KEEYASK HYDROPOWER LIMITED PARTNERSHIP

Response to Undertaking #10 – Provide Updated Fire Information

December 31, 2013

Background

On November 25, 2013, the CEC requested that the Partnership update the filed fire history information to reflect the 2013 burns, and to include an updated caribou sustainability assessment (CEC Hearing Transcripts November 25, 2013: pp. 3435-3440, 3482; recorded in the transcripts as "Undertaking 10: Provide 2013 fire information affecting caribou, p. 3483).

In reviewing the implications of the 2013 fires, the fire history of the region was first updated, including an update to Table 2D-3 from the Terrestrial Environment Supporting Volume to 2013, as noted in the response to CEC Round 2 CAC-0159. This was followed by an assessment of the potential effects to caribou, with an emphasis on summer resident caribou – the one population in the area that may potentially be sedentary, boreal woodland caribou.

The following provides a summary of the findings, followed by the more detailed assessment, including tables and maps. Appendix A provides a summary of the methods used in the analysis.

Summary

In total, Manitoba Conservation recorded 38 fires in Study Zone 6 during 2013, encompassing 219,256 ha of Study Zone 6. The 2013 fire boundaries provided by Manitoba Conservation are fire perimeters which include burned areas, most waterbodies, and the areas skipped over by the fire. After removing waterbodies and the areas skipped over by the fire, an estimated 151,714 ha burned within Study Zone 6 during 2013.

Putting the 2013 fires into the historical perspective, the total area burned each year varied considerably from 1979 to 2013, with nine years accounting for 82% of the area burned in Study Zone 6 during this 34-year period (see Table 1 in the detailed section below). The total area burned during the 1989 to 1999 period was considerably higher than in other ten-year periods for Study Zone 6 and for Manitoba as a whole, which includes data going back to 1914 for Manitoba. Charting of "recent" fire disturbance (matching the 40-year age cut-off used in the Environment Canada woodland caribou habitat model) demonstrates that the recent disturbance percentage in Study Zone 5 or 6:

- constantly fluctuates;
- spikes in years when fires burn a relatively large area;
- gradually declines until the next large burn year occurs: and,
- the sizes of the spikes and subsequent declines can be dampened or exaggerated by unusual burn events that happened up to 40 years in the past.

Using past fire history as a predictor of future fire disturbance, the recent disturbance percentage is expected to continue fluctuating into the future, and to show an overall decline from the 2013 level. This will especially be the case as the unusually large area burned from 1989 to 1999 grows older than 39 years.

This information has been used to determine what the 2013 fire may mean for caribou, with an emphasis on summer resident caribou (potentially boreal woodland caribou), and based on the habitat intactness model developed by Environment Canada, which is applicable specifically to boreal woodland caribou and not to migratory populations. A variety of study zones are referenced, recognizing the uncertainty regarding the range of this summer resident population, as well as its designation.

Based on 2013 fires in the Keeyask region, calculated intactness for caribou indicated that the quantity of undisturbed habitat in the region following the 2013 fire and **without Keeyask or other future projects** changed from those reported in CEC Rd 1 CEC-0021 as follows:

- Study Zone 5: from 64.4% to 51.5%
- Study Zone 6: from 66.1% to 59.0%, and
- Pen Island Evaluation Area: from 73.1% to 63.2%

With Keeyask and other future projects in place, caribou intactness is anticipated to change as follows with the 2013 fire:

- Study Zone 5: from 62.7% to 50.4%
- Study Zone 6: from 65.9% to 58.5%, and
- Pen Island Evaluation Area: from 72.6% to 60.9%.

In all cases, these results are below the desired 65% undisturbed habitat for a woodland caribou population according to the current Environment Canada (2011, 2012) habitat intactness model. This suggests that the persistence for a possible boreal woodland caribou **local population** would either be "not **self-sustaining**[1]" (Zone 5) or "as likely as **not self-sustaining**[2]" (Zone 6 or Pen Islands Evaluation Area), depending on its range.

However, these results should be viewed with caution because there are limitations to the predictive strength and applicability of the Environment Canada model in the Keeyask region, as has been seen for other woodland caribou herds in Canada. Reasons for this are as follows:

[1] Self-sustaining local population: a local population of boreal caribou that on average demonstrates stable or positive population growth over the short-term (≤20 years), and is large enough to withstand stochastic events and persist over the long-term (≥50 years), without the need for ongoing active management intervention (Environment Canada 2012).
[2] Not self-sustaining local population: in the population and distribution objectives “not self-sustaining local population” includes both the local populations assessed as “as likely as not self-sustaining” and those assessed as “not self-sustaining.”

- The model was developed based on woodland caribou herds in regions where fire (natural) disturbance is considerably lower and human disturbance considerably higher than experienced in the Keeyask region. This means it is not entirely applicable to the Keeyask area, as has been demonstrated for Saskatchewan's identified SK1 'Boreal Shield' range (Environment Canada 2011, 2012). Application of the Environment Canada model to fit a local population range which is subject to substantially different fire and human disturbance levels than those used to develop the model results in model imprecision in forecasting results and the potential for erroneous conclusions.
- Caribou populations are resilient to the effects of fire owing to large home ranges. Contrary to expectations in Alberta, for example, where as much as 76% of individual home ranges of three caribou populations burned, fire had no effect on subsequent home range size. Large areas allow caribou to compensate for a reduction in lichen availability due to fire by selecting unburned lichen patches within burned areas or by using alternative areas of their range (Dalerum et al. 2007).
- Human disturbance, and particularly linear disturbance, has been shown to have a greater effect on woodland caribou populations than natural disturbances like fire. The Keeyask region, with or without any future development, is still relatively undeveloped and is affected by relatively large fire disturbances when compared to many other regions where woodland caribou populations have been designated. Caribou are adapted to the long-term cyclic nature of fires in northern Manitoba and elsewhere - on average, about 30% to 35% of the landscape in the Keeyask region has been recently (last 40 years) disturbed by fires. It has been shown elsewhere, that caribou populations tend to move to other habitat following a fire (Schaefer and Pruitt 1991), provided other habitat is available and is not affected by human disturbance (Environment Canada 2012). For this reason, Environment Canada (2012) has indicated that quantities of natural disturbances should not be treated similarly to buffered anthropogenic disturbance. In the future, habitat burned in the Keeyask region during large burn years is expected to recover and once again provide suitable habitat for caribou.
- Despite times of comparable disturbance (e.g., from 1995 to 2003 the recent fire disturbance percentage average in Study Zone 5 was above 35% compared to about 30% between 2007 and 2010), caribou have continued to persist in the Keeyask region, suggesting that other factors are also relevant to the long-term viability of this local population. For example, as indicated in CEC Rd 1 CEC-0037b, population persistence also depends on the size of this population.

While the Environment Canada model is a valuable approach for assessing caribou habitat quality and provides a straightforward means of identifying cumulative effects, for the reasons cited above additional and complementary assessment tools have been used in the EIS to evaluate the potential effects on the Project on caribou. These include linear feature density, wolf density (as derived from moose biomass), the availability of winter habitat, and the availability of calving and rearing habitat. Applying these benchmarks to the Keeyask region, it is expected that the effects of the Keeyask Project and anticipated future projects will only be of a low magnitude for caribou (even with the 2013 fire). Despite the temporary loss of available habitat in the Regional Study Area, in looking at all indicators of caribou sustainability, there is no change in the conclusions reached as part of the Project effects assessment as a result of the 2013 fires.

