Manitoba Hydro

Keeyask Transmission Project
Environmental Effects Monitoring Plan
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KEEYASK TRANSMISSION PROJECT

BIRD-WIRE COLLISION MONITORING 2016

Prepared for

Licensing and Environmental Assessment Department

Manitoba Hydro

By

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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 (Map) 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.

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 late breeding bird season and the fall migration period of 2016, the second year of Project construction. Surveys for evidence of bird-wire collision mortality occurred at stream crossings under the Keeyask GOT lines, the Keeyask CP line, and the R26K transmission line.

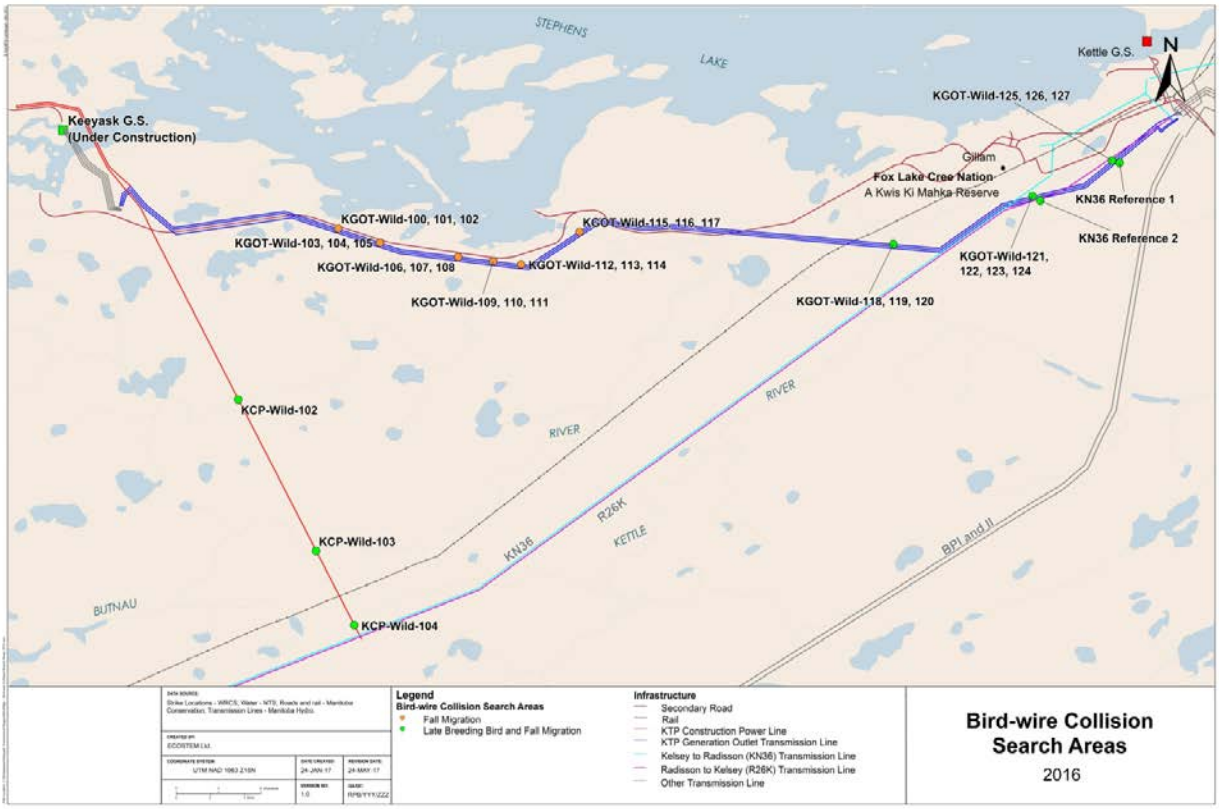
Canada geese flying above the Keeyask Transmission Project's generation outlet transmission lines. Bird diverters can be seen on the sky wires.

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 lines, the Keeyask CP line, and the KN36 transmission line during the late 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 the R26K line were searched and used as reference sites as this 20 year old line did not have bird diverters. Carcass searches alone provide a minimum biased estimate of actual fatalities as searchers may not always find all carcasses. To account for the efficiency of the search team and scavengers removing evidence of bird collision mortalities, searcher efficiency and scavenger removal trials were conducted. Dead juvenile ring-necked pheasants, 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. Minimum estimated collision mortality was determined 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). Habitat bias was the proportion of formal search areas that were searched; open water, low-lying wet areas and dense forest were not searched.



Areas searched for bird-wire collision evidence under the Keeyask Transmission Project's generation outlet transmission lines, construction power line, and R26K line (reference) in 2016.

What was found?

