# KEEYASK GENERATION PROJECT

# ERRATA PART 2

Prepared by

Keeyask Hydropower Limited Partnership

Winnipeg, Manitoba

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# TABLE OF CONTENTS

# 1.0 RESPONSE TO EIS GUIDELINES

| Section | Location | Incorrect Text | Correct Text |
|---|---|---|---|
| 6.2.3.4.1 | 6-81/Table 6-6 | Moose LSA – Study Zone 3 | Moose LSA – Study Zone 4 |
| 6.2.3.4.1 | 6-82/Table 6-6 | Footnote 6"The Moose Local Study Area also includes the offset areas where individual moose are harvested (see the off-set harvest program description in the SE SV, Resource Use). Assumes that a moose population residing in an area approximating the size." | Footnote 6 "The Moose Local Study Area also includes the offset areas where individual moose are harvested (see the offset harvest program description in the SE SV, Resource Use). **Harvest effects located in the Split Lake Resource Management Area will be managed by the Moose Harvest Sustainability Plan**." |
| 6.5.8.2.1 | 6-378 | In comparison, 38% of the Moose Regional Study Area is primary moose habitat, and the remainder is considered secondary habitat. | In comparison, ~~38%~~ **24%** of the Moose Regional Study Area is primary moose habitat, and ~~the remainder consists of~~ **71% is** secondary habitat. |

# 1.1 APPENDIX 6A

## 1.1.1 GN 9.5.7

**STATEMENT EXPLAINING WHY GN 9.5.7 IS NOT BEING DISTRIBUTED**

The Physical Environment technical memo titled Historical Flow Trend Analysis (GN 9.5.7) should have been excluded from the list of technical memos provided in Appendix 6A of the Keeyask Generation Project Environmental Impact Statement: Response to EIS Guidelines. The analysis was initiated as a potential method for describing climate change effects on future inflows for the Keeyask Project. This work was terminated in 2008 without being finalized because it was determined that historic trends cannot be used to project flow trends over the time frame of an environmental effects assessment extending 40 or more years into the future. An alternative approach was taken, and the Project inflows that were actually used in the Keeyask environmental assessment are described in the Physical Environment Supporting Volume (see Section 4 "Surface Water and Ice Regimes" and Section 11 "Sensitivity of Effects Assessment to Climate Change").

## 1.1.2 GN 9.5.2

The changes to GN 9.5.2 Rev 1 were made in Section 2.4 only, the rest of the document was untouched. Table 3 (*Trends and projections of extremes for which there is an observed late-20th century trend*) was added in order to provide a summary of future projections of extreme events as reported by the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report. The text in Section 2.4 was also slightly modified in order to include a reference to Table 3.

# 1.2 SOCIO-ECONOMIC ENVIRONMENT, RESOURCE USE AND HERITAGE RESOURCES SUPPORTING VOLUME

**Table 5-1 Risk Estimates from Consumption of Fish: Present Conditions**

| Fish Species | Standardized Concentration[1] (µg/g, wet weight) | Hazard Quotient from Consumption of Three Large Meals per Week (Acceptable Value = 1)*** | | |
|---|---|---|---|---|
| | | Toddlers | Women of Childbearing Age | Adult Males and All Seniors |
| Stephens Lake | | | | |
| Lake Whitefish | 0.09 | 1.2 (previous = 1.3) | 1.3 (previous = 1.4) | 0.5 (no change) |
| Northern Pike | 0.26 | 3.3 (previous = 3.5) | 3.7 (previous = 3.8) | 1.3 (previous = 1.4) |
| Walleye | 0.29 | 3.7 (previous = 4.2) | 4.1 (previous = 4.7) | 1.5 (previous = 1.7) |

1. Standard lengths: lake whitefish 350 mm; northern pike 550 mm; walleye 400 mm. Individual mercury concentrations would be dependent upon the size of the fish with the smaller fish having generally lower concentrations than bigger fish.
2. Based on information provided by local First Nation communities, all fish were assumed to be consumed at a frequency of three meals per week with a serving size of 100 g for toddlers and 400 g for adults.

# 1.3 TERRESTRIAL ENVIRONMENT SUPPORTING VOLUME

| Section | Location | Incorrect Text | Correct Text |
|---|---|---|---|
| 1.3.5 | p.1-21/Table 1-3 | Moose LSA – Study Zone 3 | Moose LSA – Study Zone 4 |
| Appendix 1A | 1A-24/ Table1A-3 | | Checkmark required under “Regulatory Requirement” for moose and beaver |
| 2.3.6.3.1 | p.2-96/Table 2-14 | *Added text to table note:* | The 12 ha of off-system marsh compensation is not subtracted from the 9,416 ha. |
| 2.3.6.3.1 | p.2-104/Para 3, Line 2 | ...approximately 8,667 ha... | ...approximately 9,416 ha... |
| 2.3.6.3.1 | p.2-106/Table 2-17 | *Add note to table:* | The 12 ha of off-system marsh compensation was subtracted to arrive at the 8,667 ha at Year 100 in last row of the table. |
| 2.10.3 | p.2-200/Para 2, Line 2 | ...an estimated 1,170 ha... | ...an estimated 1,270 ha... |
| 2.10.4 | p.2-200/Para 6, Line 2 | ...an estimated 990 ha... | ...an estimated 1,087 ha... |
| 6.5.4.2.1 | p.6-332 Para.2 L.4 | ...the Project could remove, later or indirectly affect up to 8,870 ha of terrestrial habitat... | ...the Project could remove, later or indirectly affect up to 8,927 ha of terrestrial habitat... |
| 6.2.3.4.2 | p. 6-100 Para.4 L3&4 | Ongoing shoreline erosion (TE SV Section 2.2.4)... | Ongoing shoreline erosion (PE SV Section 6.3.1.4)... |
| 6.5.3.1 | p. 6-308 Para.6 L.1 | The TE SV Section 2.3.4 provides a detailed... | The TE SV Section 2.3.6 provides a detailed... |
| 7.2.6.2 | 7-10 | Benchmark values for intactness indicated a low magnitude adverse effect where core area, as a percentage of land area, is greater than 65%, a moderate magnitude adverse effect where core area percentage is between | Benchmark values for intactness indicated a low magnitude adverse effect where core area, as a percentage of land area, is greater than 65%, a moderate magnitude adverse effect where core area percentage is between 45% and 65%, and a high magnitude adverse effect where |

KEEYASK Hydropower Limited Partnership

| Section | Location | Incorrect Text | Correct Text |
|---|---|---|---|
| | | 45% and 65%, and a high magnitude adverse effect where core area percentage is lower than % (Salmo Consulting Inc *et al*. 2003; Athabasca Landscape Team 2009; Dzus *et al*. 2010). Benchmark values for intactness indicated a low magnitude adverse effect where less than 35% of the range is undisturbed, a moderate magnitude adverse effect when 35% to 45% of the range is undisturbed and a high magnitude adverse effect when more than 45% of the range is disturbed (Salmo Consulting Inc *et al.* 2003). This benchmark was only used in the assessment of caribou as recommended in the woodland caribou recovery strategy (Environment Canada 2011). | core area percentage is lower than **45**% (Salmo Consulting Inc. *et al.* 2003; Athabasca Landscape Team 2009; Dzus *et al.* 2010). Benchmark values for intactness indicated a low magnitude adverse effect where less than 35% of the range is un**disturbed**, a moderate magnitude adverse effect when 35% to 45% of the range is un**disturbed**, and a high magnitude adverse effect when more than 45% of the range is disturbed (Salmo Consulting Inc. *et al.* 2003). |
| 7.3.5.3, 7.3.5.4 | 7-50 | | 7.3.5.3 Ungulates and 7.3.5.4 Rare and Regionally Rare Species should be heading level 3 (i.e., at the same level as other mammal groups), and not in the Large Carnivores section. |
| 7.3.6.4.4 | 7-76 | Primary moose habitat includes forest stands dominated by broadleaf trees, jack pine, and tall shrubs (Table 7-27) and covers 38% of the Regional Study Area. Willow | Primary moose habitat includes forest stands dominated by broadleaf trees, jack pine, and tall shrubs (Table 7-27) and covers **24%** of the Regional Study Area. Willow communities provide important winter cover |

KEEYASK Hydropower Limited Partnership

| **Section** | **Location** | **Incorrect Text** | **Correct Text** |
|---|---|---|---|
| | | communities provide important winter cover and food (Palidwor *et al.* 1995). Secondary moose habitat consists of forest stands dominated by black spruce and low vegetation and covers 74% of the Regional Study Area. | and food (Palidwor *et al.* 1995). Secondary moose habitat consists of forest stands dominated by black spruce and low vegetation and covers **71%** of the Regional Study Area. |
| 7.3.6.4.5 | 7-79 | Approximately 10% of the Local Study Area contains primary moose habitat and 69% contains secondary moose habitat (Map 7-42). | Approximately **25%** of the Local Study Area contains primary moose habitat and **71%** contains secondary moose habitat (Map 7-42). |
| 7.4.6.3.1 | 7-124 | Primary moose habitat covers about 10% of the Local Study Area (Map 7-49) and 69% is secondary moose habitat. In comparison, 38% of the Moose Regional Study Area consists of primary moose habitat, and the remainder is considered secondary habitat. | Primary moose habitat covers about ~~10%~~ **25%** of the Local Study Area (Map 7-49) and ~~69%~~ **71%** is secondary habitat. In comparison, ~~38%~~ **24%** of the Moose Regional Study Area consists of primary moose habitat, and ~~the remainder consists of~~ **71% is** secondary habitat. |

# 2.0 RESPONSES TO INFORMATION REQUESTS

## 2.1 CEC ROUND 1

The Response to CEC Round 1 CEC-0005 has been updated.