A more detailed description of the results is provided below. Appendix A documents the methods used in arriving at these findings.

Detailed Fire History Update

Manitoba Conservation recorded 38 fires in Study Zone 6 during 2013 (Map 1). Three of these fires were entirely within the boundaries of other 2013 fires. While the 38 fires ranged from 0.02 ha to 94,900 ha in size, only eight were larger than 200 ha. In combination, these fires encompassed 219,256 ha of Study Zone 6 using the data available on Manitoba Conservation's website.

The 2013 fire boundaries provided by Manitoba Conservation are fire perimeters. That is, the fire boundaries include burned areas, most waterbodies (all but the very large waterbodies are included), and the unburned areas within the fire perimeter (i.e., skips; see Figure 1 for example photos of skips in the 2013 burns). The fire regime analysis provided in Section 2.5 of the Terrestrial Environment Supporting Volume uses burned area only, where this can be mapped from available data. After removing water and skips, an estimated 151,714 ha burned within Study Zone 6 during 2013 (see Appendix A for methods), which is 69% of the area obtained if using the Manitoba Conservation fire boundaries.

Map 2 updates Map 2-16 from the Terrestrial Environment Supporting Volume to 2013. Table 1, which corresponds with Map 2, updates Table 2D-3 from the Terrestrial Environment Supporting Volume to 2013. It is noted that some areas for years prior to 2008 differ in Table 1 compared with Table 2D-3 because burns occurring after 2008 overlap some older burns. An additional column is included in Table 1 that provides the total area burned in a year after removing within-year burn overlaps.

Table 1 demonstrates that the total area burned each year varied considerably from 1979 to 2013, with nine years accounting for 82% of the area burned in Study Zone 6 during this 34-year period. Looking further back, only 16 of the 58 years with suitable fire history data had more than 20,000 ha burned (average area burned for the 58-year period was 27,700 ha; Figure 2). More area burned in three of these years than burned in 2013. In descending order, the five years contributing the highest area burned were 1989, 1992, 1964, 2013 and 2003. The total area burned during the 1989 to 1999 period was considerably higher than in other ten-year periods (Figure 2). While this was similar to what occurred throughout Manitoba (Figure 3), this phenomenon was much more pronounced in Study Zone 6 than for Manitoba as a whole (Figure 2). In contrast, the total area burned during the 1970s was relatively low in Study Zone 6 and Manitoba as a whole (Figure 2). For the longer-term record in Manitoba, total area burned during the 1989 to 1999 period was high (Figure 3).

Figure 1. Example photos of areas that were skipped over (i.e., skips) in the 2013 burns.

Table 1. Update to Terrestrial Environment Supporting Volume Table 2D-3, and Total Area Burned Each Year Before Removing Year-to-Year Overlaps.

Burn Year	Burn Age (years old)	Study Zone 6 (%) (Fire Regime Regional Study Area)	Study Zone 5 (%)	Study Zone 4 (%)	Area Burned (ha) in Study Zone 6	Area Burned (ha) in Study Zone 6 Before Removing Year-to-Year Overlaps
2013	0	12.7	23.8	54.0	151,714	151,714
2012	1	0.2	0.0	0.0	2,957	4,202
2011	2	0.0	0.0	0.0	5	46,568
2010	3	0.9	0.3	0.0	10,698	11,022
2009	4	0.0	0.0	0.0	1	1
2008	5	0.0	0.0	0.0	0	0
2007	6	0.1	0.0	0.0	626	626
2006	7	0.8	0.0	0.0	9,412	9,415
2005	8	6.6	7.0	16.7	79,297	80,637
2004	9	0.0	0.0	0.0	73	80
2003	10	6.9	6.8	0.6	82,284	112,209
2002	11	0.9	1.7	0.0	10,451	10,452
2001	12	0.8	0.2	0.2	9,786	10,406
2000	13	0.8	0.0	0.0	9,286	9,286
1999	14	2.2	0.9	5.8	26,601	31,105
1998	15	9.0	4.0	0.1	107,567	108,822
1997	16	0.0	0.0	0.0	282	282
1996	17	3.5	1.4	0.1	41,908	42,312
1995	18	7.6	12.7	7.0	90,970	91,610
1994	19	7.7	4.4	0.1	92,200	100,842
1993	20	0.0	0.0	0.0	32	64
1992	21	12.0	10.0	1.3	143,618	157,993
1991	22	0.3	0.0	0.0	4,048	4,083
1990	23	0.6	1.4	0.0	7,549	8,480
1989	24	15.1	15.4	4.3	179,997	181,302
1988	25	0.3	0.3	0.0	3,064	4,008
1987	26	0.0	0.0	0.0	495	532
1986	27	0.1	0.0	0.0	757	757
1985	28	0.2	0.2	0.0	2,010	2,093
1984	29	1.5	3.2	1.0	17,545	20,459
1983	30	0.0	0.0	0.0	3	5
1982	31	0.2	0.4	0.0	2,428	2,510
1981	32	7.6	2.9	8.5	91,018	91,613

Burn Year	Burn Age (years old)	Study Zone 6 (%) (Fire Regime Regional Study Area)	Study Zone 5 (%)	Study Zone 4 (%)	Area Burned (ha) in Study Zone 6	Area Burned (ha) in Study Zone 6 Before Removing Year-to-Year Overlaps
1980	33	1.3	2.9	0.2	16,009	16,727
1979	34	0.0	0.0	0.0	8	8
All	All	100.0	100.0	100.0	1,194,701	1,312,225

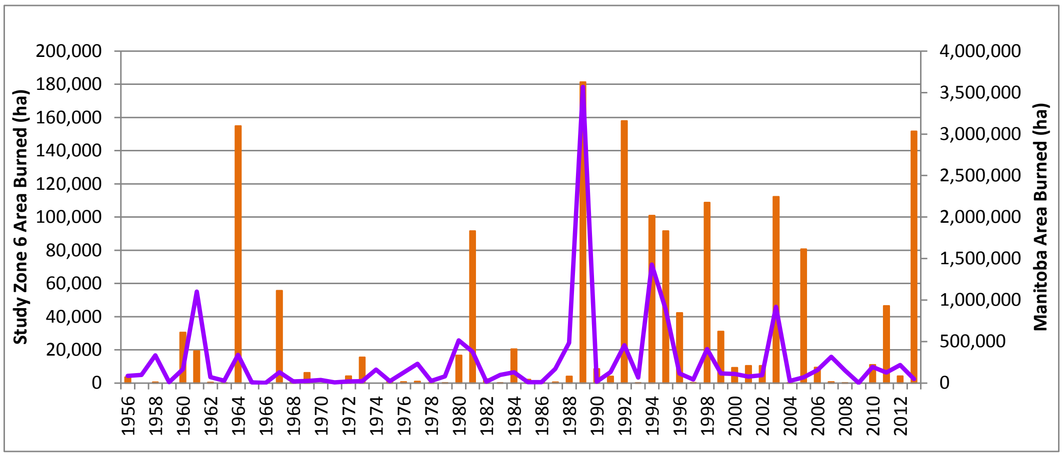

Figure 2. Total annual area burned (ha) in Study Zone 6 (orange bars) and in Manitoba (purple line) from 1956 to 2013.

