APPENDIX 5-3

TERRESTRIAL IMPACT TABLES

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1 INTRODUCTION

This appendix contains separate terrestrial tables for the Jackpine Expansion Mining Area (JEMA) and the Pierre River Mining Area (PRMA). Data from these tables were combined to create tables in the Environmental Impact Assessment (EIA) on which the terrestrial impact assessment is based. Tables 1 to 20 are for the terrestrial vegetation, wetlands and forestry data (Volume 3, Section 7.3.3) and Tables 22 and 23 are for the biodiversity data (Volume 3, Section 7.5.2). Tables detailing effects of the Project on wildlife habitat are reported in Appendix 5-4 Wildlife Modelling.

1.1 TERRESTRIAL VEGETATION, WETLANDS AND FORESTRY

Table 1 Total Area and Percent Cover of Ecosite Phases and Wetlands Types Within the Pierre River Mining Area Local Study Area

Code	Description	Area	
		[ha]	% of LSA
Central Mixedwood Natural Subregion Ecosite Phases			
a1	lichen jack pine	16	<1
b1	blueberry jack pine-aspen	242	1
b2	blueberry aspen (white birch)	43	<1
b3	blueberry aspen-white spruce	104	<1
b4	blueberry white spruce-jack pine	173	1
c1	Labrador tea-mesic jack pine-black spruce	19	<1
d1	low-bush cranberry aspen	734	3
d2	low-bush cranberry aspen-white spruce	478	2
d3	low-bush cranberry white spruce	250	1
e1	dogwood balsam poplar-aspen	6	<1
e2	dogwood balsam poplar-white spruce	121	1
e3	dogwood white spruce	45	<1
f1	horsetail balsam poplar-aspen	4	<1
f2	horsetail balsam poplar-white spruce	4	<1
f3	horsetail white spruce	7	<1
g1	Labrador tea-subhygric black spruce-jack pine	12	<1
h1	Labrador tea/horsetail white spruce-black spruce	118	1
	central mixedwood ecosite phase subtotal	*2,375*	*11*
Athabasca Plain Natural Subregion Ecosite Phases			
a1	bearberry jack pine	2,740	13
b1	Canada buffalo-berry-green alder jack pine-aspen-white birch	2,922	14
b2	Canada buffalo-berry-green alder aspen	2,151	10
b3	Canada buffalo-berry-green alder aspen-white spruce-black spruce	1,728	8
b4	Canada buffalo-berry-green alder white spruce-black spruce-jack pine	927	4
c1	Labrador tea-mesic jack pine-black spruce	60	<1
d1	Labrador tea-subhygric black spruce-jack pine	130	1

Table 1 Total Area and Percent Cover of Ecosite Phases and Wetlands Types Within the Pierre River Mining Area Local Study Area (continued)

Code	Description	Area	
		[ha]	% of LSA
e1	willow/horsetail aspen-white birch-balsam poplar	325	2
e2	willow/horsetail aspen-white spruce-black spruce	404	2
e3	willow/horsetail white spruce-black spruce	307	1
PJ-Lt Comp	jack pine-tamarack complex	3	<1
	Athabasca plain ecosite phase subtotal	*11,695*	*55*
Wetlands			
BFNN	forested bog	73	<1
BONS	shrubby bog	1	<1
BTNN	wooded bog	1,186	6
FONG	graminoid fen	702	3
FONS	shrubby fen	905	4
FOPN	open patterned fen	69	<1
FTNN	wooded fen	1,580	7
MONG	marsh	146	1
SONS	shrubby swamp	372	2
STNN	wooded swamp	517	2
WONN	shallow open water	57	<1
	wetlands subtotal	*5,609*	*27*
Miscellaneous Vegetation Types			
Me	meadow	7	<1
Sh	shrubland	87	<1
	miscellaneous vegetation types subtotal	*95*	*<1*
Non-Vegetation Types			
Lake	lake	84	<1
River	river	263	1
Sand	sand	41	<1
	non-vegetation types subtotal	*388*	*2*
Disturbances			
CC	cutblock	535	3
DIS	disturbance	439	2
	disturbances subtotal	*974*	5
Total		**21,136**	**100**

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 2 Total Area and Percent Cover of Ecosite Phases and Wetlands Types Within the Jackpine Expansion Mining Area Local Study Area excluding Jackpine Mine – Phase 1

Code	Description	Area [ha]	Area % of LSA
Central Mixedwood Natural Subregion Ecosite Phases			
a1	lichen jack pine	164	1
b1	blueberry jack pine-aspen	518	3
b2	blueberry aspen (white birch)	201	1
b3	blueberry aspen-white spruce	227	1
b4	blueberry white spruce-jack pine	80	<1
c1	Labrador tea-mesic jack pine-black spruce	59	<1
d1	low-bush cranberry aspen	484	3
d2	low-bush cranberry aspen-white spruce	239	1
d3	low-bush cranberry white spruce	90	<1
e1	dogwood balsam poplar-aspen	7	<1
e2	dogwood balsam poplar-white spruce	5	<1
e3	dogwood white spruce	4	<1
f3	horsetail white spruce	16	<1
g1	Labrador tea-subhygric black spruce-jack pine	72	<1
h1	Labrador tea/horsetail white spruce-black spruce	167	1
Pj-Lt Comp	jack pine-tamarack complex	14	<1
	central mixedwood ecosite phase subtotal	*2,346*	*13*
Wetlands			
BFNN	forested bog	<1	<1
BONN	open bog	61	<1
BTNI	wooded bog with internal lawns	714	4
BTNN	wooded bog	633	3
BTNR	wooded bog with raised islands of forested peat plateau	17	<1
BTXC	wooded bog with collapsed scars	89	<1
FFNN	forested fen	2	<1
FONG	graminoid fen	878	5
FONS	shrubby fen	2,477	13
FOPN	open patterned fen	792	4
FTNI	wooded fen with internal lawns	409	2
FTNN	wooded fen	3,453	19
FTPN	wooded patterned fen	415	2
SONS	shrubby swamp	744	4
STNN	wooded swamp	167	1
WONN	shallow open water	2	<1
	wetlands subtotal	*10,853*	*59*

Table 2 Total Area and Percent Cover of Ecosite Phases and Wetlands Types Within the Jackpine Expansion Mining Area Local Study Area (continued)

Code	Description	Area	
		[ha]	% of LSA
Miscellaneous Vegetation Types			
BUu	burn upland	1,126	6
BUw	burn wetlands[(a)]	1,903	10
Sh	shrubland	5	<1
	miscellaneous vegetation types subtotal	*3,034*	*17*
Non-Vegetation Types			
lake	lake	104	1
river	river	<1	<1
	non-vegetation types subtotal	*104*	*1*
Disturbances			
CC	cutblock	120	1
DIS	disturbance	1,891	10
	disturbances subtotal	*2,011*	*11*
Total		**18,348**	**100**

(a) The burn wetlands type is also considered to be a peatlands wetlands type.

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 3 Total Area and Percent Cover of Ecosite Phases and Wetlands Types Within the Jackpine Mine – Phase 1 Local Study Area

Code	Description	Area[(a)]	
		[ha]	% of LSA
Central Mixedwood Natural Subregion Ecosite Phases			
a1	lichen jack pine	87	1
b1	blueberry jack pine-aspen	298	3
b2	blueberry aspen (white birch)	318	3
b3	blueberry aspen-white spruce	62	1
b4	blueberry white spruce-jack pine	11	<1
c1	Labrador tea-mesic jack pine-black spruce	61	1
d1	low-bush cranberry aspen	526	5
d2	low-bush cranberry aspen-white spruce	1,951	17
d3	low-bush cranberry white spruce	455	4
e1	dogwood balsam poplar-aspen	274	2
e2	dogwood balsam poplar-white spruce	62	1
e3	dogwood white spruce	4	<1
f2	horsetail balsam poplar-white spruce	68	1
f3	horsetail white spruce	245	2
g1	Labrador tea-subhygric black spruce-jack pine	118	1
h1	Labrador tea/horsetail white spruce-black spruce	66	1
	central mixedwood ecosite phase subtotal	*4,606*	*41*

Table 3 Total Area and Percent Cover of Ecosite Phases and Wetlands Types Within the Jackpine Mine – Phase 1 Local Study Area (continued)

Code	Description	Area[(a)]	
		[ha]	% of LSA
Wetlands			
BTNN	wooded bog	157	1
FONG	graminoid fen	108	1
FONS	shrubby fen	245	2
FTNN	wooded fen	191	2
MONG	marsh	525	5
SONS	shrubby swamp	1,307	12
STNN	wooded swamp	439	4
WONN	shallow open water	22	<1
	wetlands subtotal	*2,994*	*27*
Miscellaneous Vegetation Types			
Me	meadow	1	<1
Sh	shrubland	359	3
	miscellaneous vegetation types subtotal	*360*	*3*
Non-Vegetation Types			
Lake	lake	2,110	19
River	river	19	<1
	non-vegetation types subtotal	*2,129*	*19*
Disturbances			
DIS	disturbance	1,067	10
	disturbances subtotal	*1,067*	10
Total		**11,156**	**100**

[(a)] The area of ecosite phases and wetlands types described are those presented at closure for the approved Jackpine Mine – Phase 1 (Shell 2002).

Landscape Heterogeneity in the Pierre River Mining Area Local Study Area

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The PRMA Local Study Area (LSA) consists of the Central Mixedwood (21%) and Athabasca Plains Natural Subregions (79%). Ecosite phases were correlated between natural subregions by comparing attributes including canopy cover, species, composition, and moisture and nutrient regimes (Table 4). All Central Mixedwood ecosite phases were classified according to Athabasca Plain ecosite phases for the heterogeneity and fragmentation analyses.

PAGE CORRECTED FOR ERRATA

Table 4 Correlation of Ecosite Phases within the Central Mixedwood and Athabasca Plain Natural Subregions

Central Mixedwood Ecosite Phase		Athabasca Plain Ecosite Phase	
Code	**Name**	**Code**	**Name**
a1	lichen jack pine	a1	bearberry jack pine
b1	blueberry jack pine-aspen	b1	Canada buffalo-berry-green alder jack pine-aspen-white birch
b2	blueberry aspen (white birch)	b2	Canada buffalo-berry-green alder aspen
b3	blueberry aspen-white spruce	b3	Canada buffalo-berry-green alder aspen-white spruce-black spruce
b4	blueberry white spruce-jack pine	b4	Canada buffalo-berry-green alder white spruce-black spruce-jack pine
c1	Labrador tea-mesic jack pine-black spruce	c1	Labrador tea-mesic jack pine-black spruce
d1	low-bush cranberry aspen	b2	Canada buffalo-berry-green alder aspen
d2	low-bush cranberry aspen-white spruce	b3	Canada buffalo-berry-green alder aspen-white spruce-black spruce
d3	low-bush cranberry white spruce	b4	Canada buffalo-berry-green alder white spruce-black spruce-jack pine
e1	dogwood balsam poplar-aspen	e1	willow/horsetail aspen-white birch-balsam poplar
e2	dogwood balsam poplar-white spruce	e2	willow/horsetail aspen-white spruce-black spruce
e3	dogwood white spruce	e3	willow/horsetail white spruce-black spruce
f1	horsetail balsam poplar-aspen	e1	willow/horsetail aspen-white birch-balsam poplar
f2	horsetail balsam poplar-white spruce	e2	willow/horsetail aspen-white spruce-black spruce
f3	horsetail white spruce	e3	willow/horsetail white spruce-black spruce
g1	Labrador tea-subhygric black spruce-jack pine	d1	Labrador tea-subhygric black spruce-jack pine
h1	Labrador tea/horsetail white spruce-black spruce	e2	willow/horsetail aspen-white spruce-black spruce

Change in landscape heterogeneity in the PRMA LSA due to the Project is measured by changes in the number and distribution of patch types (i.e., ecosite phases, wetlands types and disturbed areas). Change in patch richness and Shannon's Evenness Index in the PRMA LSA is presented in Table 5 and is summarized below:

- No net decrease in patch richness will occur in the PRMA LSA as a result of the Project because the loss of jack pine-tamarack complex (Pj-Lt Comp) and shrubby bog (BONS) ecosite phases and wetlands types is offset by the gain of two shrubland types (i.e., shrubland 2 and shrubland 3).
- At closure, evenness (0.81) will be the same as at Base Case (0.80), because the site reclamation plan aims to incorporate different upland vegetation types in conjunction with open water habitats that will be relatively evenly distributed throughout the LSA.

Table 5 Patch Richness and Shannon's Evenness Index in the Pierre River Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Base Case	Closure	Net Change Due to Project[(a)]	
				Change in Parameter	[%]
patch richness (PR)	n/a	29	29	0	0
Shannon's Evenness Index (SHEI)	n/a	0.80	0.81	-0.22	-28

(a) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

n/a = Not applicable.

Distribution of Cover Classes

Changes in the distribution of terrestrial, wetlands, water and disturbed classes (Table 6) illustrate the effects of the Project on general landscape patterns in the PRMA LSA. Changes in the abundance of individual ecosite phases, wetlands types and disturbed areas are provided in Table 7 and are summarized below:

- Terrestrial areas will increase 17% from Base Case (14,205 ha) to closure (16,602 ha), as a result of increases in the Labrador tea-mesic jack pine-black spruce (c1), Labrador tea-subhygric black spruce-jack pine (d1), willow/horsetail white spruce-black spruce (e3) and two shrubland ecosite phases. In comparison, terrestrial areas in the RSA increase by only 1% from Base Case to closure.
- The Canada buffalo-berry-green alder aspen-white spruce-black spruce (b3) ecosite phase shows the greatest decrease in total area, 1,445 ha, which is a 63% decline from Base Case conditions.
- The majority of terrestrial ecosite phases will be less abundant on the landscape at closure than at Base Case, with all of the jack pine-tamarack complex (Pj-Lt Comp) (3 ha), and 77% of the d1 ecosite phases removed.
- Wetlands will decrease by 5,609 ha from Base Case (67%) to closure (1,846 ha) with the largest decrease in area occurring in the wooded fen (FTNN; -1,170 ha) and wooded bog (BTNN; -858 ha) wetlands types. In comparison, the amount of wetlands decreases by only 1% in the RSA from Base Case to closure.
- One wetlands type, shrubby bog (BONS), will be completely removed (1 ha) from the PRMA LSA and cannot be reclaimed.
- At closure, open water will increase by 2,112 ha (608%) compared to Base Case due to the addition of pit lakes to the landscape. In comparison, open water in the RSA increases by a much smaller percentage (12%) from Base Case to closure.

- Disturbed areas will decrease by 974 ha (77%) from Base Case to closure (228 ha) primarily due to the reclamation of Base Case disturbance with terrestrial vegetation and the creation of large lakes. In comparison, disturbed areas decreases by only 1% in the RSA from Base Case to closure.

Table 6 Class Area of Cover Categories in the Pierre River Mining Area Local Study Area – Application Case

Cover Category	Base Case [ha]	Loss/Alteration Due to Project[a]		Closure [ha]	Net Change Due to Project[b]	
		[ha]	[%]		[ha]	[%]
terrestrial	14,205	-5,819	-41	16,602	2,397	17
wetlands	5,609	-3,774	-67	1,846	-3,763	-67
water	347	-62	-18	2,459	2,112	608
disturbed[c]	974	-746	-77	228	-746	-77
Total	**21,136**	**-10,403[d]**	**-49**	**21,136**	**0**	**0**

(a) These columns are calculated as the net loss/alteration in each cover category including the increase in disturbance during operations.

(b) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(c) This category includes burns, cutblocks, industrial and other human disturbances within the LSAs.

(d) This is the PRMA development area.

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 7 Class Area for Ecosite Phases, Wetlands Types and Other Areas in the Pierre River Mining Area Local Study Area – Application Case

Ecosite Phase/ Wetlands Type/Other[a]	Base Case [ha]	Loss/Alteration Due to Project[b]		Closure [ha]	Net Change Due to Project[c]	
		[ha]	[%]		[ha]	[%]
Ecosite Phase						
a1	2,756	-718	-26	2,304	-451	-16
b1	3,164	-1,037	-33	2,132	-1,032	-33
b2	2,928	-1,237	-42	2,588	-340	-12
b3	2,309	-1,445	-63	1,352	-957	-41
b4	1,350	-661	-49	693	-658	-49
c1	79	-40	-51	1,867	1,789	2,275
d1	142	-109	-77	3,048	2,906	2,051
e1	335	-40	-12	295	-40	-12
e2	647	-373	-58	431	-215	-33
e3	358	-150	-42	743	385	108
meadow	7	-1	-17	6	-1	-17
Pj-Lt Complex	3	-3	-100	0	-3	-100
sand	41	-5	-12	36	-5	-12
shrubland	87	0	0	87	0	0
shrubland 2	0	0	0	355	100	100

Table 7 Class Area for Ecosite Phases, Wetlands Types and Other Areas in the Pierre River Mining Area Local Study Area – Application Case (continued)

Ecosite Phase/ Wetlands Type/Other[(a)]	Base Case [ha]	Loss/Alteration Due to Project[(b)]		Closure [ha]	Net Change Due to Project[(c)]	
		[ha]	[%]		[ha]	[%]
shrubland 3	0	0	0	665	100	100
subtotal	*14,205*	*-5,820*	*-41*	*16,602*	*1,577*	*11*
Wetlands Type						
BFNN	73	-45	-61	28	-45	-61
BONS	1	-1	-100	0	-1	-100
BTNN	1,186	-858	-72	340	-847	-71
FONG	702	-642	-92	60	-642	-92
FONS	905	-569	-63	336	-569	-63
FOPN	69	-57	-81	13	-57	-81
FTNN	1,580	-1,170	-74	410	-1,170	-74
MONG	146	-99	-67	48	-99	-67
SONS	372	-154	-41	218	-154	-41
STNN	517	-143	-28	374	-143	-28
WONN	57	-37	-65	20	-37	-65
subtotal	5,609	-3,774	-67	1,846	-3,763	-67
Water						
lake	84	-50	-59	1,955	1,871	2,214
river	263	-13	-5	504	241	92
subtotal	*347*	*-63*	*-18*	*2,459*	*2,112*	*608*
Disturbed						
cutblock	535	-475	-89	60	-475	-89
other disturbances[(d)]	439	-271	-62	168	-271	-62
subtotal	*974*	*9,656*	*991*	*228*	*-746*	*-77*
Total	**21,136**	**-10,403[(e)]**	**-49**	**21,136**	**0**	**0**

(a) Full names of vegetation types are provided in Table 1.

(b) These columns are calculated as the net loss/alteration in each vegetation type including the increase in disturbance during operations.

(c) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(d) This category includes burns, cutblocks, industrial and other human disturbances within the LSAs.

(e) This is the PRMA development area.

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

Median Patch Size

Median patch size is the midpoint in rank order of size distribution for patches of a particular patch type. Since the distribution of patch sizes in the data is skewed towards smaller patches, the median is a more accurate estimate of typical patch size. Changes in the median patch size of individual ecosite phases, wetlands types and disturbed areas (Table 8) illustrate the effects of the Project on the size distribution of habitat patches in the LSA and are summarized below:

- At closure, median patch size of terrestrial ecosite phases will generally increase, with the exception of the Canada buffalo-berry-green alder jack pine-aspen-white birch (b1), Canada buffalo-berry green alder white spruce-black spruce-jack pine (b4), willow/horsetail aspen-white birch-balsam poplar (e1), willow/horsetail aspen-white spruce-black spruce (e2) and jack pine-tamarack complex (Pj-Lt Comp) ecosite phases. The shrubland 3 ecosite phase will have the largest median patch size at closure, 81.1 ha. The largest proportional increase, 3,398%, will occur in the Labrador tea-subhygric black spruce-jack pine (d1) ecosite phase, which will increase from a median patch size of 1.8 ha at Base Case to 44.1 ha at closure. A general increase in median patch size is predicted for terrestrial ecosite phases at closure because the landscape will contain fewer human-caused disturbances compared to Base Case conditions and because many wetlands types are reclaimed as terrestrial ecosite phases.
- At closure, median patch size of wetlands types will generally decrease because many wetlands types (i.e., fens) cannot be reclaimed and others (e.g., MONG) are not reclaimed.
- The creation of pit lakes and other open water areas results in an 89% increase in median patch size of lakes from 1.8 ha at Base Case to 3.3 ha at closure.

Table 8 Median Patch Size of Ecosite Phases, Wetlands Types and Other Areas in the Pierre River Mining Area Local Study Area – Application Case

Ecosite Phase/ Wetlands Type/Other[a]	Base Case [ha]	Loss/Alteration Due to Project[b]		Closure [ha]	Net Change Due to Project[c]	
		[ha]	[%]		[ha]	[%]
Ecosite Phase						
a1	2.2	0.2	7	2.4	0.2	7
b1	3.4	-0.8	-23	2.7	-0.8	-22
b2	1.7	0.0	2	2.0	0.3	16
b3	1.6	-0.3	-20	1.8	0.1	8
b4	2.0	-0.5	-22	1.6	-0.4	-22
c1	1.5	1.6	105	13.7	12.2	813
d1	1.8	1.1	64	44.1	42.3	2,398
e1	3.8	-1.5	-39	2.8	-1.0	-26
e2	1.9	-0.3	-14	1.8	-0.2	-9
e3	1.8	0.4	20	2.7	0.9	48
meadow	1.0	0.0	0	1.0	0.0	0
Pj-Lt Complex	1.6	-1.6	-100	0.0	-1.6	-100
sand	1.8	0.1	7	1.9	0.1	7
shrubland	1.7	0.0	0	1.7	0.0	0
shrubland 2	0	0	0	19.6	19.6	100
shrubland 3	0	0	0	81.1	81.1	100

Table 8 Median Patch Size of Ecosite Phases, Wetlands Types and Other Areas in the Pierre River Mining Area Local Study Area – Application Case (continued)

Ecosite Phase/ Wetlands Type/Other[(a)]	Base Case [ha]	Loss/Alteration Due to Project[(b)]		Closure [ha]	Net Change Due to Project[(c)]	
		[ha]	[%]		[ha]	[%]
Wetlands Type						
BFNN	2.7	-1.8	-69	0.8	-1.8	-69
BONS	0.4	-0.4	-100	0.0	-0.4	-100
BTNN	1.5	-0.4	-28	1.1	-0.3	-23
FONG	1.2	-0.5	-39	0.7	-0.5	-39
FONS	1.5	0.0	-2	1.5	0.0	-2
FOPN	34.7	-31.7	-91	3.0	-31.7	-91
FTNN	2.2	-0.5	-21	1.6	-0.6	-26
MONG	1.5	-1.0	-68	0.5	-1.0	-68
SONS	1.8	-0.3	-14	1.5	-0.3	-14
STNN	1.8	-0.6	-34	1.2	-0.6	-34
WONN	1.8	1.1	64	2.9	1.1	64
Water						
lake	1.8	-0.3	-16	3.3	1.6	89
river	<1.0	0.0	0	<1.0	0.0	0
Disturbed						
cutblock	0.9	0.2	23	1.1	0.2	23
other disturbances[(d)]	0.2	0.0	0	0.2	0.0	0

(a) Full names of vegetation types are provided in Table 1.

(b) These columns are calculated as the net loss/alteration in each vegetation type.

(c) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(d) This category includes industrial and other human disturbances within the LSA.

Landscape Heterogeneity in the Jackpine Expansion Mining Area Local Study Area

Change in landscape heterogeneity in the JEMA LSA due to the Project is measured by changes in the number and distribution of patch types (i.e., ecosite phases, wetlands types and disturbed areas). Change in patch richness and Shannon's Evenness Index in the JEMA LSA is presented in Table 9 and is summarized below:

- A net decrease in patch richness will occur in the JEMA LSA due to the Project because loss of some wetlands types (e.g., forested bog [BFNN], wooded permafrost bog with collapse scar [BTXC], forested fen [FFNN] and wooded patterned fen [FTPN]) are not compensated for by the addition of some terrestrial types (e.g., two shrubland types).
- The Shannon's Evenness Index decreases from 0.82 at Base Case to 0.73 at closure. The patch types in the closure landscape are different (i.e., change in patch richness) and are also less evenly distributed than at Base Case.

Table 9 Patch Richness and Shannon's Evenness Index in the Jackpine Expansion Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Base Case	Closure	Net Change Due to Project[a]	
				Change in Parameter	[%]
patch richness (PR)	n/a	42	39	-3	-7
Shannon's Evenness Index (SHEI)	n/a	0.82	0.73	-0.09	-10.98

(a) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

n/a = Not applicable.

Distribution of Cover Classes

Changes in the distribution of terrestrial, wetlands, water and disturbed classes (Table 10) illustrate the effects of the Project on general landscape patterns in the JEMA LSA. Changes in the abundance of individual ecosite phases, wetlands types and disturbed areas are provided in Table 11 and are summarized below:

- Terrestrial areas will increase 149% from Base Case (7,316 ha) to closure (18,243 ha), mostly because of increases in the Labrador tea-mesic jack pine-black spruce (c1) and Labrador tea-subhygric black spruce-jack pine (g1) ecosite phases. In comparison, terrestrial areas in the RSA increase by only 1% from Base Case to closure.
- The low-bush cranberry aspen-white spruce (d2) ecosite phase shows the greatest decrease in total area (966 ha), which is a 44% decline from Base Case conditions.
- Eleven terrestrial ecosite phases will be less abundant on the landscape at closure compared to Base Case and eight will be more abundant or remain unchanged. The overall abundance of terrestrial ecosite phases increases in the closure landscape due to the use of these types for reclamation.
- Wetlands will decrease by 74% from Base Case (13,846 ha) to closure (3,563 ha), with the largest decrease in area occurring in the wooded fen (FTNN) (3,322 ha) and shrubby fen (FONS) (2,298 ha) wetlands types. In comparison, the amount of wetlands decreases by only 1% in the RSA from Base Case to closure.
- Four wetlands types (forested bog [BFNN], wooded permafrost bogs with collapse scars [BTXC], forested fen [FFNN] and wooded patterned fen [FTPN]) will be completely removed from the LSA and cannot be reclaimed. Although these four types comprised less than 2% of the JEMA LSA, they are very rare in the RSA (Golder 2007). Only 2 ha of marshes (MONG) will remain in the closure LSA, a decrease of more than 99%. Although not as rare as some of the peatlands wetlands types, marshes are also relatively rare in the Oil Sands Region (Golder 2007).

- At closure, open water will increase by 2,700 ha (121%), due to the addition of pit lakes. In comparison, open water in the RSA increases by a much smaller percentage (12%) from Base Case to closure.
- Disturbed areas will decrease by 6,107 ha (55%) from Base Case to closure (2,764 ha) primarily due to the reclamation of baseline disturbance with terrestrial vegetation and the creation of large lakes. In comparison, disturbed areas decreases by only 1% in the RSA from Base Case to closure.

Table 10 Class Area of Cover Categories in the Jackpine Expansion Mining Area Local Study Area – Application Case

Cover Category	Base Case [ha]	Loss/ Alteration Due to Project[(a)]		Closure [ha]	Net Change Due to Project[(b)]	
		[ha]	[%]		[ha]	[%]
terrestrial	7,316	-6,073	-83	18,243	10,927	149
wetlands	13,846	-11,258	-81	3,563	-10,283	-74
water	2,234	-1,417	-63	4,934	2,700	121
disturbed[(c)]	6,107	-3,344	-55	2,764	-3,344	-55
Total	**29,503**	**22,092[(d)]**	**75**	**29,503**	**0**	**0**
Jackpine Mine – Phase 1	11,156	-11,156	-70	11,156	0	0
Application Case[(e)]	**18,347**	**-10,936**	**-78**	**18,347**	**0**	**0**

(a) These columns are calculated as the net loss/alteration in each cover category including the increase in disturbance during operations.

(b) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(c) This category includes burns, cutblocks, industrial and other human disturbances within the LSAs.

(d) This is the JEMA development area.

(e) The Jackpine Mine – Phase 1 area has been previously approved. It has been presented as the total LSA area to show the changes brought about by the integration of the Jackpine Mine – Phase 1 and Jackpine Mine Expansion Closure Plans.

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 11 Class Area for Ecosite Phases, Wetlands Types and Other Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case

Ecosite Phase/ Wetlands Type/Other[(a)]	Base Case [ha]	Loss/Alteration Due to Project[(b)]		Closure [ha]	Net Change Due to Project[(c)]	
		[ha]	[%]		[ha]	[%]
Ecosite Phase						
a1	251	-158	-63	875	624	249
b1	817	-609	-75	428	-388	-48
b2	519	-435	-84	84	-435	-84
b3	289	-195	-68	94	-195	-68

Table 11 Class Area for Ecosite Phases, Wetlands Types and Other Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case (continued)

Ecosite Phase/ Wetlands Type/Other[a]	Base Case [ha]	Loss/Alteration Due to Project[b]		Closure [ha]	Net Change Due to Project[c]	
		[ha]	[%]		[ha]	[%]
b4	91	-50	-55	614	523	575
c1	120	-113	-94	1,831	1,711	1,423
d1	1,010	-834	-83	1,796	785	78
d2	2,190	-1,925	-88	1,224	-966	-44
d3	545	-453	-83	477	-68	-12
e1	281	-261	-93	19	-261	-93
e2	67	-37	-55	30	-37	-55
e3	8	-1	-9	7	-1	-9
f2	68	-68	-100	256	188	278
f3	260	-260	-100	919	659	253
g1	190	-148	-78	6,963	6,773	3,563
h1	233	-151	-65	183	-49	-21
meadow	1	0	0	1	0	0
shrubland	364	-360	-99	4	-360	-99
shrubland 2	0	0	0	556	556	100
shrubland 3	0	0	0	1,882	1,882	100
Pj-Lt complex	14	-14	-100	0	-14	-100
subtotal	*7,316*	*-6,073*	*-83*	*18,243*	*10,927*	*149*
Wetlands Type						
BFNN	<1	0	-100	0	0	-100
BONN	61	-53	-86	9	-53	-86
BTNI	714	-490	-69	224	-490	-69
BTNN	789	-616	-78	174	-616	-78
BTNR	17	0	0	17	0	0
BTXC	89	-89	-100	0	-89	-100
FFNN	2	-2	-100	0	-2	-100
FONG	986	-806	-82	181	-806	-82
FONS	2,722	-2,298	-84	424	-2,298	-84
FOPN	792	-114	-14	677	-114	-14
FTNI	409	-405	-99	3	-405	-99
FTNN	3,644	-3,322	-91	322	-3,322	-91
FTPN	415	-415	-100	0	-415	-100
MONG	525	-523	-100	2	-523	-99
SONS	2,052	-1,591	-78	460	-1,591	-78

Table 11 Class Area for Ecosite Phases, Wetlands Types and Other Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case (continued)

Ecosite Phase/ Wetlands Type/Other[(a)]	Base Case [ha]	Loss/Alteration Due to Project[(b)]		Closure [ha]	Net Change Due to Project[(c)]	
		[ha]	[%]		[ha]	[%]
STNN	605	-511	-84	95	-511	-84
WONN	24	-23	-96	976	952	3,986
subtotal	*13,846*	*-11,258*	*-81*	*3,563*	*-10,283*	*-74*
Water						
lake	2,215	-1,400	-63	4,932	2,717	123
river	19	-17	-91	2	-17	-91
subtotal	*2,234*	*-1,417*	*-63*	*4,934*	*2,700*	*121*
Disturbed						
burned uplands	1,126	-991	-88	135	-991	-88
burned wetlands	1,903	-1,879	-99	24	-1,879	-99
cutblock	120	-56	-47	63	-56	-47
other disturbances[(d)]	2,959	21,675	733	2,542	-417	-14
subtotal	*6,107*	*18,748*	*307*	*2,764*	*-3,344*	*-55*
Total	**29,503**	**22,092**[(e)]	**75**	**29,503**	**0**	**0**
Jackpine Mine – Phase 1	11,156	-11,156	-70	11,156	0	0
Application Case[(f)]	**18,347**	**-10,936**	**78**	**18,347**	**0**	**0**

(a) Full names of vegetation types are provided in Table 2.

(b) These columns are calculated as the net loss/alteration in each vegetation type including the increase in disturbance during operations.

(c) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(d) This category includes burns, cutblocks, industrial and other human disturbances within the LSAs.

(e) This is the JEMA development area.

(f) The Jackpine Mine – Phase 1 area has been previously approved. It has been presented as the total LSA area to show the changes brought about by the integration of the Jackpine Mine – Phase 1 and Jackpine Expansion Mining Area Closure Plans.

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

Median Patch Size

Median patch size is the midpoint in rank order of size distribution for patches of a particular patch type. Since the distribution of patch sizes in the data is skewed towards smaller patches, the median is a more accurate estimate of typical patch size. Changes in the median patch size of individual ecosite phases, wetlands types and disturbed areas (Table 12) illustrate the effects of the Project on the size distribution of habitat patches in the LSA and are summarized below:

- The median patch size of five terrestrial ecosite phases (Labrador tea-mesic jack pine-black spruce [c1], low bush cranberry aspen [d1], horsetail balsam poplar-white spruce [f2], horsetail white spruce [f3] and Labrador tea-subhygric black spruce-jack pine [g1]) will increase at closure. The shrubland 2 vegetation type will have the largest median patch size at closure (277.8 ha). The largest proportional increase (3,391%) will occur in the c1 ecosite phase, which will increase from a median patch size of 1.4 ha at Base Case to 48.3 ha at closure. A general increase in median patch size is predicted for terrestrial ecosite phases that are added at the reclamation stage because the landscape will contain fewer human disturbances compared to Base Case conditions and the reclamation planting prescriptions, which are primarily terrestrial types, will be planted in larger, contiguous patches.
- At closure, median patch size of wetlands types will generally decreases because many wetlands types cannot be reclaimed if the soil is disturbed (i.e., fens and bogs) and others (e.g., marshes [MONG]) are not reclaimed. The shallow open water (WONN) wetlands type experiences a large increase in median patch size, from 3.6 ha at Base Case to 79.4 ha at closure, due to the addition of littoral zones in the closure landscape.
- The creation of reclamation pit lakes results in a 2,886% increase in median patch size of lakes from 7.8 ha at Base Case to 232.6 ha at closure.

Table 12 Median Patch Size of Ecosite Phases, Wetlands Types and Other Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case

Ecosite Phase/Wetlands Type/ Other[a]	Base Case [ha]	Loss/Alteration Due to Project[b]		Closure [ha]	Net Change Due to Project[c]	
		[ha]	[%]		[ha]	[%]
Ecosite Phase						
a1	1.3	-0.7	-56	1.0	-0.3	-20
b1	2.0	-0.6	-31	1.6	-0.4	-21
b2	4.5	-3.8	-85	0.7	-3.8	-85
b3	1.3	-0.6	-47	0.7	-0.6	-47
b4	1.6	-0.7	-46	1.6	0.0	-1
c1	1.4	-1.2	-85	48.3	46.9	3,391
d1	0.9	-0.2	-17	1.0	0.1	10
d2	1.3	-0.3	-23	1.2	-0.1	-8
d3	2.2	-0.6	-27	2.1	-0.1	-5
e1	1.5	-1.1	-74	0.4	-1.1	-74
e2	0.8	-0.2	-18	0.7	-0.2	-18
e3	1.8	0.0	0	1.8	0.0	0
f2	67.6	-67.6	-100	83.0	15.4	23
f3	4.6	-4.6	-100	145.4	140.8	3065
g1	1.1	-0.2	-21	3.4	2.3	216
h1	1.6	-0.9	-54	0.8	-0.8	-50

Table 12 Median Patch Size of Ecosite Phases, Wetlands Types and Other Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case (continued)

Ecosite Phase/Wetlands Type/ Other[(a)]	Base Case [ha]	Loss/Alteration Due to Project[(b)]		Closure [ha]	Net Change Due to Project[(c)]	
		[ha]	[%]		[ha]	[%]
meadow	0.5	0.0	0	0.5	0.0	0
Pj-Lt complex	14.1	-14.1	-100	0.0	-14.1	-100
shrubland	0.9	-0.5	-54	0.4	-0.5	-54
shrubland 2	0	0	0	277.8	277.8	100
shrubland 3	0	0	0	0.3	0.3	100
Wetlands Type						
BFNN	<1	0.0	-100	0.0	0.0	-100
BONN	1.7	6.9	408	8.6	6.9	408
BTNI	2.4	-1.2	-48	1.3	-1.2	-48
BTNN	0.9	-0.4	-43	0.5	-0.4	-43
BTNR	2.6	0.0	0	2.6	0.0	0
BTXC	0.3	-0.3	-100	0.0	-0.3	-100
FFNN	1.7	-1.7	-100	0.0	-1.7	-100
FONG	1.1	-0.6	-49	0.6	-0.6	-49
FONS	1.1	-0.4	-39	0.7	-0.4	-39
FOPN	5.8	16.0	275	21.8	16.0	275
FTNI	1.5	0.2	10	1.6	0.2	10
FTNN	1.4	-0.6	-42	0.8	-0.6	-41
FTPN	4.2	-4.2	-100	0.0	-4.2	-100
MONG	27.3	-25.4	-93	2.0	-25.4	-93
SONS	2.8	-2.0	-73	0.7	-2.0	-73
STNN	2.6	-2.2	-85	0.4	-2.2	-85
WONN	3.6	-2.7	-75	79.4	75.8	2103
Water						
lake	7.8	131.1	1682	232.6	224.8	2886
river	1.2	-1.0	-82	0.2	-1.0	-82
Disturbed						
burned uplands	2.4	-2.1	-86	0.3	-2.1	-86
burned wetlands	1.5	-1.2	-81	0.3	-1.2	-81
cutblock	33.6	29.5	88	63.1	29.5	88
other disturbances[(d)]	0.2	0.0	0	0.2	0.0	0

(a) Full names of vegetation types are provided in Table 2.

(b) These columns are calculated as the net loss/alteration in each vegetation type.

(c) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(d) This category includes industrial and other human disturbances within the LSA.

Landscape Fragmentation in the Pierre River Mining Area Local Study Area

Natural and Human Disturbed Areas

Ecosite phases, wetlands types and disturbed areas are grouped into natural and human disturbed areas to examine fragmentation of natural patches by disturbance. The ‘natural’ category includes all ecological land cover classes for the PRMA LSA and the ‘human disturbed’ category includes all cutblocks, agricultural areas, and urban (e.g., municipalities and roads) and industrial (e.g., mines, seismic lines, wellpads and pipelines) developments. Landscape metrics are used to analyze the number and size of natural areas in the PRMA LSA (Table 13). A summary of the results is provided below:

- The natural class area will increase 4% from Base Case to closure as all of the existing disturbed areas within the development area will be reclaimed.
- The number of natural patches will decrease by 95%, from 148 patches at Base Case to 8 patches at closure because the reclaimed areas consist of larger patches. Median patch size will increase by 336% at closure because there will be less fragmentation in the reclaimed landscape. Natural patch size will be less variable at closure, a decrease of 42%. Thus, the closure landscape consists of fewer, but larger, natural areas compared to the Base Case landscape.
- Core area index-weighted mean for natural patches will increase 20%, from 74% at Base Case, to 89% at closure because disturbances will be reclaimed in the closure landscape.
- Total edge will decrease 71%, from 600 km at Base Case to 177 km at closure, indicating a reduction in the fragmentation of the landscape.

Table 13 Natural and Human Disturbed Areas in the Pierre River Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Class	Base Case	Loss/ Alteration Due to Project	Closure	Net Change Due to Project[(a)]	
						Change in Parameter	[%]
class area	ha	natural	20,162	-9,656	20,908	746	4
		human disturbed	974	9,656	228	-746	-77
number of patches	n/a	natural	148	-69	8	-140	-95
		human disturbed	170	-126	98	-72	-42
median patch size	ha	natural	2	6	11	8	336
		human disturbed	0.2	0.0	0.3	0.0	7
patch size coefficient of variation	%	natural	452.5	-226.0	261.3	-191.2	-42
		human disturbed	1,022	-371	253	-769	-75
core area index area weighted median[(b)]	%	natural	74	-5	89	15	20
		human disturbed	n/a	n/a	n/a	n/a	n/a
total edge	km	both areas	600	-233	177	-423	-71

(a) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(b) Core area was calculated using a 100-m buffer inside perimeter of natural areas.

n/a = Not applicable.

Forested and Non-Forested Areas

Ecosite phases and wetlands types are grouped into forested and non-forested areas to examine fragmentation of forested patches. The ‘forested’ category includes all habitats with treed vegetation and the ‘non-forested’ category includes all naturally occurring non-treed habitats, including water and burns. Landscape metrics are used to analyze the size and proximity of forested areas in the PRMA LSA (Table 14). A summary of the results is provided below:

- Forested areas will decrease 5%, from 17,442 ha at Base Case to 16,606 ha at closure, because previously forested areas will be converted to shrubland and pit lakes during reclamation.
- Non-forested areas will increase 58%, from 2,720 ha at Base Case to 4,302 ha at closure, because of the addition of large pit lakes during reclamation.
- The median patch size of forested areas will increase 51%, from 1.5 ha at Base Case to 2.3 ha at closure. Median distance between forested patches will also increase from 8.9 m at Base Case to 57.4 m at closure. Thus, the closure landscape will consist of fewer, but larger patches of forest that are farther apart compared to the Base Case landscape.
- The median patch size of non-forested areas will decrease only slightly between Base Case and closure from 1.1 ha at Base Case to 1.0 ha at

closure, but there is 58% more variability in non-forested patch size at closure. Median distance between non-forested patches will increase greatly from 13.5 m at Base Case to 50.6 m at closure. Thus, the closure landscape will consist of non-forested patches that are more variable in size and farther apart compared to the Base Case landscape.

- Core area index-weighted mean of forested areas will increase 14%, from 58% at Base Case to 66% at closure, despite a large increase in median patch size. This indicates that forest patches at closure are highly complex in shape, in part due to the planting of shrublands along a network of drainage channels. Core area index-weighted mean of non-forested areas will increase 182%, from 17% at Base Case to 49% at closure, in part due to the creation of pit lakes, which are relatively large and simple in shape.

Table 14 Forested and Non-Forested Areas in the Pierre River Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Class	Base Case	Loss/ Alteration Due to Project	Closure	Net Change Due to Project[a]	
						Change in Parameter	[%]
class area	ha	forested	17,442	-8,044	16,606	-836	-5
		non-forested	2,720	-1,612	4,302	1,582	58
median patch size	ha	forested	1.5	1.7	2.3	0.8	51
		non-forested	1.1	-0.1	1.1	0.0	2
patch size coefficient of variation	%	forested	521	-233	598	76	15
		non-forested	493	-211	778	285	58
median nearest neighbour	m	forested	8.9	12.6	57.4	48.4	541
		non-forested	13.5	33.1	50.6	37.1	274
core area index area weighted median[b]	%	forested	58	1	66	8	14
		non-forested	17	-7	49	32	182

(a) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(b) Core area was calculated using a 100-m buffer inside perimeter of forested and non-forested areas.

Riparian Areas

Ecosite phases and wetlands types are grouped into riparian areas to examine fragmentation of riparian communities. All potential riparian habitat within 100 m of a watercourse with a patch area greater than 0.1 ha was included in this analysis. Landscape metrics are used to analyze the size and proximity of riparian areas in the PRMA LSA (Table 15). A summary of the results is provided below:

- Riparian areas will increase 13%, from 1,721 ha at Base Case to 1,948 ha at closure, because riparian areas will be reclaimed using shrubland vegetation types that have riparian potential.
- The median patch size of riparian areas will increase 15%, from 2.2 ha at Base Case to 2.5 ha at closure, and patch size variability will decrease by 53%. Riparian patches will be farther apart, increasing in median nearest neighbour distance from 14.4 m at Base Case to 41.2 m at closure.

Table 15 Riparian Areas in the Pierre River Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Base Case	Loss/Alteration Due to Project	Closure	Net Change Due to Project[a]	
					Change in Parameter	[%]
class area	ha	1,721	-1,026	1,948	227	13
median patch size	ha	2.2	-0.4	2.5	0.3	15
patch size coefficient of variation	%	736	-566	345	-391	-53
median nearest neighbour	m	14.4	226.1	41.2	26.8	186

(a) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

Old Growth Forest

Landscape metrics are used to analyze the size and proximity of old growth forest in the PRMA LSA to examine the fragmentation of old growth forests due to the Project (Table 16). Forests will not become old growth within the 80-year closure time frame because it takes between 100 to 140 years for forest to become old growth; therefore, the values for the Application Case are carried through to closure. A summary of the results is provided below:

- Old growth forest will decrease 34%, from 2,088 ha at Base Case to 1,378 ha at closure, as old growth forest lost during construction and operation of the Project will not return by closure.
- The median patch size of old growth forest will increase 7%, from 2.7 to 2.8 ha, and patches will be farther apart, increasing median nearest neighbour distance from 31.2 to 43.1 m.
- The predicted increases in old growth forest median patch size are artifacts of the loss of smaller patches in the development area and the retention of larger, more distal patches within the buffer area.

Table 16 Old Growth Forest in the Pierre River Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Base Case	Loss/Alteration Due to Project	Closure[(a)]	Net Change Due to Project[(b)]	
					Change in Parameter	[%]
class area	ha	2,088	-710	1,378	-710	-34
median patch size	ha	2.7	0	2.8	0.2	7
patch size coefficient of variation	%	271	-43	229	-43	-16
median nearest neighbour	m	31.2	12	43.1	11.8	38

(a) Forests will not become old growth by closure so the values for the Application Case are carried through to closure.

(b) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

Landscape Fragmentation in the Jackpine Expansion Mining Area Local Study Area

Natural and Human Disturbed Areas

Ecosite phases, wetlands types and disturbed areas were grouped into natural and human disturbed areas to examine fragmentation of natural patches by disturbance. The ‘natural’ category includes all ecological land cover classes for the JEMA LSA and the ‘human disturbed’ category includes all cutblocks, agricultural areas, and urban (e.g., municipalities and roads) and industrial (e.g., mines, seismic lines, wellpads and pipelines) developments. Landscape metrics were used to analyze the number and size of natural areas in the JEMA LSA (Table 17). A summary of the results is provided below:

- The natural class area will increase 473 ha (2%) from Base Case to closure as all of the existing disturbed areas within the mine area will be reclaimed.
- The number natural patches decrease by 60%, from 215 patches at Base Case to 85 patches at closure because the reclaimed areas consist of larger patches. Median patch size will decrease by 80% at closure because there will be less fragmentation in the reclaimed landscape. Natural patch size will be more variable at closure, an increase of 44%. Thus, the closure landscape consists of fewer, but larger natural areas compared to the Base Case landscape.
- Core area index-weighted mean for natural patches will increase 32%, from 69% at Base Case to 91% at closure because disturbances will be reclaimed in the closure landscape.
- Total edge will decrease 71%, from 962 km at Base Case to 274 km at closure, indicating a reduction in the fragmentation of the landscape.

Table 17 Natural and Human Disturbed Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Category	Base Case	Loss/ Alteration Due to Project	Closure	Net Change Due to Project[a]	
						Change in Parameter	[%]
class area	ha	natural	26,425	-21,618	26,898	473	2
		human disturbed	3,078	21,618	2,605	-473	-15
number of patches	n/a	natural	215	-56	85	-130	-60
		human disturbed	294	-208	120	-174	-59
median patch size	ha	natural	8.3	-6.6	1.6	-6.6	-80
		human disturbed	0.2	0.0	0.2	0.0	0
patch size coefficient of variation	%	natural	616	-265	890	273	44
		human disturbed	1,302	-381	821	-481	-37
core area index area weighted median[b]	%	natural	69	-18	91	22	32
		human disturbed	n/a	n/a	n/a	n/a	n/a
total edge	km	both areas	962	-626	274	-688	-71

(a) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(b) Core area was calculated using a 100-m buffer inside perimeter of natural areas.

n/a = Not applicable.

Forested and Non-Forested Areas

Ecosite phases and wetlands types are grouped into forested and non-forested areas to examine fragmentation of forested patches. The 'forested' category includes all habitats with treed vegetation and the 'non-forested' category includes all naturally occurring non-treed habitats, including water and burns. Landscape metrics are used to analyze the size and proximity of forested areas in the JEMA LSA (Table 18). A summary of the results is provided below:

- Forested areas will increase 22%, from 13,635 ha at Base Case to 16,635 ha at closure, because previously non-forested wetlands will be converted to either terrestrial forested areas or pit lakes during reclamation. Non-forested areas will decrease 20%, from 12,790 ha at Base Case to 10,264 ha at closure.
- The median patch size of forested areas will decrease 31%, from 1.3 ha at Base Case to 0.9 ha at closure. Median distance between forested patches will remain the same, 8.9 m at Base Case and closure. Thus, the closure landscape will consist of more, smaller patches of forest that are the same distance apart compared to the Base Case landscape.
- The median patch size of non-forested areas will decrease 93% between Base Case and closure, from 8.3 to 0.6 ha, but there is 26% more variability in non-forested patch size at closure. Median distance

between non-forested patches will increase slightly, from 11.3 m at Base Case to 12.0 m at closure. Thus, the closure landscape will consist of non-forested patches that are typically smaller, more variable in size and slightly further apart compared to the Base Case landscape.

- Core area index-weighted mean of forested and non-forested areas will increase 70% and 56%, respectively, between Base Case and closure despite both areas decreasing in median patch size. This indicates that, with the reclamation of existing disturbance, the closure landscape consists of more habitat suitable for interior species.

Table 18 Forested and Non-Forested Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Class	Base Case	Loss/ Alteration Due to Project	Closure	Net Change Due to Project[a]	
						Change in Parameter	[%]
class area	ha	forested	13,635	-11,562	16,635	2,999	22
		non-forested	12,790	-10,056	10,264	-2,526	-20
median patch size	ha	forested	1.3	-0.2	0.9	-0.4	-31
		non-forested	8.3	-7.6	0.6	-7.7	-93
patch size coefficient of variation	%	forested	555	-208	649	93	17
		non-forested	961	-507	1,215	254	26
median nearest neighbour	m	forested	8.9	0.0	8.9	0.0	0
		non-forested	11.3	0.7	12.0	0.7	6
core area index area weighted median[b]	%	forested	39	-12	66	27	70
		non-forested	41	4	65	23	56

[a] Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

[b] Core area was calculated using a 100-m buffer inside perimeter of forested and non-forested areas.

Riparian Areas

Ecosite phases and wetlands types are grouped into riparian areas to examine fragmentation of riparian communities. All potential riparian habitat within 100 m of a watercourse with a patch area greater than 0.1 ha was included in this analysis. Landscape metrics are used to analyze the size and proximity of riparian areas in the JEMA LSA (Table 19). A summary of the results is provided below:

- Riparian areas will decrease 2%, from 3,243 ha at Base Case to 3,177 ha at closure, because riparian areas will be reclaimed using upland terrestrial vegetation types that do not have riparian potential (e.g., lichen jack pine [a1], Labrador tea-mesic jack pine-black spruce [c1] and Labrador tea-subhygric black spruce-jack pine [g1]).

