evidence of Threatened or Endangered bird species mortality was found during all bird collision mortality searches under the Keeyask GOT lines, the CP lines, or reference transmission lines.

During the spring migration searches under the GOT lines, evidence of four collision mortalities were found during the initial site visit and evidence of nine collision mortalities were found during the second visit (Table 1) (Map 2). Collision mortalities found under the GOT lines during the spring migration were identified as willow ptarmigan (*Lagopus lagopus*), Canada goose (*Branta canadensis*), Dark-eyed junco, mallard, spruce grouse (*Falcipennis canadensis*), American widgeon (*Anas americana*), yellow-bellied sapsucker (*Sphyrapicus varius*) (Appendix 2: Photo 2-1), savannah sparrow (*Passerculus sandwichensis*), and chipping sparrow (*Spizella passerina*) (Table 1) (Appendix 1). During the breeding bird season searches under the GOT lines, evidence of three collision mortalities were found during the initial site visit and none were found a week later (Table 2) (Map 3). Collision mortalities found under the GOT lines during the breeding bird season were identified as mallard (*Anas platyrhynchos*) (Appendix 2: Photo 2-2), killdeer (*Charadrius vociferus*), and willow ptarmigan (Table 2) (Appendix 1). During the early fall migration searches, no evidence of collision mortality was found during the initial site visit and one collision mortality was found a week later (Table 3) (Map 4). During the late fall migration searches, evidence of four collision mortalities were found under the GOT lines during the initial site visit and two were found a week later (Table 3) (Map 4). Collision mortalities found under the GOT lines during the fall migration were identified as Smith's longspur (*Calcarius pictus*), song sparrow, dark-eyed junco, northern waterthrush (*Parkesia noveboracensis*), common grackle, Swainson's thrush, pine grosbeak (*Pinicola enucleator*), savannah sparrow, and mallard (Table 3) (Appendix 1).

During the spring migration searches under the CP lines, evidence of one collision mortality was found during the initial site visit and evidence of two collision mortalities were found a week later (Table 1) (Map 2). Collision mortalities found under the CP lines during the spring migration were identified as mallard, song sparrow, and Swainson's thrush (Table1) (Appendix 1). During the breeding bird season searches, evidence of one unknown sparrow collision mortality was found during the initial site visit and no evidence of collision mortality was found a week later (Table 2) (Map 3). This unknown sparrow was found in an advanced state of decomposition (Appendix 2: Photo 2-3) and was excluded for collision mortality estimates. During the early fall migration searches, evidence of one red-tailed hawk (*Buteo jamaicensis*) collision mortality was found under the CP lines during the initial site visit and no evidence of collision mortality was found a week later (Table 3) (Map 4). During the late fall migration searches, no evidence of collision mortality was found under the CP lines (Table 3) (Appendix 1).

Table 1. Number of carcasses found, search area lengths, and habitat bias (*Hbi*) for the Keeyask generation outlet transmission (GOT), the construction power line (CP), and the R26K transmission line bird-wire collision monitoring sites during spring migration in May 2017.

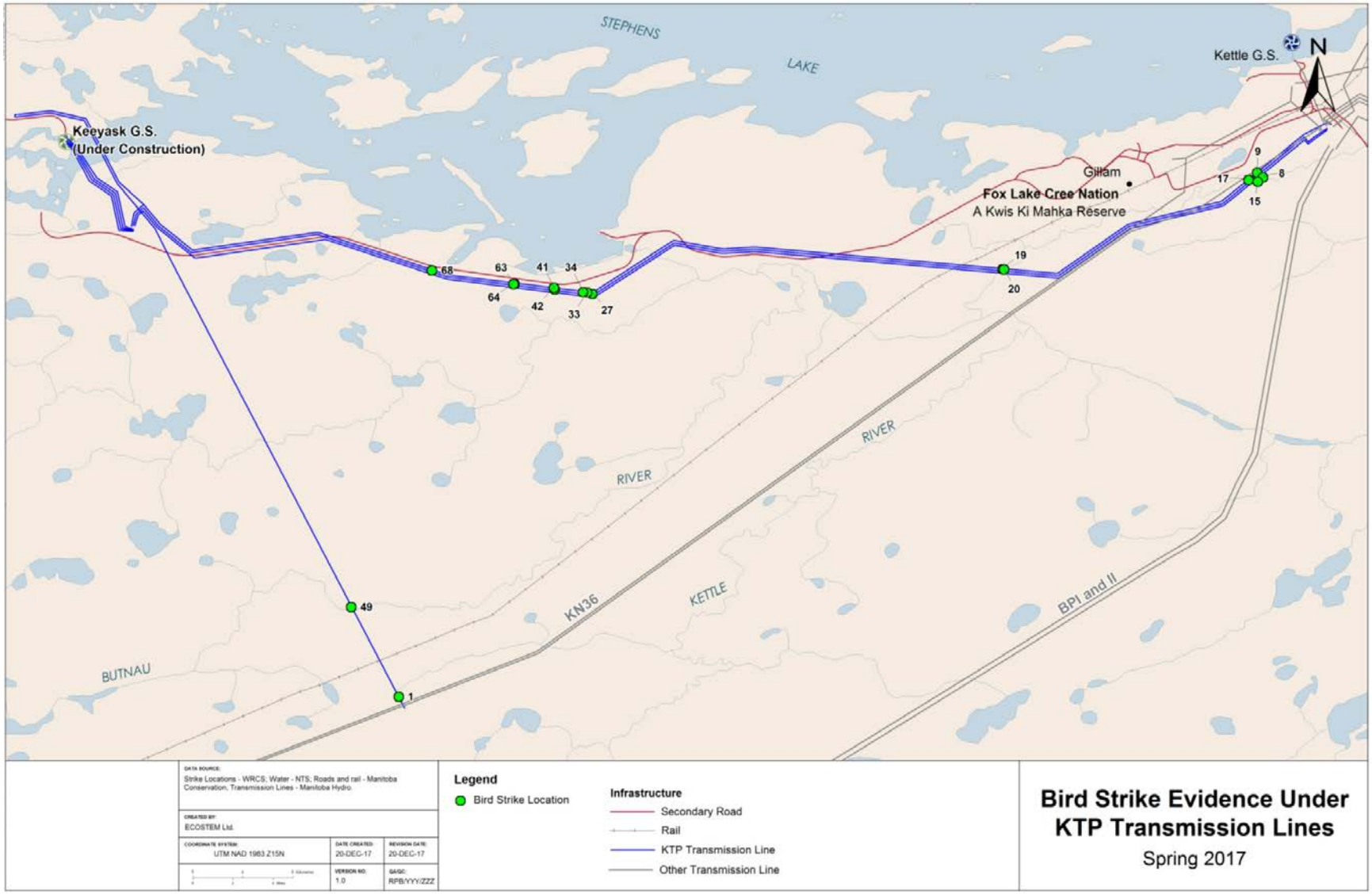
		Number of collision mortalities found		Site length	Formal search	Searched	
Line type	**Site**	**Initial visit**	**2nd visit**	**(m)**	**area (ha)**	**area (ha)**	***Hbi***
GOT	KGOT-Wild-103, 104, 105	1	0	400	2.4	2.3	0.96
GOT	KGOT-Wild-106, 107, 108	0	1	400	2.4	2.3	0.96
GOT	KGOT-Wild-109, 110, 111	0	2	300	1.8	1.8	1.00
GOT	KGOT-Wild-112, 113, 114	3	2	350	2.1	2.1	1.00
GOT	KGOT-Wild-115, 116, 117	0	0	350	2.1	1.0	0.48
GOT	KGOT-Wild-118, 119, 120	0	2	400	2.4	2.0	0.83
GOT	KGOT-Wild-121, 122, 123, 124	0	0	880	5.3	4.3	0.81
GOT	KGOT-Wild-125, 126, 127	0	2	400	2.4	1.9	0.79
	GOT Total	***4***	***9***	***3,480***	***20.9***	***17.7***	***0.85***
CP	KN36-Wild-103	1	1	300	1.8	1.5	0.83
CP	KN36-Wild-104	0	1	400	4.0	3.5	0.88
	CP Total	***1***	***2***	***700***	***5.8***	***5.0***	**0.86**
	GOT & CP Total	***5***	***11***	***4,180***	***26.7***	***22.7***	***0.85***
R26K	Reference 1	2	2	400	1.2	1.0	0.83
GOT	Reference 4	5	3	370	1.9	1.7	0.89
	Reference Total	***7***	***5***	***770***	***3.1***	***2.7***	**0.87**