## REFERENCE: Volume: Response to EIS Guidelines; Section: 6.6.5.6.5 Conclusion about Residual Effects on Culture and Spirituality; p. 6-494

# CEC Rd 1 CEC-0005

## QUESTION:

On Page 6-494 of the Environmental Effects Assessment it is stated that cultural impacts are small. How was this conclusion arrived at? and/or provide explanation as to how a cultural impact is geographically small?

## RESPONSE:

The conclusion on page 6-494 that the geographic extent of cultural impact is small is an error.

The correct determination is medium in geographic extent. Table 6-62 on pg. 6-519 illustrates the correct assessment characteristics, which are consistent with the Socio-Economic Supporting Volume, Section 5.5.

Geographic Extent is defined in Chapter 5, Section 5.5 on pg. 5-11 of the Response to EIS Guidelines as "the spatial boundary within which the residual environmental effect is expected to occur". A geographic extent of medium is consistent with the definition which states:

> "Geographic Extent is defined in Chapter 5, Section 5.5 on pg 5-11 of the Response to EIS Guidelines as the spatial boundary within which the residual environmental effect is expected to occur. Geographic extent is described as:
>
> - Small geographic extent – Effects that are confined to a small portion of one or more small areas where direct and indirect effects can occur (e.g., rights-of-way or component sites and adjacent buffer areas);
> - Medium geographic extent – Effects that extend into local surrounding areas where direct and indirect effects can occur; or
> - Large geographic extent – Effects that extend into the wider regional area where indirect or cumulative effects may occur."

## 2.2 TAC ROUND 2

The response to TAC Round 2 HC-0003 has been updated.

**REFERENCE: Volume: Socio-Economic Supporting Volume; Section: 5.3.3 Mercury and Human Health; p. 5-104 to 5-120**

# TAC Public Rd 2 HC-0003

## PREAMBLE:

Mercury and human health: The EIS indicates that communication products to address adverse health impacts will be developed. It should be noted that the determination and implementation of risk management strategies for country foods in the project area fall under the responsibilities of provincial and/or municipal authorities. However, HC considers accurate communication strategies a very important tool in the reduction of risk to Aboriginal health with regards to country foods. HC would be willing to review proposed risk management approaches and communication products to provide its opinion.

## QUESTION:

HC has reviewed the communication products provided, and some preliminary comments are provided in the attached table (Formative Review of Risk Comm Products). HC would be pleased to meet with the proponent to undertake a more thorough discussion of the communication products, upon request. HC advises that the focus of the communication products be on the protection of the most sensitive receptors first (i.e. pregnant women and women of child-bearing age, and children). HC is available to review communication products that are developed for the post-impoundment scenario, upon request.

## RESPONSE:

The Partnership appreciates the opportunity to discuss the communication products with Health Canada, along with Manitoba Health. At a March 2013 technical meeting among Health Canada, Manitoba Health, Manitoba Conservation and Water Stewardship, Department of Fisheries and Oceans and the Partnership, there was agreement to a process in which this discussion would continue to occur.

As noted in the response to TAC Rd 2 HC-002, there was agreement to a process in which the Partnership would continue to work with Manitoba Health and Health Canada in the addressing mercury related risk communication strategies. Manitoba Health indicated a willingness to work with partners to develop provincial messaging for subsistence fishing that can be adapted to the Keeyask area and expressed a willingness to work with First Nations and Inuit Health, the Keeyask Partnership and the Northern Health Region to develop communication materials regarding mercury and health for the Keeyask area under present conditions, including continued consultation with the Partnership. The Partnership agrees that the communication products should focus on the protection of the most sensitive receptors first (i.e., women of child-bearing age and children).

The Partnership appreciates the opportunity to review communication products for the post-impoundment scenario with Health Canada and Manitoba Health, when they are developed closer to the beginning of the operations phase.

# 3.0 SUPPLEMENTAL FILING #2

## 3.1 UPDATED CARIBOU SECTIONS

The Terrestrial Environment technical report titled Keeyask Caribou Aerial Survey Winter 2013 should have been included with this submission.

# KEEYASK GENERATION PROJECT

Keeyask Caribou
Aerial Survey
Winter 2013

ENVIRONMENTAL STUDIES PROGRAM

# KEEYASK GENERATION PROJECT

Environmental Studies Program

Report # 13-01

## Keeyask Caribou Aerial Survey
## Winter 2013

Draft Report Prepared for Manitoba Hydro

by

Nicholas LaPorte, Robert Berger and Peter Hettinga

Wildlife Resource Consulting Services MB, Inc.

495B Madison Street

Winnipeg, MB R3J 1J2

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# TABLE OF CONTENTS

# LIST OF TABLES



# LIST OF FIGURES



# LIST OF MAPS

# LIST OF PHOTOS

# ACKNOWLEDGMENTS

We would like to thank Pat Chartier of Gillam Air, Maria Zbigniewicz of Manitoba Hydro and Ron Bretecher of North/South Consultants Inc., for logistical assistance in the field. We would also like to thank Carl Hrenchuk, North/South Consultants Inc., for editorial comments and review of the manuscript and James Ehnes, ECOSTEM for GIS analysis and maps.

We are grateful to members of Tataskweyak Cree Nation, and York Factory First Nation for field and logistical assistance.

# AERIAL SURVEY TEAM

**Wildlife Resource Consulting Services MB Inc.**

Robert Berger, M.N.R.M., Sr. Wildlife Biologist

Peter Hettinga, M.N.R.M. Wildlife Biologist

Nicholas LaPorte, M.N.R.M. Wildlife Biologist

Jason Kelly, M.N.R.M. Wildlife Biologist

Joseph Guay, B.Sc. Wildlife Technician

Scott MacKenzie, B.Sc. Wildlife Technician

**Tataskweyak Cree Nation**

Marcel Beardy

Clayton Flett

**York Factory First Nation**

Darcy Wastesicoot

# 1.0 EXECUTIVE SUMMARY


In late January 2013, Manitoba Hydro personnel, First Nations community members and Manitoba Conservation and Water Stewardship biologists observed many caribou migrating into the Keeyask Generating Station (GS) Study Area (Zone 5). Due to the unusually high numbers of caribou, a fixed-wing aerial survey for caribou was conducted from February 5 to 8, 2013, with the goal of estimating caribou density and abundance in the area. Strip transects were used to sample and count animals. Estimates of both caribou density and abundance were based on the results of distance sampling line transect methods and quantitative analysis in the program DISTANCE v.6.0.

In total, 4,169 caribou were observed during the survey. On the distance sampling line transects, 3,486 caribou grouped in 262 clusters were observed. Population modelling results indicated a density of 1.66 caribou/km$^2$ and a population estimate of 13,985 (± 18.17%, 95% CI) caribou in the eastern half of Zone 5. Based on physical appearance, the presence of radio-collared Pen Islands caribou in the Keeyask GS area at the time of the survey, the absence of radio-collared Cape Churchill caribou in the Keeyask GS area at the time the survey, and no track evidence of Beverly-Qamanirjuaq caribou movements into the study area, the caribou are believed to be coastal caribou originating from the Pen Islands herd and migrating through the study area. This determination was made with a moderate level of certainty. Future results of genetic testing of faecal samples collected in the area at the time of the survey and further analysis are expected to strengthen this assertion.

In addition to the population estimate, 36 sites were identified where caribou crossed the Nelson River and Stephens Lake. Seventeen sites were located on the Nelson River between Birthday Rapids and Gull Rapids, 14 sites were on Stephens Lake between Gull Rapids and Gillam and five sites crossed the north arm of Stephens Lake.

