KEEYASK TRANSMISSION PROJECT

OLIVE-SIDED FLYCATCHER AND RUSTY BLACKBIRD SENSORY DISTURBANCE MONITORING 2019

Prepared for

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By

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SUMMARY

Background

The Keeyask Transmission Project (the Project) provides generation outlet transmission (GOT) capacity and construction power (CP) 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 KN transmission line that extends from the Kelsey Generating Station to the Radisson Converter Station. The R26K line runs parallel to KN36. Construction of the Project began in October 2014.

Olive-sided flycatcher and rusty blackbird are migratory songbirds that are found in the Keeyask region. Both species are considered at risk in Canada and are protected under the federal *Species at Risk Act*. In Manitoba, the olive-sided flycatcher is also listed as Threatened under *The Endangered Species and Ecosystems Act*.

Why is the study being done?

Both the olive-sided flycatcher and rusty blackbird are near the edge of their breeding ranges in northern Manitoba and are found in relatively low numbers in the Keeyask region. Both are species at risk, have been experiencing widespread declines throughout their ranges, and may be vulnerable to Project effects. The goal of this study was to monitor the effect of Project-related disturbance on these species.

Rusty Blackbird

What was done?

Olive-sided flycatcher and rusty blackbird territories near the Project were mapped and then automated recording units, designed to record bird calls, were placed within. For each territory surveyed near the Project, an undisturbed reference territory was also surveyed. In all, 98 recorders were placed at 27 territories.

Recordings were analyzed and olive-sided flycatcher and rusty blackbird calls were identified. Recordings made in 2016 and 2017 were also analyzed and the amount of olive-sided flycatcher and rusty blackbird activity at each territory was evaluated for the three survey years.

Biologist Setting up an Automated Recording Unit to Record Bird Calls

What was found?

Olive-sided flycatchers and rusty blackbirds selected territories near the Project in all three survey years. Olive-sided flycatcher calls were recorded at all four of the territories analyzed in 2016, at all eight of the territories analyzed in 2017, and at 12 of the 13 territories (92%) analyzed in 2019. There was somewhat more activity at disturbed than reference territories. Rusty blackbird calls were recorded at all nine territories analyzed in 2016, all eight territories analyzed in 2017, and all 14 territories analyzed in 2019. There was somewhat more activity at reference than disturbed territories. The differences in olive-sided flycatcher and rusty blackbird activity at disturbed and reference territories were small over the combined three-year survey period.

What does it mean?

Project-related disturbance did not appear to influence the amount of olive-sided flycatcher and rusty blackbird activity at nearby territories from 2016 to 2019.

What will be done next?

To further study potential Project effects on olive-sided flycatchers and rusty blackbirds, bird response to sensory disturbance will be estimated by mapping call density as a function of distance from the transmission lines, while controlling for differences in habitat. Additional analyses such as resource selection function analysis will be used to further evaluate potential Project effects on these species.

STUDY TEAM

We would like to thank Sherrie Mason and Rachel Boone of Manitoba Hydro and Ron Bretecher of North/South Consultants Inc. for logistical assistance in the field. We would also like to thank James Ehnes of ECOSTEM Ltd. for GIS support and mapping. Biologists and other personnel who designed, participated in, and drafted the survey results included:

- Robert Berger, Wildlife Resource Consulting Services MB Inc. (WRCS) – Design and reporting
- James Ehnes, ECOSTEM Ltd. – Design

  Alex McIlraith, Myrica Systems Inc. - Design and bird audio recording analysis
- Andrea Ambrose, WRCS – Data analysis and reporting
- Kevin McCrae, WRCS – Field lead, survey personnel
- Mark Baschuk, WRCS – 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 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 lines 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 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 the GOT lines.

Olive-sided flycatcher (*Contopis cooperi*) and rusty blackbird (*Euphagus carolinus*) are migratory songbirds protected under the federal *Species at Risk Act* (SARA). The olive-sided flycatcher is listed as Threatened under the SARA and is listed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In Manitoba, the olive-sided flycatcher is listed as Threatened under *The Endangered Species and Ecosystems Act*. Its breeding habitat consists mainly of mature coniferous forest with open patches created by natural disturbance (e.g., fire), wetlands, or forestry clear-cuts (Altman and Sallabanks 2012 in Environment Canada 2016). Snags (dead standing trees) and live trees left behind after logging are important for perching while foraging for flying insects in open areas (Altman and Sallabanks 2012 in Environment Canada 2016).

The rusty blackbird is listed as Special Concern under the SARA and has no designation under *The Endangered Species and Ecosystems Act* of Manitoba. Despite being a migratory bird, the rusty blackbird is not protected under the federal *Migratory Birds Convention Act 1994*. Rusty blackbirds inhabit the boreal forest during the breeding season, using wetland habitat such as sedge meadows, beaver ponds, muskegs, swamps, riparian scrub, and shrubby patches of willow and alder (COSEWIC 2017). Their diet consists mainly of aquatic invertebrates such as insect larvae and snails, and also of grasshoppers, beetles, and spiders (COSEWIC 2017).

Pilot studies for olive-sided flycatcher and rusty blackbird were conducted in 2015, to identify and enumerate breeding pairs of birds in the Keeyask region. Disturbance surveys were conducted in 2016, 2017, and 2019, to determine if and how the Project affects the distribution and abundance of each species. These Project surveys were conducted in conjunction with construction monitoring for the Keeyask Generation Project as described in the *Keeyask Generation Project Terrestrial Effects Monitoring Plan* (TEMP; Keeyask Hydropower Limited Partnership 2015).

