Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Moose Population Estimate Report

TEMP-2022-12

KEEYASK

Manitoba Environment, Climate and Parks Client File 5550.00
Manitoba Environment Act Licence No. 3107

2021 - 2022

KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2022-12

MOOSE POPULATION ESTIMATE 2022

Prepared for

Manitoba Hydro

By

Wildlife Resource Consulting Services MB Inc.

June 2022

This report should be cited as follows:

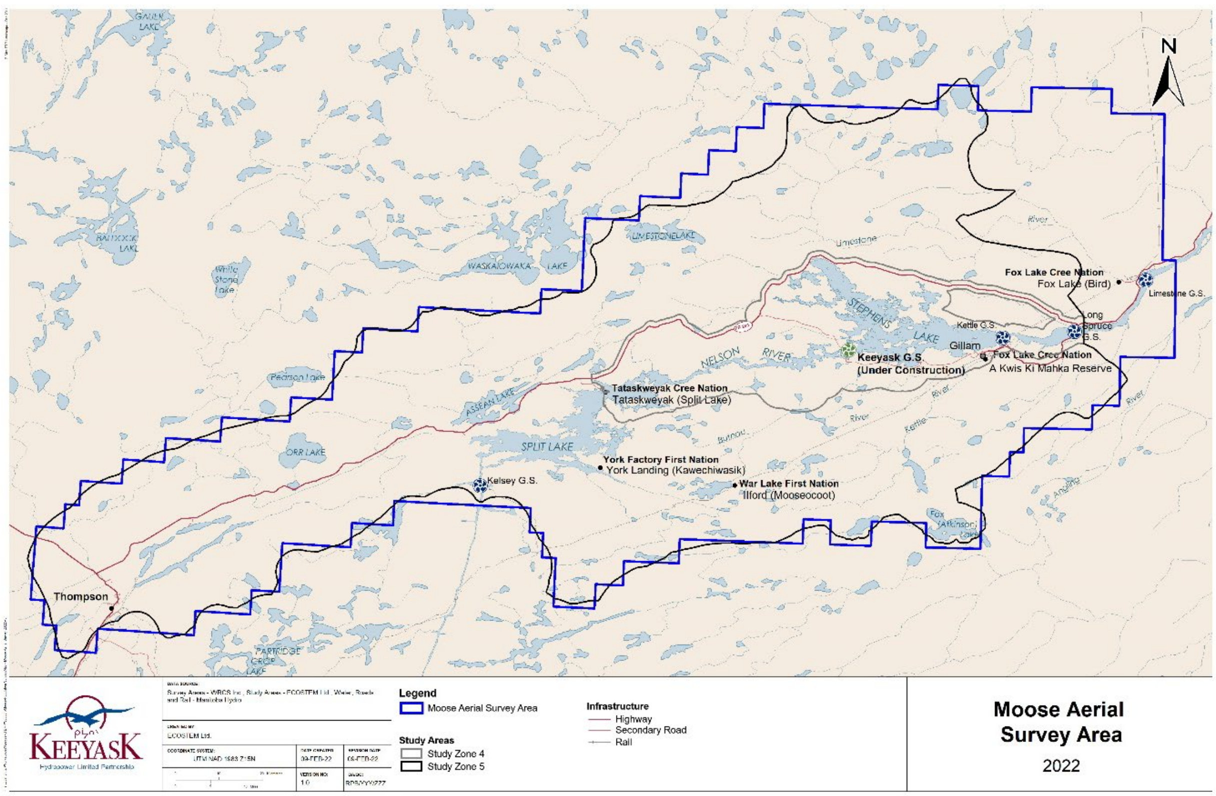
Wildlife Resource Consulting Services MB Inc. 2022. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2022-12: Moose Population Estimate 2022. A report prepared for Manitoba Hydro by Wildlife Resource Consulting Services MB Inc., June 2022.

SUMMARY

Background

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. The Keeyask Hydropower Limited Partnership (KHLP) was responsible for monitoring the effects of construction and operation of the generating station on the terrestrial environment. Monitoring results will help the KHLP, government regulators, members of local First Nation communities, and the general public understand how construction and operation of the generating station will affect the environment, and whether or not more needs to be done to reduce harmful effects.

A moose survey was designed as part of the Project's Terrestrial Effects Monitoring Plan. The objectives of the survey were to evaluate how the Project may be affecting patterns and trends in moose numbers, where moose are found, and their population structure in the Keeyask region. This report describes the results of the aerial survey conducted for moose in the winter of 2022.



Moose Survey Area in 2022 (black outline shows the Keeyask region)

Why is the study being done?

Moose are widely distributed and common in the Keeyask region. While there was a high degree of certainty for predicted effects of the Project on moose, the partner First Nations expressed concerns about Project effects on moose habitat and populations. In 2010, prior to Project construction, the number of moose in the Split Lake Resource Management Area (RMA) was counted and the population was estimated. During Project construction, moose surveys were conducted in the Keeyask region in 2015 and 2018 to monitor any changes of the moose population and their distribution that may have occurred.

What was done?

In January 2022, aerial surveys were conducted in the Keeyask region. A crew of three observers and a pilot flew regularly spaced lines over the area in a fixed-wing aircraft, recording all instances of moose tracks. The area was divided into rectangular sample units and the density of moose tracks in each unit was categorized as low, medium, or high. Following the fixed wing survey, a random sample of units from each track density category were intensively searched for moose by helicopter, with a crew of three observers and a pilot. Each moose was counted, and its basic age and sex were recorded. These counts were used to estimate the size and composition of the moose population in the Keeyask region and in the two overlapping Split Lake RMA moose management units. The ratio of bulls and calves to cows were compared with values from previous moose surveys.

Observer's View from Fixed-Wing Aircraft While Searching for Moose Tracks in 2022

What was found?

The moose population in the entire survey area was estimated at 1,119 individuals and was unevenly distributed. There were an estimated 1,007 moose in the Keeyask region, a 3% decrease since the previous survey in 2018 and a 5% increase from the 2010 pre-construction population estimate. The population structure also changed since 2010 with a lower bull to cow ratio and a higher calf to cow ratio.

Bull Moose Observed during the 2022 Aerial Survey

What does it mean?

The moose population in the Keeyask region is considered stable. Moose numbers have been relatively stable in the Keeyask region during the construction-phase surveys in 2015, 2018, and 2022, and were higher than numbers seen during the pre-construction survey in 2010. No direct, adverse effects from Project construction were found on moose abundance, distribution, or population structure. Some of the predicted adverse effects on moose from Project construction such as noise disturbance and habitat loss may have been reduced due to habitat regenerating in the area from the 2013 forest fire and a reduction in hunting pressure near the Project site.

The lower number of bulls observed in the Keeyask region does not appear to be caused by Project construction. A small increase in the number of moose hunters in the area and some increased hunting pressure along the South Access Road were noted during Project construction but would not likely account for the lower number of bulls seen in the Keeyask region. The lower number of bulls is a result of the overall hunting pressure and harvest in the entire survey area and hunters selectively harvesting bulls and leaving more cows and calves. This is an effective moose population management strategy advocated by the partner First Nations in 2013.

The lower number of bulls is not affecting moose reproduction in the Keeyask region. The number of calves produced in 2022 was high in comparison to other survey years and shows that most cows are becoming pregnant and calf survival is high.

What will be done next?

The 2022 moose survey was the final construction-phase survey for the Project. As the Project moves into the operation phase, moose population monitoring will continue approximately every three years for the next 15 years. The next moose population survey is tentatively scheduled for the winter of 2023/24.

STUDY TEAM

We would like to thank Sherrie Mason and Rachel Boone of Manitoba Hydro for their assistance and editorial contributions, 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 cartography. Biologists and other personnel who designed, participated in, and drafted the survey results included:

- Robert Berger, Wildlife Resource Consulting Services MB Inc. (WRCS) – Reporting
- Mark Baschuk, WRCS - Design, analysis, and reporting
- Kevin McRae, WRCS – Field study lead
- Levi Warkentin, WRCS – Survey personnel
- Ken DeSmet, WRCS – Survey personnel
- Timothy Kroeker, WRCS – Survey personnel
- Leslie Flett, Tataskweyak Cree Nation - Survey personnel
- Tyler Kitchekeesik, Tataskweyak Cree Nation - Survey personnel

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTOS

LIST OF APPENDICES

1.0 INTRODUCTION

Construction of the Keeyask Generation Project (the Project), a 695-megawatt hydroelectric generating station (GS) and associated facilities, began in July 2014. The Project is located at Gull Rapids on the lower Nelson River in northern Manitoba, 35 km upstream of the existing Kettle GS. In 2020, the Project’s reservoir footprint changed from terrestrial habitat to aquatic habitat due to the water-up phase and impoundment of the reservoir. Water-up occurred from February 26 to April 16, 2020 and included the transfer of water into work areas contained by temporary and permanent structures up to the prevailing upstream water levels. Reservoir impoundment, which is the flooding of the full reservoir area, occurred from August 31 to September 5, 2020. The construction phase of the Project will be completed in spring 2022 and will shift to the operation phase.

The *Keeyask Generation Project Response to EIS Guidelines* (the EIS), completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the terrestrial environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement Terrestrial Supporting Volume* (TESV). The *Keeyask Generation Project Terrestrial Effects Monitoring Plan* (TEMP) was developed as part of the licensing process for the Project. Monitoring activities for various components of the terrestrial environment were described, including the focus of this report, regional moose population estimates, during the construction phase.