- The median patch size of riparian areas will decrease 74%, from 3.1 ha at Base Case to 0.8 ha at closure, and patch size variability will increase 147%. Riparian patches will be farther apart, increasing in median nearest neighbour distance from 8.9 m at Base Case to 12.0 m at closure.

Table 19 Riparian Areas in the Jackpine Expansion Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Base Case	Loss/ Alteration Due to Project	Closure	Net Change Due to Project[(a)]	
					Change in Parameter	[%]
class area	ha	3,243	-2,384	3,177	-66	-2
median patch size	ha	3.1	-1.8	0.8	-2.3	-74
patch size coefficient of variation	%	266	-54	657	391	147
median nearest neighbour	m	8.9	3.1	12.0	3.1	35

(a) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

Old Growth Forest

The size and proximity of old growth forest in the JEMA LSA is analyzed to examine the fragmentation of old growth forest due to the Project (Table 20). Forests will not become old growth within the 80-year closure time frame because it takes between 100 and 140 years for forest to become old growth; therefore, the Application Case values are carried through to closure. A summary of the results is provided below:

- Old growth forest will decrease 52%, from 980 ha at Base Case to 466 ha at closure, as old growth forest lost during construction and operation of the Project will not be reclaimed by closure.
- The median patch size of old growth forest will decrease slightly (10%), from 1.0 to 0.9 ha, and patches will be farther apart from 12.0 m at Base Case to 22.0 m at closure.

Table 20 Old Growth Forest in the Jackpine Expansion Mining Area Local Study Area – Application Case

Landscape Metric	Unit	Base Case	Loss/Alteration Due to Project	Closure[(a)]	Net Change Due to Project[(b)]	
					Change in Parameter	[%]
class area	ha	980	-513	466	-513	-52
median patch size	ha	1.0	-0.1	0.9	-0.1	-10
patch size coefficient of variation	%	300	-7	293	-7	-2
median nearest neighbour	m	12.0	10.0	22.0	10.0	83

(a) Forests will not become old growth by closure so the values for the Application Case are carried through to closure.

(b) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

Table 21 Areas Potentially Affected by Dust in the Local Study Areas

Natural Subregion	Map Code	Description	Base Case		Application Case		Net Change Due to the Project		
			[ha]	% of LSAs	[ha]	% of LSAs	[ha]	% of LSAs	% of Resource
Vegetated Land									
Central Mixedwood	a1	lichen jack pine	2	<1	116	<1	113	**<1**	4,596
	b1	blueberry jack pine-aspen	32	<1	267	1	235	**<1**	737
	b2	blueberry aspen (white birch)	2	<1	74	<1	72	**<1**	3,267
	b3	blueberry aspen-white spruce	6	<1	87	<1	81	**<1**	1,451
	b4	blueberry white spruce-jack pine	1	<1	66	<1	65	**<1**	5,288
	c1	Labrador tea−mesic jack pine-black spruce	5	<1	22	<1	17	**<1**	335
	d1	low-bush cranberry aspen	78	<1	268	1	190	**<1**	242
	d2	low-bush cranberry aspen-white spruce	119	<1	494	1	375	**<1**	315
	d3	low-bush cranberry white spruce	18	<1	68	<1	50	**<1**	284
	e1	dogwood balsam poplar-aspen	0	<1	4	<1	4	**<1**	n/a
	e2	dogwood balsam poplar-white spruce	6	<1	77	<1	70	**<1**	1,090
	e3	dogwood white spruce	0	<1	4	<1	4	**<1**	n/a
	g1	Labrador tea-subhygric black spruce-jack pine	13	<1	128	<1	115	**<1**	858
	h1	Labrador tea/horsetail white spruce-black spruce	32	<1	84	<1	52	**<1**	164
Athabasca Plain	a1	bearberry jackpine	145	<1	979	2	834	**<1**	573
	b1	Canada buffalo-berry-green alder jack pine-aspen-white birch	110	<1	643	1	533	**<1**	484
	b2	Canada buffalo-berry-green alder aspen	163	<1	628	1	465	**<1**	285
	b3	Canada buffalo-berry-green alder aspen-white spruce-black spruce	110	<1	415	1	305	**<1**	278
	b4	Canada buffalo-berry-green alder white spruce-black spruce-jack pine	38	<1	227	<1	189	**<1**	499

Table 21 Areas Potentially Affected by Dust in the Local Study Areas (continued)

Natural Subregion	Map Code	Description	Base Case		Application Case		Net Change Due to the Project		
			[ha]	% of LSAs	[ha]	% of LSAs	[ha]	% of LSAs	% of Resource
Athabasca Plain (continued)	c1	Labrador tea-mesic jack pine-black spruce	5	<1	17	<1	12	**<1**	217
	d1	Labrador tea-subhygric black spruce-jack pine	3	<1	1	<1	-1	**-<1**	-52
	e1	willow/horsetail aspen-white birch-balsam poplar	4	<1	37	<1	33	**<1**	900
	e2	willow/horsetail aspen-white spruce-black spruce	27	<1	94	<1	68	**<1**	255
	e3	willow/horsetail white spruce-black spruce	11	<1	87	<1	77	**<1**	706
Both Natural Subregions	BFNN	forested bog	4	<1	0	<1	-4	**-<1**	-100
	BONN	open bog	0	<1	14	<1	14	**<1**	n/a
	BTNI	wooded bog with internal lawns	0	<1	80	<1	80	**<1**	n/a
	BTNN	wooded bog	119	<1	383	1	263	**<1**	221
	FONG	graminoid fen	300	1	269	1	-30	**-<1**	-10
	FONS	shrubby fen	148	<1	859	2	710	**<1**	479
	FOPN	open patterened fen	146	<1	146	<1	0	**0**	0
	FTNI	wooded fen with internal lawns	0	<1	15	<1	15	**<1**	n/a
	FTNN	wooded fen	125	<1	746	1	622	**<1**	499
	SONS	shrubby swamp	353	1	567	1	215	**<1**	61
	STNN	wooded swamp	70	<1	291	1	220	**<1**	315
	WONN	shallow open water	2	<1	5	<1	3	**<1**	146
	Meadow	meadow	1	<1	7	<1	7	**<1**	1,181
	Shrubland	shrubland	5	<1	27	<1	21	**<1**	388
	BUu	burned uplands	565	1	360	1	-206	**-<1**	-36
	BUw	burned wetlands	294	1	144	<1	-149	**-<1**	-51
	CC	cutblock	19	<1	49	<1	30	**<1**	157
		vegetated subtotal	*3,081*	*6*	*8,849*	*17*	*5,769*	*11*	*187*
Non-Vegetated Land									
Both Natural Subregions	Lake	lake	535	1	361	1	-174	**-<1**	-33
	River	river	3	<1	27	<1	24	**<1**	816
	Sand	sand	<1	<1	1	<1	<1	**<1**	<1
		non-vegetated subtotal	*538*	*1*	*389*	*1*	*-150*	*-<1*	*-28*
Total			**3,619**	**7**	**9,238**	**18**	**5,619**	**11**	**155**

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

n/a = Not applicable.

1.2 BIODIVERSITY

Table 22 Biodiversity Potential in the Pierre River Mining Area Local Study Area – Application Case

Natural Subregion[a]	Ecosite Phase/ Wetlands Type/ Other[b]	Base Case [ha]	Application Case [ha]	Loss/Alteration Due to Project and Jackpine Mine – Phase 1		Closure [ha]	Net Change Due to Project[c]	
				[ha]	[%]		[ha]	[%]
High Biodiversity Potential								
AP/CM	FOPN	69	13	-56	-81	13	-56	-81
AP/CM	FTNN	1,580	410	-1,170	-74	410	-1,170	-74
AP/CM	MONG	146	48	-99	-67	48	-99	-67
AP/CM	SONS	372	218	-154	-41	218	-154	-41
	subtotal	*2,168*	*688*	*-1,479*	*-68*	*688*	*-1,479*	*-68*
Moderate Biodiversity Potential								
CM	b2	43	12	-31	-72	12	-31	-72
CM	e3	45	13	-32	-71	13	-32	-71
CM	f1	4	<1	<4	<100	<1	<-4	<-100
CM	f2	4	0	-4	-100	0	-4	-100
CM	f3	7	4	-2	-36	4	-3	-39
AP	e3	307	191	-116	-38	726	419	137
AP/CM	BFNN	73	28	-45	-61	28	-45	-62
AP/CM	BONS	1	0	-1	-100	0	-1	-100
AP/CM	FONG	702	60	-642	-92	60	-642	-91
AP/CM	FONS	905	336	-569	-63	336	-569	-63
AP/CM	STNN	517	374	-143	-28	374	-143	-28
AP/CM	WONN[d]	57	20	-37	-65	20	-37	-65
AP/CM	lake	84	35	-50	-59	1,955	1,871	2,214
	subtotal	*2,747*	*1,074*	*-1,675*	*-61*	*3,528*	*781*	*28*
Low Biodiversity Potential								
CM	a1	16	4	-12	-74	4	-12	-75
CM	b1	242	107	-135	-56	107	-135	-56
CM	b3	104	30	-74	-72	30	-74	-71
CM	b4	173	47	-126	-73	47	-126	-73
CM	c1	19	9	-10	-51	9	-10	-53
CM	d1	734	363	-372	-51	363	-371	-51
CM	d2	478	150	-327	-69	150	-328	-69
CM	d3	250	130	-119	-48	130	-120	-48
CM	e1	6	2	-4	-66	2	-4	-69
CM	e2	121	80	-41	-34	80	-41	-34
CM	g1	12	5	-7	-59	5	-7	-59
CM	h1	118	58	-60	-51	58	-60	-51

Table 22 Biodiversity Potential in the Pierre River Mining Area Local Study Area – Application Case (continued)

Natural Subregion[(a)]	Ecosite Phase/ Wetlands Type/ Other[(b)]	Base Case [ha]	Application Case [ha]	Loss/Alteration Due to Project and Jackpine Mine – Phase 1		Closure [ha]	Net Change Due to Project[(c)]	
				[ha]	[%]		[ha]	[%]
AP	a1	2,740	2,033	-707	-26	2,301	-439	-16
AP	b1	2,922	2,021	-901	-31	2,025	-897	-31
AP	b2	2,151	1,316	-835	-39	2,213	62	3
AP	b3	1,728	684	-1,044	-60	1,172	-556	-32
AP	b4	927	512	-415	-45	515	-412	-44
AP	c1	60	29	-30	-51	1,858	1,798	3,020
AP	d1	130	27	-102	-79	3,043	2,913	2,249
AP	e1	325	293	-32	-10	293	-32	-10
AP	e2	404	136	-268	-66	293	-111	-27
AP	PJ-Lt comp	3	0	-3	-100	0	-3	-100
AP/CM	BTNN	1,186	328	-858	-72	340	-846	-71
AP/CM	shrubland	87	87	0	0	87	0	0
AP/CM	shrubland 2[(e)]	n/a	n/a	n/a	n/a	355	355	100
AP/CM	shrubland 3[(e)]	n/a	n/a	n/a	n/a	665	665	100
AP/CM	meadow	7	6	-1	-17	6	-1	-20
AP/CM	river	263	250	-13	-5	250	-13	-5
AP/CM	sand	41	36	-5	-12	36	-5	-12
AP/CM	cutblock	535	60	-475	-89	60	-475	-89
AP/CM	disturbance	439	10,570	10,132	2,308	168	-271	-62
	subtotal	*16,221*	*19,374*	*3,153*	*19*	*16,665*	*444*	*3*

(a) AP: Athabasca Plain; CM: Central Mixedwood.

(b) Full names of vegetation types are provided in Table 1.

(c) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(d) WONN includes littoral zones.

(e) These shrubland classes are specific to the closure landscape and are described in the C,C&R Plan (Appendix 5-2).

Table 23 Biodiversity Potential in the Jackpine Expansion Mining Area Local Study Area – Application Case

Ecosite Phase/ Wetlands Type/Other[(a)]	Base Case [ha]	Application Case [ha]	Loss/Alteration Due to Project		Closure [ha]	Net Change Due to Project[(b)]	
			[ha]	[%]		[ha]	[%]
High Biodiversity Potential							
FFNN	2	0	-2	-100	0	-2	-100
FOPN	792	677	-114	-14	677	-114	-14
FTNI	409	3	-405	-99	3	-405	-99
FTNN	3,644	322	-3,322	-91	322	-3,322	-91
FTPN	415	0	-415	-100	0	-415	-100
MONG	525	2	-523	-100	2	-523	-100

Table 23 Biodiversity Potential in the Jackpine Expansion Mining Area Local Study Area – Application Case (continued)

Ecosite Phase/ Wetlands Type/Other[(a)]	Base Case [ha]	Application Case [ha]	Loss/Alteration Due to Project		Closure [ha]	Net Change Due to Project[(b)]	
			[ha]	[%]		[ha]	[%]
SONS	2,052	460	-1,591	-78	460	-1,591	-78
subtotal	*7,838*	*1,465*	*-6,373*	*-81*	*1,465*	*-6,373*	*-81*
Moderate Biodiversity Potential							
b2	519	84	-435	-84	84	-435	-84
e3	8	7	-1	-9	7	-1	-9
f2	68	0	-68	-100	256	188	278
f3	260	0	-260	-100	919	659	253
BFNN	0.04	0	-0.04	-100	0	0	-100
BONN	61	9	-53	-86	9	-53	-86
BTNI	714	224	-490	-69	224	-490	-69
BTXC	89	0	-89	-100	0	-89	-100
FONG	986	181	-806	-82	181	-806	-82
FONS	2,722	424	-2,298	-84	424	-2,298	-84
STNN	606	95	-511	-84	95	-511	-84
WONN[(c)]	24	1	-23	-96	976	952	3,987
lake	2,214	814	-1,400	-63	4,932	2,717	123
subtotal	*8,272*	*1,838*	*-6,434*	*-78*	*8,105*	*-167*	*-2*
Low Biodiversity Potential							
a1	251	93	-158	-63	875	624	249
b1	816	208	-609	-75	428	-388	-48
b3	289	94	-195	-68	94	-195	-68
b4	91	41	-50	-55	614	523	575
c1	120	7	-113	-94	1,831	1,711	1,423
d1	1,010	176	-834	-83	1,796	785	78
d2	2,190	265	-1,925	-88	1,224	-966	-44
d3	545	92	-453	-83	477	-68	-12
e1	281	19	-261	-93	19	-261	-93
e2	67	30	-37	-55	30	-37	-55
g1	190	42	-148	-78	6,964	6,774	3,564
h1	233	81	-151	-65	183	-49	-21
PJ-Lt complex	14	0	-14	-100	0	-14	-100
BTNN	790	174	-616	-78	174	-616	-78
BTNR	17	17	0	0	17	0	0
shrubland	364	4	-360	-99	4	-360	-99
shrubland 2[(d)]	n/a	n/a	n/a	n/a	556	556	100
shrubland 3[(d)]	n/a	n/a	n/a	n/a	1,882	1,882	100
burned uplands	1,126	135	-991	-88	135	-991	-88
burned wetlands	1,903	24	-1,879	-99	24	-1,879	-99
meadow	1	1	0	0	1	0	0
river	19	2	-17	-91	2	-17	-91
cutblock	120	63	-56	-47	63	-56	-47
disturbance	2,958	24,633	21,674	733	2,541	-417	-14
subtotal	*13,393*	*26,200*	*12,807*	*96*	*19,933*	*6,540*	*49*

Table 23 Biodiversity Potential in the Jackpine Expansion Mining Area Local Study Area – Application Case (continued)

(a) Full names of vegetation types are provided in Table 2.

(b) Net change is calculated as the difference between the Base Case and closure, a value upon which the environmental consequence is assessed.

(c) WONN includes littoral zones.

(d) These shrubland classes are specific to the closure landscape and are described in the C,C&R Plan (Appendix 5-1).

2 REFERENCES

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3 ABBREVIATIONS

%	Percent
<	Less than
ha	Hectare
km	Kilometre
LSA	Local Study Area
m	Metre
n/a	Not applicable

APPENDIX 5-4

WILDLIFE MODELLING

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1 HABITAT SUITABILITY MODELS

1.1 INTRODUCTION

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 wildlife habitat. Output from HS models provides an excellent foundation for informative mapping and as a guide for evaluating land management alternatives.

The HS model output provides an estimate of habitat quality for specific wildlife species, including a percentage error that is an inherent part of the estimate. This error arises due to natural variation, as well as many additional factors affecting populations which operate independently of habitat quality, such as history, weather, disease, parasites, predators and human harvest (Schamberger and O'Neil 1986; Levin 1998). Relationships between wildlife and habitat variables are also likely to change with habitat type (Stauffer and Best 1986), scale of measurement (Meyer and Thuiller 2006) and population density (Hobbs and Hanley 1990). Despite the challenges inherent in HS models, they are a powerful and important tool for quantifying the effects of a project on wildlife.

Resource Selection Functions (RSF) were developed and validated for Local Study Area (LSA) and Regional Study Area (RSA) levels from empirical data for moose, lynx, and fisher/marten. RSF's for black-throated green warbler and barred owl were applied from the literature and from researchers at the Alberta Sustainable Resource Development (ASRD), respectively. As the warbler and barred owl models require Alberta Vegetation Inventory (AVI) data to operate, they could not be applied at the RSA level. Instead, a simple Habitat Suitability Index (HSI) coding system was developed for mapping at the regional scale for these two species.

An expert knowledge-based HSI modelling approach was utilized for determining LSA and RSA-level habitat quality for Canadian toad, black bear, beaver, and yellow rail. The Canadian toad HSI model was used as developed and validated for the Sustainable Ecosystem Working Group (SEWG) of the Cumulative Environmental Management Association (CEMA) (Golder 2006). Black bear and beaver models are the same as those used in the Suncor Voyageur Project Environmental Impact Assessment (EIA) (Suncor 2005). All models used are described in detail in Section 1.2.

1.2 METHODS

Two modelling approaches (RSF and HSI) were used for the Wildlife assessment. The RSF models for moose, lynx, and fisher/marten were developed for application at the LSA and RSA scales to evaluate the effects of the Project on wildlife habitat. The RSF models for black-throated green warbler and barred owl were applied from the literature and from researchers at the ASRD, respectively. The HSI models were used for determining effects of the Project on habitat at the LSA and RSA-level for Canadian toad, black bear, beaver, and yellow rail.

1.2.1 Moose, Lynx and Fisher/Marten Resource Selection Functions Development

1.2.1.1 Resource Selection Functions

A RSF is a particular class of HS model that is defined as any function that estimates probabilities of habitat use (Manly et al. 2002). The benefit of RSFs is that they take advantage of available data and are simple to apply. For these reasons, they are increasingly used for wildlife assessments (Johnson et al. 2004; Lemaitre and Villard 2005; Richardson et al. 2005; Sawyer et al. 2006).

As wildlife distribution information is most often in the form of presence and less commonly, absence data, logistic regression is used to produce predictive equations in RSF modelling. Logistic regression has numerous advantages as a statistical tool (Tabachnick and Fidell 2001) including the capability to represent non-linear wildlife population responses to varying habitat quality (e.g., the sigmoidal form described by Hassell and May [1974]) for explaining the numerical response of predators to changing prey densities).

If only samples of “used” sites are available, as is usually the case, random samples of “available” can be produced in a Geographic Information System (GIS) environment. Several conditions must be met when applying a “use versus available” sampling scheme. First, to retain the independence of observations, which is a requirement of logistic regression, the number of “available” samples must be sufficient to describe pertinent landscape variability, but must not be tied directly to the number of “used” observations (Manly et al. 2002). Second, as used-available samples do not indicate the proportion of the landscape that is actually used, predictive output can only be in terms of relative probabilities of use. To accomplish this, coefficients estimated with logistic regression must be transposed into an exponential form (Manly et al. 2002). All coefficients are transposed except the intercept, which implies knowledge of proportional use.

Although estimates are then no longer constrained between 0 and 1, but as relative probabilities, this is unimportant (Pearce and Boyce 2006). For ease of interpretation, output will be standardized to a 0 to 1 scale.

The RSF models produced here were based on indirect observations of species presence as well as GIS data describing vegetation, disturbance and geographic features. Data indicating the presence of moose, lynx and fisher/marten at particular co-ordinates came from winter snow track transects conducted by Golder Associates Ltd. (Golder) within the Oil Sands Region from 1999 to 2005 (Suncor 2007). The process used here for building RSFs can be separated into the following stages: literature review, data management, candidate model set construction, model selection and model validation/evaluation.

A brief literature review (summarized below) was undertaken to inform the selection of variables and the structure of candidate models. Well-informed consideration is an integral part of model construction, serving to reduce the incidence of spurious relationships in models (Anderson et al. 2001). Spurious relationships are those which are highly variable from one data set to the next and/or are biologically irrelevant, yet arise frequently when model construction is based primarily on data analysis. As data used was taken from winter track transect data in the Oil Sands Region, wildlife-habitat relationships relevant to winter in northeastern Alberta were the focus of model building efforts. Relationships emphasized in this literature review reflect the limited variables available when using data at the scale of AVI and base map detail.

Moose Habitat Requirements

Moose dietary requirements and forage preferences vary with season (Robbins 1993; Osko et al. 2004). During the winter season, habitat preference shifts with snow depth (Hauge and Keith 1981). However, snow does not tend to influence moose habitat selection until snow depths reach about 65 cm (Pierce and Peek 1984). As such depths are seldom present in the Oil Sands Region, habitat relationships related to shelter from severe winter conditions are unlikely to play an important role.

Factors have been shown to exist that complicate efforts to effectively model the habitat preferences of moose. These issues are likely true to some degree for the moose, fisher/marten, and lynx RSF models, but they have been specifically documented for moose. First, habitat preferences have been shown to vary considerably between individuals as well as between moose “herds” (Osko 2003; Osko et al. 2004). Second, moose have been observed displaying site fidelity, remaining in an area even after it has been altered into what should theoretically be undesirable habitat (Cederlund and Okarma 1988). Third, the scale of measurement should affect perception of most, if not all wildlife-habitat relationships (Guisan and Zimmerman 2000; Boyce 2006). Moose in particular have been shown, for example, to select closed canopy forest stands within local (i.e., less than 100 km^2) areas, but selected for canopy disturbance within regional (i.e., 1,000 km^2) areas (Forbes and Theberge 1993).

Stand Age

When snow depth avoidance plays a role in habitat selection (i.e., depths greater than about 65 cm), moose appear to prefer mature forest (Simpson et al. 1988). When winter conditions are not limiting, as well as in spring and summer, moose tend to prefer herb/shrub communities and young forest stands (Serrouya and D'Eon 2002).

Canopy Cover

When snow depths are limiting (i.e., depths greater than about 65 cm), moose will likely be drawn to degrees and types of forest cover that moderate climatic extremes and intercept snow (Bonar 1985; McNicol 1990). In periods without deep snow, however, moose will prefer lower levels of canopy cover due to the increased quality and quantity of forage that will develop there (Hundertmark et al. 1990; Schwab and Pitt 1990; Serrouya and D'Eon 2002).

Forest Edge

Numerous researchers have found that moose prefer a mixture of mature forest for cover and early successional forage that are near one another (Goddard 1970; Thompson and Vukelich 1981). This preference for edge habitats has been shown to be particularly strong in winter (Telfer 1984; Cederlund and Okarma 1988; McNicol 1990).

Stand Type

Stand type refers to the classifications of coniferous, deciduous or mixedwood. Although preferences for particular stand types appear to vary with location, there is ample evidence to believe that stand type should be an important indicator for moose habitat suitability. For example, numerous researchers have shown that moose prefer coniferous forests (Goddard 1970; Thompson and Vukelich 1981; Bonar 1985), or coniferous wetlands (Leresche et al. 1974; Hauge and Keith 1981). Moose have also been shown to display more complexity in their preferences. For example, Mytton and Keith (1981) found that moose selected aspen stands in winter in addition to conifer stands.

Elevation

Moose generally prefer low elevation areas in winter (Simpson et al. 1998; Serrouya and D'Eon 2002). In circumstances where snow depths become limiting, moose may be forced to more upland sites (Hauge and Keith 1981).

Slope

Moose appear to select areas that possess low slope in winter (Serrouya and D'Eon 2002).

Linear Disturbance

Moose have been documented showing a preference for seismic lines and utility lines, although avoidance may vary with time of year (Mytton and Keith 1981) and location (Higgelke 1994).

Roads

Moose have been found to display a preference for logging roads (Serrouya and D'Eon 2002) and may be drawn to salt on and around highways in winter (Miller and Litvaitis 1992). Preference for roads may vary with time of year (Mytton and Keith 1981) and location (Higgelke 1994).

Disturbance

Moose have been shown to avoid human disturbance such as clearings caused by agricultural activity (e.g., Mytton and Keith 1981).

Riparian Areas

Moose appear to have a preference for riparian areas in winter (Simpson et al. 1988).

Wetlands

Wetlands appear to be important for moose as they tend to provide access to escape cover as well as good forage (Allen et al. 1987). In the Athabasca River region of northern Alberta, moose tend to be more abundant in fen/bog habitat than in upland habitat (Latham and Boutin 2005).

Canada Lynx Habitat Requirements

Lynx habitat preference, in general and particularly in winter, reflects that of its primary prey; the snowshoe hare (Mowat et al. 2000). However, snowshoe hare abundance is known to follow a 10-year periodic cycle (Krebs et al. 2001). This complicates the production of HS models, as lynx habitat preferences would be expected to shift with snowshoe hare abundance. Also, the primary determinant of habitat preference for snowshoe hares seems to be the density of understorey cover (Hodges 2000), which cannot be estimated directly from AVI data and must instead be inferred from correlations with stand age.

According to results collected at Kluane Lake, Yukon, snowshoe hare populations should have been near a cyclic low when the 2003, 2004 and 2005 winter tracking observations used in model construction were collected (Figure 1). As such, lynx habitat preferences may have become more general to seek out alternative prey. Diet composition studies suggest that lynx in Alberta have broader diets than lynx on average (Mowat et al. 2000). This makes application of *a priori* knowledge in model building a more difficult endeavour, as the vast majority of knowledge on lynx habitat preferences is based on optimal hare hunting opportunities. A more investigative approach to variable selection was therefore necessary for lynx.

As an additional consideration, the importance of hare to lynx suggests that RSF's validated at one position on the hare cycle will be of questionable accuracy when applied at a different position in the hare cycle. The broader prey preferences of lynx in Alberta suggest that the impact will be even greater here, as lynx may be more likely to switch habitat preferences when hare availability shifts.

Disturbance

Lynx appear generally tolerant of humans and human disturbance (Mowat et al. 2000). However, Nielsen et al. (2006) found that there is a fairly strong negative relationship between the probability of lynx occurrence and road density. Also, there is evidence that habitat near linear features may have negative demographic impacts, as increased human access tends to increase lynx mortality due to trapping (Higgelke et al. 2000; Koehler and Aubry 1994).

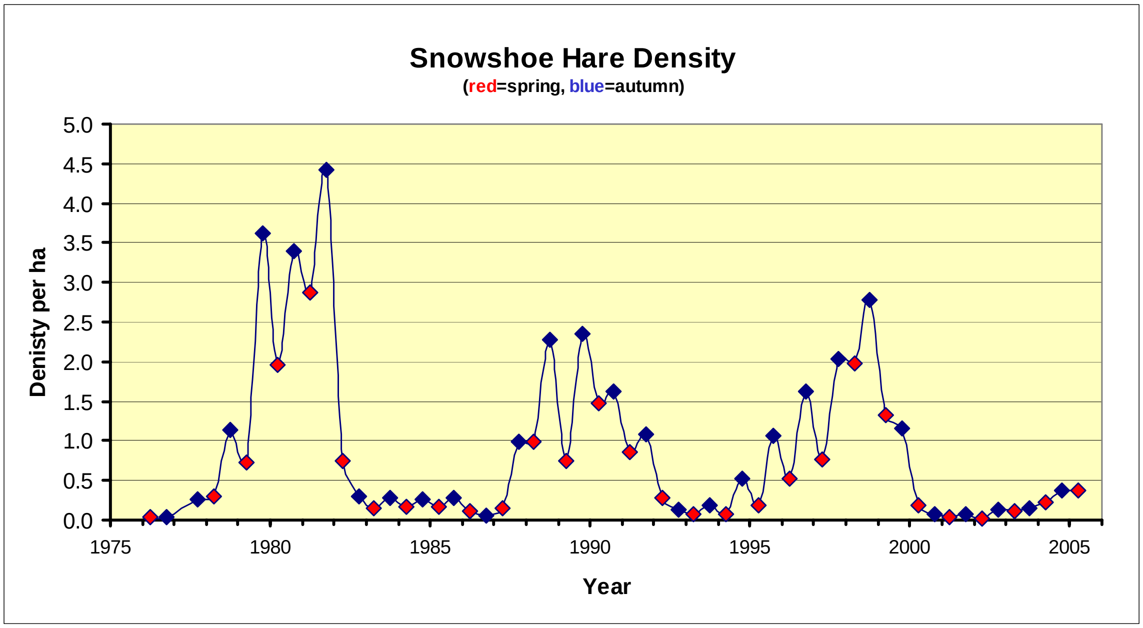
Cover

Lynx appear to prefer a continuous closed canopy for travel cover, although they will cross openings up to 100 m wide (Koehler and Aubry 1994).

Stand Age

There is a general consensus that lynx select regenerating stands that are over 20 years of age as hunting habitat (Thompson et al. 1989; Mowat et al. 2000; Higgelke et al. 2000). This is in apparent contrast to the preference of snowshoe hares for stands that are less than 20 years old (Higgelke et al. 2000). However, younger regenerating stands and climax shrub stands are avoided by lynx even when they contain large hare populations because the density of stems and cover in those habitats makes hunting very difficult. Lynx will use more dense stands (i.e., younger stands) out of necessity when hare populations are low, as this is the area to which hares retreat (Mowat et al. 2000).

Figure 1 Changes in Snowshoe Hare Density at Kluane Lake, Yukon



Note: From the Kluane Ecosystem Monitoring Program (Krebs 2006, pers. comm.).

Lynx preferences for mature stands appear to vary, sometimes selecting them (Koehler and Brittell 1990) and sometimes avoiding them (Thompson et al. 1989). This discrepancy may be explained by apparent preferences for certain canopy tree species and an apparent preference for mature/regenerating forest edge.

Preferred Canopy Species

Mature aspen, white spruce and black spruce stands in central Alberta have been shown to contain substantial browse and horizontal cover, as well as persistent modest numbers of hares, regardless of the state of the snowshoe hare population cycle (Mowat et al. 2000).

Edge

Lynx may have a hunting preference for mature to regenerating forest edge habitat, as it may provide fringe access to areas that would otherwise be too dense to hunt (Mowat et al. 2000).

Fisher/Marten Habitat Requirements

As fishers are ranked as "Sensitive" in the Province of Alberta (ASRD 2005, website), the emphasis of model building efforts was to represent fisher habitat selection. The habitat association literature review for variable selection therefore focuses on fisher habitat. However, due to the practical impossibility of discerning between the tracks of marten and fisher within most of their size range, the resulting model must be considered one of fisher and marten habitat selection combined.

Fishers are generalist predators that will eat any animal they can catch and overpower (Allen 1983; Powell and Zielinski 1994). They consume mostly small- to medium-size mammals and birds, but they will readily eat carrion and fruits. Many fisher populations rely on snowshoe hare as primary food, but are successfully opportunistic enough that populations do not usually track hare cycles (Kuehn 1985).

Fishers are also territorial animals and with the exception of males in the spring, adult home ranges usually do not overlap with individuals of the same sex (Arthur et al. 1989a). Home range size has been shown to be affected by population density. This is an important point because model development for territorial species is inherently difficult. Presence and abundance is likely to become uncoupled from habitat quality to some degree because sub-dominant individuals are forced into less desirable habitat, and perhaps even population sinks. In certain circumstances, there may be more individuals in less desirable habitats than there are in optimal habitat. For example, it has been suggested that young forest stands are sink habitat for juveniles (Paragi et al. 1996). Also, animals may spend a large proportion of their time at territorial boundaries strictly for the purpose of territorial defence (Bushkirk and Millspaugh 2006). Therefore, derived correlations between presence and habitat quality have the potential to be misleading (van Horne 1983).

Similar to fisher, marten have been shown to prefer mature forest stands with shrubby understoreys (Thompson and Harestad 1994; Slauson et al. 2007). However, marten have also been shown to effectively utilize younger deciduous stands (Poole et al. 2004). It is possible then that marten may prefer younger stands more than fisher and if considerably more abundant on the landscape, marten may confound accurate representation of fisher habitat preference in this model. However, at this point information gathered from the literature does not seem to suggest that fisher and marten habitat preferences diverge significantly with regard to stand age or distance to edge. While no information could be found regarding fishers and effects of roads, marten appear to avoid roads (Robitaille and Aubry 2000).

Cover

There is a consistent emphasis in the literature that fishers are associated with closed canopy forests, and a general avoidance of non-forested areas, particularly in winter (Allen 1983; Powell 1993; Powell and Zielinski 1994; Carroll et al. 1999; Wier 2003). This association with heavy canopy cover is often due to reliance by fisher on coarse woody debris, as the two are often correlated (Powell and Zielinski 1994). Also, snow depth has been shown to affect habitat selection (Powell 1993), with areas of greater canopy cover intercepting more snow and reducing ground accumulation (Bunnell et al. 1985).

Age

Fishers are generally associated with mature and late successional forests (Wier 2003). This is generally because early and mid-successional forests, particularly those that arise after logging operations, often do not provide the essential combination of prey resources, rest sites and den sites as more mature forests (Powell and Zielinski 1994). Young stands with good structural complexity may provide adequate habitat types; however, they are likely avoided in winter regardless of complexity (Powell 1993). Other researchers have found that fishers have shown a preference for both young and old growth stands in winter (Jones and Garton 1994). In heavy snowfall zones, fisher would be expected to be tied even more tightly to late successional forests.

Stand Type

Fishers have been shown to generally prefer coniferous forests, to use mixedwood forests roughly in relation to their availability and to avoid open hardwood forests (Powell 1979; Allen 1983; Raine 1983; Arthur et al. 1989b; Powell 1993; Wier 2003).

Elevation

Areas of low elevation appear to be selected, most likely because the high canopy cover associated with fertile lowland forests is more effective at intercepting snow (Powell 1993). The importance of low elevation seems to increase with snowfall (Powell and Zielinski 1994).

Riparian Association

The literature suggests that fishers may prefer habitat that is near to riparian areas (Powell 1993). However, this preference does not appear to be particularly strong and may be a correlation between riparian areas and dense cover with complex structure.

Edge

Fishers may prefer edge habitat due to the availability of cover as well as a diversity of foraging opportunities (Allen 1983).

Data Management

Literature reviews for moose, lynx and fisher suggest that wildlife relationships with vegetation variables should be of importance to model development. However, as one of the objectives of this modelling effort is to project predictions across the landscape, variables sourced from intensive vegetation studies could not be used as they are, by definition, limited in extent. Due to the different vegetation cover data available at the LSA and RSA scale, different RSF's were estimated for lynx, moose and fisher at each extent.

Local Study Area Level Models

The AVI data were the highest resolution vegetation cover data available at the LSA level. As models built using AVI data cannot form predictions in areas that lack those data, species presence observations that did not fall within available AVI data sheets were removed from further consideration for LSA-level model development.

When possible, variables desired from AVI and geophysical GIS data that were suggested by literature but were not directly available were created. Distances to various landscape features were produced, and those used in final models are listed in Table 1. Numerous other variables were produced, including forest cover classification variables, but they were not sufficiently important to predictive ability, as scored by Akaike's Information Criterion (AIC_c).

Table 1 Distance Measures Calculated in ArcGIS

Variable Name	Description
distance to Edge C	distance to Edge C, which is <10 years adjacent to >60 years
distance to Edge E	distance to Edge E, which is <20 years adjacent to >60 years
distance to linear	distance to nearest linear disturbance, not including roads
distance to road	distance to nearest road

Note: Linear disturbance refers to cutlines, pipeline rights-of-ways and transmission lines, but not roads.

"Distance to" measurements may not be accurately portrayed, particularly for observations near the edge of the limited AVI cover data that were available. For example, there may be rivers, linear disturbances or edges that are closer than available AVI data suggests if they occur immediately outside the AVI coverage. This could weaken predictive models, especially if quantified relationships are applied outside the study area. However, the potential importance of "distance to" variables necessitated their inclusion. The distance to industrial facilities could not be included in "distance to" calculations for model development because the disturbance layers available for the accumulated years of wildlife observations (i.e., 2001 and 2004 layers) estimated disturbance footprint instead of actual disturbed land. These factors introduce a component of uncertainty into the models. However, model predictive strength is quantified by validation efforts (Model Validation/Evaluation subsection, pp.16-18, this Appendix), which implicitly account for these sources of uncertainty. .

Observations used to produce RSF models originated from winter track surveys within the Oil Sands Region from winter 2001 to winter 2005. Before these data could be used, several modifications had to be made. First, although at times an observation identified more than one individual animal, the binary dependent variable requirement of logistic regression and generally accepted RSF approaches required observations to be reduced to zeros (absence) and ones (presence). Next, 600 random "available" observations were created on the landscape, following the "used and available" approach to RSF model production of Manly et al. (2002). Before creating the random points, the landscape was masked in ArcGIS so that points did not land on areas that would generally be unavailable for species use (i.e., non-habitat), such as lakes, rivers or industrial disturbances present in the AVI data set. Linear disturbances (i.e., cutlines, pipeline rights-of-ways and transmission lines) were not masked. Although placement of random points could not be controlled beyond masking of unavailable locations, points were later examined to ensure than none fell closer than 50 m from its nearest neighbour. Although actual observations of “unused” were available as presence observations of the numerous other species recorded on transects, these absence observations incorporated an unquantifiable bias in number and location towards the location and apparent preference of other recorded species. As such, it was decided to simply use a random sample of “available” sites (Manly 2006, pers. comm.).

Regional Study Area Level Models

The AVI data were not available at the RSA scale. Variables available for model production were limited to those arising from Digital Elevation Model (DEM) data (e.g., percent slope, aspect, elevation) and habitat classifications derived from Landsat data. Disturbance features were disproportionately prevalent in the LSAs relative to the RSA. Therefore, disturbance-related features could not be used in RSA-level models, as models produced with disturbance relationships could not be extrapolated to the full RSA scale. Further variables that were produced and were considered important enough by AIC scoring to be considered in final models are listed and described in Table 2. Stream density was calculated using a search radius of 5 km. Additional snow tracking observations could be used for RSA-level model development because the Landsat vegetation classification covers the entire Oil Sands Region.

Table 2 Variables Calculated From Landscape Features in Final Regional Study Area-Scale Models

Variable	Description
stream density	density of streams within 5 km search radius (km/km^2)
distance to stream	distance to nearest stream
distance to wetlands	distance to nearest wetlands

After variables were produced, 1,000 random “available” points were selected on the landscape without replacement (Boyce 2006). A sampling scheme for the placement of random available points was designed to mimic the sampling scheme for the placement of track transects as closely as possible. This is necessary to control for sampling biases that could otherwise result in final models that more effectively describe sampling design and effort than habitat preference (Pearce and Boyce 2006).

Few transects were located far from rivers or streams and very few fell outside the extent of the available AVI data. Sampling transects intentionally focused on gradients moving from riparian to upland habitats. Also, sampling was strongly correlated with the AVI extent because study design purposely focused on the region of most intensive disturbance, and the LSA and AVI data are required for effective mapping and planning at that scale. Therefore, the placement of random points was constrained by the extent of the AVI data, with water and disturbances within the AVI excluded from consideration.

Candidate Model Set Construction

Once the data were checked for errors and organized, candidate models were constructed. Variables were first ranked in order of importance suggested by literature. Where order was unclear, or when importance seemed sensible but was not directly suggested by literature, univariate logistic regression was used to assess the potential importance of variables.

Lists of continuous variables considered for use in the models for each species were then assessed for collinearity (i.e., high univariate correlations) and multicollinearity (i.e., linear redundancy of variables) in Statistical Analysis System (SAS Systems 2002). Highly correlated variables must be excluded from final models, as such redundancy would serve to increase error terms and produce less reliable predictive equations, especially when predicting outside the range of sample data (Hocking 1976). For the LSA-level models, the variables representing elevation, distance to nearest river, and distance to nearest road were highly correlated with each other. For the RSA-level models, no variables were so strongly correlated that they were likely to affect model reliability.

Once a final variable list was completed, candidate model sets of plausible combinations of variables were compiled, keeping the total number of models below about 20 for each species (Burnham and Anderson 2002). Model coefficients were estimated using logistic regression in SAS (SAS Systems 2002). As coefficients were estimated from data that came from a used/available sampling scheme, traditional logistic regression diagnostic approaches such as Receiver Operating Characteristics (ROC) curves or goodness-of-fit tests were invalid and therefore not used (Boyce et al. 2002; Johnson et al. 2006).

Model Selection

Candidate models were scored and ranked after models were fit to the data. As the best model is assumed to be of essentially infinite complexity, model selection criteria from the AIC family (Akaike 1973) were selected due to their competitive advantage over all other readily available methods under these circumstances (Hurvich and Tsai 1989). Because the ratio of sample size to number of parameters is considerably less than 40 (i.e., the ratio varied from approximately 10 to 17 for final models), AIC_c was used to correct for small sample bias in AIC (see Burnham and Anderson 2002 for a detailed discussion). The particular version of the AIC_C equation used follows Hurvich and Tsai (1989). The model selected as best was the one with the lowest AIC_C score.

Model selection based on data analysis is more likely to incorporate spurious relationships (Anderson et al. 2001). However, strong trends that lie within the data may hold important information. Therefore, a cautiously iterative approach was undertaken after *a priori*-based model construction and selection. This allowed investigation of the relative strength of variable combinations that were not included in the original candidate set, but were suggested by AIC_C scoring results. The best scoring LSA- and RSA-level models are listed in Tables 3 and 4, respectively.

Table 3 Most Strongly Supported Local Study Area-Level Resource Selection Functions Models, as Scored by AIC_c

Species	Variables in Selected Model
moose	stand age (-), distance to nearest Edge C (+), distance to nearest road (-), distance to nearest linear feature (+), slope (+)
lynx	elevation (-), slope (-), stream density (-), distance to nearest stream (-)
fisher/marten	stand age (-), distance to nearest Edge C (-), elevation (-)

Note: Coefficient signs indicating direction of correlation are represented in parentheses as "+" for a positive correlation, or "-" for a negative one.

Table 4 Most Strongly Supported Regional Study Area-Level Resource Selection Function Models, as Scored by AIC_c

Species	Variables in Selected Model
moose	elevation (-), stream density (-), distance to stream (-), elevation X stream density (+)
lynx	elevation (-), slope (-), stream density (-), distance to nearest stream (-)
fisher/marten	elevation (-), slope (+), stream density (-), distance to nearest wetlands (-)

Note: Coefficient signs indicating direction of correlation are represented in parentheses as "+" for a positive correlation, or "-" for a negative one.

Once the best models are identified, further adjustments were made before they could produce meaningful predictions. First, the GIS coverages were turned into a raster format at a 10-m resolution at the LSA level and a 50-m resolution at the RSA level. Next, the form of the function estimated by logistic regression had to be adjusted slightly. This is because absolute probabilities of use, as obtained from logistic regression model output, are not correct when data comes from a "used" and "available" sampling scheme. Instead, estimates of relative probabilities of use can be produced by inserting coefficients estimated from logistic regression into the following log-linear form of an RSF, following Manly et al. (2002):

$$w(x) = \exp(B_1 x_1 + ...B_p x_p)$$

Local Study Area-Level Model Selection Results

The LSA-level models (Table 3) were applied to the LSA scale for calculation of area per habitat class for the Base Case, and Application Case, as well as for closure. However, the LSA-level moose and fisher/marten RSF models can not function with unaltered closure and reclamation data, which contains only ecophase identification.

Stand ages at closure for estimation of edges were calculated using the reclamation schedule. This methodology was applied for the southern portion of the JEMA LSA for Base Case and Application Case (i.e., Jackpine Mine – Phase 1), as well as for closure, because Base Case for that portion of the JEMA LSA is the Closure and Reclamation Plan as described in Jackpine Mine – Phase 1 Supplemental Information (Shell 2002). For the purpose of estimating habitat quality at closure, stand ages were assigned assuming closure dates of 2065 and 2049 for the JEMA and PRMA LSAs, respectively. Updated ages at closure outside of the footprint were calculated by subtracting appropriate closure dates from AVI stand origin dates.

Regional Study Area-Level Model Selection Results

The RSA-level models (Table 4) were used for estimating area per habitat class for Base Case, Application Case and Planned Development Case (PDC).

Model Validation/Evaluation

Models must be evaluated for reliability in a process generally referred to as model validation (Marcot et al. 1983). Validation was conducted on final models to evaluate reliability and establish credibility. Due to the lack of available independent data, a cross-validation approach was applied using k-fold partitioning (Fielding and Bell 1997; Boyce et al. 2002; Johnson et al. 2006). Huberty's (1994) 'rule of thumb' was used to guide the number of partitions and the number of observations to go into each. Moose data were split into four sets, iteratively using three quarters of the total data for coefficient estimation and one quarter of the "used" observations for testing. Fisher/marten and lynx data, due to the reduced number of observations, were split three times, iteratively withholding a third of the observations for testing.

After test models were fit, predictive output of each was projected onto a rasterized GIS surface. For the LSA and RSA-level models, predictions were split into ten quantile (i.e., equal area) divisions, otherwise known as "bins". Ten bins were used because recent investigations have revealed that more numerous divisions result in high variance in estimates of predictive accuracy, and lower divisions result in underestimations of model accuracy (Hirzel et al. 2006). Divisions were collapsed to produce numbers of observations per bin that were as equal as possible. Observed numbers of observations per bin were divided by the areal extent per bin and compared to bin ranks. Model validation was then conducted.

Validation follows an approach similar to that outlined by Boyce et al. (2002). Area adjusted frequencies of occurrence per bin were converted to rank scores and relationships with bin number were quantified using Spearman-rank correlations in SAS (SAS Systems 2002). Spearman-rank correlations range from -1 for perfectly reversed rank pairings to 1 for perfectly matched ranks (Kutner et al. 2005). Statistically significant, strong positive correlations between area-adjusted track counts represent evidence that models perform relatively well at this level of precision. Tables 5 and 6 present validation results for LSA- and RSA-level models, respectively, using methods described by Boyce et al. (2002).

Table 5 Spearman-Rank Correlations Between Bin and Associated Area-Adjusted Observation Ranks for the Project Local Study Areas

Species	Validation Model	Spearman-Rank Correlation
moose	A	0.333, p=0.381
	B	0.762, p=0.028
	C	0.794, p=0.006
	D	0.467, p=0.174
lynx	A	0.667, p=0.219
	B	0.949, p=0.051
	C	0.348, p=0.499
fisher/marten	A	0.892, p=0.007
	B	0.857, p=0.014
	C	0.548, p=0.160

Table 6 Spearman-Rank Correlations Between Bin and Associated Area-Adjusted Observation Ranks for the Regional Study Area

Species	Validation Model	Spearman-Rank Correlation
moose	A	-0.024, p=0.955
	B	0.029, p=0.957
	C	0.829, p=0.042
	D	0.086, p=0.872
lynx	A	0.667, p=0.219
	B	0.949, p=0.051
	C	0.348, p=0.499
fisher/marten	A	-0.214, p=0.645
	B	0.500, p=0.667
	C	1.000, p<0.0001

JPME R1
AENV SIR
465

As these models were built using winter observation data, validation results are only reliable for estimating winter habitat preference. However, as winter habitat is often a limiting factor for wildlife species, models predicting winter habitat preferences are particularly valuable for wildlife conservation and management. Also, as snowshoe hares were at a low in their population cycle in the period that observations were collected (i.e., 2001 to 2005, Figure 1), validation results for the lynx model may be less reliable during periods of higher snowshoe hare density.

Local Study Area-Level Validation Results

The moose model validation, adapted from Boyce et al. (2002) averages a moderate correlation of approximately 0.6 (Table 5). The LSA-scale lynx model used is the same as that used at the RSA scale, and shows a moderate mean Spearman-rank correlation of 0.65. Fisher/marten was the strongest model showing strong Spearman-rank correlations averaging 0.77 between bin number and bin ranks (Table 5, Attachment I). Performance of the moose and fisher/marten model at the LSA scale was sufficiently strong that five categories of habitat quality could be retained.

Regional Study Area-Level Validation Results

JPME R1
AENV SIR
477

The moose RSA model performed relatively poorly, with an average correlation of 0.23 (Table 6). The lynx RSA model performed moderately well with a mean correlation between bin number and rank of 0.65. The fisher/marten RSA model fell between the moose and lynx models in predictive reliability, with a mean correlation of 0.43. The poorer performance of the moose and fisher/marten RSA-level RSF models relative to their LSA-level counterparts suggests that these species select habitat based on finer details (e.g. stand ages) than that available in the RSA-level vegetation classification data.

1.2.2 Black-Throated Green Warbler Resource Selection Functions Application

Habitat Requirements

The black-throated green warbler is classified as a forest interior species and a long distance migrant. The species tends to be absent from fragmented landscapes, yet is abundant within contiguous forest (Hobson and Bayne 2000b). Abundance tends to decrease in response to forest harvest (Hanowski et al. 2003). In New Hampshire, the movement of black-throated green warblers decreased considerably when forest gaps reached 25 to 40 m in width (Rail et al. 1997). In Quebec, these birds were nearly absent from 20 m riparian buffers, and Darveau et al. (1995) suggested that species required 60 m wide buffer. Aversion to edge may not be a constant (Rodewald and Brittingham 2002), although it is likely a useful generalization. Due to this strong preference, and perhaps requirement for continuous forest, black-throated green warblers have been designated as “Sensitive” by the province of Alberta (ASRD 2005, website).

The black-throated green warbler is generally associated with coniferous forests, but also breeds in mixedwoods and less commonly, deciduous forests in some parts of its range (Morse 2005, website). Preference for coniferous trees and stands varies geographically (Robichaud and Villard 1999). In the boreal forest of Alberta, Hobson and Bayne (2000a) found that black-throated green warblers were abundant in stands dominated by white spruce and in mixedwood stands, while they were absent from jackpine or black spruce dominated stands. Also in Alberta’s boreal forest, Hobson and Bayne (2000b) found that these warblers preferred white spruce and mixedwood stands over aspen stands. Near Calling Lake in northern Alberta, Robichaud and Villard (1999) found that preference for breeding and foraging habitat increased with conifer density. Also, at the scale of individual trees, white spruce and paper birch were strongly preferred over aspen and preferred over balsam poplar to a lesser degree.