2.0 METHODS

2.1 TERRITORY MAPPING AND AUDIO RECORDING

Olive-sided flycatcher and rusty blackbird nesting territories identified in previous survey years were re-visited in 2019. A paired habitat sample design was employed, where survey sites represented either Project-disturbed or reference areas. Project-disturbed sites (disturbed sites) were within 500 m of the Project. For each disturbed site, a reference site, located in similar habitat but beyond the expected range of disturbance for olive-sided flycatchers and rusty blackbirds (500 m), was also surveyed (Map 1).

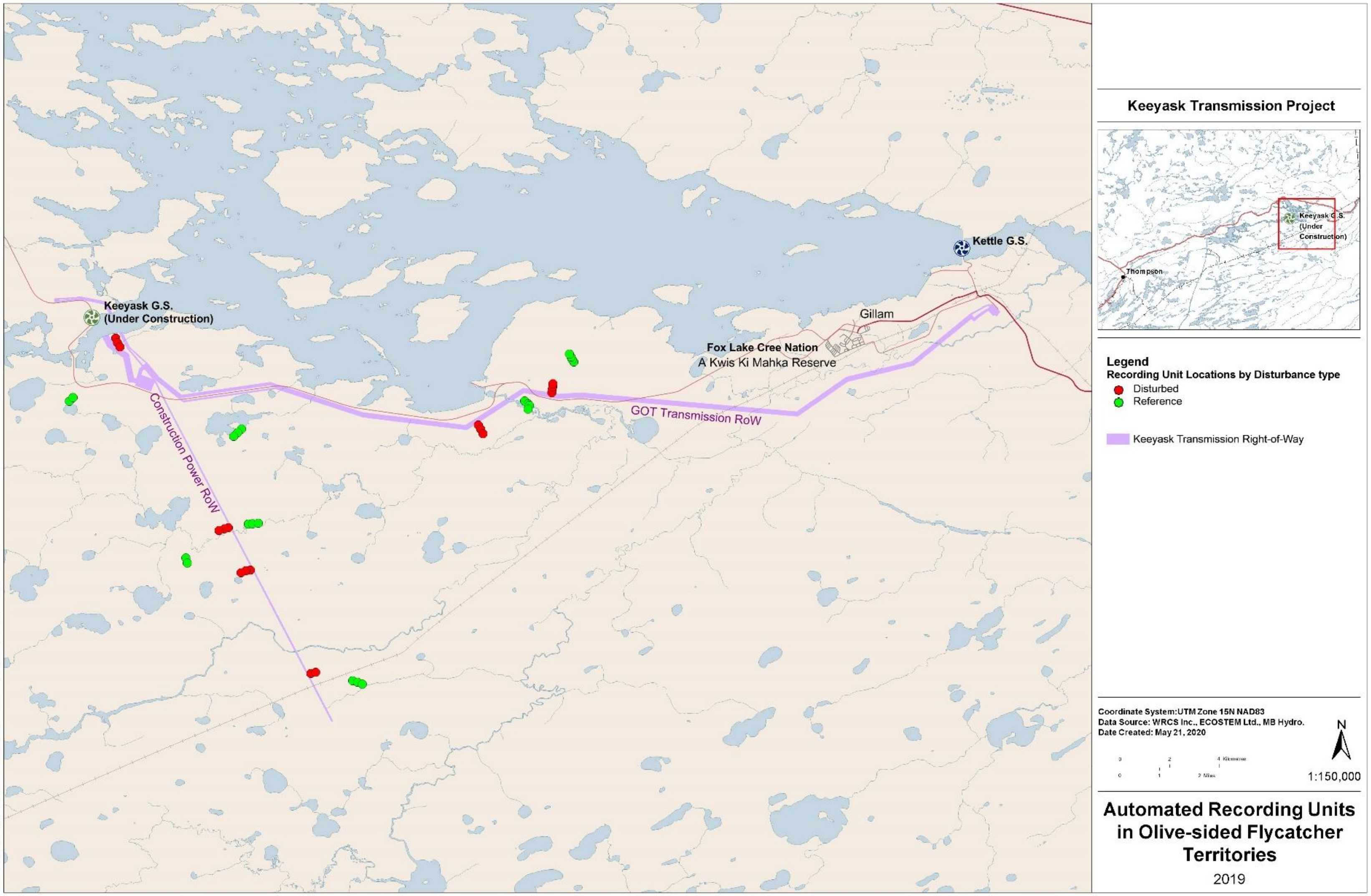
Surveys were conducted from June 5 to 22, 2019. Surveys began half an hour before sunrise and ended no later than 10:00 am. At each survey site, observers watched and listened for olive-sided flycatchers and rusty blackbirds for a period of 10 minutes. If no bird was heard or observed, the observer repeated the process at the next site. When a bird was heard or observed, its position was marked with a Global Positioning System (GPS) unit. The bird was observed until at least five perches were marked, defining its territory. Observers maintained a sufficient distance from the bird to avoid disturbance and record natural perch locations.

Two to four second-generation automated recording units (ARUs; Photo 1) were placed in the centre of disturbed territories, at distances of 100 metres (m), 300 m, and 500 m from the transmission line right-of-way (ROW). Two to four ARUs were placed in each reference territory 100 m, 300 m, and 500 m from a non-habitat patch edge such that they were centrally located through the long side of the habitat patch. In all, 98 recorders were placed at 27 territories from June 14 to 26, 2019. Forty-two ARUs were placed in 13 olive-sided flycatcher territories and 56 ARUs were placed in 14 rusty blackbird territories (Table 1). The ARUs were programmed to record for five minutes at 10-minute intervals (i.e., six times per hour) for seven hours beginning half an hour before sunrise and for four hours beginning an hour before sunset. Audio recording units were left in place for 10 to 23 days. Sixty-six recordings were made daily at each territory over the duration of the survey period.