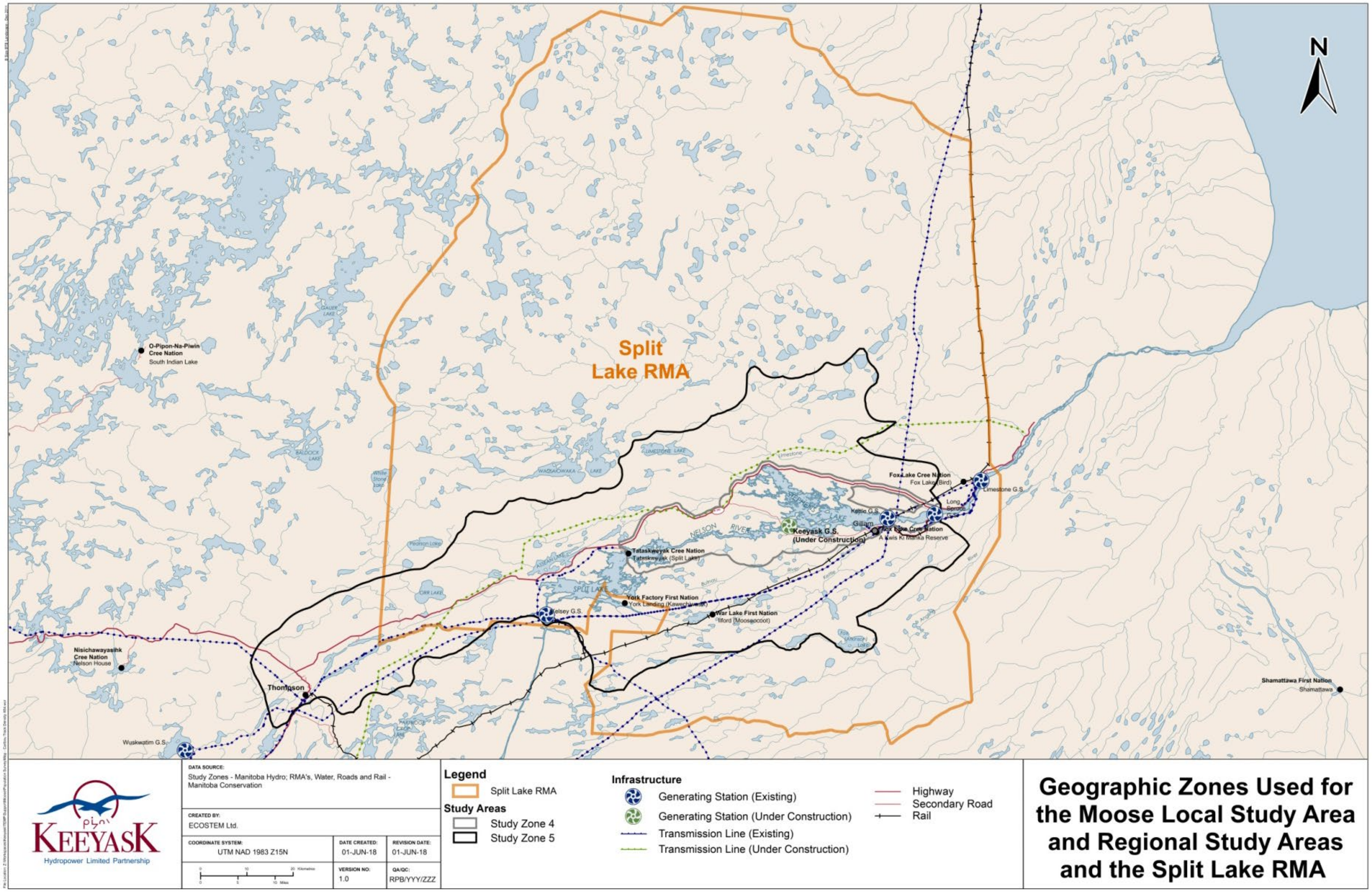
Predicted Project effects on moose in the EIS included the loss or alteration of habitat, sensory disturbance, and increased mortality due mainly to harvest and predation. Monitoring studies for moose focus in part on verifying Project effects predictions related to regional population estimates and on how moose distribution and abundance could be altered by habitat changes.

Moose are widely distributed and common in the Keeyask region. While there was a high degree of certainty for predicted Project effects on moose, the partner First Nations expressed concerns about effects on moose habitat and populations. A Moose Harvest Sustainability Plan was developed by the Cree Nation Partners (CNP; which included two of the partner First Nations - Tataskweyak Cree Nation and War Lake First Nation) in 2013 and changes in moose abundance, harvest, and habitat within seven Moose Management Units contained in the Split Lake Resource Management Area (RMA) is planned to be documented by the CNP. As outlined in Section 6.3.2 of the TEMP, the moose survey described in this report was conducted to evaluate how the Project could be affecting patterns and trends in moose distribution, abundance, and population characteristics (KHLP 2015). To that end, the size and structure of the mid-winter moose populations in Study Zones 4 and 5 were estimated (Map 1). The mid-winter moose populations in Moose Management Units 5 (Wasekanoosees) and 7 (Kitchisippi) of the CNP Moose Harvest Sustainability Plan (Map 2), which largely overlapped Study Zone 5, were also described.

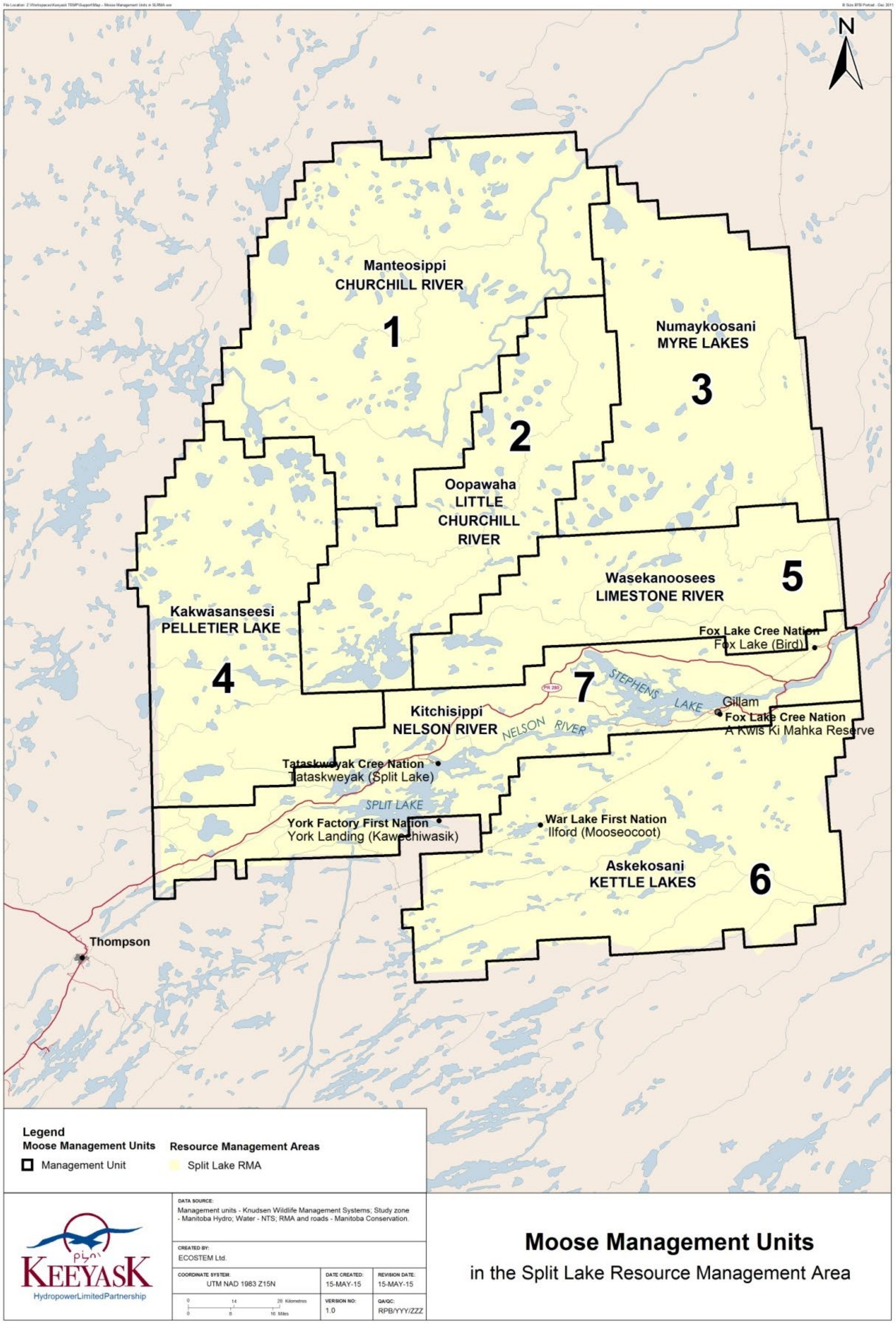
During the preparation of the EIS, prior to Project construction, a moose survey was conducted in January and February 2010 in the Split Lake Regional Management Area (RMA) (Knudsen *et* *al.* 2010). The RMA includes most of the Moose Regional Study Area (Study Zone 5). It also includes all of the Moose Local Study Area (Study Zone 4). The 2010 survey generated estimates of the moose populations in these study areas and in the RMA, which can be used for comparison with current results to quantify the trends in the number of moose in the local and regional study areas and to evaluate whether moose winter habitat use is affected by the Project.

In the winter of 2015 and 2018, a moose survey was conducted to estimate the size and structure of the mid-winter moose populations of Study Zone 5, Study Zone 4, and in Moose Management Units 5 and 7 (KWMS and WRCS 2016; KWMS and WRCS 2018). Projections were created for the size and structure of the moose population of the Split Lake RMA for the period 2010 to 2015, against which cumulative effects can be measured. This report documents a survey conducted in January 2022[1] that replicated the 2015 and 2018 surveys to monitor the ongoing status of the moose population in the Keeyask region.

[1] A moose survey was attempted in January 2021 but was cancelled due to Covid-19 safety concerns.



Map 1: **Geographic Zones Used for the Moose Local Study Area (Study Zone 4) and Regional Study Area (Study Zone 5) and the Split Lake Resource Management Area**



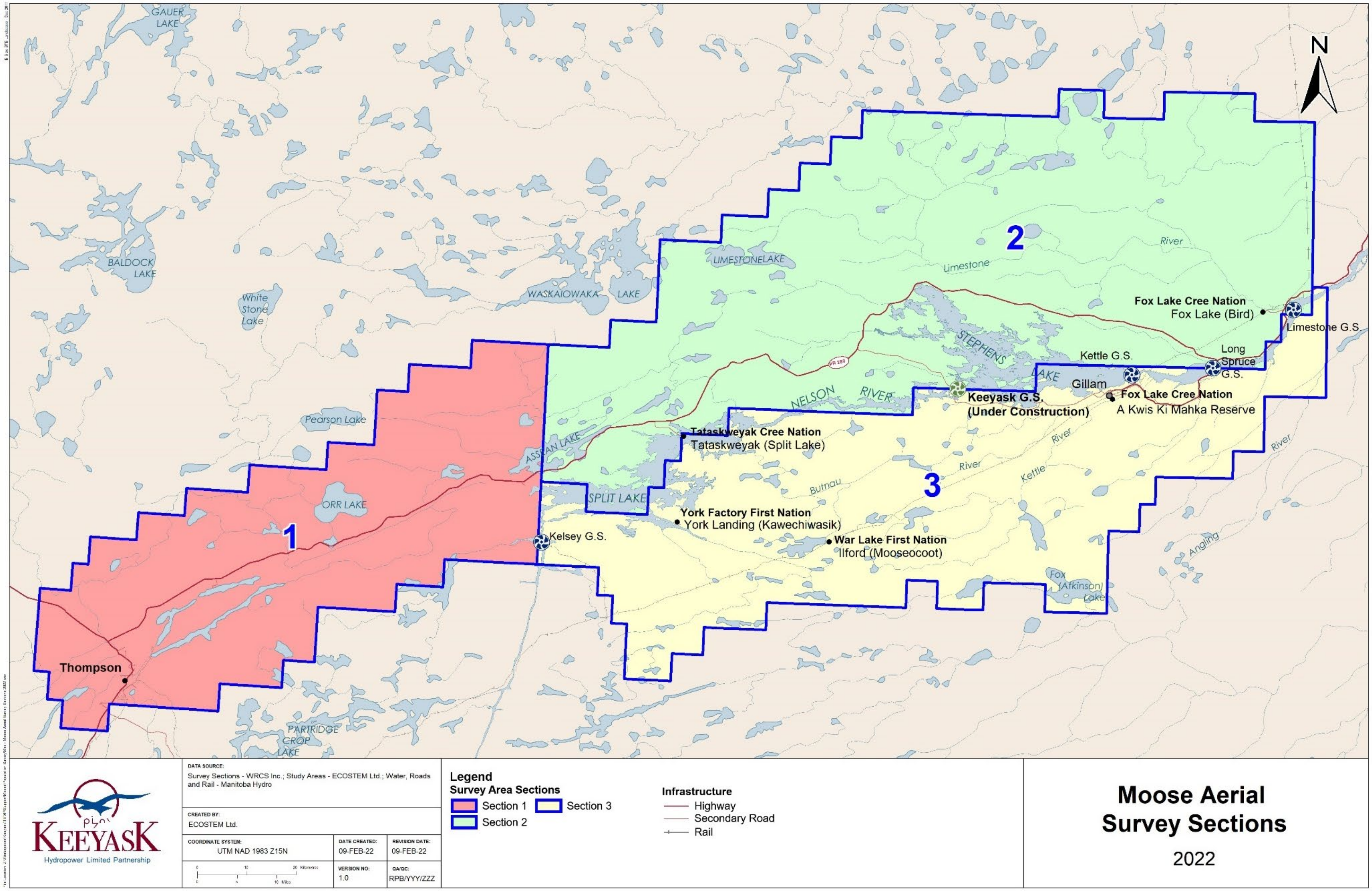
Map 2: Moose Management Units in the Split Lake Resource Management Area