# 2.0 INTRODUCTION

## 2.1 CARIBOU IN THE REGIONAL STUDY AREA

Larger numbers of caribou were first observed in the Gillam area by the author during a moose survey of the Fox Lake Resource Management Area in mid-January 2013. Numerous First Nations members also reported caribou occurrences to the author around this time. In late January 2013, Manitoba Hydro personnel began observing caribou migrating near and crossing the Keeyask Infrastructure Project north access road, which was under construction. Large numbers of caribou were reported by Wildlife Resource Consulting staff and confirmed by Manitoba Conservation and Water Stewardship (V. Trim, Pers. Comm.) during a reconnaissance survey in the order of several thousand animals. Many observed animals were located near the proposed Keeyask Generating Station (GS). Due to the unusually high numbers of caribou, a comprehensive investigation into caribou abundance and distribution in this area at this time was undertaken. Because of overlapping ranges of Manitoba's northern caribou herds (Map 1) and extreme annual variability in herd movements (Abraham and Thompson 1998, Thompson and Abraham 1994, Abraham *et al.* 2012), necessitated by changing snow conditions, predator avoidance, and the need for adequate food resources (Hummel and Ray 2008), identification of which herd was present in the Keeyask GS area at this time also required clarification.

Coastal woodland caribou (*Rangifer tarandus caribou*) which are a forest-tundra ecotype from the Cape Churchill and Pen Islands herds occur within the Regional Study Area in winter and leave in spring to calve near the Hudson Bay coast. Coastal woodland caribou have occupied the southern Hudson Bay coast since the 1700s (Abraham *et al.* 2012). These animals were observed migrating from the Hudson Bay coast to what is now known as York Factory and Fort Severn, and were rarely seen near the coast in winter (Abraham and Thompson 1998). Surveys in the 1950s, 1960s, and 1980s confirmed that this group of caribou was absent from the coast in winter, and movement inland in winter was documented (Abraham and Thompson 1998). Large numbers of caribou were observed at the coast near the Manitoba-Ontario border in 1979 (Abraham and Thompson 1998). This group was documented in the area during the calving period when studies were conducted in the 1980s and 1990s and this group was named the Pen Islands herd (Thompson and Abraham 1994).

Migratory caribou, possibly from the Pen Islands herd, were observed and harvested in the Shamattawa, Manitoba area in the 1980s, and hunters indicated the animals moved west toward Oxford House in the fall, returning to the coast in spring (Abraham and Thompson 1998). Aboriginal Traditional Knowledge suggests that the Pen Islands herd migrates from Ontario to the area south of the Nelson River (FLCN 2010 Draft), through Shamattawa to the Atkinson Lake area (WLFN 2002), as far west as the Nelson River at York Landing (YFFN 2012) and as far south as Oxford House (Abraham and Thompson 1998 ). Animals from the Pen Islands herd were first reported in the Keeyask region in the 1990s (Thompson 1994; Thompson and Abraham 1994; Abraham and Thompson 1998; Abraham *et al.* 2012). In the mid-1990s, the herd size peaked and was estimated at 10,800 individuals (Abraham and Thompson 1998; Abraham *et al.* 2012). Although larger migrations into the Regional Study Area were observed in the winters between 2001 and 2005 (Patenaude *et al.* 2005; Kibbins and Berger 2007; Keeyask Hydropower Limited Partnership 2012), less than 300 animals believed to be Pen Islands caribou are observed in most winters. In the winter of 2011–2012, approximately 30 caribou were observed in the Keeyask GS area during three aerial surveys that sampled the eastern half of Zone 5. All caribou observed in winter of 2011–2012 were observed approximately 10 km due south of Birthday Rapids (WRCS unpubl. data). These other unpublished data since the 1990s and recent radio-collaring studies from 2010 to date (Manitoba Conservation and Water Stewardship unpubl. data) serve as a baseline for determining caribou use of the Keeyask GS area.

The Cape Churchill herd of coastal caribou is thought to have increased rapidly in size beginning in the 1960s (Gunn *et al.* 2011). The herd was estimated at 58 individuals in 1965 (Campbell 1995; Gunn *et al.* 2011), in the hundreds in the 1970s (Manitoba Hydro 2012), at 1,700 animals in the mid-1980s (Elliott 1986), and at least 3,013 in the mid-1990s (Gunn *et al.* 2011). The population was estimated to be from 1,800 to 2,200 individuals in 1998 (Campbell 1995; Gunn *et al.* 2011). As reported in Manitoba Hydro (2012), Manitoba Conservation and Water Stewardship now estimate this herd to be approximately 3,500-5,000 caribou. Although a large migration into the Gillam area was observed in winter 2010 (Manitoba Hydro 2011) and there is uncertainty in how far this herd extended into this area , there are generally fewer than 50 animals in most winters in the Keeyask Local Study Area (WRCS unpubl. data).

Barren-ground caribou from the Qamanirjuaq herd ranged as far south as Split Lake and as far east as the Hudson Bay railway track running between Ilford and Churchill (Miller and Robertson 1967; Split Lake Cree 1996). Caribou migration began to diminish in the 1950s, reducing hunting activity (Split Lake Cree 1996). A substantial decline in barren-ground caribou numbers began in the 1950s, and after construction of the Kettle GS, there were virtually none south of the Nelson River (FLCN 2010). The population was estimated at less than 50,000 individuals in the 1970s (Beverly and Qamanirjuaq Caribou Management Board 2002). However, hunters indicated that the population was not declining but was increasing; and it is believed that the herd was larger than surveys indicated (Beverly and Qamanirjuaq Caribou Management Board 2002). The discrepancy is thought to be due in part to changes in the herd's distribution (Beverly and Qamanirjuaq Caribou Management Board 2002). In the 1990s, there was a limited return of caribou (Split Lake Cree 1996). In winter 2004-2005, about 10,000 caribou were estimated to have reached Stephens Lake (WRCS unpubl. data). The range-wide population was estimated at 496,000 individuals in 1994 (Beverly and Qamanirjuaq Caribou

Management Board 2002) and 348,000 individuals in 2008 (Beverly and Qamanirjuaq Caribou Management Board 2011). Range use and movement patterns of Qamanirjuaq barren-ground caribou continue to be variable and unpredictable (Beverly and Qamanirjuaq Caribou Management Board 2002). Movements and range use vary with weather, snowmelt, predator avoidance and the availability of food (Beverly and Qamanirjuaq Caribou Management Board 2012).

In addition to barren-ground and Pen Islands caribou, some KCNs have identified a third variety of caribou common to the Keeyask region: woodland caribou, which are present year-round and can be distinguished from migratory caribou based on their appearance (FLCN 2010; FLCN 2012; YFFN 2012). This group of caribou has recently been described as migratory woodland caribou (Mammals Working Group 2012, January 24; FLCN 2012). The exact core range, long-term calving frequency and herd association of the caribou that remain in the Keeyask region year-round cannot be clearly determined. This group could be coastal caribou, woodland caribou or a mixture of both, and are referred to as summer resident caribou. Based on what is known of the area, a conservative estimate for the group of animals residing in the Regional Study Area in summer is 20 to 50 individuals.

While the Nelson River serves as a physical boundary for Pen Islands, Cape Churchill and Beverley-Qamanirjuaq caribou in the Keeyask area, river crossing locations have been reported in the Regional Study Area and on the lower Nelson River (Map 2; WRCS unpubl. data). Genetic studies indicated that coastal and barren-ground caribou genotypes were found north and south of the Nelson River between 2004 and 2006 (Ball and Wilson 2007). Recent radio-collaring data since 2010, indicate that most of the Cape Churchill coastal caribou activity is north of the Nelson River and east of Gillam, while Pen Islands coastal caribou activity is south of the river and can occur as far west as York Landing (Manitoba Conservation and Water Stewardship unpubl. data; Manitoba Hydro 2011, 2012). Slightly more Pen Islands coastal caribou tend to use habitat north and south of the Nelson River and Stephens Lake than Cape Churchill coastal caribou (Manitoba Conservation and Water Stewardship unpubl. data; Manitoba Hydro 2011).

## 2.2 ESTIMATING CARIBOU POPULATIONS

Abundance estimates are essential for the management of wildlife and for developing a robust understanding of conservation and population dynamics. Wildlife managers require survey techniques that (1) allow completion of surveys in a cost and time effective manner, (2) provide a reasonably accurate estimate of a herd's population size, and (3) provide indicators to assess confidence in the estimate (Guenzel 1994). Consequently, different techniques have been developed to estimate the size of ungulate populations. There are a number of methods available (reviewed in Heard 1985), with mark-recapture and distance sampling being the most widely employed (Williams *et al.* 2002). Line transect distance sampling and related techniques have been successfully used to survey many species of wildlife (Thomas *et al.* 2010) and have been applied to caribou populations as early as the 1950s (Banfield *et al.* 1955) and more recently by the Nunavut government (Jenkins *et al.* 2011). Distance sampling uses the perpendicular distances from the observer to clusters of objects (caribou) to obtain a measure of detection probability as a function of distance (Buckland *et al.* 2001). Larger clusters are easier to detect than smaller clusters and observers are more likely to detect animals that are closer to the observer than those farther away are (Guenzel 1997). As such, distance-sampling techniques correct for effects of cluster size and distance on detectability. The gregarious nature of caribou, particularly in winter, and their use of shorelines and frozen lakes for travel (Banfield 1954; Miller 2003), makes caribou a suitable species for the use of distance sampling.