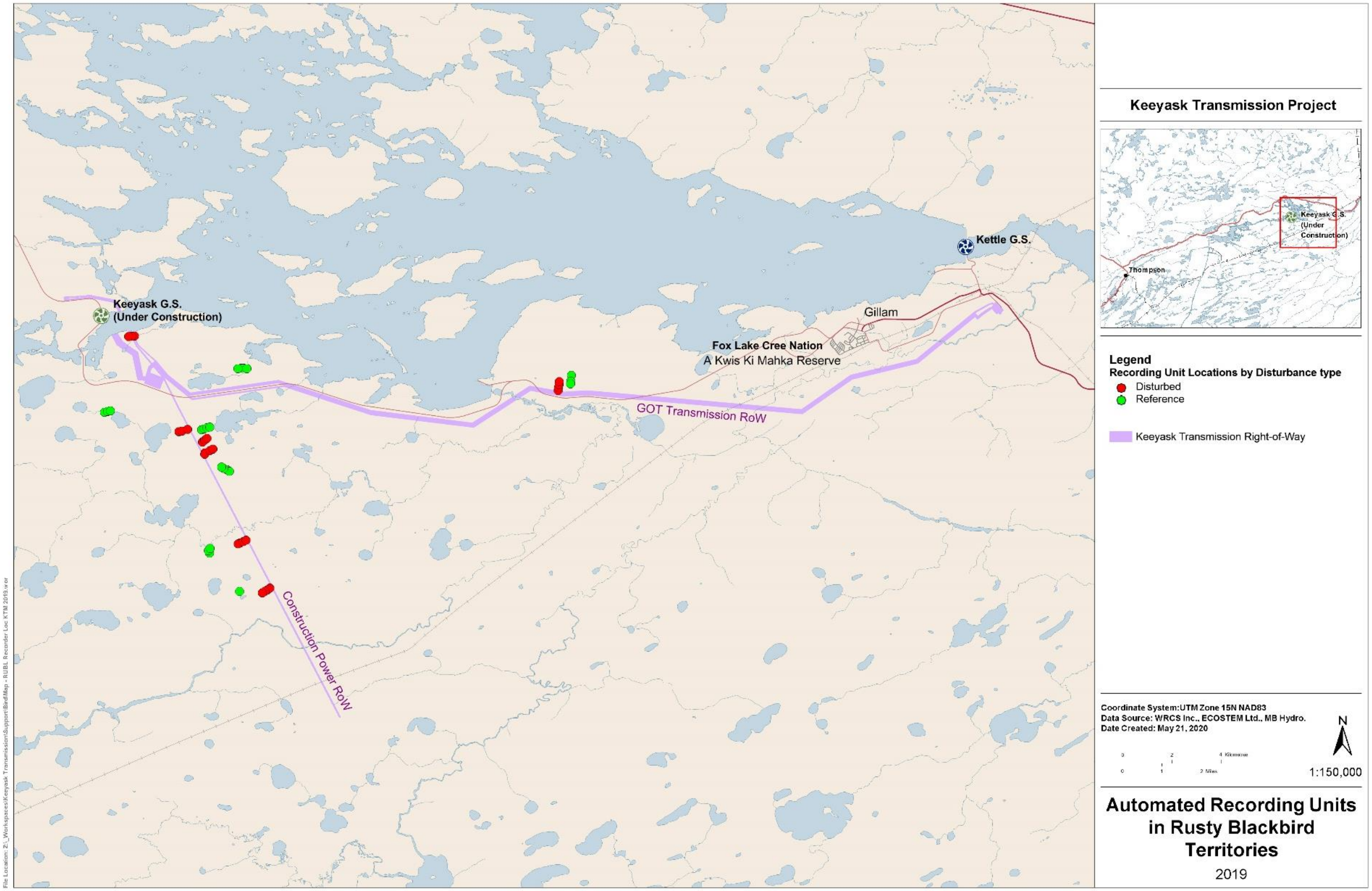
Photo 1: Four-microphone Automated Recording Unit Housed in Protective Case

Table 1: Survey Effort for Olive-sided Flycatchers and Rusty Blackbirds, 2019

Species	Disturbed		Reference		Total	
	Number of Territories	Number of Recorders	Number of Territories	Number of Recorders	Number of Territories	Number of Recorders
Olive-sided flycatcher	6	19	7	23	13	42
Rusty blackbird	7	28	7	28	14	56



Map 1: Automated Recording Units in Olive-sided Flycatcher Territories, 2019



Map 2: Automated Recording Units in Rusty Blackbird Territories, 2019

2.2 AUDIO RECORDING SUPPORT AND ANALYSIS

To identify the presence or absence of olive-sided flycatcher or rusty blackbird calls, analyses of bird vocalizations were performed using the statistical package R (Hafner and Katz 2018). A stepwise process was used to remove most false positives, where other species were initially identified as the target species. Classification of audio clips involved setting a threshold for target and off-target calls and calculating a difference between the two (see Appendix 1 for detailed analysis methods). All calls identified as olive-sided flycatcher or rusty blackbird were isolated and reviewed for potential false positives not removed during the initial identification process.

Recordings from a total of 13 olive-sided flycatcher territories and 14 rusty blackbird territories (Table 2) were analyzed in 2019. Recordings made in 2016 and 2017 (Wildlife Resource Consulting Services MB Inc. 2018) were also analyzed. Because recorders were left in place for varying amounts of time over the three survey years (two to 23 days), sites with fewer than seven days of recordings were removed from the analysis (n = 1 in 2016 and n = 2 in 2017). For olive-sided flycatcher, recordings were analyzed from four territories in 2016 and from eight territories in 2017 (Table 3). For rusty blackbird, recordings were analyzed from nine territories in 2016 and from eight territories in 2017. Calls from the first recorder were analyzed, or from the next recorder with calls if the first recorder could not be included, to avoid double-counting calls in the preliminary analysis presented in this report. Only calls from the first nine or 10 days of recordings were included in the analysis, to standardize the results.