2.0 METHODS

An aerial survey for moose was conducted from January 4 - 23, 2022, replicating the previous surveys conducted during the winters of 2015 and 2018 (KWMS and WRCS 2016; KWMS and WRCS 2018). The Gasaway method (Gasaway *et al.* 1986) was used to allow for an efficient population estimate of moose in the survey area. The survey consists of two main components: stratification, which uses a fixed-wing aircraft to count moose tracks and identify relative densities of moose, and sampling, which uses a helicopter to conduct an intensive search for moose within sample units. These survey components are discussed in detail in the following sections.

The survey area was divided into three sections (Map 3), each of which was surveyed as if it were a separate survey area. Boundaries were chosen to cover Study Zone 4 and 5 and align with Moose Management Units 5 and 7 (Wasekanoosees and Kitchissippi, respectively) of the Split Lake RMA. Aircraft and crew were based out of Thompson for Section 1, while Sections 2 and 3 were based out of Gillam.

The survey area was further divided into 974 sample units that aligned with a grid of three-minute cells (three minutes of latitude by three minutes of longitude). Each of these cells was approximately 3 km by 5.5 km. The width varied slightly with latitude, so the area of the cells ranged from approximately 17.5 km² in the southern portions to approximately 17.0 km² in the north.



Map 3: Moose Aerial Survey Sections

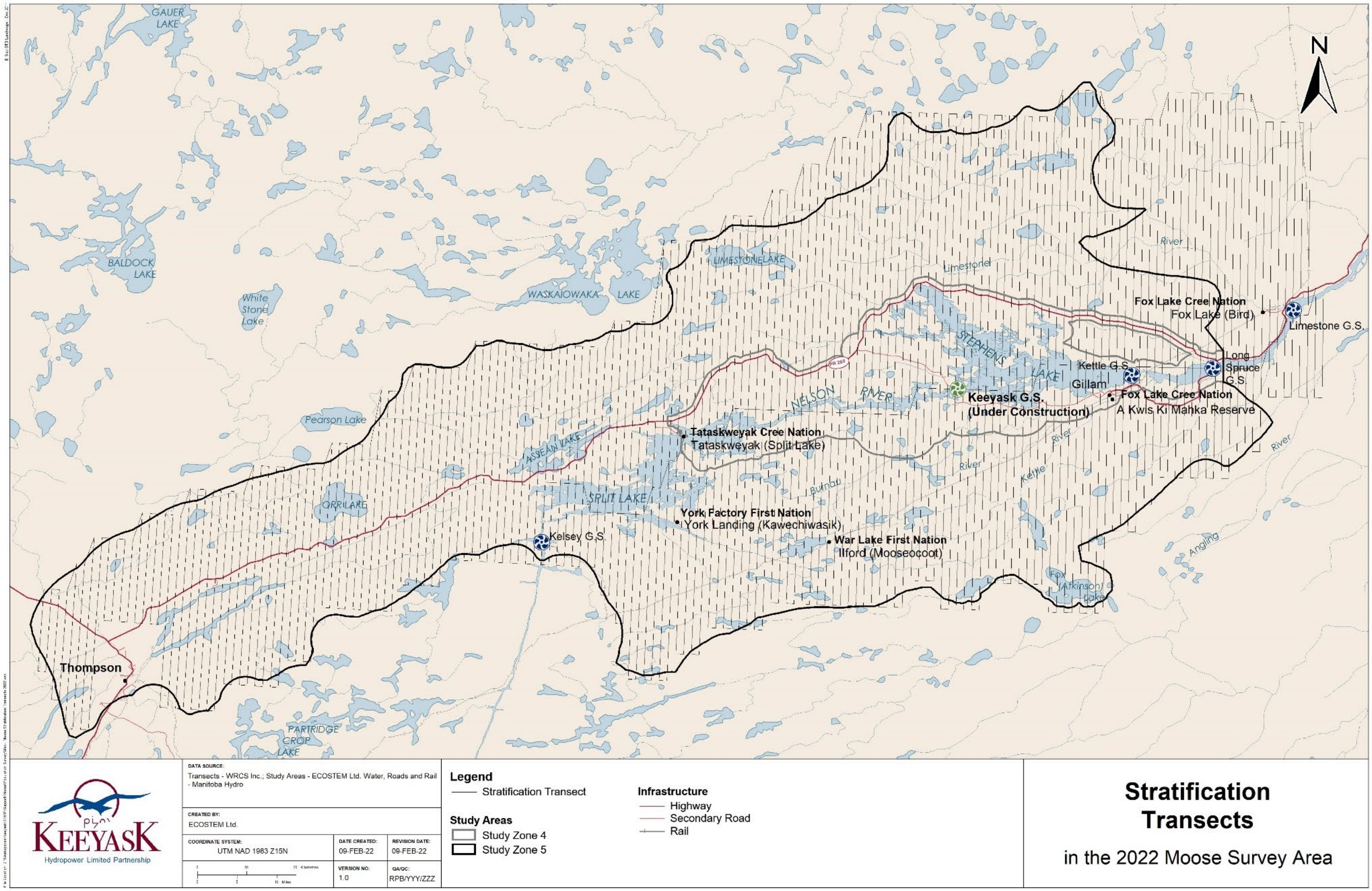
2.1 STRATIFICATION

Stratification was conducted from a fixed-wing aircraft, either a Cessna 206 or Cessna 185 (Photo 1), with three observers (one in the front seat and two in the back seats), in addition to the pilot. The aircraft followed north-south transects within each section, at approximately 160 km/hr and 100 m above ground. Both airspeed and elevation varied with factors such as wind direction and terrain. Transects were 1.5 minutes of longitude apart (approximately 1.5 km) and were arranged so that two transects were flown through each of 974 sample units (Map 4). Stratification surveys were only conducted if there was no significant snowfall the previous day and if light conditions were sufficient to allow observers to discern tracks (*i.e.,* not under flat light).

When moose tracks, or moose were observed, the observer indicated the observation to the front seat observer. The front seat observer marked the location as a waypoint with a GPS unit, and noted the waypoint number on a data sheet, along with the associated data. The relative density of caribou tracks in proximity to the observed moose track was also recorded and expressed as an approximate value (low, medium, or high; Photo 2-Photo 4).

Observed moose tracks were associated to the sample unit in which they were contained using GIS software (ArcGIS). The densities of moose tracks in the sample units were analysed using a Jenks natural classification breaks method and separated in three categories, representing high (HI), medium (MED), and low (LO) densities. Additionally, if a low density sample unit had two or more sets of tracks and shared a side with a high density sample, it was promoted to the medium strata to reflect the higher probability that it would contain moose.

Photo 1: Cessna 206 (left) and Cessna 185 (right) Fixed-wing Aircraft Used for Stratification in the 2022 Moose Survey



Map 4: Stratification Transects in the 2022 Moose Survey Area

Photo 2: Representative Pattern of Low Density Caribou Tracks

Photo 3: Representative Pattern of Medium Density Caribou Tracks

Photo 4: Representative Pattern of High Density Caribou Tracks

2.2 SAMPLING

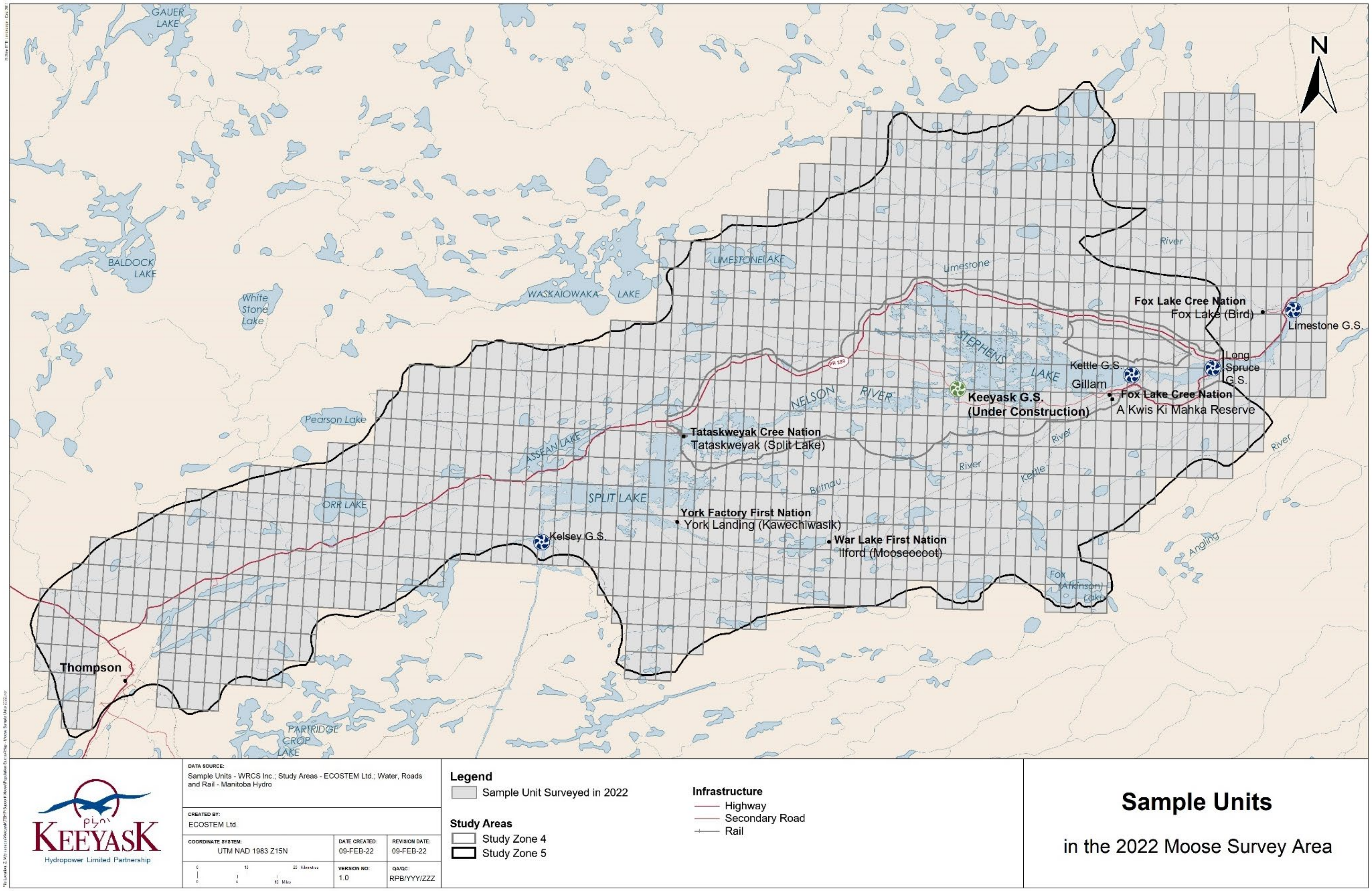
Sample units were randomly selected from each track density strata. The number of grids sampled from each strata was determined by examining the confidence intervals of the population estimates, with a precision goal of a 95% confidence interval within 25% of the population estimate (Gasaway *et al.* 1986). Sample units were not selected if they consisted of greater than 60% water or had infrastructure such as powerlines or communication towers present that were a hazard for sampling with the helicopter. Sampling was conducted using a Bell Jet Ranger helicopter with three observers (one in the front seat and two in the back seats) in addition to the pilot (Photo 6). The aircraft followed north-south transects within the sample unit, spaced 500 m apart at a height of approximately 50 m and a speed of approximately 90 km/h. The spacing resulted in six transects in each sample unit and allowed observers to scan a 250 m strip and intensively survey the sample unit for moose. When moose were sighted, the front seat observer was notified, a waypoint was taken with a GPS, and animals were classified as bull, cow, calf, or unknown age/sex. Sampling was conducted on all days with adequate visibility for detecting moose.