No mortality evidence for provincially or federally listed threatened or endangered bird species was found during the 2016 surveys. A total of five carcasses and/or evidence of collision mortalities were detected at four of the sites searched under the GOT and CP lines. No carcasses and/or evidence of bird-wire collision mortality was found at the two R26K reference sites. At all the study sites, species collected as evidence of collision mortalities included Canada goose, unidentified gulls, savannah sparrow, unidentified sparrow, and an unidentified bird.

After correcting for searcher efficiency, scavenger removal bias, and habitat bias, minimum estimated collision mortality was 10.80 birds/km in the late breeding bird season and 10.32 birds/km in the fall migration period when the GOT and CP lines are considered as a single sampling unit. Minimum estimated bird-wire collision mortality could not be estimated for the R26K line because no carcasses were found under the R26K line.

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. That bird-wire collision mortality estimates were lower than rates reported in the literature, supports this assertion.

What will be done next?

Additional bird-wire collision mortality surveys will be conducted in 2017 to continue monitoring the effectiveness of installed mitigation measures.

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. Caroline Walmsley 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. Thank are also extended to Dr. James Ehnes, ECOSTEM Ltd., for providing cartography services for this report.

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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.

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 1-1).

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 June and September 2016 bird-wire collision mnitoring at the Project's outlet transmission lines and the construction power line.

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

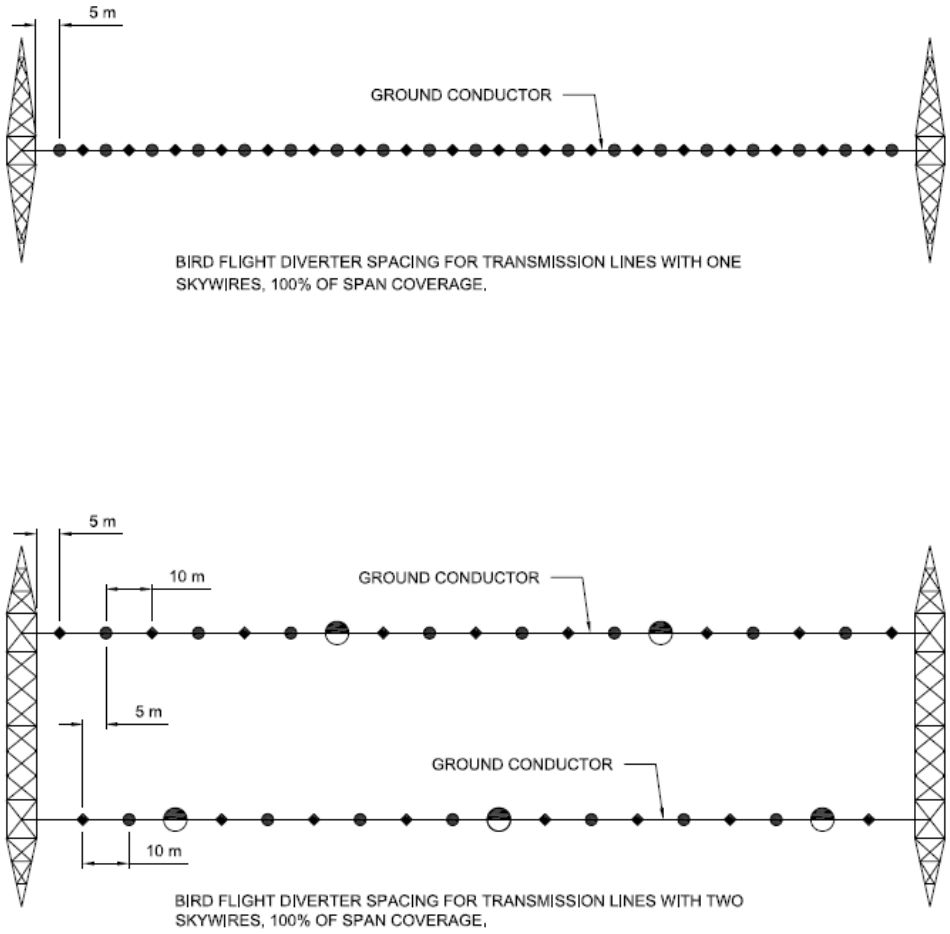


Figure 1-1: Manitoba Hydro installation protocol for spiral flight diverters and bird flight diverters, with and without aerial marker cones