In addition to preferring continuous coniferous or mixedwood forests, black-throated green warblers also appear to prefer mature forests. In New Hampshire, Holmes and Sherry (2001) found that abundance increased significantly over 30 years of observations in a deciduous forest. Also, Robichaud and Villard (1999) found that preference for breeding and foraging habitats increased with mean stand diameter at breast height (DBH). Trees with DBH less than 10 cm were not used.

The Local Study Area-Level Model

The model used here for predicting relative probabilities of habitat use by black-throated green warblers was produced by Boyce et al. (2002). Coefficients were calculated using logistic regression on data collected in a 140 km^2 study area of mixedwood boreal forest near Calling Lake in north-central Alberta. Because data arose from point-count surveys and absences were documented, sampling is a presence/absence design. Therefore standard logistic diagnostic tools could be used for model validation (Boyce et al. 2002).

The area under the ROC curve is a well-recognized measure of predictive accuracy for logistic regression equations (Hosmer and Lemeshow 2000). With areas under the ROC curves averaging between 0.8 and 0.9 across eight years of data, this black-throated green warbler model possesses an excellent capability to discriminate between used and unused sites, making it a very strong model

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(Hosmer and Lemeshow 2000). Due to the geographic proximity and ecological similarity of the Calling Lake area to the Oil Sands Region, this model can be applied to the study area with little loss in the reliability of predictions.

Variables required for expression of the warbler model over a digital landscape using GIS were produced following Vernier et al. (2002). Greater specifics on variables were provided by P. Vernier (2006, pers. comm.).

Several variables had to be produced in relation to local and neighbourhood areas around each landscape pixel. The single local variable is mean stand height of forested polygons within a 100-m-radius buffer, referred to as L_HT. Neighbourhood variables are created by calculating habitat characteristics within a 500-m-radius buffer, less a 100-m interior buffer (i.e., an annulus) (Table 7).

Table 7 Variables Calculated Within an Annulus Neighbourhood With a 500 m Outer Buffer and a 100-m Inner Buffer

Variable	Type	Description
L_HT	numeric	mean stand height within forested polygons
N_CUT	numeric	proportion of neighbourhood that is in a clearcut (AVI field MOD1, code CC) less than 15 years old
N_LATE	numeric	proportion of neighbourhood with a stand age (AVI field ORIGIN) of more than 90 years
N_DEC	numeric	proportion of neighbourhood that is greater than 70% deciduous. Percent is on a 0 to 10 scale in the AVI Sp_per fields. Total percent deciduous is calculated by adding up the Sp_per columns every time the associated species is Aw or Bw
N_SW	binary	presence in the neighbourhood of a stand that is greater than 70% white spruce (AVI code Sw in field Sp1, and greater than 7 in associated Sp1_per field)
N_SIMP	numeric	habitat patch diversity as calculated by Simpson's index (defined below). Habitat patches are defined in Table 8

Simpson's Index was calculated by $N\_SIMP = 1 - \sum (p_i)^2$, where p_i is the proportion of the landscape within the annulus neighbourhood of a pixel, occupied by a given habitat type (Vernier 2006, pers. comm.). The landscape was first broken up into habitat types as described in Table 8 using a program code provided by P. Vernier, and modified to accommodate the particular AVI field names and the appropriate date for age calculations.

Table 8 Habitat Classification Structure Used on the Landscape for the Purpose of Calculating Simpson's Index of Diversity

Habitat Class Name	Comments
water	water; if the code in the AVI field NAT_NON is NWL, NWI, or NWR
nonfor	nonforest and wetlands. If there is any code in the AVI field NFL, or if the code in the NAT_NON field is NWF, NMC, NMR, NMS, NMB, or if the code in the MOD1 field is BU or WF since less than 15 years ago
y_decid	>70% deciduous and ≤90 years
o_decid	>70% deciduous and >90 years
w_spruce	>70% coniferous
b_spruce	leading black spruce (Sb or Lt in sp1 field)
pine	leading pine (P, Pl, or Pj in sp1 field)
mixed	mixed deciduous/coniferous (>20% of a stand is deciduous and >20% is coniferous)
ccut	clearcuts (CC in MOD1 field) <15 years old
anthro	anthropogenic (e.g., wellsites, cutlines; CL in MOD1 field, or any value in the ANTH_VEG and ANTH_NON fields)

Coefficients for this model were used as reported in Boyce et al. (2002). Models were then projected onto digital maps using the following form (Manly et al. 2002; Vernier 2006, pers. comm.):

$$w(x) = \frac{\exp(B_0 + B_1 x_1 + ...B_p x_p)}{1 + \exp(B_0 + B_1 x_1 + ...B_p x_p)}$$

The RSF model could not be used for calculating habitat suitability using unaltered closure and reclamation data, which contains only ecophase identification. Therefore, more detailed stand information had to be extrapolated using LSA-specific averages of AVI data per ecophase.

For each ecophase, an average percent overstory species composition was calculated from Oil Sands AVI data, and applied to the closure landscape. Stand ages at closure were calculated using the reclamation schedule. Stand heights at age were estimated using ASRD growth and yield curves for the expected leading species per ecophase. Heights at 50 years per ecophase (i.e., SI(50)) for expected leading tree species were taken from the Canadian Forest Service Field Guide to Ecosites of the Mid-boreal Ecoregions of Saskatchewan (Beckingham et al. 1996). This methodology was applied for closure and reclamation as well as the southern portion of the JEMA LSA for the Base Case and Application Case. To estimate habitat quality at closure, stand ages were assigned assuming closure dates of 2065 and 2049 for the JEMA and PRMA LSAs, respectively. Updated ages at closure outside of the footprint were calculated by subtracting the LSA-specific closure date from AVI stand origin dates.

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The black-throated green warbler RSF model cannot be applied at the RSA level because vegetation data at the landscape scale is too coarse for the model to operate. Vegetation distribution projections do not contain the level of detail regarding stand components that is present in AVI data and required by the model of Boyce et al. (2002). Therefore, a simple scoring (i.e., a simple HSI model) using Landsat-derived vegetation classes was produced, based on an understanding of black-throated green warbler habitat requirements and associations (Table 9). These habitat quality scores were mapped in the RSA using ArcGIS. Due to the current resolution available in Landsat vegetation classification, potentially important variables to black-throated green warblers, such as stand age and distance to edge, could not be included in this scoring system. As nil habitat at Base Case and Application Case is defined as soil disturbances and water bodies only, cutblocks, burns, cutlines and non-treed wetlands present within the LSAs at closure were placed into the 'low' quality habitat class.

Table 9 Estimated Black-Throated Green Warbler Habitat Quality for Vegetation Classes in the Regional Study Area

RSA Vegetation Class	Estimated Habitat Quality
cutblock	nil
burn	nil
coniferous jack pine-black spruce	low
coniferous jack pine	low
coniferous white spruce	high
deciduous aspen-balsam poplar	moderate
mixedwood aspen-white spruce	high
mixedwood aspen-jack pine	moderate
treed bog/poor fen	low
treed fen	low
non-treed wetlands	nil

1.2.3 Barred Owl Resource Selection Function Application

The barred owl is considered "Sensitive" by the province of Alberta, where it is believed that less than 2,000 breeding birds exist (ASRD 2005, website). In a review of over 80 years of records, Priestly (2004) showed that barred owls have been and continue to be distributed throughout much of the boreal forest and aspen parkland, as well as foothill and mountain regions of Alberta.

Habitat Requirements

Barred owls appear to prefer mixedwood forests over 80 years of age in Alberta's boreal forest with a strong preference shown in breeding season. Primarily large balsam poplars are used as nesting trees (Priestly 2004), although aspen and other deciduous tree species may also be used (Allen 1987). Within breeding territories, these owls also show preference for mature mixedwood and deciduous forest stands (Mazur et al. 1998). Young stands, coniferous stands, treed muskegs and open areas appear to be avoided. It has been suggested that wetlands are not preferred or avoided, but they may appear to be preferred if they contain a disproportionate amount of the large, senescent (old) stands of trees in an area (Allen 1987).

The Local Study Area-Level Model

An RSF model was used to represent relative probabilities of occurrences for barred owl nest sites in northeastern Alberta, following the structure set out by Anne Hubbs in an unpublished ASRD report (Hubbs 2007, pers. comm.). This model was developed using location data from 15 barred owl nests located within the Calling Lake and Athabasca areas of northeastern Alberta. "Old coniferous" (i.e., OLDCON) was one of the variables that best explained the distribution of barred owl nests. Given that barred owls prefer to nest in large deciduous trees, these deciduous trees are likely interspersed throughout older coniferous stands. Five random "available" locations were placed around each nest in a GIS environment, with a minimum of 1,050 m between points. Cutblocks and open water were removed from consideration, as these areas are non-habitat for barred owls and therefore should not be considered "available".

Unique variables were first produced in a GIS environment using AVI data. The landscape was pixilated at a 10-m resolution to be consistent with other models in this EIA. In this way, impacts on habitat have consistent meaning across models. Two variables were then produced on the landscape. The first, OLDCON, was intended to represent the amount of old coniferous stands in a neighbourhood for any given location. The variable was produced by first giving a value of 100 to any pixel whose centre fell upon an AVI polygon with a stand age more than or equal to 90 years, and with an overstorey species composition ranging from more than or equal to 80% to less than 100% white spruce, alpine fir, balsam fir or Douglas fir. Any pixel not having these characteristics was given a value of 0. Then, a final value of OLDCON was calculated for each pixel by taking the mean percentage in a 1,000-m-radius neighbourhood. A 1,000-m-radius was chosen as the approximate size of breeding home ranges of barred owls in the study area (Hubbs 2007, pers. comm.).

The second variable, BOG, represents treed muskeg. First, a value of 100 was given to any pixel whose centre overlaid an AVI polygon with an overstorey composed of greater than or equal to 80% black spruce or larch. Pixels with any other characteristic were given a 0. Next, a final value was assigned to each pixel based on a mean percentage of BOG within a 1,000-m-radius neighbourhood.

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Relative probabilities of barred owl occurrence were then calculated for each pixel using the following RSF log linear function (Hubbs 2007, pers. comm.):

W (x) = Exp (15.791 OLDCON – 5.127 BOG)

Due either to eccentricities in the model, or in the characteristics of the LSA landscape, the model produced values at the upper range of predictions that were too large for ArcGIS Version 9.2 to calculate. This resulted in error messages being assigned to high-quality habitat across the landscape. Model builder code in the original model showed that final values had been truncated to allow no value over 650. For ArcGIS to calculate a habitat value for every pixel within the LSAs, calculated habitat values greater than 50 had to be truncated at 50. To some degree, this will likely reduce some of the model output variation within high-quality habitat. However for practical purposes, the extreme predictions put out by the model suggest that output translates into “probably used” and “probably not used”. The landscape distribution of these two categories are not affected by any truncation of model output. The RSF model could not be used for calculating habitat suitability using unaltered closure and reclamation data, which contains only ecophase information. Therefore, more detailed stand information had to be extrapolated using LSA-specific averages of AVI data per ecophase.

For each ecophase, an average percent overstory species composition was calculated from Oil Sands AVI data, and applied to the closure landscape. Stand ages at closure were calculated using the reclamation schedule. This methodology was applied for closure and Reclamation as well as for the southern portion of the JEMA LSA for Base Case and Application Case. For the purposes of estimating habitat quality at closure, stand ages were assigned assuming closure dates of 2065 and 2049 for the JEMA and PRMA LSAs, respectively. Updated ages at closure outside of the footprint were calculated by subtracting the LSA-specific closure date from AVI stand origin dates.

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The barred owl RSF model developed by ASRD requires AVI vegetation cover data. Therefore, it could not be used at the RSA level. Instead, as for black-throated green warblers, simple expert knowledge-based estimates of habitat quality per Landsat-derived vegetation class were produced (i.e., a simple HSI model; Table 10). Due to the current resolution available in Landsat vegetation classification, potentially important variables to barred owls, such as stand age, could not be included in this scoring system. Nonetheless, the predictions of the barred owl HSI model are consistent with expected habitat associations of barred owls at the RSA scale.

Table 10 Estimated Barred Owl Habitat Quality by Vegetation Class in the Regional Study Area

RSA Vegetation Class	Estimated Habitat Quality
cutblock	nil
burn	nil
coniferous jack pine-black spruce	low
coniferous jack pine	low
coniferous white spruce	low
deciduous aspen-balsam poplar	moderate
mixedwood aspen-white spruce	high
mixedwood aspen-jack pine	high
treed bog/poor fen	low
treed fen	low
non-treed wetlands	nil

1.2.4 Canadian Toad Habitat Suitability Index Model

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Canadian toads are known to occur in low numbers, have a wide distribution and occur in isolated areas in the Oil Sands Region. Therefore, habitat modelling techniques used to stratify areas for focused and intensive surveys may be the best means for assessing the status of Canadian toads in northeast Alberta (Westworth 2002). An all-season Canadian toad model was developed for the boreal forest region of Alberta (Golder 2006). The model is focused on suitable overwintering (hibernacula) habitat and also addresses breeding habitats that are near overwintering habitat.

1.2.4.1 Habitat Requirements

Hibernation Substrates

Canadian toads begin to move towards their overwintering habitat in early to mid-September in northern Alberta (Kuyt 1991; Timoney 1996). The main limiting factor affecting Canadian toad distribution is likely the availability of suitable overwintering habitat (Hamilton et al. 1998; Roberts 2003, pers. comm.). Hibernation sites for Canadian toads are communal and involve burrowing below the frostline in loose, coarse-textured soil (Tester and Breckenridge 1964), as it is believed that Canadian toads are not freeze-tolerant and are poor burrowers (Hamilton et al. 1998). These coarse-textured soils facilitate burrowing below the frostline and toad hibernacula have been found to be as deep as 1.17 m (Breckenridge and Tester 1961).

Breeding Habitat

Breeding begins between mid-May and early June in the boreal forest (Tester and Breckenridge 1964). Canadian toads breed in a variety of waterbody types and do not appear to be specific in choosing breeding habitats. Breeding habitats may include natural and man-made ponds, streams, lakes with shallow margins, rivers and ephemeral waterbodies (Westworth 2002; Russell and Bauer 1993; Roberts and Lewin 1979). Canadian toads have been known to use temporary waterbodies, which is thought to reflect a trade-off in risk between desiccation prior to metamorphosis in ephemeral waterbodies and predation pressure in more permanent water sources (Hamilton et al. 1998).

To compensate for potential desiccation, Canadian toads have higher fecundity (i.e., egg production) rates than other toads and amphibians (Roberts and Lewin 1979). Male toads tend to stay close to breeding areas for two months, while females only stay long enough to lay eggs (Roberts and Lewin 1979; Breckenridge and Tester 1961). Breeding season for Canadian toads lasts about two months after which they relocate to upslope areas where they remain until the following breeding season (Hamilton et al. 1998).

Seasonal Movements

Canadian toads travel between wetlands breeding habitat and suitable upland wintering habitat. Most reports have found Canadian toads within 100 m of open water; however, they have been found up to 1,000 m away from breeding areas (Kuyt 1991; Roberts and Lewin 1979). Thus, ideal areas would be suitable overwintering habitats close to breeding habitat.

1.2.4.2 Model Development

Assumptions

The assumptions for the Canadian toad model include:

- overwintering habitat is the critical factor determining toad distribution (Roberts 2003, pers. comm.);
- overwintering habitat will be defined solely on the availability of coarse-textured soils;

- suitable toad habitat occurs within 1,000 m from overwintering habitat;
- any waterbody within 1,000 m of overwintering habitat will have some degree of suitability for breeding;
- toads are not over-selective towards breeding waterbodies; however, permanent waterbodies are likely to be more successful and have higher suitability ratings;
- ephemeral waterbodies will likely not be detected through remote sensing technologies, therefore wintering habitat detected without a water source within the given buffer zones is still assumed to provide valuable toad habitat; and
- although the model is considered to be year-round, overwintering habitat is weighted more than breeding habitat.

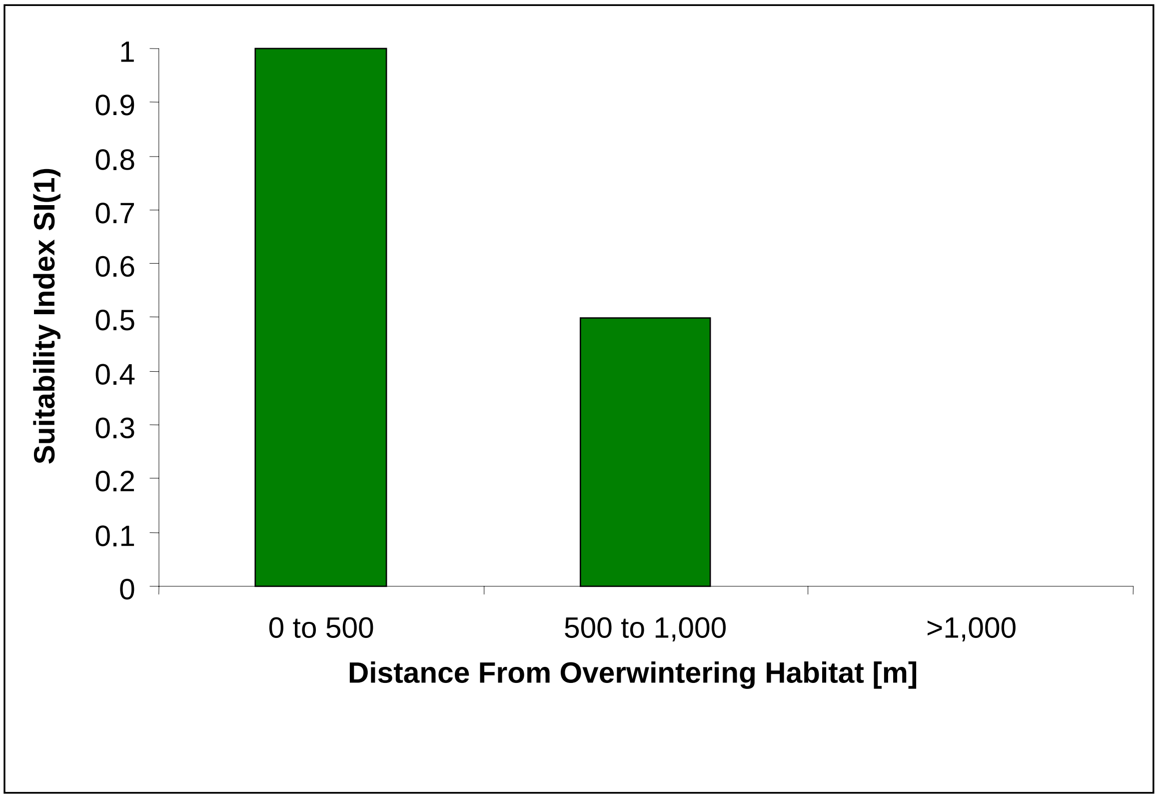
Distance From Overwintering Habitat [SI(1)]

Suitable coarse-textured soils data were obtained primarily from the JEMA and PRMA LSAs soil series maps (Golder 2007b, Figure 12) and the RSA regional soils classification map (Golder 2007b, Figure 9). The coarse-textured soil polygons were then buffered for 500 and 1,000 m from polygon edge. Each of these buffers was weighted to describe the probability of toads occurring near coarse-textured soils. The weighted values are as follows with 1 indicating the highest suitability (Figure 2):

- 0 to 500 m = 1;
- 500 to 1,000 m = 0.5; and
- greater than 1,000 m = 0

As indicated in the assumptions, the premise for this model is that overwintering habitat is a limiting factor for toads; therefore, overwintering habitat is weighted at 60% of the overall suitability index.

Figure 2 **Canadian Toad Suitability Index in Relation to Distance From Over-Wintering Habitat [SI(1)]**



Breeding Habitat [SI(2)]

Toads use a variety of waterbody types for breeding; thus all waterbody types were assumed to be suitable for breeding habitat. River and stream line coverages were buffered by 50 m and incorporated as suitable breeding habitat. At the LSA scale, vegetation types likely to possess ephemeral waterbodies were also given a HSI ranking. However, due to the scale at which mapping occurs for the RSA (i.e., 30-m pixels), there are likely suitable ephemeral waterbodies that are not captured in the spatial coverage and are therefore not accounted for. Breeding habitat is weighted at 40% of the overall suitability score and Suitability Index (SI) values were assigned as detailed in Table 11.

Table 11 Canadian Toad Breeding Habitat Suitability by Wetlands Type in the Local Study Area [SI(2)]

Habitat Suitability Class	Ecotype	Habitat Suitability Index
high	marsh (MONG)	1
	shallow open water (WONN)	1
	rivers and streams (buffered 50 m)	1
	deep water	0.75
moderate	graminoid fen (FONG)	0.5
	shrubby fen (FONS)	0.5

At the RSA scale, breeding habitat suitability was much simpler because habitat classification at the RSA scale is at a lower resolution (Table 12).

Table 12 Canadian Toad Breeding Habitat Suitability by Land Cover Class in the Regional Study Area [SI(2)]

Habitat Suitability Class	Land Cover Class	Habitat Suitability Index
high	water	0.75
moderate	non-treed wetlands	0.5

Model Equation

The overall HSI value for habitat within 1,000 m of overwintering habitat is derived as follows:

HSI = [(SI[1]) (0.6)] + [(SI[2]) (0.4)]

As travel beyond 1,000 m from overwintering habitat is extremely rare, all habitat beyond the 1,000-m buffer is considered nil habitat (i.e., HSI = 0).

Calculations of habitat loss due to disturbance at both the LSA and RSA scale include the additional project effect of wetlands drainage. This water table drawdown is represented by a 0.1 m drawdown isopleth. Within the drawdown, SI(2) values for marshes (MONG), shallow open water (WONN), graminoid fens (FONG) and shrubby fens (FONS) become zero.

Validation

There are very little Canadian toad habitat data for the boreal forest region of Alberta. However, Canadian toads have been detected during several amphibian Base Case surveys within the Oil Sands Region. To validate the above model, all Canadian toad observations within the Biological Species Observation Database (BSOD 2004) were acquired from ASRD and were overlaid on the habitat suitability coverage created for the Athabasca Oil Sands.

Two main analyses were performed. First, Manly`s standardized selection ratio (Manly et al. 1972, 2002) was used to quantify observed preference for each of the three projected habitat types (low, moderate and high). Second, a likelihood ratio test, otherwise known as a G-test, was performed to detect significant differences between classes. The G-test is advocated over the more traditional chi-square test, mainly for being slightly more accurate (Sokal and Rohlf 1995). Canadian toad HSI model validation results are shown in Table 13.

Table 13 Validation Results for the Canadian Toad Habitat Suitability Index Model

Habitat Suitability Index Class	Manly's Standardized Selection Ratio	G-test Result
high	0.57	significant
moderate	0.30	
low	0.13	

1.2.5 Black Bear

The boreal forest in Canada comprises the largest continuous area of occupied black bear habitat in North America (Young and Ruff 1982). Black bears are considered fairly common in the Oil Sands Region (Golder 2007a). The model emphasizes summer and fall (berry feeding season) habitat selection by black bears.

1.2.5.1 Habitat Requirements

Food

The feeding behaviour of black bears varies in response to the seasonal availability of certain foods. In the Cold Lake area of east central Alberta, scat analysis revealed that carrion formed a large part of the diet of black bears in the spring when other foods are unavailable (Young and Ruff 1982). Plant foods were more widely available during summer and fall (Young and Ruff 1982). Black bears rely heavily on berries such as blueberry, saskatoon, low-bush cranberry, buffaloberry, rose, current, raspberry, bearberry and bunchberry as a major food source in summer and early fall (Ruff 1978). Berry consumption allows black bears to store enough energy for over-winter survival and reproduction.

Cover

Black bears are well adapted to forested environments and use forest cover to avoid humans and other bears. Dense shrub cover and adequate mature trees and canopy cover provide optimal habitat for resting, travelling and escape (Zapisocki et al. 1998). Extensive open areas are generally avoided except when feeding.

1.2.5.2 Model Development

Assumptions

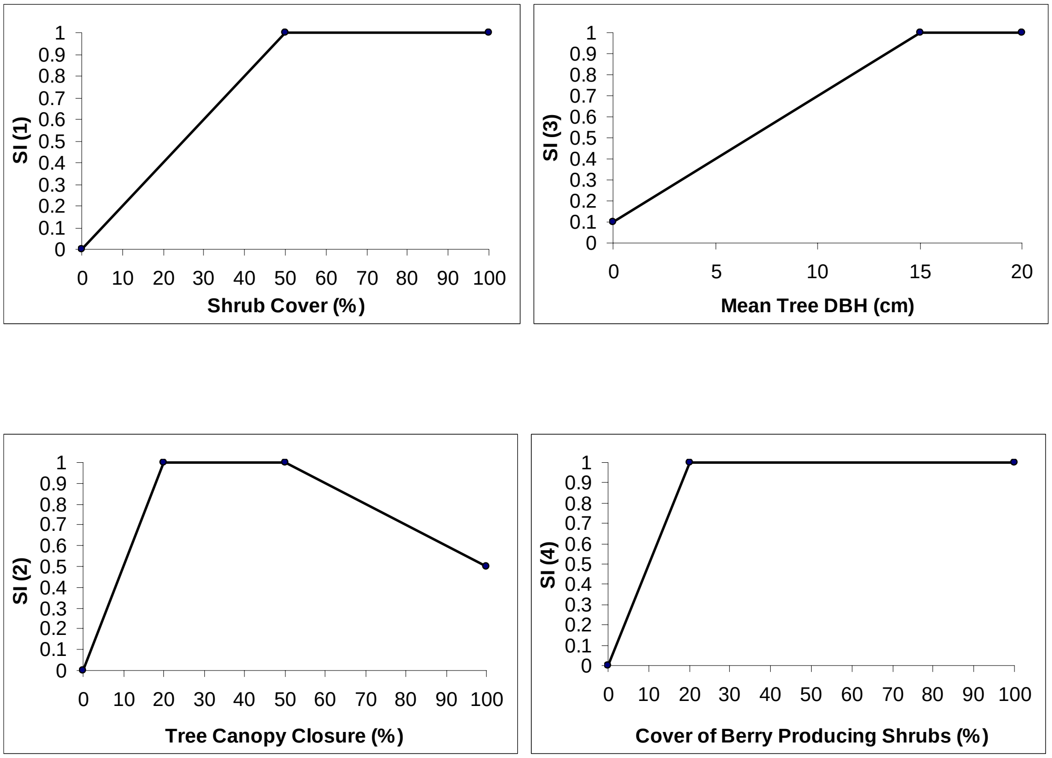
The assumptions for the black bear HSI model are that black bear:

- are highly dependant on the availability of berries in late summer and early fall;
- use cover for security from humans and other bears; and
- averages of stand characteristics at the local scale can reasonably be extrapolated across the regional scale using overlapping Landsat vegetation classes.

Shrub Cover

Shrub cover is derived by summing the percent cover of tall shrubs in the understorey that include jack pine, white spruce, black spruce, fir, tamarack, aspen, balsam poplar, paper birch, alders, saskatoon, dwarf birch, dogwood, hazelnut, cherries, willow and low-bush cranberry. A stand with no shrub cover is considered unsuitable. Over the range of 0 to 50% shrub cover, the shrub cover Suitability Index SI(1) increases to the optimum, 1.0. From 50 to 100% shrub cover, the suitability remains optimum (Figure 3).

Figure 3 Suitability Index Values in Relation to Habitat Variables in the Black Bear HSI Model



Tree Canopy Closure

Areas with no tree canopy closure are considered unsuitable. There is a linear increase from 0% closure to a 1 suitability value at 20% canopy closure. The optimal suitability value (i.e., 1) for this variable is between 20 and 50% cover with a linear decrease from a 1 suitability value at 50% canopy closure to 0.5 suitability value at 100% canopy closure (Figure 3). Increasing tree canopy closure beyond 50% reduces berry production (Hamer 1996; Martin 1983).

Mean Tree Diameter at Breast Height

The suitability for escape cover SI(3) increases from 0.1 (DBH = 0) to 1 (DBH = 15 cm) as tree diameter increases. For all trees greater than 15 cm, the suitability is optimum (Figure 3).

Cover of Berry Shrubs

Berry shrub cover was determined by summing the percent cover of buffaloberry, blueberry, saskatoon, low-bush cranberry, pin/choke cherry, currant/gooseberry and raspberry.

For this model, areas with no berry-producing shrubs are considered unsuitable [SI(4) = 0]. Suitability increases to optimum over the range of 0 to 20% shrub cover and remains optimum at all higher values (Figure 3).

Food and Cover Habitat Suitability Index Equations

As shrub cover, mean tree diameter at breast height and shrub cover by species are not available in AVI data, averages of these values were calculated from field vegetation survey plots per ecotype for the LSA scale, and per land cover class at the RSA scale. The total HSI value for cover across scales was then derived from the following equation involving SI(1) and SI (3):

HSI Cover = (SI[1] + SI[3])/2

For both scales, the HSI food was directly related to SI(4):

HSI Food = SI(4)

Overall Habitat Suitability Index Equation

The overall HSI for bear habitat was determined by weighting the value of food at 70% and cover at 30% in a weighted average.

HSI Overall = [(0.7 x HSI Food) + (0.3 x HSI Cover)] x DC

A site with no cover could be considered suitable habitat for black bears if food is available and vice versa, but it cannot have optimum conditions unless both food and cover are high. The overall HSI is then reduced by the disturbance coefficient within zones of influence of developments.

Habitat Effectiveness

A 250 m zone of influence buffer was applied to roads and industrial facilities, within which all HSI values are multiplied by a disturbance coefficient of 0.5. Habitat surrounding roads and facilities is penalized because bears may actively avoid these areas (*e.g.*, Aune 1994). Also, even if they are not actively avoided, habitat near human access tends to produce high rates of direct (e.g., road collisions; Brody and Pelton 1989) and indirect mortality (e.g., access for hunters; Manville 1983), thus reducing its effective habitat quality.

Effects of water table drawdown are represented by a 0.1-m drawdown isopleth around the mine footprint. Within that isopleth, HSI scores are multiplied by 0.5 to give a total habitat effectiveness score across the landscape.

Validation

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This HSI model is based on expert opinion and ecological relationships that are supported by the literature. Its assumptions, structure and output are in line with what is known of black bear behaviour, and as such it has value as a management tool. However, sufficient black bear location data are not available within the LSAs or the RSA to validate the model and quantify predictive strength.

1.2.6 Beaver

The beaver HSI model was adapted from one developed by Westworth, Brusnyk and Associates (1996) for the Suncor Steepbank Mine study area and used most recently in the Suncor Voyageur South EIA (Suncor 2007). This model assesses beaver habitat by first determining the proximity of terrestrial habitat to suitable open water (i.e., low gradient rivers, creeks, ponds, or marshes). The model then determines the availability of food and cover in areas surrounding open water.

1.2.6.1 Habitat Requirements

Food

Water is the most important factor affecting beaver habitat in that beavers cannot survive for long in areas where the water supply fluctuates or is fast-moving (Novak 1999). Ideal beaver habitat includes ponds, small lakes with muddy bottoms and meandering streams (Novak 1999). Beavers feed primarily on deciduous shrubs and trees within a limited zone surrounding open water. Jenkins (1980) reported that beaver foraging extended 100 m from the edge of waterbodies.

Cover

Beavers use cover provided by the canopy of large trees and shrubs when travelling and foraging on land.

1.2.6.2 Model Development

Assumptions

The assumptions for the beaver model are that:

- critical habitat includes low-gradient rivers, creeks, ponds and marshes;
- the bark of deciduous trees and shrubs is their main food source;
- the cover provided by both trees and shrubs is required; and
- averages of stand characteristics at the local scale can reasonably be extrapolated across the regional scale using overlapping Landsat vegetation classes.

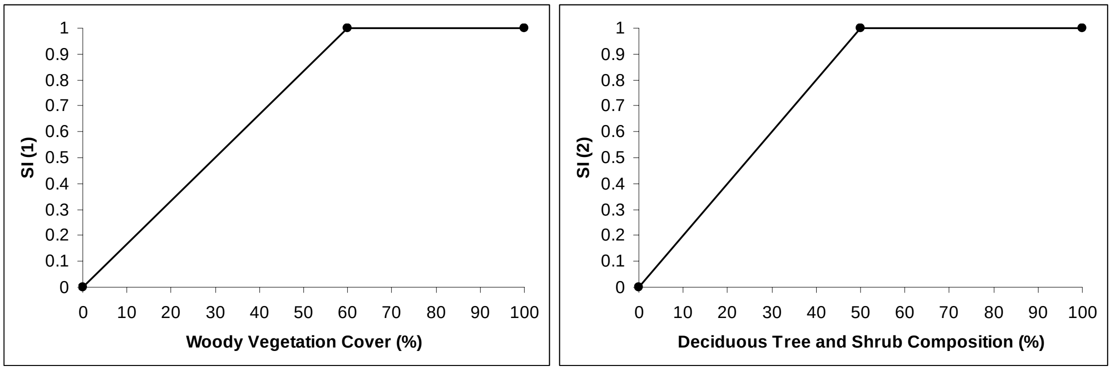
Distance From Water

All open water and marshes in the LSAs and RSA were considered suitable habitat for beavers. These waterbodies and marshes were buffered by a distance of 100 m to identify suitable adjacent habitat on land. Areas greater than 100 m from the waterbodies and marshes were considered unsuitable habitat for beavers.

Woody Vegetation Cover [SI(1)]

Within the 100-m zone, woody vegetation cover was determined as the total canopy cover of trees and shrubs. Over the range 0 to 60% cover, the cover suitability index SI(1) increases from 0 to 1. The cover suitability index SI(1) remains optimal for woody vegetation cover values greater than 60% (Figure 4).

Figure 4 Suitability Index Values in Relation to Habitat Variables in the Beaver HSI Model



Deciduous Tree and Shrub Composition [SI(2)]

Deciduous tree and shrub composition was determined as the relative percentage of deciduous trees and shrubs that make up the woody vegetation cover and is determined as the sum of the deciduous tree cover and selected species of deciduous shrub cover divided by the total woody vegetation cover:

(aspen trees + aspen shrubs + balsam poplar trees + balsam poplar shrubs + paper birch trees + paper birch shrubs + alder + saskatoon + dwarf birch + dogwood + hazelnut + cherry + willow + low-bush cranberry)/(total tree + shrub cover) x 100.

The deciduous composition suitability index SI(2) increases from 0 to 1 over the range of 0 to 50%. Suitability remains optimal for composition values greater than 50% (Figure 4).

Overall Habitat Suitability Index Equation

As shrub cover detail is not available in AVI data, averages of woody vegetation cover and deciduous tree and shrub composition were calculated from field vegetation survey plots per ecotype for the LSA scale and per land cover class at the RSA scale.

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The HSI model for beavers assumes that the suitability values for adjacent terrestrial habitat are equally significant in determining what qualifies as suitable habitat for beavers. The overall HSI model is calculated as:

- HSI = [SI(1)] x [SI(2)], for terrestrial habitat areas within 100 m of the waterbodies or marshes;
- HSI = 1 for all aquatic habitats (waterbodies and marshes); and
- HSI = 0 for areas more than 100 m from aquatic habitats.

Calculations of habitat loss due to disturbance at both the LSA and RSA scale include the additional effect of water table drawdown. This water table drawdown is simulated by a 0.1-m drawdown isopleth. All marshes falling within this isopleth are considered to have a nil habitat value.

1.2.7 Yellow Rail

This yellow rail (*Corturnicops noveboracensis*) model was developed by Golder specifically for this EIA. The yellow rail is considered a species of special concern by the Committee on the Status of Endangered Wildlife

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(COSEWIC 2007). In Alberta, this bird has "Undetermined" status due to a lack of information on population size and trends.

1.2.7.1 Habitat Requirements

The yellow rail occupies sedge meadow wetlands with little or no standing water (Prescott et al. 2002). Beckingham and Archibald (1996) describe yellow rail habitat as wetlands dominated by sedge and reed grasses, with brown moss and less than 10% willow cover (i.e., FONG or MONG). Based on current knowledge of yellow rail habitat, non-patterned, open, shrub (i.e., FONS) and graminoid (i.e., FONG) dominated fens and graminoid marshes as described by Halsey et al. (1997) are classified as good yellow rail habitat. When yellow rails have been recorded in the Oil Sands Region, they have occurred in wetlands (e.g., AXYS 2005).

1.2.7.2 Model Development

As yellow rails appear to exhibit fairly narrow habitat requirements, the model functions to differentiate between "good" habitat and non-habitat. It considers FONS, FONG and MONG wetlands at the LSA scale to be yellow rail habitat. At the RSA scale, lower resolution wetlands differentiation required that all non-treed wetlands be considered yellow rail habitat. Calculations of habitat loss due to disturbance at both the LSA and RSA scale include the additional project effect of wetlands drainage. This water table drawdown is represented by a 0.1 m drawdown isopleth. FONS, FONG and MONG wetlands that fall within the drawdown are considered non-habitat.

1.3 RESULTS

Habitat suitability modelling results for the LSAs and RSA at the Base Case, Application Case and closure scenario are presented below.

Variables that were strong predictors of habitat quality at Base Case in the LSAs (e.g., stand age, distance to edge and distance to linear disturbance features) were not available for the closure scenario because stand dynamics and natural disturbances were not simulated spatially over time, and disturbances are absent. Therefore, all species for which RSF models were applied at the Base Case in the LSAs required the application of models produced for use at the RSA scale to estimate habitat at closure. As a result of the use of different models at Base Case and at closure, habitat classified in the Base Case could be classified differently in the closure landscape even though the area was not affected by the Project (e.g., area outside the Project footprint classified as high-quality habitat for moose could be rated lower at closure). This scenario for determining the impact to wildlife habitat was considered preferable to using untested HSI models with their inherent immeasurable errors in both the Base Case and closure scenarios.

Errors in calculating area for the toad model arose due to overlapping buffers, the large areas being analyzed, and software bugs within ESRI ArcGIS 9.2. These software bugs lie within the geodatabase file format, as well as the geoprocessing tools (note: ESRI has been made aware of these bugs, but they are unresolved as of the time of completion of this report). However, the average resulting error is effectively negligible, amounting to a 0.019% increase in total area at the LSA scale, and 0.0018% increase at the RSA scale. Regarding the fisher/marten, moose and lynx models at the RSA scale, total areas underestimate actual area of the RSA by 21 ha (0.0009%). This error is due to the procedure used for defining the RSA extent for these models, but its effect is considered negligible.

1.3.1 Local Study Area Scale

Results from HS modelling at the LSA scale for the Base Case, Application Case and closure Scenarios are summarized in Table 14. This summary is for the Project related impact within the combined JEMA and PRMA LSAs. A summary of HS modelling results separated by LSA can be found in Tables B1 and B2, respectively (Attachment II). All habitat quality assessments are the result of predictive model output as described in the previous section. The HS maps for all species listed in Table 14 are provided for the LSAs and RSA in Figures 5 to 31.

1.3.1.1 Base Case

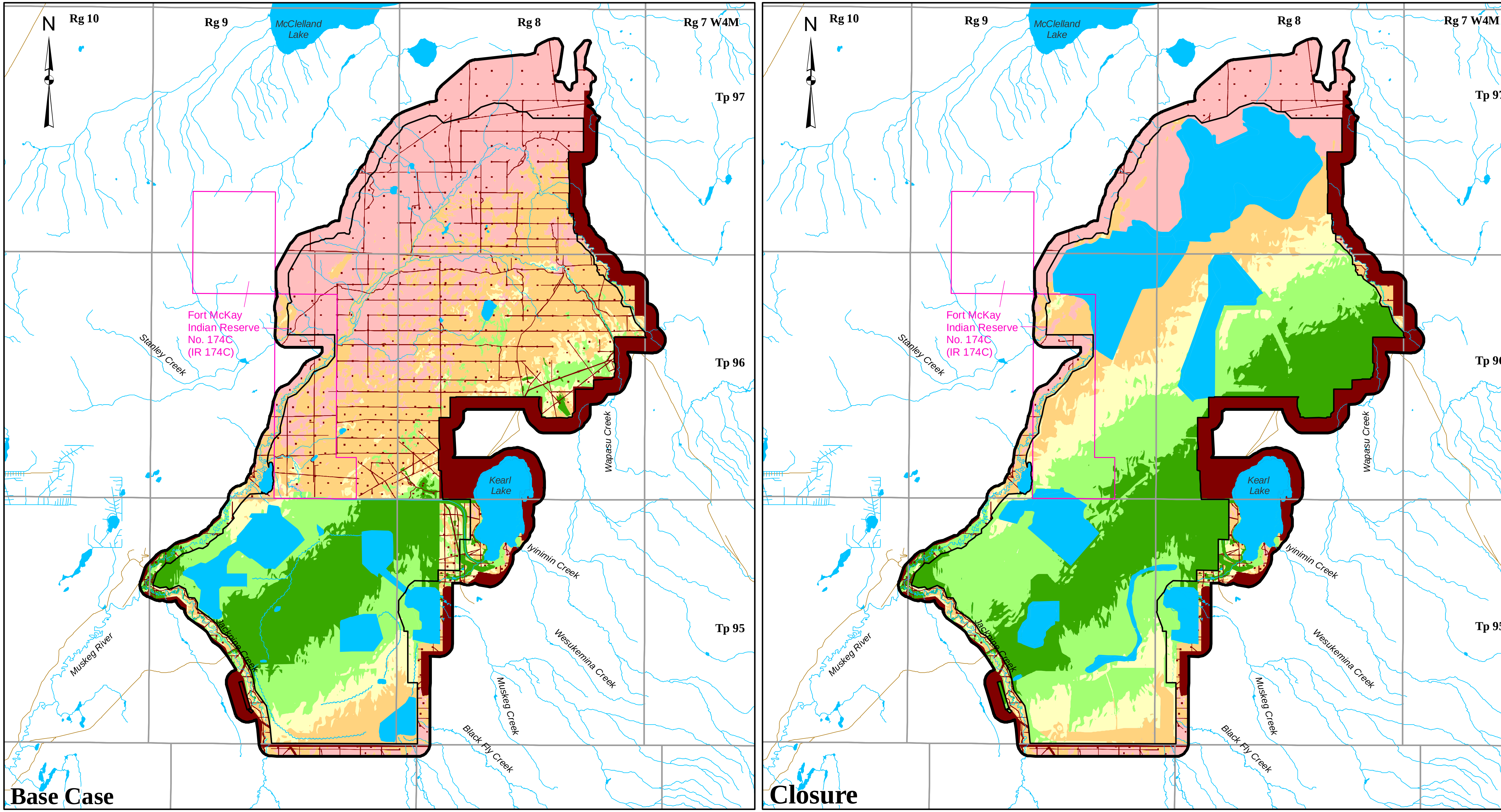
The moose model predicts that moose habitat is approximately 17% high quality and 19% moderate high quality on the landscape in the Base Case (Table 14). Lynx habitat is predicted to be about 28% high quality and 25% moderate high quality at Base Case. High-quality habitat for fisher/marten accounts for 26% of the landscape at Base Case, while moderate high-quality habitat takes up about 30%. For black-throated green warbler, the landscape at Base Case is dominated by low-quality habitat (78%), while high-quality habitat makes up only 3%. Barred owl habitat at Base Case is split fairly evenly between low- (41%) and high-quality habitat (48%). For black bear, the high-quality habitat makes up about 30% of the combined JEMA and PRMA LSAs. High-quality habitat for Canadian toads, beaver and yellow rail make up 11, 15 and 12% of the combined LSAs, respectively (Table 14).

