October 2013

SHELL CANADA ENERGY

Appendix 3.7: Wildlife Modelling

Project Number: 13-1346-0001

REPORT

Golder Associates

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1.0 HABITAT SUITABILITY MODELS

1.1 Introduction

The Joint Review Panel (JRP) Supplemental Information Requests (SIRs) for the Pierre River Mine (PRM) dated October 25, 2012 included, among others, the following requests:

- an Environmental Impact Assessment (EIA) 2013 PRM Application Case, excluding the Jackpine Mine Expansion (JME), for specific Key Indicator Resources (KIRs; JRP SIR 5); and
- an updated Cumulative Effects Assessment due to changes from the Pre-Industrial Case (PIC) to the 2013 PRM Application Case, and the 2013 Planned Development Case (2013 PDC) (JRP SIR 8).

To address these requests, the EIA Base Case, EIA Application Case and EIA PDC wildlife model predictions were reassessed. The EIA Base Case and EIA PDC wildlife model predictions were updated to be current to June 2012, and are referred to as the 2013 Base Case and 2013 PDC, respectively. The 2013 Base Case presents updated predictions to allow a reasonable comparison between assessment cases. The EIA Application Case was updated to remove JME. This updated EIA Application Case is referred to as the 2013 PRM Application Case. The results of these updated assessments are included in this submission, as follows:

- Appendix 1 of this submission presents the 2013 PRM Application Case assessment for specific KIRs requested by JRP SIR 5, which includes a wildlife assessment that compares 2013 Base Case and 2013 PRM Application Case predictions.
- Appendix 2 of this submission presents the Pre-Industrial Case (PIC), 2013 PRM Application Case and 2013 Planned Development Case (2013 PDC) assessment requested by JRP SIR 8.

This appendix provides technical information on updated wildlife model results supporting the updated wildlife assessment information presented in Appendices 1 and 2 of this submission. The information in this appendix replaces the corresponding information in the EIA, Volume 5, Appendix 5-4, and in the *May 2011, Submission of Information to the Joint Review Panel*, Appendix 2, Federally Listed Species at Risk Assessment, Appendix B.

Habitat Suitability (HS) models quantify the measurable habitat preferences of wildlife and have been used extensively to predict the potential impacts of habitat alteration (Marzluff et al. 2002). These models facilitate an assessment that applies technology, scientific knowledge and available data for producing scientifically defensible, site-specific estimates of effects to wildlife habitat. Predictive output from HS models are used to inform the assessment of direct and indirect effects to wildlife habitat due to the PRM, along with existing, approved, and planned developments. Where abundance information is lacking for particular KIRs and habitat loss in the Oil Sands Region is potentially affecting abundance, to be precautionary the HS modelling results were used to estimate the effects of the PRM on abundance.

1.2 Assessment Methods

Habitat modelling was conducted for all wildlife KIRs and federally listed wildlife Species at Risk (SAR) likely to occur in the Local Study Area (LSA), and that may therefore be affected by habitat loss in the LSA (Table 1.2-1). The structure of the HS models used was detailed in the EIA, Volume 5, Appendix 5-4, Section 1.2 for wildlife KIRs and in the *May 2011, Submission of Information to the Joint Review Panel*, Appendix 2, Federally Listed Species at Risk Assessment, Appendix B. In addition, habitat modelling was conducted for woodland caribou in accordance with JRP SIR 40. However, woodland caribou are virtually absent from the LSA, which is located outside designated caribou areas. The structure of the woodland caribou HS model is detailed below in Section 1.2.1.

Table 1.2-1 Wildlife Key Indicator Resources and Federally Listed Species at Risk That May be Affected by Habitat Loss in the Local Study Area

Common Name	COSEWIC[(a)]	SARA[(a)]	Alberta Provincial Status[(b)]
barred owl	not listed	not listed	Sensitive
beaver	not listed	not listed	Secure
black bear	Not At Risk	not listed	Secure
black-throated green warbler	not listed	not listed	Sensitive
Canada lynx	Not At Risk	not listed	Sensitive
Canadian toad	Not At Risk	not listed	May be at risk
fisher	not listed	not listed	Sensitive
moose	not listed	not listed	Secure
Canada warbler	Threatened	Schedule 1: Threatened	Sensitive
common nighthawk	Threatened	Schedule 1: Threatened	Sensitive
horned grebe	Special Concern	No Schedule, No Status	Sensitive
olive-sided flycatcher	Threatened	Schedule 1: Threatened	May Be At Risk
rusty blackbird	Special Concern	Schedule 1: Special Concern	Sensitive
short-eared owl	Special Concern	Schedule 3: Special Concern	May be at risk
western toad	Special Concern	Schedule 1: Special Concern	Sensitive
wolverine (western population)	Special Concern	No Schedule: No Status	May be at risk
wood bison	Threatened	Schedule 1: Threatened	At Risk
yellow rail	Special Concern	Schedule 1: Special Concern	Undetermined

(a) Species At Risk Public Registry 2013, internet site.

(b) Alberta ESRD 2013, internet site.

Forest stands at closure are considered to be 80 years old (EIA, Volume 5, Section 7.2.3 and *May 2011, Submission of Information to the Joint Review Panel*, Appendix 2, Federally Listed Species at Risk Assessment, Appendix B). Eighty years represents the estimated time required for the development of mature forest on the reclaimed landscape, and is a more appropriate time frame upon which to compare vegetation, wildlife and biodiversity values in the reclaimed landscape against the 2013 Base Case values (EIA, Volume 5, Section 7.2.3). However, the use of an 80-year-old reclaimed landscape represents a change from the EIA (EIA, Volume 5, Section 7.2.3) for habitat suitability modelling, in which stand ages of original wildlife KIRs were assigned using mine progression diagrams to represent stand ages at the point in time at which closure occurs (i.e., 2070), and therefore resulted in closure landscape much younger than that used for habitat suitability modelling here. The assumptions regarding stand age at closure were changed from those used in the EIA because mature forest stands at closure represent a more appropriate time frame for the assessment of long-term PRM effects. Robust ecological communities and processes will take time to develop on the closure landscape. This approach is also consistent with assumptions underlying the vegetation and biodiversity assessments.

Resource Selection Function (RSF) modelling could not be used for calculating habitat suitability where Alberta Vegetation Inventory (AVI) data were not available, or using unaltered reclamation area data. These areas contain only ecosite phase and wetlands type identification. Therefore, more detailed stand vegetation information had to be extrapolated using LSA-specific averages of AVI data fields per ecosite phase and wetlands type.

For each ecosite phase and wetlands type, an average percent overstorey species composition was calculated from AVI data within the vicinity of the LSA, and applied to areas lacking AVI data. Prior to Closure, stand ages for land cover polygons with missing AVI data were extrapolated by first merging polygons with adjacent AVI polygons, where appropriate. Where professional judgment determined that merging polygons was not appropriate, stand ages were applied using area-weighted average ages per ecosite phase and wetlands type within the LSA. Stand heights at age were estimated using Alberta Environment and Sustainable Resource Development (ESRD) growth and yield curves for the expected leading species per ecosite phase and wetlands type, using ecosite and wetlands type-specific site indices. Heights at 50 years breast height per ecosite phase and wetlands type (i.e., site index, or SI[50]) for expected leading tree species per ecosite and wetlands type were taken from the Canadian Forest Service *Field Guide to Ecosites of the Mid-boreal Ecoregions of Saskatchewan* (Beckingham et al. 1996).

1.2.1 Woodland Caribou Habitat Suitability Index Model

The woodland caribou Habitat Suitability Index (HSI) model was created by Golder Associates Ltd. (Golder) specifically for populations that inhabit northeastern Alberta (Suncor 2000). The model was developed with reference to studies of woodland caribou behaviour and existing caribou models from other areas. The final model structure reflects the outcome of a review of the woodland caribou model conducted by Golder and Mr. Robert Anderson of Applied Ecosystem Management Ltd. (Anderson 2001, pers. comm.).

Woodland caribou are not likely to occur in the PRM LSA and would typically be excluded from an assessment of this location. This modelling has been conducted to meet the requirements of JRP SIR 40.

1.2.1.1 Habitat Requirements

Within the boreal region of Alberta, winter habitat selection by woodland caribou is strongly associated with peatland habitats (Anderson 1999; Bradshaw et al. 1995; Edmonds and Bloomfield 1984; Fuller and Keith 1981; Stuart-Smith et al. 1997). Habitat selection is hierarchical (Johnson 1980) and woodland caribou may select habitats at a number of spatial scales (Anderson 1999; Bradshaw et al. 1995; Dyer et al. 1999; Stuart-Smith et al. 1997). As a result, a multi-scale assessment of habitat suitability is recommended to provide a better understanding of woodland caribou ecology (Anderson 1999).

On a regional scale, woodland caribou may select home ranges that encompass large peatland complexes to reduce their risk of predation (Anderson 2001, pers. comm.; Bergerud et al. 1984). Predation is an important limiting factor for woodland caribou populations (Dyer et al. 2001; Dzus 2001; Fuller and Keith 1981; Stuart-Smith et al. 1997). Woodland caribou avoid predators by separating themselves spatially from other ungulate prey (Bergerud et al. 1984; James 1999; Stuart-Smith et al. 1997). Calf survival is higher in landscapes with larger fens, a lower proportion of uplands, and landscapes that have the capability to support larger home ranges (Stuart-Smith et al. 1997). As a result, upland areas considered suitable habitat for ungulates such as moose are not considered suitable habitat for woodland caribou due to the higher concentrations of predators in upland habitats, while wetlands complexes provide refuge from predators (Latham 2009; Stuart-Smith et al. 1997). The majority of upland habitat use tends to be in patches found within large peatland complexes (Schneider et al. 2000).

The identification of large peatland complexes on a regional scale is important for describing habitat suitability for woodland caribou. Within their home range, a finer scale of habitat selection may occur based on the availability of forage (Anderson 2001, pers. comm.). In the boreal region of Alberta, woodland caribou exhibit seasonal shifts in their diet. The most important winter food source for woodland caribou are terrestrial lichens (Edmonds and Bloomfield 1984; Fuller and Keith 1981; Manitoba Model Forest 1995), which are mostly found in peatlands, in particular treed fens and bogs (Anderson 1999; Beckingham and Archibald 1996). Preferred lichen forage species include *Cladina* species, such as *C. mitis*, *C. uncialus and C. rangiferina; Centraria islandica* and *Stereocaulon* spp. (Manitoba Model Forest 1995). *Cladina* species were most commonly found in snow craters dug by woodland caribou in northeastern Alberta (Bradshaw et al. 1995). In years of high snow accumulation or when snow crust makes it difficult for caribou to access terrestrial lichens, there may be greater use of arboreal lichens (e.g., *Usnea* species, *Evernia mesomorpha*, *Alectoria* spp., *Bryoria trichoides*) (Manitoba Model Forest 1995; Simpson et al. 1985).

Other food sources that are more frequently consumed in spring and summer are: sedges, cotton-grass, fungi, grasses, ericaceous shrubs (e.g., Labrador tea, blueberry, bearberry), twinflower, mosses and woody browse (e.g., willows, birch and aspen). Knowledge of the relative importance of these forage species in the spring and summer seasons is limited (Anderson 2001, pers. comm.).

Woodland caribou are considered sensitive to numerous forms of human disturbances (Bradshaw et al. 1995). These disturbances include any activities generating loud noise (e.g., blasting, heavy equipment operation, traffic, airstrip use), activities that alter habitat (e.g., road development, logging, well pad construction, linear corridor clearing, human-caused fires, loss of lichens as a result of atmospheric pollution) and activities that directly interfere with woodland caribou (e.g., human access to wilderness areas, especially on all-terrain vehicles [ATVs] and snowmobiles, vehicle collisions, hunting, peat harvest operations) (Magnusson and Wasel 1999; Manitoba Model Forest 1995). Habitat alteration or fragmentation may also affect woodland caribou by creating suitable conditions for moose and deer. Healthy moose and deer populations attract and support a greater number of predators (e.g., wolves, black bear), which may result in increased woodland caribou predation and possible population decline (Latham et al. 2011).