Table 2: Number of Territories, Recordings, and Recording Days with Olive-sided Flycatcher or Rusty Blackbird Recordings, 2019

Species	Disturbed			Reference		
	Territories	Recording Days	Recordings	Territories	Recording Days	Recordings
Olive-sided flycatcher	6	60	3,960	7	70	4,620
Rusty Blackbird	7	70	4,620	7	70	4,620
Total	13	130	8,580	14	140	9,240

Table 3: Number of Territories, Recordings, and Recording Days with Olive-sided Flycatcher or Rusty Blackbird Recordings, 2016 and 2017

Species	Year	Disturbed			Reference		
		Territories	Recording Days	Recordings	Territories	Recording Days	Recordings
Olive-sided flycatcher	2016	2	20	1,320	2	20	1,320
	2017	4	40	2,640	4	40	2,640
Rusty blackbird	2016	5	49	3,234	4	40	2,640
	2017	4	40	2,640	4	40	2,640

The amount of olive-sided flycatcher and rusty blackbird activity at disturbed and reference territories was evaluated with the percentage of days calls were recorded, the percentage of recordings on which calls were recorded, and the mean number of calls per territory over the nine- or 10-day analysis periods at all territories at each disturbance source. The percentage difference in each metric between disturbed and reference territories was calculated for comparison.

3.0 RESULTS

3.1 OLIVE-SIDED FLYCATCHER

Olive-sided flycatcher calls were recorded at all four of the territories analyzed in 2016, at all eight of the territories analyzed in 2017, and at 12 of the 13 territories (92%) analyzed in 2019 over the standardized analysis period. Olive-sided flycatcher territories were roughly delineated by identifying the locations of singing birds relative to the ARUs, examples of which are depicted in Appendix 2, Map 2-1.

There was little difference in the amount of olive-sided flycatcher activity at disturbed and reference territories in 2016 and 2017 (22% or less; Table 4). The difference in recording days with calls (39%) was somewhat greater in 2019. While the amount of activity was similar at disturbed and reference sites, there was consistently more activity at disturbed sites over the survey period.

Table 4: Recording Days and Recordings with Olive-sided Flycatcher Calls, 2016, 2017, and 2019

Year	Percentage Recording Days			Percentage Recordings		
	Disturbed	Reference	% Difference	Disturbed	Reference	% Difference
2016	55	55	0	5	4	22
2017	93	85	9	17	16	6
2019	95	64	39	14	13	7

When the mean number of olive-sided flycatcher calls per territory was considered, there was relatively little difference between disturbed and reference territories (less than 100%) in all survey years (Table 5). The greatest difference (67%) was in 2019, when the mean number of calls was greatest at disturbed territories. The mean number of calls was greatest at reference territories in 2016 and 2017.

Table 5: Mean Number of Olive-sided Flycatcher Calls per Territory, 2016, 2017, and 2019

Year	Disturbed		Reference		% Difference
	Mean	Range	Mean	Range	Mean
2016	592	2 – 1,182	858	4 – 1,711	37
2017	874	131 – 2,175	1,193	28 – 2,258	31
2019	1,935	135 – 3,831	959	0 – 3,074	67

When the three survey years were combined, there was a small difference in the percentage of recording days with olive-sided flycatcher calls at disturbed and reference territories, with the greater percentage at disturbed territories (Figure 1). Calls were recorded on the same percentage of recordings at disturbed and reference sites. The mean number of calls was similar at disturbed (1,357) and reference (1,015) territories over the three-year survey period, a difference of 29%.

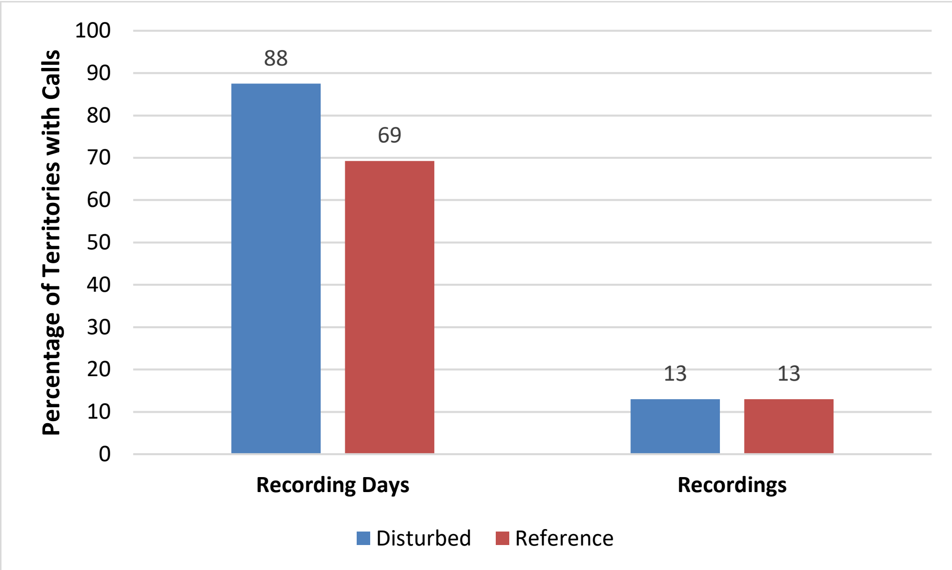


Figure 1: Percentage of Recording Days and Recordings with Olive-sided Flycatcher Calls Over the Combined Survey Period, 2016, 2017, and 2019

3.2 Rusty Blackbird

Rusty blackbird calls were recorded at all nine territories analyzed in 2016, all eight territories analyzed in 2017, and all 14 territories analyzed in 2019 over the standardized analysis period. Rusty blackbird territories were roughly delineated by identifying the locations of singing birds relative to the ARUs, examples of which are depicted in Appendix 2, Map 2-2.