2.3 ANALYSES

Data analyses of the previous moose surveys conducted in 2015 and 2018 were done using the MoosePop program (Reed 1989). A modern version of the original program is available as a function for the R statistics software (R Core Team 2021). The MoosePopR() function was used to determine the population estimates, population structure, sex ratios, and calf to cow ratios. A Wilcoxon signed-rank test (α=0.05) was used to examine for differences between the 2015, 2018, and 2022 populations estimates for the entire survey area.

Upon completion of stratification, moose densities were compared between the track density strata of the different sections. Sample units from strata with similar moose densities were combined, if necessary, for the final population estimate. No sightability correction factor was used in the calculations due to the relatively low density of moose, openness of habitat, and low chances of interference of other ungulate tracks.

Following the population estimate, the number of unknown age/sex class moose were divided proportionally into the estimate according to the proportions of bulls, cows, and calves observed. The adjusted estimates of bull, cows, and calves, was then used to determine the population structure in the other subsections, including Study Zones 4 and 5, and Moose Management Units 5 and 7. Moose population estimates from the 2015, 2018, and 2022 construction surveys were compared against the 2010, pre-construction survey conducted in the Split Lake RMA to determine if the population estimates, population structure, sex ratios, and calf to cow ratios have been affected by Project construction. The moose population estimates from construction surveys were also compared against the 2015 projected sustainable population estimates produced by CNP (2013). The 2015 projected sustainable population estimates were modelled from the 2010 population estimate in the Split Lake RMA and represent the population trends in MMUs if hunter harvest is changed to maintain a sustainable population (CNP 2013).



Map 5: Sample Units in the 2022 Moose Survey Area

Photo 5: Cow and Two Calves Observed during the 2022 Moose Survey

Photo 6: Observer in Helicopter during the 2022 Moose Survey

2.4 MORTALITY

Project-related moose mortality was qualitatively assessed using information from the Project's Resource Use Monitoring Plan, which surveys workforce moose harvest and describes licensed harvest hunting pressure in the area, as well as information from Project staff on moose-vehicle collisions during Project construction.

Predation pressure was qualitatively assessed using incidental gray wolf sightings from the moose surveys conducted in 2015, 2018, and 2022, as well as from caribou aerial surveys conducted in the winters of 2013, 2016, 2019, and 2020 (LaPorte *et al.* 2013; WRCS 2016; WRCS 2019).

3.0 RESULTS

3.1 STRATIFICATION

3.1.1 MOOSE TRACKS

Moose tracks were seen in 690 of the 961 sample units that were flown during the 2022 stratification surveys (Map 6). Tracks were observed at 3,062 locations and the number of tracks per sample unit ranged from 0 to 36. The frequency distribution of track locations per sample unit is shown in Figure 1.

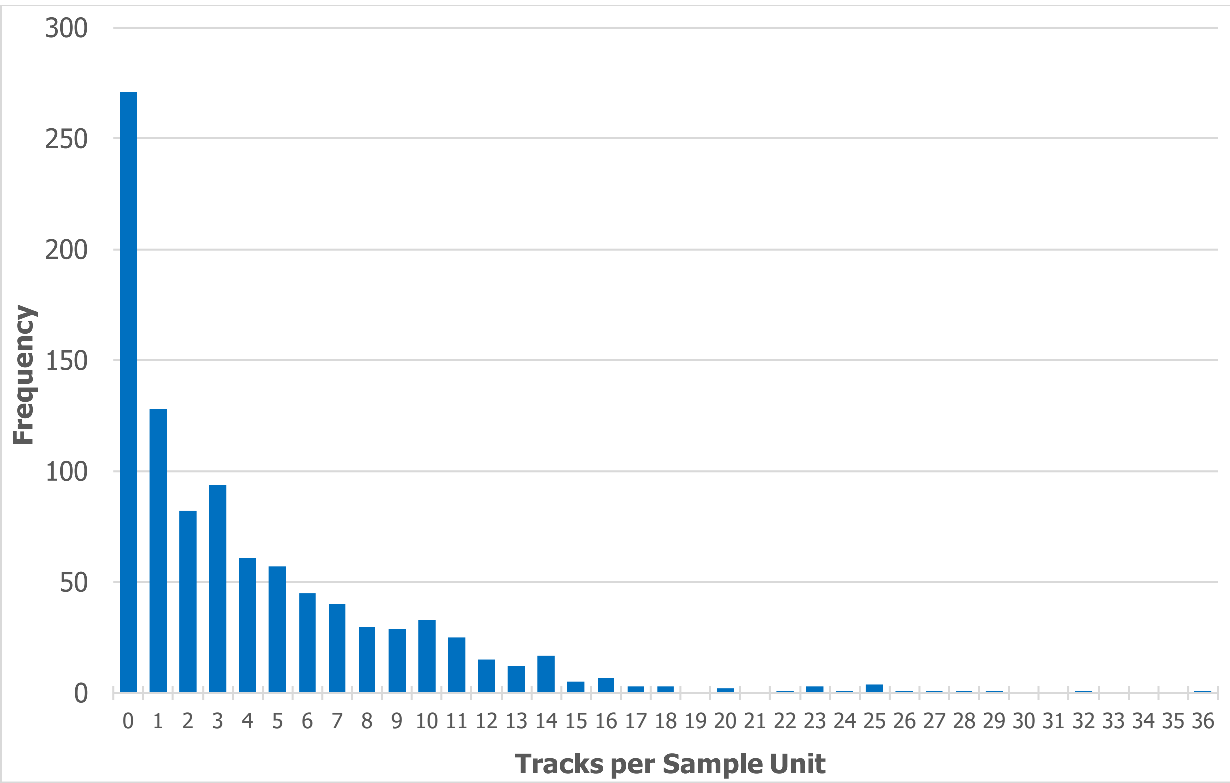


Figure 1: Frequency Distribution of Moose Track Locations per Sample Unit in 2022

All 974 sample units were assigned to a track density stratum. Like the 2015 and 2018 surveys, 13 sample units around Thompson and the Thompson airport were not included in the stratification survey due to safety concerns from air-traffic (Map 6). These sample units were assigned to the LO strata as they were unlikely to contain moose.

Mean track densities increased from the LO to HI strata as was expected (Table 1). The relatively low coefficient of variation (CV) for the MED and HI strata indicates the data are consistent (Table 1). The CV around the LO strata is higher but is mainly due the absence of tracks in a large proportion of the sample units.

Track density strata were adjusted in Section 1 sample units after combining the data from all sections. Sample units in Section 1 were initially partitioned into the three strata (HI, MED, and LO). After examination of the moose densities in these strata, the average moose densities of the HI strata in Section 1 were closer to the MED strata in Sections 2 and 3 and were adjusted accordingly. Similarly, the MED strata in Section 1 was closer to the LO strata in Section 2 and 3 and were adjusted accordingly. The moose densities in the LO strata in Section 1 were similar to Sections 2 and 3 and not adjusted.

Table 1: Comparison of Track Density Strata used in 2022

Tracks/Sample Unit	Stratum		
	LO	MED	HI
Mean	1.70	7.96	16.25
Standard Deviation	2.14	3.49	5.84
Range*	0-13	2-27	10-36
Coefficient of Variation	1.26	0.44	0.36
No. of Sample Units	671	242	61

*The range of tracks in strata appear to overlap as each section was surveyed independently and combined upon stratification completion

Caribou tracks were relatively sparse during the 2022 survey and were mainly observed along the eastern and southeastern edges of Sections 2 and 3 (Map 7). High densities of caribou tracks were only observed in three sample units and moderate densities were observed in 12 sample units in 2022 (Map 7). Overall, caribou track densities had a small impact on observers' abilities to detect and count moose tracks in 2022.

Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.

Map 6: Moose Track Locations Identified during the Stratification Survey in 2022

Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.

Map 7: Caribou Track Density in Sample Units Observed During Stratification Survey in 2022

Photo 7: Caribou Observed during the 2022 Moose Survey

3.2 SAMPLING

As in 2015 and 2018 the stratification of sample units and the optimization of effort were conducted within each of the three sections: Section 3, then Section 2, then Section 1. Within all sections there were clusters of sample units with many moose tracks, many sample units with an intermediate abundance of tracks, and large areas with almost no tracks. These three levels of track abundance were used to create three strata labelled HI, MED and LO, one of which was assigned to each sample unit. The number of sample units surveyed in each section is shown in Table 2.

Table 2: Number and Stratum Density of Sample Units Surveyed in each Section in 2022

Section	Stratum			Total
	LO	MED	HI	
1	27	3	0	30
2	17	15	13	45
3	7	14	14	35
Total	51	32	27	110

Figure 2 shows the relationship between track densities and the number of moose observed in the different sample unit strata. The HI strata sample units more frequently contained higher numbers of moose, with lower numbers observed in the MED and LO strata sample units, as anticipated (Figure 2).