Table 14 Wildlife Habitat Change Within the Combined Jackpine Expansion and Pierre River Mining Areas Local Study Areas: Application Case

Key Indicator Resource	Habitat Suitability Class	Base Case Habitat		Direct Habitat Change Due to Site Clearing of the Project and Jackpine Mine – Phase 1		Indirect Habitat Change Due to the Project and Jackpine Mine – Phase 1		Net Change From the Project and Jackpine Mine – Phase 1		Closure	
		Habitat Area [ha]	% of LSAs	Change in Habitat Area [ha]	Change [%]	Change in Habitat Area [ha]	Change [%]	Change in Habitat Area [ha]	Change [%]	Change From Base Case to Closure [ha]	Change [%]
moose	nil	5,622	11.1	30,572	543.8	0	0	30,572	543.8	4,178	74.3
	low	8,950	17.7	-6,439	-71.9	0	0	-6,439	-71.9	-5,014	-56.0
	moderate low	13,103	25.9	-10,069	-76.8	0	0	-10,069	-76.8	-7,130	-54.4
	moderate	4,994	9.9	-3,461	-69.3	0	0	-3,461	-69.3	-428	-8.6
	moderate high	9,596	18.9	-5,783	-60.3	0	0	-5,783	-60.3	1,697	17.7
	high	8,374	16.5	-4,820	-57.6	0	0	-4,820	-57.6	6,697	80.0
Canada lynx	nil	5,622	11.1	30,572	543.8	0	0	30,572	543.8	4,178	74.3
	low	4,235	8.4	-2,712	-64.0	0	0	-2,712	-64.0	-4,228	-99.8
	moderate low	4,225	8.3	-3,714	-87.9	0	0	-3,714	-87.9	-2,174	-51.5
	moderate	9,766	19.3	-7,897	-80.9	0	0	-7,897	-80.9	-3,120	-32.0
	moderate high	12,413	24.5	-8,952	-72.1	0	0	-8,952	-72.1	2,741	22.1
	high	14,379	28.4	-7,298	-50.8	0	0	-7,298	-50.8	2,603	18.1
fisher/marten	nil	5,622	11.1	30,572	543.8	0	0	30,572	543.8	4,178	74.3
	low	2,749	5.4	-2,281	-83.0	0	0	-2,281	-83.0	74	2.7
	moderate low	4,876	9.6	-3,057	-62.7	0	0	-3,057	-62.7	-1,358	-27.9
	moderate	9,000	17.8	-5,811	-64.6	0	0	-5,811	-64.6	-3,410	-37.9
	moderate high	15,100	29.8	-10,429	-69.1	0	0	-10,429	-69.1	-4,229	-28.0
	high	13,293	26.2	-8,995	-67.7	0	0	-8,995	-67.7	4,746	35.7
black-throated green warbler	nil	5,622	11.1	30,572	543.8	0	0	30,572	543.8	4,178	74.3
	low	39,685	78.4	-26,663	-67.2	0	0	-26,663	-67.2	-11,875	-29.9
	moderate	3,688	7.3	-2,597	-70.4	0	0	-2,597	-70.4	1,415	38.4
	high	1,644	3.2	-1,312	-79.8	0	0	-1,312	-79.8	6,282	382.1
barred owl	nil	5,622	11.1	30,572	543.8	0	0	30,572	543.8	4,178	74.3
	low	20,955	41.4	-16,466	-78.6	0	0	-16,466	-78.6	6,959	33.2
	high	24,062	47.5	-14,106	-58.6	0	0	-14,106	-58.6	-11,137	-46.3

Table 14 Wildlife Habitat Change Within the Combined Jackpine Expansion and Pierre River Mining Areas Local Study Areas: Application Case (continued)

Key Indicator Resource	Habitat Suitability Class	Base Case Habitat		Direct Habitat Change Due to Site Clearing of the Project and Jackpine Mine – Phase 1		Indirect Habitat Change Due to the Project and Jackpine Mine – Phase 1		Net Change From the Project and Jackpine Mine – Phase 1		Closure	
		Habitat Area [ha]	% of LSAs	Change in Habitat Area [ha]	Change [%]	Change in Habitat Area [ha]	Change [%]	Change in Habitat Area [ha]	Change [%]	Change From Base Case to Closure [ha]	Change [%]
Canadian toad	nil	19,148	37.7	18,724	97.8	0	0.0	18,724	97.8	-5,837	-30.5
	low	3,645	7.2	-3,062	-84.0	18	0.5	-3,044	-83.5	275	7.5
	moderate	22,506	44.3	-12,406	-55.1	76	0.3	-12,330	-54.8	5,253	23.3
	high	5,521	10.9	-3,260	-59.1	-95	-1.7	-3,355	-60.8	303	5.5
black bear	nil	5,622	11.1	30,572	543.8	0	0.0	30,573	543.8	4,116	73.2
	low	20,917	41.3	-16,622	-79.5	508	2.4	-16,114	-77.0	-14,947	-71.5
	moderate	9,007	17.8	-6,160	-68.4	720	8.0	-5,440	-60.4	5,774	64.1
	high	15,093	29.8	-7,790	-51.6	-1,229	-8.1	-9,019	-59.8	5,057	33.5
beaver	nil	39,618	78.2	6,938	17.5	0	0	6,938	17.5	-4,838	-12.2
	low	2,023	4.0	-1,457	-72.0	0	0	-1,457	-72.0	887	43.8
	moderate	1,428	2.8	-1,003	-70.2	0	0	-1,003	-70.2	-953	-66.7
	high	7,569	14.9	-4,479	-59.2	0	0	-4,479	-59.2	4,905	64.8
yellow rail	nil	44,652	88.2	4,937	11.1	208	0.5	5,145	11.5	4,937	11.1
	high	5,987	11.8	-4,938	-82.5	-207	-3.5	-5,145	-85.9	-4,938	-82.5



LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

MOOSE HABITAT SUITABILITY
IN THE JACKPINE EXPANSION MINING AREA
LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 5	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

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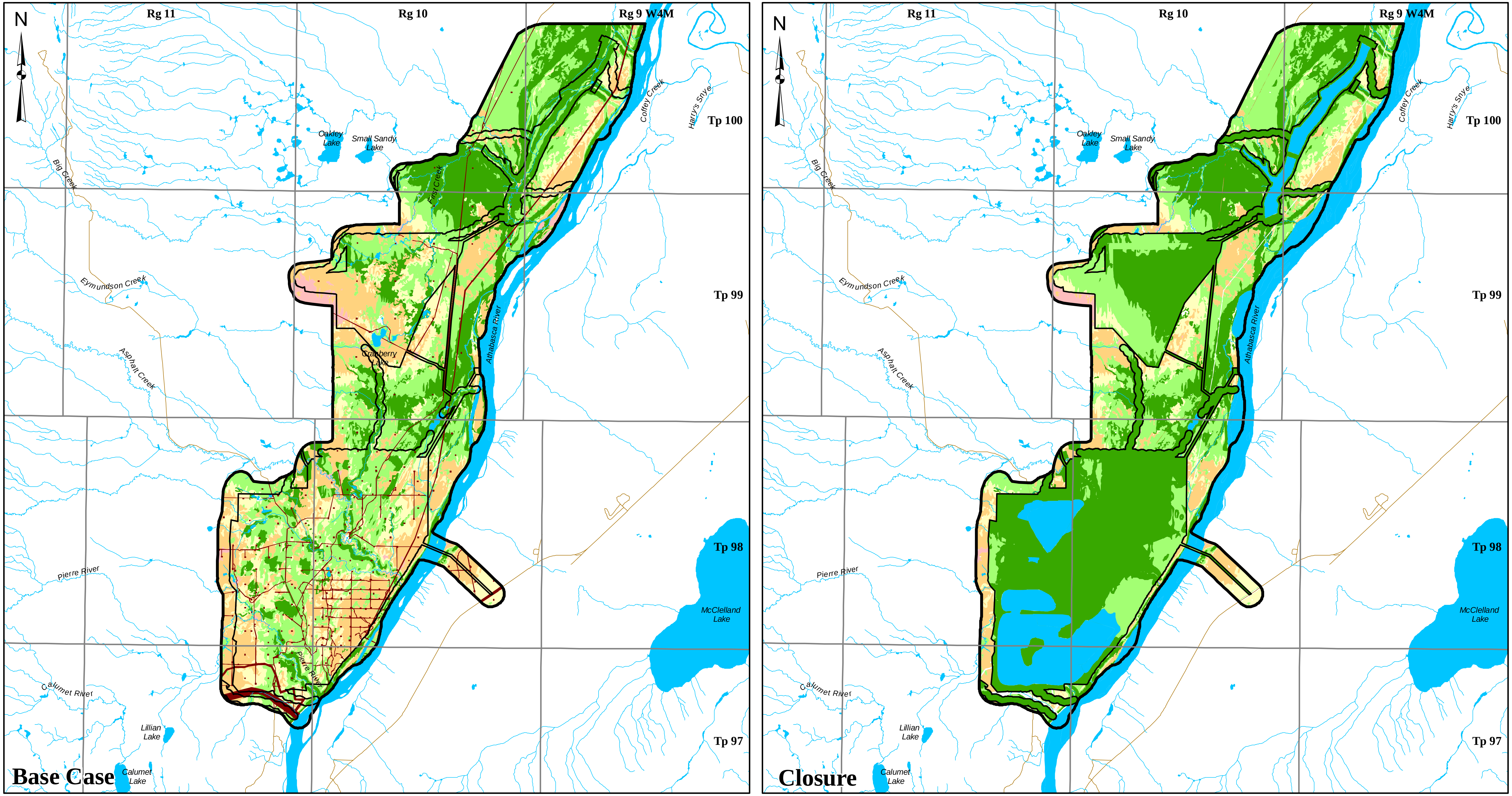

LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE
MOOSE HABITAT SUITABILITY IN THE
PIERRE RIVER MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
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CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 6

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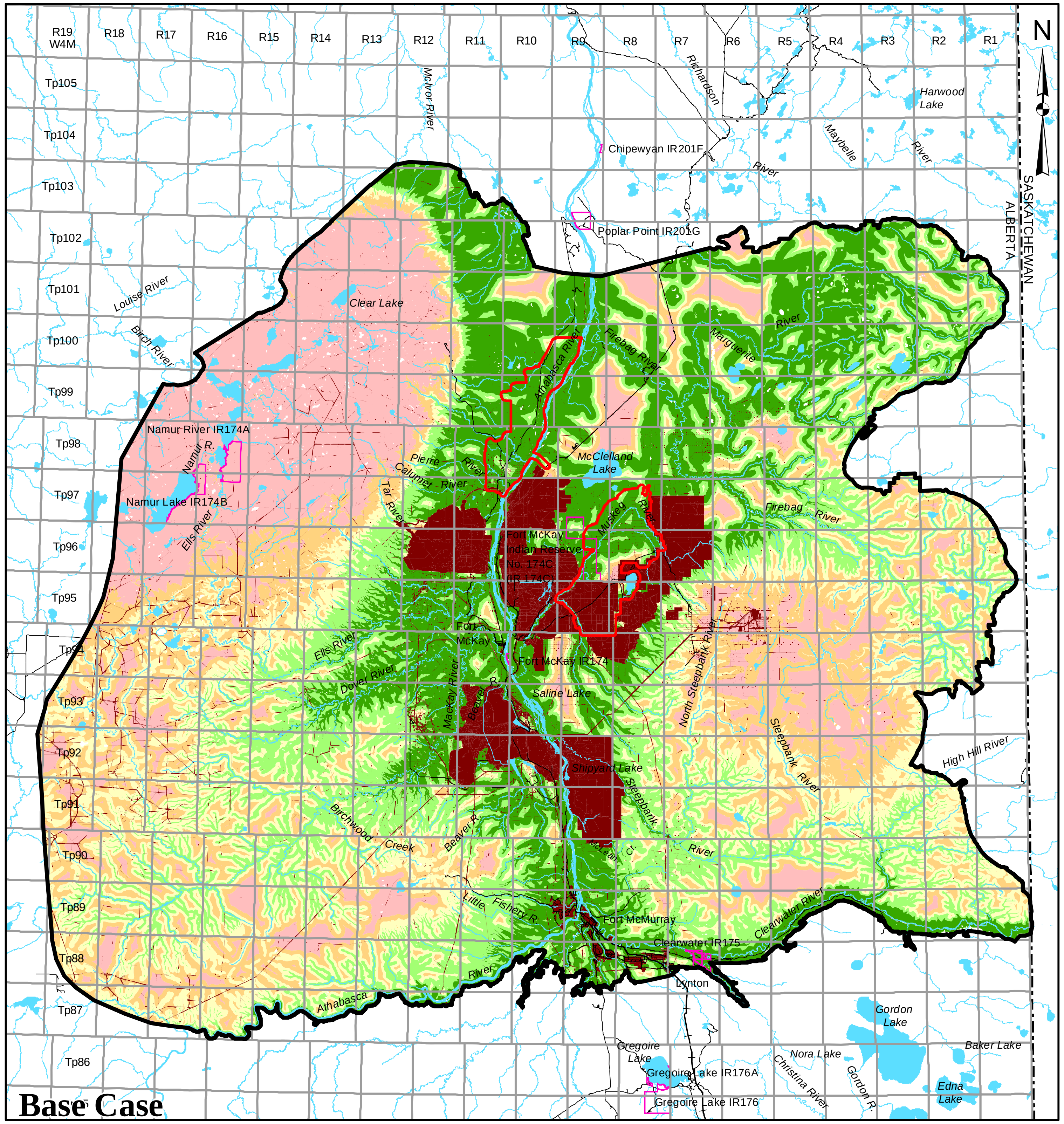

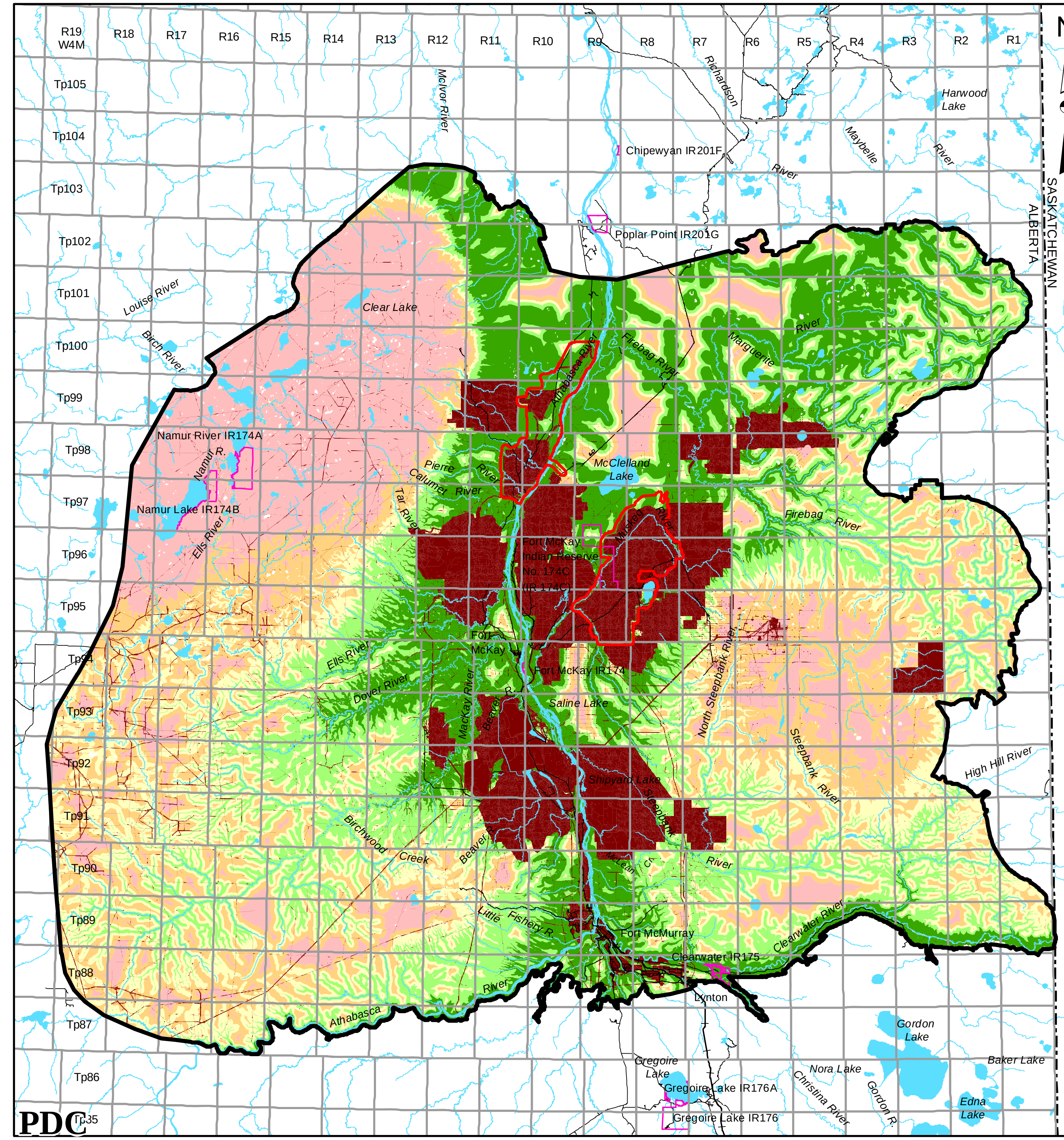

LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

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SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

MOOSE HABITAT SUITABILITY
IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
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CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

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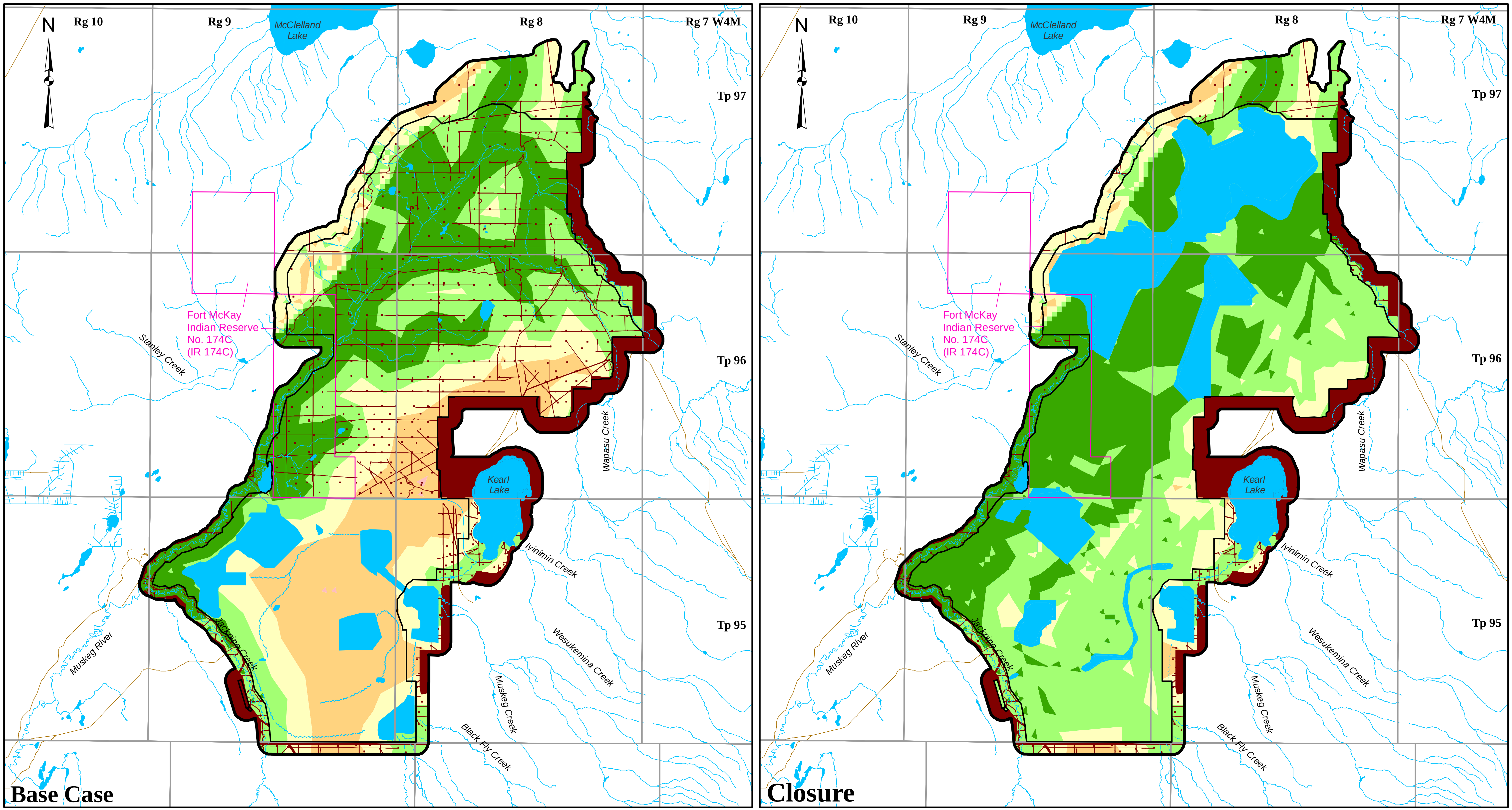

LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT: JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE: CANADA LYNX HABITAT SUITABILITY IN THE JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
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CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

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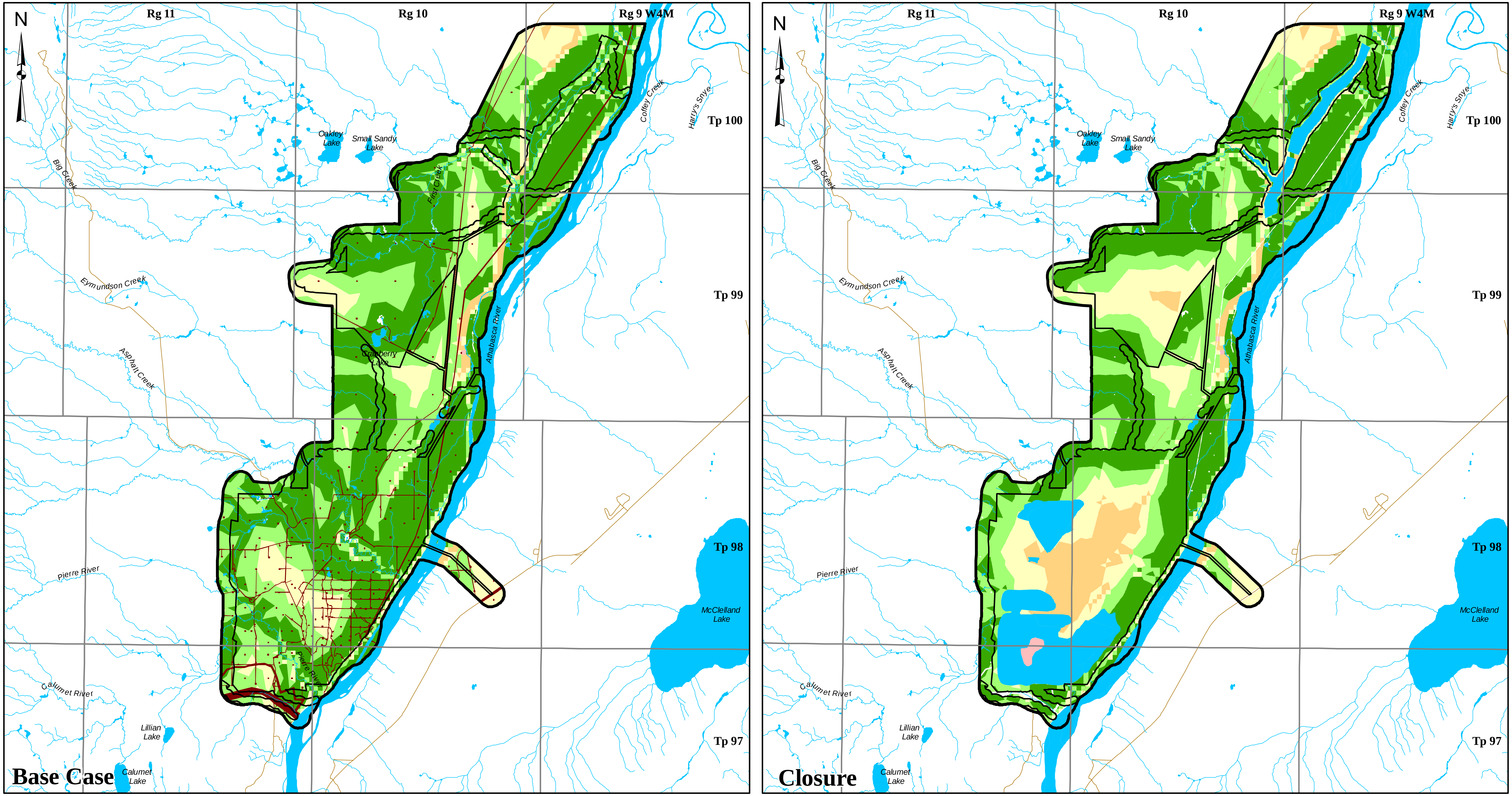

LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE
CANADA LYNX HABITAT SUITABILITY IN THE PIERRE RIVER MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
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REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 9

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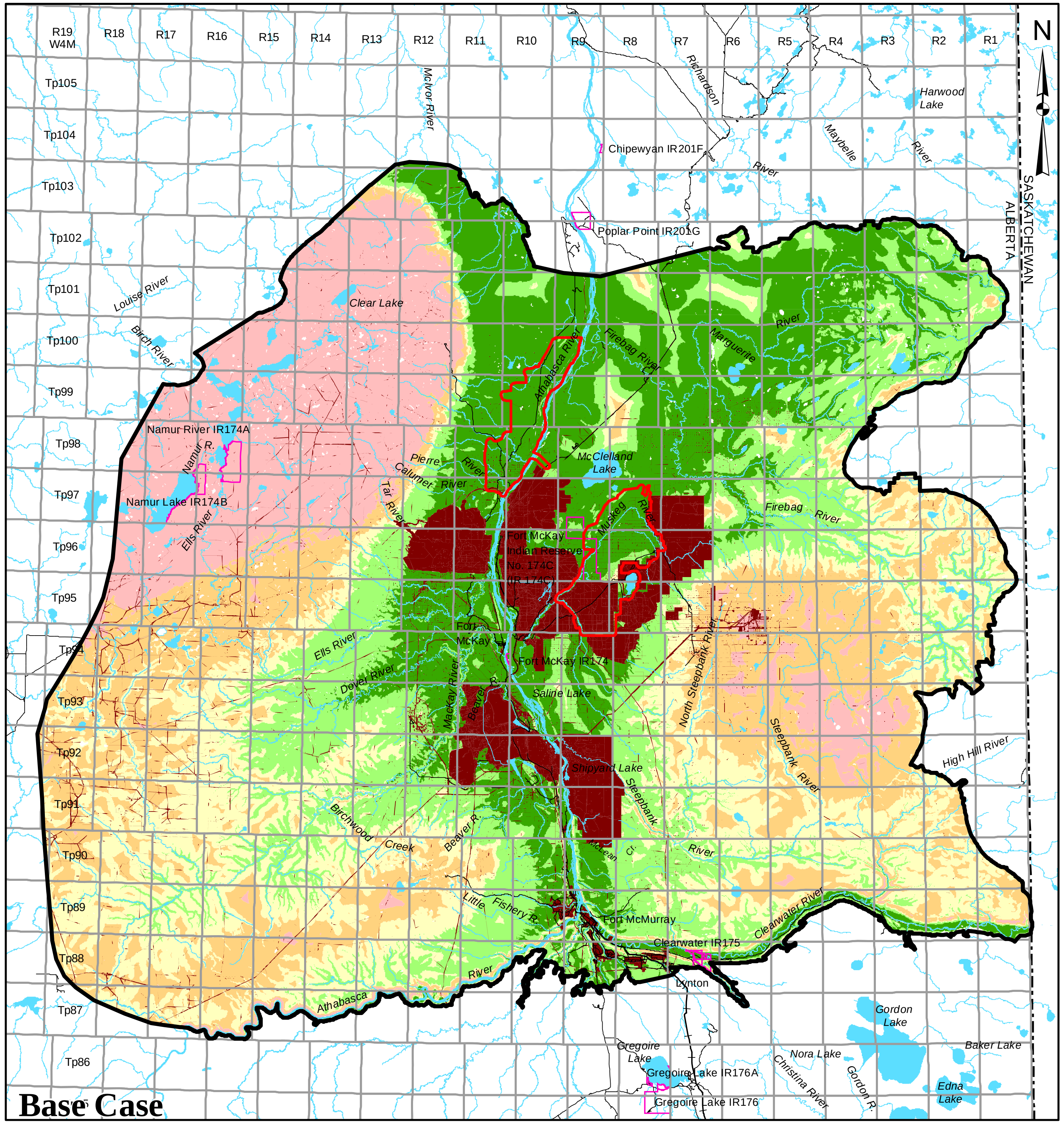

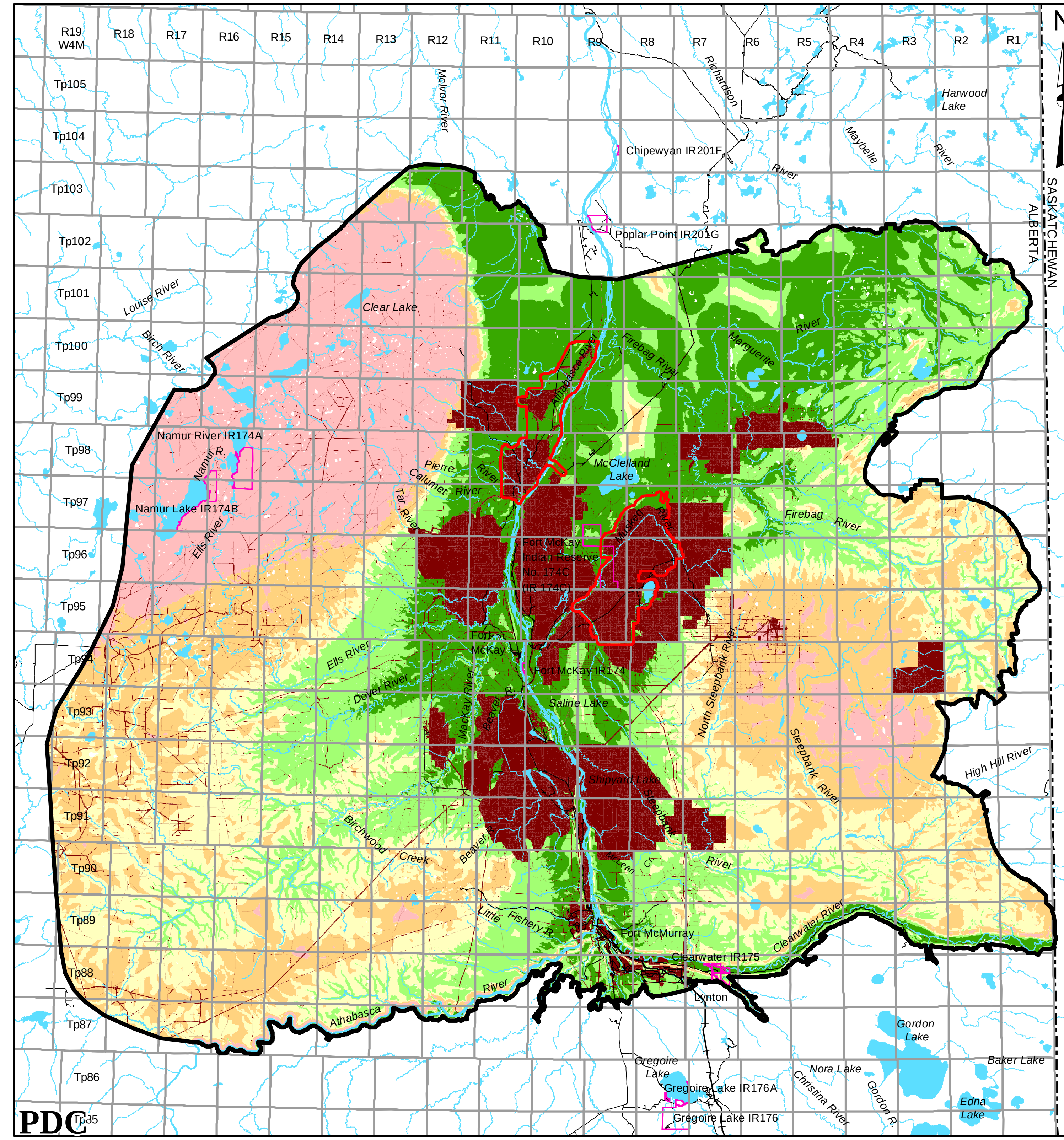

LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

DRAFT

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE
CANADA LYNX HABITAT SUITABILITY IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
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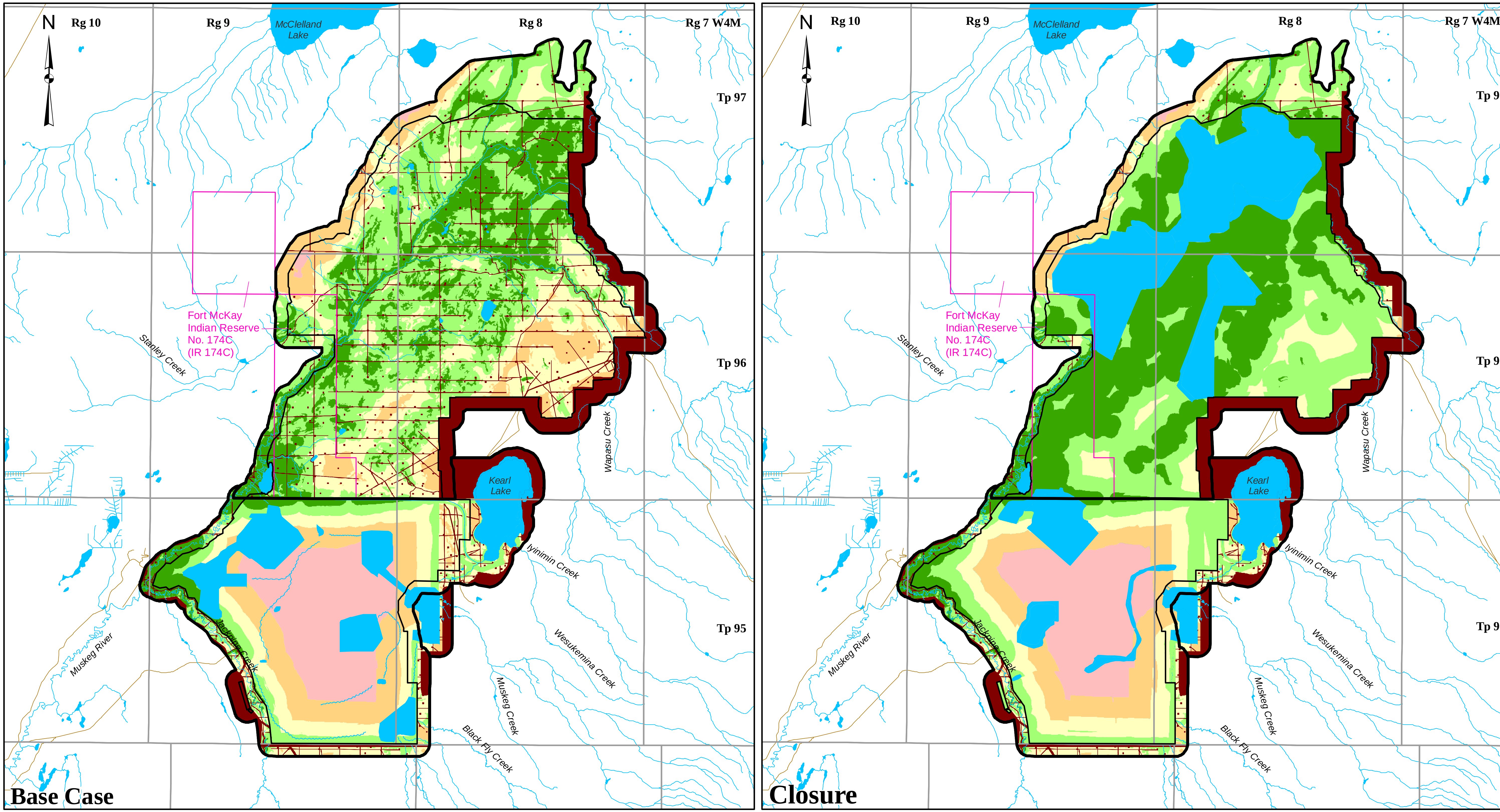

LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE

FISHER/MARTEN HABITAT SUITABILITY IN THE JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
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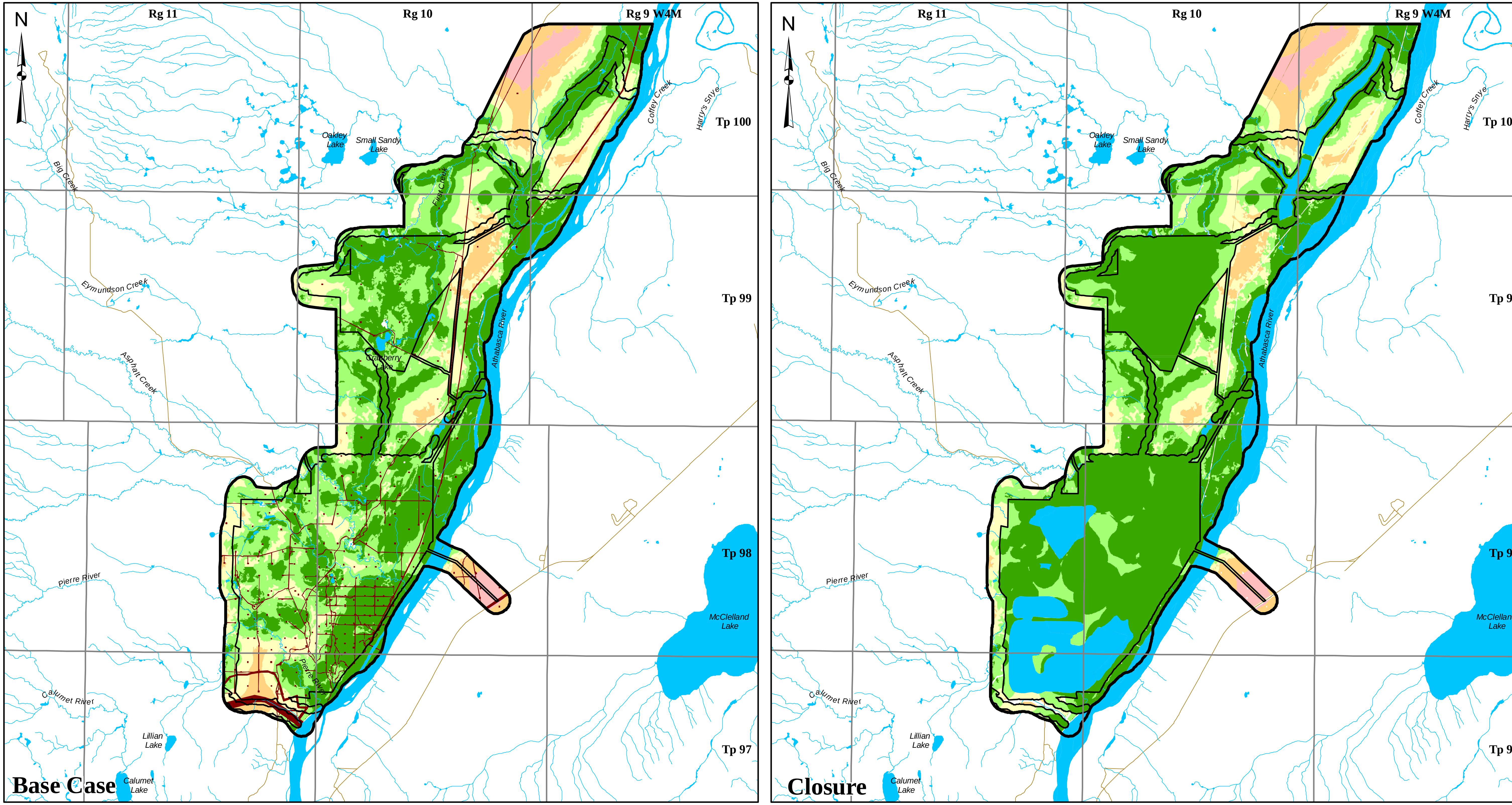


LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE

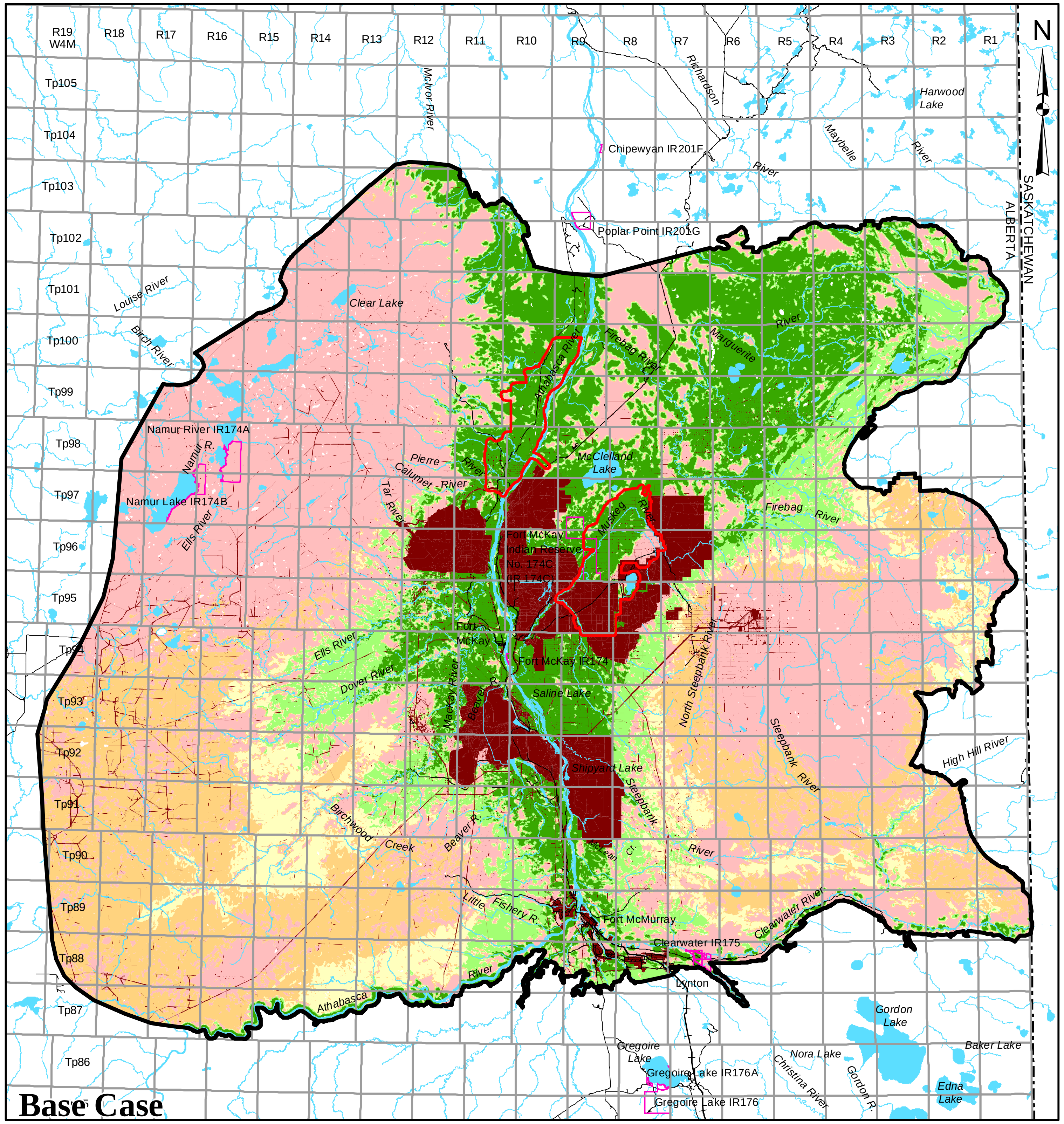
FISHER/MARTEN HABITAT SUITABILITY IN THE PIERRE RIVER MINING AREA LOCAL STUDY AREA

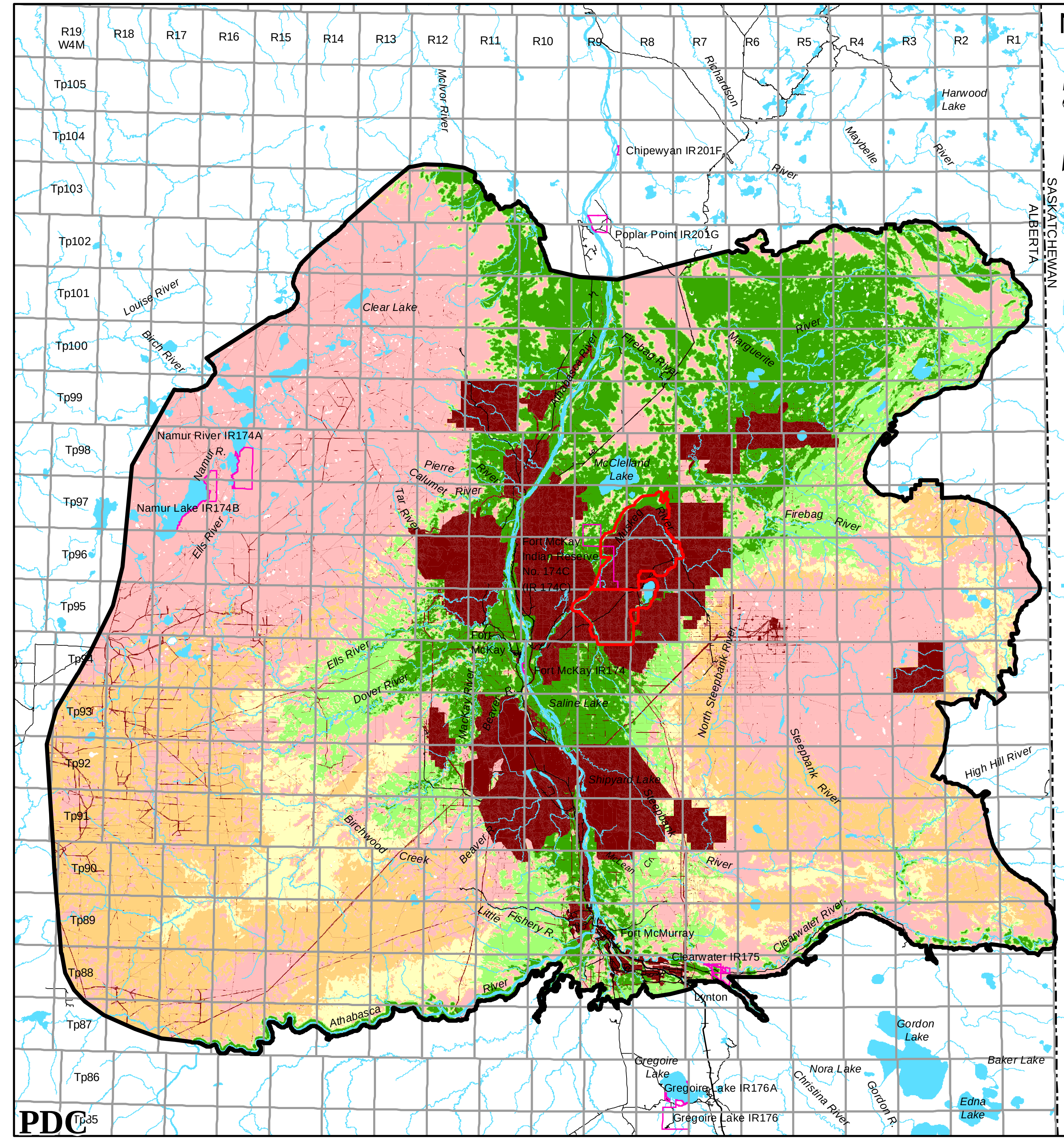
Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 12

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/pierreriver/lsa_hsi_pr_fisher.mxd





LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

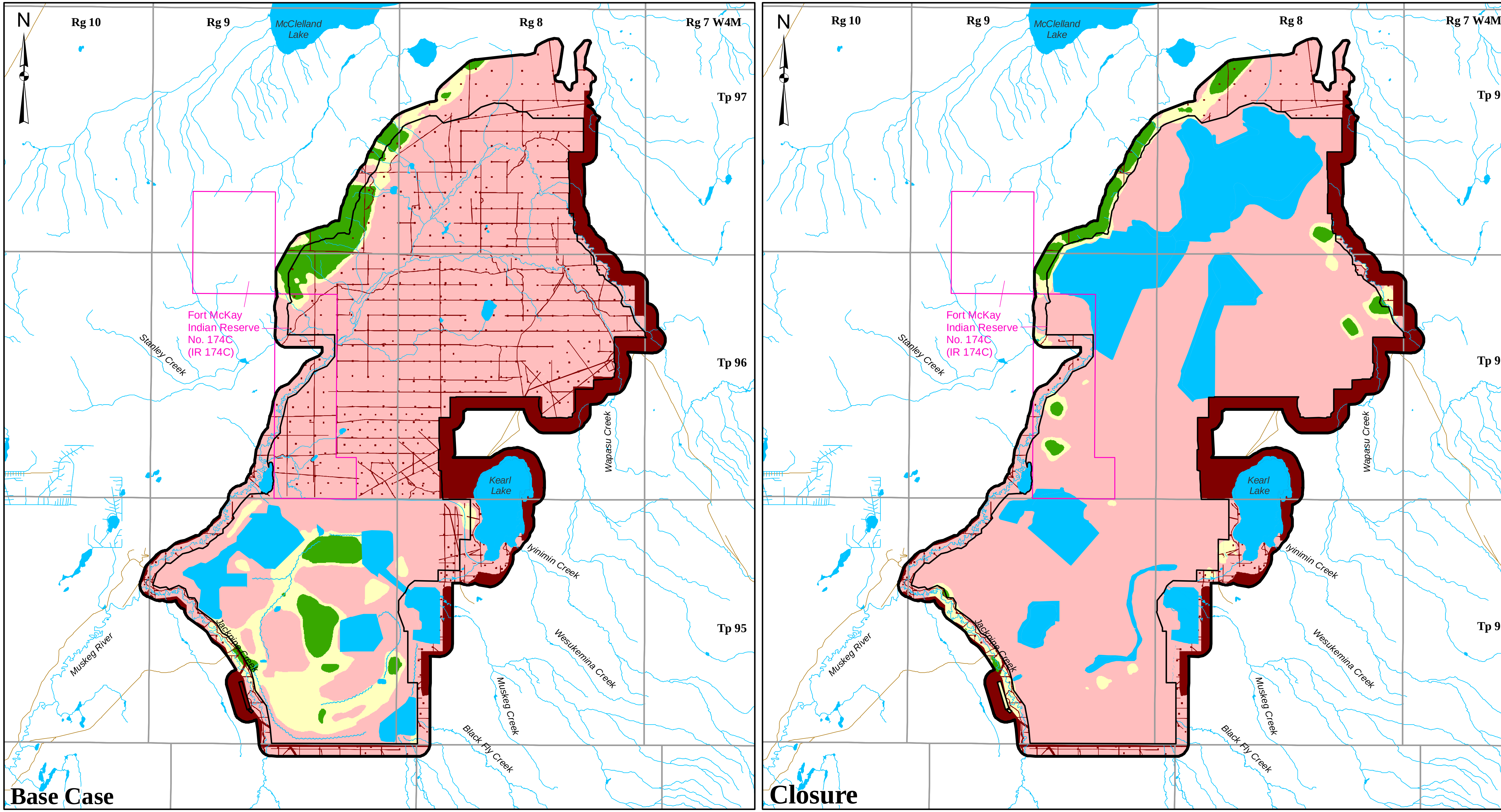
PROJECT
JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE
FISHER/MARTEN HABITAT SUITABILITY
IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 13	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/rsa_hsi_fisher.mxd



LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

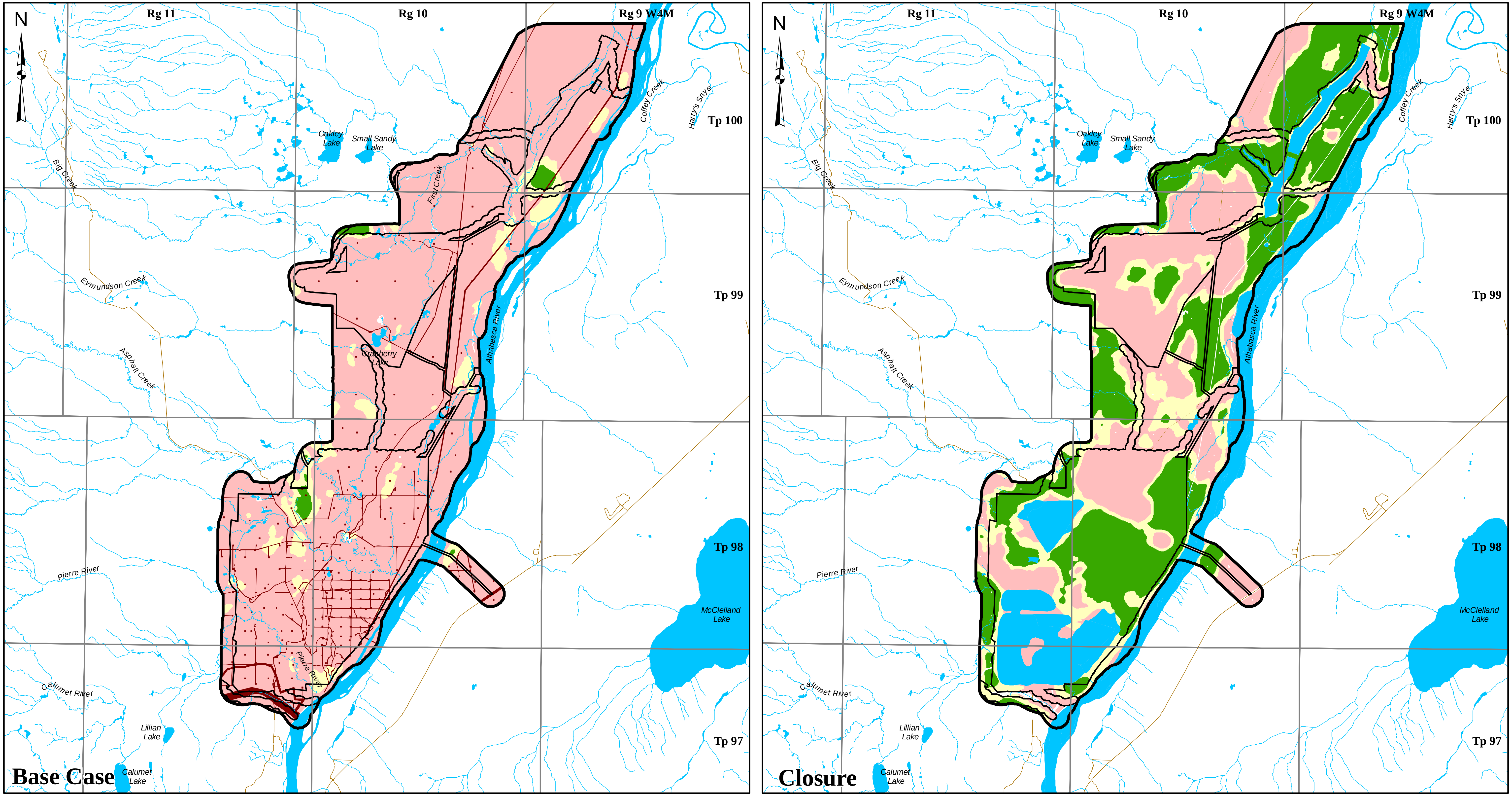
TITLE

BLACK-THROATED GREEN WARBLER
HABITAT SUITABILITY IN THE JACKPINE EXPANSION
MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 14	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/jackpine/lsa_hsi_jp_warbler.mxd



LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT: JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