In order to generate reliable population estimates through distance sampling techniques, there are three key assumptions to be met (Buckland *et al.* 2001):

1. all objects (caribou clusters) are detected with certainty on the transect line ($g(0)$);
2. objects do not move; and
3. measurements are exact.

However, these assumptions can be relaxed (Buckland *et al.* 2001, Thomas *et al.* 2010). Although there are other minor assumptions to be met (Buckland *et al.* 2001), they are seldom of great practical significance (Thomas *et al.* 2010). It is assumed that object locations are independent of the position of the transect lines, which is ensured by having an adequate sample of lines, and by randomizing their locations (Buckland *et al.* 2001, Thomas *et al.* 2010). It is also assumed that detections are independent events, though distance-sampling methods are very robust to failures of this assumption (Thomas *et al.* 2010). By defining the cluster, and not individual animals, as the object of interest, violations of the independent detections assumption are of minor importance (Buckland *et al.* 2001).

Distance Sampling is more cost and time efficient in larger study areas with sparsely distributed animal populations (Buckland *et al.* 2001, Nielson *et al.* 2006). This report estimates the relative density, and thus abundance, of caribou in the eastern half of the Keeyask GS Study Area (Zone 5) in northern Manitoba.

# 3.0 METHODS

## 3.1 FIELD METHODS

Surveys for caribou in the Keeyask GS area (Map 3) were conducted over four days from February 5 to 8, 2013. Caribou were dispersed over a large geographical area. A complete census is not possible and abundance and density estimates are based on distance sampling methods. Standard aerial survey techniques and distance sampling methods were followed (Buckland *et al.* 2001). Surveys were conducted during high visibility weather and complete snow coverage with two BN2A Britten Norman Islander twin propeller fixed-wing aircraft. Systematic north-south transects were established every 2 km, and transects flown following a Global Positioning System (GPS, Garmin GPSMAP 60 CSx) at 80 m AGL (range 70-100 m AGL) and 80-140 km/h, depending on topography and forest cover density. One crew sampled the north side of the Nelson River, while the second crew simultaneously sampled the south side of the Nelson River. Transect lengths took an average of 13.3 minutes (SD=4.15 min, min=5 min, max=23 min) to survey. The average length of time to ferry between transects was 2.5 minutes (SD=1.1 min, min=1 min, max=9 min). The average length of time to and from the study area and the Gillam Airport (refuelling, aircraft maintenance) was 70 minutes (SD=28.5 min, min=34 min, max=94 min). The average length of time to survey a transect, ferry to the next transect, and survey the following transect was 28.6 minutes (SD=8.03, min=14 min, max=46 min).

Two crews comprised of three experienced observers per crew conducted surveys. The unit of observation was clusters of caribou, where a cluster refers to an individual or group of caribou that were closely spatially aggregated (i.e. <50 m apart) to ensure independence (Buckland *et al.* 2001). The front right observer was responsible for detecting caribou clusters near the transect line through the front window of the aircraft, while the rear observers were responsible for sighting caribou clusters on either side. The pilots also assisted with spotting wildlife near the transect line. The front right observer recorded cluster locations with an independent GPS and recorded cluster size estimates and perpendicular distance from the aircraft to the centre of clusters. Exact distance measurements were not taken, but were grouped by 50 m distance intervals out to a maximum distance of 450 m. Animal care and safety was a high priority, and to minimize disturbance, the aircraft never circled wildlife. We recorded observations that were detected upon leaving transects (i.e. while ferrying) as off-transect, and excluded such observations from the final analysis.

## 3.2 DATA ANALYSIS

Distance sampling data were analysed in the program DISTANCE v. 6.0 (Thomas *et al.* 2010) to model the line transect data and estimate density and abundance of caribou in the Keeyask GS area. Exploratory analyses were conducted to determine an appropriate truncation distance of at least 5% of extreme right tail observations (Buckland *et al.* 2001) to avoid extra adjustment terms to fit a long tail to the detection function, to discard outliers, and to improve model fit of the detection functions (Buckland *et al.* 2001).

As larger clusters of caribou may be easier to detect than smaller groups further from the transect line (Drummer and McDonald, 1987), a size bias leading to overestimation of density is potentially introduced (Buckland *et al.* 2001). To obtain an unbiased estimate of the expected cluster size, a size bias regression estimator was employed in the program DISTANCE by regressing the log of caribou cluster size against the probability of detection at distance x. This method estimates expected cluster size on the transect line, where size bias should be negligible (Buckland *et al.* 2001). Expected cluster size was used to estimate the caribou population density rather than the mean cluster size, which positively biases the estimator (Buckland *et al.* 2001). Density of caribou was estimated by the program DISTANCE as:

$$D = n^* g(0)/2L$$

where $L$ is the sum of all transect lengths, $n$ denotes the number of detected caribou clusters and $g(0)$ is the probability density function of observed perpendicular distances evaluated at zero distance. The probability density function is a function of three model components: the estimated detection probability, the encounter rate and cluster size (Buckland *et al.* 2001).

To model the detection function, combinations of three key functions and three adjustment terms were considered following recommendations of Buckland *et al.* (1997 and 2001). *A priori* candidate models were a half-normal key function with the option of cosine or hermite adjustment terms, a uniform key function with the option of cosine or polynomial adjustments, and a hazard-rate key function with cosine adjustments. The best model was determined using Akaike's Information Criterion (AIC), where the model with the lowest AIC value is considered the most parsimonious (Akaike 1974; Anderson *et al.* 1998). Goodness-of-fit tests ($\chi^2$ GOF) and qq-plots (especially at distance 0) results were examined to detect assumption violations (Buckland *et al.* 2001). Estimates for all models were produced with the objective of obtaining a coefficient of variation (CV) less than 20% (Otis *et al.* 1978, White *et al.* 1982). Robson and Regier (1964) recommend an accuracy of ±25% for management studies that estimate the size of animal populations. In addition, variance was estimated using a weighted average of several plausible models (Buckland *et al.* 2001, Burnham and Anderson 2002) in a non-parametric bootstrap method that estimated variance from 1,000 bootstrap iterations, which requires fewer assumptions than parametric methods (Buckland *et al.* 2001).

## 3.3 CARIBOU ICE CROSSINGS

A reconnaissance survey was flown in a west to east direction on Jan 31, 2013 covering the Nelson River between Birthday Rapids and Gull Rapids (WRCS unpubl. data). Between February 5 - 8, 2013, caribou trails detected on the Nelson River and Stephens Lake were also recorded to identify caribou crossing locations during distance sampling transect surveys. Trails crossing open areas of the Nelson River and Stephens Lake were difficult to detect due to drifting snow obscuring caribou tracks. Points of convergence in near-shore areas were recorded as potential crossing points.

# 4.0 RESULTS

## 4.1 DENSITY AND POPULATION SIZE

Fifty-six transects were flown covering an area of 8,400 $km^2$ in the eastern half of Study Zone 5 (Map 3) with a total transect length of 12,844 km. In total, 4,169 caribou in 305 clusters were observed during the survey, although many clusters were observed off-transect. On the distance sampling line transects, 3,486 caribou in 262 clusters were observed. The distribution of caribou in the Keeyask GS area from Feb 5 to 8, 2013, was not uniform (Map 4). Mean cluster size was 13.56 and ranged from one to 250 caribou. We selected a truncation distance of >450 m which removed 26 (9.9%) data points, leaving 3,200 caribou in 236 clusters (Table 1) that provided a sufficiently large sample size and a good fit to the data for most detection function models.

Based on the lowest AIC values, model fit close to the transect line, and low %CV, a half-normal model with a cosine adjustment term was selected as the best detection function (Table 2, Figure 1). We observed high model selection uncertainty ($\Delta$AIC <2; Anderson *et al.* 1998) between the best model and other top two detection functions. The half normal with cosine adjustments and the hazard key with cosine adjustments showed good fit with p-values from $\chi^2$ GOF tests between 0.893 and 0.952 and yielded the same detection probability of 0.50, similar density estimates (1.66 and 1.68 caribou/$km^2$), and overlapping CI's (Table 2).

The averaged model, obtained by generating 1,000 bootstrap iterations, showed good fit with a $\chi^2$ GOF test p-value of 0.952, and a detection probability of 0.50. Bootstrap caribou density of 1.73 caribou/$km^2$ was near parametric estimates, although with a much greater %CV (Table 2).