Table 2. Number of carcasses found, search area lengths, and habitat bias (*Hbi*) for the Keeyask generation outlet transmission (GOT), the construction power line (CP), and the R26K transmission line bird-wire collision monitoring sites during the breeding bird season in June 2017.

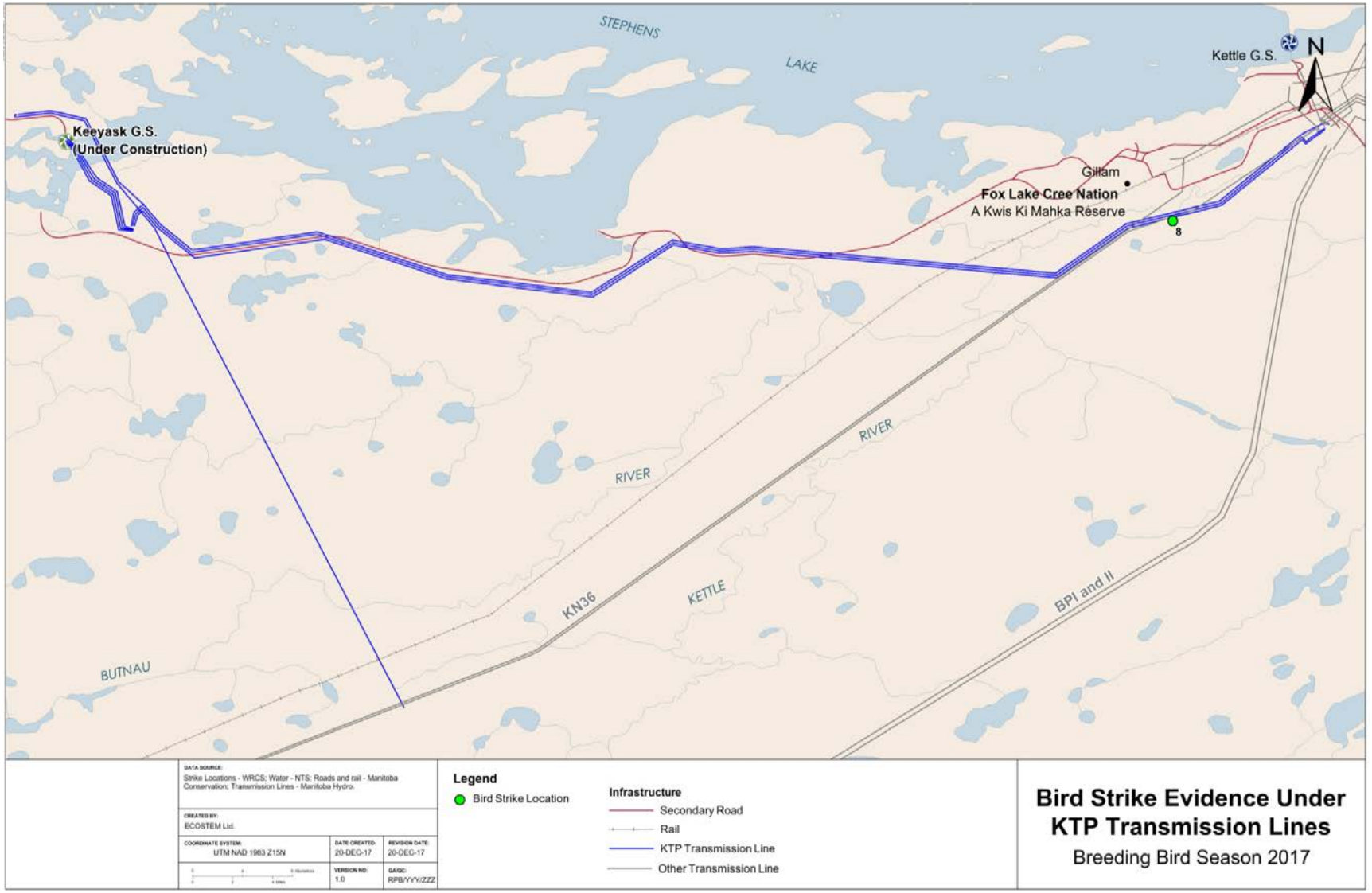
		Number of collision mortalities found		Site length	Formal search	Searched	
Line type	**Site**	**Initial visit**	**2nd visit**	**(m)**	**area (ha)**	**area (ha)**	***Hbi***
GOT	KGOT-Wild-100, 101, 102	0	0	300	1.8	1.7	0.94
GOT	KGOT-Wild-103, 104, 105	0	0	400	2.4	2.2	0.92
GOT	KGOT-Wild-106, 107, 108	0	0	400	2.4	2.3	0.96
GOT	KGOT-Wild-109, 110, 111	2	0	300	1.8	1.7	0.94
GOT	KGOT-Wild-112, 113, 114	0	0	350	2.1	2.0	0.95
GOT	KGOT-Wild-115, 116, 117	0	0	350	2.1	1.0	0.48
GOT	KGOT-Wild-118, 119, 120	0	0	400	2.4	2.2	0.92
GOT	KGOT-Wild-121, 122, 123, 124	1	0	880	5.3	4.3	0.81
GOT	KGOT-Wild-125, 126, 127	0	0	400	2.4	2.1	0.88
	GOT Total	***3***	***0***	***3,780***	***22.7***	***19.5***	**0.86**
CP	KN36-Wild-103	0	1	300	1.8	1.5	0.83
CP	KN36-Wild-104	0	0	400	4.0	3.6	0.90
	CP Total	***0***	**0**	***700***	***5.8***	***5.1***	**0.88**
	GOT & CP Total	***3***	***0***	***4,480***	***28.5***	***24.6***	**0.86**
R26K	Reference 1	3	1	400	1.2	1.1	0.92
R26K	Reference 2	1	2	400	1.2	1.2	1.00
KN36	Reference 3	0	0	400	1.3	0.5	0.38
GOT	Reference 4	2	0	370	1.9	1.7	0.89
	Reference Total	***6***	***3***	***1,570***	***5.6***	***4.5***	***0.80***

Table 3. Number of carcasses found, search area lengths, and habitat bias (*Hbi*) for the Keeyask generation outlet transmission (GOT), the construction power line (CP), and the R26K transmission line bird-wire collision monitoring sites during fall migration in September 2017.