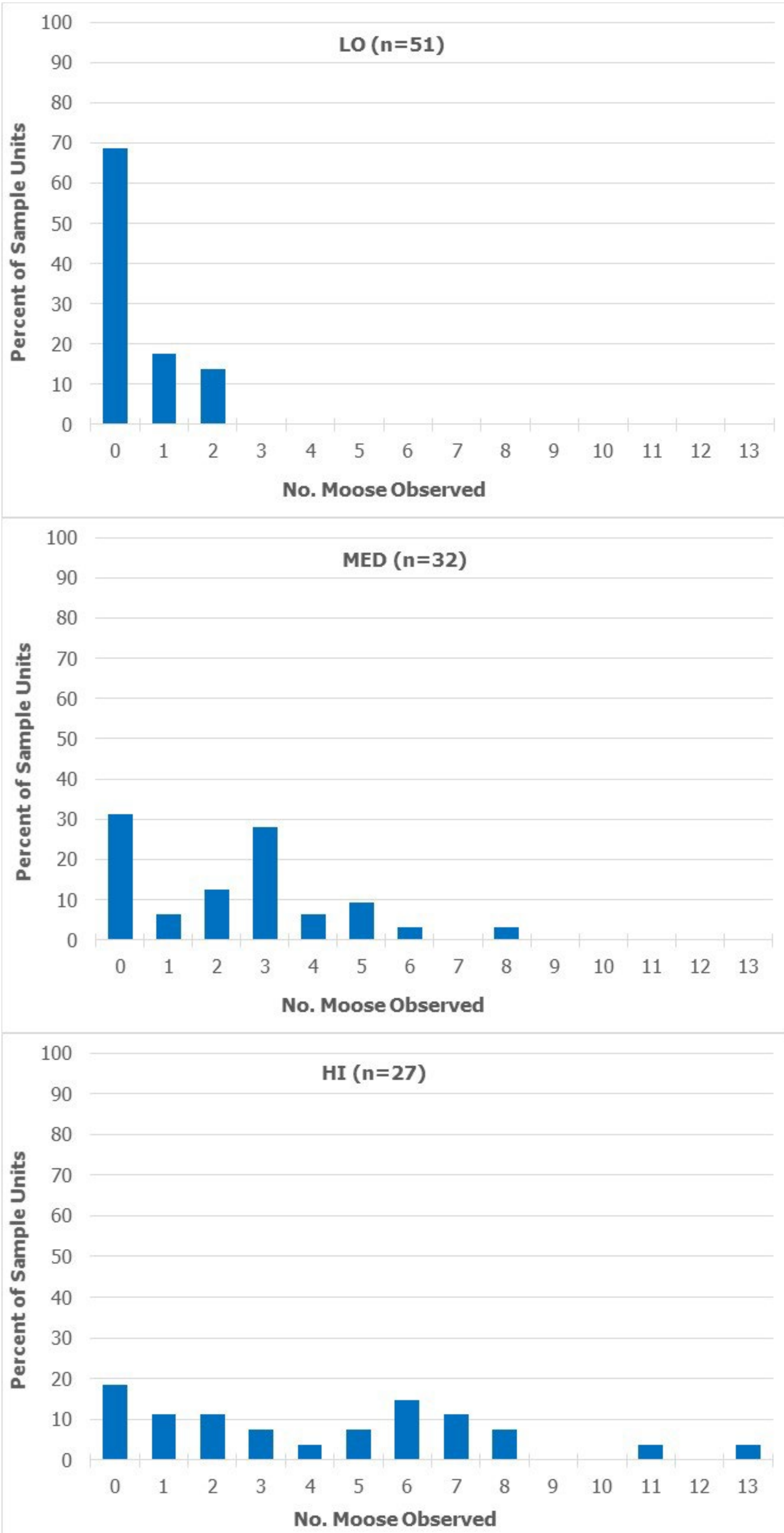


Figure 2: Frequency Distribution of Moose Observed in the Sample Unit Strata in 2022

3.3 POPULATION ESTIMATES

3.3.1 POPULATION ESTIMATE OF ENTIRE SURVEY AREA

The population estimate for the entire survey area is 1,119 moose, with a 95% confidence interval of ±19% (903-1,335 moose). The distribution of the population is provided in Map 8 and the complete model output is provided in Appendix 1.

A total of 211 moose were observed in the 110 sample units surveyed in 2022 (Table 3). Most moose observed, and the highest densities of moose, occurred in the HI density sample units as anticipated. The number of moose and densities decreased in the MED and LO density sample units (Table 3). The majority of the estimated population occurred within the MED density sample units, and the remaining estimated population was split between the LO and HI density sample units in the survey area (Table 3).

Table 3: Summarized Moose Population Estimate for the Entire Survey Area in 2022

	Stratum			Total
	LO	MED	HI	
No. sample units	671	242	61	974
Total area (km²)	11,577	4,162	1,052	16,791
Sample size	51	32	27	110
Percent of samples	46	29	25	100
Sampling intensity (%)	8	13	44	11
Area surveyed (km²)	881	551	465	1,897
Moose observed	23	74	114	211
Density (per 100 km²)	3	13	25	11
Estimated population	302	559	258	1,119

The moose population estimate for 2022 is similar to the 2018 estimate (1,159 moose) and lower than the 2015 estimate (1,349 moose), with all years having overlapping 95% confidence interval estimates (Figure 3). The difference between the 2022 moose population estimate was not significantly different from the 2018 estimate (P=0.09), but it was significantly different from the 2015 estimate (P=2.63E-17).

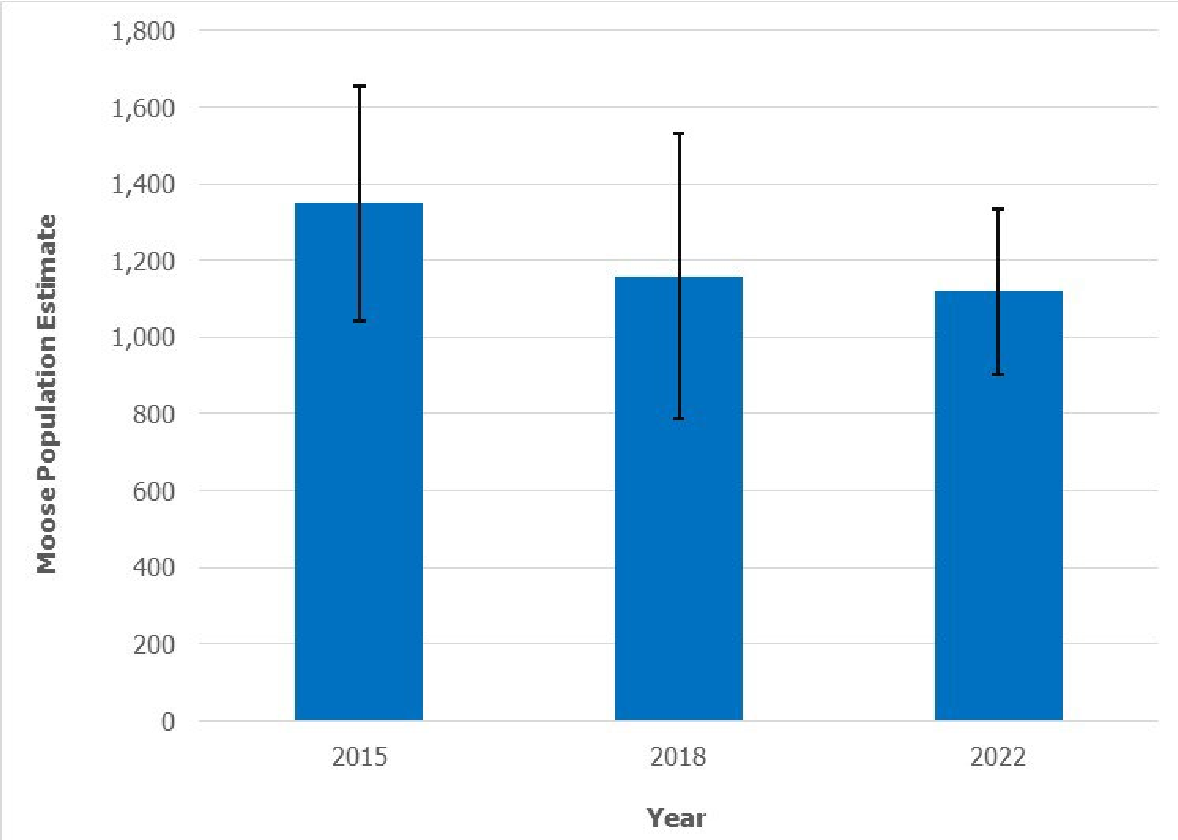


Figure 3: Comparison of Moose Population Estimates during Construction-phase Surveys from 2015, 2018, and 2022. Note: the error bars show the 95% confidence interval estimates

Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.

Map 8: Moose Densities in the Entire Survey Area in 2022

3.3.2 POPULATION STRUCTURE OF ENTIRE SURVEY AREA

Moose density ranged from 3 moose/100 km² in the LO strata to 25/100 km² in the HI strata (Table 4). The overall density of moose in the survey area in 2022 (7/100 km²) (Table 4) was lower than that observed in 2015 (8/100 km²) and identical to 2018 (7/100 km²) (KWMS and WRCS 2016; KWMS and WRCS 2018).

The ratio of 38 bulls/100 cows in 2022 (Table 4) was relatively low in comparison to 2015 (50 bulls/100 cows), but higher than in 2018 (29 bulls/100 cows) (KWMS and WRCS 2016; KWMS and WRCS 2018).

The ratio of 55 calves/100 cows in 2022 (Table 4) was higher than both 2015 (51 calves/100 cows) and 2018 (49 calves/100 cows) (KWMS and WRCS 2016; KWMS and WRCS 2018).

Table 4: Summarized Estimates of Population Structure for the Entire Survey Area 2022*

Estimate	Stratum			Total	95% Confidence Interval (±%)
	LO	MED	HI		
No. Bulls	79	83	47	209	39
Bull Density (individuals/100 km²)	1	2	5	1	-
No. Cows	145	272	131	548	23
Cow Density (individuals/100 km²)	1	7	13	3	-
No. Calves	66	166	68	300	29
Calf Density (individuals/100 km²)	1	4	7	2	-
No. Unknowns	13	38	11	62	70
Unknown Density (individuals/100 km²)	<1	1	1	<1	-
Total Population	302	559	258	1,119	19
Total Density (individuals/100 km²)	3	13	25	7	-
Bulls/100 Cows	55	31	36	38	45
Calves/100 Cows	46	61	52	55	25

* Densities are rounded to the nearest integer to facilitate comparisons

Eleven observed moose (5%) were classified as unknown age/sex class, and therefore in the estimated total population of 1,119 there were 62 moose labelled as unknown. This information is a useful indicator of the degree to which observers could confidently assign moose to an age/sex class, but all of these moose are bulls, cows or calves. The proportions within this group are not known however, and in the absence of any further information, it was assumed that the unknowns had the same composition as the rest of the population: 18.0% bulls, 49.8% cows and 27.0% calves. After the unknowns were partitioned and added to the other three age/sex classes, the population of 1,119 moose was estimated to have 221 bulls, 580 cows and 318 calves.

3.3.3 POPULATION ESTIMATES OF SUBSECTIONS

The moose population was estimated to be 1,007 individuals in Study Zone 5, a decrease of 3% compared to 2018 and an increase of 5% over the 2010 estimate (Table 5; Figure 4). Similarly, the moose population estimate in Study Zone 4 showed a decrease of 13% in 2022, compared to 2018, but was an increase of 36% over the 2010 estimate (Table 5; Figure 4).