## 4.2 CARIBOU ICE CROSSINGS

Several locations where caribou crossed the Nelson River and Stephens Lake were identified on January 31, 2013, and while surveying transect lines from February 5 - 8, 2013. During the reconnaissance survey on January 31, 2013, 10 caribou crossing sites were recorded between Birthday Rapids and Gull Lake (Map 5, Photos 1 and 2). Seven additional sites between Birthday Rapids and Gull Lake were recorded during line transect distance sampling (Map 5, Photos 1 & 2). On Stephens Lake, five crossing sites were recorded on the north arm of the lake and 14 were recorded between Gull Rapids and 3 km west of Gillam (Map 5, Photo 3 and 4). No caribou trails were detected from open water areas to terrestrial habitats near Birthday Rapids and Gull Rapids.

# 5.0 DISCUSSION

The best-supported distance-sampling model (half normal with a cosine adjustment key) indicated that the density of caribou in the Keeyask GS area (Zone 5) from February 5 to 8, 2013, was approximately 1.66 caribou/km$^2$. Thus, the surveyed area of 8,400 km$^2$ hosted approximately 13,984 caribou from February 5 to 8, 2013. It is worth noting however, that the effect of caribou moving away from the observers might have negatively biased our estimates, though this effect was probably minimal (Buckland *et al.* 2001).

Based on the physical appearance including size, colour and antler shape of caribou detected during the aerial survey, all of the caribou detected were assumed to be from the Pen Islands herd, though some individuals, especially those north of Hwy 280, may have been from other herds (i.e. Cape Churchill herd, Qamanirjuaq herd). Other corroborative evidence tends to support this assertion. Up to seven radio-collared Pen Islands caribou were located in Study Zone 5 at the time of the survey (V. Trim, Pers. Comm.). Based on radio-collaring of individuals in the Cape Churchill herd at this time, representative animals from this group were in their traditional territory and outside of the survey area (V. Trim Pers. Comm..), and as such, the presence of Cape Churchill coastal caribou was unlikely. Based on the lack of track evidence observed in the northern fringe of the survey area, it is unlikely that Qamanirjuaq animals were present. Upcoming DNA analysis of 74 caribou faecal samples collected in the Keeyask GS area on Feb 9, 2013 (WRCS unpubl. data) will likely improve confidence in determining the dominant origins of the caribou reported in the study area at this time.

Although our survey does not assume that all of the caribou in the Pen Islands herd were in the surveyed area, our abundance estimate surpasses the minimum population size of 10,800 estimated for the Pen Islands herd in 1994 (Abraham and Thompson 1998, Abraham *et al.* 2012), by approximately 30%. However, as our current estimate is only accurate within 18.17% (95% CI), population trends derived from these data are not reliable. Furthermore, our estimate approaches the population estimate of approximately 16,600 Pen Islands caribou made by provincial wildlife managers in 2012 (G. Racey, Pers. Comm.), though the differences are not statistically comparable as the provincial estimate does not include confidence limits for such unpublished data. Caribou numbers estimated during the survey would likely have included minor additions from individuals referred to as summer resident caribou.

Although this large caribou migration into the Keeyask area is unusual, it is not particularly surprising considering the general irruptive, dynamic, and sometimes unpredictable movement patterns of migratory caribou (Banfield 1955; Miller 2003). Pen Islands caribou use substantially different areas yearly. In 1987-88, the Pen Islands herd spanned the Manitoba Ontario border throughout the autumn and winter. In 1988-89, they congregated in Manitoba during the fall, shifted into Ontario in November, and returned to Manitoba in

December through late winter. Finally, in 1989-90, they moved from Manitoba to Ontario in December though late winter (Abraham and Thompson 1998). Abraham and Thompson (1998) concluded that Pen Islands caribou showed a complex movement and habitat use pattern that varied among months and years. Furthermore, a survey of the same geographic area in 2011, using the same techniques employed in 2013, resulted in zero caribou observed (Keeyask Hydropower Limited Partnership 2012).

The assumptions of distance sampling (Buckland *et al.* 2001) were reasonably met. Because our estimated detection probability at $g(0)$ was 1.0, the assumption that all animals on or near the transect line were detected was met. The assumption that caribou did not move in response to the observer was relaxed. Caribou were observed moving away from the aircraft during the survey, however, transect lines were spaced sufficiently apart (2 km) so that animals that did move were not likely to be counted again on subsequent transect line (Guenzel 1994). A negative bias in density estimates is expected in distance sampling if animals move away from the observer prior to being detected (Buckland *et al.* 2001). By having our observers look well ahead and by taking perpendicular measurements to caribou clusters from the original position of the clusters, detections occurred beyond the likely range of the effect of the observer, thus keeping negative bias in the density estimate to a minimum (Buckland *et al.* 2001). Furthermore, an examination of our distance data histogram did not detect evasive movements by caribou (Buckland *et al.* 2001). By grouping perpendicular distances into intervals, the assumption that distance measurements were exact was relaxed. However, line transect distance sampling models remain robust when observations are assigned to distance intervals (Buckland *et al.* 2001).

All distance-sampling models gave results with large, overlapping confidence intervals. The relatively low amount of variability between model estimates indicated good survey design and data collection (Buckland *et al.* 2001). Although three models demonstrated greater accuracy in abundance estimates (small %CVs), these models were rejected due to higher AIC values, and poor model fit. Although there was high model selection uncertainty ($\Delta$AIC <2; Anderson *et al.* 1998) between the two top models, better model fit and lower %CV indicated that the half-normal model with a cosine adjustment term was the best model with the least bias associated with density and abundance estimates. Additionally, estimates from the averaged model were rejected based on a very high %CV that was above the ±25% recommended for management studies (Robson and Regier 1964).

Abundance may be over-estimated if animals move ahead of the observer and are double-counted (Buckland *et al.* 2001). During the survey, some clusters of caribou responded to the observers with evasive movements away from the aircraft. However, evasive movements appeared to end quickly once the aircraft was moving away from them. Double-counting may have occurred while surveying the longest transects, however, it is unlikely that this occurred on shorter lines as these caribou would have to be moving at consistent high speeds, often through dense forested areas and deep snow conditions in order to be counted twice.

Furthermore, the distribution and abundance of cratering sites throughout the survey area indicate that caribou were not moving rapidly through the area, but rather that these animals were searching periodically for food resources and could have remained in certain areas for extended periods of time. Caribou may have also been double-counted from one day to the next, although, this is unlikely as the survey was conducted in an overall east to west direction and caribou were predominately moving in a north-easterly to easterly direction. If some double-counting occurred during the survey, this would have over-estimated density and therefore, the abundance estimates. As repeated double-counting was probably not common, this bias is likely to be small (Buckland *et al.* 2001). Although speculative, small positive bias from double-counting and small negative bias from caribou moving away from the observer (Buckland *et al.* 2001) may have somewhat cancelled each other out, although this cannot be quantified.

Ten caribou ice crossing locations were recorded over continuous ice conditions between Birthday Rapids and Gull Lake on Jan 31, 2013. Discontinuous ice, open water and all ice jams that continued approximately one km east of Birthday Rapids may have impeded caribou movements across the Nelson River, as no tracks crossing the river in this geographic area were observed. During distance sampling transect surveys, seven additional ice crossings between Birthday Rapids and Gull Lake, 14 ice crossings on Stephens Lake between Gull Rapids and Gillam, and five on the north arm of Stephens Lake were detected. Ice conditions at the time likely affected caribou movements across frozen water bodies. Miller and Gunn (1986) observed some barren-ground caribou sniffing the edge of thin ice and returning into the forest after attempting to cross thin ice on lakes in the Northwest Territories. Fox Lake Cree Nation elders indicated that caribou drowning events in the Nelson River and Stephens Lake were related to unsafe ice conditions in hydroelectric reservoirs and changes in water level (FLCN 2010). Furthermore, one FLCN Member indicated that when thousands of barren ground caribou crossed PR 280 and moved towards Stephens Lake, they could not cross the lake as it was not safe to cross (FLCN 2010). Thus, ice conditions, especially near Birthday and Gull Rapids, likely contributed to the distribution of caribou ice crossing sites on the Nelson River and Stephens Lake. Finally, movements across Stephens Lake occurred at distances greater than 3 km west of the edge of the town of Gillam. Based on the distribution of the caribou observed at ice crossing sites, sensory disturbances from the town (i.e., noise, vibrations, smells, lights or other factors) may have contributed to caribou crossing Stephens Lake at certain locations and avoiding the community.

This study demonstrated a cost and time effective survey technique that provided a reasonably accurate population estimate of the large number of caribou in the Keeyask GS area in early February, 2013, as well as indicators to assess confidence in our estimated population size.

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## 6.2 PERSONAL COMMUNICATIONS

Gerry Racey, Ontario Ministry of Natural Resources. Email communication with Robert Berger, WRCS, via Vicki Trim, Manitoba Conservation and Water Stewardship. October 17, 2012.

Vicki Trim, Caribou Biologist. Manitoba Conservation and Water Stewardship. Telephone communication with Robert Berger, WRCS. February, 2013.