In northeastern Alberta, Dyer et al. (1999) found that woodland caribou in open coniferous wetlands (i.e., peatland) used areas adjacent to roads less than other areas during all time periods (i.e., late winter, calving, summer and rut). The maximum avoidance distance for roads that was statistically significant was 250 m. Road avoidance was generally less when woodland caribou were in closed coniferous forest that provided effective security cover (Dyer et al. 1999).

Woodland caribou also avoided habitat within 250 to 1,000 m of new well sites. Avoidance of well sites was generally greatest during late winter when human activity was highest and during calving when female woodland caribou are most sensitive to disturbance. Dyer et al. (1999) reported that woodland caribou temporarily avoided industrial developments until related activities stopped. Bradshaw et al. (1995) also noted that noise disturbance led to increased rates of movement of woodland caribou, but not complete displacement. Overall, development activities may result in habitat avoidance, lower habitat productivity or direct mortality of woodland caribou.

1.2.1.2 Model Development

Assumptions

The assumptions for the woodland caribou HSI model are that:

- woodland caribou habitat selection is largely affected by two factors: predation risk and forage availability;
- woodland caribou select areas of predominantly peatland habitat (i.e., bogs and fens) to avoid predation risk on a regional scale;
- woodland caribou select peatlands and some upland habitats (e.g., pine-dominant stands) on a local scale that provide suitable opportunities to forage on terrestrial lichens, the main winter food source for woodland caribou;
- woodland caribou avoid areas with a high density of human use; and
- woodland caribou use habitat adjacent to roads, oil and gas developments, and forestry operations less than expected by chance.

Habitat Effectiveness

Wildlife species may reduce their use of habitat adjacent to areas of human activity. These indirect effects are related to sensory disturbance and reduce the effectiveness of habitat in supporting wildlife needs. Effects that result from sensory disturbance are greater if the adjacent habitat is of high quality and if the total supply of habitat in the area is limiting.

The approach used in estimating the amount of habitat affected by sensory disturbance (i.e., habitat effectiveness) was to create a displacement model that assumes disturbance Zones of Influence (ZOI) and Disturbance Coefficients (DC). A ZOI is the maximum distance to which a disturbance (e.g., traffic noise) influences wildlife use of habitat. The DC is the effectiveness of the habitat within the ZOI in fulfilling the requirements of a particular species. For example, a habitat with a DC of 0.9 represents 90% habitat effectiveness. Different ZOI and DC are applied for each KIR and each human activity type.

For most wildlife species, data on the degree of habitat avoidance due to sensory disturbance are limited. As a result, most displacement models rely heavily on professional judgement when quantifying the degree of sensory disturbance a development produces and how it affects the behaviour of a given species. Research on woodland caribou has provided some indication of the degree to which woodland caribou reduce their use of habitats adjacent to human development (Dyer 1999; Table 1.2-2).

These research results were used to derive DC and ZOI for woodland caribou (Table 1.2-3). Because disturbance avoidance patterns vary between seasons, professional judgment was used to interpret the results of Dyer (1999) to select disturbance coefficients. Also, although Dyer et al. (1999) did not find statistically significant avoidance of areas beyond 250 m from roads, professional judgment was used to interpret results and infer that reduced habitat use may occur out to 1,000 m. Selection of DCs and representing avoidance out to 1,000 m was done based on professional judgment to be a conservative interpretation of Dyer's (1999) results and to contribute to a more conservative EIA.

Table 1.2-2 Mean Woodland Caribou Use of Habitat Within the Zones of Influence Surrounding Industrial Developments

Type of Development	Zone of Influence [m]	Effectiveness of Habitat Use[a] (percentage of expected use)
roads[b]	0 to 100	3.65 (late winter) to 33.93 (summer)
	100 to 250	22.7 (summer) to 25.18 (calving)
	250 to 500	31.55 (summer) to 57.52 (calving)
facilities (new wellpads)	0 to 250	45.31 (late winter) to 117.84 (summer)
	250 to 500	70.57 (calving) to 108.15 (late winter)
seismic lines[c]	0 to 100	47.64 (calving) to 75.66 (rut)
	100 to 250	85.43 (late winter) to 113.78 (calving)

(a) Summarized from Dyer (1999).

(b) These values are related to woodland caribou use of road development buffers in open conifer forest.

(c) There is no distinction between seismic lines with different levels of human activity.

Table 1.2-3 Woodland Caribou Zones of Influence and Disturbance Coefficients by Disturbance Type

KIR	Disturbance Type					
	Roads		Facilities and Developments[b]		Utility Corridors[c]	
	ZOI	DC[a]	ZOI	DC	ZOI	DC
woodland caribou	100	0.0	250[b]	0.5	100[c]	0.5
	250	0.25	>250	1.0	>100	1.0
	500	0.50	n/a	n/a	n/a	n/a
	1,000	0.75	n/a	n/a	n/a	n/a
	>1,000	1.0	n/a	n/a	n/a	n/a

(a) Disturbance Coefficients (DCs) are based on the mean woodland caribou use of ZOI presented as a percentage of expected use (Dyer 1999).

(b) Value based on woodland caribou avoidance of new wellpads.

(c) Value based on woodland caribou avoidance of seismic lines (applied to power lines, pipelines and seismic lines).

n/a = Not applicable.

Research completed by Dyer (1999) is limited in terms of providing a distinction between different types of linear disturbance features, (i.e., roads, utility corridors, seismic lines), and the relative influence of these types on wildlife use of habitat. In particular, Dyer (1999) was not able to determine relative use or avoidance of habitat adjacent to seismic lines with different levels of human activity. Factors such as the type, season and intensity of human use will affect woodland caribou use of habitat adjacent to these and other linear disturbance features. Despite these limitations, Dyer's (1999) research provides the best indication to date of woodland caribou behaviour in response to human disturbance.

Regional Component to Habitat Suitability Index

Peatland Area

Regional level habitat selection by woodland caribou involves selection of areas with a high coverage of peatlands. Schneider et al. (2000) assessed woodland caribou habitat on a regional scale by applying a digital version of the *Peatland Inventory of Alberta* (Vitt et al. 1997). Schneider et al. (2000) used this inventory to determine the habitat composition of ecodistricts across the Province of Alberta. Ecodistricts are landscape units delineated based on similar geology, landforms and vegetation characteristics (Strong 1992). Based on an assessment of 11,000 telemetry locations, Schneider et al. (2000) concluded that areas with greater than 50% uplands were not considered suitable habitat for woodland caribou.

In Alberta, the large-scale delineation of areas with similar climate, topography, geomorphology and vegetation is more recently represented by natural subregions (NRC 2006). Therefore, the habitat composition of natural subregions within the Regional Study Area (RSA) was assessed to determine the relative proportion of peatlands available for woodland caribou. The area of peatlands within each natural subregion was then used to rank the habitat at the landscape scale and determine the first component of the model, suitability index SI(1), which ranges from 0.0 to 1.0 (Figure 1.2-1). Based on research conducted by Schneider et al. (2000), areas with greater than 50% peatland were considered highly suitable habitat for woodland caribou (SI(1) = 1.0). The minimum peatland patch size or habitat configuration that will support woodland caribou (Anderson 2001, pers. comm.) is unknown. As a result, the Regional Suitability Index (SI(1)) is set on a scale that gradually increases from 0.0 to 1.0 as peatland area expands from 0% to 50% for a given natural subregion. At this regional scale, areas with greater than 50% peatland are considered highly suitable habitat for woodland caribou.

Local Component to Habitat Suitability Index

Food Availability

Local-level habitat selection by woodland caribou is likely affected by several factors. In particular, it involves the selection of certain vegetation types that provide the opportunity for woodland caribou to forage on terrestrial lichens. To date, field research has not revealed whether the relative abundance of terrestrial lichen affects site-specific habitat selection by woodland caribou (Anderson 2001, pers. comm.). As a result, food availability was assessed based on the presence or absence of lichens.

The mean percent lichen cover (*Cladina* spp.) for each ecosite phase and wetlands type was generated with data collected during summer vegetation surveys on sites near or within the RSA (Table 1.2-4). The mean lichen percent cover was used to calculate suitability index SI(2) (Figure 1.2-2). Vegetation types without terrestrial lichens were assumed to be unsuitable habitat for woodland caribou (SI(2) = 0.0). Vegetation types with less than 5% lichens were assumed to provide limited forage opportunity for woodland caribou and were assigned a value of 0.1. All vegetation types with greater than 5% cover of terrestrial lichens were assigned a value of 1.0 to indicate that these habitats were suitable for woodland caribou.

Suitability index SI(2) is used in the model's predictions of habitat suitability within the RSA and LSA. The SI(2) scores were generalized for expression at the RSA scale using correspondence between ecosite phases and regional land cover classes (Table 1.2-5). In circumstances where ecosite phases and wetlands types with different SI(2) scores translated to the same regional land cover class, a weighted mean SI(2) was calculated. Weights were calculated based on proportional representation of competing ecosite phases and wetlands types within the extent of the AVI data available for the RSA.

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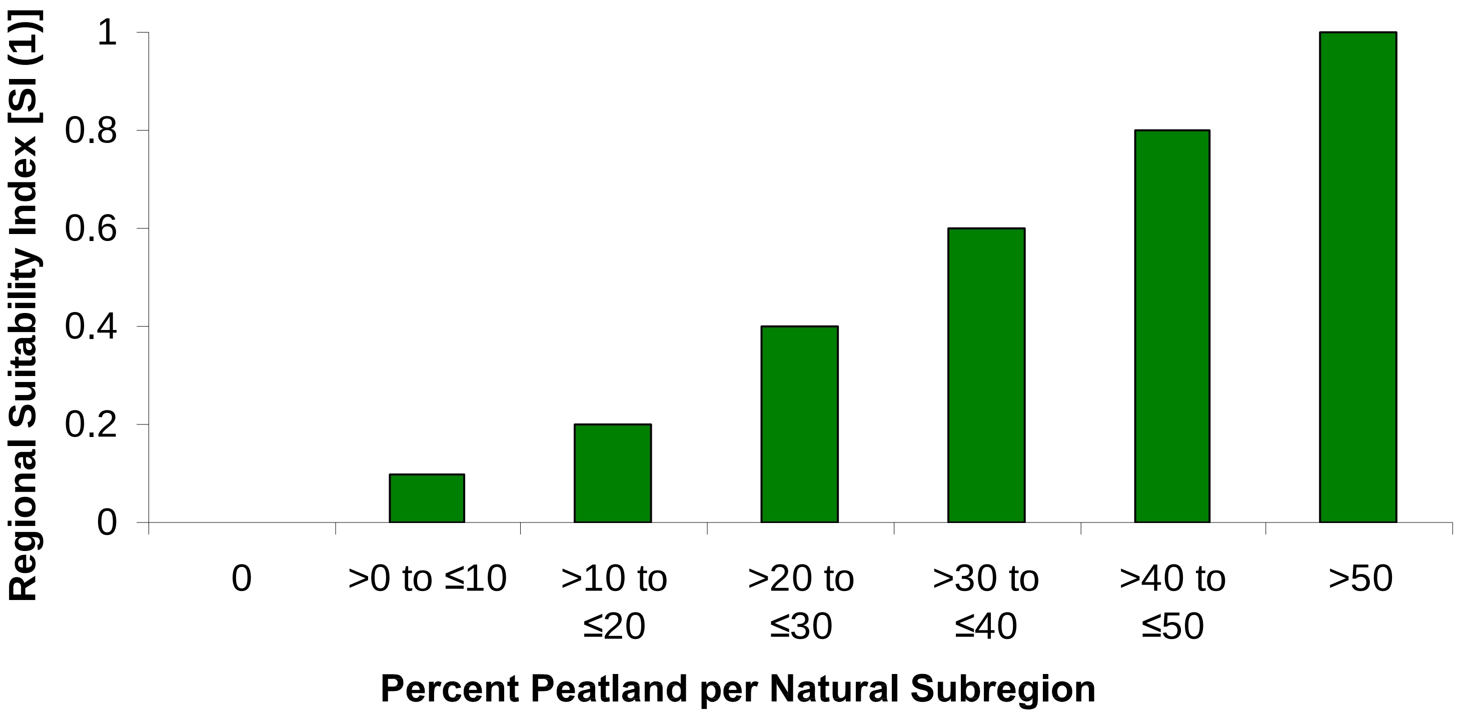