The bull/cow ratios observed in 2022 in the entire survey area and all subsections were greater than the bull/cow ratios observed in 2018, and less than the bull/cow ratios observed in 2015 (Table 6). It was also much lower than the bull/cow ratios observed in the Split Lake RMA and Moose Management Units 5 and 7 in 2010 (Table 6).

The calf/cow ratios observed in 2022 in the entire survey area and all subsections were greater than those observed in the same areas in 2018, 2015, and 2010 (Table 6).

Table 5: Moose Populations Estimates of Subsections

Subsection	2022				Total 2010	Total 2015	Total 2018	% Change 2018-2022	% Change 2010-2022
	Bulls	Cows	Calves	Total					
Study Zone 5	198	523	286	1,007	961	1,162	1,040	-3	5
Study Zone 4	33	88	49	170	125	176	196	-13	36
Moose Management Unit 5	64	179	101	345	369	451	314	10	-7
Moose Management Unit 7	74	187	101	362	337	446	395	-8	7

Table 6: Moose Population Structure Estimates of Subsections

Subsection	2010		2015		2018		2022	
	Bulls/100 cows	Calves/100 cows	Bulls/100 cows	Calves/100 cows	Bulls/100 cows	Calves/100 cows	Bulls/100 cows	Calves/100 cows
Entire Survey Area (*Split Lake RMA)	118*	36*	50	51	29	45	38	55
Study Zone 5	-	-	51	50	29	44	38	55
Study Zone 4	-	-	51	49	28	43	38	56
Moose Management Unit 5	120	31	52	51	29	46	38	56
Moose Management Unit 7	111	38	51	50	27	44	40	54

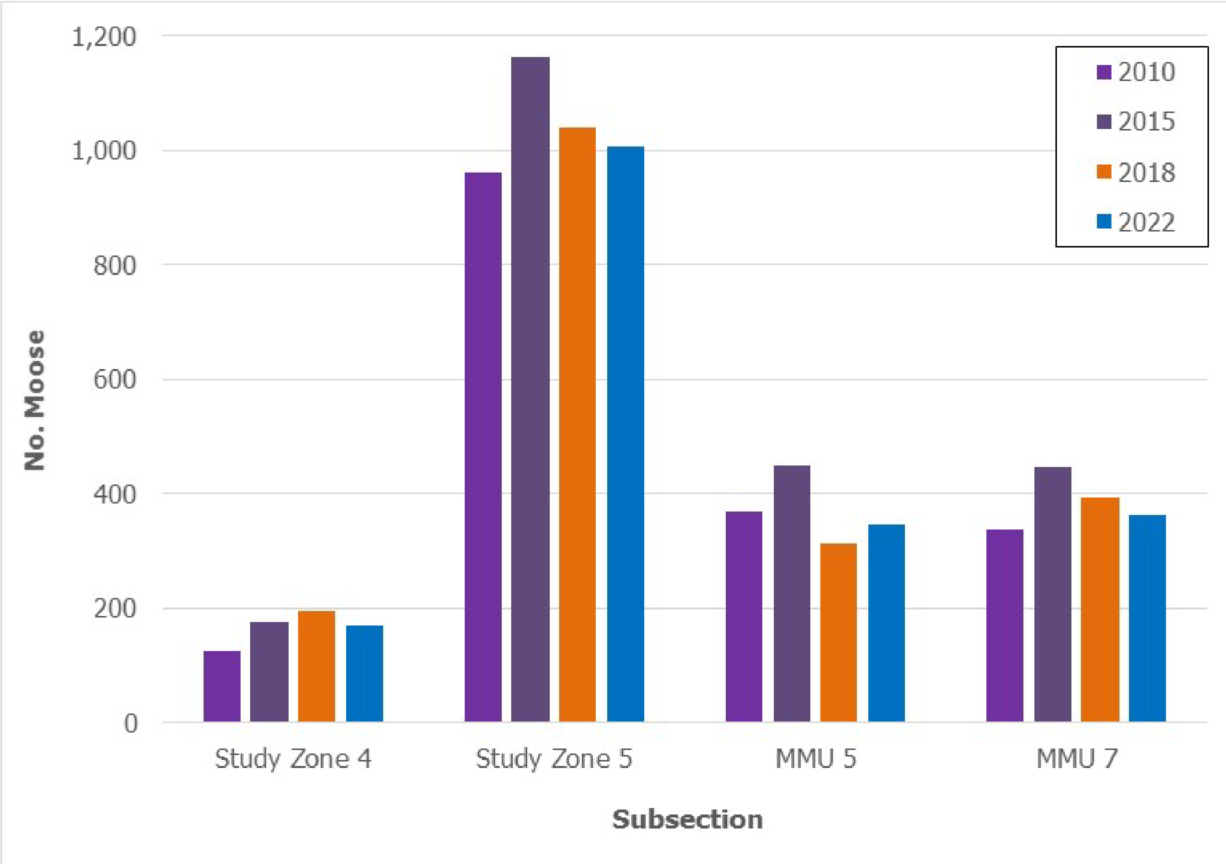


Figure 4: Number of Moose Observed in Subsections in 2010, 2015, 2018, and 2022

The population estimate for MMU 5 in 2022 was higher than the estimate for 2018, but lower than the estimates for 2015, the 2015 projected sustainable, and the 2010 estimate (Table 7; Figure 4) (Knudsen *et al.* 2010; CNP 2013). The number of calves estimated was higher than the 2010 estimate and similar to the 2015 projected sustainable estimate (Table 7).

The population estimate for MMU 7 in 2022 was higher than the estimate for 2010 and the 2015 projected sustainable estimate, but lower than the estimate for 2015 and 2018 (Table 8; Figure 4) (Knudsen *et al.* 2010; CNP 2013). The number of cows and calves in the 2022 estimate was higher than the estimate for 2010 and the 2015 projected sustainable (Table 8).

Table 7: Moose Population in Management Unit 5: Wasekanoosees*

	2010	2015 Projected Sustainable	2015	2018	2022
Bulls	176 (48%)	96 (23%)	116 (26%)	52 (17%)	64 (19%)
Cows	147 (40%)	217 (52%)	222 (49%)	180 (57%)	179 (52%)
Calves	46 (12%)	102 (25%)	113 (25%)	83 (26%)	101 (29%)
Total moose	369	414	451	314	345
Density: 8/100 km²					

* Total area = 4,269 km²

Table 8: Moose Population in Management Unit 7: Kitchissipi*

	2010	2015 Projected Sustainable	2015	2018	2022
Bulls	154 (46%)	76 (22%)	113 (25%)	62 (16%)	74 (20%)
Cows	133 (39%)	178 (53%)	222 (50%)	232 (59%)	187 (52%)
Calves	50 (15%)	84 (25%)	112 (25%)	101 (26%)	101 (28%)
Total moose	337	338	446	395	362
Density: 6/100 km²					

* Total area = 6,207 km²

Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.

Map 9: Moose Densities in Study Zones 4 and 5 in 2022

Note: This map has been removed due to the sensitive nature of the information. This map will be provided to the regulators, but will not be included in the version of the report that is publicly available.

Map 10: Moose Densities in Moose Management Unit 5 (Wasekanoosees) and Unit 7 (Kitchisippi) in 2022

3.4 MORTALITY

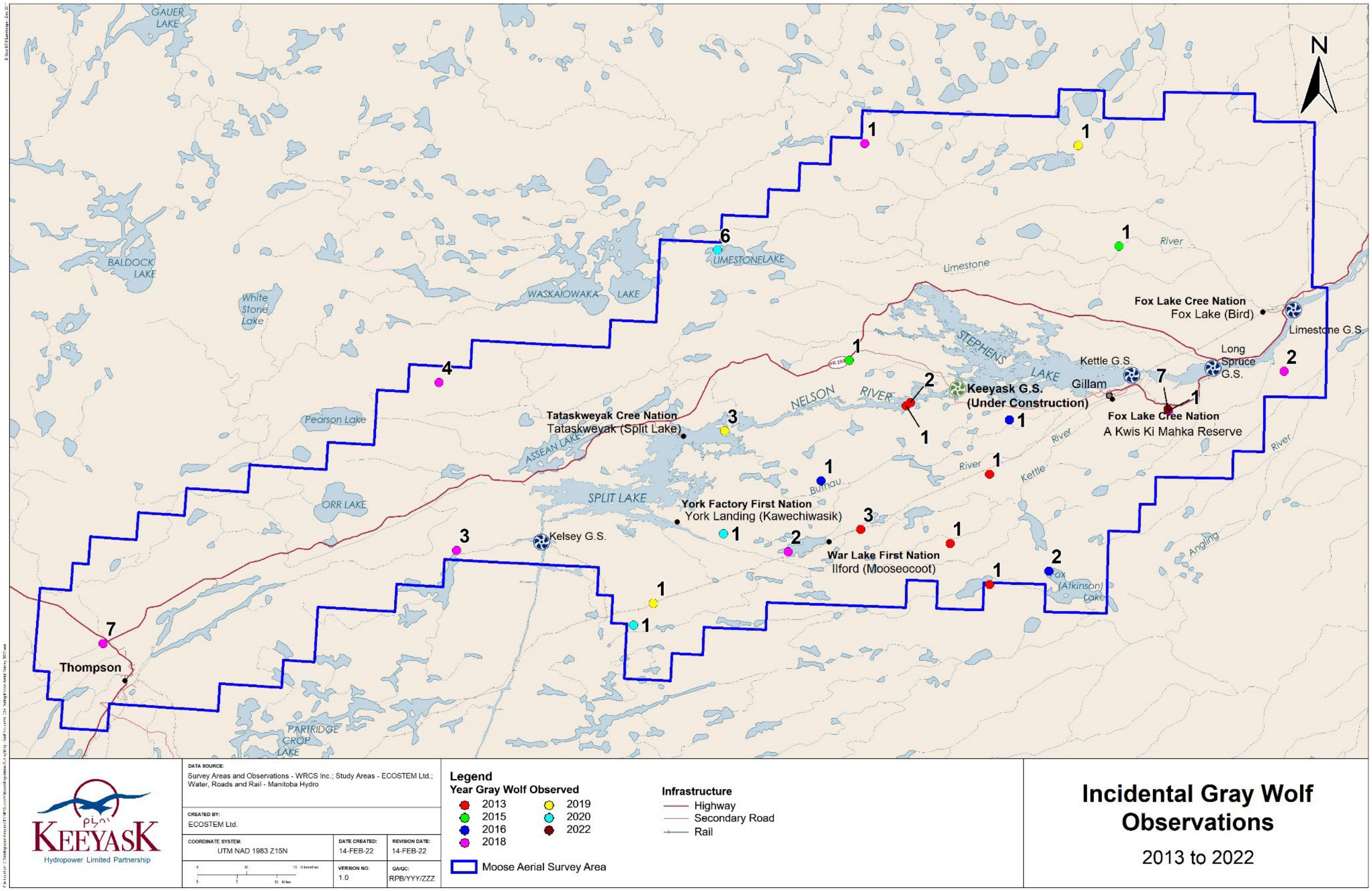
The Project's Resource Use Monitoring Plan reporting suggests that during most years of construction the number of local, licensed hunters and workforce hunters was stable and did not increase due to the Project (Eaton 2015; Eaton 2016; Eaton and Bretecher 2017; Mazur and Eaton 2019). However, in 2019 an increased demand for moose licenses and a small increase in hunting activity were noted due to Project workers making connections with local residents (Assuah and Eaton 2020). An increase in hunting pressure along the public portion of the South Access Road and associated trails was also noted as the security gate along the road was moved closer to the Project site (Assuah and Eaton 2020). Overall, the surveys found that 26 moose were harvested by workforce hunters - three in 2014, four in 2015, two in 2016, 10 in 2018, and seven in 2019 (no survey was conducted in 2017; Assuah and Eaton 2020). Additionally, one moose mortality, caused by a vehicle collision, was recorded on the Project site in 2019.