**Table 1. Number of caribou clusters and individuals detected on distance sampling line transects in each distance interval.**

| Distance interval (m) | Number of clusters | Number of caribou |
|---|---|---|
| 0-50 | 52 | 1134 |
| 51-100 | 57 | 693 |
| 101-150 | 22 | 253 |
| 151-200 | 37 | 402 |
| 201-250 | 9 | 65 |
| 251-300 | 30 | 360 |
| 301-350 | 5 | 33 |
| 351-450 | 24 | 260 |
| **Total** | **236** | **3,200** |

**Table 2. Ranked fitted detection function models used in the program DISTANCE v.6.0 to estimate caribou density From February 5 to 8, 2013, in the Keeyask Generating Station area. Ranking is based on the difference in Akaike's Information Criterion (ΔAIC).**

| Model Key | Adjustment Term | AIC | ΔAIC | $\chi^2$ GOF P-value | P | D | %CV | N | LCI | UCI |
|---|---|---|---|---|---|---|---|---|---|---|
| Half Normal | Cosine | 728.07 | 0.00 | 0.952 | 0.50 | 1.66 | 18.17 | 13,984 | 9,810 | 19,933 |
| Hazard rate | Cosine | 728.20 | 0.13 | 0.893 | 0.50 | 1.68 | 20.97 | 14,131 | 9,400 | 21,243 |
| Uniform | Cosine | 729.50 | 1.43 | 0.461 | 0.54 | 1.52 | 17.59 | 12,798 | 9,078 | 18,043 |
| Uniform | Simple polynomial | 730.25 | 2.18 | 0.596 | 0.52 | 1.57 | 18.02 | 13,221 | 9,301 | 18,792 |
| Half Normal | Hermite polynomial | 732.10 | 4.03 | 0.107 | 0.61 | 1.32 | 16.80 | 11,107 | 7,997 | 15,426 |
| **Averaged model** | | **728.07** | **0.00** | **0.952** | **0.50** | **1.73** | **27.60** | **14,536** | **8,876** | **24,019** |

* $\chi^2$ GOF is the p-value of the $\chi^2$ goodness of fit test, *P* is the estimated average detection probability, *D* is the estimated caribou density (caribou/km$^2$) for the study area and CV is its coefficient of variation at 95% confidence intervals, N is the total abundance estimate, and LCI and UCI are lower and upper confidence limits.

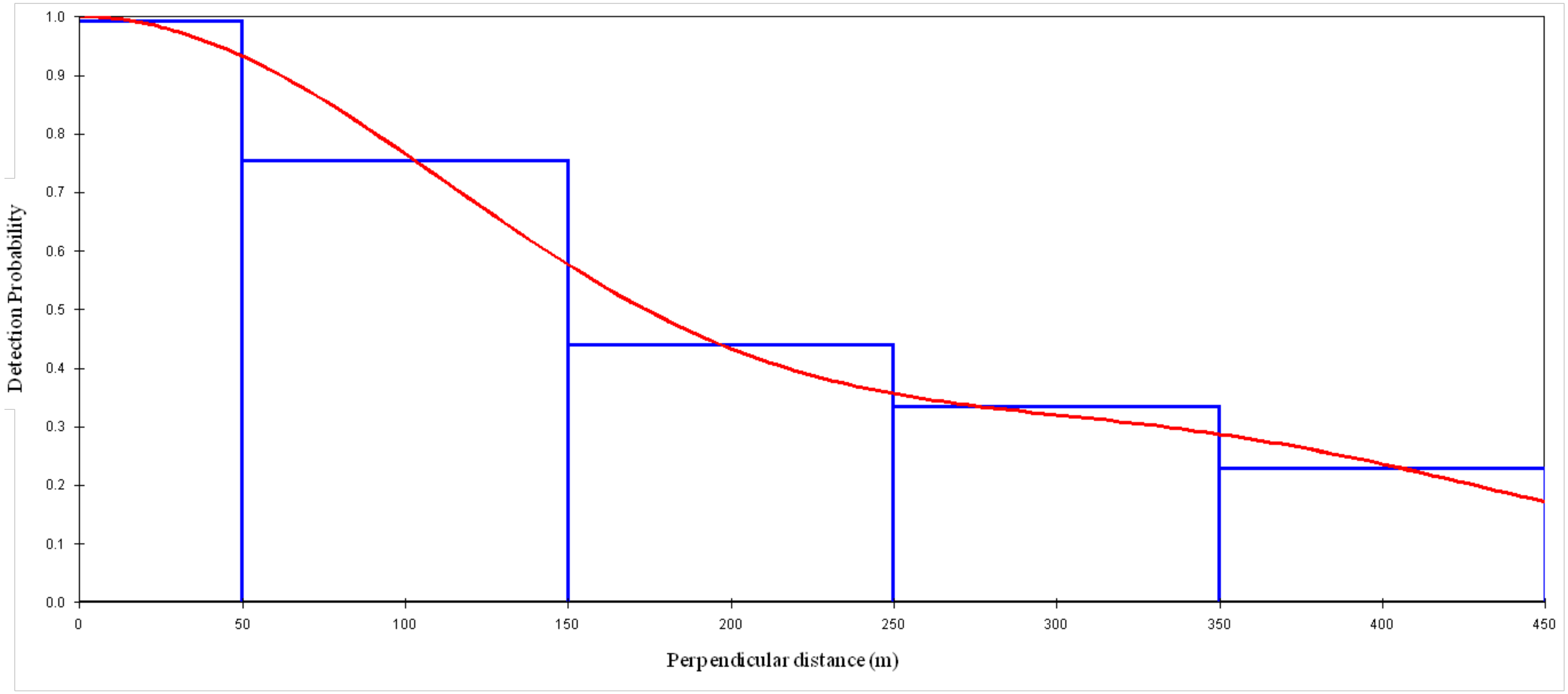
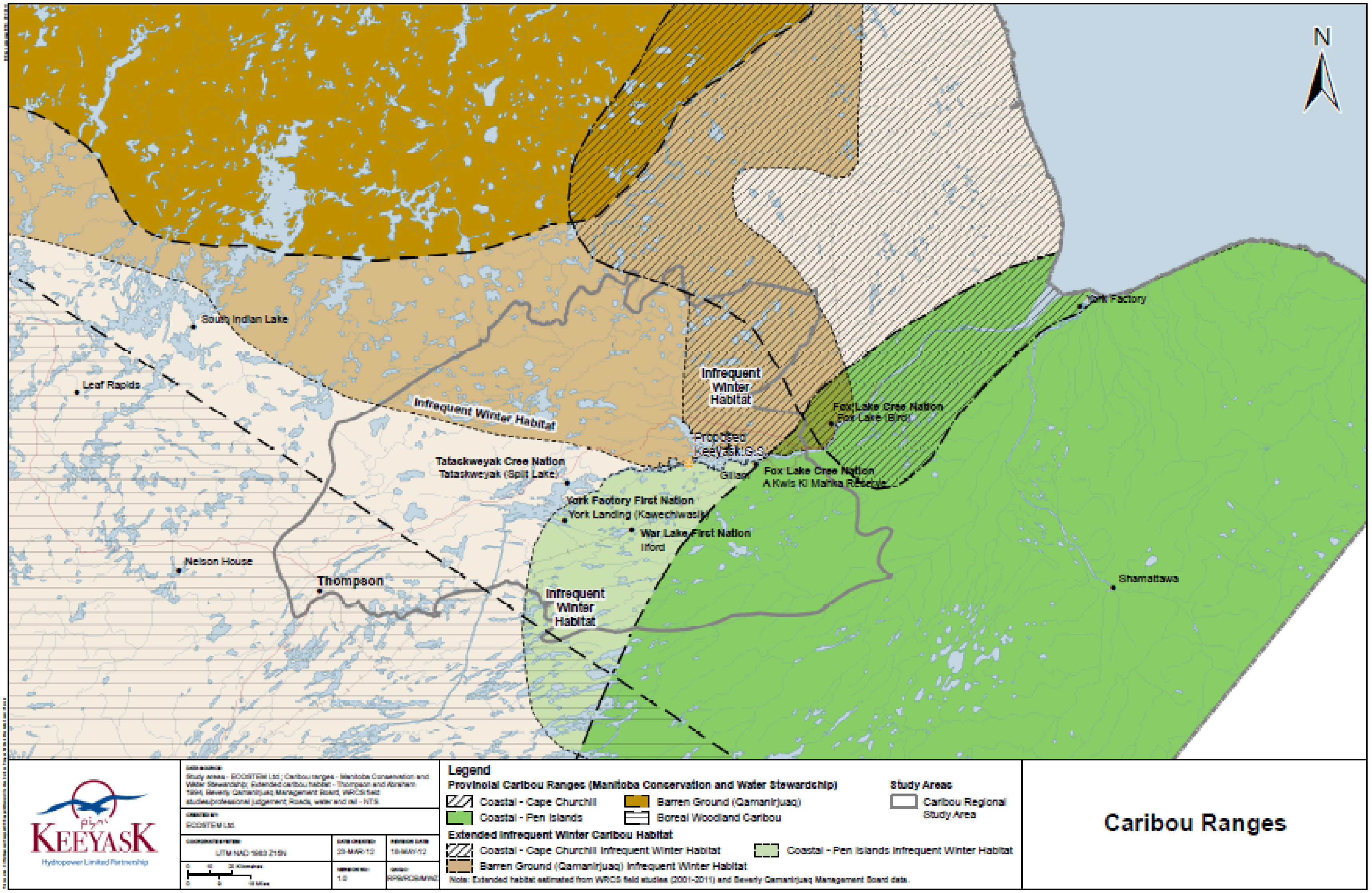
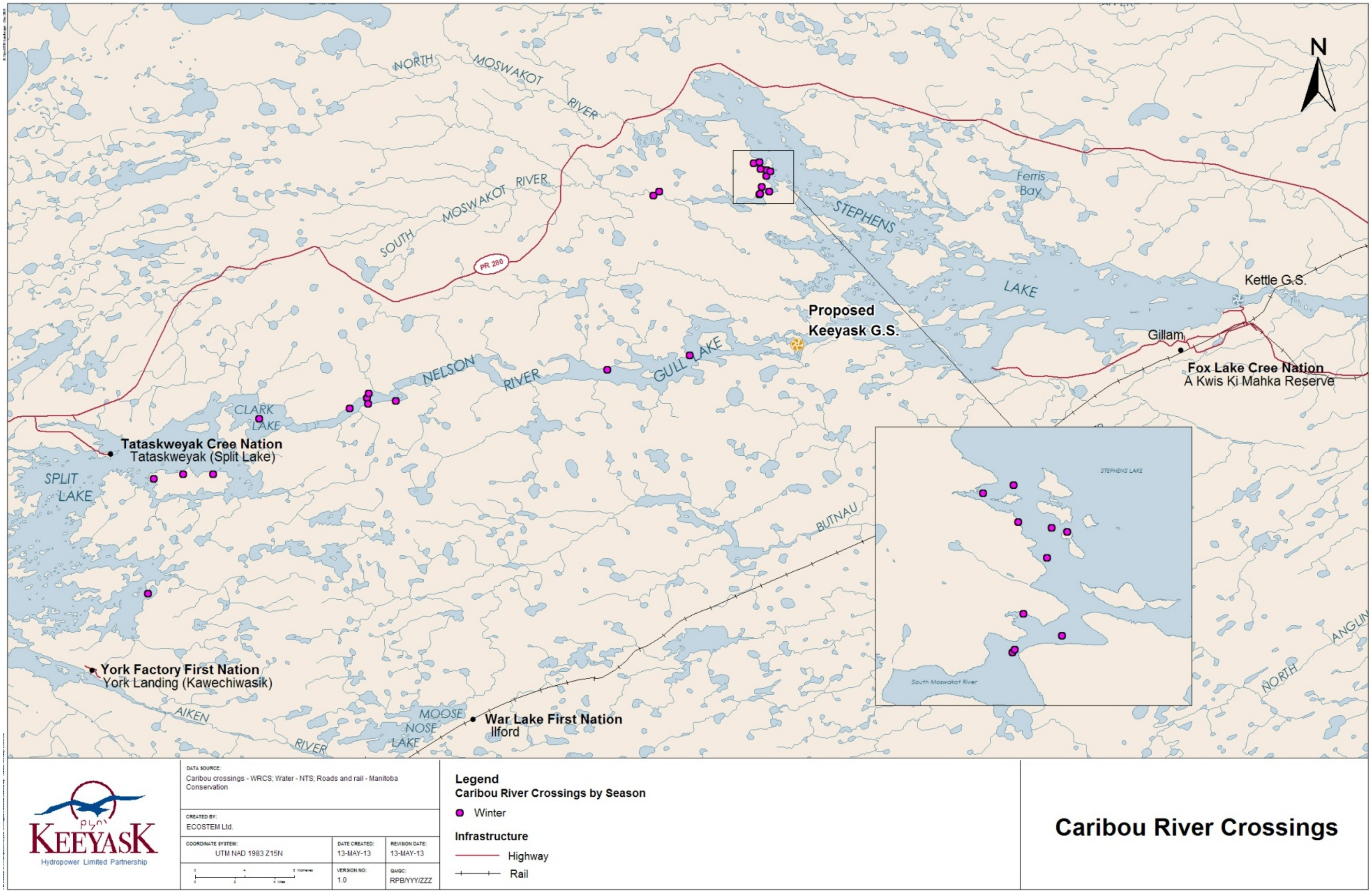