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

RELATIONSHIP BETWEEN PEATLAND COVER AND THE REGIONAL SUITABILITY INDEX SI(1) FOR WOODLAND CARIBOU

Shell Canada Limited

PROJECT	13.1346.0001.6100		FILE No.	13134600016100A001
DESIGN	BS	03 May 2013	SCALE AS SHOWN	REV. 0
CADD	PSR	03 Jun. 2013	**FIGURE: 1.2-1**	
CHECK	BS	03 Jun. 2013		
REVIEW	MGJ	03 Jun. 2013		

Table 1.2-4 Food Index Value SI(2) for Each Vegetation Type in the Local Study Area

Map Code	Ecosite Phase/Wetlands Type	Terrestrial Lichens [%]	SI(2)
BFNN	forested bog	5.6[(a)]	1.0
BONN	open bog	5.6[(a)]	1.0
BTNI	wooded bog with internal lawns	7.0	1.0
BTNN	wooded bog	7.0	1.0
BUu	burn uplands	0.5	0.1
BUw	burn wetlands	0.5	0.1
CC	cutblock	< 0.1	0.1
DIS	disturbance	0.0	0.0
FFNN	forested fen	3.3[(a)]	0.1
FONG	graminoid fen	0.5	0.1
FONS	shrubby fen	0.8	0.1
FOPN	open patterned fen	<1.0[(a)]	0.1
FTNI	wooded fen with internal lawns	2.9	0.1
FTNN	wooded fen	2.9	0.1
FTNR	wooded fen with internal lawns and islands of forested peat plateau	0.5	0.1
FTPN	wooded patterned fen	2.9	0.1
Lake	lake	0.0	0.0
MONG	marsh	0.0[(a)]	0.0
SONS	shrubby swamp	0.2	0.1
STNN	wooded swamp	3.5	0.1
WONN	shallow open water	0.0	0.0
a1	lichen jack pine	18.2	1.0
b1	blueberry jack pine-aspen	5.0	0.1
b2	blueberry aspen (white birch)	4.5	0.1
b3	blueberry aspen-white spruce	15.3	1.0
b4	blueberry white spruce-jack pine	4.0	0.1
c1	Labrador tea-mesic jack pine-black spruce	9.7	1.0
d1	low-bush cranberry aspen	0.5	0.1
d2	low-bush cranberry aspen-white spruce	0.6	0.1
d3	low-bush cranberry white spruce	2.5	0.1
e1	dogwood balsam poplar-aspen	<1.0[(a)]	0.0
e2	dogwood balsam poplar-white spruce	<1.0[(a)]	0.0
e3	dogwood white spruce	< 0.1	0.1
f3	horsetail white spruce	<1.0[(a)]	0.0
g1	Labrador tea-subhygric black spruce-jack pine	6.0	1.0
h1	Labrador tea/horsetail white spruce-black spruce	3.5	0.1

(a) Due to data deficiencies, some terrestrial lichen percentages were estimated based on a combination of professional judgment and comparisons to similar ecosite phases and wetlands types.

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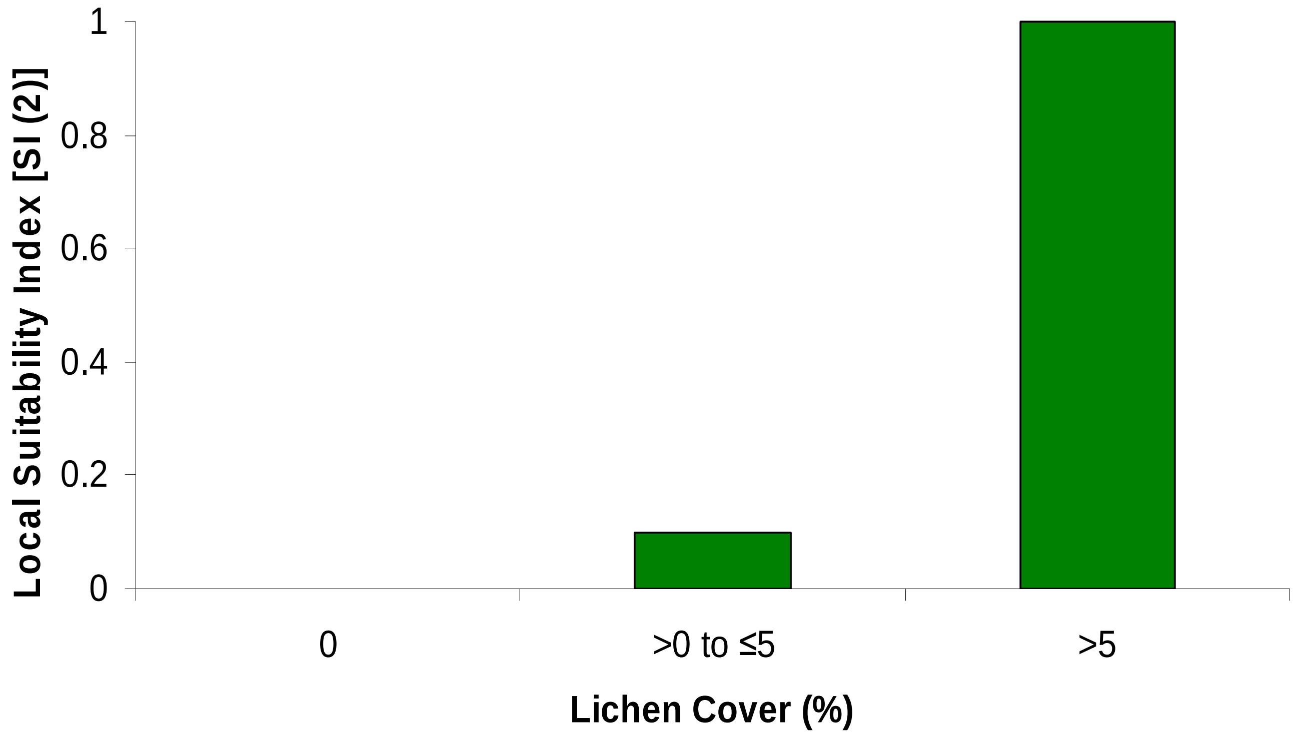

PROJECT				
PIERRE RIVER MINE PROJECT				
TITLE				
LOCAL SUITABILITY INDEX FOR MEAN LICHEN COVER SI(2) FOR WOODLAND CARIBOU				
Shell Canada Limited	PROJECT	13.1346.0001.6100		FILE No. 13134600016100A002
	DESIGN	BS	03 May 2013	SCALE AS SHOWN REV. 0
	CADD	PSR	03 Jun. 2013	**FIGURE: 1.2-2**
	CHECK	BS	03 Jun. 2013	
	REVIEW	MGJ	03 Jun. 2013	

Table 1.2-5 Food Index Value SI(2) for Regional Land Cover Classes

Regional Land Cover Class	SI(2)
treed poor fen/bog	1.0
burn	0.1
cutblock	0.1
agriculture	0.0
non-treed wetlands	0.1
treed fen	0.1
water	0.0
coniferous jack pine	1.0
mixedwood aspen−jack pine	0.1
deciduous aspen−balsam poplar	0.1
mixedwood aspen−white spruce	0.3
coniferous jack pine−black spruce	0.7
coniferous white spruce	0.1

Combined Habitat Suitability Index Model

The regional and local habitat suitability indices are assumed to be equal in importance to woodland caribou habitat. The two are added together and the average obtained. Habitat suitability is then reduced by the disturbance coefficient within zones of influence of disturbances:

$$HSI = [SI(1) + SI(2)]/2 \; x \; DC$$

1.2.1.3 Validation

The woodland caribou model was validated using available caribou telemetry observations, as well as RSA-scale baseline model output produced for previous oil sands EIAs. Observations were first split into separate data sources to maximize ease of direct comparison. Observations were derived from the Very High Frequency (VHF) collar data collected from 130 animals and from Global Positioning System (GPS) collar data collected from one animal (ACC 2004). The VHF collar data ranged from 2 to 376 observations per individual (491 observation points total), meaning the behaviour of more frequently observed individuals had a greater effect on validation results than less frequently observed individuals. The GPS collar data consisted of 3,576 observations, averaging about 10 GPS locations per day. To remove some of the spatial autocorrelation between observations, the GPS collar dataset was reduced by randomly selecting one observation per day. For each model output extent, only observations that were taken within one year of the Geographic Information System (GIS) disturbance layer creation date were considered, so that observations remained relevant to model output.

Manly's standardized selection ratio (Manly et al. 1972, 2002) was used to quantify habitat preference (i.e., low, moderate and high classes), and a G-test was performed to detect statistically significant differences ($\alpha = 0.05$) between classes. Validation results using VHF and GPS collar data suggested that caribou habitat preference increased with increasing predicted habitat quality classes, indicating a good model (Table 1.2-6).

Table 1.2-6 Validation Results for the Woodland Caribou Habitat Suitability Index Model

Data Source	HSI Class	Manly's Selection Ratio[a]	G-Test
VHF collar data	high	0.515	significant, α = 0.05
	moderate	0.326	
	low	0.159	
GPS collar data	high	0.627	significant, α = 0.05
	moderate	0.265	
	low	0.107	

[a] Manly et al. 1972, 2002.

Overall, collar data are likely to be a more reliable indicator of habitat preference than caribou track transect data. First, transect data can only be collected in winter, and is therefore representative only of winter habitat selection. Also, field identification of caribou tracks can be difficult, and observer error may occasionally result in moose tracks being misidentified as caribou tracks. In contrast, collar data represent habitat selection year-round, and overall risks of error are greatly reduced. The favourable results, found when validating with VHF and GPS collars, suggests that model predictions of woodland caribou habitat quality class are reliable.

1.2.2 Habitat Suitability Model Evaluation

The HS models for Canadian toad, moose, Canada lynx and fisher/marten at the LSA and RSA scales, and black-throated green warbler and barred owl at the LSA scale were evaluated using empirical data (EIA, Volume 5, Appendix 5-4, Section 1.2.2). The evaluation of the woodland caribou HSI model with empirical data is described in Section 1.2.1.3. Although data for formal statistical validation of the remaining HS models are not available, model structures and predictive outputs conform to the current state of knowledge regarding the ecology and habitat preferences of this species. Therefore, based on professional judgement, the RSA- and LSA-scale models provide reasonable assessments of the effects of PRM and planned developments on habitat for these species.

Although data for statistical model validation are not available, a further evaluation of the predictive strength of songbird HSI models is possible using Alberta Biodiversity Monitoring Institute (ABMI) data. The ABMI breeding bird survey data were analyzed to calculate habitat associations based on estimates of relative population densities per plot, and compared to assumptions regarding habitat associations underlying the HSI model structures. The assumptions and structure of the RSA-scale HSI model for black-throated green warbler are stated in the EIA, Volume 5, Appendix 5-4, Section 1.2.2. The assumptions and structures of the LSA and RSA-scale HSI models for Canada warbler, olive-sided flycatcher and rusty blackbird are discussed in the Species at Risk Assessment (*May 2011, Submission of Information to the Joint Review Panel,* Appendix 2, Federally Listed Species at Risk Assessment, Appendix B).

For the black-throated green warbler RSA HSI model, the results of the analysis of the ABMI data are consistent with expectations. Habitat types with the highest observed relative densities of black-throated green warblers coincided with those habitat types classified as high and moderate suitability. Validation of the empirically derived LSA-scale resource selection function for black-throated green warbler was discussed in the EIA, Volume 5, Appendix 5-4, Section 1.2.2.

The ABMI data were also generally consistent with the LSA-scale Canada warbler HSI model, with the highest relative densities observed in those ecosite phases identified as high suitability habitat for the species. However, numerous Canada warbler observations were collected in Labrador tea/horsetail white spruce-black spruce (h1) stands, which were identified in the HSI model as nil suitability. These observations are unusual, given that Canada warbler is a bird of deciduous, and to a lesser degree mixedwood stands, but is generally absent from conifer-dominated stands (Campbell et al. 2001; Campbell et al. 2007). Coniferous stands are avoided because they have less shrub development. These observations likely occurred because mature deciduous stands are near ABMI plots in Labrador tea/horsetail white spruce-black spruce (h1) stands. Because the habitat associations of Canada warbler are well-known, the model was not adjusted as a result of this analysis. At the RSA scale, the highest relative densities of Canada warbler were observed within habitat types that correlate with the deciduous aspen-balsam poplar regional land cover class, which was classified as high suitability habitat in the HSI model.