There was no clear trend in rusty blackbird activity over the three survey years. In 2016 there were calls on a greater percentage of recording days at reference than disturbed territories, but calls were recorded on a greater percentage of recordings at disturbed territories than reference territories (Table 6). There was more activity on disturbed than reference territories in 2017; the reverse was true in 2019.

Table 6: Recording Days and Recordings with Rusty Blackbird Calls, 2016, 2017, and 2019

Year	Percentage Recording Days			Percentage Recordings		
	Disturbed	Reference	% Difference	Disturbed	Reference	% Difference
2016	20	25	22	2	1	67
2017	70	58	19	5	1	133
2019	46	63	31	3	7	185

The mean number of rusty blackbird calls per territory was greater at disturbed than reference territories in 2016 and 2017 (Table 7). The difference was relatively large in 2017 (146%). In 2019, the mean number of calls was greater at reference territories, a difference of 130%. A single call was recorded at one disturbed territory and one reference territory in 2016 and 2019, and at one reference territory in 2017.

Table 7: Mean Number of Rusty Blackbird Calls per Territory, 2016, 2017, and 2019

Year	Disturbed		Reference		% Difference
	Mean	Range	Mean	Range	Mean
2016	60	1 – 218	26	1 – 72	79
2017	84	18 – 140	13	1 – 22	146
2019	61	1 – 221	290	1 – 1,572	130

When the survey periods were combined, rusty blackbird calls were recorded on a somewhat greater percentage of recording days at reference than disturbed territories (Figure 2). Calls were also recorded at a greater percentage of reference territories than disturbed territories, but the difference was small. The mean number of calls was greater at reference (146) than disturbed (67) territories over the three-year survey period, a difference of 74%.

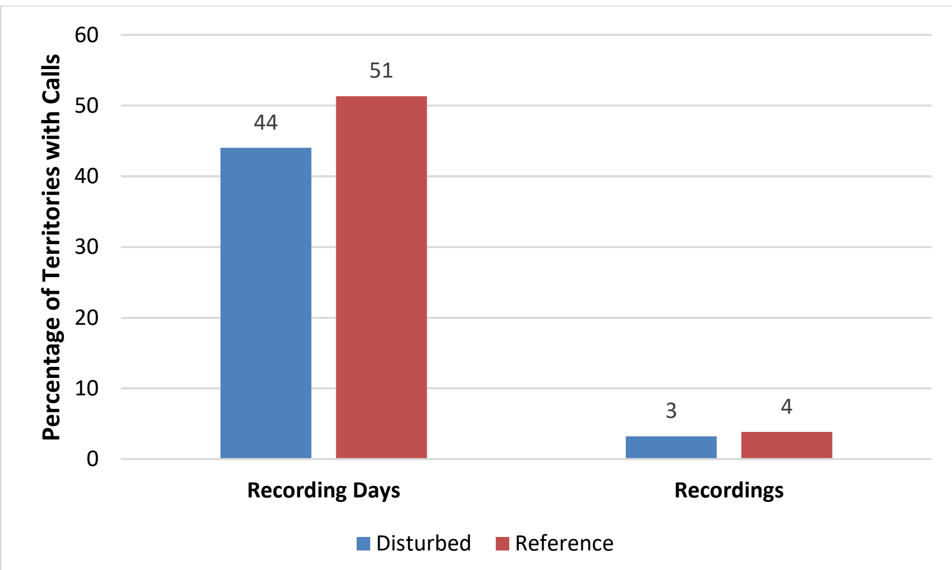


Figure 2: Percentage of Recording Days and Recordings with Rusty Blackbird Calls Over the Combined Survey Period, 2016, 2017, and 2019

4.0 DISCUSSION

Olive-sided flycatcher and rusty blackbird are species at risk and vulnerable to potential Project effects. Each species selected territories near the Project during all three study years.

Olive-sided flycatcher activity appeared to be similar at disturbed and reference territories. When measured as the percentage of recording days with olive-sided flycatcher calls and the mean number of calls per territory over the combined survey period, there was somewhat more activity at disturbed than reference territories; however, the differences were small. No Project-related effects on olive-sided flycatcher activity were apparent.

Rusty blackbird activity also appeared to be similar at disturbed and reference territories. There was somewhat more activity at reference than disturbed territories over the combined survey period, when measured as the percentage of recording days with rusty blackbird calls, the percentage of recordings with calls, and the mean number of calls per territory. As with olive-sided flycatcher, the differences were small, and no Project-related effects on rusty blackbird were apparent.

To further study the potential effects of the Project on olive-sided flycatchers and rusty blackbirds, bird response to sensory disturbance will be estimated by mapping call density as a function of distance from the rights-of-way, while controlling for differences in habitat. Potential Project effects on habitat use and distribution will be evaluated.

5.0 SUMMARY AND CONCLUSIONS

Minor or no Project effects on olive-sided flycatcher and rusty blackbird activity were observed from 2016 to 2019. Additional analyses such as resource selection function analysis will be used to further evaluate potential Project effects on these species.

6.0 LITERATURE CITED

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2017. COSEWIC assessment and status report on the rusty blackbird *Euphagus carolinus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. 64 pp.

Environment Canada. 2016. Recovery strategy for the olive-sided flycatcher (*Contopus cooperi*) in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa, ON. 52 pp.

Hafner, S.D. and Katz, J. 2018. A short introduction to acoustic template matching with monitoR. Available from https://cran.r-project.org/web/packages/monitoR/vignettes/monitoR_QuickStart.pdf [accessed May 15, 2018].

Keeyask Hydropower Limited Partnership. 2015. Keeyask Generation Project – Terrestrial Effects Monitoring Plan. Keeyask Hydropower Limited Partnership, Winnipeg, MB. 355 pp.