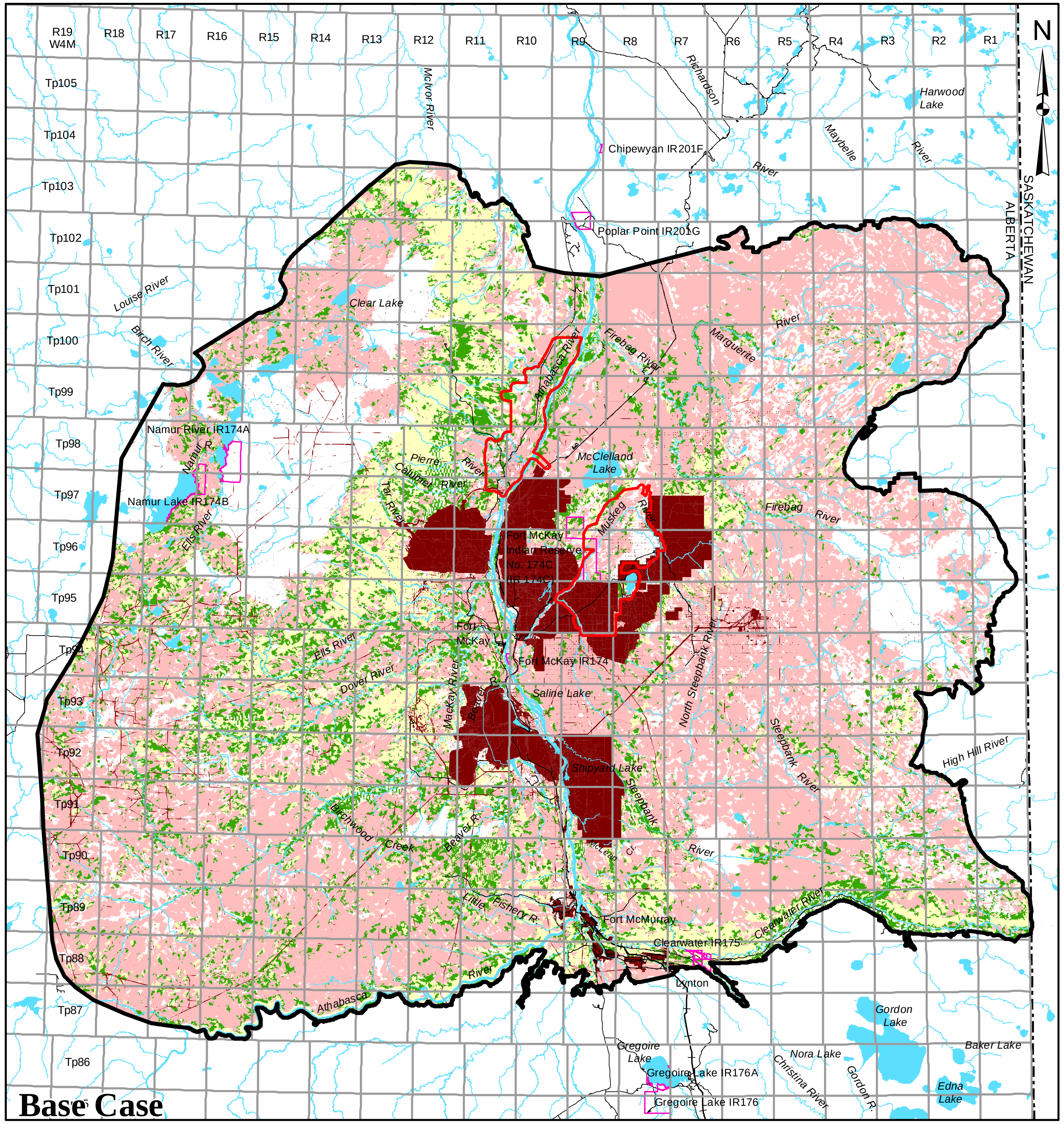
TITLE: BLACK-THROATED GREEN WARBLER HABITAT SUITABILITY IN THE PIERRE RIVER MINING AREA LOCAL STUDY AREA

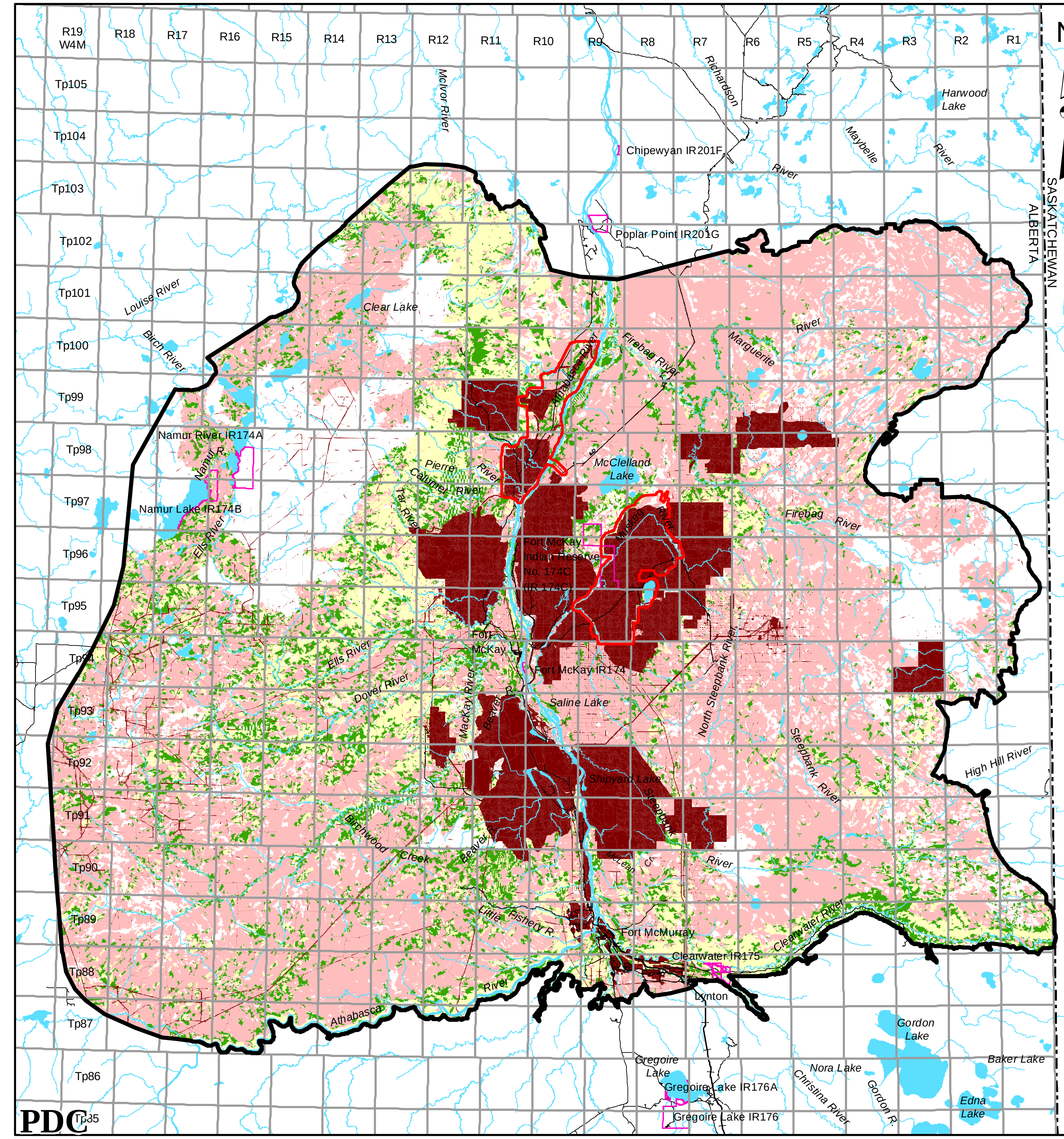
Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 15

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/pierreriver/lsa_hsi_pr_warbler.mxd





LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

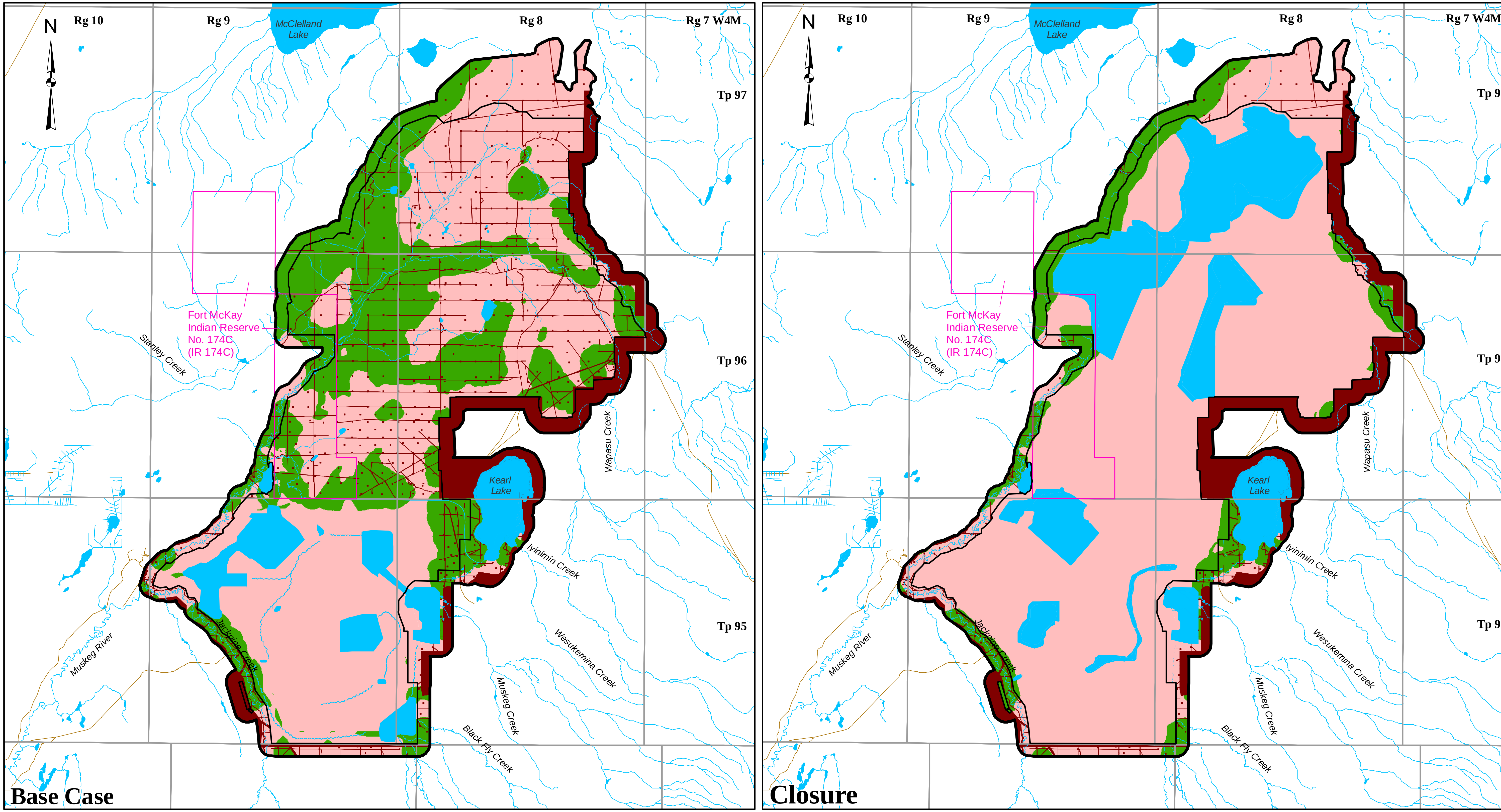
PROJECT
JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE
BLACK-THROATED GREEN WARBLER
HABITAT SUITABILITY
IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 16	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/rsa_hsi_warbler.mxd



LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

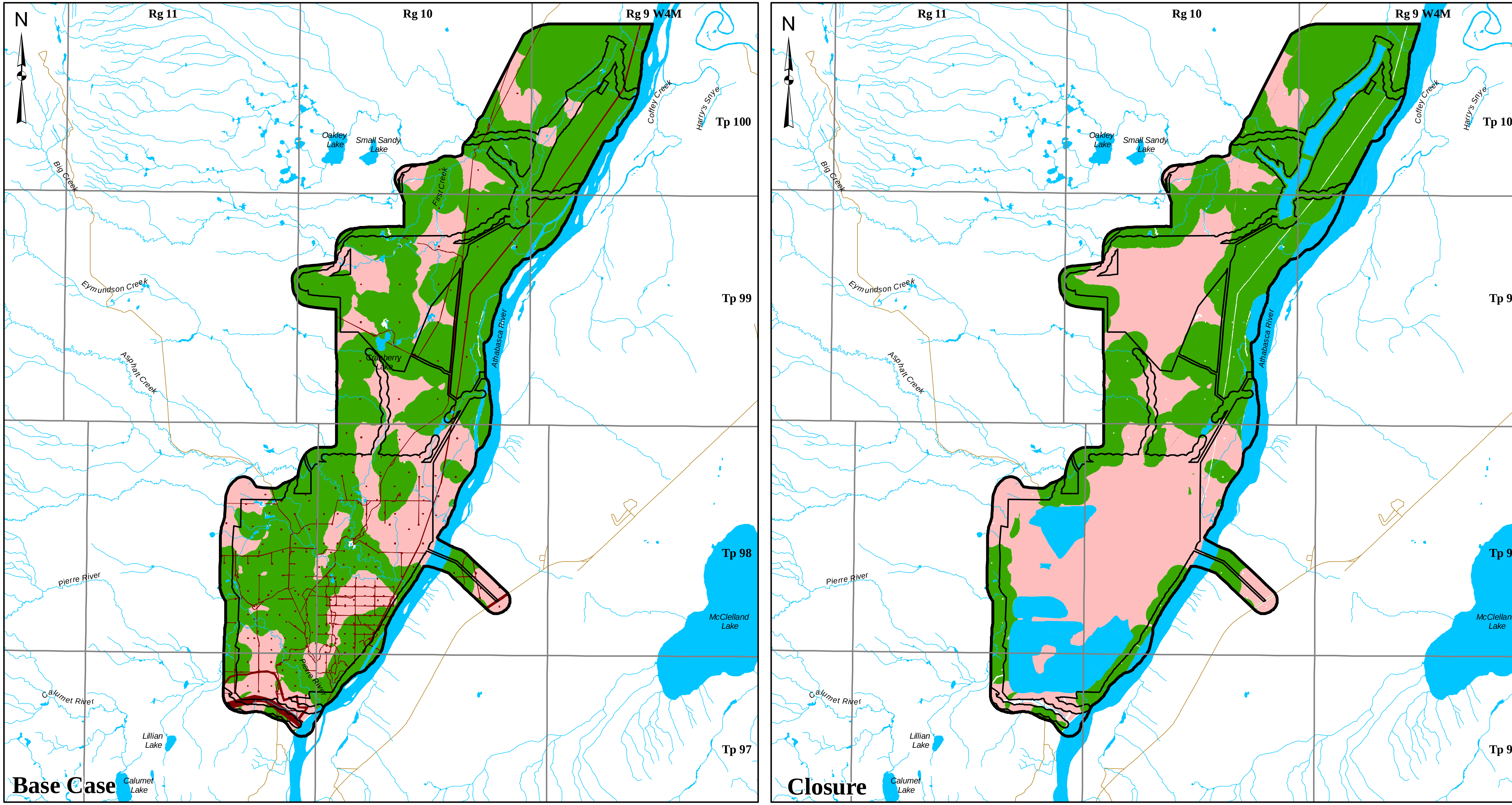
TITLE

BARRED OWL HABITAT SUITABILITY IN THE JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 17	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/jackpine/lsa_hsi_jp_owl.mxd



LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

HABITAT SUITABILITY

- HIGH
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

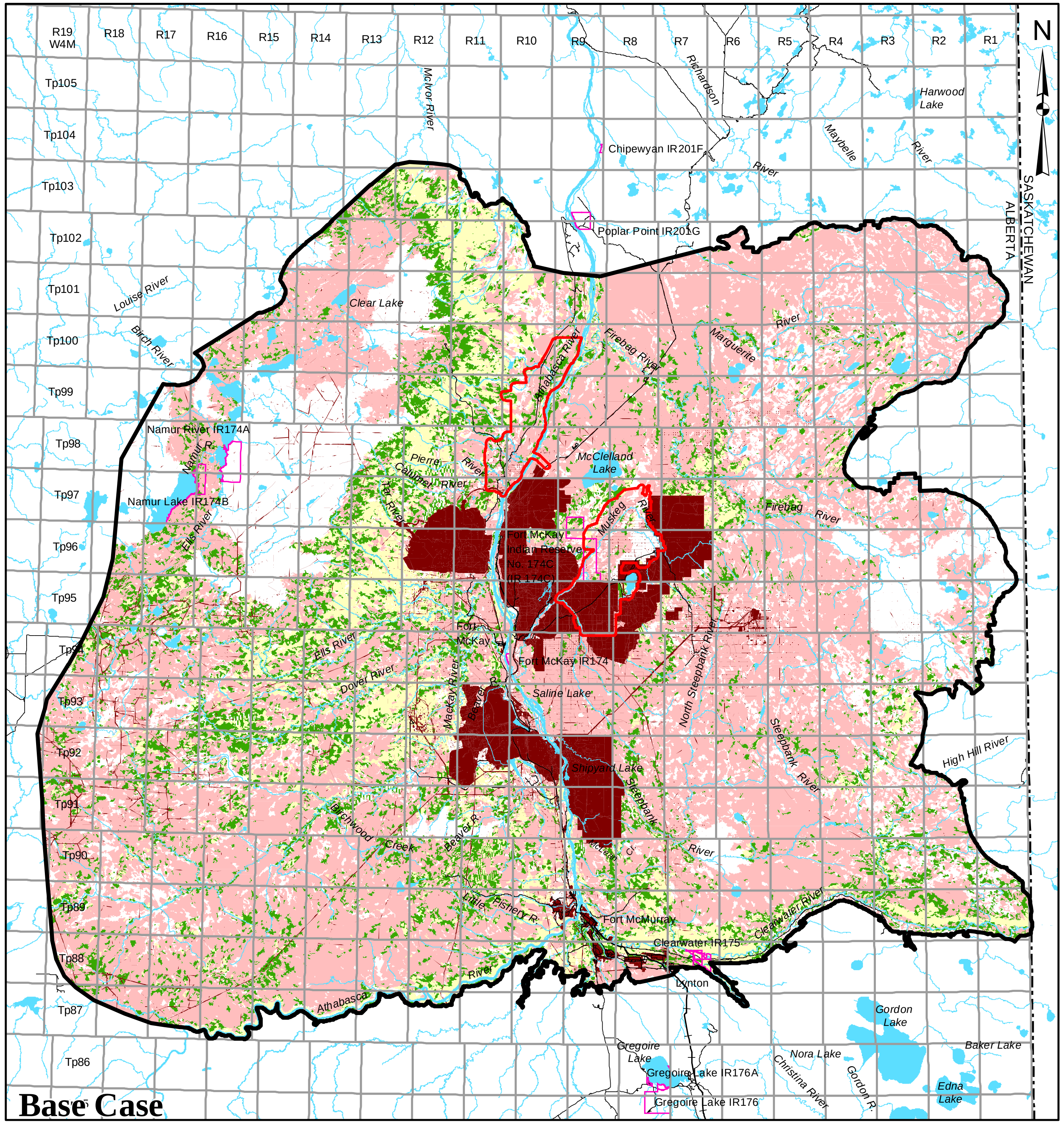
TITLE

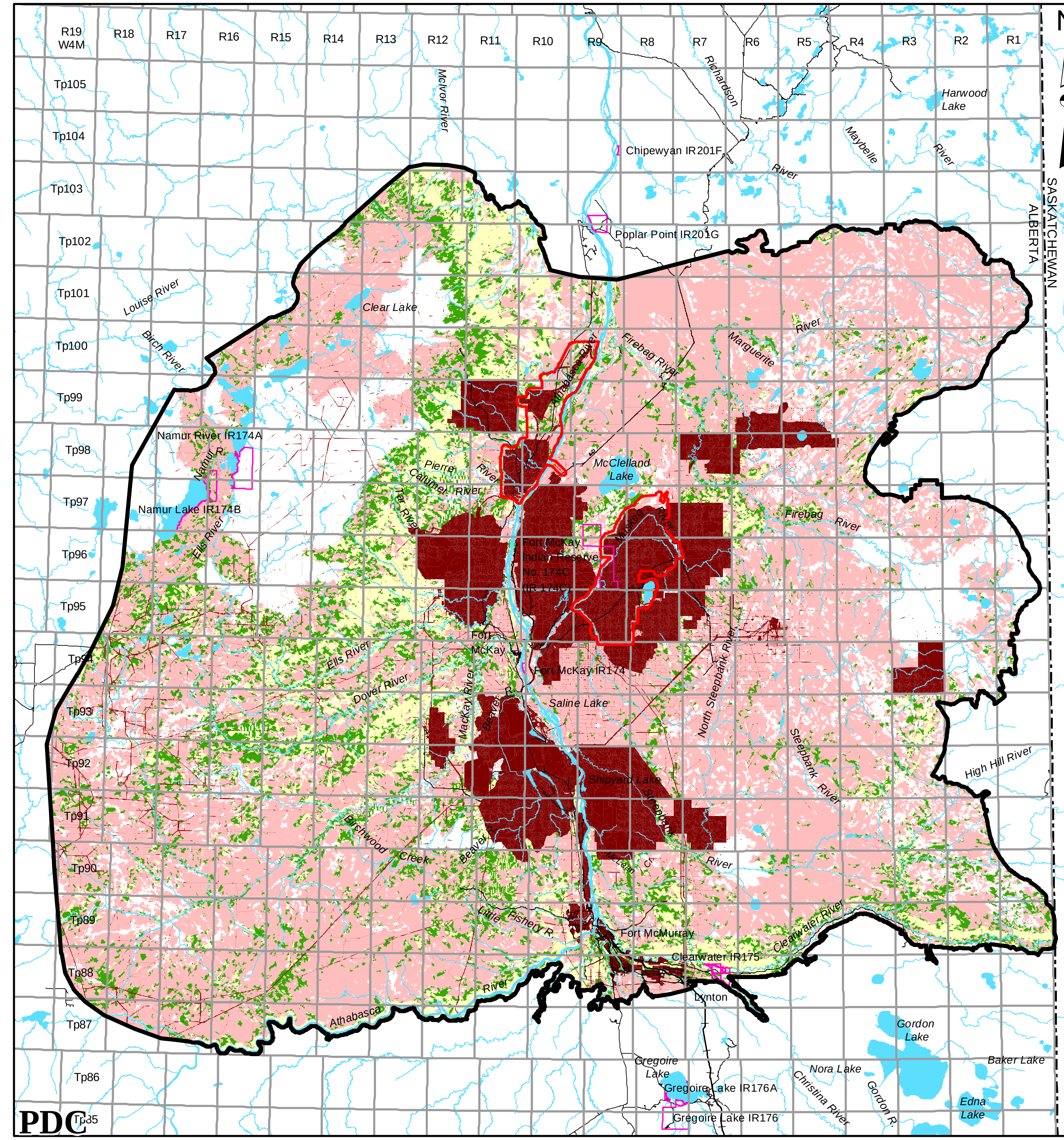
BARRED OWL HABITAT SUITABILITY IN THE PIERRE RIVER MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 18	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/pierreriver/lsa_hsi_pr_owl.mxd





LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE
BARRED OWL HABITAT SUITABILITY IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 19	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

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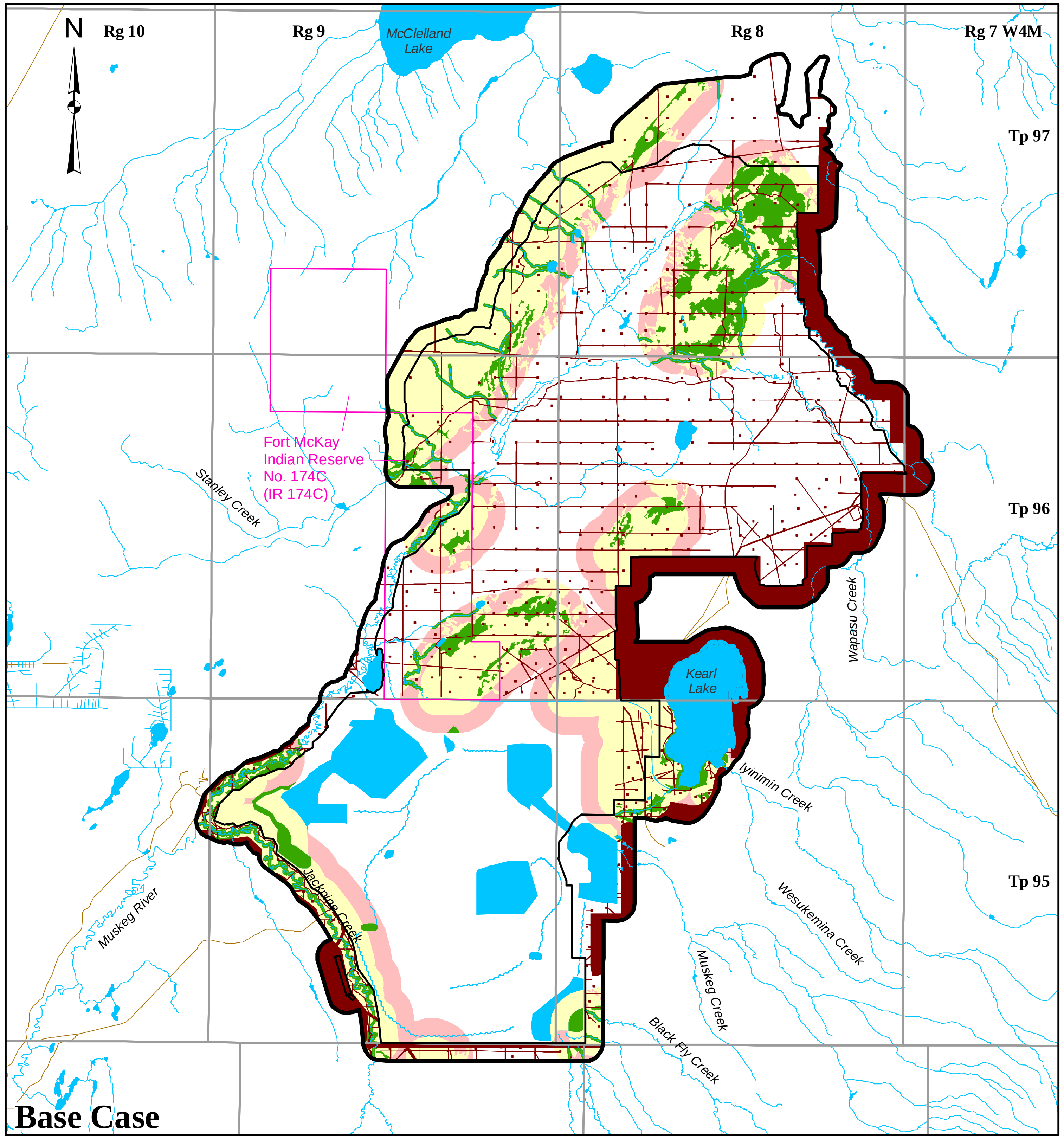
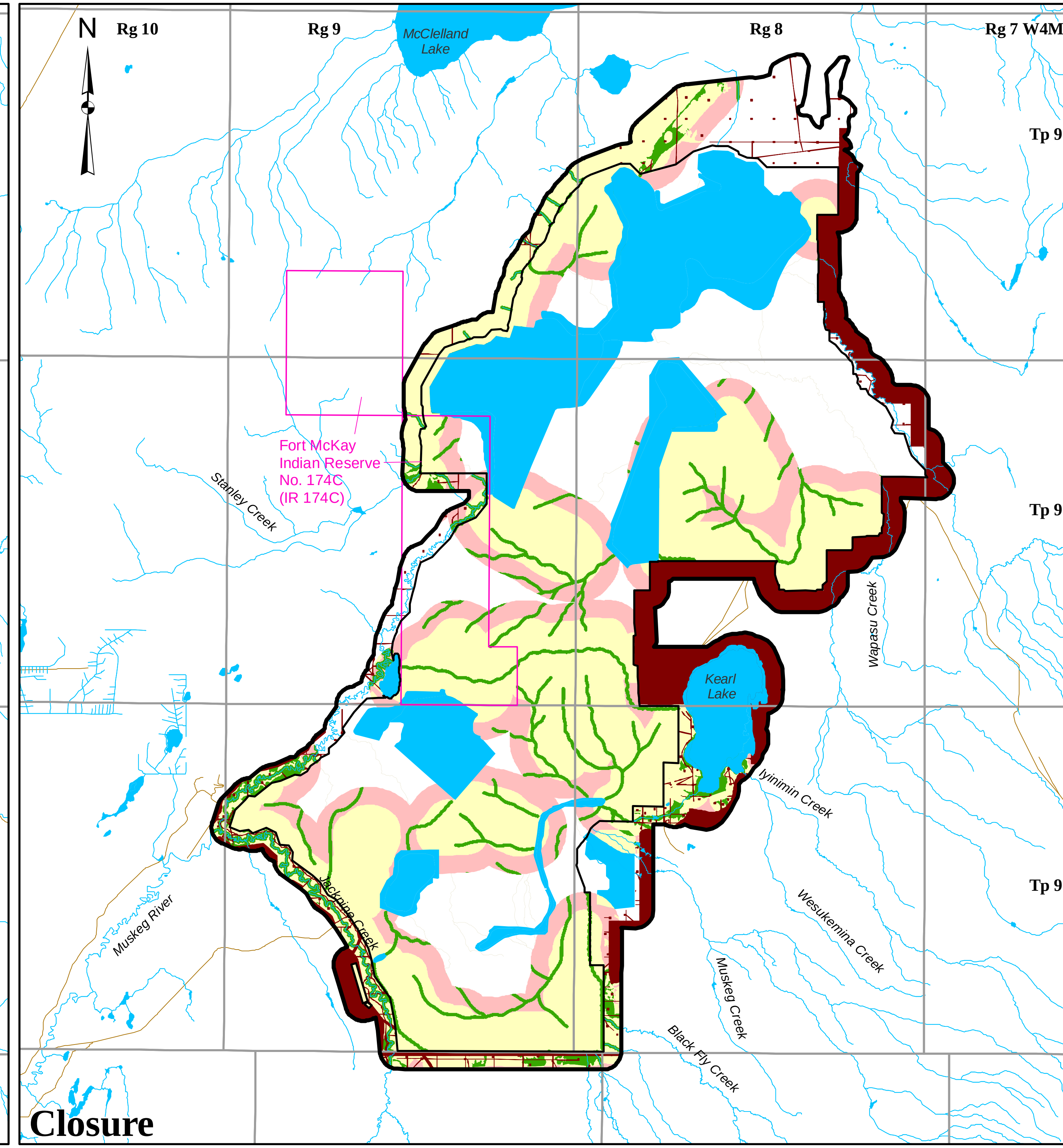




LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

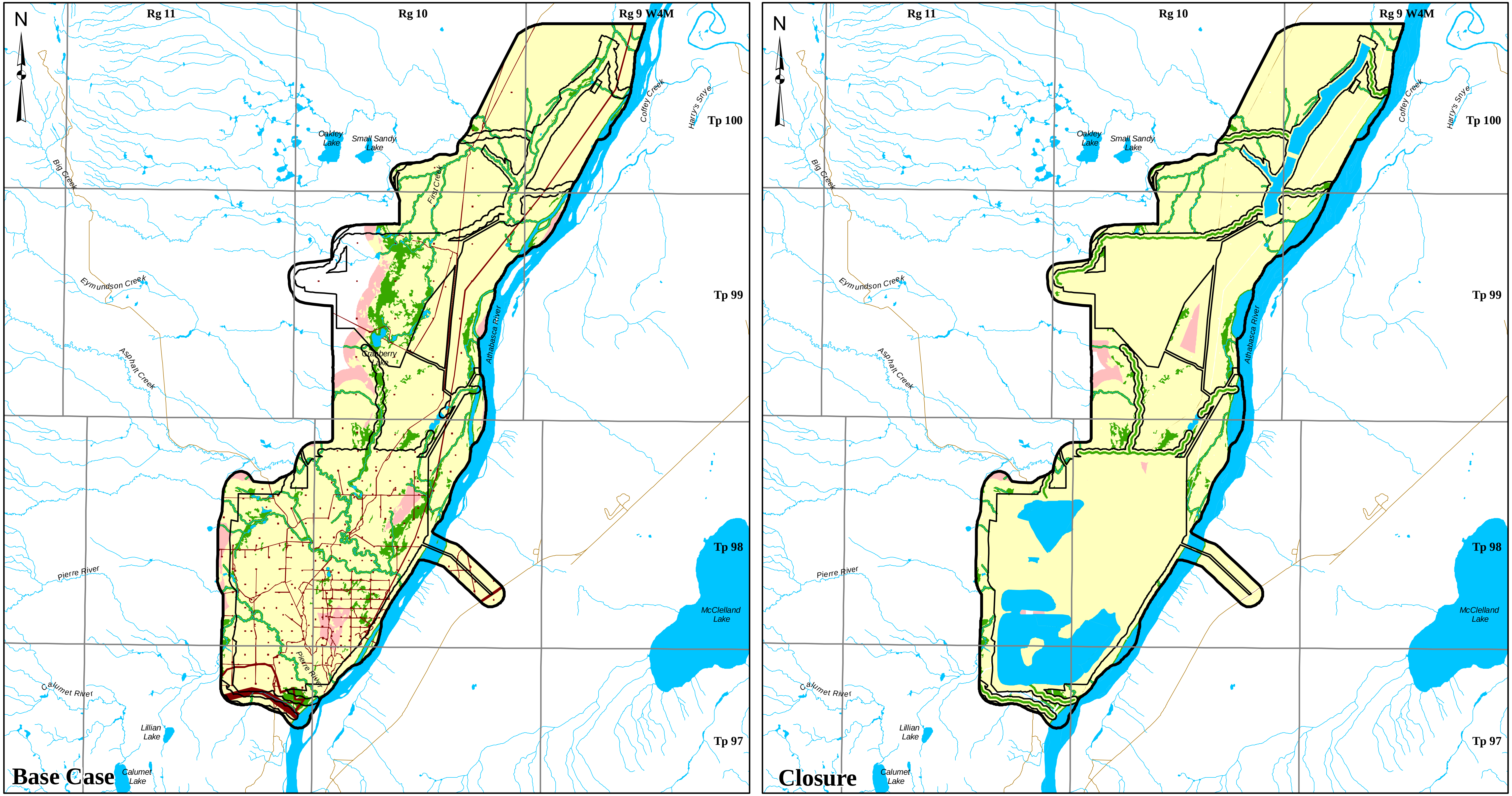
TITLE

CANADIAN TOAD HABITAT SUITABILITY
IN THE JACKPINE EXPANSION MINING AREA
LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 20	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/jackpine/lsa_hsi_jp_toad.mxd



LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

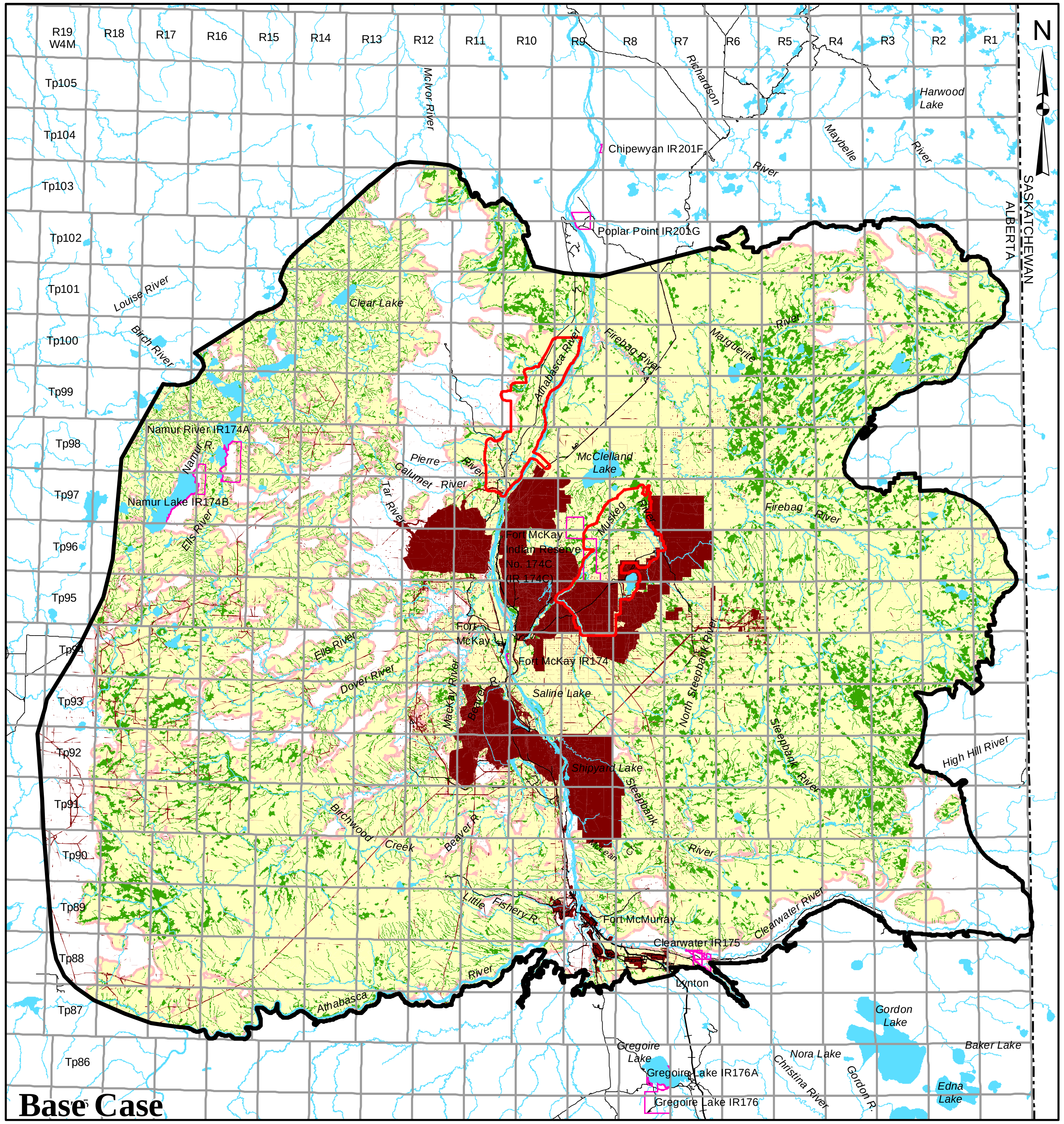
TITLE

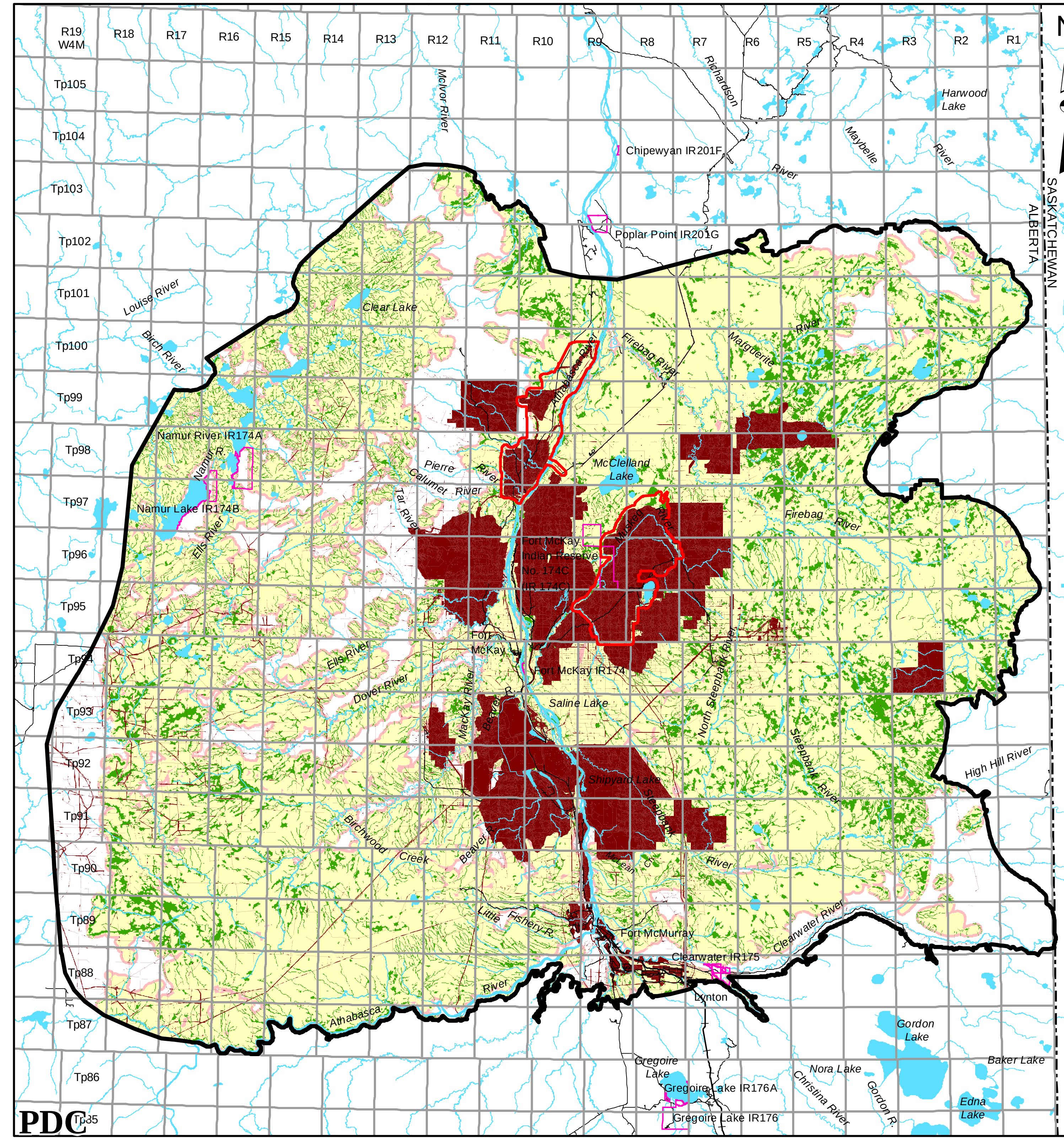
CANADIAN TOAD HABITAT SUITABILITY IN THE PIERRE RIVER MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 21	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/pierreriver/lsa_hsi_pr_toad.mxd





I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/rsa_hsi_toad.mxd

LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

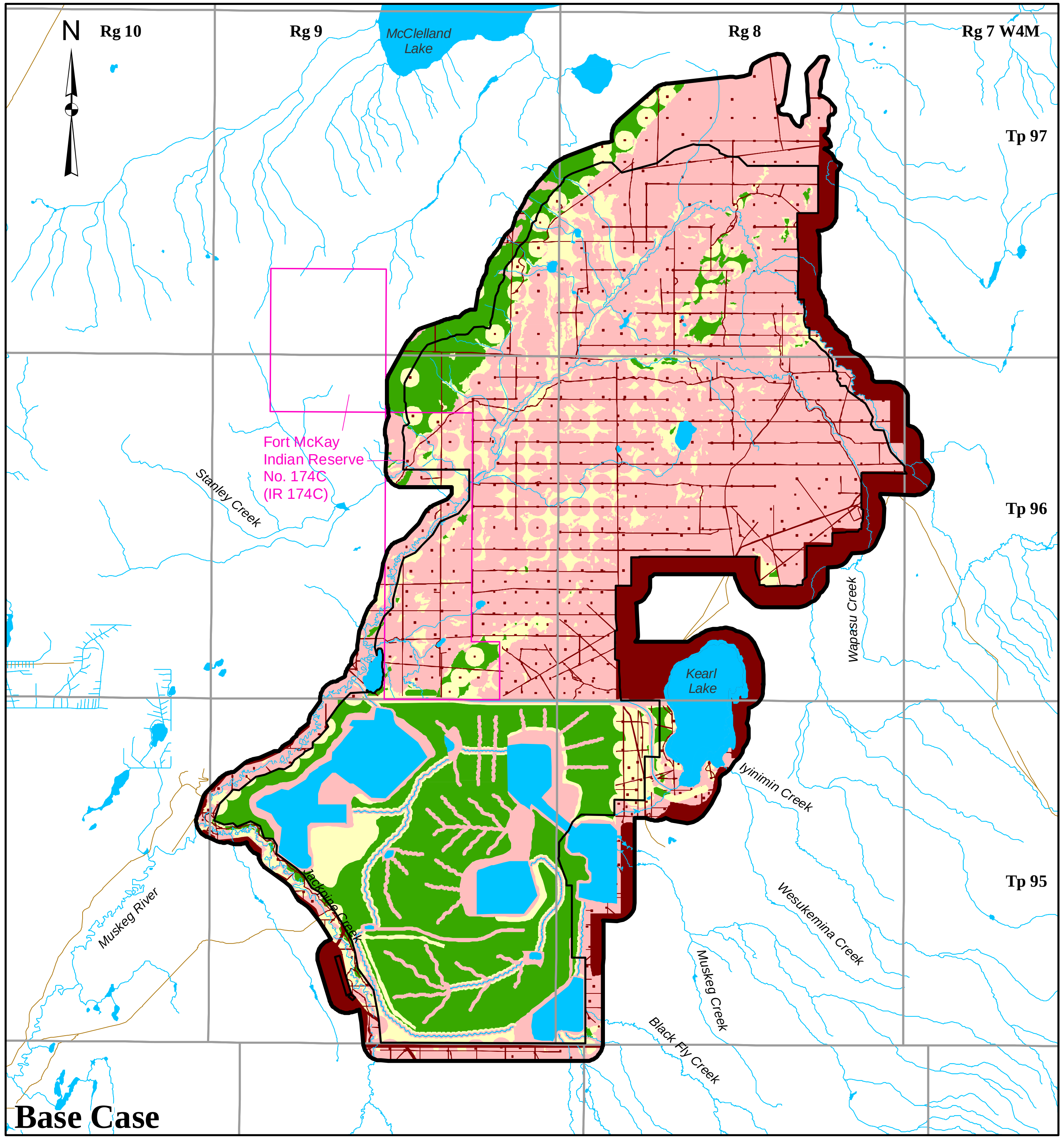
TITLE

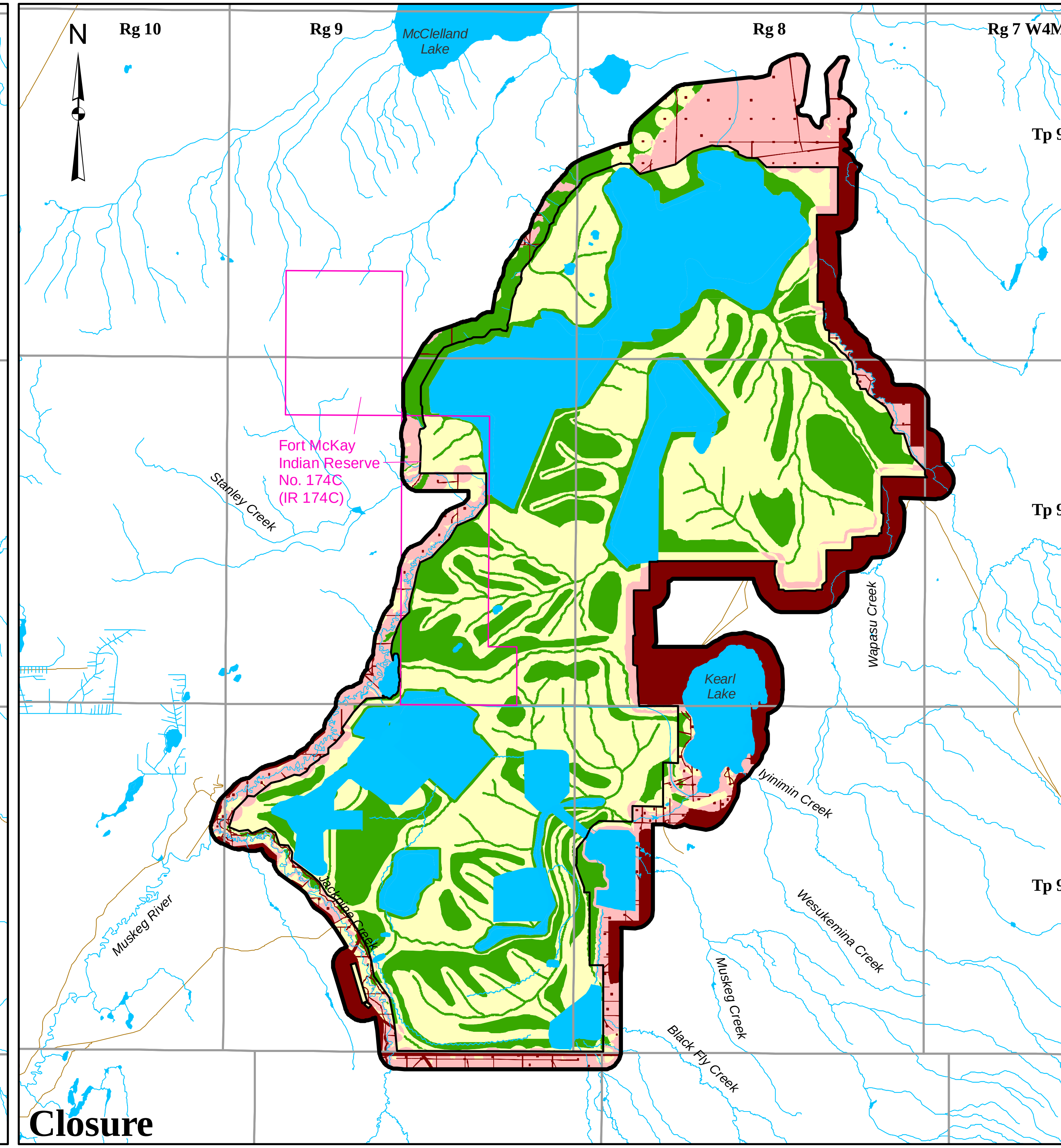
CANADIAN TOAD HABITAT SUITABILITY IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 22





LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

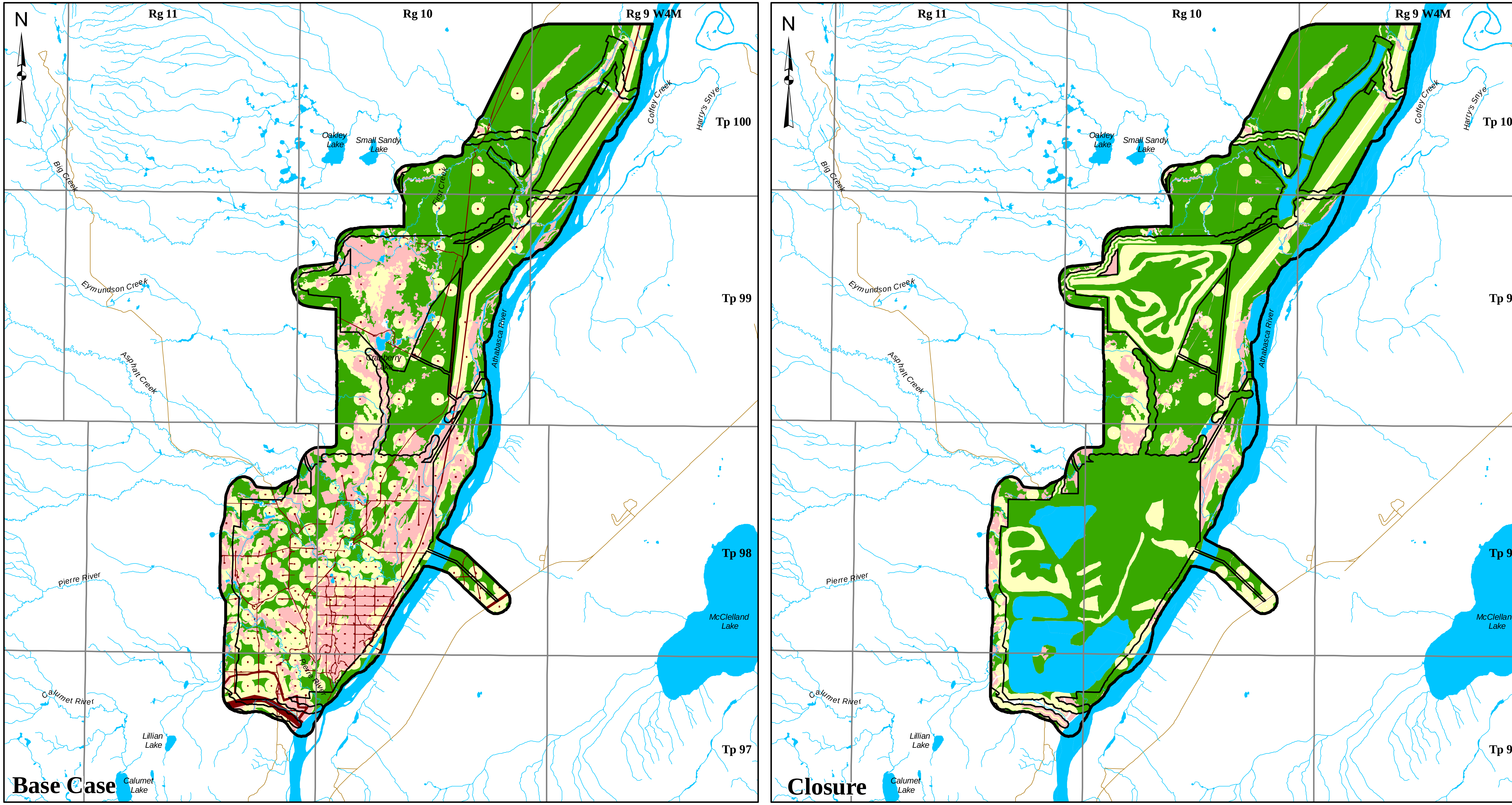
PROJECT: JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE: BLACK BEAR HABITAT SUITABILITY IN THE JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 23	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/jackpine/lsa_hsi_jp_black_bear.mxd



LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

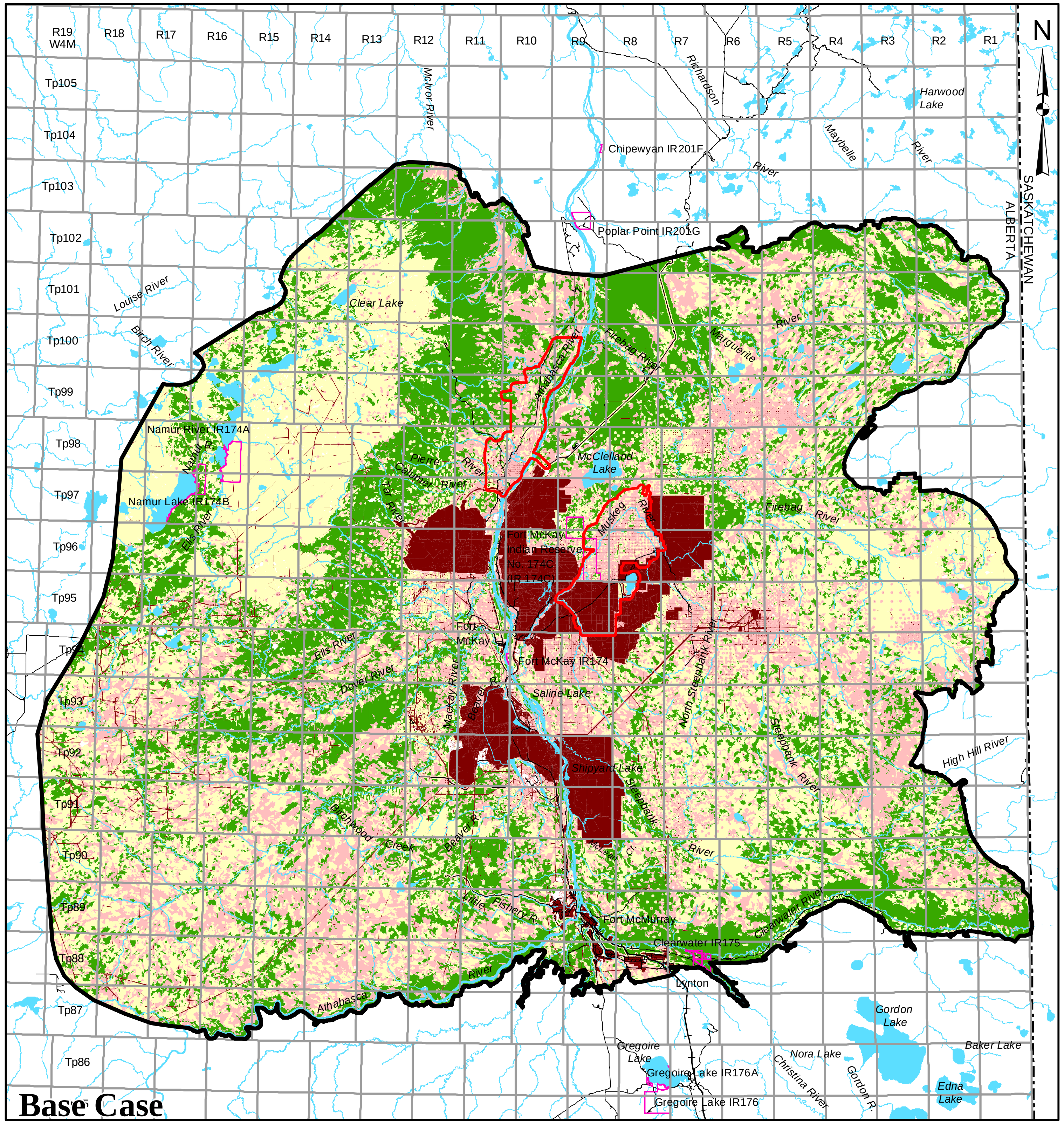
TITLE
BLACK BEAR HABITAT SUITABILITY IN THE
PIERRE RIVER MINING AREA LOCAL STUDY AREA

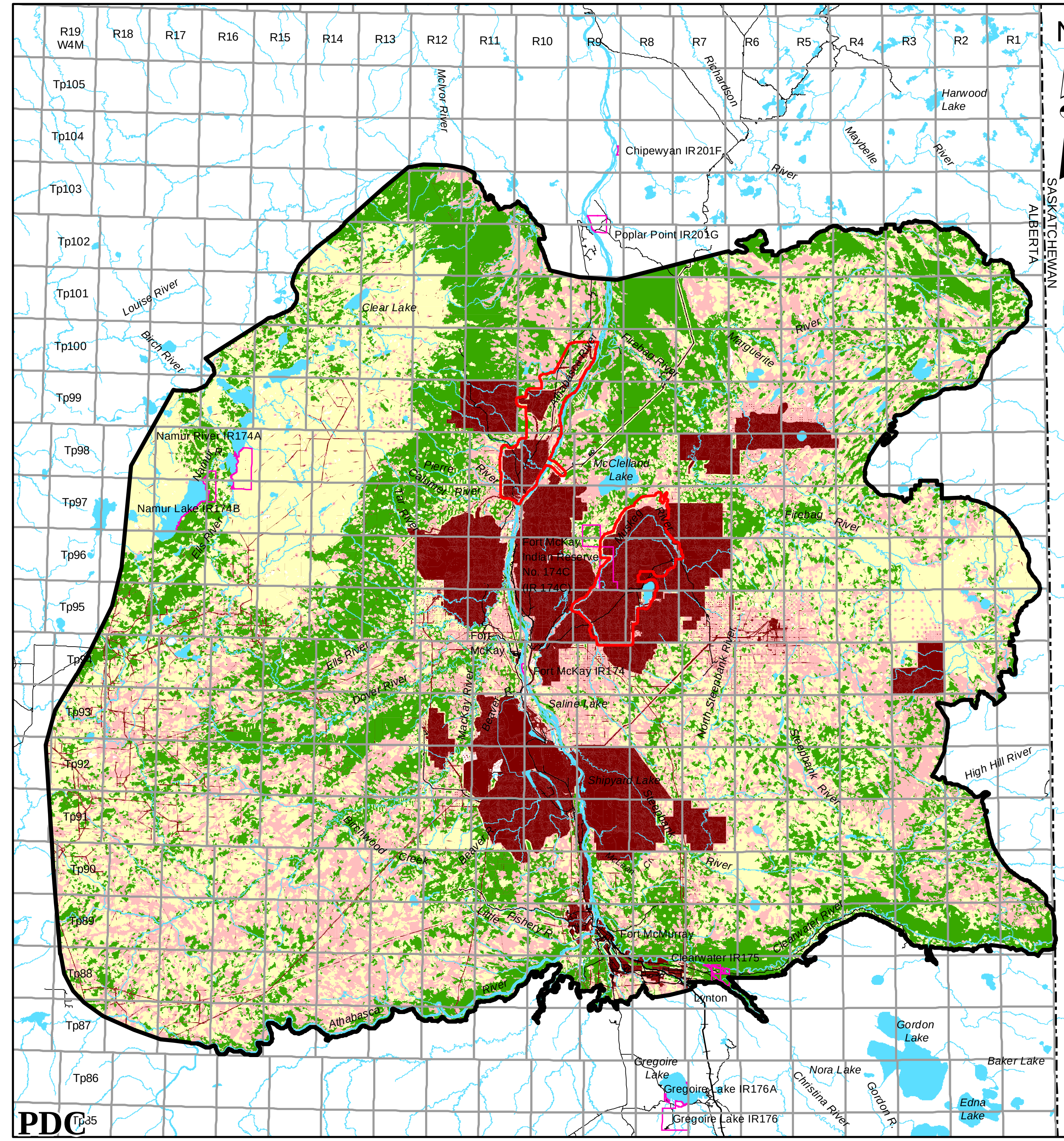
Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 24

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/pierreriver/lsa_hsi_pr_black_bear.mxd





LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

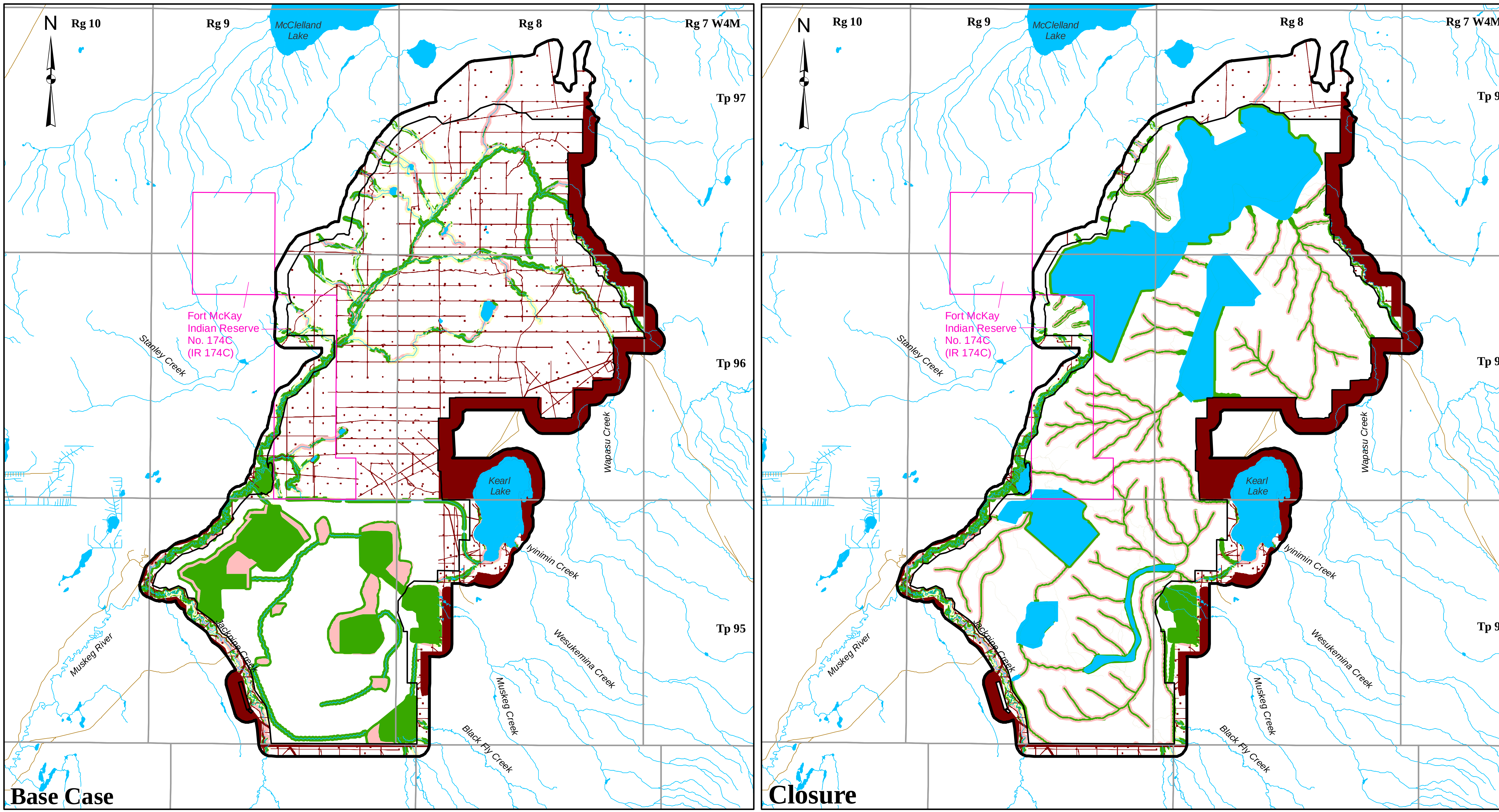
PROJECT
JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE
BLACK BEAR HABITAT SUITABILITY
IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 25	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/rsa_hsi_black_bear.mxd



LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT: JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

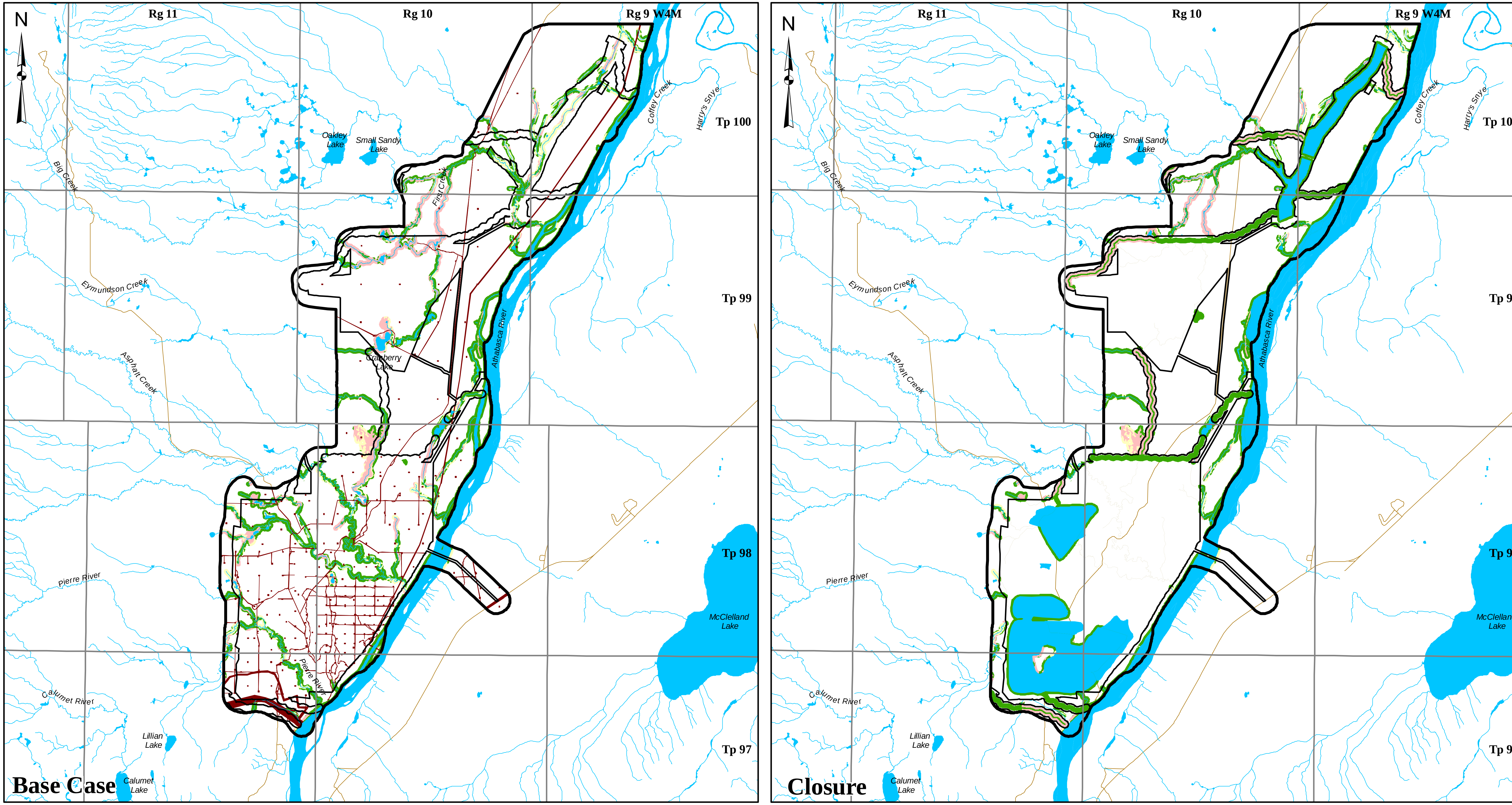
TITLE: BEAVER HABITAT SUITABILITY IN THE JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 26

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/jackpine/lsa_hsi_jp_beaver.mxd



LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

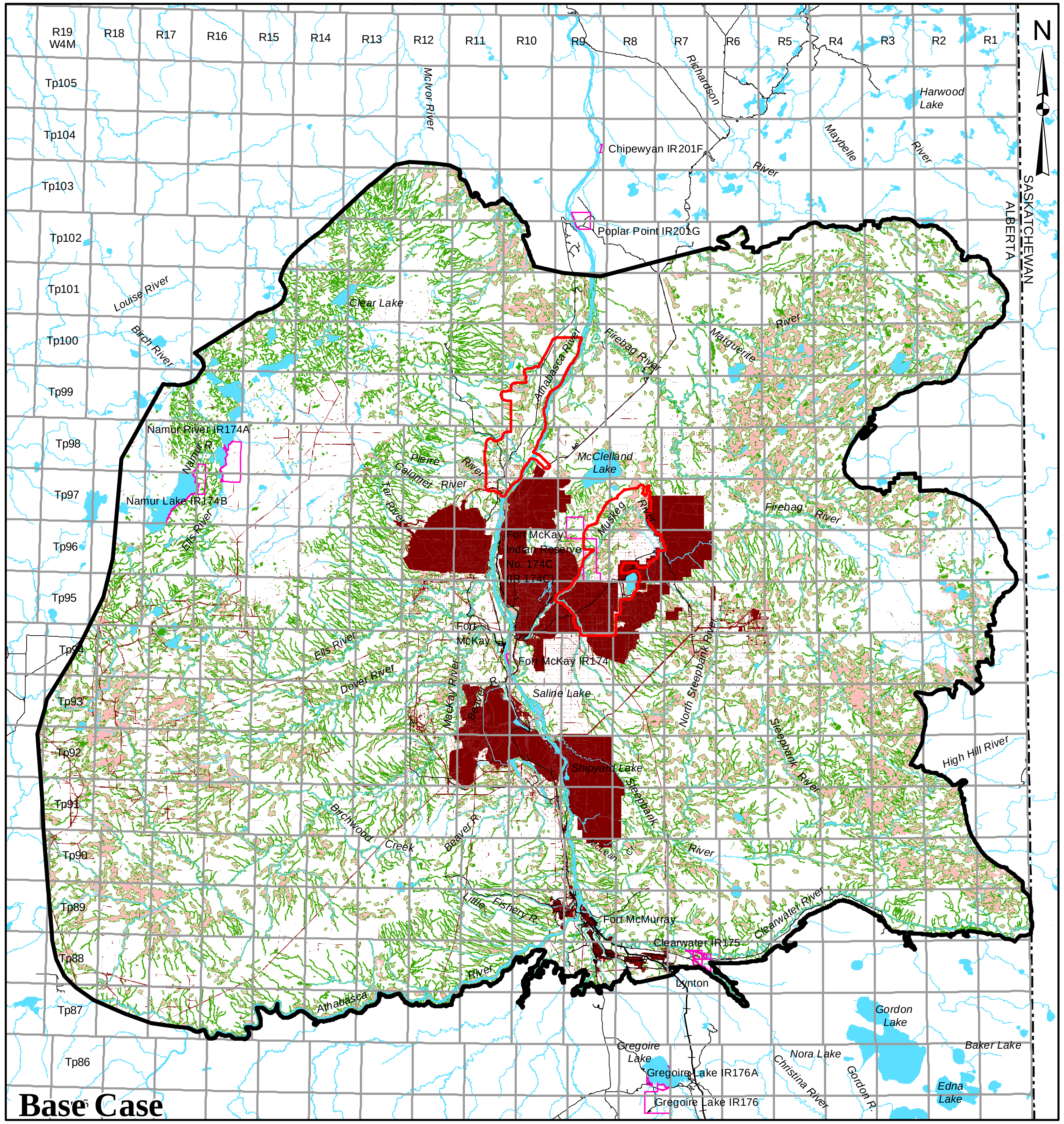
PROJECT
JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

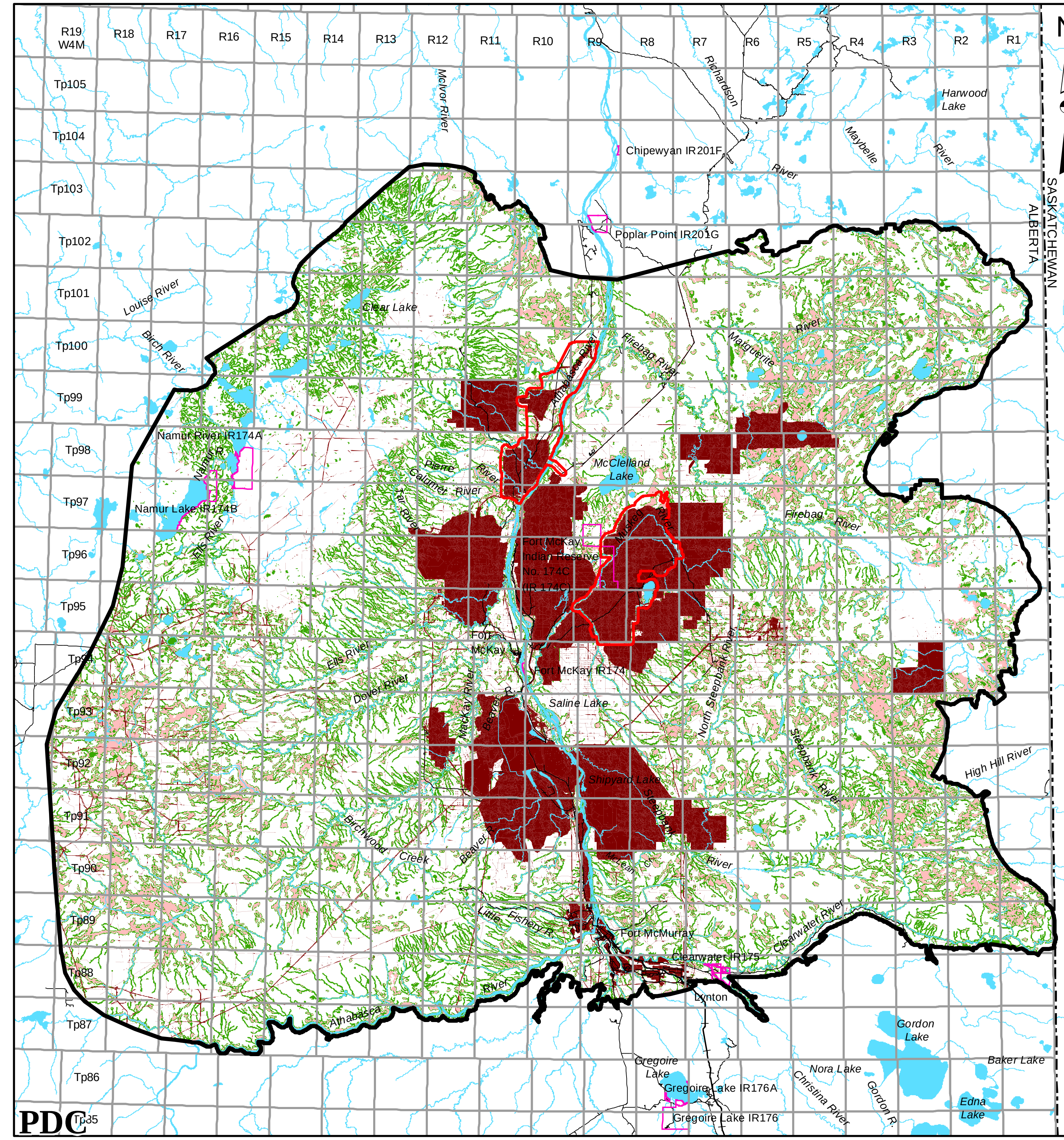
TITLE
BEAVER HABITAT SUITABILITY IN THE PIERRE RIVER MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 27	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/pierreriver/lsa_hsi_pr_beaver.mxd





LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

HABITAT SUITABILITY

- HIGH
- LOW
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

BEAVER HABITAT SUITABILITY
IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 28	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

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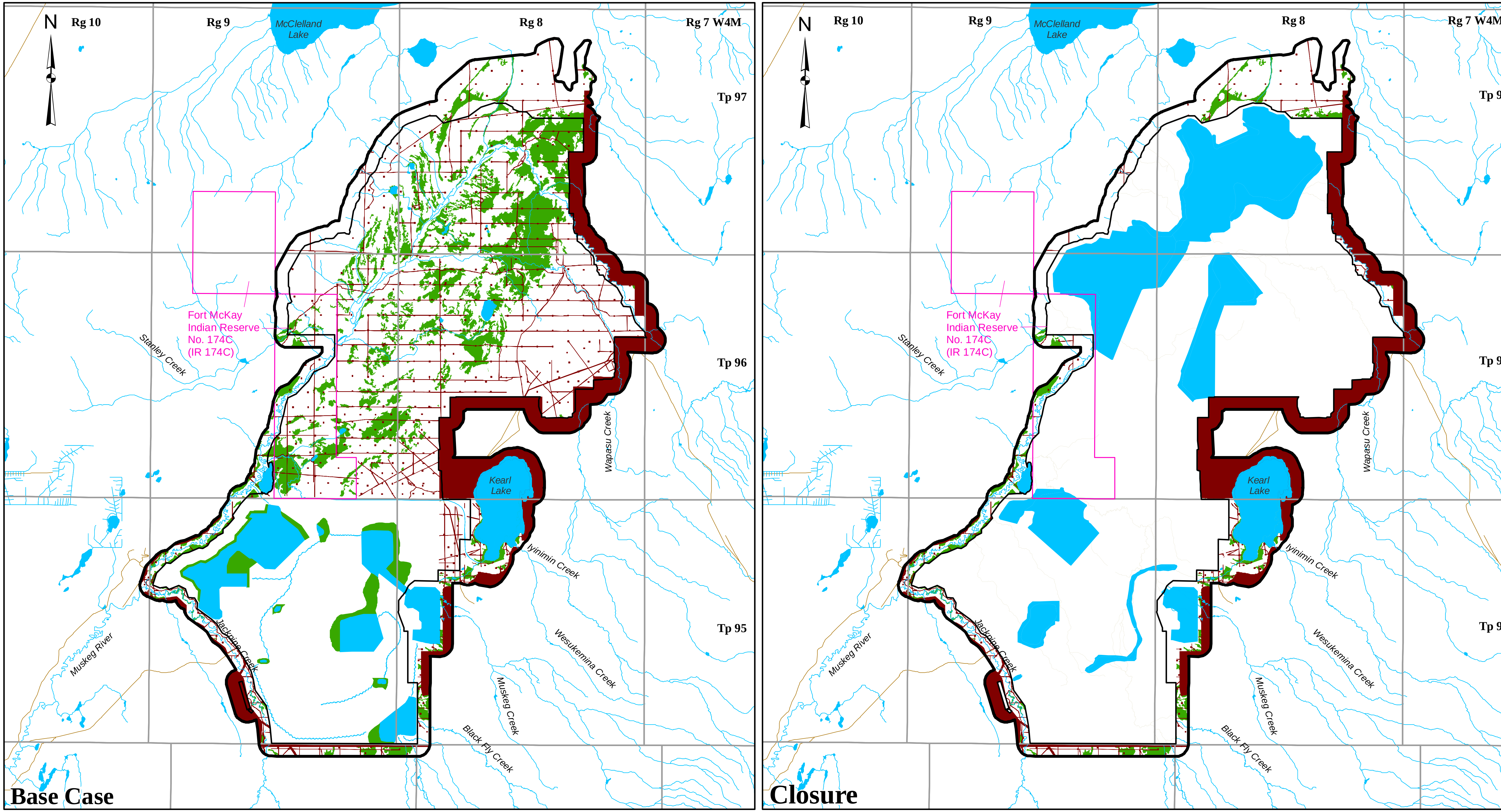

LEGEND

- JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- NIL

5 0 5

SCALE 1:150,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), and Alberta SRD, used under license.

Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE
YELLOW RAIL HABITAT SUITABILITY IN THE JACKPINE EXPANSION MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 29	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

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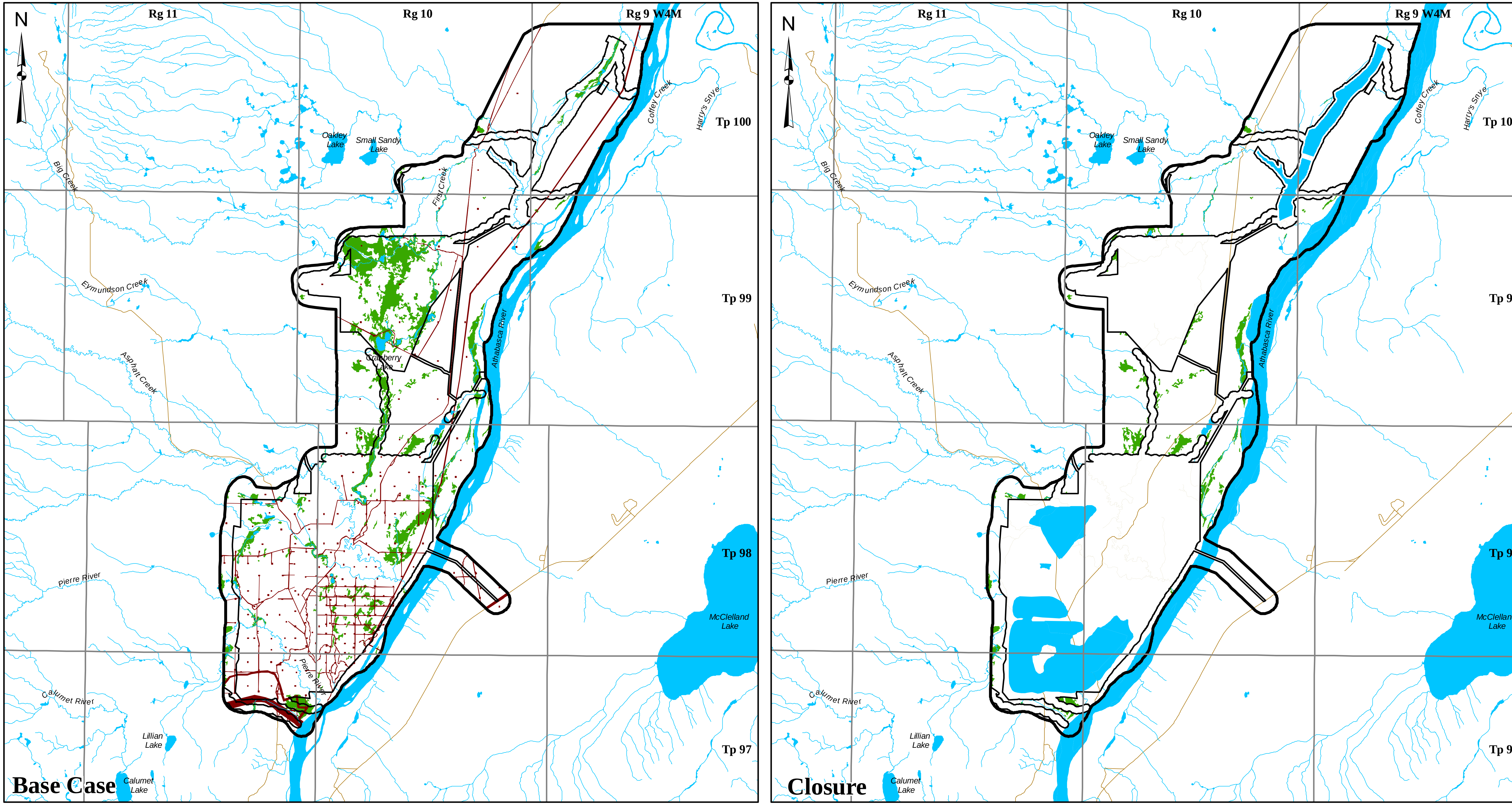

LEGEND

- PIERRE RIVER MINING AREA LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER
- PUBLIC ROADWAY

HABITAT SUITABILITY

- HIGH
- NIL

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

6 0 6

SCALE 1:160,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

YELLOW RAIL HABITAT SUITABILITY IN THE
PIERRE RIVER MINING AREA LOCAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 30	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

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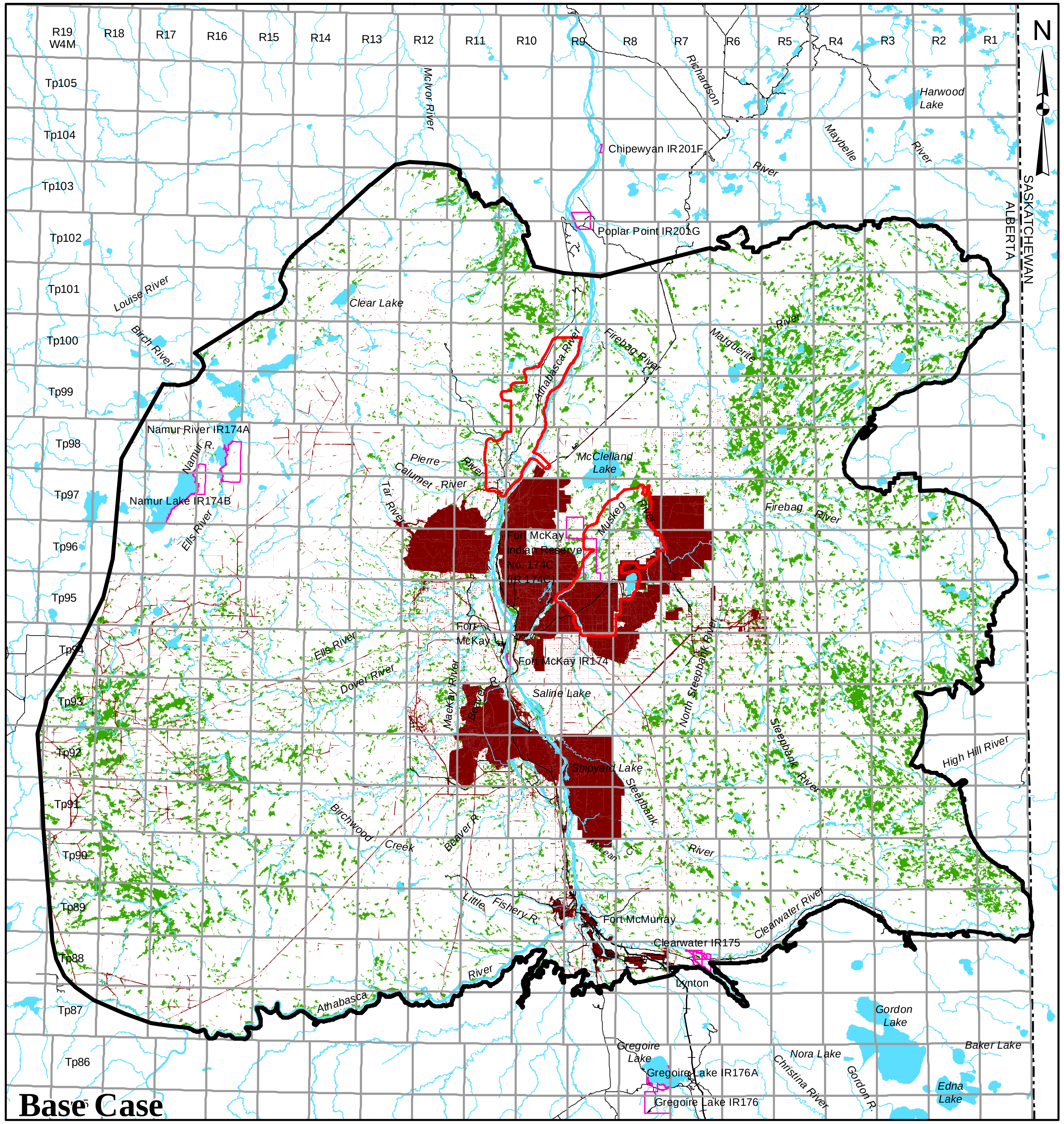

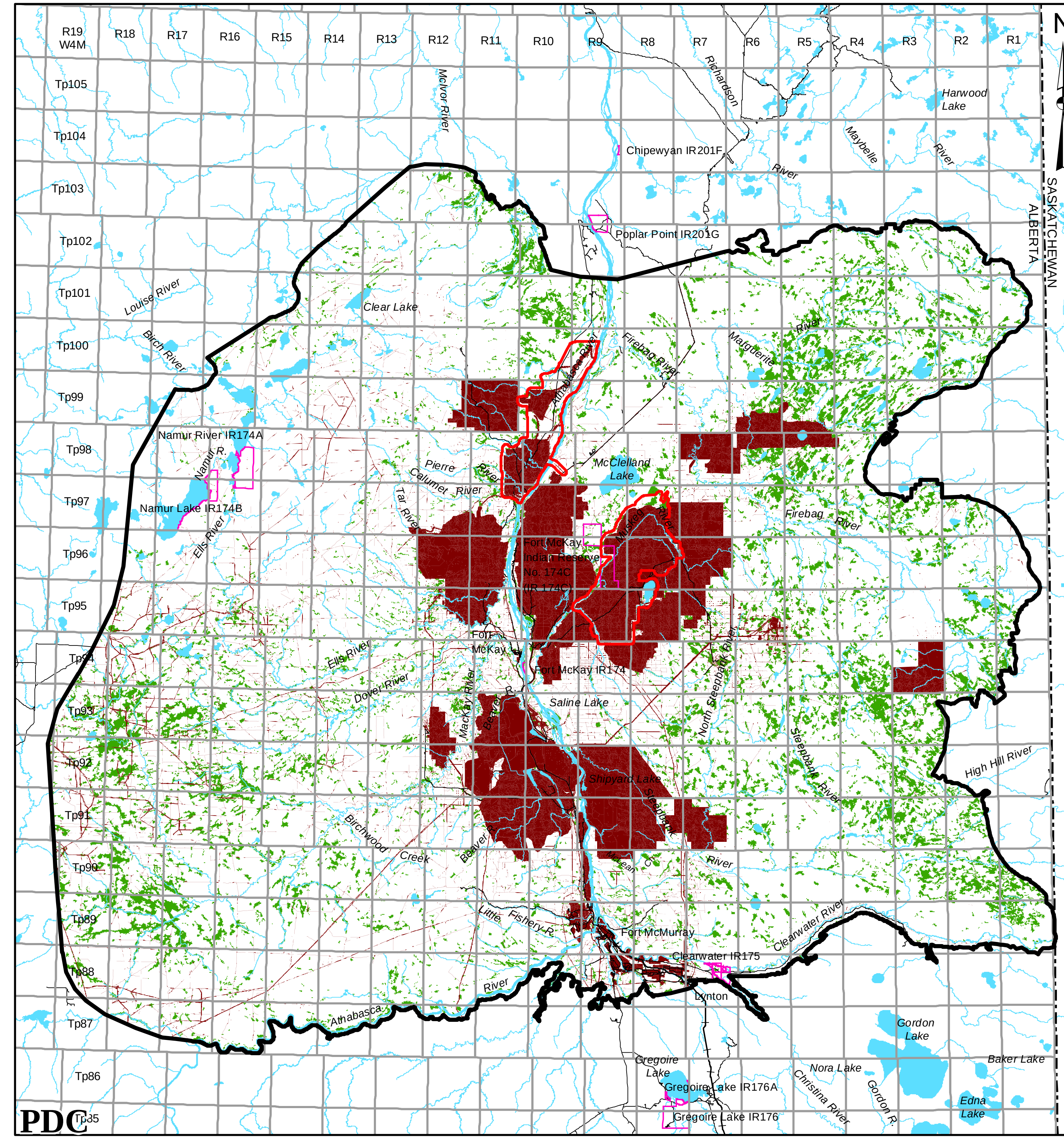

LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

HABITAT SUITABILITY

- HIGH
- NIL

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT

TITLE
YELLOW RAIL HABITAT SUITABILITY IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007	FIGURE: 31	
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/rsa_hsi_yellow_rail.mxd

1.3.1.2 Application Case

Construction and Operations

Habitat impacts during construction and operations of the Project will result in a substantial decrease in available habitat for all species at the LSA scale because the majority of the LSAs fall within the disturbance of the proposed project development areas. For most species, areas of the LSA that are unavailable for use will increase approximately six-fold across the two LSAs (Table 14). The exceptions are Canadian toad, beaver and yellow rail, which are predicted to show increases in non-habitat of approximately 98, 18 and 12%, respectively.

Moose are predicted to lose about 58% of high-quality habitat and 60% of moderate high-quality habitat present at Base Case (Table 14). Lynx are predicted to lose approximately 51% of high-quality and 72% moderate high-quality habitat. The fisher/marten RSF model predicts that just less than 70% of both high and moderate high-quality habitat classes will be lost. Black-throated green warblers are predicted to lose 80% of the high-quality habitat present at Base Case, which presently takes up only 3.2% of LSAs. The barred owl RSF model predicts that the species will lose almost 60% high-quality habitat.

The Canadian toad HSI model predicts that this amphibian will lose about 59% of the high-quality habitat that previously existed in the LSAs due to direct impacts and 2% due to water table drawdown. Black bears are predicted to lose 60% of high-quality habitat within the two LSAs, 8% of that due to water table drawdown and sensory disturbance from facilities. Finally, beaver and yellow rail are predicted to lose about 59 and 86% of high-quality habitat, respectively. For beaver, the effects of water table drawdown are negligible, while yellow rail are predicted to lose 3.5% of high-quality habitat due to drawdown (Table 14).

Closure

After reclamation and closure, the moose RSF models predict that there will be increases in high and moderate high-quality habitat relative to Base Case of 80% and 18%, respectively. The fisher/marten RSF model predicts an increase in high-quality habitat of 36% from Base Case to closure, but a decrease in moderate high-quality habitat of 28%. The lynx model predicts an increase in high and moderate high-quality habitat of 18 and 22%, respectively.

Predictions of the black-throated green warbler model suggest a very large increase in high-quality habitat at closure of almost 400%, relative to Base Case conditions. The barred owl model predicts a substantial decrease in high-quality habitat of 46% from the Base Case to closure.

The Canadian toad HSI model predicts a 5.5% increase in high-quality habitat at closure. The black bear and beaver HSI models predict approximately 34% and 65% increases respectively, in high-quality habitat at closure. The yellow rail HSI model predicts a 83% loss in high-quality habitat due to the changing assortment of wetlands available on the closure landscape.

1.3.2 Regional Study Area Scale

Results from habitat suitability modelling at the RSA scale for the Base Case, Application Case and PDC are summarized in Table 15. The habitat suitability maps for all species listed in Table 15 are provided for the LSAs and RSA in Figures 5 to 31. Unlike the local scale assessment, the regional scale assessment does not account for reclamation of the various projects as this cannot be accurately defined at this scale.

1.3.2.1 Base Case

RSF habitat suitability models at the RSA scale predict that moose have about 21% high and 19% moderate high-quality habitat on the landscape. For lynx, the RSA is predicted to be approximately 20% high and 19% moderate high-quality habitat. Fisher/marten habitat at Base Case is 17% high- and 10% moderate high-quality habitat.

The barred owl and black-throated green warbler habitat suitability models predict that between 11% and 12% of the regional landscape is high-quality habitat for both species. HSI models for Canadian toad and black bear predict that the landscape is made up of about 15 and 30% high-quality habitat, respectively. Beaver and yellow rail HSI models predict that the regional-scale landscape is made up of 22 and 10% high-quality habitat in the Base Case, respectively.

1.3.2.2 Application Case

The impacts of the Application Case at the RSA scale do not take reclamation into account for habitat suitability modelling purposes. This is due to the difficulty of simulating regional landscape changes such as forestry operations and wild fires forward in time to the date of Closure. The RSF model for moose predicts a loss of approximately 4% high-quality habitat, and less than 1% moderate high-quality habitat from Base Case to Application Case. The lynx RSF model predicts a loss of 5% high-quality and 0.4% moderate high-quality habitat. The fisher/marten model predicts that high-quality habitat for these species will decrease by about 5% and moderate high-quality habitat by 1%.

Table 15 Habitat Change for Focal Species in the Regional Study Area - Planned Development Case

Key Indicator Resource	Habitat Suitability Class	Base Case		Application Case, Direct Habitat Change From Base Case Due to Project and Jackpine Mine – Phase 1		PDC, Direct Habitat Change From Base Case Due to Project and Jackpine Mine – Phase 1	
		Habitat Area [ha]	% of Total Area	Change in Habitat Area [ha]	Change [%]	Change in Habitat Area [ha]	Change [%]
moose	nil	192,415	8.4	24,474	12.7	113,649	59.1
	low	368,874	16.2	-402	-0.1	-2,314	-0.6
	moderate low	379,457	16.7	-738	-0.2	-7,807	-2.1
	moderate	429,477	18.9	-948	-0.2	-14,168	-3.3
	moderate high	437,138	19.2	-3,040	-0.7	-27,776	-6.4
	high	470,016	20.6	-19,345	-4.1	-61,585	-13.1
Canada lynx	nil	192,428	8.4	24,474	12.7	113,636	59.1
	low	316,133	13.9	0	0.0	-127	0.0
	moderate low	417,701	18.3	-12	0.0	-6,419	-1.5
	moderate	465,347	20.4	-209	0.0	-11,321	-2.4
	moderate high	435,172	19.1	-1,563	-0.4	-30,537	-7.0
	high	450,596	19.8	-22,690	-5.0	-65,232	-14.5
fisher/marten	nil	192,415	8.4	24,492	12.7	113,665	59.1
	low	822,303	36.1	-2,114	-0.3	-21,642	-2.6
	moderate low	462,941	20.3	-1,000	-0.2	-10,466	-2.3
	moderate	184,158	8.1	928	0.5	-7,539	-4.1
	moderate high	230,402	10.1	-2,093	-0.9	-19,872	-8.6
	high	385,158	16.9	-20,213	-5.2	-54,146	-14.1
black-throated green warbler	nil	667,313	29.3	16,637	2.5	86,151	12.9
	low	1,086,153	47.7	-12,499	-1.2	-48,031	-4.4
	moderate	265,188	11.6	-1,029	-0.4	-19,541	-7.4
	high	258,722	11.4	-3,108	-1.2	-18,579	-7.2
barred owl	nil	667,313	29.3	16,637	2.5	86,151	12.9
	low	1,144,352	50.2	-13,209	-1.2	-52,592	-4.6
	moderate	203,653	8.9	-1,013	-0.5	-17,643	-8.7
	high	262,059	11.5	-2,415	-0.9	-15,916	-6.1
Canadian toad	nil	471,727	20.7	24,339	5.2	97,227	20.6
	low	131,565	5.8	-578	-0.4	-6,371	-4.8
	moderate	1,325,793	58.2	-18,351	-1.4	-71,224	-5.4
	high	348,326	15.3	-5,313	-1.5	-19,628	-5.6
black bear	nil	203,235	8.9	24,445	12.0	111,116	54.7
	low	596,440	26.2	-16,043	-2.7	-47,227	-7.9
	moderate	803,261	35.3	-4,477	-0.6	-33,746	-4.2
	high	674,440	29.6	-3,925	-0.6	-30,143	-4.5
beaver	nil	1,550,039	68.1	9,345	0.6	41,054	2.6
	low	235,861	10.4	-4,190	-1.8	-15,886	-6.7
	moderate	0	0.0	0	0.0	0	0.0
	high	491,476	21.6	-5,155	-1.0	-25,168	-5.1
yellow rail	nil	2,047,209	89.9	4,086	0.2	15,298	0.7
	high	230,167	10.1	-4,086	-1.8	-15,298	-6.6

The black-throated green warbler, barred owl and beaver HSI models all predict a loss of about 1% in high-quality habitat due to proposed project disturbance. The black bear and yellow rail HSI models predict losses of less than 1% and about 2% high-quality habitat, respectively. The Canadian toad HSI model predicted a decrease of 1.5% in the amount of high-quality habitat over the landscape.

1.3.2.3 Planned Development Case

The Planned Development Case (PDC) is represented at the RSA scale, and includes Project effects, as well as the effects of all approved projects and other human disturbances (e.g., planned and approved forest harvest areas) within the RSA. In contrast, Application Case at the RSA scale takes into consideration only the effects of the Project as well as existing disturbances.

The moose RSF model predicts a decline in high and moderate high-quality habitat of 13 and 6% from Base Case to PDC, respectively. Lynx are predicted to lose about 15% high-quality habitat and 7% moderate high-quality habitat. The fisher/marten RSF model predicts a loss of 14% in high-quality habitat, and a decrease in moderate high-quality habitat of approximately 9% from Base Case to PDC.

The black-throated green warbler and barred owl HSI models predicted losses in high quality habitat of about 7 and 6% from Base Case to PDC, respectively. Losses in high-quality habitat of 6% for Canadian toad, 5% for black bear, 5% for beaver and 7% for yellow rail were predicted by HSI models.