Relative densities of olive-sided flycatcher from ABMI data also coincided well with the habitat rankings of the LSA-scale HSI model, with the highest relative densities occurring in the ecosite phases and wetlands types identified as being of high suitability due to canopy compositions that exceeded 70% coniferous species. However, the RSA-scale model showed more variability in the relationship between habitat suitability and relative densities obtained from ABMI data. Olive-sided flycatchers are often found close to forest edges, taking advantage of standing snags in forest openings for effective foraging (Altman and Sallabanks 2000). The LSA-scale model is able to represent this complexity well because higher resolution vegetation data is available at that scale. At the RSA scale, these details are more difficult to represent, and as a result the relationship between observed relative density and habitat suitability is weaker. However, this does not necessarily mean that the RSA-scale olive-sided flycatcher model is unreliable. Rather, it is likely that the scale at which ABMI habitat types are classified, and the manner in which they are classified by dominant habitat type rather than occurring within contiguous habitats, may make ABMI breeding bird survey data inappropriate for evaluating olive-sided flycatcher habitat suitability predictions at the RSA scale for olive-sided flycatcher.

For rusty blackbird, the highest relative densities calculated from ABMI data occurred in wetlands types classified as high suitability at the LSA and RSA-scales. Again, the ABMI breeding bird survey data provide evidence that the models are consistent with empirical data collected in the region.

1.3 Results

Habitat suitability modelling results for the LSA at the 2013 Base Case, 2013 PRM Application Case and at Closure are presented in Table 1.3-1. Direct habitat change refers to habitat loss due to the PRM footprint. Indirect habitat change refers to a reduction in habitat quality outside of the PRM footprint due to the effects of sensory disturbance and surficial aquifer drawdown. Changes in habitat suitability in the RSA from the 2013 Base Case to the 2013 PRM Application Case and to the 2013 PDC are presented in Table 1.3-2. Changes in habitat suitability in the RSA at the 2013 Base Case, 2013 PRM Application Case and 2013 PDC relative to the Pre-Industrial Case are presented in Table 1.3-3.

Table 1.3-1 Change in Wildlife Habitat Due to the Pierre River Mine Expansion Within the Local Study Area: 2013 PRM Application Case

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	2013 Base Case Habitat		Direct Habitat Change From 2013 Base Case Due to Site Clearing of Pierre River Mine		Indirect Habitat Change From 2013 Base Case Due to Pierre River Mine		Net Habitat Change From 2013 Base Case Due to Pierre River Mine		Net Habitat Change From 2013 Base Case At Closure	
		Area [ha]	% of LSA	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]
barred owl	high	11,501	50	-5,440	-47	-348	-3	-5,788	-50	-3,053	-27
	low	10,793	47	-5,968	-55	348	3	-5,620	-52	1,379	13
	nil	835	4	11,408	1,366	0	<1	11,408	1,366	1,674	200
beaver	high	3,030	13	-1,506	-50	-120	-4	-1,626	-54	2,923	96
	moderate	769	3	-523	-68	-40	-5	-562	-73	-557	-72
	low	740	3	-516	-70	-45	-6	-561	-76	-59	-8
	nil	18,590	80	2,544	14	205	1	2,749	15	-2,307	-12
black bear	high	15,921	69	-7,647	-48	-4,976	-31	-12,623	-79	-543	-3
	moderate	3,145	14	-1,789	-57	3,143	100	1,353	43	440	14
	low	3,228	14	-1,972	-61	1,834	57	-138	-4	-1,571	-49
	nil	835	4	11,408	1,366	0	-<1	11,408	1,366	1,674	200
black-throated green warbler	high	329	1	-92	-28	-214	-65	-306	-93	-303	-92
	moderate high	844	4	-464	-55	-237	-28	-701	-83	-718	-85
	moderate	2,382	10	-1,501	-63	-488	-20	-1,990	-84	-2,086	-88
	moderate low	5,431	23	-3,010	-55	-61	-1	-3,072	-57	-3,188	-59
	low	13,307	58	-6,339	-48	1,000	8	-5,339	-40	4,621	35
	nil	835	4	11,408	1,366	0	<1	11,408	1,366	1,674	200
Canada lynx	high	11,341	49	-6,822	-60	-29	-<1	-6,850	-60	5,233	46
	moderate high	5,935	26	-3,274	-55	-155	-3	-3,430	-58	-3,229	-54
	moderate	3,261	14	-969	-30	30	<1	-939	-29	-2,515	-77
	moderate low	1,363	6	-300	-22	145	11	-155	-11	-953	-70
	low	394	2	-42	-11	9	2	-33	-8	-209	-53
	nil	835	4	11,408	1,366	0	-<1	11,408	1,366	1,674	200
Canadian toad	high	3,064	13	-1,840	-60	-210	-7	-2,050	-67	400	13
	moderate	16,225	70	-8,195	-51	60	<1	-8,135	-50	8	<1
	low	1,025	4	-466	-45	13	1	-454	-44	903	88
	nil	2,815	12	10,501	373	138	5	10,639	378	-1,311	-47

Table 1.3-1 Change in Wildlife Habitat Due to the Pierre River Mine Expansion Within the Local Study Area: 2013 PRM Application Case (continued)

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	2013 Base Case Habitat		Direct Habitat Change From 2013 Base Case Due to Site Clearing of Pierre River Mine		Indirect Habitat Change From 2013 Base Case Due to Pierre River Mine		Net Habitat Change From 2013 Base Case Due to Pierre River Mine		Net Habitat Change From 2013 Base Case At Closure	
		Area [ha]	% of LSA	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]
fisher / marten	high	14,067	61	-7,538	-54	-98	-<1	-7,636	-54	-4,397	-31
	moderate high	7,293	32	-3,494	-48	42	<1	-3,452	-47	1,715	24
	moderate	925	4	-375	-41	56	6	-319	-35	988	107
	moderate low	8	<1	0	0	0	0	0	0	21	271
	low	0	0	0	0	0	0	0	0	0	0
	nil[(a)]	836	4	11,408	1,365	0	-<1	11,408	1,365	1,674	200
moose	high	2,433	11	-1,052	-43	-139	-6	-1,191	-49	-763	-31
	moderate high	4,846	21	-2,710	-56	-241	-5	-2,951	-61	-2,331	-48
	moderate	7,962	34	-4,612	-58	-75	-<1	-4,686	-59	-1,744	-22
	moderate low	5,812	25	-2,562	-44	315	5	-2,247	-39	2,906	50
	low	1,240	5	-473	-38	140	11	-332	-27	259	21
	nil[(a)]	836	4	11,408	1,365	0	-<1	11,408	1,365	1,674	200
Canada warbler	high	1,374	6	-414	-30	-397	-29	-811	-59	3,414	248
	moderate	2,424	10	-898	-37	-207	-9	-1,105	-46	297	12
	low	2,146	9	-1,112	-52	604	28	-507	-24	225	10
	nil	17,185	74	2,423	14	0	<1	2,423	14	-3,936	-23
common nighthawk	high	7,738	33	-4,120	-53	-1,328	-17	-5,447	-70	-3,587	-46
	moderate	9,853	43	-5,408	-55	-322	-3	-5,729	-58	-1,144	-12
	low	3,782	16	-1,536	-41	1,649	44	113	3	2,370	63
	nil	1,755	8	11,064	630	0	<1	11,064	630	2,360	134
horned grebe	high	223	<1	-157	-71	-48	-22	-205	-92	119	54
	moderate	25	<1	-11	-47	12	51	1	4	-12	-49
	nil	22,882	99	169	<1	36	<1	204	<1	-107	-<1
olive-sided flycatcher	high	2,142	9	-1,101	-51	-564	-26	-1,665	-78	1,584	74
	moderate	2,117	9	-1,106	-52	-50	-2	-1,156	-55	-576	-27
	low	6,636	29	-2,650	-40	614	9	-2,037	-31	2,392	36
	nil	12,234	53	4,857	40	0	<1	4,857	40	-3,400	-28

Table 1.3-1 Change in Wildlife Habitat Due to the Pierre River Mine Expansion Within the Local Study Area: 2013 PRM Application Case (continued)

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	2013 Base Case Habitat		Direct Habitat Change From 2013 Base Case Due to Site Clearing of Pierre River Mine		Indirect Habitat Change From 2013 Base Case Due to Pierre River Mine		Net Habitat Change From 2013 Base Case Due to Pierre River Mine		Net Habitat Change From 2013 Base Case At Closure	
		Area [ha]	% of LSA	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]
rusty blackbird	high	3,036	13	-1,639	-54	-936	-31	-2,575	-85	-574	-19
	moderate	1,442	6	-1,030	-71	20	1	-1,010	-70	-941	-65
	low	296	1	-197	-66	17	6	-180	-61	-90	-30
	nil	18,355	79	2,865	16	900	5	3,765	21	1,605	9
short-eared owl	high	6,806	29	-3,572	-52	-1,202	-18	-4,773	-70	-3,561	-52
	moderate	4,646	20	-3,327	-72	741	16	-2,587	-56	-3,216	-69
	low	795	3	-343	-43	461	58	118	15	757	95
	nil	10,881	47	7,242	67	0	<1	7,242	67	6,019	55
western (boreal) toad	high	2,925	13	-1,741	-60	-897	-31	-2,638	-90	-1,457	-50
	moderate	3,436	15	-2,236	-65	-569	-17	-2,805	-82	-2,209	-64
	low	833	4	-490	-59	223	27	-267	-32	-513	-62
	nil	15,935	69	4,467	28	1,242	8	5,709	36	4,180	26
wolverine	high	15,574	67	-7,684	-49	-5,804	-37	-13,489	-87	3,385	22
	low	6,784	29	-3,638	-54	5,804	86	2,167	32	-2,965	-44
	nil	771	3	11,322	1,468	0	-<1	11,322	1,468	-420	-54
wood bison	high	2,860	12	-1,638	-57	-1,116	-39	-2,753	-96	-1,306	-46
	moderate	4,502	19	-2,367	-53	655	15	-1,712	-38	-1,785	-40
	low	12,785	55	-6,418	-50	461	4	-5,957	-47	-481	-4
	nil	2,982	13	10,423	349	0	<1	10,423	349	3,572	120
woodland caribou	high	631	3	-202	-32	-382	-61	-583	-92	1,989	315
	moderate	1,632	7	-815	-50	391	24	-425	-26	228	14
	low	18,150	78	-9,205	-51	55	<1	-9,150	-50	-2,662	-15
	nil	2,717	12	10,223	376	-64	-2	10,158	374	445	16
yellow rail	high	1,871	8	-1,295	-69	-460	-25	-1,755	-94	-1,176	-63
	moderate	129	<1	-52	-40	112	87	61	47	-61	-47
	nil	21,129	91	1,347	6	348	2	1,695	8	1,236	6

(a) Nil includes 0.51 ha of area that was unaccounted for due to limitations while projecting vegetation in raster format.