Gray wolf numbers observed during aerial surveys for caribou and moose were variable annually (Table 5). The greatest number of gray wolves observed (20) were seen during the 2018 moose aerial survey and coincided with large numbers of migratory caribou in the survey area. Most gray wolf observations were made south of the Nelson River in Section 3 of the moose survey area (Map 11).

Photo 8: Two Gray Wolves Observed during an Aerial Survey in 2019

Table 9: Gray Wolf Numbers and Number of Groups Observed in the Moose Survey Area during Various Caribou and Moose Aerial Surveys from 2013-2022

Year	No. Wolves	No. Groups
2013	9	6
2015	2	2
2016	4	3
2018	20	7
2019	5	3
2020	8	3
2022	7	1
Total	55	25



Map 11: Gray Wolf Observations made during Various Caribou and Moose Aerial Surveys from 2013-2022

4.0 DISCUSSION

The moose population in the entire survey area showed a decrease from 2015 to 2018 and has remained stable into 2022. Moose population estimates from Study Zones 4 and 5 suggest that construction activities at the Project site did not have a large impact on moose populations in these areas as numbers remained relatively stable in both areas during the construction-phase surveys in 2015, 2018, and 2022, and overall, were higher than the estimates produced during the pre-construction survey in 2010.

Project construction was estimated to cause the loss or alteration of 12,116 ha, or approximately 1%, of the moose habitat in Study Zone 5 (KHLP 2015). Despite these changes to moose habitat, the moose populations in Study Zones 4 and 5 remained relatively stable during the construction period. The changes in moose habitat along with any sensory disturbance caused by the Project may have been countered by the regeneration of habitat from the large forest fire that occurred in the area in 2013, and the reduction of harvest pressure in the area due to the restricted access to the construction site and the prohibition of hunting by site staff.

Moose may have moved into Study Zones 4 and 5 following the forest fires in 2013, accounting for some of the population increase observed from 2010 to 2015. Moose may return to burned areas shortly after a fire, with population increases in the first two years (Peek 1974). As vegetation regenerates, particularly deciduous vegetation, it provides good moose forage (Weixelman *et al.* 1998; Lord and Kielland 2015), particularly after 11 to 30 years following a fire (Kelsall *et al.* 1977 in Peek 2007). Supported by the regenerating food source, moose density typically peaks 11 to 30 years post-burn (Maier *et al.* 2005).

The reduction of harvest pressure near the Project may have made the area, particularly in Study Zone 4, more attractive for moose and may have facilitated greater survival and recruitment of calves. Moose densities can increase quickly in an area following hunting closures. In Ontario, a 154 km^2 area was closed to hunting for five years and moose densities increased from 0.10 moose/km^2 to 0.37 moose/km^2 (Eason 1985). Similarly, in Manitoba, a 62 km^2 area was closed to hunting for seven years and moose densities increased from 0.6 moose/km^2 to 2.3 moose/km^2 (Crichton *et al.* 2004). With restricted access to the Project site and the prohibition of hunting by site staff since construction started in 2014, it is possible that the local moose population responded favourably due to decreased mortality.

The ratio of bulls to cows in Study Zones 4 and 5 during the construction-phase surveys (28-51:100) was considerably lower than the ratio in the Split Lake RMA in 2010 (118:100). In 2010, the high ratio of bulls to cows was considered a surplus and indicated that too many cows were being harvested (CNP 2013). The current numbers of bulls now suggest the opposite is occurring, with more bulls being harvested in comparison to cows. The selective harvesting of bulls advocated in the Moose Harvest Sustainability Plan (CNP 2013) could have accounted, at least in part, for the change in the population structure.

The current bull to cow ratio in the survey area and other subsections is lower than the management objectives recommended by several provinces for a sustainable moose population. British Columbia recommends a minimum of 50 bulls:100 cows in low density (<200/1,000 km²) moose populations (MFLNRO 2015). Ontario recommends 67 bulls:100 cows (40:60), and Saskatchewan recommends approximately 90 bulls:100 cows (OMNR 2009; SME 2015). However, the current bull to cow ratio is within the range of 30 bulls:100 cows recommended in the Yukon (Environment Yukon 2016; Jessup *et al.* 2014).

The relatively low bull to cow ratio in the survey area and other subsections is likely related to an increase in the number of bulls harvested. The relatively small changes in hunting pressure and harvest noted in the Resource Use Monitoring Plan reporting by the workforce, and accidental mortality from the Project, would not likely account for the relatively large changes in the number of bulls from 2010 to 2022. The changes in the sex ratio likely reflect the overall hunting pressure in the entire survey area.

Although the ratio of bulls to cows has decreased since 2010, it appears that there are still a sufficient number of bulls to keep the pregnancy rate high. Given that the mortality of moose calves is extremely high in the first three months of life, the estimate of 55 calves per 100 cows in the 2022 survey indicates that a very high percentage of cows were pregnant in 2021. A greater proportion of females in a population can result in greater recruitment rates (Courtois and Lamontagne 1999; Solberg *et al.* 1999; Solberg *et al.* 2000; Sæther *et al.* 2001; Milner *et al.* 2007) because a single bull can impregnate more than one cow in a breeding season (Schwartz 2007). However, if the density of bulls becomes too low, some cows may not be impregnated, and recruitment may decrease.

Other factors that may influence the moose population include predation and habitat availability. Predators such as black bears and gray wolves can take 50% or more of moose calves born each spring (Ballard and Van Ballenberghe 2007; Schwartz 2007). Gray wolves are infrequently observed during aerial surveys in the area and are likely underrepresented in these surveys as they are difficult to detect. The incidental observations made from 2013-2022 suggests that gray wolves may be more abundant south of the Nelson River, in Section 3 of the moose survey area. This is likely due to a relatively high density of moose in the area and the occasional passage of large numbers of migratory caribou.

Migratory caribou, that occasionally occupy the area, may influence the gray wolf population by providing a source of alternative prey. Generally, the presence of caribou in the survey area is sparse (KHLP 2012), but during the winters of 2013, 2018, and 2019 large numbers of migratory caribou were present in the survey area (LaPorte *et al.* 2013; WRCS 2016; WRCS 2019). These influxes of caribou could have resulted in resident wolves shifting from moose to the more abundant caribou. In southeastern British Columbia, gray wolf diets switched from moose to caribou in summer when moose, caribou, and wolves occupied the same areas (Seip 1992). In Alaska, gray wolves switched from moose to a diet that was almost entirely caribou when a migratory herd moved into their territory (Ballard *et al.* 1997 in CNP 2013). In the short term, such a shift in gray wolf diets could have resulted in reduced predation on moose and an increased birth rate in the following year. Alternatively, if migratory caribou regularly enter the area as they did for two consecutive winters (2017/18 and 2018/2019) the abundance of caribou prey could subsidize gray wolf diets, increasing gray wolf populations and resulting in greater predation rates on moose (Barber-Meyer and Mech 2016; Latham *et al.* 2011).

Changes in habitat availability could have contributed to the moose population variations in the entire survey area from 2010 to 2022. A changing mosaic of recently burned and older, regenerating areas could have resulted in shifts in carrying capacity and moose distribution (e.g., Lord and Kielland 2015) within and beyond Study Zone 5.

The moose population in MMU 5 increased slightly from 2018 to 2022, but the numbers of bulls and cows remain below the 2015 projected sustainable estimates and below the 2010 estimates. The number of calves, however, is only slightly below the 2015 projected sustainable estimate and more than double the 2010 estimate. These changes are likely driven by harvest, predation, and habitat availability, with little influence from Project construction.

The moose population in MMU 7 has generally followed the population variations observed in the entire survey area and in Study Zone 5. Moose density in this area (6/100 km^2) was lower in comparison to MMU 5 (8/100 km^2), but the overall population estimate for 2022 was greater than the 2010 estimate and the 2015 projected sustainable estimate. However, the number of bulls in 2022 (74) was much lower than the 2010 estimate (154) and slightly lower than the 2015 projected sustainable (76). The amount of road access, trails, and transmission lines in MMU 7 likely result in greater harvest pressure in comparison to MMU 5 and contributes to the lower moose density in the area. The decrease in the number of bulls is likely related to harvest in the area, but the high number of calves present suggests reproduction is not being affected.

5.0 SUMMARY AND CONCLUSIONS

The overall moose population in the moose aerial survey area was higher at the end of the Project construction period compared to pre-construction numbers in 2010. During Project construction the moose population was highest in 2015, decreased in 2018, and remained stable into 2022. Construction of the Project did not have a large impact on moose populations as shown by the consistent number of moose observed In Study Zones 4 and 5 during this time. Effects of habitat loss and sensory disturbance from Project construction may have been reduced due to a combination of the regeneration of burned habitat in the area, particularly forage, following the 2013 forest fire, and reduced hunting pressure from access restrictions in place at the Project construction site.

The population structure of moose in the Keeyask region has changed since 2010 with a large decrease in the number of bulls present. The reduced number of bulls does not appear to be caused by Project construction as the decline extends well beyond the Project footprint. A small increase in the number of moose hunters in the area and some increased hunting pressure along the public portion of the South Access Road were noted during Project construction but would not likely account for the lower number of bulls seen in the Keeyask region. The lower number of bulls is a result of the overall hunting pressure and the selective harvest of bulls in the entire survey area.

Despite the lower number of bulls in the population, the pregnancy rate of cows has remained high. The number of calves produced per cow observed in 2022 was high, suggesting enough bulls are present to impregnate cows and calf survival is relatively high.

The moose population in MMU 5 and 7 generally follow the population variations seen in the entire survey area. In MMU 5 the number of bulls and cows are below the 2015 projected sustainable estimates, but the number of calves is high. In MMU 7 the number of bulls is also below the 2015 projected sustainable estimate, but the number of calves is high. In both these areas the selective harvest of bulls is likely driving the population structure.

As the Project moves into the operation phase, moose population monitoring will continue approximately every three years for the next 15 years. The next moose population survey is tentatively scheduled for the winter of 2023/24. The survey will be coordinated with any aerial surveys for moose being done within the Split Lake RMA to support the Moose Harvest Sustainability Plan (CNP 2013).

6.0 LITERATURE CITED

Assuah, A. and G.J. Eaton, 2020. Resource Use Monitoring: Year 6 Construction. Keeyask Generation Project Resource Use Monitoring Report #RUMP-2020-01. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2020, vii+32 pp.

Ballard, W.B. and Van Ballenberghe, V. 2007. Predator/prey relationships. In Ecology and management of the North American moose. Edited by A.W. Franzmann and C.C. Schwartz. University Press of Colorado, Boulder, CO. 247–273 pp.