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2 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 METHODS

Habitat fragmentation analysis was used to describe changes in the degree of habitat fragmentation in the landscape resulting from the Project and other planned developments at the RSA scale. Unlike the local scale assessment, the regional scale assessment does not account for reclamation of the various projects as this cannot be accurately defined at this scale. Habitat fragmentation analysis was not conducted at the LSA level for the Project as site clearing alone accounts for most of the total disturbance. Therefore, at the LSA scale, direct habitat loss is the concern and the relevant measure rather than fragmentation.

Habitat fragmentation analysis was performed for moose, lynx, fisher/marten and black bears. These focal species are of particular management concern, and may be sensitive to habitat fragmentation at both the local and regional scale. To conduct the analysis, the RSA was first classified into patches based on HS model predictions for nil, low, moderate (in the case of black bears) and high-quality habitat. Black bear, fisher/marten and lynx HS model output were then rasterized into a grid with 20 x 20 m cells. The spatial distribution and characteristics of these patch types for each focal species were then analyzed in FRAGSTATS (McGarigal et al. 2002, website).

Five fragmentation indices were used to describe changes in habitat structure in the RSA from the Base Case to Application Case and PDC. Number of Patches (NP), Mean Patch Size (MPS), total habitat Class Area (CA) and mean Euclidian Nearest Neighbour distance (ENN_MN) were used for moose, black bears, fisher/marten and lynx at the RSA level. Wildlife habitat fragmentation indices used in the section are described in Table 16.

Table 16 Fragmentation Indices Applied in the Regional Study Area

Type of Metric	Fragmentation Index	Description	Units
area	number of patches (NP)	number of patches on the landscape	number
	mean patch size (MPS)	mean patch size on the landscape	hectares
	class area (CA)	total area of a given habitat quality class on the landscape	hectares
isolation	Euclidian nearest neighbour mean distance (ENN_MN)	mean measure of the distance between a patch and the nearest patch of the same habitat quality class	metres

2.3 RESULTS

Detailed results of the fragmentation analysis are presented in Table 17. Due to the raster approach, total area of linear disturbances had to be overestimated to ensure their representation on the landscape. This was necessary for the analysis of fragmentation, but does mean that total habitat loss will be overestimated as well.

To minimize the overestimation of linear disturbance area impacts for all models, these features were not buffered. Instead, arcs were drawn through them in ArcGIS and any portion of a pixel which the arc passed through was then incorporated into the linear disturbance. Finally, total areas for Base Case, Application Case and PDC for black bear are not equal due to errors produced by the rasterization of polygons. However, the difference will have a negligible effect on results, as it represents only a 0.002% error. This difficulty was avoided for fisher/marten, moose and lynx, as these models were originally produced in a raster format.

Table 17 Predicted Key Indicator Resource Habitat Fragmentation Effects for the Base Case, Application Case and Planned Development Case in the Regional Study Area

Key Indicator Resource		Base Case				Application Case				Net Change From Base Case to PDC			
		NP	MPS [ha]	TCA [ha]	ENN_MN [m]	NP	MPS [ha]	TCA [ha]	ENN_MN [m]	NP [%]	MPS [%]	TCA [%]	ENN_MN [%]
moose	nil	9,894	20.9	153,639.1	462.9	9,256	24.9	176,824.0	468.0	-28.0	115.0	71.8	11.2
	low	1,540	238.0	320,324.8	344.2	1,549	236.4	320,126.9	341.4	0.3	-1.0	-0.6	-6.6
	moderate low	1,776	212.6	267,681.3	333.0	1,777	212.1	267,332.0	337.5	-0.2	-1.9	-2.1	-2.5
	moderate	1,365	313.4	254,186.4	300.7	1,366	312.5	253,809.9	301.6	0.5	-3.8	-3.2	9.7
	moderate high	1,503	289.5	278,054.0	256.3	1,501	287.9	276,383.8	255.3	-5.5	-0.9	-6.0	13.1
	high	1,169	396.8	358,771.6	81.1	1,225	363.0	342,111.5	82.5	2.7	-15.4	-13.0	26.7
lynx	nil	9,894	20.9	153,639.1	462.9	9,256	24.9	176,824.8	468.0	-28.0	115.0	71.8	11.3
	low	1,161	270.7	283,029.1	215.6	1,161	270.7	283,029.1	215.6	0.2	-0.2	0.0	-0.2
	moderate low	1,801	230.7	325,024.2	272.0	1,799	230.9	325,024.0	272.3	0.4	-2.0	-1.8	-0.4
	moderate	1,276	363.5	341,386.3	248.9	1,277	363.1	341,315.6	249.0	0.7	-3.1	-2.2	5.8
	moderate high	1,898	227.9	320,464.2	216.0	1,892	227.8	319,664.2	218.1	-6.2	-0.8	-6.8	7.3
	high	1,536	289.7	359,961.7	112.6	1,570	269.1	340,204.2	114.3	0.7	-15.1	-14.2	5.8
fisher/marten	nil	9,894	20.9	153,639.1	462.9	9,256	24.9	176,825.4	468.0	-28.0	115.0	71.8	11.3
	low	9,816	83.2	656,331.4	164.0	9,018	90.3	646,032.8	182.0	-9.4	7.5	-3.6	11.1
	moderate low	6,165	74.9	267,471.7	193.9	5,709	80.6	258,914.2	211.9	-11.7	10.7	-4.1	11.9
	moderate	9,741	18.8	87,589.3	121.0	5,578	33.1	83,748.7	205.8	-45.7	76.6	-7.0	73.1
	moderate high	5,510	41.5	92,401.7	173.6	5,378	42.1	87,769.5	179.9	-11.9	3.7	-10.4	7.5
	high	2,330	163.4	267,789.5	143.5	2,259	159.7	245,126.0	148.4	-9.0	-5.6	-15.9	5.3
black bear	nil	9,730	22.5	159,314.4	459.2	9,092	26.7	182,491.8	464.0	-27.9	108.4	68.6	11.3
	low	9,905	66.0	261,564.6	113.5	9,932	64.1	253,969.1	114.2	-5.5	-2.4	-7.9	3.1
	moderate	22,513	33.7	368,941.2	80.2	21,842	34.5	368,556.6	80.6	-9.9	6.5	-2.5	1.2
	high	13,806	46.9	341,854.9	104.6	13,600	47.3	340,494.5	104.5	-7.6	3.4	-4.2	0.2

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

2.3.1 Application Case

In the Application Case, the number of patches of predicted moderate high-quality moose habitat remains the same, while the number of patches of high-quality habitat increases slightly (4.8%). The mean patch size of high- and moderate high-quality habitat declines (8.5 and 0.6%, respectively), as does the total core area (4.6 and 0.6%, respectively). Mean Euclidian nearest neighbour distance increases slightly for high-quality moose habitat (1.7%), and decreases slightly for moderate high-quality habitat (0.4%). Impacts on quality habitat for moose primarily consist of fragmentation into more numerous patches of decreased size.

The predicted number of high-quality lynx patches increases by 2.2%, while the number of moderate high-quality patches decreases by 0.3%. The mean size of high-quality patches decreases (7.1%), as does the total core area of high- (5.5%) and moderate-high quality habitat (0.2%). Mean nearest neighbour distance increases by 1.5% for high-quality lynx habitat and by 1.0% for moderate high-quality habitat. Therefore, project-related changes to quality lynx habitat may be generalized as a fragmentation of larger patches into smaller, more distant patches.

Patches of fisher/marten habitat decrease in number by 3% for high-quality habitat and by 2.4% for moderate high quality habitat. The average size of patches decreases by 2.3% for high-quality habitat and increases by 1.5% for moderate high-quality habitat. Total core area of high- and moderate high-quality habitat decreases by 8.5 and 5%, respectively. The mean distance between patches of fisher and marten habitat patches increases by about 3.5% for high- and moderate high-quality habitat.

Relative to the Base Case, bear habitat patches in the Application Case decrease by 1.5% in number for high-quality habitat. The mean patch size increases by 0.9% for high-quality habitat, while the mean distance between patches decreases by 0.1%. The total core area of high-quality habitat decreases by 0.4%. Impacts on high-quality bear habitat within the RSA take the form of a relatively minor loss of patches that are smaller and more isolated on average.

2.3.2 Planned Development Case

The impacts of fragmentation at the RSA scale in the PDC increase relative to the Base Case. The number of habitat patches predicted to be high-quality for moose increase by 2.7%, while moderate high-quality patches decrease by 5.5%. The mean patch size of habitat patches decreases by 15.4% for high-quality habitat and by 0.9% for moderate high-quality habitat. Total core area of high and moderate high-quality habitat also decreases, by 13 and 6% respectively. The mean distance between patches increases by about 27% for high-quality habitat and by 13% for moderate high-quality habitat. From these results it is expected that quality moose habitat will be fragmented into smaller, more distant patches on average in the PDC.

Lynx habitat patches increase by 0.7% in number for high-quality habitat and decrease by 6.2% for moderate high-quality habitat. The mean size of high-quality patches decreases by 15.1%, while moderate high-quality patches decrease by 0.8%. Total core area of high- and moderate high-quality habitat decreases by 14.2 and 6.8%, respectively. The mean distance between lynx habitat patches increases by 5.8% for high-quality and by 7.3% for moderate-quality habitat. Therefore, impacts on quality habitat for lynx are expected to primarily take the form of losses of patches that are larger than average, and interspersed between other patches.

The number of patches of high- and moderate high-quality habitat for fisher and marten decreases by 9 and 11.9% from Base Case to PDC, respectively. Mean patch size decreases by 5.6% for high-quality habitat and increases by 3.7% for moderate high-quality habitat. The total core area of high- and moderate high-quality habitat decreases by 15.9 and 10.4%, respectively. The average distance between patches increases from Base Case to PDC; by 5.3% for high-quality and by 7.5% for moderate high-quality habitat.

For black bears, the number of patches of high-quality habitat decreases by 7.6%, while mean patch size and mean nearest neighbour distance both increase slightly (3.4 and 0.2%, respectively). The total core area of high-quality bear habitat decreases by 4.2% from Base Case to PDC. Impacts on bear habitat may be generalized as losses of habitat patches that are small, and interspersed with other patches, on average.

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3 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 the probability of species extinction within a given period of time and space (Soulè 1987; Shaffer 1990). Information on the potential effects of the Project and other planned developments on wildlife populations is provided by PVA. Specifically, 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 METHODS

The PVA was conducted for moose and black bears at the RSA scale using RAMAS® GIS. These focal species were selected because they are species of special management concern, their populations are wide-ranging, and sufficient information on their life histories exists to conduct a PVA. The RAMAS® GIS program links habitat changes and associated changes in habitat suitability to changes in population performance (Akçakaya 1998). Output maps from RSA-scale predictive habitat suitability models were first converted to a 50 x 50 m cell size raster grid, and then imported into the RAMAS® GIS program for a calculation of patch characteristics in the RSA.

For moose, only areas classified as “moderate”, “moderate high” or “high” habitat quality were considered for inclusion into a patch. For black bears, only areas that fell into the “moderate” or “high” habitat quality classes were considered for inclusion into a patch. For both species, a neighbourhood distance of 3 km was chosen and any habitat that fell beyond this distance from the next nearest habitat would be considered a separate patch.

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Also for both species, a maximum carrying capacity (K; i.e., maximum population density) of one female per km^2 and one male per km^2 was selected. This was modified by multiplying K by the total habitat suitability score per patch. Small and ineffective patches were removed from consideration by only considering patches that could support 20 or more female moose or black bears.

For each species, a stage-dependent matrix containing survival and fecundity rates for each age class (i.e., Leslie matrix; Carey 1993) was constructed. In addition, a secondary stage (age class) matrix containing standard deviations for

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survival and fecundity was constructed. The RAMAS® uses these two matrices during the simulation routine to calculate a probability distribution (i.e., mean and associated 95% Confidence Interval) of population abundance and risk of extinction for a specified duration (Akçakaya 1998). Several studies were reviewed to determine the geometric mean and standard deviations of survival and fecundity rates (Tables 18 and 19 for each species (Golder 2002).

For moose, survival and fecundity rates were estimated for three age classes: calves, yearlings and adults, with only adults capable of reproducing (Table 18). For black bears, 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). Similar to moose, reproduction was assumed to occur in adults only (Table 19).

Table 18 Stage-Dependent Average (±1SD) Survival and Fecundity Rates for the Moose Population Model

Stage	Survival	Fecundity
calves	0.65 ± 0.05	0.00
yearlings	0.78 ± 0.03	0.00
adults	0.78 ± 0.03	0.601 ± 0.201

Table 19 Stage-Dependent Average (±1SD) Survival and Fecundity Rates for the Black Bear Population Model

Stage	Survival	Fecundity
cubs	0.64 ± 0.08	0.00
yearlings	0.78 ± 0.06	0.00
sub-adults	0.63 ± 0.12	0.00
adults	0.82 ± 0.05	0.633 ± 0.243

The initial abundance per functioning patch was set as approximately 40% of the carrying capacity of an optimal patch for black bears and 20% for moose. The initial abundance of individuals for each stage was determined by assuming a stable age distribution at time N_0. Density dependence was applied to survival and fecundity rates using a ceiling type model (i.e., Type 1 functional response), where the population growth rate is exponential until the population size reaches K. At carrying capacity, a population's growth rate will equal zero (i.e., $N_t = N_{t+1}$) until environmental stochasticity or a catastrophe depresses the population size below K.

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Environmental variation or stochasticity was incorporated in the model through the following mechanisms:

- variation in stage-dependent survival and fecundity rates;
- a standard deviation for carrying capacity that is 10% of K; and
- a catastrophe.

For moose, snow depth or hardness can decrease population size by limiting access to food resources, increasing energy expenditure and/or the risk of predation (Modafferi and Becker 1997). The frequency of such a severe winter was simulated to occur once every 20 years on average, and the geographic extent was regional. The magnitude of the effect was a stage-dependent impact on abundances, removing 10% of calves, 5% of yearlings and 5% of adults.

For black bears, berry crop failure can also decrease population size (Young and Ruff 1982). The frequency of berry crop failure was assumed to occur once every 20 years across the entire RSA. The simulation removed 10% of cubs and 5% of yearlings. It was assumed that berry crop failure would not affect the abundance of subadult and adult black bears (Young and Ruff 1982).

Population models were simulated over a projected period of 30-years with 1,000 replications. At the end of simulations, results were summarized and a sensitivity analysis was conducted to evaluate the potential impact of errors in assumptions.

3.3 RESULTS

3.3.1 Moose

3.3.1.1 Changes in Population Patch Characteristics

Base Case, Application Case and PDC landscape models identified one patch for the moose population within the RSA (Table 20). In the Base Case, this patch took up 58.3% of the landscape, with a carrying capacity of over 5,300. This percentage is only slightly lower than the 58.7% of the Base Case landscape that was predicted to be of moderate to high quality habitat over the RSA in the habitat quality assessment (Table 15). The discrepancy suggests that some of this habitat was excluded as it was too sparsely distributed across the RSA to be included in the PVA. From Base Case to PDC, carrying capacity decreases by 8.6% overall and patch size decreases by 7.7% of the RSA.

Table 20 Variation in Characteristics of the One Habitat Patch From the Moose Base, Application and Planned Development Case Landscape Models

Species	Variable	Model		
		Base Case	Application Case	Planned Development Case
Moose	initial abundance	5,306	5,214	4,896
	carrying capacity	21,372	20,932	19,540
	population density over RSA at carrying capacity [females/km^2]	0.9	0.9	0.9
	number of populations	1	1	1
	area of patch as % of RSA	58.3	57.2	53.7

3.3.1.2 Temporal Change in Population Abundance and Risk of Extinction

Based on the survival and fecundity values in the stage matrix, the finite rate-of-increase (λ) for the moose population was 1.05 assuming no density dependence or environmental variation. A finite increase of 1.0 would represent a population that is replacing itself exactly (Krebs 1994). Including density dependence effects on survival and fecundity rates as well as environmental stochasticity (i.e., the potential catastrophe of a severe winter), the Base Case, Application Case and PDC population models indicated that the moose population would steadily increase over time, approaching but not reaching carrying capacity within the RSA by year 30 (Figure 32).

The carrying capacity for all cases is estimated to be 0.9 moose/km^2. From an initial population density of 0.23 moose/km^2, population density for the Base Case and Application Case is expected to reach 0.78 and 0.74 moose/km^2, respectively. In the PDC, populations increase from an initial density of 0.21 to 0.71 moose/km^2. For all cases, the population is still increasing at 30 years. The positive projected rate of increase for all planning scenarios should not be interpreted literally, as it is dependent upon estimates of initial abundances. It may be that moose on the landscape are currently nearer to carrying capacity than estimated. The population may therefore be increasing more slowly, if at all. The more important result of this analysis is that populations are not decreasing under the assumptions used for simulation modelling.

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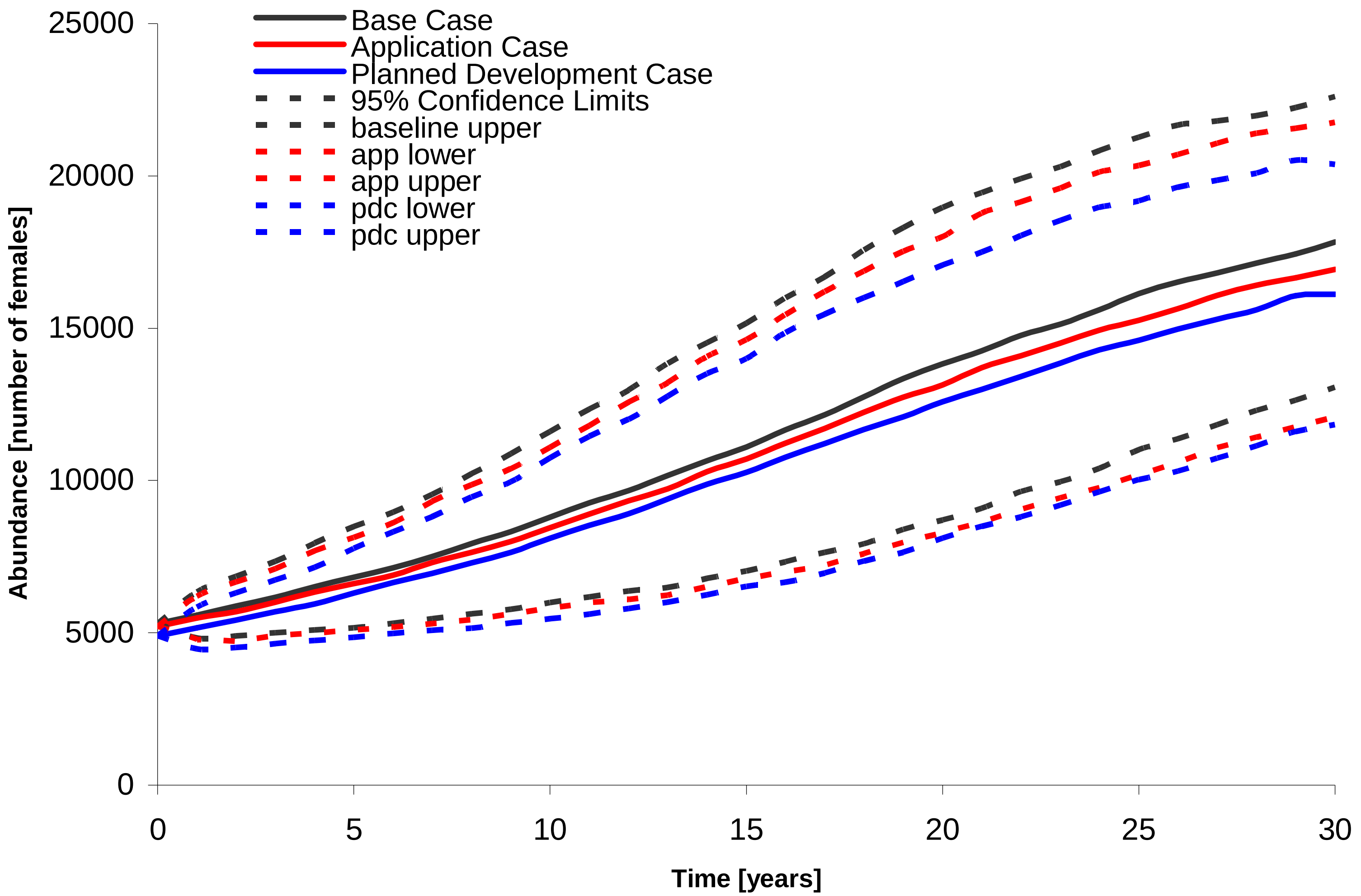

PROJECT	JACKPINE MINE EXPANSION & PIERRE RIVER MINE PROJECT			
TITLE	**CHANGES IN MOOSE POPULATION SIZE OVER TIME USING THE BASE, APPLICATION AND PLANNED DEVELOPMENT CASE SIMULATIONS**			
Shell Canada Limited	PROJECT 06-1346-022.7720			FILE No. Change-Moose Pop..
	DESIGN	BS	06/09/07	SCALE AS SHOWN REV. 0
	CADD	YW	06/09/07	**FIGURE: 32**
	CHECK	OM	06/12/07	
	REVIEW	TC	06/12/07	

Analysis of extinction risk probabilities indicate that at over the next 30 years, there is a 5% chance the moose population will dip below 3,932 individuals at least once in the Base Case. For the Application Case and PDC there is a 5% chance that the population will drop below 3,774 and 3,715 individuals at least once in the next 30 years, respectively. Figure 33 illustrates the risk of a population falling below a given threshold at least once over 30 years. By the end of the 30-year period, there is a 5% chance that the population will be below about 8,700 individuals in the Base Case and 8,200 in the Application Case. For the PDC, there is a 5% chance that the population will be below about 7,900 individuals after 30 years.

Sensitivity Analysis

Results of the sensitivity analysis are shown in Table 21. For the most part, population sizes at the end of the 30-year simulation varied only slightly due to 10 and 20% fluctuations in parameters. The notable exception, however, is decreases in survival and fecundity estimates. Should survival or fecundity be below those assumed by only 10%, the population will decline. If survival or fecundity fall below assumed rates by 20%, regional extinction is very likely.

Table 21 Sensitivity Analysis for the Population Viability Analysis of the Moose Population in the Regional Study Area

Assessment Case	Population Size at 30 Years As a Mean of All Iterations [Number of Individuals]						
	No Change	Probability of Catastrophe		Stage Matrix Means		Carrying Capacity	
		+10%	+20%	-10%	-20%	-10%	-20%
Base Case	12,255	12,326	12,054	606	18	11,876	10,970
Application Case	12,320	12,202	12,104	610	17	11,488	11,012
Planned Development Case	11,311	11,846	11,356	551	18	11,156	10,406

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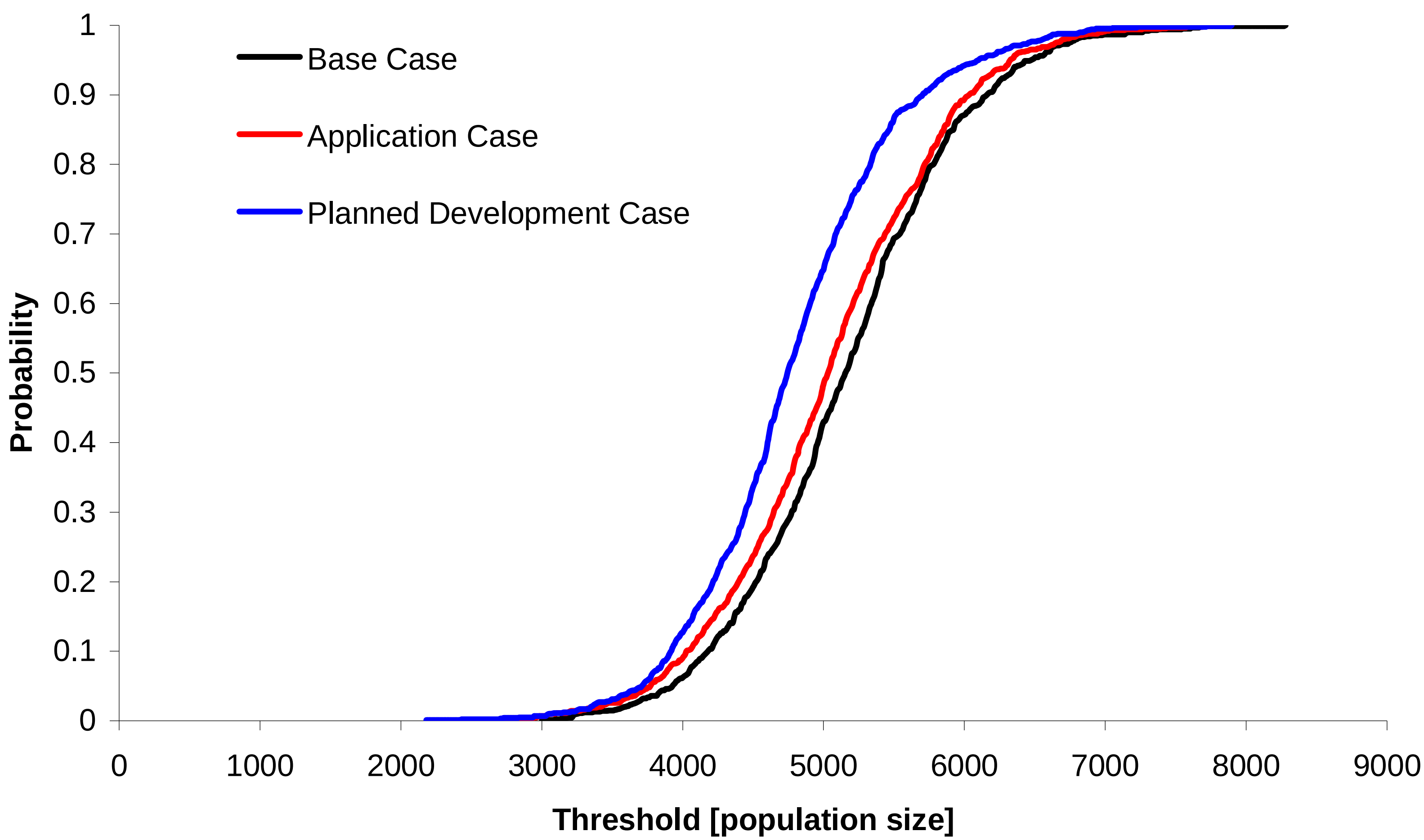

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

PROBABILITY OF MOOSE POPULATION DECLINING BELOW A GIVEN THRESHOLD AT LEAST ONCE DURING THE 30-YEAR SIMULATION

Shell Canada Limited

PROJECT 06-1346-022.7720			FILE No.Probability-Moose Pop	
DESIGN	BS	06/09/07	SCALE AS SHOWN	REV. 0
CADD	YW	06/09/07	**FIGURE: 33**	
CHECK	OM	06/12/07		
REVIEW	TC	06/12/07		

3.3.2 Black Bears

3.3.2.1 Changes in Landscape Attributes, Carrying Capacity and Initial Abundance

Landscape models identified one patch for the black bear population within the RSA for the Base Case, Application Case and PDC (Table 22). In the Base Case, this patch included over 61% of the RSA, with a carrying capacity of over 23,000 individuals. This percentage is only slightly lower than the 64.9% of the Base Case landscape that was predicted to be in the combined “moderate” and “high” quality habitat classes over the RSA (Table 15). The discrepancy suggests that some of this habitat was excluded as it was too sparsely distributed across the RSA to be included in the patch calculated by RAMAS for the PVA. From Base Case to PDC, carrying capacity decreases by 4.3% overall, while patch size decreases by 4.2% of the total landscape.

Table 22 Variation in Characteristics of the One Habitat Patch From the Black Bear Base, Application and Planned Development Case Landscape Models

Species	Variable	Model		
		Base Case	Application Case	Planned Development Case
black bear	initial abundance	10,116	10,064	9,688
	carrying capacity	23,044	22,924	22,062
	population density over RSA at carrying capacity [females/km^2]	1.0	1.0	1.0
	number of populations	1	1	1
	area of patch as % of RSA	61.7	61.4	59.1

3.3.2.2 Temporal Change in Population Abundance and Risk of Extinction

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. As mentioned previously, a population that is replacing itself exactly would have a finite rate-of-increase of increase of 1.0 (Krebs 1994). Including density dependence effects on survival and fecundity rates as well as environmental stochasticity (i.e., the potential catastrophe of a berry failure), simulations for all cases indicated that the bear population would increase slowly to a density approaching 0.5 bears/km^2 by about 18 years and remain fairly stable in later years (Figure 34).

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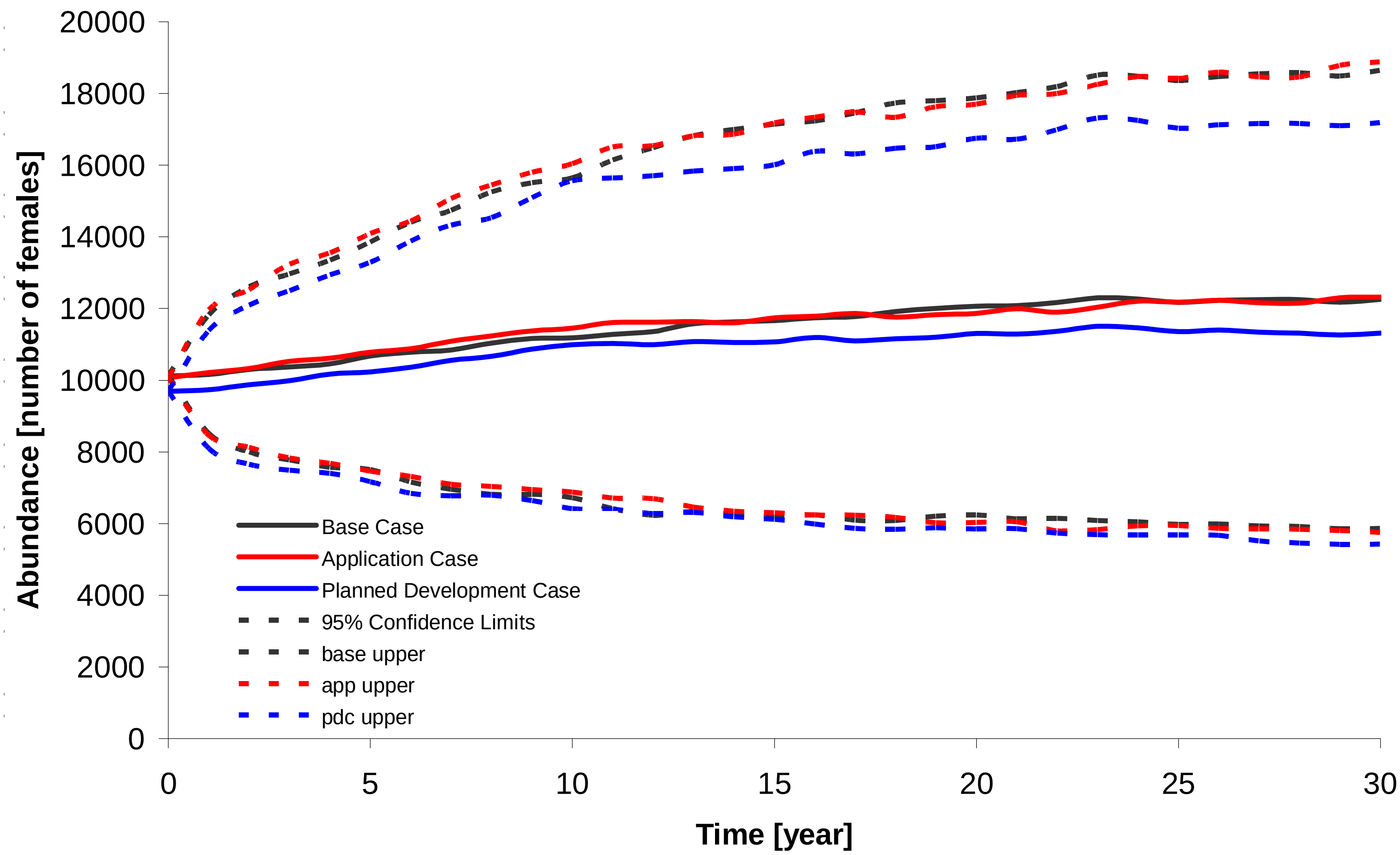

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

CHANGES IN BEAR POPULATION SIZE OVER TIME USING THE BASE, APPLICATION AND PLANNED DEVELOPMENT CASES SIMULATIONS

Shell Canada Limited

PROJECT 06-1346-022.7720		
DESIGN	BS	06/09/07
CADD	YW	06/09/07
CHECK	OM	06/12/07
REVIEW	TC	06/12/07

FILE No. Change-Bear Pop

SCALE AS SHOWN REV. 0

FIGURE: 34

Carrying capacities for all cases reflect population densities of 1.0 bears/km^2 over the entire Project RSA, respectively. Initial population densities are estimated to be 0.44 bears/km^2 for the Base Case and Application Case and 0.43 bears/km^2 for the PDC. After 30 years, bear population densities are estimated to reach 0.54 bears/km^2 for the Base Case and Application Case, and 0.50 bears/km^2 for the PDC. The low assumed finite rate-of-increase does not allow bears to increase to levels approaching carrying capacity within the time period of analysis. Proposed project impacts will decrease carrying capacity slightly.

Analysis of extinction risk probabilities indicate that over the next 30 years, there is a 5% chance the black bear population will dip below about 3,000 individuals at least once in the Base Case and Application Case (Figure 35). For the PDC, there is a 5% chance that the population will drop below about 2,700 individuals at least once in the next 30-years. Figure 34 illustrates the risk of a population falling below a given threshold at least once over 30 years. By the end of the 30-year period, there is a 5% chance that the population will be below about 3,400 individuals in all cases.

Sensitivity Analysis

Results of the sensitivity analysis for parameters affecting the black bear PVA are shown in Table 23. As with moose, population sizes at the end of the 30-year simulation varied only slightly due to 10 and 20% fluctuations in parameters. Again, the notable exception is the effects of declines in survival and fecundity estimates. Should survivability or fecundity decrease by 10% of those assumed, the population will decline. If survival and reproduction rates fall by 20% below those assumed for simulations, regional extinction is very likely.

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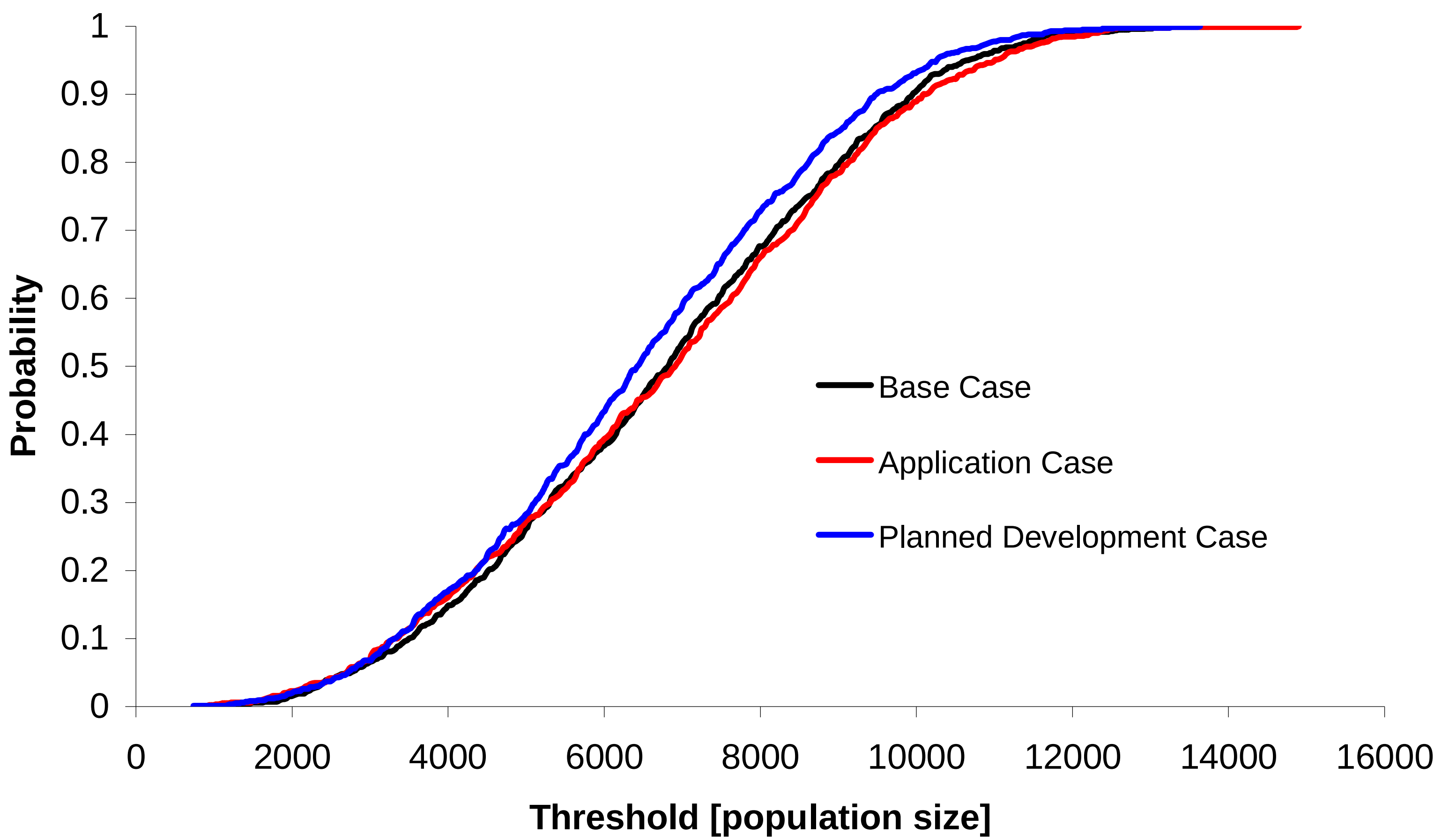

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

PROBABILITY OF BEAR POPULATION DECLINING BELOW A GIVEN THRESHOLD VALUE AT LEAST ONCE DURING THE 30-YEAR SIMULATION

Shell Canada Limited

PROJECT 06-1346-022.7720		
DESIGN	BS	06/09/07
CADD	YW	06/09/07
CHECK	OM	06/12/07
REVIEW	TC	06/12/07

FILE No. Probability-Bear Pop

SCALE AS SHOWN REV. 0

FIGURE: 35

Table 23 Sensitivity Analysis for the Population Viability Analysis of the Black Bear Population in the Regional Study Area

Assessment Case	Mean of Population Trajectory Over 30 Years [Number of Individuals]						
	No Change	Probability of Catastrophe		Stage Matrix Means		Carrying Capacity	
		+10%	+20%	-10%	-20%	-10%	-20%
Base Case	17,835	17,408	17,754	1,042	31	16,514	14,770
Application Case	16,929	17,460	17,268	971	28	15,972	14,746
Planned Development Case	16,111	16,132	15,850	920	27	15,162	13,712

3.4 POPULATION VIABILITY ANALYSIS SUMMARY

For moose and black bears, one population patch was identified for each species, comprising about 58% of the RSA for moose and 62% for black bears in the Base Case. The areal extent of this single population decreased by 7.7% of the RSA area for moose and 4.2% for bear from Base Case to PDC. This resulted in a reduction of carrying capacity of almost 9% for moose and over 4% for bears when compared to Base Case conditions. Under the assumptions used in this analysis, although habitat loss affects carrying capacity, extinction risk remains negligible at much less than 0.1%. However, results of sensitivity analysis suggest that population performance projections are strongly tied to assumptions regarding rates of survival and reproduction for both moose and black bears; reductions in those rates may result in population declines or extirpation.

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4 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. A Linkage Zone Analysis (LZA) was completed to assess the impacts of the Project on moose movement in the RSA (Meitz 1994; Gibeau et al. 1996). The LZA was produced through modifications to moose RSF 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., above ground pipelines, roads).

4.2 METHODS

Methods for the LZA were adapted from those used by Meitz (1994) and Kehoe (1995). In essence, the LZA functions by laying a grid over the RSA, and quantifying the proportion of habitat that is unsuitable for wildlife movement within each row (east-west) and column (north-south). The LZA was limited to an assessment of potential moose movement in the RSA. Moose were chosen as they are a CEMA Priority 1 species (Westworth 2002) and a CEMA-SEWG environmental indicator, and have extensive home ranges. Scenarios analyzed demonstrate two areas:

- Linkage areas that allow free movement among habitat patches according to moose RSA-scale RSF output. All areas where output from the moose RSF model was greater than zero was considered a potential linkage zone.
- Disturbances such as roads and industrial developments, which act as barriers to moose movement, were given a 250 m zone of influence buffer. This acts as a liberal representation of effective habitat loss due to both direct habitat loss and indirect loss due to sensory disturbance. The area within the zone of influence buffer was assumed to be part of a fracture zone and reduced to a habitat value of zero. All areas where RSF model output values were greater than zero were considered potential linkage areas.

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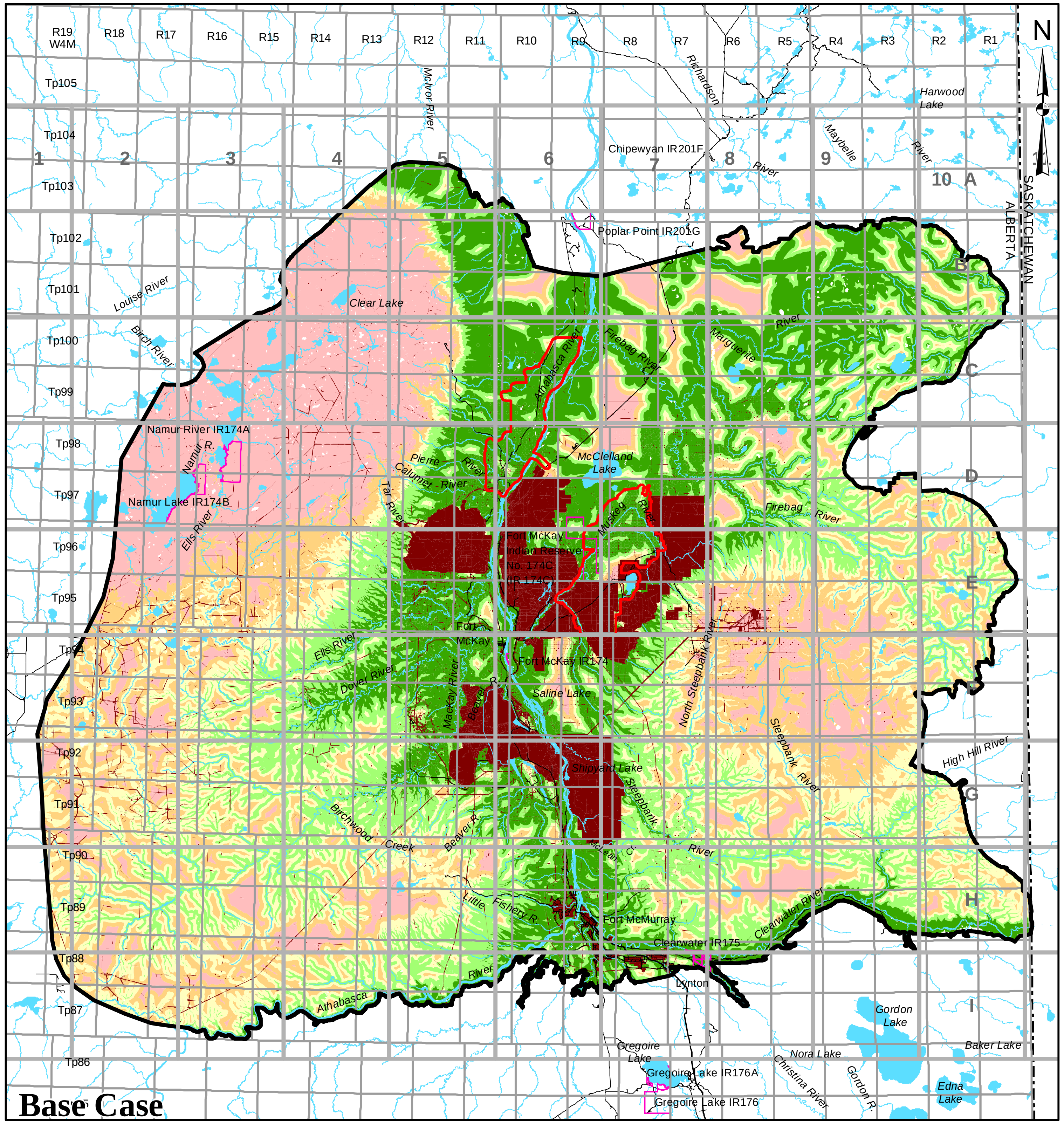
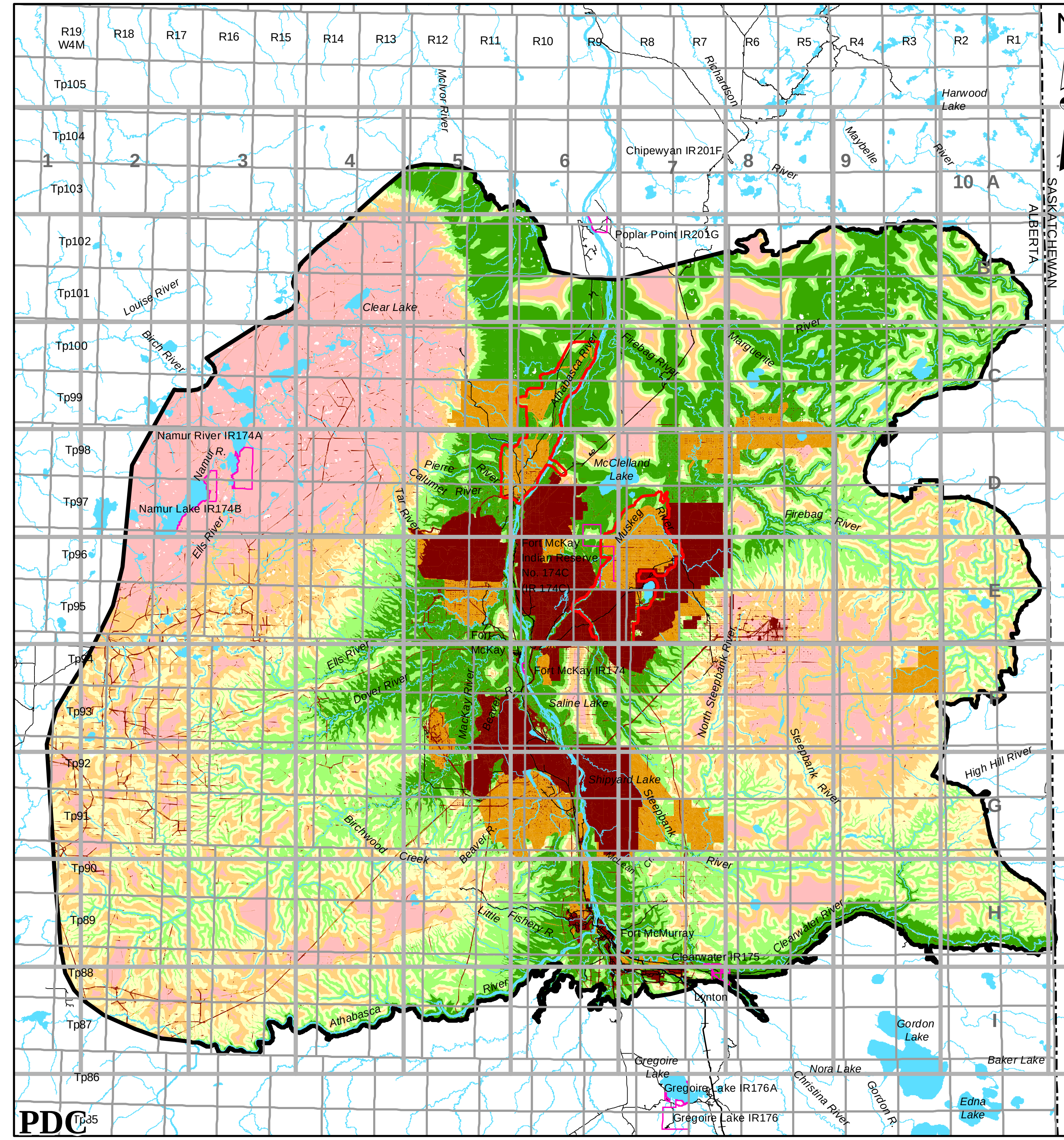
4.3 RESULTS

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 (Table 24, Figure 36). 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. However, the results highlight areas of the RSA that present challenges to the free movement of moose across the landscape.

Table 24 Percentage of Habitat Unsuitable for Moose Movement in East-West Rows and North-South Columns of the Linkage Zone analysis Grid in the Regional Study Area

Corridor	Base Case [%]	Application Case		Planned Development Case	
		% of Corridors	% Change From Base Case	% of Corridors	% Change From Base Case
east-west A	1.0	1.0	0.0	1.0	0.0
east-west B	3.0	3.0	0.0	3.0	0.0
east-west C	12.1	13.7	1.6	16.9	4.8
east-west D	25.9	27.7	1.7	30.1	4.2
east-west E	38.8	39.8	1.0	40.5	1.7
east-west F	24.0	24.0	0.0	26.4	2.3
east-west G	20.8	21.0	0.2	27.6	6.8
east-west H	8.2	8.2	0.0	9.5	1.4
east-west I	14.3	14.3	0.0	16.3	1.9
north-south 1	15.7	15.7	0.0	16.3	0.6
north-south 2	14.0	14.0	0.0	14.3	0.3
north-south 3	9.0	9.0	0.0	9.3	0.4
north-south 4	6.7	6.7	0.0	7.1	0.4
north-south 5	27.4	27.9	0.4	32.4	4.9
north-south 6	47.7	50.8	3.1	55.2	7.5
north-south 7	36.1	37.5	1.4	43.0	6.9
north-south 8	16.4	16.4	0.0	18.5	2.1
Total Percentage of Habitat Unsuitable for Movement in the RSA	**21.0**	**21.6**	**0.7**	**24.2**	**3.2**





LEGEND

- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- 20 km GRID
- LOCAL STUDY AREAS
- INDIAN RESERVE
- OPEN WATER
- PUBLIC ROADWAY
- RAILROAD

HABITAT SUITABILITY

- HIGH
- MODERATE HIGH
- MODERATE
- MODERATE LOW
- LOW
- NIL

DISTURBED

- PLANNED DEVELOPMENT CASE URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
- EXISTING AND APPROVED URBAN AND INDUSTRIAL LINEAR DISTURBANCE

40 0 40

SCALE 1:1,000,000 KILOMETRES

REFERENCE

Alberta digital data obtained from AltaLIS Ltd. (September 2004), IHS Energy Ltd. (August 2006), Alberta Pacific Ltd. (April 2004), Pearson Timberline Ltd. (April 2004), LANDSAT 7 ETM Imagery (July 2006), and Alberta SRD, used under license. Saskatchewan digital data obtained from Information Services Corp. (September 2004), used under license.
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 12.