Wildlife Resource Consulting Services MB Inc. 2018. Keeyask Generation Project, Terrestrial Effects Monitoring Plan Report #TEMP 2018-13, Olive-sided Flycatcher and Rusty Blackbird Sensory Disturbance Monitoring 2017. A report prepared for Manitoba Hydro by Wildlife Resource Consulting Services MB, Inc., June 2018.

APPENDIX 1:
AUDIO RECORDING ANALYSIS METHODS

Automated Recording Units (ARUs)

Although there is extensive precedent for using automated recording units (ARUs) for avian studies (Shonfield and Bayne 2017)[1], we had difficulty finding an ARU to meet our needs. In some of the species at risk studies proposed for the *Terrestrial Effects Monitoring Plan* (TEMP), for example, it was necessary to estimate distance and direction to the vocalizing birds. This required more than two channels of audio recording. Study design also demanded a large number of recorders to meet sample size requirements. After surveying the available technology, no recorders were found that could record four channels at a reasonable cost. Wildlife Resource Consulting Services MB Inc. commissioned Myrica Systems Inc. to design custom ARUs and a local contract assembler was hired to build them.

There were a number of criteria to be met in the ARU design:

- **Time accuracy**: ARUs contained a temperature-compensated quartz clock with an accuracy of +/- 2 minutes per year over a range of -40°C to 85°C.
- **Flexible time scheduling**: Timing parameters included start times, recording duration, interval, and number repetitions. Recordings can be corrected for sunrise and sunset over the season; units were loaded with daily sunrise and sunset times determined from National Oceanic and Atmospheric Administration (NOAA) calculations given the year, latitude, and longitude.
- **Lengthy unattended run time**: The design was optimized for minimal power consumption. ARUs could be powered from AA, D and 6V lantern batteries as required to meet recording time requirements.
- **Audio sensitivity**: Microphones were mounted in a separate case containing low-noise pre-amplifiers. Gain was set to match the sensitivity of human observers trained to identify bird calls.
- **Noise insensitivity**: Filtering was designed to remove frequencies above and below the range of interest for the bird species being recorded. This reduces, for example, wind noise. Microphones were also fitted with open-cell foam “windsocks”.
- **Environmental tolerance**: ARUs were designed and components chosen to operate in the full range of temperatures expected in the field. Microphone cables were sheathed in metal braid to resist chewing by rodents. Electronics were protected in weather proof cases.
- **Directionality**: Each of four microphones was mounted in a recessed hole on each face of a square enclosure. This provided a degree of audio isolation of each from its neighbours. The ‘north’ microphone was labelled on enclosures to permit alignment in the field.
- **Data storage**: ARUs were fitted with secure digital (SD) cards (8 gigabyte [GB] or 32GB) as appropriate for each study. The audio sampling rate was also varied to match study, storage,

[1] Shonfield, J. and Bayne. E.M. 2017. Autonomous recording units in avian ecological research: current use and future applications. Avian Conservation and Ecology 12(1):14. https://doi.org/10.5751/ACE-00974-120114.

and analysis requirements (16.0 kilohertz [kHz] or 44.1 kHz). Files were compressed in Ogg Vorbis format (OGG) using a patent-and-royalty-free algorithm, which provided no noticeable signal degradation. Each field recording consisted of two stereo recordings on the SD card (A and B). An audible time marker (click) was used to verify synchronization of the two stereo recordings.

- **Data identification**: Each ARU had a serial number label and was programmed with the same number in software. Recording file names contained the day of the year (DOY), hour (HH) and minute (MM) that the recording started. For example, two stereo recordings would be labelled 1832110A.ogg and 1832110B.ogg. As a back-up, data were embedded within the audio file that included time, date, and serial number.

Pre-processing Data

For each survey year, field recordings from each recorder were copied from SD cards into a directory structure on a hard drive matching the respective year, study, and site. Each recording for olive-sided flycatcher and rusty blackbird was 300 seconds in length. Data from each year comprised several terabytes despite data being in compressed format. Data were kept in separate working and backup repositories.

Analysis of bird vocalizations was performed using the statistical package R[2]. In order for data to be analyzed in R, OGG files had to be converted to wave (WAV) format using either SOX[3] or LameXP[4]. It was determined that an audio bandwidth of 5.5 kHz was sufficient to recognize the species of interest in recordings. For this reason, OGG files were converted to WAV format with a sampling rate of 11.025 kHz; this reduced the storage volume of uncompressed data and speeded file reading during analysis.

[2] R (www.r-project.org), a free statistical analysis software environment. The Package 'monitoR' (https://CRAN.R-project.org/package=monitoR) was used. monitoR is described briefly in "A short introduction to acoustic template matching with monitoR." Sasha D. Hafner and Jonathan Katz. February 14, 2018 (available from www.r-project.org) and in more detail in: "monitoR: Automation Tools For Landscape-scale Acoustic Monitoring - PhD Dissertation. Jonathan Katz. The University of Vermont. May, 2015.

[3] SOX (http://sox.sourceforge.net) is a free command line application for converting formats of and processing data in audio files.

[4] LameXP (http://lamexp.sourceforge.net) is a free audio file format converter with a windows front end.

Species Detection

Templates were created from exemplars of species vocalizations (calls) of interest. MonitoR uses a method called template matching to identify species by their sounds. The method can be thought of as taking a low-resolution spectrogram and measuring its correlation against the spectrogram of a whole recording. In fact, templates can be plotted as spectrograms.

It was necessary to use multiple exemplars for a given species to cover the range in variation of calls. It was also necessary to measure correlation against other non-target sounds (calls and environmental sound) that also had a high correlation with the same species.

Due to the very large collection of recordings for analysis, a balance needed to be struck between the detail of templates used and the speed of analysis; recording analysis with detailed templates would take much longer. Attention was also paid to the duration and frequency bandwidth chosen for each template. To reduce analysis time to a practical order of magnitude, a two-step process of analysis was required.