2.0 METHODS

2.1 STUDY SITE

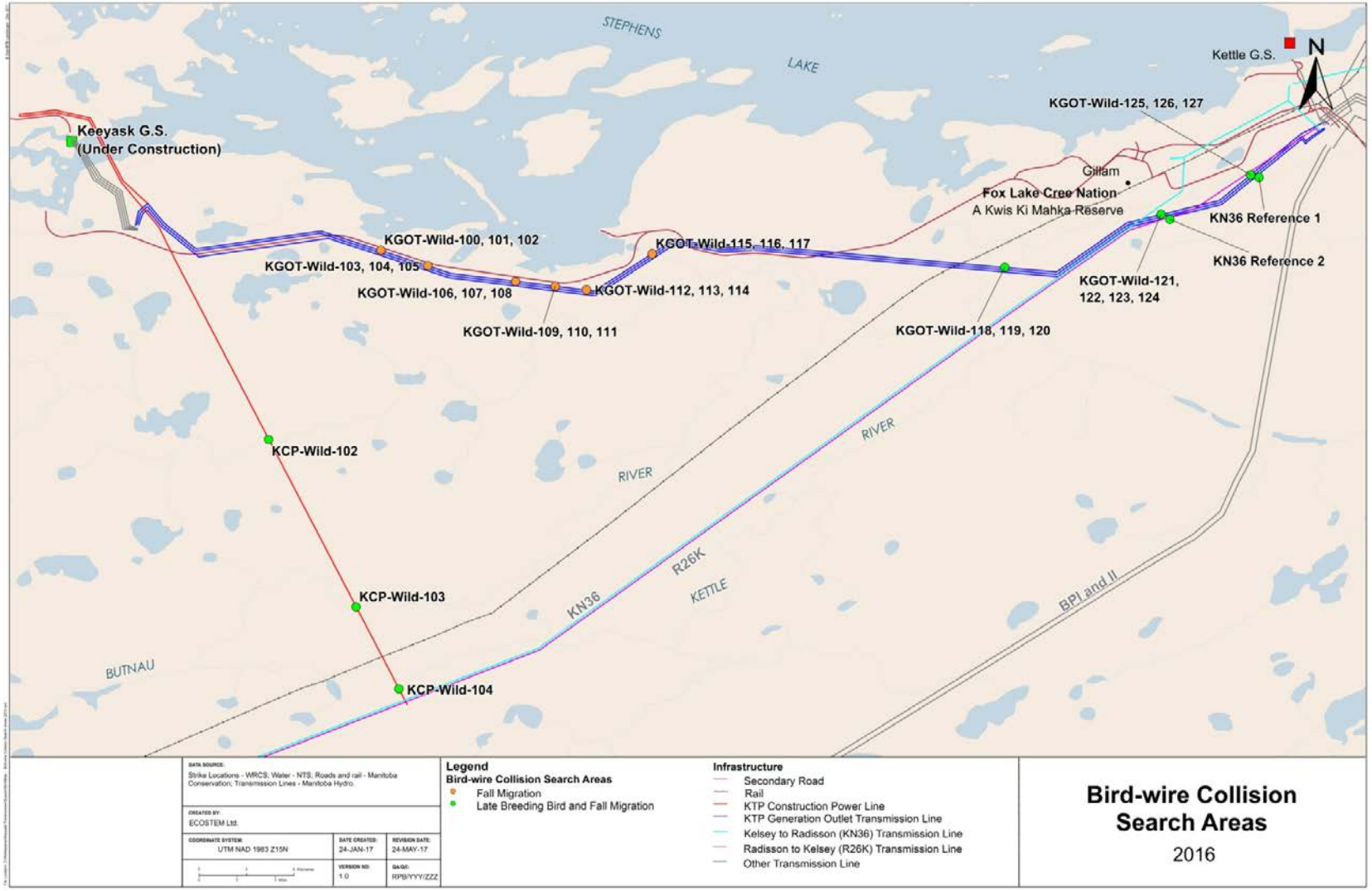
Monitoring of potential bird-wire collisions was conducted at stream crossings under the Keeyask GOT lines, the Keeyask CP line, and at two reference sites under the R26K line. The GOT lines extend 38 km from the Keeyask Switching Station to the Radisson Converter Station at Gillam (Map 2-1). The CP line extends 21 km from the Keeyask Switching Station to the KN36 transmission line (Map 2-1). Areas searched under the R26K transmission line were 150 m southeast of, and parallel to two GOT search areas (Map 2-1).

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 was 3.78 km under the GOT lines, 1.1 km under the CP line, and 800 m under the R26K line. In total, the formal search area under the GOT lines was 22.7 ha, 6.6 ha under the CP line, and 2.4 ha under the R26K line.

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 line was characterized by low to moderate density tree and shrub regrowth. One R26K reference site parallels a river and the GOT line, and the RoW is buffered by intermediate to mature-aged forest. The second reference site crosses a river. These two sites did not have bird diverters.