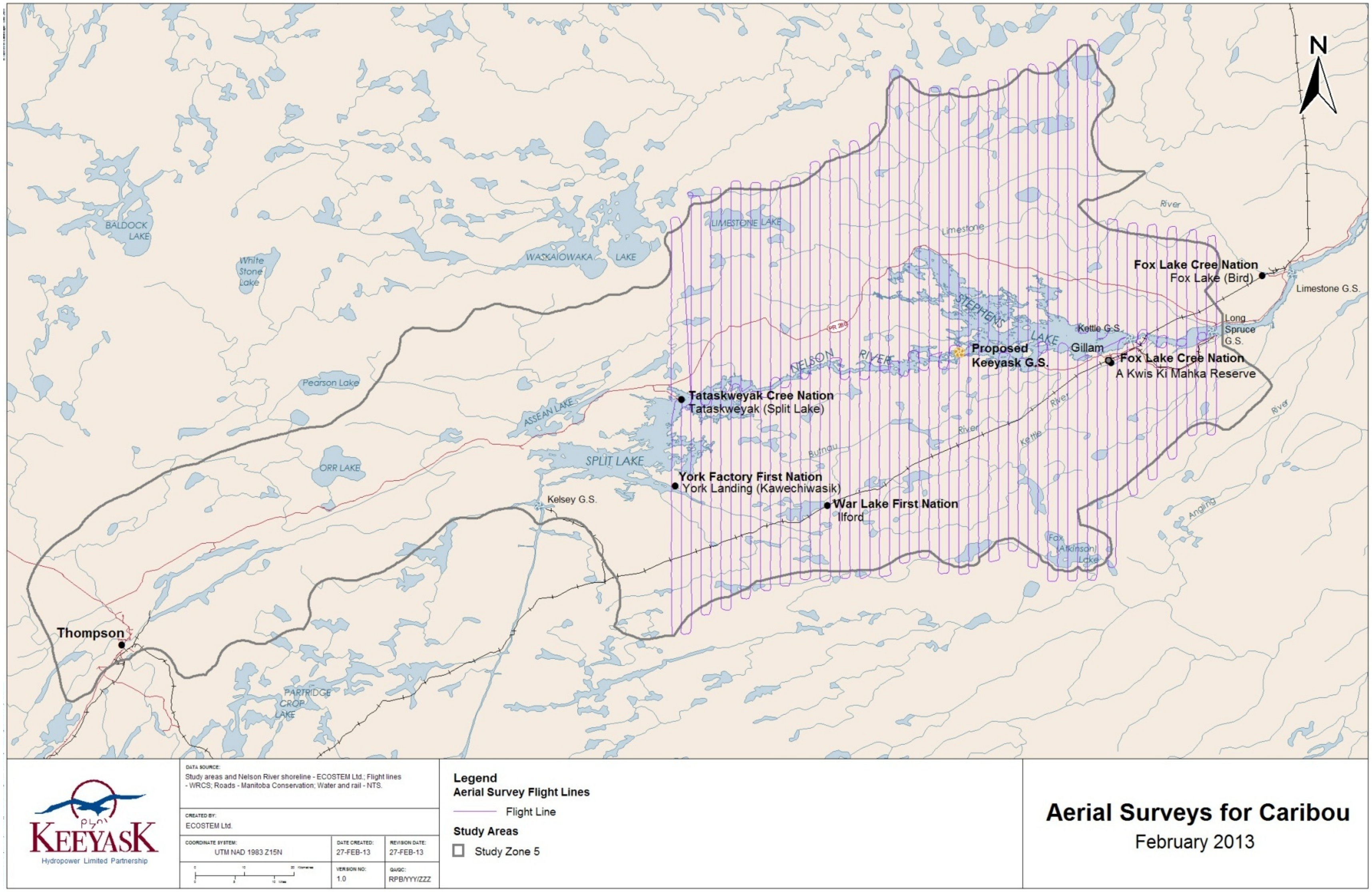

**Figure 1. Estimated detection probability of caribou clusters in the Keeyask Generating Station area, modeled in the program DISTANCE v. 6.0. The model is a half-normal key with a cosine adjustment term.**