In the first step, a limited number of low-resolution templates were used to discover candidate calls of the target species, recognizing that there would be many false positives. These candidate calls were extracted as two-second sound clips with each clip starting one second prior to the centre of the call detection and running to one second after the centre of the call. Datasets were also created at this step that included clip file name and statistics about the candidate clip. A clip spectrogram was created for each clip that was useful for validation. By the second step, the volume of data had been greatly reduced and only clips were processed. These could then be analyzed at high resolution to remove most false positives.

Classification of clips involved setting a threshold for target and off-target calls and calculating a difference between the two. A viewing system for validation was developed to allow experts to view each call (clip) as a spectrogram along with its classification and to listen to it by simply clicking on the spectrogram. Summary statistics were created for all detections to aid in validation.

Distance and Direction Estimation

Sound pressure level in decibels (SPL), which humans perceive as ‘sound volume’, has been shown to provide a good estimate of distance to a calling bird (Yip et al. 2017)[5]. Direction can be estimated using the equivalent of Interaural Level Difference (ILD); from a human perspective this would be equivalent to using sound volume as a cue about direction (Nelson and Suthers 2004)[6]. Although many automated direction estimation algorithms use Interaural Time Difference (ITD), humans do not use this for frequencies high frequencies (Roman et al. 2003)[7]. There were several

[5] Yip, D.A., Leston, L., Bayne, E.M., Sólymos, P., and Grover, A. 2017. Experimentally derived detection distances from audio recordings and human observers enable integrated analysis of point count data. Avian Conservation and Ecology 12(1):11. https://doi.org/10.5751/ACE-00997-120111.

[6] Nelson, B.S. and Suthers, R.A. 2004. Sound localization in a small passerine bird: discrimination of azimuth as a function of head orientation and sound frequency. The Journal of Experimental Biology 207: 4121–4133.

[7] Roman, N., Wang, D., and Brown, G. 2003. Speech segregation based on sound localization. The Journal of the Acoustical Society of America 114: 2236–2252. https://doi.org /10.1121/1.1610463.

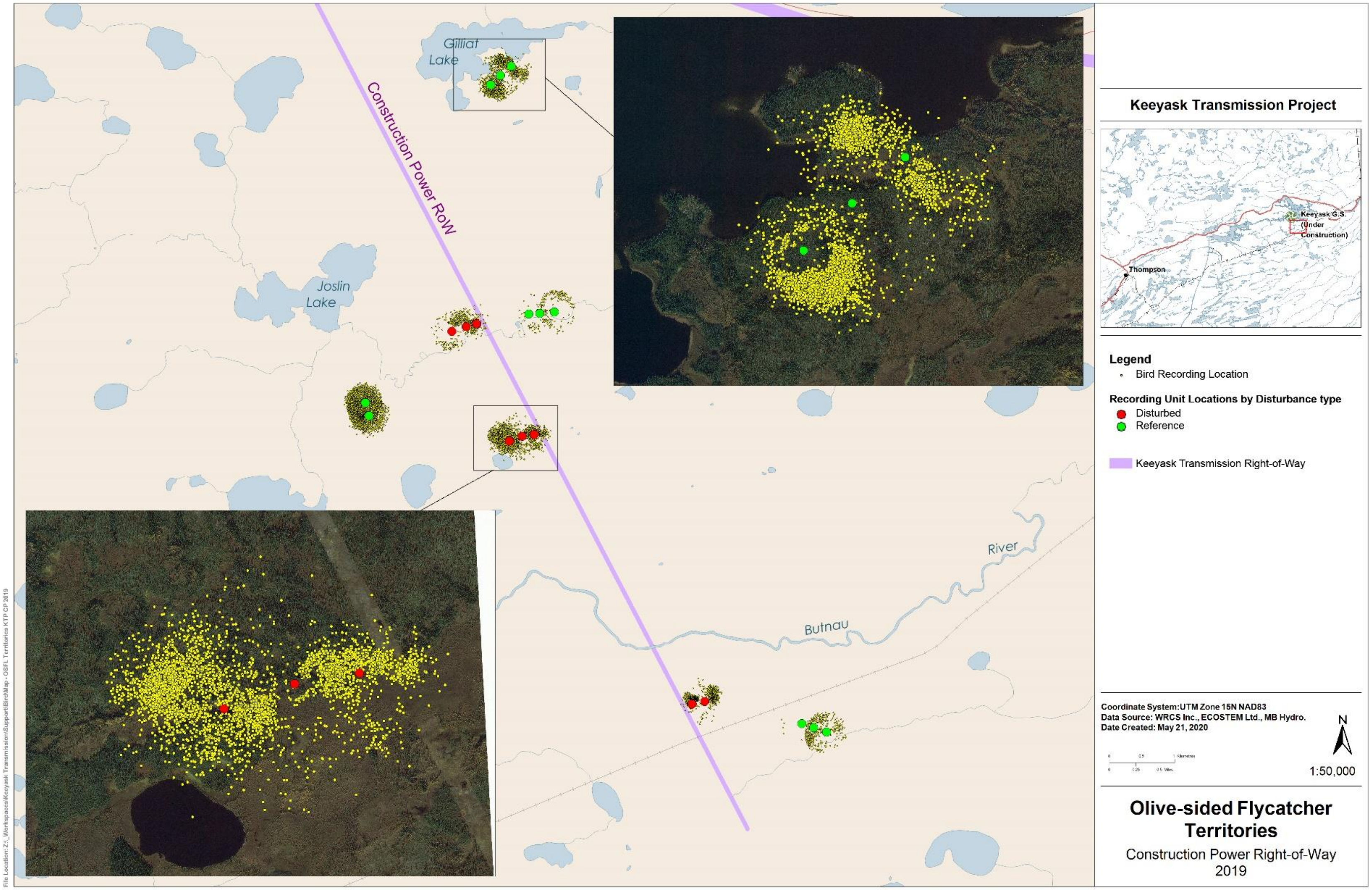
reasons why we were concerned that ITD might be unreliable in our studies. Some include: low signal to noise ratios (SNR), reverberation, environmental noise like wind, etc. In addition, our recording hardware was expected to have small differences that would be more pronounced at the high frequencies of bird calls. Microphones and circuits were identical by design, but tolerances in components were not and phase errors were expected. Exact synchronization of the two stereo recordings was problematic, even with the synchronization click that was used. We concluded that ILD was the best choice.