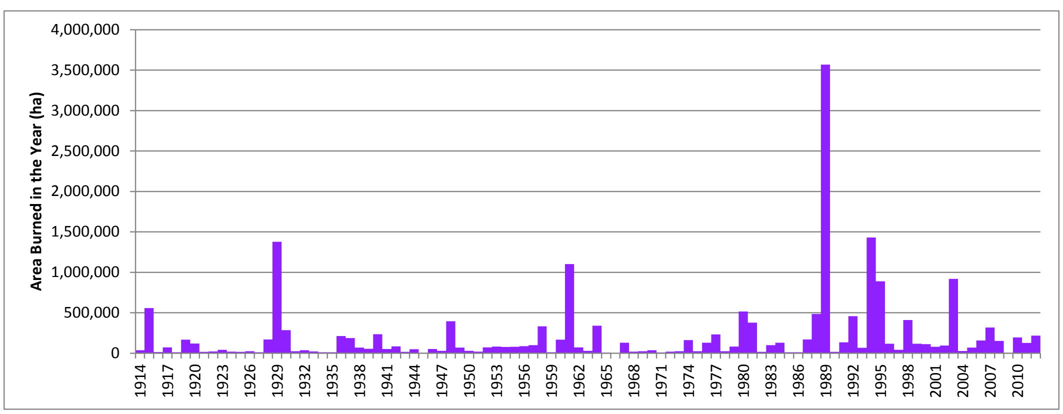

Figure 3. Total annual area burned (ha) in Manitoba from 1914 to 2013.

"Recent" Fire Disturbance

Figure 4 shows fire disturbance for each year from 1994 to 2013 (1994 is the earliest year that can be represented for recent disturbance percentage as it captures the 1956 to 1994 period (see Appendix A for fire mapping methods and limitations); see Figure 2 for total annual area burned prior to 1994). The green bars represent the area burned within Study Zone 6 in a given year. The orange and blue lines represent the percentage of land area with vegetation younger than 40 years in Study Zones 5 and 6, respectively (e.g., the first point on the lines is the percentage of land area burned over the 1956 to 1994 period after removing burn overlaps). For convenience, this document uses "recent disturbance percentage" as the term for the percentage of land area with vegetation younger than 40 years (note that 40 years is much older than what the EIS generally considers to be recent disturbance). A 40-year-old age cut-off was selected for illustrative purposes because this is the same age cut-off used in the Environment Canada woodland caribou habitat model (note that, as described in the Caribou Intactness and Method Notes sections below, the fire disturbance mapping criteria for the fire regime and Environment Canada analyses are somewhat different).

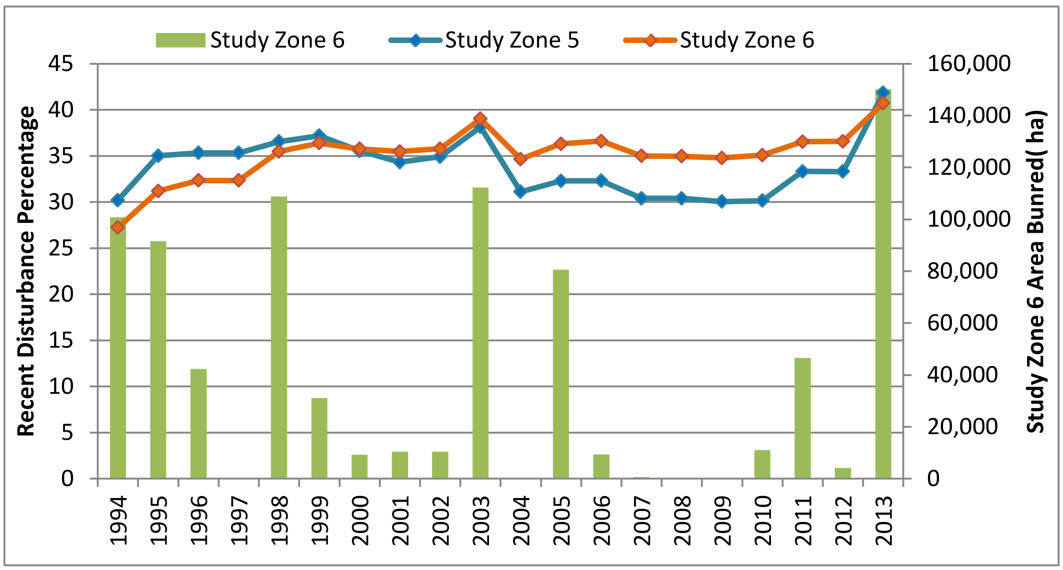

Figure 4. Percentage of land area younger than 40 years (blue and orange lines) and total area burned (ha) in the year (green bars).

The orange and blue recent disturbance percentage lines illustrate how the high year-to-year variability in area burned (green bars) translates into the percentage of land area with vegetation younger than 40 years old. Compared with the green annual area burned bars, the recent disturbance percentage lines in Figure 4 change more smoothly from one year to the next because each point on the line represents the accumulated area burned over the preceding 39 years. Even when a relatively large area burns in one year, the total percentage of area younger than 40 years does not change to a similar relative degree. Similarly, a large drop in the recent disturbance percentage does not occur in years when no area burns.

Figure 4 shows that the recent disturbance percentage for 2009 in Study Zone 5 was low relative to the preceding 20 years. Looking back in time in Study Zone 5, 1994 was the most recent year when fire disturbance was as low as it was in 2009. Prior to 2013, the recent disturbance percentage for the 1994 to 2013 period peaked at 38.2% in 2003 (compared with 41.8% in 2013). The difference in recent disturbance percentages for 2013 compared with 2003 was lower for Study Zone 6 (40.7% versus 39.0%)

than for Study Zone 5, which illustrates the effect of study area size and shape on recent disturbance percentage.

The 2013 recent disturbance percentage for Study Zone 5 was unusually high for two reasons. First, while it is often the case that portions of large burns will overlap other burned areas younger than 40 years, the large area burned in 2013 was concentrated in portions of Study Zone 5, which had escaped fire for a long period of time (compare Map 2 below with Map 2-16 in the Terrestrial Environment Supporting Volume). Second, it reflects the unusually high total area burned during the 1989 to 1999 period. Assuming future fire disturbance will follow the same general pattern as past fire disturbance, the recent disturbance percentage is expected to show an overall decline as the unusually high area burned during the 1989 to 1999 period becomes at least 40 years old.

The EIS analysis used the historical pattern of fire disturbance as the model for the future pattern of fire disturbance. It was expected that Study Zones 6 was large enough to support a relatively stable inland habitat composition in a shifting habitat mosaic over the century time frame as large fires continued to occur (Terrestrial Environment Supporting Volume Section 2.14.2.1).

The historical pattern of fire disturbance was expected to be a better predictor of future fire disturbance than a model that would include some simplifying and potentially unrealistic assumptions. As examples, assuming that all areas have an equal probability of burning is not supported by the literature (Cumming 2001; Krawchuk et al. 2006) and does not reflect the history of Study Zone 6. Similarly, using a Monte Carlo model to predict the probability that various recent disturbance percentages will occur could be based on several very large burn years in a row, which does not reflect the historical pattern in Study Zone 6 or Manitoba as a whole (Figure 3).