Barber-Meyer, S.M and L.D. Mech. 2016. White-tailed deer (*Odocoileus virginianus*) subsidize gray wolves (*Canis lupus)* during a moose (*Alces americanus*) decline: A case of apparent competition? Canadian Field Naturalist 130: 308-314.

CNP (Cree Nation Partners). 2013. Moose Harvest Sustainability Plan September 2013 Draft. Prepared for Manitoba Hydro by Cree Nation Partners, Tataskweyak Cree Nation and War Lake First Nation, MB. 74 pp.

Crichton, V., Barker, T., and D. Schindler. 2004. Response of a wintering moose population to access management and no hunting – A Manitoba experiment. Alces 40: 87-94.

Courtois, R., and Lamontagne, G. 1999. The protection of cows: its impact on moose hunting and moose populations. Alces 35: 11–30.

Eason, G. 1985. Overharvest and recovery of moose in a recently logged area. Alces 21: 56-75.

Eaton, G.J. 2015. Resource Use Monitoring: Year 1 Construction. Keeyask Generation Project Resource Use Monitoring Report #RUMP-2015-01. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2015.

Eaton, G.J. 2016. Resource Use Monitoring Report: Year 2 Construction. Keeyask Generation Project Resource Use Monitoring Report #RUMP-2016-01. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2016.

Eaton, G.J. and Bretecher, R. 2017. Keeyask Generation Project Resource Use Monitoring Plan, #RUMP-2017-01. Resource Use Monitoring Report: Year 3 Construction. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2017.

Environment Yukon. 2016. Science-based guidelines for management of moose in Yukon. Yukon Fish and Wildlife Branch Report MR-16-02. Whitehorse, Yukon, Canada. 35 pp.

Gasaway, W.C., DuBois, S.D., Reed, D.J., and Harbo, S.J. 1986. Estimating moose population parameters from aerial surveys. Biological Papers of the University of Alaska, Number 22. Institute of Arctic Biology, University of Alaska, Fairbanks, AK. 108 pp.

Jessup, L., Taylor, S., Westover, S., Clarke, M., O'Donovan, K., Czetwertynski, S., and Ward, R. 2014. Moose survey Whitehorse south early-winter 2010. Technical report TR-13-1. Yukon Department of Environment Fish and Wildlife Branch 4, Whitehorse, YT. 33 pp.

KHLP (Keeyask Hydropower Limited Partnership). 2012. Keeyask Generation Project Environmental Impact Statement Supporting Volume Terrestrial Environment: Mammals. Keeyask Hydropower Limited Partnership, Winnipeg, MB. 154 pp.

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

Knudsen, B., Berger, R., Johnstone, S., Kiss, B., Paillé, J., and Kelly, J. 2010. Split Lake Resource Management Area Moose Survey 2009 and 2010. Keeyask Project Environmental Studies Program Report #10-01. Prepared for Manitoba Hydro by Knudsen Wildlife Management Systems and Wildlife Resource Consulting Services MB Inc., Winnipeg, MB. 144 pp.

KWMS and WRCS (Knudsen Wildlife Management Systems and Wildlife Resource Consulting Services MB Inc.). 2016. Moose Population Estimate Report. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2016-09. Prepared for Manitoba Hydro by Knudsen Wildlife Management Systems and Wildlife Resource Consulting Services MB Inc., Winnipeg, MB. 59 pp.

KWMS and WRCS (Knudsen Wildlife Management Systems and Wildlife Resource Consulting Services MB Inc.). 2018. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2018-20: Moose Population Estimate 2018. A report prepared for Manitoba Hydro by Knudsen Wildlife Management Systems and Wildlife Resource Consulting Services MB Inc., June 2018.

LaPorte, N., Berger, R., and Hettinga, P. 2013. Keeyask caribou aerial survey winter 2013. Keeyask Generation Project Environmental Studies Program Report # 13-01. Prepared by Wildlife Resource Consulting Services MB Inc. Winnipeg, for Manitoba Hydro, Winnipeg, MB. 28 pp.

Latham, A.D.M., Latham, M.C., Mccutchen, N.A., and Boutin S. 2011. Invading white-tailed deer change wolf-caribou dynamics in northeastern Alberta. Journal of Wildlife Management 75(1): 204-212.

Lord, R. and Kielland, K. 2015. Effects of variable fire severity on forage production and foraging behaviour of moose in winter. Alces 51: 23–34 pp.

Maier, J.A.K., Ver Hef, J.M., McGuire, A.D., Bowyer, R.T., Saperstein, L., and Maier, H.A. 2005. Distribution and density of moose in relation to landscape characteristics: effects of scale. Canadian Journal of Forest Research 35: 2233–2243.

Mazur, J. and G.J. Eaton. 2019. Resource Use Monitoring: Year 5 Construction. Keeyask Generation Project Resource Use Monitoring Report #RUMP-2019-01. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2019, vii+31 pp.

Milner, J.M., Nilsen, E.B., and Anderassen, H.P. 2007. Demographic side effects of selective hunting in ungulates and carnivores. Conservation Biology 21(1): 36–47.

MFLNRO (Ministry of Forests, Lands and Natural Resource Operations). 2015. Provincial framework for moose management in B.C. Ministry of Forests, Lands and Natural Resource Operations Fish and Wildlife Branch, Victoria, BC. 44 pp.

OMNR (Ontario Ministry of Natural Resources). 2009. Moose harvest management guidelines. Ontario Ministry of Natural Resources, Peterborough, ON. 24 pp.

Peek, J.M. 1974. Initial response of moose to a forest fire in northeastern Minnesota. American Midland Naturalist 91(2): 435–438.

Peek, J.M. 2007. Habitat relationships. In Ecology and management of the North American moose. Edited by A. W. Franzmann and C. C. Schwartz. University Press of Colorado, Boulder, CO. 351–375 pp.

R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria.

Reed, D.J. 1989. MOOSEPOP. Alaska Department of Fish and Game, Fairbanks, AK. Unpublished.

Sæther, B.-E., Engen, S., and Solberg, E.J. 2001. Optimal harvest of age-structured populations of moose *Alces alces* in a fluctuating environment. Wildlife Biology 7: 171–179.

SME (Saskatchewan Ministry of Environment). 2015. Saskatchewan Wildlife Management Report 2013-2014. Saskatchewan Ministry of Environment, Regina, SK. 109 pp.

Schwartz, C.C. 2007. Reproduction, natality and growth. In Ecology and management of the North American moose. Edited by A.W. Franzmann and C.C. Schwartz. University Press of Colorado, Boulder, CO. 141–171 pp.

Solberg, E.J., Loison, A., Sæther, B.-E., and Strand, O. 2000. Age-specific harvest mortality in a Norwegian moose *Alces alces* population. Wildlife Biology 6: 41–52.

Solberg, E.J., Sæther, B.-E., Strand, O., and Loison, A. 1999. Dynamics of a harvested moose population in a variable environment. Journal of Animal Ecology 68: 186–204.

Weixelman, D.A., Bowyer, R.T., and Van Ballenberghe, V. 1998. Diet selection by Alaskan moose during winter: effects of fire and forest succession. Alces 34(1): 213–328.

WRCS (Wildlife Resource Consulting Services MB Inc.). 2016. Caribou Winter Abundance Estimates Report. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2016-06.

WRCS (Wildlife Resource Consulting Services MB Inc.). 2019. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2019-16: 2019 Caribou Winter Abundance Estimate. A report prepared for Manitoba Hydro by Wildlife Resource Consulting Services MB Inc., June 2019.

APPENDIX 1: RAW OUTPUT TABLES FROM MOOSEPOPR() POPULATION ESTIMATES 2022

Table 1: Moose Abundance 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	NMoose	Block.Area	114	465.2758	258	31.0452	0.95	196.8246	318.5196
MED	NMoose	Block.Area	74	551.0149	559	82.9636	0.95	396.2907	721.5019
LO	NMoose	Block.Area	23	880.5410	302	65.9349	0.95	173.1566	431.6165
OVERALL			211	1896.8317	1119	110.4272	0.95	902.5216	1335.3883

Table 2: Moose Density 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	NMoose	Block.Area	114	465.2758	0.2450	0.0295	0.95	0.1872	0.3029
MED	NMoose	Block.Area	74	551.0149	0.1343	0.0199	0.95	0.0952	0.1734
LO	NMoose	Block.Area	23	880.5410	0.0261	0.0057	0.95	0.0150	0.0373
OVERALL			211	1896.8317	0.0666	0.0066	0.95	0.0538	0.0795

Table 3: Bull Abundance 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	Bull	Block.Area	21	465.2758	47	9.2009	0.95	29.4325	65.4993
MED	Bull	Block.Area	11	551.0149	83	21.7041	0.95	40.5399	125.6185
LO	Bull	Block.Area	6	880.5410	79	34.4656	0.95	11.3320	146.4349
OVERALL			38	1896.8317	209	41.7565	0.95	127.5873	291.2698

Table 4: Cow Abundance 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	Cow	Block.Area	58	465.2758	131	16.6108	0.95	98.5397	163.6529
MED	Cow	Block.Area	36	551.0149	272	46.0297	0.95	181.6789	362.1120
LO	Cow	Block.Area	11	880.5410	145	41.6480	0.95	62.9912	226.2481
OVERALL			105	1896.8317	548	64.2589	0.95	421.6664	673.5566

Table 5: Calf Abundance 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	Calf	Block.Area	30	465.2758	68	9.5065	0.95	49.1761	86.4408
MED	Calf	Block.Area	22	551.0149	166	34.1831	0.95	99.1607	233.1561
LO	Calf	Block.Area	5	880.5410	66	27.1220	0.95	12.5780	118.8944
OVERALL			57	1896.8317	300	44.6594	0.95	212.1721	387.2339

Table 6: Unknown Abundance 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	Adult	Block.Area	5	465.2758	11.3014	3.4722	0.95	4.4960	18.1068
MED	Adult	Block.Area	5	551.0149	37.7633	17.8181	0.95	2.8405	72.6860
LO	Adult	Block.Area	1	880.5410	13.1472	12.6377	0.95	-11.6222	37.9166
OVERALL			11	1896.8317	62.2119	22.1190	0.95	18.8594	105.5644

Table 7: Bull/Cow Ratio 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	Bull	Cow	21	58	0.3621	0.0607	0.95	0.2430	0.4811
MED	Bull	Cow	11	36	0.3056	0.0867	0.95	0.1356	0.4755
LO	Bull	Cow	6	11	0.5455	0.3040	0.95	-0.0504	1.1414
OVERALL			38	105	0.3824	0.0877	0.95	0.2106	0.5543

Table 8: Calf/Cow Ratio 2022

Stratum	Var1	Var2	Var1.obs.total	Var2.obs.total	Estimate	SE	conf.level	LCL	UCL
HI	Calf	Cow	30	58	0.5172	0.0615	0.95	0.3967	0.6378
MED	Calf	Cow	22	36	0.6111	0.1054	0.95	0.4046	0.8177
LO	Calf	Cow	5	11	0.4545	0.1564	0.95	0.1480	0.7611
OVERALL			57	105	0.5473	0.0685	0.95	0.4131	0.6815