In order to calculate distance and direction to a singing bird recorded by the four-channel recorders, it was necessary to calibrate the system using bird songs recorded at varying distances. When a singing olive-sided flycatcher or rusty blackbird was observed, the observer would record the calls using a handheld recorder (Tascam DR100-MKII). The distance of the bird from the observer was estimated using a rangefinder or waypoints taken at the observer's location and the bird's perch after it moved. Recordings were taken at approximately 20 m increasing increments until the bird could no longer be heard. Several dozen examples were collected using these techniques.

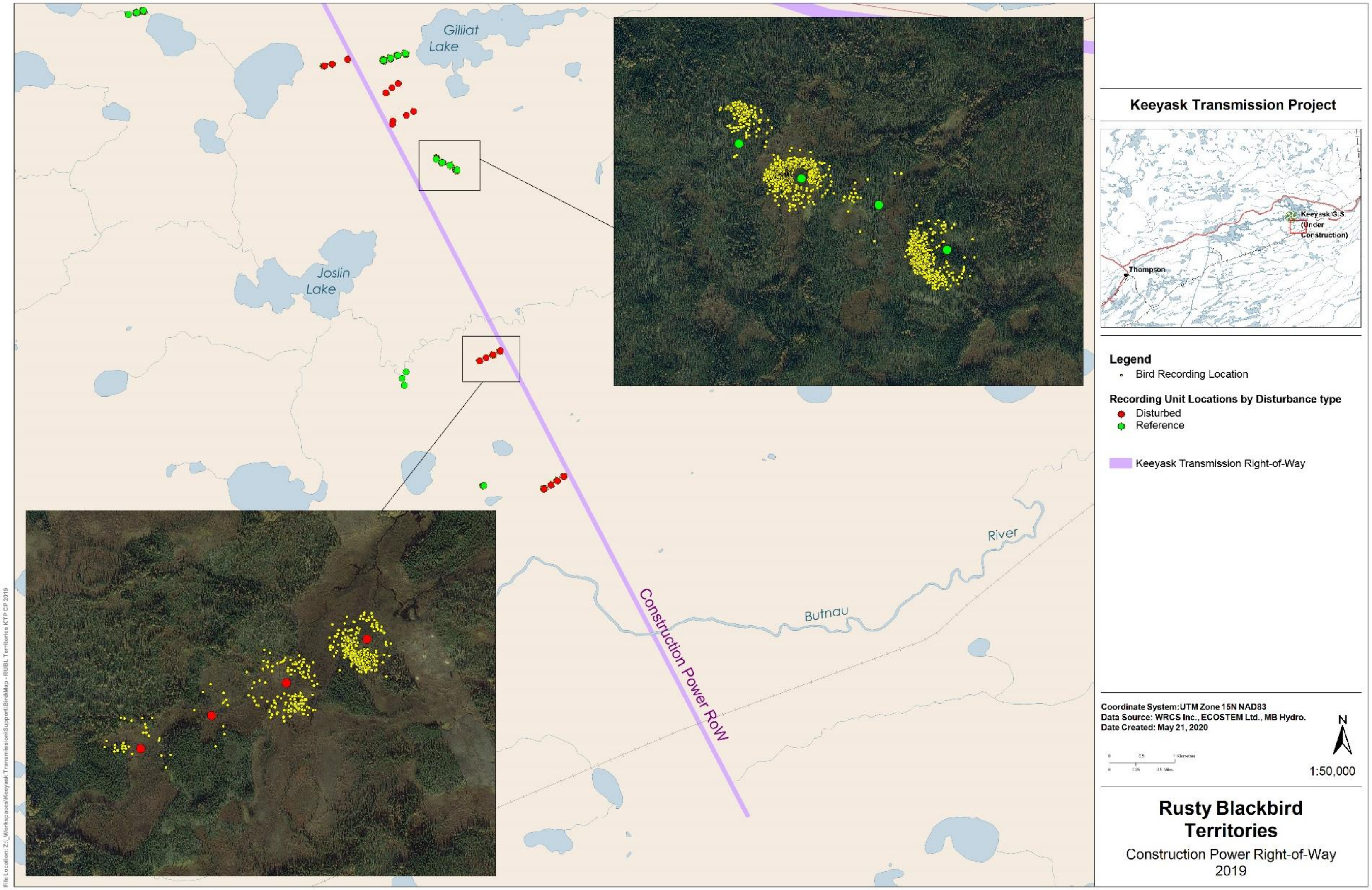
An algorithm was devised to find the peak root mean square (RMS) amplitude within each clip and convert it to a decibel value with an accurate time stamp. The four peak values were then used to triangulate the direction of the call; it was assumed that the calling bird was in the horizontal plane of the microphone array.

In the final data set, distance of the calling bird was estimated using decibel-distance curves created with field calibration recordings. Using the sound clips, distances were estimated by choosing the largest decibel value measured by the four microphones.

APPENDIX 2: OLIVE-SIDED FLYCATCHER AND RUSTY BLACKBIRD TERRITORIES 2019



Map 2-1: Olive-sided Flycatcher Territories at the Construction Power Right-of-Way, 2019



Map 2-2: Rusty Blackbird Territories at the Construction Power Right-of-Way, 2019

Available in accessible formats upon request.