2.2 DATA COLLECTION

To monitor avian mortality resulting from collisions with GOT lines and CP lines associated with the Keeyask Transmission Project site, searches for evidence of bird-wire collisions were completed in 2016. Monitoring of potential bird-wire collisions was conducted during the breeding bird season over a two week period in June (10, 17), and two weeks in the fall migration period in September (12, 13, 18, 19). In June, three GOT sites, three CP sites and two R26K sites were searched (Map 2-1). In September, an additional seven sites under the GOT lines were searched (Map 2-1). These additional areas were searched in September to examine whether future bird collision mortality monitoring was warranted at these sites. Two reference sites (R26K 1 and 2) were chosen for comparison because they were the only two sites on an existing transmission line in the regional study area that crossed or paralleled streams or creeks, and because there are no bird diverters at these locations.



Map 2-1. Areas searched for bird-wire collision evidence under the Keeyask Transmission Project's generation outlet transmission lines, construction power line, and R26K line (reference) in the late breeding bird season and the fall migration period, 2016.

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.

Photo 2. Survey personnel searching for evidence of bird-wire collisions under the Keeyask generation outlet transmission lines on June 10, 2016.

While surveying, personnel visually inspected the area for signs of bird collisions, including carcasses and clusters of feathers. Collisions were recorded when the remains found consisted of more than five feathers in a square meter (Barrientos et al. 2012), because a smaller number of feathers cannot safely be interpreted as a collision, since they could have been lost by a bird during preening, moulting or fighting (Bevanger 1999). Bird remains were collected under scientific permit (CWS 16-AB-SC005) 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, dead juvenile ring-necked pheasants (*Phasianus colchicus*; hereafter referred to as pheasants)(Photo 3) purchased from a commercial supplier were used to conduct searcher efficiency and scavenger removal trials. Planting carcasses in blind trials is a commonly used technique to estimate searcher efficiency and scavenger removal bias (CEC 2003, CWS 2007, APLIC 2012). Juvenile pheasants were selected for their moderate size and because their cryptic plumage makes finding them challenging. Searcher efficiency is a measure of the ability of the search team, not individual searcher efficiency, to find evidence of bird collision mortality occurring within the search area. The search team was tested during each site visit where pheasants were planted. In knowing that planted birds are in the search area, searcher efficiency can be high as the searchers are "*on guard*" during the search (CWS 2007). Frozen pheasants were thawed before being placed within search areas at locations unknown to the searcher team. Following the search, the proportion of carcasses found by the search team was recorded. Searcher efficiency was assessed by pooling the results all searcher efficiency trials under both the GOT and CP lines in June and September. Planted birds were similarly used to estimate the proportion of birds not removed by scavengers.

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

We planted a limited number of pheasants (*n* = 12) in 2016 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). In the ROW under the GOT lines, three pheasants were planted on June 10 and three were planted on September 12. Under the CP line, three pheasants were planted on June 10 and three were planted on September 12.

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

Carcass searches alone provide a minimum biased estimate of actual fatalities as searchers may not always find all carcasses. Searcher efficiency, scavenger removal, habitat, and crippling can all affect detection (APLIC 2006). Preferably, bias should be determined to more 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 in 2016 under both the GOT and CP lines. Searcher efficiency (*Se*) was calculated as:

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

Because the GOT and CP lines 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 scavenger removal bias, are similar at both sites. Scavenger removal bias was calculated by pooling results of scavenger removal trials from both the GOT lines and the CP line in each of the two seasons. Scavenger bias (*Sbi*) was calculated as:

$$Sbi = \frac{Number\ of\ pheasants\ not\ removed\ by\ scavengers}{Number\ of\ pheasants\ planted}$$

To account for unsearchable portions of the formal search, areas that were not searched were estimated by examining search team GPS track logs in Google Earth and were subtracted from the formal search area. 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 late breeding bird period (June 1 - July 15) when adults are feeding nestlings, and the fall migration period (Sep 1 - Oct 15). When zero carcases were found under a transmission line, existing biases dictate that collision mortality is necessarily unknown under that particular line. The minimum estimated collision mortality (MECM) was calculated as follows:

$$MECM = \frac{Number\ of\ carcasses\ found}{Se * Sbi * Hbi}$$

To estimate seasonal total collision mortality, weekly minimum collision mortality estimates were multiplied by a factor of six weeks for both periods. To standardize minimum estimated collision mortality, minimum estimated collision mortality was divided by the total surveyed length of the transmission lines.

3.0 RESULTS

3.1 COLLISION MORTALITY EVIDENCE

In 2016, no evidence of Threatened or Endangered bird species mortality was found during the bird collision mortality searches under the Keeyask generation outlet transmission lines and the construction power line.