Table 1.3-2 Predicted Habitat Change From the 2013 Base Case for Key Indicator Resources and Wildlife Species at Risk in the Regional Study Area During Construction and Operations

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	2013 Base Case		Change from the 2013 Base Case to the 2013 PRM Application Case		Change from the 2013 Base Case to the 2013 Planned Development Case	
		Habitat Area [ha]	% of Total Area	Area [ha]	[% of Resource]	Area [ha]	[%of Resource]
barred owl	high	141,903	6	-1,496	-1	-15,870	-11
	moderate	101,421	4	-443	-<1	-18,169	-18
	low	775,185	34	-6,599	-<1	-54,250	-7
	nil	1,258,866	55	8,538	<1	88,290	7
beaver	high	512,674	23	-3,651	-<1	-35,227	-7
	low	250,833	11	-2,609	-1	-21,783	-9
	nil	1,513,869	66	6,261	<1	57,009	4
black bear	high	1,031,129	45	-7,424	-<1	-85,044	-8
	moderate	485,175	21	615	<1	-15,336	-3
	low	521,888	23	-4,652	-<1	-34,677	-7
	nil	239,184	11	11,460	5	135,057	56
black-throated green warbler	high	153,209	7	-2,064	-1	-18,612	-12
	moderate	132,119	6	-443	-<1	-20,057	-15
	low	931,265	41	-6,212	-<1	-54,656	-6
	nil	1,060,783	47	8,719	<1	93,325	9
Canada lynx	high	371,949	16	-11,483	-3	-65,319	-18
	moderate high	371,936	16	16	<1	-30,844	-8
	moderate	422,457	19	-<1	-<1	-23,506	-6
	moderate low	440,699	19	8	<1	-7,586	-2
	low	431,152	19	0	0	-7,801	-2
	nil[(a)]	239,184	11	11,460	5	135,057	56
Canadian toad	high	172,249	8	-2,542	-1	-11,481	-7
	moderate	658,050	29	-7,699	-1	-31,656	-5
	low	159,794	7	-442	-<1	-7,156	-4
	nil	1,287,284	57	10,683	<1	50,293	4
fisher / marten	high	425,242	19	-10,964	-3	-64,950	-15
	moderate high	433,077	19	-393	-<1	-29,835	-7
	moderate	434,231	19	-103	-<1	-17,392	-4
	moderate low	417,673	18	-5	-<1	-16,758	-4
	low	327,970	14	5	<1	-6,122	-2
	nil[(a)]	239,184	11	11,460	5	135,057	56
moose	high	405,095	18	-8,371	-2	-50,815	-13
	moderate high	414,448	18	-2,061	-<1	-31,877	-8
	moderate	410,547	18	-819	-<1	-27,004	-7
	moderate low	404,382	18	-299	-<1	-20,134	-5
	low	403,720	18	89	<1	-5,226	-1
	nil[(a)]	239,184	11	11,460	5	135,057	56

Table 1.3-2 Predicted Habitat Change from the 2013 Base Case for Key Indicator Resources and Wildlife Species at Risk in the Regional Study Area During Construction and Operations (continued)

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	2013 Base Case		Change from the 2013 Base Case to the 2013 PRM Application Case		Change from the 2013 Base Case to the 2013 Planned Development Case	
		Habitat Area [ha]	% of Total Area	Area [ha]	[% of Resource]	Area [ha]	[%of Resource]
Canada warbler	high	89,875	4	-854	-<1	-19,102	-21
	moderate	113,010	5	-1,597	-1	-16,046	-14
	low	40,440	2	511	1	1,108	3
	nil	2,034,051	89	1,939	<1	34,040	2
common nighthawk	high	322,587	14	-654	-<1	-12,338	-4
	moderate	1,242,485	55	-9,742	-<1	-95,263	-8
	low	347,580	15	-604	-<1	-5,281	-2
	nil	364,724	16	10,999	3	112,883	31
horned grebe	high	232,411	10	-2,815	-1	-23,951	-10
	moderate	20,403	<1	273	1	2,881	14
	low	0	0	0	0	0	0
	nil	2,024,562	89	2,541	<1	21,071	1
olive-sided flycatcher	high	393,308	17	-154	-<1	-18,996	-5
	moderate	868,598	38	-9,106	-1	-67,819	-8
	low	401,944	18	140	<1	-8,073	-2
	nil	613,526	27	9,119	1	94,889	15
rusty blackbird	high	470,085	21	-9,192	-2	-56,877	-12
	moderate	559,027	25	-2,503	-<1	-33,784	-6
	low	44,336	2	-56	-<1	10,585	24
	nil	1,203,929	53	11,750	<1	80,075	7
short-eared owl	high	401,433	18	-2,565	-<1	-29,721	-7
	moderate	289,237	13	-4,623	-2	-27,024	-9
	low	567,340	25	-1,126	-<1	-22,105	-4
	nil	1,019,365	45	8,314	<1	78,850	8
western (boreal) toad	high	226,134	10	-2,774	-1	-24,114	-11
	moderate	368,124	16	-6,198	-2	-36,589	-10
	low	662,586	29	-3,725	-<1	-29,498	-4
	nil	1,020,531	45	12,697	1	90,201	9
wolverine	high	1,796,370	79	-13,606	-<1	-169,892	-9
	low	268,406	12	2,284	<1	36,309	14
	nil	212,601	9	11,322	5	133,583	63
wood bison	high	181,691	8	-1,622	-<1	-21,544	-12
	moderate	577,954	25	-2,139	-<1	-47,486	-8
	low	595,789	26	-4,762	-<1	-29,739	-5
	nil	921,941	40	8,523	<1	98,769	11
woodland caribou	high	216,975	10	-723	-<1	-16,548	-8
	moderate	158,788	7	-1,134	-<1	-12,813	-8
	low	1,374,348	60	-8,720	-<1	-96,113	-7
	nil	527,265	23	10,578	2	125,473	24
yellow rail	high	220,491	10	-2,754	-1	-23,916	-11
	moderate	24,476	1	189	<1	2,759	11
	nil	2,032,409	89	2,565	<1	21,158	1

Table 1.3-3 Predicted Habitat Change From the Pre-Industrial Case for Key Indicator Resources and Wildlife Species at Risk in the Regional Study Area During Construction and Operations

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	Pre-Industrial Case		Change from the Pre-Industrial Case to the 2013 Base Case		Change from the Pre-Industrial Case to the 2013 PRM Application Case		Change from the Pre-Industrial Case to the 2013 Planned Development Case	
		Habitat Area [ha]	% of Total Area	Habitat Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]
barred owl	high	222,863	10	-80,960	-36	-82,455	-37	-96,830	-43
	moderate	186,478	8	-85,056	-46	-85,499	-46	-103,225	-55
	low	925,294	41	-150,109	-16	-156,708	-17	-204,359	-22
	nil	942,742	41	316,124	34	324,662	34	404,414	43
beaver	high	586,995	26	-74,321	-13	-77,972	-13	-109,548	-19
	low	275,397	12	-24,564	-9	-27,174	-10	-46,347	-17
	nil	1,414,984	62	98,885	7	105,146	7	155,895	11
black bear	high	1,156,744	51	-125,616	-11	-133,040	-12	-210,660	-18
	moderate	519,334	23	-34,159	-7	-33,544	-6	-49,496	-10
	low	544,983	24	-23,095	-4	-27,746	-5	-57,771	-11
	nil	56,314	2	182,869	325	194,330	345	317,926	565
black-throated green warbler	high	240,349	11	-87,139	-36	-89,203	-37	-105,752	-44
	moderate	231,520	10	-99,401	-43	-99,844	-43	-119,458	-52
	low	862,807	38	68,458	8	62,246	7	13,802	2
	nil	942,701	41	118,082	13	126,801	13	211,407	22
Canada lynx	high	473,755	21	-101,806	-21	-113,290	-24	-167,126	-35
	moderate high	428,628	19	-56,692	-13	-56,676	-13	-87,535	-20
	moderate	435,964	19	-13,508	-3	-13,508	-3	-37,014	-8
	moderate low	447,484	20	-6,786	-2	-6,778	-2	-14,372	-3
	low	435,230	19	-4,078	-<1	-4,078	-<1	-11,879	-3
	nil[(a)]	56,314	2	182,869	325	194,330	345	317,926	565
Canadian toad	high	193,370	8	-21,121	-11	-23,663	-12	-32,602	-17
	moderate	721,523	32	-63,474	-9	-71,173	-10	-95,130	-13
	low	171,913	8	-12,119	-7	-12,561	-7	-19,275	-11
	nil	1,190,569	52	96,714	8	107,397	9	147,007	12

Table 1.3-3 Predicted Habitat Change from the Pre-Industrial Case for Key Indicator Resources and Wildlife Species at Risk in the Regional Study Area During Construction and Operations (continued)

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	Pre-Industrial Case		Change from the Pre-Industrial Case to the 2013 Base Case		Change from the Pre-Industrial Case to the 2013 PRM Application Case		Change from the Pre-Industrial Case to the 2013 Planned Development Case	
		Habitat Area [ha]	% of Total Area	Habitat Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]
fisher / marten	high	547,806	24	-122,565	-22	-133,529	-24	-187,514	-34
	moderate high	463,711	20	-30,634	-7	-31,027	-7	-60,469	-13
	moderate	449,251	20	-15,020	-3	-15,123	-3	-32,412	-7
	moderate low	428,437	19	-10,764	-3	-10,769	-3	-27,521	-6
	low	331,857	15	-3,887	-1	-3,883	-1	-10,010	-3
	nil[(a)]	56,314	2	182,869	325	194,330	345	317,926	565
moose	high	474,607	21	-69,511	-15	-77,883	-16	-120,326	-25
	moderate high	457,165	20	-42,718	-9	-44,778	-10	-74,595	-16
	moderate	446,519	20	-35,972	-8	-36,791	-8	-62,977	-14
	moderate low	429,125	19	-24,743	-6	-25,042	-6	-44,877	-10
	low	413,645	18	-9,925	-2	-9,836	-2	-15,151	-4
	nil[(a)]	56,314	2	182,869	325	194,330	345	317,926	565
Canada warbler	high	186,246	8	-96,371	-52	-97,225	-52	-115,473	-62
	moderate	177,765	8	-64,755	-36	-66,351	-37	-80,801	-45
	low	45,330	2	-4,890	-11	-4,379	-10	-3,782	-8
	nil	1,868,036	82	166,016	9	167,955	9	200,055	11
common nighthawk	high	353,022	16	-30,435	-9	-31,089	-9	-42,774	-12
	moderate	1,366,640	60	-124,155	-9	-133,897	-10	-219,419	-16
	low	321,427	14	26,153	8	25,549	8	20,872	6
	nil	236,287	10	128,438	54	139,437	59	241,320	102
horned grebe	high	287,315	13	-54,904	-19	-57,719	-20	-78,856	-27
	moderate	170	<1	20,233	11,880	20,506	12,040	23,114	13,571
	low	0	0	0	0	0	0	0	0
	nil	1,989,891	87	34,671	2	37,213	2	55,742	3
olive-sided flycatcher	high	440,399	19	-47,092	-11	-47,245	-11	-66,088	-15
	moderate	1,049,211	46	-180,613	-17	-189,718	-18	-248,432	-24
	low	248,712	11	153,233	62	153,373	62	145,160	58
	nil	539,055	24	74,472	14	83,591	16	169,360	31

Table 1.3-3 Predicted Habitat Change from the Pre-Industrial Case for Key Indicator Resources and Wildlife Species at Risk in the Regional Study Area During Construction and Operations (continued)

Key Indicator Resources and Wildlife Species At Risk	Habitat Suitability Class	Pre-Industrial Case		Change from the Pre-Industrial Case to the 2013 Base Case		Change from the Pre-Industrial Case to the 2013 PRM Application Case		Change from the Pre-Industrial Case to the 2013 Planned Development Case	
		Habitat Area [ha]	% of Total Area	Habitat Area [ha]	[% of Resource]	Area [ha]	[% of Resource]	Area [ha]	[% of Resource]
rusty blackbird	high	587,732	26	-117,647	-20	-126,839	-22	-174,524	-30
	moderate	608,101	27	-49,074	-8	-51,576	-8	-82,858	-14
	low	137	<1	44,199	32,372	44,143	32,331	54,784	40,124
	nil	1,081,407	47	122,522	11	134,272	12	202,597	19
short-eared owl	high	392,447	17	8,987	2	6,421	2	-20,734	-5
	moderate	312,601	14	-23,364	-7	-27,987	-9	-50,388	-16
	low	603,490	26	-36,150	-6	-37,276	-6	-58,255	-10
	nil	968,838	43	50,527	5	58,841	6	129,377	13
western (boreal) toad	high	287,274	13	-61,140	-21	-63,914	-22	-85,254	-30
	moderate	429,709	19	-61,585	-14	-67,782	-16	-98,174	-23
	low	686,295	30	-23,709	-3	-27,435	-4	-53,207	-8
	nil	874,097	38	146,434	17	159,131	18	236,635	27
wolverine	high	2,273,964	100	-477,594	-21	-491,200	-22	-647,486	-28
	low	1,856	<1	266,550	14,363	268,834	14,486	302,858	16,319
	nil	1,557	<1	211,044	13,557	222,366	14,285	344,628	22,139
wood bison	high	275,067	12	-93,376	-34	-94,998	-35	-114,920	-42
	moderate	647,036	28	-69,082	-11	-71,220	-11	-116,568	-18
	low	519,110	23	76,679	15	71,917	14	46,940	9
	nil	836,163	37	85,779	10	94,301	11	184,548	22
woodland caribou	high	423,700	19	-206,725	-49	-207,448	-49	-223,272	-53
	moderate	1,794,282	79	-1,635,494	-91	-1,636,628	-91	-1,648,307	-92
	low	3,181	<1	1,371,166	43,099	1,362,446	42,825	1,275,054	40,078
	nil	56,213	2	471,052	838	481,630	857	596,525	1,061
yellow rail	high	275,245	12	-54,754	-20	-57,508	-21	-78,670	-29
	moderate	152	<1	24,324	15,994	24,512	16,118	27,082	17,808
	nil	2,001,979	88	30,430	2	32,995	2	51,588	3

(a) Nil includes 717.81 ha of area classified as cloud in PIC vegetation data due to remote sensing limitations.