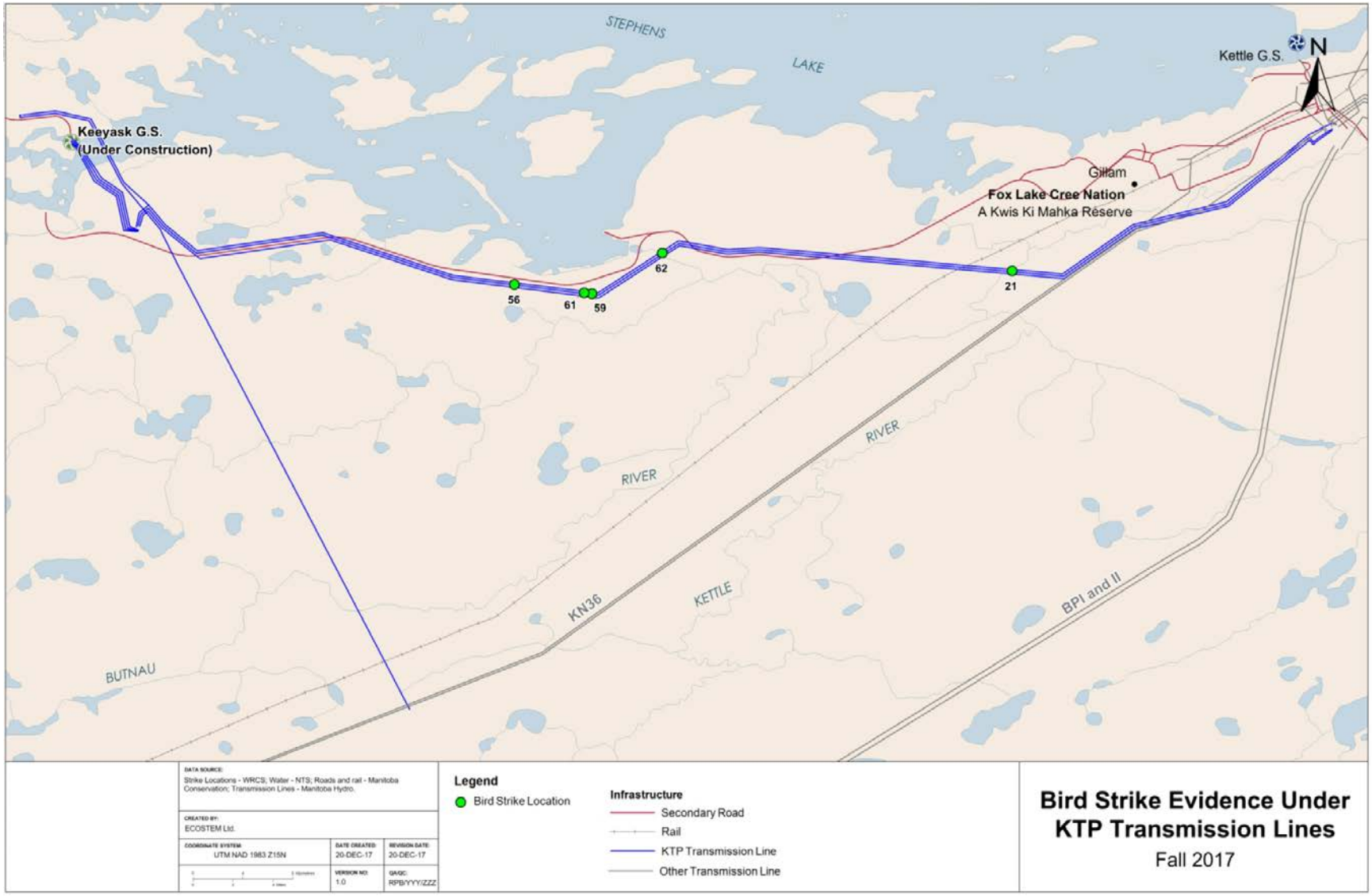
Line type	Site	Number of collision mortalities found: Early September – Initial visit	Early September – 2nd visit	Late September – Initial visit	Late September – 2nd visit	Site length (m)	Formal search area (ha)	Searched area (ha)	*Hbi*
GOT	KGOT-Wild-100, 101, 102	0	0	0	0	300	1.8	1.3	0.72
GOT	KGOT-Wild-103, 104, 105	0	0	0	0	400	2.4	2.3	0.96
GOT	KGOT-Wild-106, 107, 108	0	0	0	0	400	2.4	2.3	0.96
GOT	KGOT-Wild-109, 110, 111	0	0	1	1	300	1.8	1.3	0.72
GOT	KGOT-Wild-112, 113, 114	0	0	2	0	350	2.1	2.0	0.95
GOT	KGOT-Wild-115, 116, 117	0	0	1	1	350	2.1	1.6	0.76
GOT	KGOT-Wild-118, 119, 120	0	1	0	0	400	2.4	2.3	0.96
GOT	KGOT-Wild-121, 122, 123, 124	0	0	0	0	880	5.3	4.3	0.81
GOT	KGOT-Wild-125, 126, 127	0	0	0	0	400	2.4	2.2	0.92
	GOT Total	**0**	***1***	***4***	***2***	***3,780***	***22.7***	***19.6***	***0.86***
CP	KN36-Wild-102	1	0	0	0	400	2.4	0.5	0.21
CP	KN36-Wild-103	0	0	0	0	300	1.8	1.7	0.94
CP	KN36-Wild-104	0	0	0	0	400	4.0	3.9	0.98
	CP Total	***0***	***0***	**0**	***0***	***1,100***	***8.2***	***6.1***	***0.74***
	GOT & CP Total	***1***	***1***	***4***	***2***	***4,880***	***30.9***	***25.7***	***0.83***
R26K	Reference 1	0	0	0	0	400	1.2	1.1	0.92
R26K	Reference 2	0	0	0	0	400	1.2	1.2	1.00
KN36	Reference 3	0	0	0	0	400	1.3	1.2	0.92
GOT	Reference 4	1	0	0	2	370	1.9	1.6	0.84
	Reference Total	***1***	***0***	**0**	***2***	***1,570***	***5.6***	***5.1***	***0.91***



Map 2. Bird-wire collision evidence encountered under the Keeyask Transmission Project's generation outlet transmission lines and construction power line in the 2017 spring migration period.



Map 3. Bird-wire collision evidence encountered under the Keeyask Transmission Project's generation outlet transmission lines and construction power line in the 2017 breeding bird season.



Map 4. Bird-wire collision evidence encountered under the Keeyask Transmission Project's generation outlet transmission lines and construction power line in the 2017 fall migration period.