Under the GOT lines evidence of two collision mortalities was found during the June searches and no evidence of collision mortalities during the September searches (Table 3-1). One intact savannah sparrow (*Passerculus sandwichensis*)(Photo Appendix B-1) was found on September 18, and a carcass of an unidentified sparrow species (Photo Appendix B-2) was found on September 19 (Table 3-1; Map 3-1). Feathers and old bones from birds were also found at search sites under the GOT lines in both periods (Appendix A-1).

Evidence of three collision mortalities was found during the June searches and no evidence of collision mortalities during the September searches under the CP line (Table 3-1). One cluster of five Canada goose (*Branta candensis*) body feathers (Photo Appendix B-3), a cluster of more than 50 gull (*Larus* sp.) feathers (Photo Appendix B-4), and the remains of an unidentified bird species that was heavily scavenged (Photo Appendix B-5), were found on June 10 (Table 3-1; Map 3-1). Feathers, old bones from birds, and an active mallard nest were also found at search sites under the CP line in both periods (Appendix A-1).

Under the R26K line (reference), no evidence of collision mortality was found (Table 3-1). One common raven (*Corvus corax*) feather and three gray jay (*Perisoreus canadensis*) feathers were found during searches at this site in June (Appendix A-1). No remains were found under the R26K line in September (Appendix A-1).

3.2 SEARCHER EFFICIENCY, SCAVENGER REMOVAL BIAS, AND HABITAT BIAS

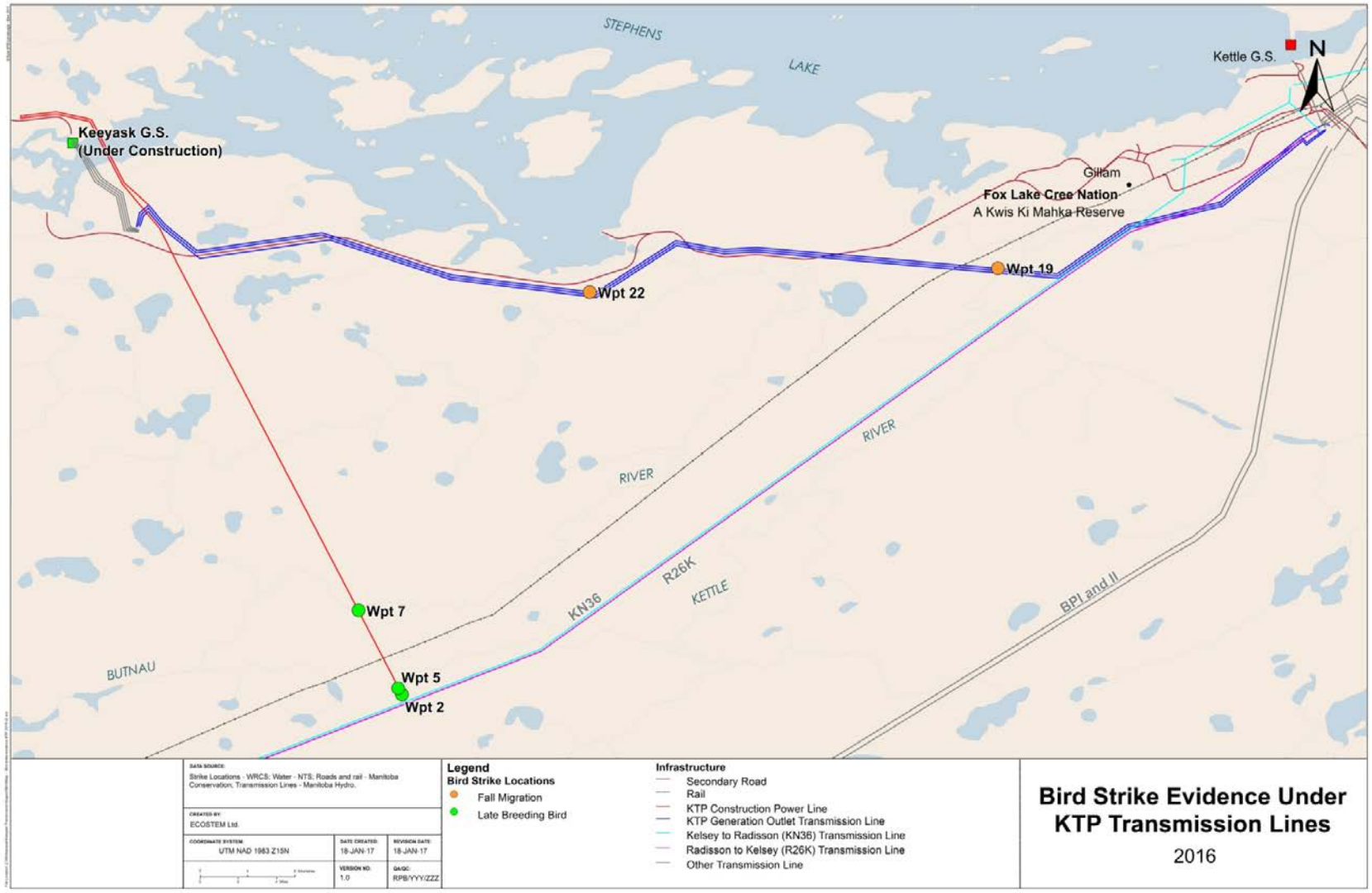
During the June 10 searcher efficiency trial, all six pheasants were found by the search team. On June 17, of the five pheasants that had not been removed by scavengers three were found. On September 12, four of five pheasants that were not removed by scavengers were found. On September 18, both of the two pheasants that were not removed by scavengers were found. When all searcher efficiency trials are combined, 15 of 18 planted pheasants were found, thus overall searcher efficiency was 0.83.