The recent disturbance percentage lines in Figure 4 demonstrate that the recent disturbance percentage in Study Zone 5 or 6: (i) constantly fluctuates; (ii) spikes in years when fires burn a relatively large area; (iii) gradually declines until the next large burn year occurs; and, (iv) the sizes of the spikes and subsequent declines can be dampened or exaggerated by unusual burn events that happened up to 40 years in the past. This general pattern is influenced by the cumulative pattern of fires over the previous 40 years. As examples, 2004 exhibited a relatively large drop in the recent disturbance percentage because this was the year when the very large area burned in 1965 became 40 years old and because virtually no area burned in 2004. In contrast, the decline in recent disturbance percentage from 2006 to 2010 was relatively low because the unusually large area burned during the 1989 to 1999 period was still strongly influencing the recent disturbance percentage.

Using the historical pattern from 1956 to 2013 (Figure 2) as the model, it is expected that the recent disturbance percentage observed in 2013 will decline in the future as the unusually large area burned from 1989 to 1999 grows older than 39 years. There is uncertainty associated with this prediction due to the highly variable nature of fire and the potential effects of future climate change on the degree of recent fire disturbance.

In summary, using past fire history as a predictor of future fire disturbance indicates that the recent disturbance percentage is expected to continue to fluctuate up and down in the future, and to show an overall decline from the 2013 level as the unusually large area burned from 1989 to 1999 grows older than 39 years.

Detailed Caribou Intactness Update

As described above, caribou are adapted to the long-term cyclic nature of fires in northern Manitoba and elsewhere. As identified by Environment Canada, quantities of natural disturbances should not be treated similarly to buffered anthropogenic disturbance: "Although caribou adapt to fire by shifting use to unburned areas until burned areas recover, this adaptation strategy is dependent on alternate undisturbed areas being available for caribou use" (Environment Canada 2012, p 71). Contrary to expectations in northern Alberta, for example, where as much as 76% of individual home ranges of three caribou populations burned, fire had no effect on subsequent home range size. "These large areas may allow caribou to compensate for a reduction in lichen availability due to fire by selecting unburned lichen patches within burned areas or by using alternative areas of their range"(Dalerum et al. 2007). Although fire did not seem to directly affect the spatial distribution of these northern populations, the generation of younger habitat may affect caribou distribution within their annual ranges. It should be noted that in these cases, population demographics were not affected as fire did not affect mortality or fecundity (Dalerum et al. 2007). As such, caribou populations are resilient to the effects of fire owing to large home ranges.

This is expected to be the case for the Keeyask Caribou Regional Study Area, which is comprised of a large portion of recent disturbance percentages, which on average, comprises about 35% of the landscape (Figure 4), and with burned areas shifting over time (Map 2). Movement of caribou would be particularly evident in large burn years including 1964, 1989, 1992, 2003 and 2013. To this extent, range shifts would occur in favour of unburned habitat found elsewhere in the Caribou Regional Study Area, or possibly extend to suitable habitat found outside the region. In the future, habitat burned in the Keeyask region during large burn years is expected to recover and once again provide suitable habitat for caribou.

Based on 2013 fires in the Keeyask region, calculated intactness estimates showed that the quantity of undisturbed habitat in the Caribou Regional Study Areas, as well as the delineated Pen Islands Evaluation Area, declined from those levels reported in CEC Rd 1 CEC-0021 (Table 2, Table 3). With 2013 fires, the current Environment Canada (2011, 2012) habitat model intactness estimates with the Project suggest that the persistence for a possible boreal woodland caribou **local population** would either be "not **self-sustaining**[3]" (Zone 5) or "as likely as **not self-sustaining**[4]" (Zone 6 or Pen Islands Evaluation

[3] Self-sustaining local population: a local population of boreal caribou that on average demonstrates stable or positive population growth over the short-term (≤20 years), and is large enough to withstand stochastic events and persist over the long-term (≥50 years), without the need for ongoing active management intervention (Environment Canada 2012).

Area). As indicated in CEC Rd1 CEC-0037b, population persistence would also depend on the size of this population.

Table 2 Calculated intactness estimates indicating quantity of undisturbed habitat in Keeyask Caribou Study Area provided in CEC Rd 1 CEC-021

	Size	Existing Environment		With Keeyask		With Keeyask and Future Projects	
	ha	ha	%	ha	%	ha	%
Study Zone 5	1,416,193	911,891	64.4%	904,502	63.9%	888,349	62.7%
Study Zone 6 (Caribou Regional Study Area)	3,049,905	2,015,340	66.1%	2,007,951	65.9%	1,991,798	65.3%
Pen Islands Evaluation Area[1]	1,469,477	1,074,793	73.1%	1,067,404	72.6%	1,041,378	70.9%

1-range identified in Manitoba Hydro (2012) and was considered further in CEC Rd1 CEC-0037b

[4] Not self-sustaining local population: in the population and distribution objectives "not self-sustaining local population" includes both the local populations assessed as "as likely as not self-sustaining" and those assessed as "not self-sustaining."

Table 3 Calculated intactness estimates indicating quantity of undisturbed habitat in Keeyask Caribou Study Area following 2013 fires

	Size	Existing Environment		With Keeyask		With Keeyask and Future Projects	
	ha	ha	%	ha	%	ha	%
Study Zone 5	1,416,193	728,780	51.5%	723,328	51.1%	713,733	50.4%
Study Zone 6 (Caribou Regional Study Area)	3,049,905	1,799,780	59.0%	1,794,328	58.8%	1,784,500	58.5%
Pen Islands Evaluation Area[1]	1,469,477	928,095	63.2%	920,706	62.7%	894,680	60.9%

1-range identified in Manitoba Hydro (2012) and was considered further in CEC Rd1 CEC-0037b

Calculation of caribou intactness follows those methods outlined by Environment Canada (2011, 2012) for identifying boreal woodland caribou critical habitat. The quantity of undisturbed habitat consists of any area within an identified caribou range that is unaffected by recent fire events (fire age ≤ 40 years) and does not occur within 500 m of various types of anthropogenic disturbance (Environment Canada 2011, 2012). While both fire and buffered anthropogenic disturbance act cumulatively to reduce the availability of critical habitat for boreal woodland caribou, Environment Canada (2011) identified habitat alteration through forest fires as being a medium level of concern and moderate severity and habitat alteration based on human land-use activities as alternately having a high level of concern and high severity to boreal woodland caribou populations (Environment Canada 2012, p. 12).

As per the Environment Canada (2011, 2012) assessment of provincially defined boreal woodland caribou ranges, calculated intactness estimates can be broken down based on the contribution of buffered anthropogenic disturbance and recent natural disturbance. With respect to intactness estimates calculated based on the 2013 fires in the Keeyask Region, the large majority of disturbances within these ranges is attributed to recent natural disturbance, rather than buffered anthropogenic disturbance (Table 4). Calculated intactness estimates provided in CEC Rd1 CEC-0021 used estimates of natural disturbance as of 2009 and similarly indicated high quantities of natural disturbance relative to quantities of buffered anthropogenic disturbance (Manitoba Hydro 2013 Appendix E). Habitat intactness estimates as they were calculated for the Pen Islands Evaluation Area are alternately provided in Appendix A.