During the spring migration searches under the reference lines, evidence of seven collision mortalities were found during the initial site visit and evidence of five collision mortalities were found a week later (Table 3) (Map 2). Collision mortalities found under the reference lines during the spring migration were identified as willow ptarmigan, Canada goose, and mallard (Appendix 1). During the breeding bird season searches, evidence of six collision mortalities were found under the reference lines during the initial site visit and evidence of three collision mortalities were found a week later (Table 2) (Map 3). Collision mortalities found under the reference lines during the breeding bird season were identified as American widgeon, mallard, ptarmigan, Canada goose, and ruffed grouse (*Bonasa umbellus*) (Appendix 1). Two of the collisions found in the second visit were identified as ptarmigan. These willow ptarmigans were not included in total collision mortality estimates as they were in advanced stages of decomposition (Appendix 2: Photo 2-4) and were thus likely to have occurred in the spring migration period preceding the breeding bird season searches. During the early fall migration searches, evidence of one collision mortality was found during the initial site visit and none were found a week later (Table 3) (Map 4). During the late fall migration searches, no evidence of collision mortality was found under the reference lines during the initial site visit and evidence of two collision mortalities were found a week later (Table 3) (Map 4). Collision mortalities found under the reference lines during the fall migration were identified as green wing teal, pine grosbeak, and savannah sparrow (Appendix 1).

3.2 SEARCHER EFFICIENCY, SCAVENGER REMOVAL BIAS, AND HABITAT BIAS

During the May 17-19 searcher efficiency trials, of the eight planted carcases not yet removed by scavengers, three were found by the search team. During the May 23-25 searcher efficiency trials, the only bird carcass not removed by scavengers was found by the search team. Thus, searcher efficiency was 0.44 during the spring migration period as four of nine planted carcasses were found. In May, 10 of 11 planted bird carcasses were removed by scavengers in a week, thus, scavenger removal bias in May was 0.09/week.

During the June 1-2 searcher efficiency trials, of the 10 planted carcases not yet removed by scavengers, five were found by the search team. During the June 8-9 searcher efficiency trials, both of the two planted carcases not removed by scavengers were found by the search team. Thus, searcher efficiency was 0.58 during the late breeding bird period as seven of 12 planted carcasses were found. In June, 11 of 13 planted carcasses were removed by scavengers, thus, scavenger removal bias in June was 0.15/week.

During the September 6-10 searcher efficiency trials, of the 11 planted carcasses not yet removed by scavengers, five were found by the search team. During the September 12-15 searcher efficiency trials, four of the six bird carcases not removed by scavengers were found by the search team. During the September 17-20 searcher efficiency trials, nine of the 13 bird carcasses not yet removed by scavengers were found. During the September 22-25 searcher

efficiency trials, six of seven bird carcasses not yet removed by scavengers were found. Thus, searcher efficiency was 0.65 during the fall migration period as 24 of 37 planted carcasses were found. During the early September search, nine of 15 planted carcasses were removed, thus, scavenger removal bias in early September was 0.40/week. During the late September search, six of 13 planted carcasses were removed, thus, scavenger removal bias in late September was 0.53/week. Therefore, average scavenger removal bias was 0.47/week in the fall migration period.

Due to the presence of open water, low-lying wet areas and dense forest, formal search areas were not entirely searchable at most sites. During the spring migration, the proportion of formal search areas that were searched at GOT sites was 0.85, 0.86 at CP sites, and 0.87 at reference sites (Table 1). During the breeding bird season, the proportion of formal search areas that were searched at GOT and CP sites was 0.86, and 0.80 at reference sites (Table 2). During fall migration, the proportion of formal search areas that were searched at GOT sites was 0.86, 0.74 at CP sites, and 0.91 at reference sites (Table 3).

3.3 ESTIMATED COLLISION MORTALITY

After correcting for searcher efficiency, scavenger removal bias, and habitat bias, estimated collision mortality for birds in the spring migration season was 461 birds/km at GOT sites, 503.37 birds/km at CP sites, and 1,130.88 birds/km at reference sites (Table 4). When the GOT and CP lines are considered as a single sampling unit, estimated collision mortality was 469.09 birds/km in the spring migration period (Table 4). Collision mortality could not be estimated for GOT or CP sites in the breeding bird season due to a lack of evidence of collision mortalities (Table 4). In the breeding bird season, estimated collision mortality for birds was 54.91 birds/km at reference sites (Table 4). During the fall migration period estimated collision mortality was 9.06 birds/km at GOT sites and 13.75 birds/km at reference sites (Table 4). Collision mortality could not be estimated for CP sites in the fall migration period due to a lack of evidence of collision mortalities (Table 4). When the GOT and CP lines are considered as a single sampling unit, estimated collision mortality was 7.27 birds/km in the fall migration period (Table 4).

Table 4. Estimated collision mortality (ECM) at the Keeyask generation outlet transmission lines (GOT), the construction power line (CP), and reference transmission lines during the 2017 spring migration, breeding bird, and fall migration periods.

Period	Line	# of Sites surveyed	TCF	*Se*	*Sbi*	*Hbi*	Total Length of Surveyed Sites (km)	ECM / Week	ECM / km	ECM / Season
Spring migration	GOT	8	9	0.44	0.09	0.85	3.48	267.38	76.83	461.00*
	CP	2	2	0.44	0.09	0.86	0.70	58.73	83.90	503.37*
	GOT & CP Total	*10*	*11*	*0.44*	*0.09*	*0.85*	*4.18*	*326.80*	*78.18*	*469.09**
	Reference	2	5	0.44	0.09	0.87	0.77	145.13	188.48	1,130.88*
Breeding bird	GOT	9	0	0.58	0.15	0.86	3.78	Unk.	Unk.	Unk.
	CP	2	0	0.58	0.15	0.88	0.70	Unk.	Unk.	Unk.
	GOT & CP Total	*11*	*0*	*0.58*	*0.15*	*0.86*	*4.48*	*Unk.*	*Unk.*	*Unk.*
	Reference	4	1	0.58	0.15	0.80	1.57	14.37	9.15	54.91*
Fall migration	GOT	9	3	0.65	0.47	0.86	3.78	12.48	3.30	9.06†
	CP	3	0	0.65	0.47	0.74	1.10	Unk.	Unk.	Unk.
	GOT & CP Total	*12*	*3*	*0.65*	*0.47*	*0.83*	*4.88*	*12.93*	*2.65*	*7.27†*
	Reference	4	2	0.65	0.47	0.91	1.57	7.86	5.01	13.75 †

*Multiplied by a factor of six weeks; †Multiplied by a factor of three weeks.

4.0 DISCUSSION

Nearly all identified avian items detected at the Keeyask Transmission Project study sites are common residents to the study area or are species that migrate through the area (Stantec 2012). None were provincially or federally listed threatened or endangered bird species. Many of the species identified as collision mortalities at the study sites are particularly prone to collisions with waterfowl, grouse, and passerines being among the most common (Brown 1995, Bevanger 1995, Bevanger 1998). This explains the high number of Canada goose, ducks, and willow ptarmigan collision mortalities encountered in 2017. The number of passerines found was greater than expected. Passerine collision mortalities did not appear to be clustered; rather they were distributed among multiple GOT, CP, and reference sites. These results were similar to studies in southern Manitoba where passerines were the most commonly encountered bird-wire collision mortalities at the Manitoba-Minnesota Transmission Project (Stantec 2015). In order of vulnerability to bird-wire collisions, the most frequently reported bird group mortalities include waterbirds (40%), waterfowl (24%), cranes and herons (14%), and passeriformes (12%) (Bevanger 1998).