2.0 HABITAT FRAGMENTATION ANALYSIS

2.1 Introduction

Habitat fragmentation is defined as the separation of contiguous areas of habitat into smaller and more isolated habitat patches (Morrison et al. 1998). Whether suitable habitat is available for use by wildlife depends on several factors including the degree to which suitable habitat is fragmented.

The effects of habitat fragmentation include reduction in the area of remaining habitat, increased isolation of the habitat fragments and increased disturbance of habitat from surrounding areas (e.g., edge effects) (Haila 1999). The effect of fragmentation on a particular species depends on the scale of the landscape, the amount of suitable habitat remaining, the species' life history, and its colonization and dispersal capability (Fahrig 1997). The effect of habitat fragmentation also depends on home range size, relationships with edge and interior stand conditions, and whether the species is a habitat specialist or generalist (Andrén 1994; Fahrig 1997). Changes in the landscape may have substantial effects on ecological processes and the long-term viability of wildlife populations, across numerous spatial scales.

2.2 Assessment Methods

A detailed description of habitat fragmentation assessment methods was presented in the EIA, Volume 5, Appendix 5-4, Section 2.2.

2.3 Results

Results of the fragmentation analysis are presented in Table 2.3-1 for the change from the 2013 Base Case to the 2013 PRM Application Case and to the 2013 PDC, and in Table 2.3-2 for the change from the PIC to the 2013 PRM Application Case and 2013 PDC during construction and operations. Changes are expressed as percent change relative to the fragmentation metrics for each habitat suitability class in the 2013 Base Case and the PIC for Tables 2.3-1 and 2.3-2, respectively. Positive percent changes represent an increase in that metric, while a negative percent change represents a decrease. Due to the raster approach in GIS, total area of linear disturbances had to be overestimated to represent them on the landscape. This approach was necessary for the analysis of fragmentation, but does mean that total habitat loss and fragmentation will also be overestimated.

Table 2.3-1 Predicted Wildlife Habitat Fragmentation Effects in the Regional Study Area During Construction and Operations: Change from the 2013 Base Case

Key Indicator Resource	Habitat Suitability Class	Change from the 2013 Base Case to the 2013 PRM Application Case				Change from the 2013 Base Case to the 2013 Planned Development Case			
		NP [%]	MPS [%]	TCA [%]	ENN_MN [%]	NP [%]	MPS [%]	TCA [%]	ENN_MN [%]
black bear	high	-1	<1	-<1	<1	-10	3	-7	8
	moderate	-<1	<1	<1	<1	-2	-1	-5	<1
	low	<1	-1	-1	<1	<1	-8	-8	2
	nil	-1	6	6	-<1	-22	95	71	4
Canada lynx	high	2	-5	-4	-<1	-1	-16	-18	11
	moderate high	<1	-<1	-<1	-<1	<1	-9	-8	3
	moderate	<1	-<1	-<1	-<1	18	-20	-7	-6
	moderate low	0	<1	<1	0	20	-19	-4	-11
	low	0	0	0	0	17	-16	-2	4
	nil	-1	6	6	-<1	-22	95	71	4
Canada warbler	high	-1	<1	-<1	<1	-21	1	-17	13
	moderate	-1	-<1	-2	<1	-13	-2	-16	8
	low	<1	<1	<1	<1	3	-2	-<1	-1
	nil	0	<1	<1	0	-23	32	2	4
fisher / marten	high	2	-4	-4	-<1	-4	-12	-16	6
	moderate high	<1	-<1	-<1	-<1	-7	-<1	-6	2
	moderate	<1	-<1	-<1	-<1	4	-8	-5	-5
	moderate low	<1	-<1	-<1	-<1	7	-11	-5	-7
	low	<1	-<1	0	<1	4	-5	-2	-4
	nil	-1	6	6	-<1	-22	95	71	4
moose	high	3	-5	-3	<1	-3	-10	-13	28
	moderate high	3	-3	-<1	1	18	-22	-8	6
	moderate	<1	-<1	-<1	-1	26	-26	-7	4
	moderate low	<1	-<1	-<1	-<1	42	-33	-6	-15
	low	1	-1	-<1	-1	32	-25	-2	-20
	nil	-1	6	6	-<1	-22	95	71	4

Note: NP = Number of patches; MPS = mean patch size; TCA = total core area; ENN_MN = mean nearest neighbour distance.

Table 2.3-2 Predicted Wildlife Habitat Fragmentation Effects in the Regional Study Area During Construction and Operations: Change From the Pre-Industrial Case

Key Indicator Resource	Habitat Suitability Class	Change from the Pre-Industrial Case to the 2013 Base Case				Change from the Pre-Industrial Case to the 2013 PRM Application Case				Change from the Pre-Industrial Case to the 2013 Planned Development Case			
		NP [%]	MPS [%]	TCA [%]	ENN_MN [%]	NP [%]	MPS [%]	TCA [%]	ENN_MN [%]	NP [%]	MPS [%]	TCA [%]	ENN_MN [%]
black bear	high	176	-68	-27	-46	172	-68	-28	-46	147	-68	-32	-42
	moderate	148	-64	-32	-51	147	-63	-32	-51	143	-64	-36	-51
	low	28	-23	-18	-45	28	-24	-19	-45	29	-29	-25	-44
	nil	596	-40	506	-51	587	-37	539	-51	445	17	937	-49
Canada lynx	high	108	-63	-33	-31	113	-65	-36	-31	105	-69	-45	-24
	moderate high	72	-50	-21	-35	73	-50	-21	-35	73	-54	-28	-33
	moderate	53	-37	-9	-28	53	-37	-9	-28	81	-50	-15	-32
	moderate low	45	-32	-8	-29	45	-32	-8	-29	74	-45	-11	-36
	low	58	-38	-5	-35	58	-38	-5	-35	86	-48	-8	-32
	nil	587	-74	510	-65	578	-72	544	-65	437	-49	944	-63
Canada warbler	high	5	-59	-70	-13	4	-59	-70	-12	-18	-58	-75	-2
	moderate	1,235	-100	-99	16	1,222	-100	-99	17	1,058	-100	-99	25
	low	-52	-50	-85	16	-52	-50	-84	16	-51	-51	-85	14
	nil	-90	56,781	19,474	-60	-90	56,817	19,500	-60	-92	74,798	19,912	-58
fisher / marten	high	58	-51	-35	-27	61	-54	-37	-27	52	-57	-45	-23
	moderate high	21	-23	-12	-19	21	-23	-12	-20	13	-24	-17	-18
	moderate	76	-45	-11	-32	76	-46	-11	-32	83	-50	-15	-35
	moderate low	25	-23	-9	-19	25	-23	-9	-19	34	-31	-13	-25
	low	22	-19	-5	-25	22	-20	-5	-24	27	-24	-7	-28
	nil	587	-74	510	-65	578	-72	544	-65	437	-49	944	-63
moose	high	362	-82	-25	-62	374	-83	-27	-62	346	-83	-35	-51
	moderate high	220	-72	-17	-55	229	-73	-17	-55	279	-78	-23	-53
	moderate	227	-72	-15	-65	229	-72	-15	-66	313	-79	-21	-64
	moderate low	186	-67	-12	-71	188	-68	-13	-72	307	-78	-18	-76
	low	164	-63	-8	-66	168	-64	-8	-66	249	-73	-9	-73
	nil	587	-74	510	-65	578	-72	544	-65	437	-49	944	-63

Note: NP = Number of patches; MPS = mean patch size; TCA = total core area; ENN_MN = mean nearest neighbour distance.
Nil includes 669.52 ha of area classified as cloud in Pre-Industrial Case vegetation data due to remote sensing limitations.

3.0 POPULATION VIABILITY ANALYSIS

3.1 Introduction

Population Viability Analysis (PVA) is a population modelling process that links changes in habitat with demographic parameters (i.e., birth and death rates) and environmental variation to calculate population trends and the probability of population extinction within a given period of time and space (Shaffer 1990; Soulè 1987). The PVA helps predict the potential effects of PRM and other planned developments on wildlife populations in the RSA. In addition, the PVA can help identify those factors or variables that are driving the changes in population size and subsequently influencing the likelihood of population persistence.

3.2 Assessment Methods

For a detailed description of PVA assessment methods, refer to EIA, Volume 5, Appendix 5-4, Section 1.2. The geometric mean and standard deviations of survival and fecundity rates for moose and black bear were determined through a comprehensive review of the literature likely to be relevant to populations of these species in the RSA (Table 3.2-1).

Table 3.2-1 Literature Sources Used to Estimate Survival and Fecundity Rates for Black Bear and Moose

Species	Region	Reference
black bear	Alaska	Schwartz and Franzmann (1991)
	Alberta	Czetwertynski et al. (2007)
		Fuller and Keith (1977)
		Kemp (1970)
		Ruff (1978)
		Young (1978)
		Young and Ruff (1982)
	Colorado	Beck (1991)
	Montana	Jonkel and Cowan (1971)
	North America	Bunnell and Tait (1985)
	North Carolina	Sorensen and Powell (1998)
	Massachusetts	Elowe and Dodge (1989)
	Ontario	Samson and Hout (1998)
		Schenk et al. (1998)
	Tennessee	McLean and Pelton (1994)
moose	Alberta	Bibaud and Archer (1973)
		BOVAR Environmental Ltd. (1996)
		Brusnyk and Westworth (1986)
		Cook and Jacobsen (1978)
		Eccles and Duncan (1988)
		Hauge and Keith (1978, 1980, 1981)
		Penner (1976)
		Rolley and Keith (1980)
		Salter et al. (1986)
		Skinner (1996)
		Thompson et al. (1980)
		Westworth (1980)
		Westworth and Associates (1978)
		Westworth and Brusnyk (1982)

For moose, survival and fecundity rates were estimated for three age classes: calves, yearlings and adults, with only adults capable of reproducing (Table 3.2-2). Some PVA inputs for moose are updated from those used in the EIA due to the availability of more recent data collected during surveys in provincial Wildlife Management Unit (WMU) 531 (2009 data; Morgan and Powell 2009), which takes up 32% of the RSA, and WMU 518 (2011 data; Morgan and Hudson 2012), which takes up 22% of the RSA. Weighted averages of calf survival (0.222) and the bull:cow ratio (33:67) were calculated from recent data from WMU 531 and WMU 518. An initial population density of 0.04 moose/km^2 across the RSA was applied based on the population density of moose estimated for WMU 531 in 2009 (Morgan and Powell 2009), because population density was not estimated for WMU 518 from the 2011 data due to small sample size and large sample variation (Morgan and Hudson 2012), and data from the previous survey (2004) may no longer be relevant. Because the estimated population density in WMU 518 in 2004 was 0.14 moose/km^2 (Morgan and Hudson 2012), using the population density of 0.04 moose/km^2 from WMU 531 in 2009 (Morgan and Powell 2009) is conservative. Recent data are available for WMU 530 (Skilnick 2013, pers. comm.), which takes up 45% of the RSA. The southern half of WMU 530 was surveyed in 2010 and resultant data suggest a population density of 0.11 moose/km^2 and a calf survival rate of 0.50. Because moose population density and calf survival in the northern half of WMU 530 are unknown and the southern half appears to have high population density relative to WMU 531 and high calf survival relative to both WMUs 518 and 531, data from WMU 530 were not used in the PVA. Not including these data results in a more conservative assessment. The remaining WMUs in the RSA are WMU 519 and WMU 529, which together make up less than 2% of the RSA.