Table 4. Calculated intactness estimates indicating quantity of disturbed habitat in Keeyask Caribou Study Areas following 2013 fires

	Size	Disturbance	Existing Environment		With Keeyask		With Keeyask and Future Projects	
	ha		ha	%	ha	%	ha	%
Study Zone 5	1,416,193	Natural	669,471	47.3%	669,471	47.3%	669,471	47.3%
		Anthro.	155,135	11.0%	164,633	11.6%	187,670	13.3%
		Total[1]	687,413	48.5%	692,865	48.9%	702,460	49.6%
Study Zone 6 (Caribou Regional Study Area)	3,049,905	Natural	1,232,530	40.4%	1,232,530	40.4%	1,232,530	40.4%
		Anthro.	188,226	6.2%	197,723	6.5%	220,993	7.2%
		Total[1]	1,250,124	41.0%	1,255,576	41.2%	1,265,404	41.5%
Pen-Islands Evaluation Area	1,469,477	Natural	476,603	32.4%	476,603	32.4%	476,603	32.4%
		Anthro.	64,779	4.4%	72,168	4.9%	98,194	6.7%
		Total[1]	541,382	36.8%	548,771	37.3%	574,797	39.1%

1-Total indicates non-overlapping quantities of natural and buffered anthropogenic disturbance as well as fragments < 20 ha

Calculated levels of natural disturbance indicated in Table 3 for Study Zones 5 and 6 are based on 38 fires that occurred between June – September 2013 (Map 1). Calculated levels of recent natural disturbance for the Pen Island Evaluation Area were alternately calculated based primarily on the quantity of fire provided in Bipole III Caribou Supplemental Filing (Manitoba Hydro 2012). Of the 38 fires, the portion of the two largest fires that occurred in 2013 in the Pen Islands Evaluation Area was added to this total. Of the remaining 36 fires, 23 were considerably less than 200 ha in size (i.e., in the range of 1 ha) and the large majority of these fires occurred outside of the Pen Island Evaluation Area. Calculations of the amount of natural disturbance in the Pen Islands Evaluation Area may slightly overestimate the area burned because of pre-existing natural disturbances, and linear feature overlap being double-counted where these new fires occurred.

Calculated intactness estimates based on the addition of 2013 fires in the Keeyask Region indicate less available boreal woodland caribou critical habitat compared to estimates provided in CEC Rd 1 CEC-0021. This would be an accurate assessment as caribou prefer mature forested areas, some of which were altered or lost due to the 2013 fires and where more habitat was lost rather than gained through the regeneration of previously burned areas. However, as Environment Canada (2011, 2012) associates the portion of undisturbed habitat within identified caribou ranges as being linked to calf recruitment rates and population rate of growth, some context as to how revised intactness estimates could affect caribou in the Keeyask Region is required.

Through quantifying the portion of a boreal woodland caribou range not suitable as habitat, Environment Canada (2008, 2011, 2012) found an inverse relationship between disturbed habitat and calf recruitment, a key parameter in the estimation of population rate of growth, lambda (Environment Canada 2011 p. 25). Through developing a model which reflects this numerical relationship, Environment Canada (2012) set a regulatory 'total disturbance threshold' of 35% disturbed habitat as associated with an increased level of uncertainty for persistence of caribou local populations with disturbance levels above 45% indicating the identified caribou local population as no longer being self-sustaining based on the condition of its range (Figure E-1).

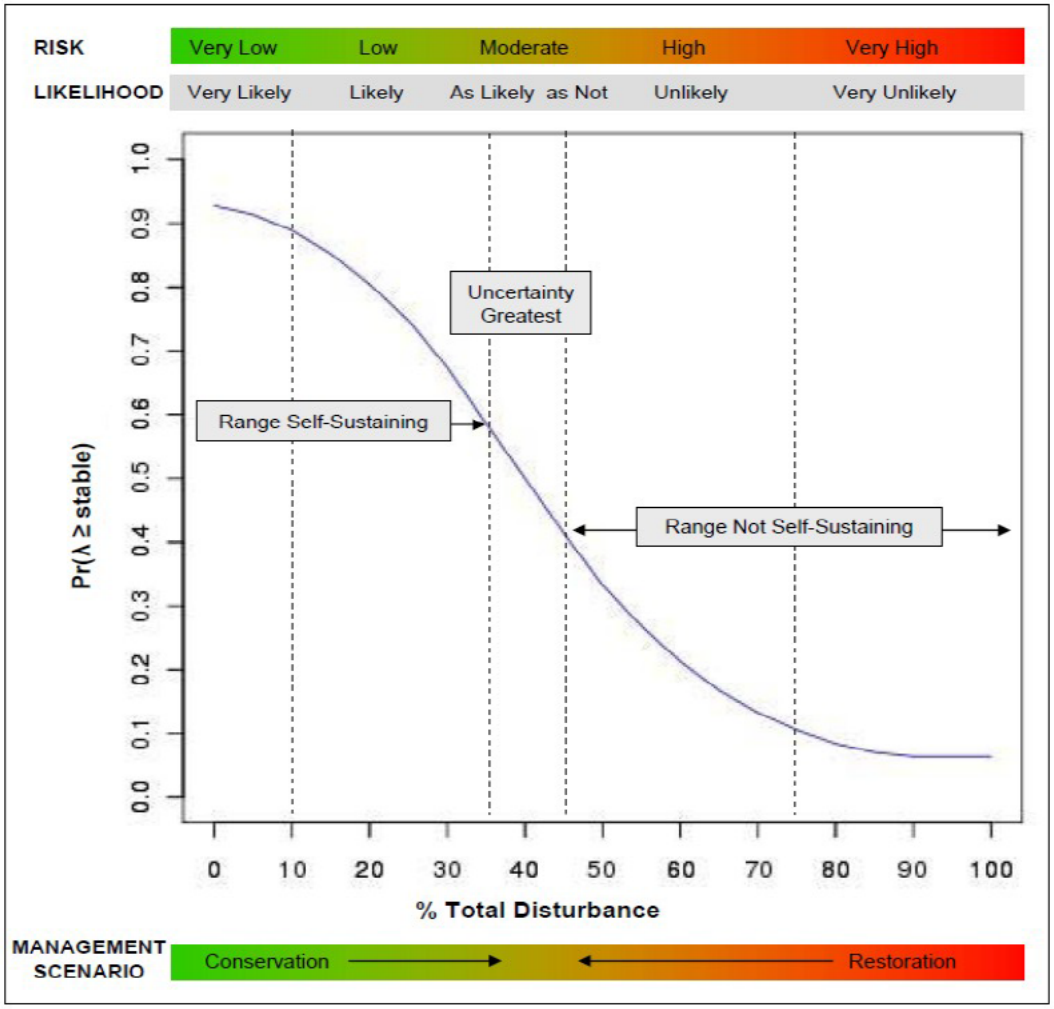

Figure E-1. Disturbance management thresholds: The probability of observing stable or positive growth (λ ≥ stable) of boreal caribou local populations over a 20-year period at varying levels of total range disturbance (fires ≤ 40 years + anthropogenic disturbances buffered by 500 m). Certainty of outcome, ecological risk, and management scenarios are illustrated along a continuum of conditions (Environment Canada 2012).