Willow ptarmigan are vulnerable to power line and tower collisions (Rioux et al. 2003), especially in winter (Bevanger and Broseth 2004). Willow ptarmigan are winter residents in the Keeyask region, breed in Churchill (Jehl 2004) and are not known to breed locally (Stantec 2012). Willow ptarmigan remains found in June were probably not found in May because snow continued to cover some of the ground, and were likely obscured by late winter snowfalls (e.g., 16 cm of snow on March 7 (Environment Canada 2017)). The advanced state of willow ptarmigan decomposition further supports this assertion. It was therefore reasonable to not include evidence of willow ptarmigan collisions in estimating total collision mortality in the breeding bird season.

Yellow-bellied sapsucker was an unusual bird-wire collision mortality identified in the study as this species of woodpecker was not identified during the Keeyask Environmental Assessment (Stantec 2012). The Project is at the fringe of yellow-bellied sapsucker breeding range (Walters et al. 2002) and its occurrence in the region is possible. Woodpeckers are conspicuously absent in a review of birds most susceptible to collide with transmission lines (Bevanger 1998). However, one yellow-bellied sapsucker was reported at a high collision risk site adjacent to the Assiniboine River along the Manitoba-Minnesota Transmission Project (Stantec 2015). Furthermore, woodpeckers generally possess moderate wing loading and low wing aspect (*i.e.,* broad wings) which places them in Bevanger's (1998) category of "poor fliers", that generally lack the manoeuvrability to quickly avoid obstacles (APLIC 2012).

Overall, spring migration collision rates were higher than fall. With the exception of reference lines, breeding season collision rate estimates were the lowest compared to the migration periods. Evidence of 11 collisions were found under GOT and CP lines in spring; just three were found in fall. No evidence of collisions were found under GOT and CP lines during summer, suggesting that collisions during the breeding bird season are very low. Similar patterns were

observed under reference lines with collisions in spring > fall > breeding bird season. Other studies (APLIC 2012, Brown and Drewein 1995, Morkill and Anderson 1991) report that migration period collisions rates are usually higher than during the breeding season.

The total estimated collision mortality of 1,600 birds/km at all sites during the spring migration period were unreasonably high, and considerably higher than other studies reporting bird-wire collision mortality. It should be noted, however, that comparisons to mortality rates in other studies are difficult as sources of bias can vary substantially between study locations (APLIC 2006, Morrison 2002). The highest reported estimated collision mortality rate found in the literature is 219 sandhill cranes/km of marked-wires during spring near a sensitive roosting site with a high daily rate of movement between the roost and feeding sites (Wright et al. 2015). Despite the rigorous method, the spring migration data appears to be dubious as the estimated collision rates are substantially higher than estimated collision rates reported in the literature at sites with exceptionally high daily rates of movements of bird species that are most susceptible to collisions.

Although daily movements of birds were not examined, rates are not likely to be high in the KTP area. High daily movements between nearby large gull colonies at Gull Rapids and feeding sites (upstream and downstream of Gull Rapids) do not bisect the KTP. In the KTP area there are no other known movement corridors, colonies, or raptor nests associated with high daily movements of birds. Small rivers in a comparable boreal forest on the east side of Lake Winnipeg did not have high rates of bird movements (Manitoba Hydro 2015). Bird movements at four rivers on the east side of Lake Winnipeg were only in the order of tens to hundreds of birds over a two-day spring migration survey (Manitoba Hydro 2015).

The anomalous spring data is most likely driven by extremely efficient local scavengers. Collision mortality estimates of 54.91 birds/km at reference sites in the breeding bird season, 7.27 birds/km at all GOT and CP sites combined and 13.75 birds/km at reference sites in the fall migration period, appear to be reasonable. Rioux *et al.* (2013) reviewed avian mortalities due to collisions with transmission power lines from a variety of studies in the U.S.A. and Europe. Their analysis of 32 study sites indicated an average number of dead birds per kilometer of unmarked transmission power lines of 42.3 ± 17.1 birds/km/year (Rioux et al. 2013).

Although searcher/scavenger removal trials indicated that the search team was efficient in finding evidence of bird collisions, scavengers were extremely efficient at removing bird carcasses during the spring migration period and in the breeding bird season having removed 91% and 85% of planted birds in each study period, respectively. Rates of carcass removal by scavengers vary by habitat, season, type of day, scavenger species, etc. (Bevanger 1999), Erickson et al. 2005). Scavenging rates detected at the Project were not atypical; scavenging usually takes place within a short time frame after a collision mortality (APLIC 2012). For example, 92% of carcasses were removed from below a communications tower in Florida within 24 hours over a 29-year study (Crawford and Engstrom 2001). In their review of a number of case studies, Erickson *et al.* (2005) noted that carcasses may persist from between one to 28 days. However, some carcasses may persist for long periods as they desiccate and proteins

decompose, thus becoming less preferred by scavengers (APLIC 2012). In this study, willow ptarmigan carcasses likely persisted for more than a month.

When scavenger trials indicate near perfect efficiency at removing carcasses, calculations of estimated collision mortality become greatly inflated. The high collision mortality estimates in the spring migration period were primarily driven by scavengers removing nearly all planted birds over the one week trial. Furthermore, if scavengers removal rates were 100%, a correction factor of one would have resulted in scavenger removal bias having no effect in calculating total estimated collision mortality. In such a scenario, estimated collision mortality would have been 42.22 birds/km at GOT and CP sites combined and 101.78 birds/km at reference sites in the spring migration period and 8.24 birds/km at reference sites in the breeding bird season, which appear to be a more reasonable estimate compared to the literature.

Although the data likely overestimated total collision mortality in these two study periods, the data do reflect other studies that suggest higher frequency of collisions are expected during migration periods (APLIC 2012, Brown and Drewein 1995, Morkill and Anderson 1991). The lack of collision mortality evidence found under the GOT and CP lines and the single collision found at reference sites during the second breeding bird season visit supports this expected seasonal pattern.

The effectiveness of bird diverters has been shown to effectively reduce avian mortalities from collisions; however, effectiveness can vary from reductions of 9.6% to 80% (Beaulaurier 1981, Morkill and Anderson 1991, APLIC 2012). At the Project, reference sites under transmission lines lacking bird deflectors had greater estimated collision mortality rates than sites with deflectors under the GOT or CP transmission lines. This suggests that the installation of bird diverters on the GOT and CP lines may have been effective at reducing avian mortalities.

During the 2017 study, only one of the three GOT transmission lines had been constructed. After the other two GOT lines are constructed in winter 2017/18, and occupy the same ROW, collision rates may decrease. Several researchers (Thompson 1978, Bevanger 1998, Crowder 2000, Drewitt and Langstrom 2008) have suggested that collision risk may be reduced when transmission lines become more visible to birds in flight when they are clustered and confined to a limited area. Conversely, caution must be exercised as poor visibility (i.e., low light, inclement weather) may increase collision risk when transmission lines, including marked transmission lines, are clustered (APLIC 2012).