In June, one of six pheasants was removed by scavengers under the GOT and CP lines, thus

Table 3-1. 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.

Line type	Site	Number of carcasses found		Length (m)	Formal search area (ha)	Searchable area (ha)	*Hbi*
		June	September				
GOT	KGOT-Wild-125, 126, 127	0	0	400	2.4	2.1	0.88
GOT	KGOT-Wild-121, 122, 123, 124	0	0	880	5.3	4.7	0.89
GOT	KGOT-Wild-118, 119, 120	0	1	400	2.4	2.3	0.96
GOT	KGOT-Wild-115, 116, 117	*NA**	0	350	2.1	1.8	0.86
GOT	KGOT-Wild-112, 113, 114	*NA**	1	350	2.1	1.8	0.86
GOT	KGOT-Wild-109, 110, 111	*NA**	0	300	1.8	1.7	0.94
GOT	KGOT-Wild-106, 107, 108	*NA**	0	400	2.4	1.7	0.71
GOT	KGOT-Wild-103, 104, 105	*NA**	0	400	2.4	1.7	0.71
GOT	KGOT-Wild-100, 101, 102	*NA**	0	300	1.8	1.7	0.94
	GOT Total	*0*	*2*	*3,780*	*22.68*	*19.5*	*0.86*
CP	KCP-Wild-104	2	0	400	4	3.4	0.85
CP	KCP-Wild-103	1	0	300	1.8	1.7	0.94
CP	KCP-Wild-102	0	0	400	2.4	2.3	0.96
	CP Total	*4*	*0*	*1,100*	*8.2*	*7.4*	*0.90*
	GOT & CP Grand Total			*4,880*	*30.88*	*26.9*	*0.87*
R26K	R26K Reference 1	0	0	400	1.2	1.1	0.92
R26K	R26K Reference 2	0	0	400	1.2	1.2	1.00
	R26K Total	*0*	*0*	*800*	*2.4*	*2.3*	*0.96*

*Not searched in June.



Map 3-1. Bird-wire collision evidence encountered under the Keeyask Transmission Project's generation outlet transmission lines and construction power line in the late breeding bird season and the fall migration period, 2016.

scavenger removal bias in June was 0.83 per week. In September, four of six pheasants were removed by scavengers, thus, scavenger removal bias in September was 0.33 per week.

Due to the presence of open water, low-lying wet areas and dense forest, not all of the formal search areas were entirely searchable. For sites under the GOT line, overall habitat bias was 0.86 whereas overall habitat bias was 0.90 at sites under the CP line (Table 3-1). When the GOT and CP lines are considered as a single sampling unit, overall habitat bias was 0.87. At the two reference sites under the R26K line, overall habitat bias was 0.96 (Table 3-1).

3.3 MINIMUM ESTIMATED COLLISION MORTALITY

Minimum estimated collision mortality for birds could not be estimated for the GOT lines in the fall migration period or for the CP line in the late breeding bird period due to a lack of carcasses and/or evidence of collision mortalities (Table 3-2). After correcting for searcher efficiency, scavenger removal bias, and habitat bias, minimum estimated collision mortality for birds was 13.48 birds/km at streams crossed by the GOT lines in the fall migration period (Table 3-2). At streams crossed by the CP line, minimum estimated collision mortality for birds was 26.39 birds/km during the late breeding bird season (Table 3-2). When the GOT and CP lines are considered as a single sampling unit, minimum estimated collision mortality was 10.80 birds/km in the late breeding bird season and 10.32 birds/km in the fall migration period (Table 3-2). Because no carcasses were found under the R26K reference transmission line during both study periods, minimum estimated collision mortality for birds could not be estimated for the R26K line (Table 3-2).