Within the Environment Canada (2011, 2012) model, buffered anthropogenic disturbance is linked to 60% of the variation in calf recruitment rates. Herein lies the primary predictive strength of the model. The following however, is noted for the performance of the leading model that was selected and used by Environment Canada with respect to fire and to reservoirs: "The top model (M3)" of 13 candidate caribou habitat models tested, "explained 69% of the variation in calf recruitment across a sample of twenty-four (24) ranges based on the percent total disturbance (fire + 500 m buffered anthropogenic disturbance; Figure 8) on each range. This model was analogous to the top model used in the 2008 Scientific Review. However, the new disturbance maps, which allowed better temporal matching of demographic data with disturbance data, and exclusion of reservoirs from the disturbance estimates, resulted in a 12% gain in explanatory power over the 2008 model. Most of the negative effects of disturbance were attributed to human development (60% in isolation), while only 5% of the variation in recruitment could be attributed to fire alone (see Appendix 7.5). Nevertheless, their combined influence was greater than the sum of their individual contributions. Decomposing anthropogenic disturbance into linear and polygonal features did little to improve the predictive power of the recruitment model, but the negative effect of linear disturbance features was greater than the negative effect of polygonal disturbances (see Appendix 7.5)." Figures and Appendices referred to in this paragraph are for Environment Canada 2011).

The Environment Canada (2011, 2012) model is a valuable tool for assessing caribou habitat quality, and provides a straightforward means of identifying cumulative effects. This model indicates the probability of caribou local population persistence over a continuum of conditions, and also identifies the point at which management actions should be applied to local populations. As a cautionary note for assessing boreal woodland caribou herds, Environment Canada (2012) indicates that the range of buffered anthropogenic disturbance used in the meta-analysis ranged from 12 to 100% while the highest value for natural disturbance used was 42% (Environment Canada 2012 p. 70). As calculated quantities of anthropogenic and natural disturbance for the Boreal Shield range exist outside the range of values tested by the Environment Canada (2012) meta-analysis, Environment Canada (2012, p 70) indicated caution was warranted in the use of its model to estimate calf recruitment rates for this range. This is highlighted by Environment Canada (2012 pp 70-71) in its discussion of Saskatchewan's Boreal Shield range which is indicated to have 55% natural disturbance and 3% buffered anthropogenic disturbance.

The Keeyask Caribou Study Areas are similar to Saskatchewan's SK1 'Boreal Shield' range in also having levels of natural and/or anthropogenic disturbance that were not represented by the Environment Canada (2012) meta-analysis. That is, fire disturbance was higher and human disturbance was lower than in the dataset used for the Environment Canada analysis, which has implications for the applicability of the Environment Canada model to Study Zone 5. Study Zone 5, post-2013 fire, contains 48.5% burned habitat and currently has 11.0% buffered anthropogenic disturbance. This quantity of natural disturbance is in excess to any of the models used in the Environment Canada (2012) meta-analysis (indicated as 42% by Environment Canada (2012 p 70)) with the quantity of buffered anthropogenic disturbance, at 11.0% based on existing environment levels, falling below 12%; the lowest level of anthropogenic disturbance tested. Similarly, Study Zone 6 and the Pen Islands Evaluation Range described from Bipole, have quantities of buffered anthropogenic disturbance comprising of 6.2% and 4.4% of the total area of these ranges, based on existing environment levels, respectively, also falling below those levels considered in the Environment Canada (2012) model.

Application of the Environment Canada (2012) model to fit a local population range which is subject to fire and human disturbance levels that are outside of the values considered in the statistical model development results in model imprecision in forecasting, and the potential for erroneous conclusions. This was indicated by Sleep and Loehle (2010) after they applied the Sorenson et al (2008) predictive model to a set of 15 local populations with nine of these not having been initially considered in model development. Sorenson et al (2008) relied on range use and demographic information from six radio-collared caribou populations in northern Alberta and found that the relationship between buffered anthropogenic disturbance (250-m buffer) and quantities of fire (fire age ≤ 50 years) was an accurate predictor of population rate of growth (R^2 = 0.96). Although the Sorenson et al. (2008) model showed great promise in displaying a conclusive habitat-population threshold, with little requirement for the expenditure of resources that often curtail large mammal management programs (i.e., radio-collaring and aerial surveys), in practice, the model had little prediction accuracy when applied to caribou ranges outside of the area from which it was originally conceived (Sleep and Loehle 2010). This indicates the relative difficulties in applying generalized conservation models to include populations outside of their initial scope. While the Environment Canada (2011, 2012) model has successfully refined the Sorenson et al. (2008) model to have better predictive capabilities, Environment Canada (2012, p 71) cautions that "it is conceivable that additional data from high fire – low anthropogenic study areas could result in a two variable model performing better and allowing greater differentiation of the relative contributions of fire and anthropogenic effects."

Rasiulis et al. (2012) indicate that a minimum of six years of radio-collaring information on multiple animals is required to appropriately assess local population range boundaries based on shifting range use patterns where monitoring intervals of four years or greater accurately captured more than 65% of the delineated herd range. This would indicate that the gap in knowledge between identified local populations, principally used in the construction of the Environment Canada (2012) model and considered by Sorenson et al. (2008), surpasses more than just an awareness of spatial use patterns but is developed over a longer term through a commitment of resources and study by various groups.

It is widely recognized that anthropogenic disturbance plays a major role in the decline of boreal woodland caribou populations based primarily on the role of linear features in creating movement corridors for predator species. To this extent various benchmarks have been utilized in the Keeyask EIS as a means of assessing how anthropogenic land uses in the Keeyask Region could affect wildlife populations, including a prospective population of boreal woodland caribou. For example, it has been recognized that there is a direct relationship between linear feature density and overall anthropogenic disturbance i.e. where people go roads follow (Antoniuk et al. 2007). To this extent, Dzus et al. (2010) suggested in their review of forestry standards as affecting caribou, that linear feature density estimates could be an effective surrogate measure for cumulative disturbance. The Keeyask EIS uses two such 'intactness' benchmarks, separate from caribou intactness, including linear feature density as well as core area intactness for which the presence of various linear features figure prominently (CEC Rd 1 CEC-0021). Based on these benchmarks in the consideration of the Keeyask Project and anticipated future projects, there is little effect associated with the Keeyask Project where, in fact, linear feature density is expected to decrease in the Regional Study Area as a result of flooding.

As outlined in the Terrestrial Supporting Volume (Section 7.2.6), and in the presentation made to the Clean Environment Commission on October 30 and 31, 2013, other benchmarks are also used in conjunction with the intactness calculation to more thoroughly examine how the Keeyask Project could affect caribou. These measures include wolf density, winter habitat and calving and rearing habitat. The calculation of wolf density is based on a precise moose population survey. It is the caribou-wolf-moose ecological relationship that is responsible for mediating the population growth of caribou populations. In general, anthropogenic disturbance serves to exaggerate the relationship to favour moose and wolf leaving caribou with less secure and available habitat. An expected outcome of the Cree Nations Partners' Moose Harvest Sustainability Plan will be to limit moose and wolf population increases that could be anticipated from further anthropogenic disturbance. Based on analysis conducted for the Keeyask EIS, the measured effects of the Keeyask Project are expected to be of a low magnitude only, while recognizing the various sources of uncertainty to this prediction.

Monitoring will necessarily seek to reduce the uncertainties around the designation and range of the summer resident caribou. During project operation it is expected these benchmarks, or variations thereof, will also be used as means of monitoring and applying adaptive management measures, if required, to promote the health of all caribou populations, and that the ecological relationship that has tied them to the Keeyask Region continues to be viable.