5.0 SUMMARY AND CONCLUSIONS

None of the identified collision mortalities at the Project were provincially or federally listed threatened or endangered bird species. Nearly all of the identified avian items were common residents to the study area or were from species that migrate through the area. Many of the identified collision mortalities are of species recognized as being prone to collisions. The collision mortalities identified at the Project in 2017 were primarily waterfowl, grouse, and passerines.

Overall, spring migration collision rates were higher than fall. With the exception of the reference area, summer collision rates were the lowest. During the spring migration period, estimated collision mortality rates for all sites were unreasonably high and reflected highly efficient scavenging of carcasses that confounded spring collision mortality estimate calculations. Collision mortality estimates of 54.91 birds/km at reference sites in the breeding bird season and 7.27 birds/km at GOT and CP sites combined and 13.75 birds/km at reference sites in the fall migration period, appear to be reasonably accurate collision mortality estimates.

Although the estimated spring collision mortality rate appears anomalously high, the pattern of higher collision rates during migration periods is reflected in these data. The lowest collision mortality rates were observed during the 2017 breeding bird season when avian movements are lower than in spring and fall migrations.

The installation of bird diverters on the GOT and CP lines may have been effective at reducing avian mortalities as sites lacking deflectors had greater estimated collision mortality rates than sites with deflectors. The addition of two more GOT transmission lines (with bird diverters), parallel to existing lines and within the same ROW, may reduce collisions as the density of lines increase and become more visible to birds during flight. However, in poor visibility conditions, birds in flight may be more at risk to collisions with clustered transmission lines.

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APPENDIX 1:
ITEMS ENCOUNTERED DURING BIRD COLLISION MORTALITY SEARCHES

A-1. Items found under the generation outlet transmission lines (GOT), construction power line (CP), and the R26K transmission line in May 2017. Items included in calculations of estimated collision mortality are denoted (***). Collisions found during the initial site visit are denoted (†).

Line	Site	Date	Wpt.	Item	Notes
CP	KN36-Wild-104	17-May-17	-	Canada goose feathers	Down
GOT	KGOT-Wild-115, 116, 117	18-May-17	-	Canada goose feather	Primary feather
GOT	Reference 4	18-May-17	-	Willow ptarmigan feathers†	Attached to skin and bone
GOT	Reference 4	18-May-17	-	Canada goose feathers†	Scavenged; four clusters of feathers
GOT	Reference 4	18-May-17	-	Dark-eyed junco carcass†	Intact
GOT	Reference 4	18-May-17	-	Small white feather	Body feather; unknown species
GOT	Reference 4	18-May-17	-	Canada goose feathers†	Scavenged; primary, covert, and body feathers
GOT	Reference 4	18-May-17	-	Canada goose feathers	Body feathers
GOT	Reference 4	18-May-17	-	Dark-eyed junco carcass†	Intact
GOT	Reference 4	18-May-17	-	Small white feather	Body feather; unknown species
GOT	KGOT-Wild-112, 113, 114	18-May-17	-	Small white feather	Down; unknown species
GOT	KGOT-Wild-112, 113, 114	18-May-17	-	Canada goose feathers†	Scavenged; primary, covert, and body feathers
GOT	KGOT-Wild-112, 113, 114	18-May-17	-	Canada goose feathers†	Scavenged; primary, covert, and body feathers
GOT	KGOT-Wild-112, 113, 114	18-May-17	-	Willow ptarmigan feathers†	Scavenged; covert feathers attached to skin
GOT	KGOT-Wild-112, 113, 114	18-May-17	-	Common raven feathers	Down
GOT	KGOT-Wild-112, 113, 114	18-May-17	-	Small white feathers	Body feathers; unknown species
GOT	KGOT-Wild-109, 110, 111	18-May-17	-	Small white feathers	Body feathers; unknown species
GOT	KGOT-Wild-106, 107, 108	18-May-17	-	Small white feather	Body feather; unknown species
GOT	KGOT-Wild-106, 107, 108	18-May-17	-	Small white feathers	Body feathers; unknown species
GOT	KGOT-Wild-106, 107, 108	18-May-17	-	Small white feather	Body feather; unknown species
GOT	KGOT-Wild-103, 104, 105	18-May-17	-	Canada goose feathers†	Scavenged; body feathers
CP	KN36-Wild-103	18-May-17	-	Small white feather	Body feather; unknown species
CP	KN36-Wild-103	18-May-17	-	Mallard feathers†	Scavenged; covert feathers
CP	KN36-Wild-103	18-May-17	-	Ring-necked pheasant feather	From previous year's scavenger bias trials
R26K	R26K Reference 1	19-May-17	-	Small white feathers	Down; unknown species
R26K	R26K Reference 1	19-May-17	-	Willow ptarmigan feathers	Primary, covert, and body feathers
R26K	R26K Reference 1	19-May-17	-	Willow ptarmigan feathers and	Scavenged; likely same individual as item

Line	Site	Date	Wpt.	Item	Notes
				intestine†	above
R26K	R26K Reference 1	19-May-17	-	Small white feathers	Down; unknown species
R26K	R26K Reference 1	19-May-17	-	Willow ptarmigan feathers†	Scavenged; primary, covert, and body feathers
R26K	R26K Reference 1	19-May-17	-	Small white feather	Down; unknown species
GOT	KGOT-Wild-121, 122, 123, 124	19-May-17	-	Small white feather	Body feather; unknown species
GOT	KGOT-Wild-121, 122, 123, 124	19-May-17	-	Hermit thrush carcass†	No apparent lacerations
GOT	KGOT-Wild-121, 122, 123, 124	19-May-17	-	Small white feather	Body feather; unknown species
GOT	KGOT-Wild-118, 119, 120	19-May-17	-	Small grey feathers	Body feather; unknown species
GOT	KGOT-Wild-103, 104, 105	25-May-17	70	Small white feathers	Down; unknown species
GOT	KGOT-Wild-103, 104, 105	25-May-17	71	Sun-bleached duck skull	Old; unknown species
GOT	KGOT-Wild-106, 107, 108	25-May-17	68	Dark-eyed junco carcass***	Broken wing
GOT	KGOT-Wild-106, 107, 108	25-May-17	69	Small white feather	Down; unknown species
GOT	KGOT-Wild-109, 110, 111	25-May-17	63	Spruce grouse feathers***	Scavenged; body and down feathers
GOT	KGOT-Wild-109, 110, 111	25-May-17	64	Canada goose feathers***	Scavenged; body and down feathers
GOT	KGOT-Wild-109, 110, 111	25-May-17	65	Canada goose feathers	Body and down feathers, likely same bird as wpt. 64
GOT	KGOT-Wild-109, 110, 111	25-May-17	66	Canada goose feathers	Body and down feathers, likely same bird as wpt. 64
GOT	KGOT-Wild-112, 113, 114	24-May-17	37	Sun-bleached sacrum and femur bones	Old, medium sized bird bones
GOT	KGOT-Wild-112, 113, 114	24-May-17	40	Grey feathers	Down; unknown species
GOT	KGOT-Wild-112, 113, 114	24-May-17	41	Spruce grouse feathers***	Scavenged; body feathers and down
GOT	KGOT-Wild-112, 113, 114	24-May-17	42	American widgeon feathers***	Scavenged; body feathers and down
GOT	KGOT-Wild-112, 113, 114	24-May-17	43	Small white feather	Down; unknown species
GOT	KGOT-Wild-112, 113, 114	24-May-17	44	Small brown & white feathers	Body feathers; unknown species
GOT	KGOT-Wild-115, 116, 117	24-May-17	22	Small Canada goose feathers	Body feathers
GOT	KGOT-Wild-115, 116, 117	24-May-17	23	Small white feather	Down; unknown species
GOT	KGOT-Wild-115, 116, 117	24-May-17	24	Canada goose feather	Secondary feather
GOT	KGOT-Wild-115, 116, 117	24-May-17	25	Small Canada goose feathers	Secondary feathers
GOT	KGOT-Wild-118, 119, 120	24-May-17	19	Yellow-bellied sapsucker carcass***	Intact; lacerated breast
GOT	KGOT-Wild-118, 119, 120	24-May-17	20	Savannah sparrow carcass***	Intact
GOT	KGOT-Wild-118, 119, 120	24-May-17	21	Ring-necked pheasant feather	From previous year's scavenger bias trials
GOT	KGOT-Wild-125, 126, 127	24-May-17	9	American widgeon feathers***	Scavenged; body feathers
GOT	KGOT-Wild-125, 126, 127	24-May-17	10	Small feather with brown tips	Body feather; unknown species