Table 3-2. Minimum estimated collision mortality (MECM) at the Keeyask generation outlet transmission lines (GOT), the construction power line (CP), and the R26K transmission line during the 2016 late breeding bird season and the fall migration period.

Period	Line	# of Sites Surveyed	*TCF*	*Se*	*Sbi*	*Hbi*	*Total Length of Surveyed Sites (km)*	*MECM* / Week	*MECM* / km	*MECM* / Season*
Late breeding bird	GOT	3	0	0.83	0.83	0.90	1.68	Unk.	Unk.	Unk.
	CP	3	3	0.83	0.83	0.90	1.10	4.84	4.40	26.39
	GOT+CP Total	*6*	*3*	*0.83*	*0.83*	*0.87*	*2.78*	*5.01*	*1.80*	*10.80*
	R26K	2	0	0.83	0.83	0.96	0.80	Unk.	Unk.	Unk.
Fall migration	GOT	9	2	0.83	0.33	0.86	3.78	8.49	2.25	13.48
	CP	3	0	0.83	0.33	0.90	1.10	Unk.	Unk.	Unk.
	GOT+CP Total	*12*	*2*	*0.83*	*0.33*	*0.87*	*4.88*	*8.39*	*1.72*	*10.32*
	R26K	3	0	0.83	0.33	0.96	0.80	Unk.	NA Unk.	Unk.

*Multiplied by a factor of 6 weeks.

4.0 SUMMARY AND CONCLUSIONS

No mortality evidence for provincially or federally listed threatened or endangered bird species was found during the 2016 surveys. No injured birds were encountered. A total of five carcasses and/or evidence of bird-wire mortalities were detected at four of the sites searched under the GOT and CP lines. No carcasses and/or evidence of bird-wire mortalities was found at the two R26K reference sites. At all the study sites, species bird-wire strike remains included Canada goose, unidentified gulls, savannah sparrow, unidentified sparrow, and an unidentified bird. All identified avian items detected at the study sites are common residents to the study area or are species that migrate through the area.

Minimum estimated collision mortality rates of 10.8 birds/km in the late breeding bird season and 10.32 birds/km in the fall migration period are practically identical. These bird-wire mortality rates are lower than other studies reporting bird-wire mortalities. Faanes (1987) estimated a bird-wire mortality rate of 69 birds/km in North Dakota during the migration period at particularly sensitive wetland habitats. Rioux et al. (2013) suggest that the average number of bird-wire mortalities/km of unmarked transmission line is 42.3 ±17.1. It should be noted, however, that comparisons to mortality rates in other studies is difficult as sources of bias can vary substantially between study locations (APLIC 2012).

It was an unexpected result that no evidence of collision mortality was found under the R26K line reference sites. Because bird diverters were not present on this line, collision mortalities were expected. Collisions at the reference sites were likely lacking due to the presence of mature forest surrounding the sites. The height of the forest was nearly the same as the height of the towers and birds species that are more vulnerable to collisions (e.g., waterfowl) would be flying at an altitude above the height of the R26K transmission line over the forest canopy. Birds approaching these sites would be flying at an altitude higher than the transmission line resulting in fewer collisions than at the CP and GOT lines where the RoW is cleared of trees to a width of about 275 m.

The estimated bird-wire mortality rate provides a minimum biased number of collision mortalities. Although three common sources of bias (searcher efficiency, scavenger removal, habitat) were estimated and incorporated into estimated collision mortality, crippling bias was not quantified in this study or included in estimates of total bird-wire mortality. If some birds are colliding with the transmission lines but are falling or moving outside of the search area (APLIC 2012), total collision mortality would be higher than the Keeyask study estimates. Crippling biases applied in other studies vary widely from 0.8 (Bevanger 1995) to 0.26 (Beaulaurier 1981). In applying a conservative crippling bias of 0.2, estimated collision mortality for all sites under the GOT and CP lines would increase to 13.5 collision mortalities/km in the late breeding bird season and 12.9 collision mortalities/km in the fall migration period.

Because bird diverters were present at surveyed sites under the Keeyask Transmission Project transmission lines, and that estimated collision mortality rates were lower than rates reported in the literature, mitigation measures may have been effective at reducing rates of bird-wire

collision mortalities. Bird diverters have been shown to effectively reduce bird-wire mortalities (Photo 4), however effectiveness can vary from reductions of 9.6% to 80% (Beaulaurier 1981, Morkill and Anderson 1991, APLIC 2012). The cost-effective mitigation technique of installing bird diverters appears to have been successful to date at protecting birds from collision mortality with the Keeyask Transmission Project transmission lines.

Photo 4. **Flock of Canada geese (*Branta canadensis*) flying above the Keeyask Transmission Project's generation outlet transmission lines. Swan Flight ™ diverters can be seen on the sky wires.**

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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 June and September 2016. Items assessed as evidence of collision mortality are denoted (***).