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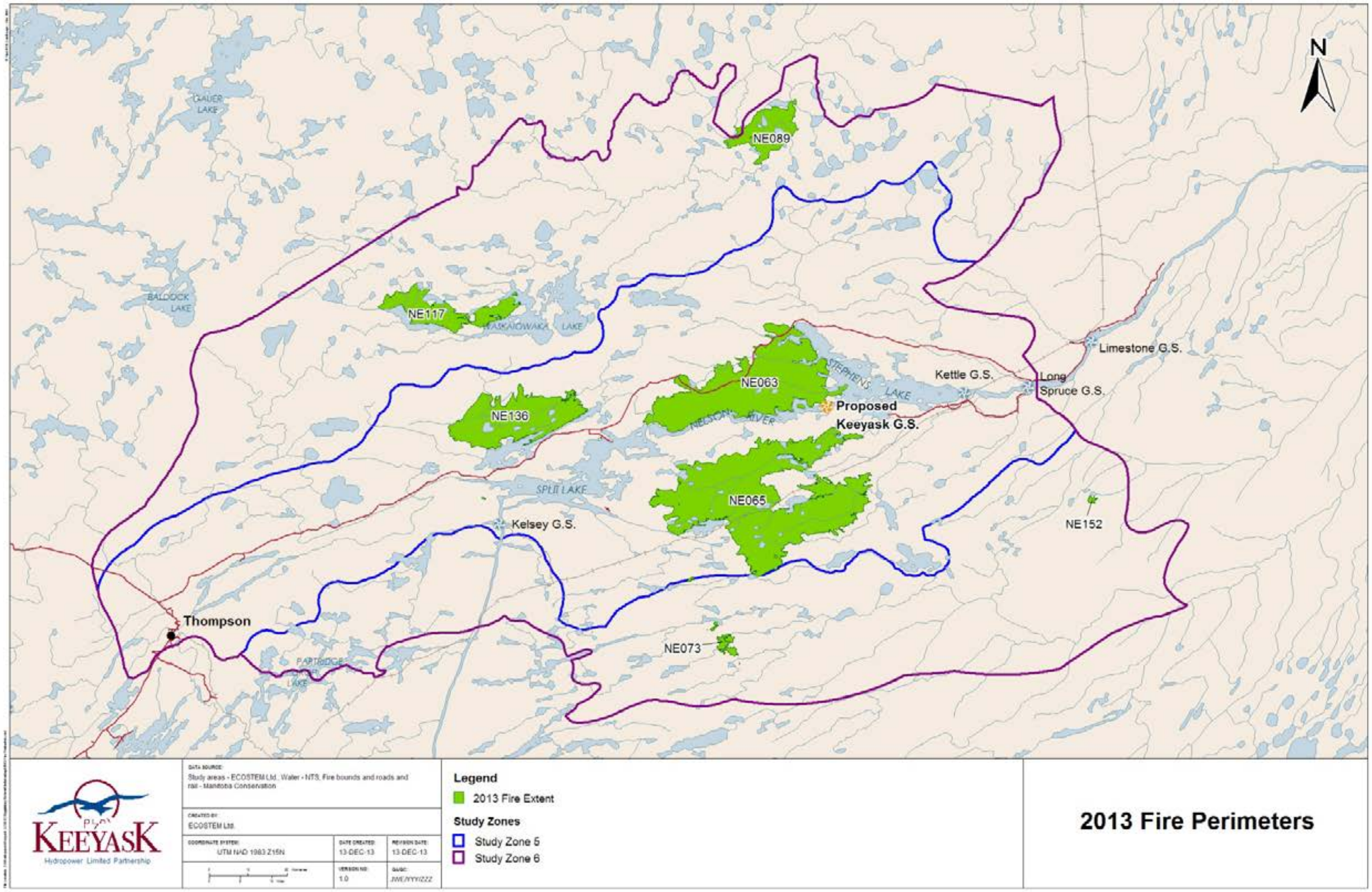
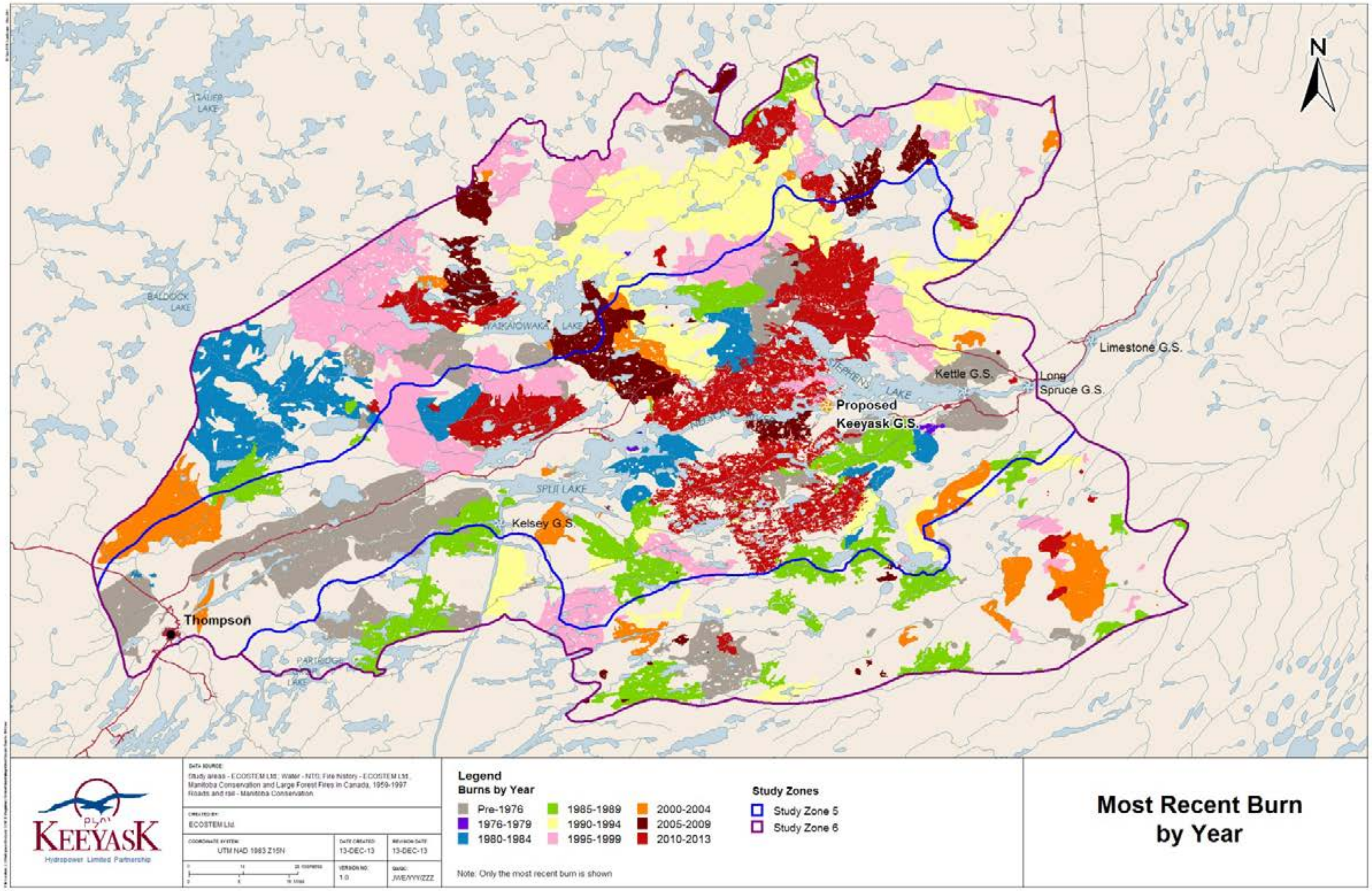


Map 1. 2013 Fire Perimeter Boundaries



Map 2. Most Recent Burn by Year

Appendix A: Method Notes

Fire Analysis

The perimeters of the 38 fires recorded by Manitoba Conservation for Study Zone 6 were obtained from Manitoba Conservation's website (Manitoba Conservation 2013). Fire perimeters include most waterbodies, burned areas and areas skipped over by the fire (i.e., skips). Suitable Landsat 7 satellite imagery was available to map the skips in the two large fires overlapping Study Zone 4. For all of the 2013 fires, surface water areas were removed using the National Hydrography Network dataset. On this basis, Table 1 updates Terrestrial Environment Supporting Volume Table 2D-3 to 2013.