Line	Site	Date	Wpt.	Item	Notes
GOT	KGOT-Wild-125, 126, 127	24-May-17	17	Chipping sparrow carcass***	Intact
CP	KN36-Wild-103	25-May-17	47	Small white feather	Down; unknown species
CP	KN36-Wild-103	25-May-17	48	Canada goose feathers	Body feathers
CP	KN36-Wild-103	25-May-17	49	Song sparrow carcass***	Intact
CP	KN36-Wild-104	23-May-17	1	Swainson's thrush feathers***	Primary, covert and body feathers
CP	KN36-Wild-104	23-May-17	2	Small white feather	Body feather; unknown species
CP	KN36-Wild-104	23-May-17	3	Small white feather	Down; unknown species
CP	KN36-Wild-104	23-May-17	4	Small white feathers	Body feather; unknown species
CP	KN36-Wild-104	23-May-17	5	Small white feathers	Down; unknown species
CP	KN36-Wild-104	23-May-17	6	Small grey common raven feathers	Down
R26K	Reference 1	24-May-17	8	Mallard feathers***	Scavenged; primary, covert, body and down feathers
R26K	Reference 1	24-May-17	12	Small white feathers	Body feather; unknown species
R26K	Reference 1	24-May-17	14	Canada goose feathers	Body feathers, likely same bird as wpt. 15
R26K	Reference 1	24-May-17	15	Canada goose feathers***	Scavenged; body feathers
R26K	Reference 1	24-May-17	16	American widgeon feathers	Body feathers
GOT	Reference 4	24-May-17	27	Canada goose feathers***	Scavenged; body feathers
GOT	Reference 4	24-May-17	30	Small white feather	Down; unknown species
GOT	Reference 4	24-May-17	32	Mallard feathers	Secondary feather and down, likely same bird as wpt. 34
GOT	Reference 4	24-May-17	33	Dark-eyed junco feathers***	Primary, secondary, and covert feathers
GOT	Reference 4	24-May-17	34	Mallard feathers***	Scavenged; body feathers

A-2. Items found under the generation outlet transmission lines (GOT), construction power line (CP), and the R26K transmission line in June 2017. Items included in calculations of estimated collision mortality are denoted (***). Collisions found during the initial site visit are denoted (†).

Line	Site	Date	Wpt.	Item	Notes
R26K	R26K Reference 1	01-Jun-17	-	American widgeon feathers†	Scavenged; primary, covert and body feathers
R26K	R26K Reference 1	01-Jun-17	-	Mallard feathers†	Scavenged; body feathers
R26K	R26K Reference 1	01-Jun-17	-	Willow ptarmigan feathers†	Scavenged; degraded primary, secondary, covert and body feathers
R26K	R26K Reference 1	01-Jun-17	-	Small white feathers	Body feathers; unknown species
R26K	R26K Reference 1	01-Jun-17	-	Small white feather	Down
R26K	R26K Reference 2	01-Jun-17	-	Mallard feathers†	Scavenged; body feathers
GOT	KGOT-Wild-121, 122, 123, 124	01-Jun-17	-	Mallard carcass†	Moderately decomposed
GOT	KGOT-Wild-121, 122, 123, 124	01-Jun-17	-	Small white feathers	Body feathers; unknown species
GOT	KGOT-Wild-115, 116, 117	01-Jun-17	-	Willow ptarmigan feathers	Degraded body feathers
R26K	Reference 4	01-Jun-17	-	Willow ptarmigan feathers†	Scavenged; degraded body feathers
R26K	Reference 4	01-Jun-17	-	Canada goose feathers†	Scavenged; primary, secondary and body feathers
R26K	Reference 4	01-Jun-17	-	Canada goose feathers	Body feathers
GOT	KGOT-Wild-109, 110, 111	01-Jun-17	-	Killdeer feathers†	Scavenged; primary, secondary, covert and body feathers
GOT	KGOT-Wild-109, 110, 111	01-Jun-17	-	Canada goose feathers	Primary feathers
GOT	KGOT-Wild-109, 110, 111	01-Jun-17	-	Willow ptarmigan wing†	Scavenged; desiccated wing
GOT	KGOT-Wild-109, 110, 111	01-Jun-17	-	Canada goose feathers	Body feathers
GOT	KGOT-Wild-106, 107, 108	02-Jun-17	-	Small white feather	Body feather; unknown species
GOT	KGOT-Wild-106, 107, 108	02-Jun-17	-	Willow ptarmigan feathers	Secondary and body feathers
GOT	KGOT-Wild-106, 107, 108	02-Jun-17	-	Small white feathers	Body feathers; unknown species
GOT	KGOT-Wild-103, 104, 105	02-Jun-17	-	Small white feather	Down; unknown species
GOT	KGOT-Wild-100, 101, 102	02-Jun-17	-	Wilson's warbler carcass†	No apparent lacerations
CP	KN36-Wild-104	02-Jun-17	-	Small white feather	Down; unknown species
CP	KN36-Wild-104	02-Jun-17	-	Spruce grouse feather	Body feather
CP	KN36-Wild-103	02-Jun-17	-	Small grey feather	Down; unknown species
CP	KN36-Wild-103	02-Jun-17	-	Savannah sparrow carcass†	Intact
CP	KN36-Wild-103	02-Jun-17	-	American robin carcass†	Moderately decomposed

Line	Site	Date	Wpt.	Item	Notes
CP	KN36-Wild-103	02-Jun-17	-	Small white feather	Down; unknown species
R26K	R26K Reference 1	08-Jun-17	1	Common raven feather	Down
R26K	R26K Reference 1	08-Jun-17	2	Willow ptarmigan feathers†	Scavenged; degraded primary, secondary and covert feathers
R26K	R26K Reference 1	08-Jun-17	4	Mallard feathers	Body feathers
GOT	KGOT-Wild-125, 126, 127	08-Jun-17	5	Small brown and white feather	Down; unknown species
R26K	R26K Reference 2	08-Jun-17	6	Willow ptarmigan feathers†	Scavenged; degraded primary, secondary and covert feathers
R26K	R26K Reference 2	08-Jun-17	7	Small white feathers	Down; unknown species
R26K	R26K Reference 2	08-Jun-17	8	Ruffed grouse feathers***	Scavenged; body feathers
CP	KN36-Wild-103	09-Jun-17	14	Unknown sparrow carcass†	Old fatality; advanced state of decomposition

A-2. Items found under the generation outlet transmission lines (GOT), construction power line (CP), and the R26K transmission line in September 2017. Items included in calculations of estimated collision mortality are denoted (***). Collisions found during the initial site visit are denoted (†).