Line	Site	Waypoint	Date	Item	Notes	UTM Coordinates
CP	KCP-Wild-104	2***	10-Jun-16	Five Canada goose feathers	Body feathers	15 V 373422 6231257
CP	KCP-Wild-104	3	10-Jun-16	One northern flicker feather	Primary feather	15 V 373404 6231264
CP	KCP-Wild-104	4	10-Jun-16	Mallard duck nest	Active; 7 eggs	15 V 373389 6231299
CP	KCP-Wild-104	5***	10-Jun-16	>50 gull (*Larus* sp.) feathers	Scavenged	15 V 373312 6231436
CP	KCP-Wild-104	6	10-Jun-16	Five gull (*Larus* sp.) feathers	80 m from wpt 5; likely same bird	15 V 373380 6231380
CP	KCP-Wild-103	7***	10-Jun-16	Possible common raven	Scavenged; black and white downy feathers	15 V 372171 6233683
CP	KCP-Wild-103	8	10-Jun-16	One Red tailed hawk feather	Secondary feather	15 V 372134 6233747
CP	KCP-Wild-102	9	10-Jun-16	One grouse feather	Body feather	15 V 369501 6238769
CP	KCP-Wild-102	10	10-Jun-16	One grouse feather	Body feather	15 V 369505 6238745
CP	KCP-Wild-102	11	10-Jun-16	Unknown small bones	Old bones; sun bleached	15 V 369508 6238739
CP	KCP-Wild-102	12	10-Jun-16	Unknown feather	Decomposing	15 V 369536 6238740
CP	KCP-Wild-102	13	10-Jun-16	Mallard duck feather	Brown and white rump feather	15 V 369540 6238725
CP	KCP-Wild-104	16	10-Jun-16	One common raven feather	Primary feather	15 V 373459 6231259
GOT	KGOT-Wild-121, 122, 123, 124	1	10-Jun-16	Mallard duck feather	Brown and white rump feather	15 V 395364 6245031
GOT	KGOT-Wild-104	14	18-Sep-16	1 white down feather		15 V 373293 6231522
GOT	KGOT-Wild-125, 126, 127	18	12-Sep-16	One common raven feather	Secondary feather	15 V 398049 6246323
GOT	KGOT-Wild-118, 119, 120	19***	18-Sep-16	Savannah sparrow carcass	Intact; lacerated forehead	15 V 390603 6243538
GOT	KGOT-Wild-118, 119, 120	20	18-Sep-16	Two Canada goose feathers	Very old	15 V 390888 6243518
GOT	KGOT-Wild-115, 116, 117	21	18-Sep-16	Old Canada goose bone	Old; sun bleached	15 V 380565 6243814
GOT	KGOT-Wild-115, 116, 117	22	18-Sep-16	Gull (Larus sp.) feather	Secondary feather	15 V 380639 6243877
GOT	KGOT-Wild-112, 113, 114	23***	19-Sep-16	Unknown sparrow carcass	Advanced state of decomposition	15 V 378835 6242849
GOT	KGOT-Wild-112, 113, 114	24	19-Sep-16	One Canada goose feather	Body feather	15 V 378934 6242830

GOT	KGOT-Wild-112, 113, 114	25	19-Sep-16	Unknown bird bones	Old; sun bleached	15 V 378721 6242901
GOT	KGOT-Wild-109, 110, 111	26	19-Sep-16	One small white feather		15 V 377746 6243017
GOT	KGOT-Wild-106, 107, 108	27	19-Sep-16	One small white down feather	Floating on creek surface	15 V 376799 6243105
GOT	KGOT-Wild-100, 101, 102	28	19-Sep-16	One brown down feather		15 V 372911 6243944
R26K	R26K Reference 1	15	10-Jun-16	Three gray jay feathers	Body feather	15 V 398207 6246252
R26K	R26K Reference 1	17	17-Jun-16	One common raven feather	Primary feather	15 V 398211 6246186

APPENDIX 2:
BIRD COLLISION MORTALITY PHOTOGRAPHS

Photo B-1. Intact savannah sparrow (*Passerculus sandwichensis*) found under the generation outlet transmission lines on September 18, 2016.

Photo B-2. Unknown sparrow found under the generation outlet transmission lines on September 18, 2016.

Photo B-3. Canada goose (*Branta canadensis*) feathers found under the construction power line on June 10, 2016.

Photo B-4. Gull (*Larus* sp.) feathers found under the construction power line on June 10, 2016.

Photo B-5. Possible common raven (*Corvus corax*) carcass found under the construction power line on June 10, 2016.

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