Section 2.5 of the Terrestrial Environment Supporting Volume applied a 1979 cutoff for fire data used to estimate fire regime parameters because this was the earliest year with highly reliable burn data. Data going back to 1956 was considered to be moderately reliable based on inferences from older satellite imagery and similarity with overall burned area patterns throughout Manitoba.

The limitations of the fire history data were noted in the EIS (TE SV Sections 2.5.2.4, 2.5.3.2). Burn data was validated back to 1979 using a variety of data sources but primarily historical Landsat 5 and 7 satellite imagery for the older burns. The same data sources were used to corroborate burn data back to 1956, but these data produced coarser burn boundaries and were more likely to be missing burns or to show some areas as burned that did not in fact burn. Consequently, the validated 35-year fire history record for Study Zone 6 is short relative to the approximately 78-year fire cycle, and the fire regime parameter results should be interpreted as coarse estimates.

Using annual area burned from Table 2D-3 for a Monte Carlo future prediction model is misleading because it is missing the decade when very little area burned and because the number of available years is much lower than the fire cycle.

Caribou Intactness

Pen Islands Intactness Calculation

Step 1

Table 47: Current disturbance regime for the Pen Islands caribou evaluation area (from Bipole III Caribou Supplemental Filing)

	Area (km^2)	**Area (ha)**	**Range (%)**
Total Range Area	14,694.77	1,469,477.00	100
Total linear features - no overlap	638.6	63,860.00	4.35

	Area (km^2)	Area (ha)	Range (%)
FPR - gross	125.58	12,558.00	0.86
FPR - Net (all other buffer area removed)	44.3	4,430.00	0.3
BPIII Infrastructure - gross	114.77	11,477.00	0.78
BPIII Infrastructure - net (all other buffer removed)	51.91	5,191.00	0.35
Kettle Infrastructure - net (all other buffer removed)	0.81	81.00	0.01
Limestone Infrastructure - net (all other buffer removed)	3.31	331.00	0.02
Longspruce Infrastructure - net (all other buffer removed)	0.82	82.00	0.01
Natural Disturbance - fire <40 yrs	3299.05	329,905.00	22.45
Drill Holes 250 m buffer - not in disturbance area	4.25	425.00	0.03
Total disturbance - water area removed	4043.05	404,305.00	27.52

Step 2

For existing environment calculation, subtract quantities of disturbed habitat as indicated by non-overlapping quantities of FPR and BP III as indicated in Table 47 (above)

	Area (km^2)	Area (ha)	Range (%)
Total disturbance - water area removed	4043.05	404,305.00	27.52
- FPR - Net (all other buffer area removed)	44.3	4,430.00	0.3
- BPIII Infrastructure - net (all other buffer removed)	51.91	5,191.00	0.35
Total disturbance – no Bipole III	3,946.84	394,684.00	26.87
Total Undisturbed Habitat (1-disturbed habitat)	10,747.93	1,074,793.00	73.13

Step 3

Add quantity of Keeyask Project based on known value for SZ5 and SZ6 intactness – 7389 ha

	Area (km^2)	Area (ha)	Range (%)
Total disturbance – no Bipole III	3,946.84	394,684.00	26.87
+ Keeyask Project	73.89	7,389.00	0.50
Total disturbance with Keeyask Project (no Bipole III)	4,020.73	402,073.00	27.36
Total Undisturbed Habitat (1-disturbed habitat)	10,674.04	1,067,404.00	72.64

Step 4

For future projects, add in future project (minus Keeyask Project) and amount previously allocated to Bipole III

	Area (km^2)	Area (ha)	Range (%)
Total disturbance with Keeyask Project (no Bipole III)	4,020.73	402,073.00	27.36
- Keeyask Project	73.89	7,389.00	0.5
+ Future Projects	237.94	23794	1.62
+ FPR - Net (all other buffer area removed)	44.3	4,430.00	0.3
+ BPIII Infrastructure - net (all other buffer removed)	51.91	5,191.00	0.35
Total disturbance with Keeyask and Future Projects	4,280.99	428,099.00	29.13
Total Undisturbed Habitat (1-disturbed habitat)	10,413.78	1,041,378.00	70.87

For quantity of disturbed habitat without fire, subtract total from quantity of natural disturbance.

	Area (km^2)	Area (ha)	Range (%)
Total disturbance – no Bipole III	3,946.84	394,684.00	26.87
Total disturbance with Keeyask Project (no Bipole III)	4,020.73	402,073.00	27.36

	Area (km^2)	Area (ha)	Range (%)
Total disturbance with Keeyask and Future Projects	4,280.99	428,099.00	29.13
-Quantity of Natural Disturbance	3,299.05	329,905.00	22.45
Total disturbance – no Bipole III (no fire)	647.79	64,779.00	4.42
Total disturbance with Keeyask Project (no Bipole III) (no fire)	721.68	72,168.00	4.91
Total disturbance with Keeyask and Future Projects (no fire)	981.94	98,194.00	6.68
Total undisturbed – no Bipole III (no fire)			95.58
Total undisturbed with Keeyask Project (no Bipole III) (no fire)			95.09
Total undisturbed with Keeyask and Future Projects (no fire)			93.32

Step 5

For quantity of disturbed habitat based on 2013 fires, identified as NE063 and NE065, add in quantity of fires to amounts previously indicated as disturbed, subtract from undisturbed

	Area (km^2)	Area (ha)	Range (%)
total range area	14,694.77	1,469,477.00	100
Pre-2013 fire calculations			
Undisturbed habitat - EE area	10,747.93	1,074,793.00	73.14
Undisturbed habitat - with Keeyask	10,674.04	1,067,404.00	72.64
Undisturbed habitat - With Keeyask and Future Projects	10,413.78	1,041,378.00	70.87
Disturbed habitat - EE area	3,946.84	394,684.00	26.86
Disturbed habitat - with Keeyask	4,020.73	402,073.00	27.36
Disturbed habitat - With Keeyask and Future Projects	4,280.99	428,099.00	29.13

	Area (km^2)	Area (ha)	Range (%)
2013 fire (NE063 and NE065)	1,466.98	146,698	9.98
Post – 2013 fire calculations			
Undisturbed habitat - EE area	9,280.95	928,095.00	63.16
Undisturbed habitat - with Keeyask	9,207.06	920,706.00	62.66
Undisturbed habitat - With Keeyask and Future Projects	8,946.80	894,680.00	60.88
Disturbed habitat - EE area	5,413.82	541,382.00	36.84
Disturbed habitat - with Keeyask	5,487.71	548,771.00	37.34
Disturbed habitat - With Keeyask and Future Projects	5,747.97	574,797.00	39.12

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