For black bear, stage-dependent survival and fecundity rates were estimated for four age-classes: cubs, yearling, subadults (2 to 3 years of age) and adults (greater than or equal to 4 years of age), and are the same as those used in the EIA. Similar to moose, reproduction was assumed to occur in adults only (Table 3.2-2).

Table 3.2-2 Stage-Dependent Average (±1SD) Survival and Fecundity Rates for the Moose Population Model

Key Indicator Resource	Stage	Survival	Fecundity
moose	calves	0.222 ± 0.150	0.000
	yearlings	0.780 ± 0.045	0.000
	adults	0.780 ± 0.045	0.601 ± 0.200
black bear	cubs	0.640 ± 0.080	0.000
	yearlings	0.780 ± 0.060	0.000
	sub-adults	0.630 ± 0.120	0.000
	adults	0.820 ± 0.050	0.633 ± 0.243

3.3 Results

3.3.1 Black Bear

Based on the survival and fecundity values in the stage matrix, the finite rate-of-increase (λ) for the black bear population was 1.01 assuming no density dependence or environmental variation. This result suggests a relatively stable population, because a population that is replacing itself exactly would have a λ of 1.0 (Krebs 1994).

From the 2013 Base Case to the 2013 PRM Application Case during construction and operations, the initial abundance, carrying capacity and population density of the RSA for black bear are predicted to decline by less than 1%. From the 2013 Base Case to the 2013 PDC, the initial abundance, carrying capacity and population density of the RSA for black bear are predicted to decline by about 7%. However, the probability of population extirpation over the life of PRM remains less than 0.0001% in all cases.

From the PIC to the 2013 Base Case and the 2013 PRM Application Case, the initial abundance, carrying capacity and population density of the RSA for black bear are predicted to decline by the same amount, about 12%. From the PIC to the 2013 PDC, the initial abundance, carrying capacity and population density of the RSA for black bear are predicted to decline by about 18%.

3.3.2 Moose

Based on the survival and fecundity values in the stage matrix, λ for the moose population was 0.91 assuming no density dependence or environmental variation. This result suggests a slowly decreasing population, since a finite increase of 1.0 would represent a population that is replacing itself exactly (Krebs 1994).

From the 2013 Base Case to the 2013 PRM Application Case during construction and operations, the initial abundance, carrying capacity and population density of the RSA for moose are predicted to decline by less than 1%. From the 2013 Base Case to the 2013 PDC, the initial abundance, carrying capacity and population density of the RSA for moose are predicted to decline by about 9%. The probability of population extirpation remains less than 1% over the life of PRM in all cases, ranging from 0.5% to 0.6%.

From the PIC to the 2013 Base Case and the 2013 PRM Application Case, the initial abundance, carrying capacity and population density of the RSA for moose are predicted to decline by about 12%. From the PIC to the 2013 PDC, the initial abundance, carrying capacity and population density of the RSA for moose are predicted to decline by about 19%.

4.0 LINKAGE ZONE ANALYSIS

4.1 Introduction

Intact movement corridors are important for sustaining healthy wildlife populations. Movement corridors allow wildlife to move through and between suitable habitat patches and fulfill critical life requisites (Meitz 1994; Gibeau et al. 1996). A Linkage Zone Analysis (LZA) was completed to assess the impacts of PRM on moose movement in the RSA. The LZA was produced through modifications to moose HS model output using information about habitat quality and the distribution of disturbance features on the landscape. The model identifies areas of suitable habitat for moose that allow the species to move through and between suitable habitats. Areas are otherwise considered fractured and act as barriers to movement. Barriers to movement may be natural (e.g., rivers) or man-made (e.g., roads).

4.2 Assessment Methods

A detailed description of LZA assessment methods can be found in the EIA, Volume 5, Appendix 5-4, Section 4.

4.3 Results

Results of the LZA for moose are expressed in terms of the percentage of fractured suitable habitat for the RSA as a whole, and within east-west rows and north-south columns of mapped habitat (Tables 4.3-1 and 4.3-2). The reported percentage of fractured habitat is higher than actually expected because the model assumes that man-made features and their zones of influence are completely avoided by moose. In reality, moose use habitat near human disturbance, although use relative to availability may decline, and areas near human use may present increased risk of mortality. The overall results highlight areas of the RSA that present challenges to the free movement of moose across the landscape.

Table 4.3-1 Habitat Unsuitable for Moose Movement in the Regional Study Area: Change From the 2013 Base Case

Corridor	2013 Base Case [% unsuitable]	2013 PRM Application Case		2013 Planned Development Case	
		% of Habitat Unsuitable	Change From 2013 Base Case [%]	% of Habitat Unsuitable	Change From 2013 Base Case [%]
east-west A	4	4	0	4	0
east-west B	5	5	0	9	4
east-west C	18	20	2	24	6
east-west D	34	35	2	36	2
east-west E	48	48	0	52	4
east-west F	33	33	0	40	6
east-west G	32	32	0	38	6
east-west H	14	14	0	20	5
east-west I	16	16	0	19	3
north-south 1	19	19	0	19	0
north-south 2	21	21	0	30	9
north-south 3	17	17	0	23	6
north-south 4	18	18	0	22	4
north-south 5	36	37	0	40	4
north-south 6	55	58	3	67	12
north-south 7	45	45	0	51	5
north-south 8	23	23	0	23	<1
north-south 9	9	9	0	10	1
north-south 10	5	5	0	5	<1
north-south 11	2	2	0	2	0
Total Percentage of Habitat Unsuitable for Movement in the RSA	**27**	**27**	**<1**	**32**	**5**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Table 4.3-2 Habitat Unsuitable for Moose Movement in the Regional Study Area: Change From the Pre-Industrial Case

Corridor	Pre-Industrial Case [% unsuitable]	2013 Base Case		2013 PRM Application Case		2013 Planned Development Case	
		% of Habitat Unsuitable	Change From Pre-Industrial Case [%]	% of Habitat Unsuitable	Change From Pre-Industrial Case [%]	% of Habitat Unsuitable	Change From Pre-Industrial Case [%]
east-west A	<1	4	3	4	3	4	3
east-west B	2	5	3	5	3	9	7
east-west C	5	18	13	20	15	24	20
east-west D	5	34	29	35	30	36	31
east-west E	2	48	46	48	46	52	50
east-west F	1	33	32	33	32	40	38
east-west G	1	32	31	32	31	38	37
east-west H	2	14	12	14	12	20	18
east-west I	4	16	12	16	12	19	15
north-south 1	<1	19	19	19	19	19	19
north-south 2	3	21	18	21	18	30	27
north-south 3	4	17	12	17	12	23	19
north-south 4	2	18	16	18	16	22	20
north-south 5	1	36	35	37	35	40	39
north-south 6	5	55	50	58	53	67	62
north-south 7	2	45	44	45	44	51	49
north-south 8	2	23	21	23	21	23	21
north-south 9	2	9	7	9	7	10	8
north-south 10	3	5	2	5	2	5	2
north-south 11	2	2	-<1	2	0	2	-<1
Total Percentage of Habitat Unsuitable for Movement in the RSA	**2**	**27**	**25**	**27**	**25**	**32**	**29**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

5.0 REFERENCES

ACC (Alberta Caribou Committee). 2004. *Caribou Research Program*.

Altman, B. and R. Sallabanks. 2000. *Olive-sided flycatcher (Contopus cooperi), The Birds of North America Online (A. Poole, Ed.)*. Ithaca: Cornell Lab of Ornithology. Available online: http://bna.birds.cornell.edu/bna/species/ 502doi:10.2173/bna.502. Accessed March 23, 2012.

Anderson, R.B. 1999. *Peatland Habitat Use and Selection by Woodland Caribou (Rangifer tarandus tarandus) in Northern Alberta*. Master of Science Thesis, University of Alberta. Edmonton, AB.

Andrén, H. 1994. *Effects of Habitat Fragmentation on Birds and Mammals in Landscape with Different Proportions of Suitable Habitats: A Review*. Oikos. 71: 355-366.

Beck, T.D.I. 1991. *Black Bears of West-central Colorado*. Colorado Division of Wildlife. Technical Report Number 39. 86 pp.

Beckingham, J.D. and J.H. Archibald. 1996. *Field guide to ecosites of northern Alberta*. Canadian Forest Service. UBC Press. University of British Columbia, Vancouver, BC.

Beckingham, J.D., D.G. Nielsen, V.A. Futoransky. 1996. *Field guide to ecosites of the mid-boreal ecoregions of Saskatchewan.* Natural Resources Canada, Canadian Forest Service, Northwest Region, Northern Forestry Centre, Edmonton, Alberta. Special Report 6. 464 pp.

Bergerud, A.T., H.E. Butler and D.R. Millar. 1984. *Anti-Predator Tactics of Calving Caribou: Dispersion in Mountains*. Canadian Journal of Zoology. 52:1566-1575Bonar, R.L. 1985. Moose winter foods in the interior of British Columbia: a preliminary analysis. ALCES®. 21: 37-53.

Bibaud, J.A. and T. Archer. 1973. *Fort McMurray Ungulate Survey of the Mineable Portion of the Bituminous (Tar) Sands Area – No. 1*. Alberta Recreation, Parks and Wildlife. Edmonton, AB.

BOVAR Environmental Ltd. 1996. *Wildlife Populations and Habitat Resources for the Syncrude Local Study Area and the Syncrude/Suncor Regional Study Area*. Calgary, AB.

Bradshaw, C.J.A., Herbert, D.M., Rippin, A.B. and S. Boutin. 1995. *Winter peatland habitat selection by woodland caribou in northeastern Alberta*. Canadian Journal of Zoology 73:1567-1574.

Brusnyk, L.M. and D.A. Westworth. 1986. *Ungulate Monitoring Studies in the Cold Lake Project Area*. Prepared for Esso Resources Canada Ltd. Calgary, AB.

Bunnell, F.L. and D.E.N. Tait. 1985. *Mortality Rates of North American Bears*. Arctic 38: 316-323.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G. Kaiser, A.C. Stewart and M.C.E. McNall. 2001. *The Birds of British Columbia, Vol. 4, Passerines: Wood-Warblers through Old World Sparrows*. University of British Columbia Press, Vancouver, BC. 741 pp.

Campbell, R.W., M.I. Preston, M. Phinney, C. Siddle and J. Deal. 2007. *Wildlife Data Centre: featured species – Canada Warbler*. Wildlife Afield 4(2): 95-160.

Cook, R.D. and J.O. Jacobsen. 1978. *The 1977 Fort McMurray AOSERP Moose Census: Analysis and Interpretations of Results*. Interdisciplinary Systems Ltd. 43 pp.

Czetwertynski, S.M., M.S. Boyce and F.K. Schmieglow. 2007. *Effects of hunting on demographic parameters of American black bears*. Ursus 18(1):1-18.

Dyer, S.J. 1999. *Movement and Distribution of Woodland Caribou (Rangifer tarandus caribou) in Response to Industrial Development in Northeastern Alberta*. Master of Science Thesis. University of Alberta. 106 pp.

Dyer, S.J., S.M. Wasel and J.P. O'Neill. 1999. *Distribution of Woodland Caribou in Response to Industrial Development in Northeastern Alberta*. The Wildlife Society-Alberta Chapter. 10th Annual Meeting. Nisku Inn. Nisku, AB.

Dyer, S.J., J.P. O'Neil, S.M. Wasel and S. Boutin. 2001. *Avoidance of Industrial Development by Woodland Caribou*. Journal of Wildlife Management. 65: 531-542.