Line	Site	Date	Wpt.	Item	Notes
GOT	KGOT-Wild-112, 113, 114	06-Sep-17	1	Canada goose feather	Body feather
GOT	KGOT-Wild-109, 110, 111	06-Sep-17	2	Red-tailed hawk feather	Secondary feather
GOT	KGOT-Wild-109, 110, 111	06-Sep-17	3	Red-tailed hawk feather	Down
GOT	KGOT-Wild-125, 126, 127	07-Sep-17	4	Grey feather	Down, unknown species
GOT	KGOT-Wild-125, 126, 127	07-Sep-17	5	Grey feathers	Down, unknown species
GOT	KGOT-Wild-125, 126, 127	07-Sep-17	6	Sandhill crane feather	Primary feather
R26K	R26K Reference 1	07-Sep-17	7	Small white feather	Body feather, unknown species
GOT	Reference 4	09-Sep-17	8	Canada goose feather	Body feather
GOT	Reference 4	09-Sep-17	9	Green-wing teal†	Advanced state of decomposition
GOT	Reference 4	09-Sep-17	10	Great-grey owl feather	Secondary feather
GOT	Reference 4	09-Sep-17	11	Partial wing of a depredated hatch-year bird	Feathers within feather shaft
GOT	Reference 4	09-Sep-17	12	Canada goose feathers	Body feathers
GOT	KGOT-Wild-103, 104, 105	09-Sep-17	13	Grey feather	Down, unknown species
CP	KN36-Wild-102	10-Sep-17	14	Juvenile red-tailed hawk feathers†	Secondary, covert and body feathers
CP	KN36-Wild-102	10-Sep-17	15	Sandhill crane feather	Primary feather
CP	KN36-Wild-102	10-Sep-17	16	Juvenile red-tailed hawk feathers	Covert feathers; likely same individual as above
GOT	KGOT-Wild-109, 110, 111	12-Sep-17	17	Small grey feather	Body feather
GOT	KGOT-Wild-125, 126, 127	12-Sep-17	18	Common raven feather	Primary feather
GOT	KGOT-Wild-125, 126, 127	12-Sep-17	19	Mallard feathers	Down
GOT	KGOT-Wild-125, 126, 127	12-Sep-17	20	Common raven feather	Secondary feather
GOT	KGOT-Wild-118, 119, 120	13-Sep-17	21	Smith's longspur carcass***	Intact, no apparent lacerations
GOT	KGOT-Wild-118, 119, 120	13-Sep-17	22	Canada goose feather	Primary feather
R26K	R26K Reference 3	13-Sep-17	23	Common raven feather	Primary feather
GOT	Reference 4	14-Sep-17	24	Sandhill crane feather	Secondary feather
GOT	KGOT-Wild-106, 107, 108	14-Sep-17	25	Small white feather	Down; unknown species
GOT	KGOT-Wild-103, 104, 105	14-Sep-17	26	Small white and brown feathers	Down; unknown species
GOT	KGOT-Wild-100, 101, 102	14-Sep-17	27	Red-tailed hawk feather	Covert feather
CP	KN36-Wild-104	15-Sep-17	28	Canada goose feather	Secondary feather

Line	Site	Date	Wpt.	Item	Notes
CP	KN36-Wild-103	15-Sep-17	29	Ring-necked pheasant bones	Persisted since previous year
GOT	KGOT-Wild-109, 110, 111	17-Sep-17	31	Sandhill crane feather	Secondary feather
GOT	KGOT-Wild-109, 110, 111	17-Sep-17	32	Sandhill crane feather	Covert feather
GOT	KGOT-Wild-109, 110, 111	17-Sep-17	33	Song sparrow carcass†	Intermediate state of decomposition
GOT	KGOT-Wild-112, 113, 114	17-Sep-17	34	Canada goose bone	Femur
GOT	KGOT-Wild-112, 113, 114	17-Sep-17	35	Dark-eyed junco feathers†	Primary, secondary and covert feathers
GOT	KGOT-Wild-112, 113, 114	17-Sep-17	36	Northern waterthrush carcass†	Advanced state of decomposition
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	37	Small brown feather	Down; unknown species
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	38	Small grey feather	Down; unknown species
R26K	R26K Reference 1	17-Sep-17	39	Common raven feather	Down
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	40	Small grey feather	Down; unknown species
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	41	Small grey feather	Down; unknown species
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	42	Common raven feather	Covert feather
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	43	Small grey feathers	Down; unknown species
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	44	Common raven feathers	Secondary feathers
GOT	KGOT-Wild-125, 126, 127	17-Sep-17	45	Canada goose feather	Secondary feather
R26K	R26K Reference 3	18-Sep-17	46	Small brown feather	Secondary feather; unknown species
R26K	R26K Reference 2	18-Sep-17	47	Owl pellet	Large owl species
R26K	R26K Reference 2	18-Sep-17	48	Common raven feather	Secondary feather
GOT	KGOT-Wild-115, 116, 117	20-Sep-17	49	Common grackle carcass†	Intact, lacerated breast
GOT	KGOT-Wild-115, 116, 117	20-Sep-17	50	Canada goose feather	Secondary feather
CP	KN36-Wild-104	20-Sep-17	51	Common raven feather	Primary feather
GOT	KGOT-Wild-125, 126, 127	22-Sep-17	54	White and grey feathers	Down; unknown species
GOT	KGOT-Wild-125, 126, 127	22-Sep-17	55	Old sun-bleached bones	Medium sized bird
GOT	KGOT-Wild-109, 110, 111	22-Sep-17	56	Swainson's thrush feathers***	Scavenged
GOT	KGOT-Wild-112, 113, 114	22-Sep-17	57	Common raven feather	Secondary feather
R26K	R26K Reference 2	23-Sep-17	58	Gray jay feather	Secondary feather
GOT	Reference 4	24-Sep-17	59	Pine grosbeak carcass***	Advanced state of decomposition
GOT	Reference 4	24-Sep-17	60	Canada goose feather	Primary feather
GOT	Reference 4	24-Sep-17	61	Savannah sparrow carcass***	Intact, no apparent lacerations
GOT	KGOT-Wild-115, 116, 117	25-Sep-17	62	Mallard hen feathers***	Flank feathers

APPENDIX 2:
BIRD COLLISION MORTALITY PHOTOGRAPHS

Photo 2-1. Intact yellow-bellied sapsucker found under the generation outlet transmission lines on May 24, 2017.

Photo 2-2. Mallard found under generation outlet transmission lines on June 1, 2017.

Photo 2-3. Unknown sparrow carcass in an advanced state of decomposition found under the construction power lines on June 9, 2017.

Photo 2-4. Desiccated willow ptarmigan wing found under generation outlet transmission lines on June 1, 2017.

Available in accessible formats upon request