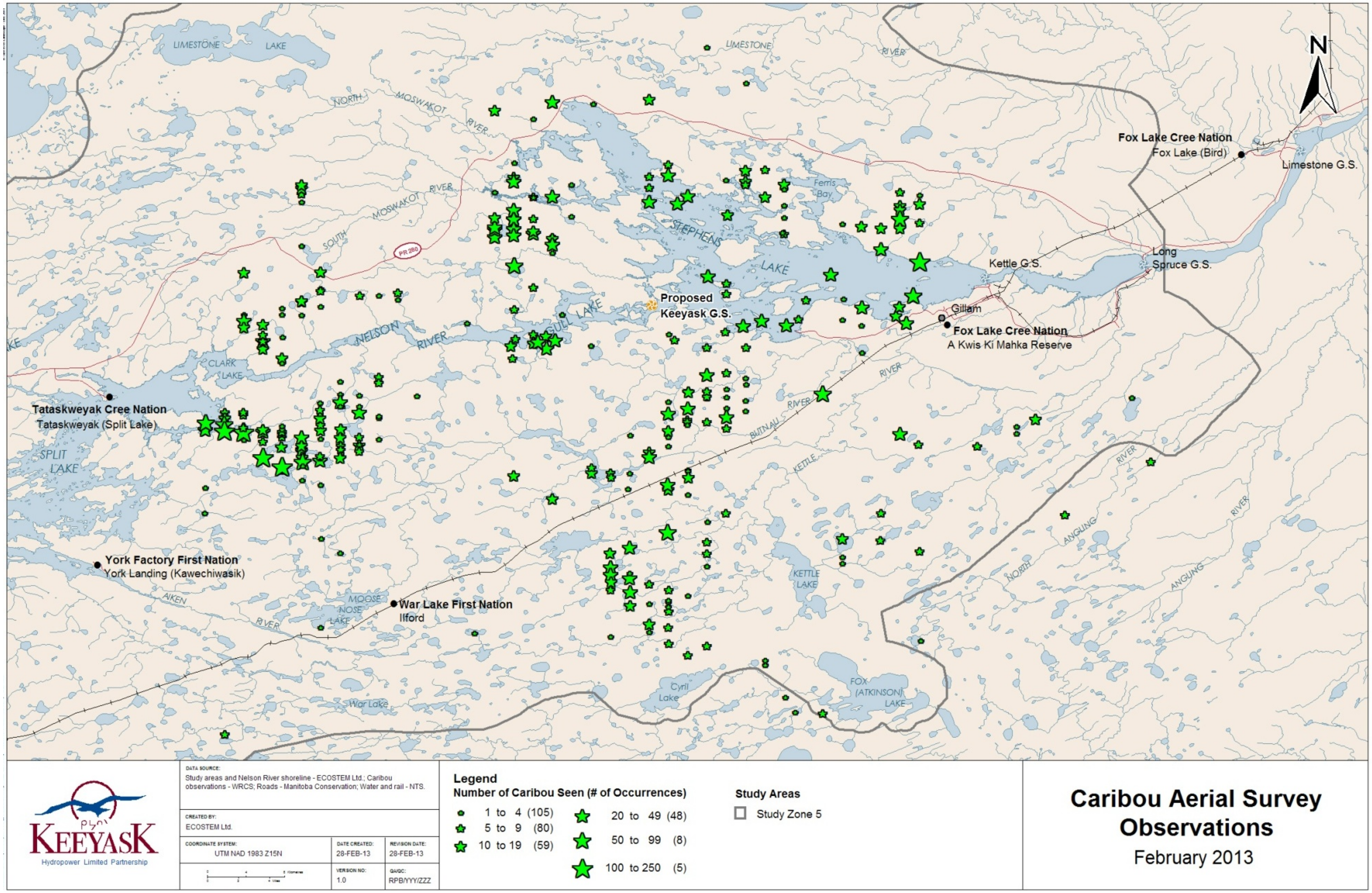

**Map 1. Caribou Ranges in the Lower Nelson River Area.**



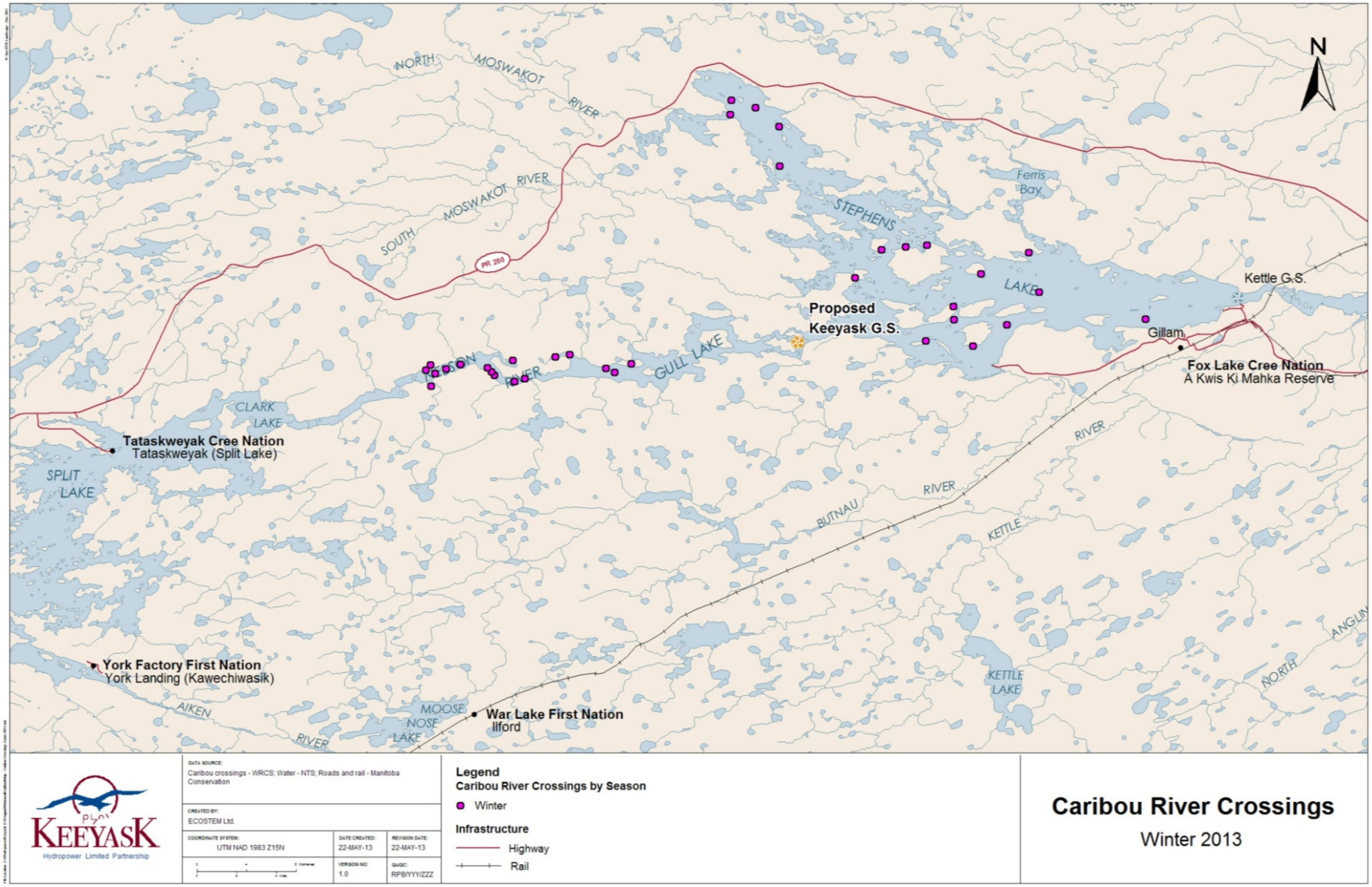

**Map 2.** Known caribou ice crossing locations in the Keeyask GS area (WRCS unpubl. data).




**Map 3.** **Caribou aerial survey area and distance sampling transects in February 2013.**




**Map 4.** **Locations of caribou clusters detected on transect during aerial surveys in February 2013.**




**Map 5.** **Caribou ice crossing locations detected on Jan 31 and Feb 5-8, 2013.**

Source: Peter Hettinga (WRCS), February 5, 2013.

**Photo 1. Caribou crossing the Nelson River and movements east along the north shore of the Nelson River between Birthday Rapids and Gull Lake.**

Source: Nichols LaPorte (WRCS), January 31, 2013.

**Photo 2. Caribou moving north across the Nelson River. Open water near Birthday Rapids and ice jams are visible to the west in the background.**

Source: Peter Hettinga (WRCS), February 5, 2013.

**Photo 3. Caribou crossing the North arm of Stephens Lake roughly 7 km south of PR 280.**

Source: Nicholas LaPorte (WRCS), February 5, 2013.

**Photo 4. Caribou crossing Stephens Lake 3 km west of Gillam. Kettle Generating Station and the town of Gillam are visible in the background.**