Dzus, E. 2001. *Status of the Woodland Caribou (Rangifer tarandus caribou) in Alberta*. Fisheries and Wildlife Management Division, Alberta Environment and Alberta Conservation Association. Wildlife Status Report No. 30. Edmonton, AB. 47 pp.

Eccles, T.R. and J.A. Duncan. 1988. *Surveys of Ungulate Populations in the OSLO Oil Sands Leases 12, 13 and 34*. Interim Report for Syncrude Canada Ltd.

Edmonds, E.J. and M. Bloomfield. 1984. *A Study of Woodland Caribou (Rangifer tarandus caribou) in West-Central Alberta, 1979-1983*. Alberta Energy and Natural Resources Fish and Wildlife Division. 203 pp.

Elowe, D.E. and W.E. Dodge. 1989. *Factors Affecting Black Bear Reproductive Success and Cub Survival in Massachusetts*. Journal Wildlife Management. 53: 962-968.

Fahrig, L. 1997. *Relative Effects of Habitat Loss and Fragmentation on Population Extinction*. Journal of Wildlife Management. 61: 603-610.

Fuller, T.K. and L.B. Keith. 1977. *Wolf, Woodland Caribou and Black Bear Population Dynamics in Northeastern Alberta*. Interim Report Prepared for AOSERP. Project TF1.1. Edmonton, AB.

Fuller, T.K. and L.B. Keith. 1981. *Woodland Caribou Dynamics in Northeastern Alberta*. Journal of Wildlife Management. 45: 197-213.

Gibeau, M.L., S. Herrero, J.L. Kansas and B. Benn. 1996. *Grizzly bear population and habitat status in Banff National Park*. A report to the Banff Bow Valley Task Force.

Haila, Y. 1999. *Islands and Fragments*. In: M.L. Hunter. 1999. Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press. Cambridge, U.K.

Hauge, T.M. and L.B. Keith. 1978. *A Census of Moose on Syncrude's Leases 17 and 22 During Early February, 1977*. Prepared for AOSERP by the University of Wisconsin. AOSERP Project TF 1.1. 14 pp.

Hauge, T.M. and L.B. Keith. 1980. *Dynamics of Moose Populations in the AOSERP Study Area in Northeastern Alberta*.

Hauge, T.M. and L.B. Keith. 1981. *Dynamics of moose populations in northeastern Alberta*. Journal of Wildlife Management. 45: 573-597.

James, A.R.C. 1999. *Effects of Industrial Development on the Predator-Prey Relationship Between Wolves and Caribou in Northeastern Alberta*. Ph.D. Thesis Submitted to the University of Alberta. Edmonton, AB.

Johnson, D.H. 1980. *The Comparison of Usage and Availability Measurements for Evaluating Resource Preference*. Ecology. 61(1): 65-71.

Jonkel, C.J. and I.M. Cowan. 1971. *The Black Bear in the Spruce-fir Forest*. Wildlife Monograph 27. 57 pp.

Kemp. G.A. 1970. *Black Bear Population Dynamics at Cold Lake, Alberta, 1968-1970*. In: Bears: Their Biology and Management. Papers and Proceedings of the International Conference on Bear Research and Management. Calgary, AB. November 6-9, 1970.

Krebs, C.J. 1994. *Ecology*. HarperCollins College Publishers, New York, New York.

Latham, A.D.M. 2009. *Wolf Ecology and Caribou-Primary Prey-Wolf Spatial Relationships in Low Productivity Peatland Complexes in northeastern Alberta*. Ph.D. Dissertation. University of Alberta, Edmonton, Alberta. 197 pp.

Latham, A.D.M., M.C. Latham, N.A. McCutchen and S. Boutin. 2011. *Invading white-tailed deer change wolf-caribou dynamics in northeastern Alberta*. J.Wildl. Manage. 75(1):204-212.

Manly, B.F.J., P. Miller and L.M. Cook. 1972. *Analysis of a selective predation experiment*. The American Naturalist. 106(952): 719-735.

Manly, B.F.J., L.L. Macdonald, D.L. Thomas, T.L. McDonald and W.P. Erickson. 2002. *Resource selection by animals*. Kluwer Academic Publishers, Netherlands.

Magnusson, K. And K. Wasel. 1999. *Effects of Simulated Traffic Noise on Woodland Caribou in Northeastern Alberta*. Presented at The Wildlife Society-Alberta Chapter 10th Annual Meeting.

Manitoba Model Forest. 1995. *Report on the Manitoba Model Forest Integrated Forestry/Woodland Caribou Management Strategy: Volume 1*. Maintaining Our Options. Manitoba Model Forest and TEAM. Pine Falls, MB.

Marzluff, J.M., J.J. Millspaugh, K.R. Cedar, C.D. Oliver, J. Withey, J.B. McCarter, C.L. Mason and J. Comnick. 2002. *Modelling changes in wildlife habitat and timber revenues in response to forest management*. Forest Science. 48(2): 191-202.

McLean, P.K. and M.R. Pelton. 1994. *Estimates of Population Density and Growth of Black Bears in the Smoky Mountains*. International Conference of Bear Research and Management. 9(1): 253-261

Meitz, S.N. 1994. *Linkage zone identification and evaluation of management options for grizzly bears in the Evaro Hill area*. MS thesis. University of Montana, Missoula. 90 pp.

Morgan, T. and V. Hudson. 2012. Wildlife Management Unit 518 moose. Pp. 75-79. In: M. Ranger and R. Anderson. Delegated aerial ungulate surveys, 2010/2011 survey season. Data Report, D-2011-009, produced by the Alberta Conservation Association, Sherwood Park, Alberta, Canada.

Morgan, T. and T. Powell. 2009. *WMU 531 Aerial Moose (Alces alces) survey, February 2009*. Alberta Sustainable Resource Development, Wildlife Division. Fort McMurray, Alberta. 25 pp.

Morrison, M.L., B.G. Marcot and R.W. Mannan. 1998. *Wildlife-Habitat Relationships: Concepts and Applications*. 2nd Edition. University of Wisconsin Press. Madison, WI. 435 pp.

NRC (Natural Regions Committee). 2006. *Natural regions and subregions of Alberta*. Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. T/852. 264 pp.

Penner, D.F. 1976. *Preliminary Baseline Investigations of Furbearing and Ungulate Mammals Using Lease 17*. Renewable Resources Consulting Services Ltd. Environmental Research Monograph 1976–3. Edmonton, AB.

Rolley, R.E. and L.B. Keith. 1980. *Moose Population Dynamics and Winter Habitat Use at Rochester, Alberta, 1965–1979*. Canadian Field Naturalist. 94(1):9–18.

Ruff, R.L. 1978. *A Study of the Natural Regulatory Mechanisms Acting on an Unhunted Population of Black Bears near Cold Lake, AB*. Proj. Rep. Dept Wildl. Ecol., Univ. Wisc., Madison. 107 pp.

Salter, R.E., J.A. Duncan and J.E. Green. 1986. *Surveys of Ungulate Populations in the OSLO Oil Sands Ungulate Study Area*. December 1985 and 1986. Prepared by LGL Limited, Environmental Research Associates. Prepared for Esso Resources Canada Ltd. Calgary AB.

Samson, C. and J. Hout. 1998. *Movements of Female Black Bears in Relation to Landscape Vegetation Type in Southern Ontario*. Journal of Wildlife Management. 62(2): 718-727.

Schenk, A., M.E. Obbard and K.M. Kovacs. 1998. *Genetic Relatedness and Home-range Overlap Among Female Black Bears (Ursus americanus) in Northern Ontario, Canada*. Canadian Journal of Zoology. 76: 1511-1519.

Schneider, R.R., B. Wynes, S. Wasel, E. Dzus and M. Hiltz. 2000. *Habitat Use by Caribou in Northern Alberta, Ca*nada. Rangifer. 20(1): 43-50.

Schwartz, C.C. and A.W. Franzmann. 1991. *Interrelationship of Black Bears to Moose and Forest Succession in the Northern Coniferous Forest*. Wildlife Monographs 113. 58 pp.

Shaffer, M.L. 1990. *Population Viability Analysis*. Conservation Biology. 4: 39-40.

Simpson, K., Woods, G.P. and K.B. Herbert. 1985. *Critical Habitats of Caribou (Rangifer tarandus caribou) in the Mountains of Southern British Columbia*. *Caribou Management Census Techniques Status in Eastern Canada*. *In:* Meredith, T.C. Martell A.M. and T.R. Moore (eds.) *Proceedings of the Second North American Caribou Workshop.* Centre for Northern Studies and Research, McGill University, Montreal, QC.

Skinner, D.L. 1996. *Wildlife Inventory of Oil Sands Leases 12, 13, and 34*. Prepared by D.A. Westworth and Associates. Edmonton, AB.

Sorensen, V.A. and R.A. Powell. 1998. *Estimating Survival Rates of Black Bears*. Canadian Journal of Zoology. 76: 1335-1343.

Soulè, M.E. (Editor). 1987. *Viable Populations for Conservation*. Cambridge University Press. New York, NY.

Strong, W.L. 1992. *Ecoregions and Ecodistricts of Alberta*. Alberta Forestry, Lands and Wildlife. Publication No. T/244. Edmonton, AB. 77 pp. + Maps.

Stuart-Smith, A.K., C.J.A. Bradshaw, S. Boutin, D.M. Hebert and A.B. Rippin. 1997. *Woodland Caribou Relative to Landscape Patterns in Northeastern Alberta*. Journal of Wildlife Management. 61: 622-633.

Suncor (Suncor Energy Inc.). 2000. *Firebag In-Situ Oil Sands Project Application*. Volumes 1, 2a, 2b, 3, 4a and 4b. Submitted to Alberta Energy and Utilities Board and Alberta Environment. Prepared by Golder Associates. May 2000.

Thompson, D.C., D.M. Ealey and K.H. McCourt. 1980. *A Review and Assessment of the Baseline Data Relevant to Oil Sands Development on Large Mammals in the AOSERP Study Area*. AOSERP Report No. 64. Prepared by McCourt Management Ltd. Prepared for Alberta Oil Sands Environmental Research Program. 155 pp.

Vitt, D.H., L.A. Halsey, M.N. Thormann and T. Martin. 1997. *Peatland Inventory of Alberta*. Phase 1: Overview of Peatland Resources in the Natural Regions and Subregions of the Province. Prepared for the Alberta Peat Task Force. Edmonton, AB. 117 pp.

Westworth, D.A. 1980. *Surveys of Moose Populations in the Vicinity of the Syncrude Development*. Winter 1979–1980. Prepared for Syncrude Canada Ltd. 13 pp.

Westworth and Associates. 1978. *Moose Populations on Syncrude's Leases 17 and 22: Results of the December 1978 Aerial Survey and a Review of Recent Trends and Seasonal Movements*. Prepared for Syncrude Canada Ltd. by DA Westworth and Associates Ltd., Edmonton, AB.

Westworth, D.A. and L.M. Brusnyk. 1982. *Wildlife Resources of the Canstar Leases: Terrestrial Furbearers*. Prepared for Canstar Oil Sands Ltd.

Young, B.F. 1978. *Potential Productivity of Black Bear Habitat of the AOSERP Study Area*. Prepared for the Alberta Oil Sands Environmental Research Program. University of Calgary. Calgary, AB. 22 pp.

Young, B.F. and R.L. Ruff. 1982. *Population Dynamics and Movements of Black Bears in East Central Alberta*. Journal of Wildlife Management. 46: 845-860.

5.1 Internet Sites

Alberta ESRD (Environment and Sustainable Resource Development). 2013. *The General Status of Alberta Wild Species 2010*. http://srd.alberta.ca/FishWildlife/SpeciesAtRisk/GeneralStatusOfAlbertaWildSpecies/GeneralStatusOfAlbertaWildSpecies2010/SearchForWildSpeciesStatus.aspx. Accessed May 22, 2013.

Species at Risk Public Registry. 2013. http://www.sararegistry.gc.ca. Accessed May 22, 2013.

5.2 Personal Communication

Anderson, R.B. (Applied Ecosystem Management). 2001. Personal Communication with Corey De La Mare (Golder Associates Ltd.). Communicated on August, 2001.

Skilnick, Joann. 2013. Personal Communication with Brock Simons (Golder Associates Ltd.). Communicated on August 19, 2013.

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