PROJECT
JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE
PLANNED DEVELOPMENT CASE RESULTS OF LINKAGE ZONE ANALYSIS FOR MOOSE HABITAT SUITABILITY IN THE REGIONAL STUDY AREA

Shell Canada Limited

PROJECT No. 06-1346-022.7700			SCALE AS SHOWN	REV. 0
DESIGN	VR	18 Jan. 2007		
GIS	JH	21 Nov. 2007		
CHECK	MJ	21 Nov. 2007		
REVIEW	WES/TC	23 Nov. 2007		

FIGURE: 36

I:/CLIENTS/SHELL/06-1346-022/mapping/mxd/hsi/DRAFT/rsa_hsi_moose_lza.mxd

4.3.1 Application Case

The impacts of the Project on linkage zones were low in the Application Case at the RSA scale. The largest change appeared in corridor north-south 6, with an increase in fractured habitat of 3.1%. Rows east-west C, D and E, as well as column north-south 7 displayed a less than 2% increase. All remaining columns and rows showed a less than 1% increase in fractured habitat. The PRMA LSA falls mostly in the intersection column 6 and row C and D. The JEMA LSA falls predominantly within the intersection of column north-south 7 with east-west rows D and E. The LZA modelling indicates that a total increase in fractured habitat of 0.7% occurs in the RSA as a result of the Application Case.

4.3.2 Planned Development Case

Cumulative regional landscape disturbances in the PDC increase fractured habitat by 3.2% increase relative to the Base Case. This total impact is relatively small, although the increase in fractured habitat over Base Case is notable in some corridors. For example, notable increases in fractured habitat are apparent in column north-south 6 (7.5%), column north-south 7 (6.9%) and row east-west G (6.8%). The increase in fractured habitat in column north-south 6 is due largely to the Suncor Voyageur South Project. The disturbance in column 7 is a combination of proposed cutblocks, the Suncor Millennium Dumps Project and the Petro-Canada Lewis Steam Assisted Gravity Drainage (SAGD) project. Increases in disturbed areas within east-west row G are a result of the proposed Suncor Voyageur, Suncor Millennium Dumps and Petro-Canada Lewis SAGD projects. All remaining rows and columns displayed increases in fractured habitat of less than 5%, the majority of which were less than 2%.

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6 ABBREVIATIONS

%	Percent
<	Less than
>	Greater than
≥	Greater than or equal to
±	Plus or minus
λ	Rate of increase
AIC_c	Akaike’s Information Criterion
ASRD	Alberta Sustainable Resource Development
AVI	Alberta Vegetation Inventory
BSOD	Biological Species Observation Database
BU	Burn/Partial Burn
CA	Class Area
CC	Clearcut/Partial Cut
CEMA	Cumulative Environmental Management Association
CL	Clearing
cm	Centimetre
DBH	Diameter at breast height
DEM	Digital Elevation Model
e.g.	For example
EIA	Environmental Impact Assessment
ESRI	Environmental Systems Research Institute
ENN_MN	Euclidian Nearest Neighbour distance
et al.	Group of authors
GIS	Geographic Information System
Golder	Golder Associates Ltd.
ha	Hectare
HS	Habitat Suitability
HSI	Habitat Suitability Index
JEMA	Jackpine Expansion Mining Area
K	Carrying Capacity
KIR	Key Indicator Resource
km	Kilometre
km^2	Square kilometre
LSA	Local Study Area
LZA	Linkage Zone Analysis

m	Metre
mod1	Alberta Vegetation Inventory (AVI) data field for codes representing conditions or treatments providing additional information about the origin or condition of the cover type.
MPS	Mean Patch Size
NP	Number of Patches
OLDCON	Old Coniferous
PDC	Planned Development Case
PVA	Population Viability Analysis
ROC	Receiver Operating Characteristic
PRMA	Pierre River Mining Area
RSA	Regional Study Area
RSF	Resource Selection Function
SAS	Statistical Analysis System
Sd	Standard deviation
SEWG	Sustainable Ecosystems Working Group of CEMA
SI	Suitability Index
WF	Windfall
yr	Year

7 GLOSSARY

A Priori-Based Modelling
A priori refers to constructing a limited set of variables and models to select from prior to data analysis. Allowing the data alone to select variables or models accentuates the risk of modeling a strong but random 'quirk' in the data that does not hold much power of prediction for an independent data set (i.e., is a poor predictor of reality). These relationships between the independent variable and random, unreliable effects are known as 'spurious' relationships.

Akaike's Information Criterion
AIC is based on the theory of maximum likelihood and the Kullback-Leibler measure of information (Kullback and Leibler 1951). It is therefore an information criterion, used in statistics as an aid to choosing between competing models. It is defined as

$$-2L_m + 2m$$

where Lm is the maximized log-likelihood and m is the number of parameters in the model.

As optimal model complexity is a compromise between parsimony and goodness of fit , an AIC score improves with increasing goodness of fit and is penalized by an increase in the number of parameters. Lower values of the index indicate the preferred model, that is, the one with the fewest parameters that still provides an adequate fit to the data."

Anthropogenic
Related to human activity.

Application Case
The Environmental Impact Assessment (EIA) case including the project that is the subject of the application, existing environmental conditions, and existing and approved projects or activities.

ArcGIS
The suite of GIS software products developed by ESRI.

AVI
Alberta Vegetation Inventory

Base Case
The EIA assessment case that includes existing environmental conditions as well as existing and approved projects or activities.

Bins Sub-divisions of model output values. These divisions take over the landscape on an areal extent when projected.

Bog Sphagnum or forest peat materials formed in an ombrotrophic environment due to the slightly elevated nature of the bog, which tends to disassociate it from the nutrient-rich groundwater or surrounding mineral soils. Characterized by a level, raised or sloping peat surface with hollows and hummocks.

Mineral-poor, acidic and peat-forming wetlands that receives water only from precipitation.

Boreal Forest The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.

Chi-Square Analysis A statistical test to determine if the patterns exhibited by data could have been produced by chance.

Canopy Disturbance An opening in the forest canopy, from natural or unnatural causes.

Class Area The area of a particular habitat quality class within the study area.

Closed Canopy Assemblages of trees with tops sufficiently close to each other that there is very little visible sky from the position of the forest floor.

Coniferous Trees in the division Pinophyta of the plant kingdom. These are cone-bearing trees with no true flower (e.g., white spruce, black spruce, balsam fir, jack pine and tamarack).

Cutblock Previously forested area that has been harvested for timber and is presently regenerating at various stages of regrowth.

Decidious Tree species that lose their leaves at the end of the growing season.

Diameter at Breast Height (DBH) The diameter of a tree 1.37 m above the ground surface.

Drawdown A reduction in the height of the water table, in this circumstance due to drainage into an open-pit mine.

Edge	Where different plant communities meet in space on a landscape; and where plant communities meet a disturbance. An outer band of a patch that usually has an environment significantly different from the interior of the patch.
Fen	Sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral rich waters. Minerotropic peat-forming wetlands that receive surface moisture from precipitation and groundwater. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium.
G Test	A statistical test which tests for a significant difference between sampled and expected frequencies of occurrence. Otherwise known as a likelihood ratio test.
Graminoid	Grasses and grass-like plants such as sedges and rushes.
Habitat Fragmentation	Fragmentation is the breaking-up of natural areas by disturbances into smaller and more isolated patches (Morrison et al. 1998)
Habitat Suitability Index (HSI) Model	Analytical tools for determining the relative potential of an area to support individuals or populations of a wildlife species. They are frequently used to quantify potential habitat losses and gains for wildlife as a result of various land use activities.
Isopleth	A line drawn through all points of equal value of some measurable quantity.
Key Indicator Resource	A focal species utilized as an indicator of ecological health and integrity.
LANDSAT 5	A specific satellite or series of satellites used for earth resource remote sensing. Satellite data can be converted to visual images for resource analysis and planning.
Mean Patch Size	The average size of habitat patches within the study area.
Mixedwood	A terrestrial forest type that is an assemblage of both deciduous and coniferous tree species.
Overstorey	Those trees that form the upper canopy in a multi-layered forest.

Patch	A continuous area of habitat.
Planned Development Case (PDC)	The Planned Development Case includes the Application Case components and planned developments that have been publicly disclosed at least six months prior to submission of the Environmental Impact Assessment.
Population Sink	A habitat within which reproductive and mortality rates should result in population declines. However, populations may be maintained in such habitat by immigration from nearby habitats that are more productive. The term was introduced by Pulliam (1988).
Raster	A graphic structure where the data is divided into cells on a grid. An example would be a computer screen where an image is represented by horizontal lines of coloured pixels. Shapes are represented by cells of the same colour or content adjacent to each other.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.
Sedge	Any plant of the genus *Carex*, perennial herbs, often growing in dense tufts in marshy places. They have triangular jointless stems, a spiked inflorescence and long grass-like leaves which are usually rough on the margins and midrib. There are several hundred species.
Senescent	Growing old; aging.
Sink Habitat	A habitat within which reproductive and mortality rates should result in population declines. However, populations may be maintained in such habitat by immigration from nearby habitats that are more productive. The term was introduced by Pulliam (1988).
Stand Age	The number of years since a forest has been affected by a stand-replacing disturbance event (e.g., fire or logging) and has since been regenerating.
Understorey	Trees or other vegetation in a forest that exist below the main canopy level.

Upland

Areas that have typical ground slopes of 1 to 3% and are better-drainage.

Wetlands

Wetlands are land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or “peatlands,” and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.

ATTACHMENT I

BASIC STATISTICS FOR VALIDATION MODELS

Table I-1. Basic statistics for model predictions from LSA-level validation models, relative to observations in withheld k-fold validation data sets. Significance between the means of predictions that corresponded to used and available observations was calculated using Welch's approximate t-test.

Table I-1 Basic Statistics for Local Study Area-Level Validation Models

Species	Validation Model	Data Type	Non-Standardized Mean Prediction Value	Standard Deviation	Significant Difference Between "Used" and "Available" Means
moose	A	used	0.573	0.823	significant
		available	0.187	0.354	
	B	used	2.213	5.791	not significant
		available	0.461	2.156	
	C	used	0.796	0.751	significant
		available	0.251	0.560	
	D	used	0.679	0.429	significant
		available	0.215	0.193	
lynx	A	used	0.161	0.214	not significant
		available	0.157	0.235	
	B	used	0.461	0.272	significant
		available	0.155	0.276	
	C	used	0.726	0.265	significant
		available	0.449	0.329	
fisher	A	used	0.011	0.009	significant
		available	0.003	0.004	
	B	used	0.013	0.006	significant
		available	0.004	0.005	
	C	used	2.465E-06	3.947E-06	significant
		available	4.009E-07	2.482E-06	

Table I-2. Basic statistics for model predictions from RSA-level validation models, relative to observations in withheld k-fold validation data sets. Means are significantly different when Welch's approximate t-values are greater than critical t-values.

Table I-2 Basic Statistics for Regional Study Area Level-Validation Models

Species	Validation Model	Data Type	Non-Standardized Mean Prediction Value	Standard Deviation	Significant Difference Between "Used" and "Available" Means
moose	A	used	0.0000553	0.0000642	significant
		available	0.0000245	0.0000747	
	B	used	0.00292	0.00232	significant
		available	0.000983	0.00206	
	C	used	0.00802	0.00285	significant
		available	0.00179	0.00287	
	D	used	0.0162	0.00757	significant
		available	0.00318	0.00580	
lynx	A	used	0.000911	0.000517	significant
		available	0.000398	0.000595	
	B	used	0.000811	0.000482	significant
		available	0.000336	0.000432	
	C	used	0.00247	0.00134	significant
		available	0.000789	0.001185	
fisher	A	used	0.00708	0.00819	not significant
		available	0.000445	0.00915	
	B	used	0.00108	0.00132	significant
		available	0.000464	0.00132	
	C	used	0.0819	0.0404	significant
		available	0.0170	0.0183	

ATTACHMENT II

SUMMARY TABLES OF LOCAL STUDY AREA SPECIFIC HABITAT IMPACTS

Table II-1 Wildlife Habitat Change Within the Jackpine Expansion Mining Area Local Study Area: Application Case

Key Indicator Resource	Habitat Suitability Class	Base Case		Direct Habitat Change Due to Site Clearing of the Project and Jackpine Mine – Phase 1		Indirect Habitat Change Due to the Project and Jackpine Mine – Phase 1		Net Change From the Project and Jackpine Mine – Phase 1		Closure	
		Habitat Area [ha]	% of LSAs	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change From Base Case to Closure [ha]	% Change
moose	nil	4,882	16.5	20,454	419.0	0	0	20,454	419.0	2,480	50.8
	low	8,640	29.3	-6,319	-73.1	0	0	-6,319	-73.1	-4,896	-56.7
	moderate low	7,955	27.0	-7,050	-88.6	0	0	-7,050	-88.6	-4,115	-51.7
	moderate	1,922	6.5	-1,648	-85.8	0	0	-1,648	-85.8	1,276	66.4
	moderate high	3,031	10.3	-2,616	-86.3	0	0	-2,616	-86.3	3,283	108.3
	high	3,073	10.4	-2,821	-91.8	0	0	-2,821	-91.8	1,972	64.2
lynx	nil	4,882	16.5	20,454	419.0	0	0	20,454	419.0	2,480	50.8
	low	4,235	14.4	-2,712	-64.0	0	0	-2,712	-64.0	-4,235	-100.0
	moderate low	4,104	13.9	-3,703	-90.2	0	0	-3,703	-90.2	-3,665	-89.3
	moderate	8,628	29.2	-7,617	-88.3	0	0	-7,617	-88.3	-5,570	-64.6
	moderate high	5,750	19.5	-5,069	-88.2	0	0	-5,069	-88.2	4,098	71.3
	high	1,905	6.5	-1,353	-71.0	0	0	-1,353	-71.0	6,892	361.8
fisher/ marten	nil	4,882	16.5	20,454	419.0	0	0	20,454	419.0	2,480	50.8
	low	2,292	7.8	-2,264	-98.8	0	0	-2,264	-98.8	90	3.9
	moderate low	3,460	11.7	-2,774	-80.2	0	0	-2,774	-80.2	-1,093	-31.6
	moderate	5,676	19.2	-4,587	-80.8	0	0	-4,587	-80.8	-2,312	-40.7
	moderate high	8,329	28.2	-6,803	-81.7	0	0	-6,803	-81.7	-1,601	-19.2
	high	4,865	16.5	-4,026	-82.8	0	0	-4,026	-82.8	2,437	50.1
black-throated green warbler	nil	4,882	16.5	20,454	419.0	0	0	20,454	419.0	2,480	50.8
	low	20,896	70.8	-17,329	-82.9	0	0	-17,329	-82.9	-469	-2.2
	moderate	2,288	7.8	-1,930	-84.3	0	0	-1,930	-84.3	-1,239	-54.1
	high	1,436	4.9	-1,195	-83.2	0	0	-1,195	-83.2	-771	-53.7
barred owl	nil	4,882	16.5	20,454	419.0	0	0	20,454	419.0	2,480	50.8
	low	15,328	52.0	-13,221	-86.3	0	0	-13,221	-86.3	4,044	26.4
	high	9,293	31.5	-7,233	-77.8	0	0	-7,233	-77.8	-6,524	-70.2

Table II-1 Wildlife Habitat Change Within the Jackpine Expansion Mining Area Local Study Area: Application Case (continued)

Key Indicator Resource	Habitat Suitability Class	Base Case		Direct Habitat Change Due to Site Clearing of the Project and Jackpine Mine – Phase 1		Indirect Habitat Change Due to the Project and Jackpine Mine – Phase 1		Net Change From the Project and Jackpine Mine – Phase 1		Closure	
		Habitat Area [ha]	% of LSAs	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change From Base Case to Closure [ha]	% Change
Canadian toad	nil	17,770	60.2	9,022	50.8	0	0.0	9,022	50.8	-4,650	-26.2
	low	2,901	9.8	-2,646	-91.2	6	0.2	-2,640	-91.0	665	22.9
	moderate	6,616	22.4	-4,877	-73.7	36	0.5	-4,841	-73.2	3,797	57.4
	high	2,216	7.5	-1,499	-67.6	-42	-1.9	-1,541	-69.5	188	8.5
black bear	nil	4,882	16.5	20,454	419.0	0	0.0	20,454	419.0	2,480	50.8
	low	15,864	53.8	-12,968	-81.7	110	0.7	-12,858	-81.1	-11,615	-73.2
	moderate	3,552	12.0	-2,986	-84.1	32	0.9	-2,954	-83.2	6,822	192.1
	high	5,205	17.6	-4,500	-86.4	-142	-2.7	-4,642	-89.2	2,313	44.4
beaver	nil	22,574	76.5	4,892	21.7	0	0	4,892	21.7	-3,498	-15.5
	low	1,190	4.0	-919	-77.2	0	0	-919	-77.2	1,129	94.9
	moderate	797	2.7	-625	-78.4	0	0	-625	-78.4	-577	-72.3
	high	4,941	16.7	-3,348	-67.8	0	0	-3,348	-67.8	2,945	59.6
yellow rail	nil	25,269	85.6	3,628	14.4	125.0	0.5	3,753	14.9	3,628	14.4
	high	4,234	14.4	-3,628	-85.7	-125.0	-3.0	-3,753	-88.6	-3,628	-85.7

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Table II-2 Wildlife Habitat Change Within the Pierre River Mining Area Local Study Area: Application Case

Key Indicator Resource	Habitat Suitability Class	Base Case Habitat		Direct Habitat Change Due to Site Clearing of the Project and Jackpine Mine – Phase 1		Indirect Habitat Change Due to the Project and Jackpine Mine – Phase 1		Net Change From the Project and Jackpine Mine – Phase 1		Closure	
		Habitat Area [ha]	% of LSAs	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change From Base Case to Closure [ha]	% Change
moose	nil	740	3.5	10,118	1367.2	0	0	10,118	1367.2	1,636	221.0
	low	310	1.5	-73	-23.6	0	0	-73	-23.6	353	113.7
	moderate low	5,148	24.4	-3,548	-68.9	0	0	-3,548	-68.9	-1,804	-35.0
	moderate	3,072	14.5	-2,163	-70.4	0	0	-2,163	-70.4	-1,430	-46.5
	moderate high	6,565	31.1	-3,816	-58.1	0	0	-3,816	-58.1	-3,210	-48.9
	high	5,300	25.1	-518	-9.8	0	0	-518	-9.8	4,455	84.0
lynx	nil	740	3.5	10,118	1,367.2	0	0	10,118	1,367.2	1,636	221.1
	low	0	0.0	1	0.0	0	0	1	0.0	1	0.0
	moderate low	121	0.6	96	79.6	0	0	96	79.6	156	128.8
	moderate	1,138	5.4	-591	-52.0	0	0	-591	-52.0	434	38.1
	moderate high	6,663	31.5	-3,653	-54.8	0	0	-3,653	-54.8	220	3.3
	high	12,474	59.0	-5,971	-47.9	0	0	-5,971	-47.9	-2,446	-19.6
fisher/marten	nil	740	3.5	10,118	1,367.2	0	0	10,118	1,367.2	1,636	221.0
	low	458	2.2	305	66.7	0	0	305	66.7	717	156.7
	moderate low	1,416	6.7	270	19.0	0	0	270	19.0	775	54.8
	moderate	3,324	15.7	-1,362	-41.0	0	0	-1,362	-41.0	420	12.6
	moderate high	6,771	32.0	-4,023	-59.4	0	0	-4,023	-59.4	-1,666	-24.6
	high	8,428	39.9	-5,309	-63.0	0	0	-5,309	-63.0	-1,882	-22.3
black-throated green warbler	nil	740	3.5	10,118	1367.2	0	0	10,118	1367.2	1,636	221.1
	low	18,788	88.9	-9,334	-49.7	0	0	-9,334	-49.7	-11,344	-60.4
	moderate	1,400	6.6	-668	-47.7	0	0	-668	-47.7	2,654	189.6
	high	208	1.0	-117	-56.2	0	0	-117	-56.2	7,054	3,396.9
barred owl	nil	740	3.5	10,118	1367.2	0	0	10,118	1367.2	1,636	221.1
	low	5,627	26.6	-3,245	-57.7	0	0	-3,245	-57.7	2,977	52.9
	high	14,768	69.9	-6,873	-46.5	0	0	-6,873	-46.5	-4,613	-31.2

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Table II-2 Wildlife Habitat Change Within the Pierre River Local Study Area: Application Case (continued)

Key Indicator Resource	Habitat Suitability Class	Base Case Habitat		Direct Habitat Change Due to Site Clearing of the Project and Jackpine Mine – Phase 1		Indirect Habitat Change Due to the Project and Jackpine Mine – Phase 1		Net Change From the Project and Jackpine Mine – Phase 1		Closure	
		Habitat Area [ha]	% of LSAs	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change in Habitat Area [ha]	% Change	Change From Base Case to Closure [ha]	% Change
Canadian toad	nil	1,378	6.5	9,702	704.2	0	0.0	9,702	704.2	-1,187	-86.1
	low	744	3.5	-416	-55.9	13	1.7	-403	-54.2	-390	-52.4
	moderate	15,890	74.5	-7,529	-47.4	40	0.3	-7,489	-47.1	1,456	9.2
	high	3,305	15.5	-1,761	-53.3	-53	-1.6	-1,814	-54.9	115	3.5
black bear	nil	740	3.5	10,118	1,367.4	1	0.1	10,119	1,367.4	1,636	221.1
	low	5,053	23.9	-3,654	-72.3	398	7.9	-3,256	-64.4	-3,332	-65.9
	moderate	5,455	25.8	-3,174	-58.2	688	12.6	-2,486	-45.6	-1,048	-19.2
	high	9,888	46.8	-3,290	-33.3	-1,087	-11.0	-4,377	-44.3	2,744	27.8
beaver	nil	17,044	80.6	2,046	12.0	0	0	2,046	12.0	-1,340	-7.9
	low	833	3.9	-538	-64.6	0	0	-538	-64.6	-242	-29.1
	moderate	631	3.0	-378	-59.8	0	0	-378	-59.8	-377	-59.7
	high	2,628	12.4	-1,130	-43.0	0	0	-1,130	-43.0	1,959	74.6
yellow rail	nil	19,383	91.7	1,309	6.8	83.0	0.4	1,392	7.2	1,309	6.8
	high	1,753	8.3	-1,310	-74.7	-82.0	-4.7	-1,392	-79.4	-1,310	-74.7

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APPENDIX 5-5

WILDLIFE MOVEMENT

TABLE OF CONTENTS

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LIST OF FIGURES

1 INTRODUCTION

This appendix provides information supplemental to Section 7.5.4 of the EIA regarding the potential effects of the Project on wildlife movement. It covers both study areas included in the Jackpine Mine Expansion & Pierre River Mine Project (the Project) – the Jackpine Expansion Mining Area (JEMA) and the Pierre River Mining Area (PRMA), both of which are located north of Fort McMurray.

Oil sands mining north of Fort McMurray affects wildlife movement both at a local and regional scale. Currently approved oil sands mining projects have resulted in strips of undisturbed wildlife habitat along the Athabasca River and major tributary drainages. These areas have become *de facto* wildlife corridors which may be used as habitat or as movement routes through the development complex in the regional landscape. Factors affecting the use of corridors by wildlife generally are not well understood. This appendix provides information on:

- wildlife use of long corridors in other areas of North America;
- wildlife habitat use around the current oil sands mining operations (Base Case), the predicted effects of the Project and proposed mitigation, as well as the effects on population viability for the PDC; and
- monitoring options to assess the efficacy of mitigation proposed for the Athabasca and Muskeg river corridors.

2 WILDLIFE MOVEMENT IN CORRIDORS

Corridors are long, thin strips of habitat that connect otherwise isolated habitat patches. Recent studies have demonstrated that corridors can increase animal movement between patches, increase population sizes, increase gene flow and maintain biodiversity (Haddad et al. 2003). Several examples that provide a perspective on the use of corridors by large mammals are provided below.

The 6-km-long Cascade Corridor north of Banff in Banff National Park is bounded on the south side by the TransCanada Highway and on the north side by Cascade Mountain and varies in width from 350 m to 1.5 km (Duke et al. 2001). In several areas, the corridor is pinched to less than 350 m by rugged terrain. Wolf use of this corridor increased after removal of several human disturbances within the corridor. This corridor is similar to the situation along the Athabasca River at the PRMA because the corridor has a disturbance on one side and a natural interface on the other.

Shepherd and Whittington (2006, website) documented the restoration of a wildlife corridor in Jasper National Park. In this case, fencing was removed from the Jasper Park Lodge Golf Course allowing free movement of wolves through a relatively wide (approximately 1 km) 2-km-long corridor. Wolves changed their travel patterns to take advantage of the high-quality habitat in the travel route within one year of fence removal.

Resident cougars occasionally used a 400 to 600 m wide, 6-km-long corridor between habitat patches in southern California (Beier 1995). In this case, the corridor was lined with estate homes, but the depth of the valley (20 to 70 m) minimized noise, light and other urban disturbances in the corridor. Beier (1995) documented cougar use of corridors as narrow as 400 m for distances less than 7 km with bottlenecks as narrow as 3.3 m at road underpasses.

3 WILDLIFE MOVEMENT ALONG THE ATHABASCA AND MUSKEG RIVERS

3.1 BASE CASE

This section provides a summary of the wildlife abundance and distribution data collected during baseline studies for the Project and monitoring results from the Canadian Natural Horizon Oil Sands Project. Winter-active wildlife tracking as well as more recently, remote cameras placed along trails and cutlines along the Athabasca River and associated drainages like the Muskeg River, have been used to assess wildlife habitat use and movement (Golder 2001, 2004, 2007a,b,c).

3.1.1 Jackpine Expansion Mining Area and Pierre River Mining Area Local Study Areas

Moose and deer were recorded in the Athabasca River and the Muskeg River valleys throughout the year (Figures 5.3-1 and 5.3-2: Golder 2007a). Moose were found throughout the JEMA LSA based on the winter track surveys (Figure 5.3-3: Golder 2007a), remote camera photos (Figure 5.3-2: Golder 2007a) and the aerial survey results (Figure 5.2-13: Golder 2007a). Winter tracking and remote camera data corroborated the aerial survey results in the PRMA LSA (Figures 5.2-14, 5.3-3 and 5.3-4: Golder 2007a) indicating that moose were encountered substantially less than in the JEMA LSA. Conversely, deer species were recorded more frequently in the PRMA LSA than the JEMA LSA. The winter distribution of deer was concentrated in the southern portion of the PRMA LSA based on winter track surveys. However, corridor and bait station cameras recorded deer throughout that LSA during the spring, summer and fall. In neither LSA was there a marked preference for either uplands or riparian habitats along the major watercourses by moose or deer.

Among canids, wolves were recorded more commonly along the Athabasca River than at bait stations west of the river in the PRMA LSA (Figures 5.3-7 and 5.3-8: Golder 2007a). Although present throughout the JEMA LSA, wolves were recorded less frequently there than in the PRMA LSA (Figures 5.3-5 and 5.3-6: Golder 2007a). Conversely, coyotes were recorded more frequently in the JEMA LSA and the southern half of the PRMA LSA than in the more remote northern leases in the PRMA LSA based on the winter tracking and bait station and corridor camera data. Track densities reported for the JEMA LSA are double the density recorded in the PRMA LSA.

Fishers and martens were recorded frequently throughout both LSAs based on winter tracking and remote camera results (Figures 5.3-13, 5.3-14, 5.3-15 and 5.3-16: Golder 2007a). In the JEMA LSA, fisher and marten tracks are encountered on all transects along the Muskeg River. Similarly, the tracks of both species are commonly recorded on transects along the Athabasca River in the PRMA LSA and both species were photographed adjacent to the river as well.

Wolverines were photographed on two occasions both in the northern portion of the PRMA LSA, while wolverine tracks were recorded five times in the JEMA LSA. Both wolverine photographs were taken along small drainages flowing into the Athabasca River, while the tracks were located along the Muskeg River. Because wolverine home ranges are very large, they likely travel through both LSAs on an irregular basis and their travel routes are probably along game trails which often follow drainages like the Muskeg and Athabasca rivers.

Black bears were found throughout the PRMA LSA. Numerous black bear visits were recorded at bait station cameras both in the Athabasca River valley and in terrestrial habitats west of the river. Black bears were recorded along all corridor cameras along the river (Figure 5.3-12: Golder 2007a). In the JEMA LSA, bears were recorded less often and were not recorded on corridor cameras along the Muskeg River (Figure 5.3-11: Golder 2007a).

3.1.2 Canadian Natural Horizon Wildlife Corridor Monitoring Program 2006

The wildlife corridor monitoring program at Horizon consists of the collection of wildlife abundance and species composition data in two study areas, an upland area distant from the Athabasca River and a corridor study area immediately adjacent to the river using winter track counts from January to March and remote cameras during the snow-free seasons (Golder 2007c). The monitoring is designed to assess the importance of the river valley to wildlife relative to upland areas further inland from the river.

Preliminary winter tracking results indicate that species composition and abundance indices were similar between the corridor and upland study areas for all species except for moose. Moose were recorded only along the Athabasca River. In addition, more moose photos were taken in the corridor study area throughout the year. However, there were twice the numbers of remote camera wildlife observations in the uplands than in the corridor study area and the total number of species detected in the upland study area was larger than the number of species detected in the corridor study area. For the most part, differences between the two areas were not statistically significant.

3.2 JACKPINE EXPANSION MINING AREA AND JACKPINE MINE – PHASE 1 WILDLIFE CORRIDOR MONITORING

The Jackpine Mine – Phase 1 Wildlife Corridor Monitoring Program was designed to collect information on wildlife composition, abundance and distribution using winter track counts from December to March, and remote cameras throughout the year along two reaches of the Muskeg River (JEMA LSA both upstream and adjacent to the Muskeg River Mine) and along the Athabasca River corridor adjacent to Muskeg River Mine (Golder 2007b). The three study areas have differing levels of development and different physical characteristics (e.g., corridor width, valley type) and results from this monitoring provide insights into the potential effects of the Project on wildlife use and movement.

Species detected during the winter tracking sessions in 2006 include red fox, coyote, wolf, Canada lynx, fisher/marten, wolverine, river otter, mink, moose, deer species, snowshoe hare, red squirrel and weasel and grouse species. Coyote track densities were significantly higher ($p<0.05$) in the Athabasca River corridor than on the Muskeg River adjacent to the Muskeg River Mine Expansion (MRME) Project. Conversely, fisher/marten track densities were significantly higher in the JEMA LSA than on the Muskeg River adjacent to the MRME Project. Moose had statistically higher track densities in the JEMA LSA than in the Athabasca River corridor. Deer tracks were significantly more common in the Athabasca River corridor than anywhere along the Muskeg River.

The remote cameras were deployed for continuous two week periods during the winter, spring, summer and fall. During the winter and spring seasons, seven species were photographed, while in the summer eight species were photographed and in the fall nine species were detected. Significantly more photographs of coyote and red fox ($p<0.05$) were recorded in the Athabasca River corridor when compared to areas along the Muskeg River, either alongside the MRME Project or in the JEMA LSA further upstream. The number of photographs for white-tailed deer was also statistically higher ($p<0.05$) in the Athabasca River corridor compared to the Muskeg River.

The combined results of the photographic and winter active wildlife tracking appear reflective of the levels of disturbance that exist along the Athabasca River corridor and the Muskeg River alongside the MRME Project and further upstream in the JEMA LSA. White-tailed deer and coyotes, both species that are well-adapted to human disturbance, were recorded most commonly in disturbed areas along the Muskeg River and along the Athabasca River corridor. Conversely, mesocarnivores, (i.e., marten, fisher, wolverine, lynx) were generally more common along the Muskeg River in the JEMA LSA than downstream along the Muskeg River and in the Athabasca River corridor. Both surveys indicate that moose and fisher/marten observations were highest in the JEMA LSA, while coyote and deer species were significantly more common in the Athabasca River corridor. The surveys also indicated that the Muskeg River adjacent to the MRM and MRME Project had the lowest species diversity compared to the two other areas.

3.3 PREDICTED PROJECT IMPACTS

The Project has two distinct development areas – the Pierre River Mining Area (PRMA) and the Jackpine Expansion Mining Area (JEMA) – that have the potential to affect wildlife movement.

The Athabasca River flows from south to north along the eastern side of the PRMA. As the Project develops in the PRMA Local Study Area (LSA), riparian and upland communities on the west side of the Athabasca River will become an 8-km-long wildlife corridor bordering Lease 9 in the PRMA with a minimum width of 250 m. Further north in Lease 17 of the PRMA, the external tailings disposal area and the raw water storage pond will result in 17 km corridor along the Athabasca River that will allow for wildlife movement. The widths of the corridor beside these two areas will range from 700 m to 3.5 km. Implementation of proposed mitigation measures is predicted to result in a low magnitude impact (Section 4).

JPME R1
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The Muskeg River is located within the JEMA LSA. During operations and before reclamation, the Project is predicted to have a high magnitude effect on wildlife movement in the LSA. The development of the JEMA including Jackpine Mine – Phase 1, in conjunction with Muskeg River Mine and Muskeg River Mine Expansion (i.e., Application Case), will create a long (~20 km) remnant corridor about 400 m wide along the Muskeg River from the Athabasca River to the Fort Hills. The degree to which wildlife would use this corridor through the active mining area is unknown.

4 MAINTAINING WILDLIFE MOVEMENT ALONG THE ATHABASCA RIVER

A remnant wildlife corridor will be created along the Athabasca River by the development of the PRMA. This 8-km-long corridor will be a minimum of 250 m wide. The PRMA will have a low filter/barrier effect both during the construction and operations as a result of narrowing remaining habitat between the PRMA development area and the river. Effects are predicted to be species-specific; wide-ranging wary carnivores will be most affected while wildlife that habituate readily to human activity will be affected least. The area adjacent to the Athabasca River will be cleared between 2012 and 2034 and active mining will occur until 2039. Closure will occur in 2049, but the area may not be suitable for wide-ranging wary wildlife for 15 to 25 years after reclamation because security cover required for these species (e.g., forest) will take time to develop in the reclaimed landscape.

The PRMA development area will be well lit throughout the night to ensure safe operating conditions. However, lighting areas between dusk and dawn may have an adverse effect on wildlife use (Kavanaugh and Ramos 1975; cougars [Beier 1995]; small mammals [Bird et al. 2004]). Light from nighttime operation of the mine may reduce the effectiveness of the wildlife corridor if it is allowed to shine into the Athabasca River corridor. The use of stationary lighting with shields to reduce glare and directing spotlights away from the adjacent wildlife corridor will minimize the effects of light pollution on nocturnal wildlife movement within the corridor.

The PRMA access road across the Athabasca River valley will be designed to cross the valley in a perpendicular fashion to minimize its footprint in the valley and increase sight lines to reduce the risk of wildlife vehicle collisions. Wildlife will cross the PRMA access road on either side of the Athabasca River. However, effects to wildlife movement across this road are expected to be low because of low traffic volume.

The design of the bridge spanning the Athabasca River, connecting Highway 63 with PRMA, will be high and long to provide for wildlife passage under the bridge on both the east and west banks (Figure 1). Long bridges allow for connectivity at the landscape level for a wide array of species, and are among the most effective mitigation measures for reducing road kill and for allowing for unhindered animal movement (Huijser et al. 2007). Landscaping both nearby and within crossing structures can increase their effectiveness for a variety of species. Vegetative cover from surrounding habitat to the bridge and under it may increase use by species like black bears. However, open lanes to the crossing structure will be maintained for species that prefer more open habitats (e.g., wolves, deer and moose). Coarse woody debris (e.g., stumps) within the wildlife crossing structure will increase its use by marten and other smaller species of wildlife. Fencing the highway approaches will be used to direct wildlife to the passageways under the bridge and reduce the likelihood of wildlife-vehicle collisions (Dodd and Gagnon 2007). Fencing will have the additional benefit of reducing human disturbance within the Athabasca River corridor if human access is not provided.

L:\2006\1344-OIL SANDS\1346\06-1346-022 Shell\7700\7720\ Drawing file: Fig 1_ Conceptual Model of the Proposed Athabasca River Bridge-PRMA.dwg Dec 06, 2007 - 6:35pm

PROJECT

JACKPINE MINE EXPANSION &
PIERRE RIVER MINE PROJECT

TITLE

CONCEPTUAL MODEL OF THE PROPOSED ATHABASCA RIVER BRIDGE CONNECTING THE PIERRE RIVER MINING AREA TO HIGHWAY 63

Shell Canada Limited

PROJECT 06-1346-022.7720			FILE No. Change-Moose Pop..	
DESIGN	MJ	15/10/07	SCALE AS SHOWN	REV. 0
CADD	PSR	15/10/07	**FIGURE: 1**	
CHECK	MJ	16/10/07		
REVIEW	TC	06/12/07		

5 REGIONAL POPULATION VIABILITY

Key challenges in evaluating the effectiveness of a proposed wildlife corridor include clearly identifying the purpose of the corridor and the expectations of the corridor's function. Although there are no established guidelines to rigorously evaluate whether wildlife corridors meet their intended purpose, researchers in Banff National Park have developed ecological criteria that can be used as guidelines to evaluate how well wildlife corridors are working (Clevenger et al. 2002). These criteria range from simple measurements to complex, long-term studies as follows:

- Maintenance of habitat connectivity - species must be present on both sides of a corridor, and a minimum amount of passage must be detected.
- Maintenance of genetic interchange - passage by breeding adults must occur, primarily males during the mating season to avoid inbreeding among populations.
- Maintenance of biological requirements - food, cover and mates must be accessible; if not, this could lead to reduced breeding opportunities, lowered reproductive and survival rates, occupation of poor habitat and increased vulnerability to predation.
- Provision for dispersal and recolonization - animals need to disperse out of maternal ranges into areas where there have been long absences or local extinctions to recolonize or replenish the population.
- Maintenance of metapopulation and ecosystem processes - if one population of animals becomes extinct another population of animals must recolonize the area in order for the population to persist.

Linkage Zone Analysis for moose indicates that the Regional Study Area has substantial fragmentation as a result of past, current and planned developments (Volume 5, Appendix 5-4). However, Population Viability Assessments (PVA) for moose and black bear within the Regional Study Areas for Shell's Jackpine Mine – Phase 1, Canadian Natural Resource Limited's Horizon Project and Petro-Canada Oil Sands Inc.'s Fort Hills Project determined that moose and black bear populations can be considered one population (i.e., past, current and planned developments do not fracture habitat sufficiently to create more than one effective population). Moose and black bear populations each continue to be considered to be one population for the Planned Development Case of this Project (Volume 5, Appendix 5-4). In addition, the Regional Study Areas for these projects are contiguous with neighbouring boreal forest, resulting in a single population likely much greater than required to maintain genetic diversity within regional wildlife populations.

Current knowledge of corridor use by wildlife in the Oil Sands Region north of Fort McMurray is based on baseline wildlife data collection for these oil sands mines and monitoring of wildlife corridors for these projects to meet Alberta *Environmental Protection and Enhancement Act* (EPEA) approval conditions. These data support the position that wildlife population viability within the Regional Study Area is not at risk as a result of the Planned Development Case. Preliminary monitoring results demonstrate that most wildlife species have been documented using habitat within the existing corridors along the Muskeg and Athabasca rivers and therefore, suggest that genetic connectivity for most species of wildlife within the regional landscape may be maintained; that is, at a minimum, one to 10 effective migrants per generation of all wildlife species will pass through the wildlife corridors (Mills and Allendorf 1996; Jinliang 2004). The maintenance of genetic connectivity will minimize loss of genetic diversity within the region.

6 MONITORING EFFECTIVENESS

The mitigation proposed for the Athabasca River corridor is predicted to reduce the effects of the Project on wildlife movement in the Regional Study Area. However, factors affecting the use of corridors by wildlife generally are not well understood. The efficacy of mitigation proposed for the Athabasca River corridor requires testing. Monitoring wildlife use in the Muskeg and Athabasca river valleys and under the proposed Athabasca River bridge will provide information required to test assessment predictions and to assess the effectiveness of and adaptively manage the proposed mitigation measures. The results from monitoring wildlife use of the remaining undisturbed land along the Muskeg and Athabasca river valley corridors will assist in the design of more effective mitigation strategies for future developments in the region.

Monitoring objectives for the Athabasca River bridge and corridor will include: relative use of the corridors and the crossing structures compared to similar areas along the Athabasca River removed from the disturbances associated with the Project, relative use by different wildlife species, seasonal differences in movement, and changes in movement patterns over the life of the Project (e.g., changes as different portions of the Project are mined and other areas are reclaimed along the river valley). The design of the program will be sufficiently rigourous that statistically meaningful results are collected.

A variety of techniques are required to fulfill the objectives of a comprehensive wildlife movement monitoring program. Winter-active mammal tracking, remote camera monitoring and track bed plots within the wildlife crossing structure will all be used. Winter-active mammal tracking is an effective technique for collecting wildlife use data when snow covers the ground. Remote cameras are a cost-effective method for collecting wildlife use during the snow-free months. Use of the cameras year-round will provide a relative index of seasonal use. Track bed plots and cameras will be used to determine use of the wildlife passageways when the ground is not frozen and year-round, respectively.

A regional research initiative between industry and government, which will examine the effectiveness of wildlife corridors and link wildlife corridor use with population demographics at the regional scale, is expected to begin in winter 2007/08. Shell Canada Limited has supported the concept of this regional initiative and has been actively involved in meetings between industry and the regulators. Wildlife information in the Project was collected using methodologies consistent with those conducted for current monitoring programs. Information collected on the LSAs will be used as part of this larger regional project.

The regional monitoring initiative is designed to answer questions that link habitat effectiveness and connectivity to population dynamics of wildlife populations in the Oil Sands Region. These population viability questions will be answered using Global Positioning System (GPS) collars or DNA sampling techniques. GPS-collared animals will yield survival and reproductive data which are necessary for assessing if and why populations are changing in size. The GPS data will also provide a more concrete assessment of spatial population structure throughout the year (e.g., individual home ranges, locations of subpopulations). Large samples of detailed movement data can be acquired over relatively short periods of time. Collecting DNA from wildlife may be used to evaluate how development and mitigation affects gene flow among populations. DNA work is necessary to verify that genetic connectivity among populations has been maintained by the current mitigation strategies.

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8 ABBREVIATIONS

DNA	Deoxyribonucleic Acid
e.g.	For example
EPEA	Alberta *Environmental Protection and Enhancement Act*
GPS	Global Positioning System
JEMA	Jackpine Expansion Mining Area
km	Kilometre
LSA	Local Study Area
m	Metre
MRME	Muskeg River Mine Expansion
$p<0.05$	Probability is less than 0.05
PRMA	Pierre River Mining Area
SAGD	Steam Assisted Gravity Drainage

9 GLOSSARY

Biodiversity	The variety of plant and animal life in a particular habitat (e.g., plant community or a country). It includes all levels of organization, from genes to landscapes and the ecological processes through which these levels are connected.
Boreal Forest	The northern hemisphere, circumpolar, tundra forest type consisting primarily of black spruce and white spruce with balsam fir, birch and aspen.
Canid	Any animal of the family *Canidae*, a family of mammals including dogs, jackals, wolves and foxes, typically having a bushy tail, erect ears and a long muzzle: order *Carnivora* (carnivores).
Carnivore	Any of an order of mammals that feed chiefly on flesh or other animal matter rather than plants.
Habitat	The place or environment where a plant or animal naturally or normally lives or occurs.
Habitat Patches	Isolated patches of habitat.
Mesocarnivore	Mid-sized carnivore species (e.g., fisher, lynx, marten).
Metapopulation	A set of local populations within a larger area, where migration from one local population to other habitat patches are possible. These groups of local populations usually occur in suitable, discrete (i.e., separate and discontinuous) habitat patches that are scattered in a landscape.
Oil Sands Region	The Oil Sands Region includes the Fort McMurray – Athabasca Oil Sands Subregional Integrated Resource Plan (IRP), the Lakeland Subregional IRP and the Cold Lake – Beaver River Subregional IRP.
Reach	A comparatively short length of river, stream channel or shore. The length of the reach is defined by the purpose of the study.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain or standing waterbody.
Upland Areas	Areas that have typical ground slopes of 1 to 3% and are better-drainage.

APPENDIX 5-7

VISUAL AESTHETICS
LANDSCAPE UNIT RATING FORMS

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1 VISUAL AESTHETICS LANDSCAPE UNIT RATING FORMS

1.1 INTRODUCTION

The Landscape Unit rating forms shown in Section 1.1.1 are consistent with those presented in the Cumulative Environmental Management Association's (CEMA) Visual Landscape System for planning and managing aesthetic resources (RDI 2003). Although the system is currently in draft form and has not been adopted by CEMA, the photographs and environmental setting landscape ratings forms are appropriate for describing the environmental setting condition of the landscape.

1.1.1 Landscape Unit Rating Forms

Landscape Unit rating forms for the Wood Buffalo region were prepared in 2002 by Ken Fairhurst of Resource Design Inc. (RDI 2003). Additional forms were prepared in 2005 by Greg Jones of Golder Associates Ltd. (Golder) for the Muskeg River Mine Expansion Project Environmental Impact Assessment (Shell 2005) to cover areas not addressed by the original set of forms. Additional landscape units were delineated and forms prepared in 2007 by Kevin Graham of Golder. Landscape Unit rating forms contain ratings for five key categories of landscape characteristics:

- attraction;
- observablity;
- significance;
- risk; and
- integrity.

Attraction is rated based on the vegetation cover, water features, colour, adjacent scenery, scarcity in the region and level of modification. Observability is rated based on the distance, orientation and frequency of viewers who will have the potential to see the site and the likely duration of viewing opportunities. Significance is based on a comparison of the landscape attraction and observability. Risk is based on the slope class, land cover, topographic diversity, colour contrast and illumination at the site. Landscape integrity is based on the level of alteration evident in the landscape.

A numerical system for each of the landscape characteristics was used to produce ratings of between one (high) and three (low) for landscape attraction, observability, significance and risk. A rating between one (very high) and five (very low) was determined for landscape integrity. Specific details regarding the ways in which scores are developed are provided in RDI (2003).

Landscape Unit Rating Form

Rating Viewpoint(s): **VP01**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	A	O	S	R	I
KL01	3	1	2	2	1

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction 3	<15% slope; low attraction (-5)
Vegetation	High attraction, interest (5)	Moderate attraction 3	Minor influence: (1); neutral: 0
Water	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence: (1); neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral: (0)
Scarcity (in region)	Rare, unique 5	Distinctive, common (3)	Minor influence: 1; neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present (0)	Unharmonious -5
Overall A Points: 5 **Circle A Rating:**	**1 (High) 26 or more**	**2 (Moderate) 11-25**	**3 (Low) (10) or less**
Vertical Relief (m):	**30**	**Percent Slope (%):**	**0-5**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground <5 km (Front) (10)	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) -5
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) (5)	Oblique; Tangential to LOS 3	Peripheral; angled away from LOS 1
Viewing Frequency	Many opportunities 5	Some 3	Few (1)
Viewing Duration	Long (5)	Moderate 3	Glimpse 1
Overall O Points: 21 **Circle O Rating:**	**(1) (High) 17 or more**	**2 (Moderate) 8-16**	**3 (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**2 Mod. LS**	**3 Low LS**
3 Low LA	**(2) Mod. LS**	**3 Low LS**	**3 Low LS**

R - Landscape Risk (LR)			
Slope Class	Steep 31%+ 10	Moderate 16-30% 5	Gentle 0-15% (-10)
Land-Cover Diversity	Low/uniform (5)	Moderate 3	High 1 n/a 0
Topographic Diversity	Low/uniform (5)	Moderate 3	High 1 n/a 0
Colour Contrast	Low/uniform (5)	Moderate 3	High 1 n/a 0
Illumination	Front/side (5)	Side only 3	Back-light 1 n/a 0
Overall R Points: 10 **Circle R Rating:**	**1 (High) 19 or more**	**(2) (Moderate) 7 – 18** **Distance factor over-ride**	**3 (Low) 6 or less** **Distance factor over-ride**

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor > 5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
(1) Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (>30%)

Integrity modifying factors:

Cumulative effect of current alteration in locality/corridor: ☐ High ☐ Moderate ☒ Low ☐ n/a
Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a
Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☐ Industrial
☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

KL01 Comments

KL 01 is the small strip of visible landscape surrounding Kearl Lake.

Landscape Unit Rating Form

Rating Viewpoint(s): **VP02**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	**A**	**O**	**S**	**R**	**I**
MR01	**3**	**1**	**2**	**2**	**1**

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction 3	<15% slope; low attraction (-5)
Vegetation	High attraction, interest 5	Moderate attraction 3	Minor influence: (1); neutral: 0
Water	High attraction, interest (5)	Moderate attraction 3	Minor influence: 1; neutral: 0
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence: (1); neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral: (0)
Scarcity (in region)	Rare, unique 5	Distinctive, common (3)	Minor influence: 1; neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present (0)	Unharmonious -5
Overall A Points:______5 **Circle A Rating:**	**1 (High) 26 or more**	**2 (Moderate) 11-25**	**(3) (Low) 10 or less**
Vertical Relief (m):	**30**	**Percent Slope (%):**	**0-3**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground <5 km (Front) (10)	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) -5
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) 5	Oblique; Tangential to LOS (3)	Peripheral; angled away from LOS 1
Viewing Frequency	Many opportunities 5	Some 3	Few (1)
Viewing Duration	Long (5)	Moderate 3	Glimpse 1
Overall O Points: _____19 **Circle O Rating:**	**(1) (High) 17 or more**	**2 (Moderate) 8-16**	**3 (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**2 Mod. LS**	**3 Low LS**
3 Low LA	**(2) Mod. LS**	**3 Low LS**	**3 Low LS**

R - Landscape Risk (LR)			
Slope Class	Steep 31%+ 10	Moderate 16-30% 5	Gentle 0-15% (10)
Land-Cover Diversity	Low/uniform (5)	Moderate 3	High 1 n/a 0
Topographic Diversity	Low/uniform (5)	Moderate 3	High 1 n/a 0
Colour Contrast	Low/uniform (5)	Moderate 3	High 1 n/a 0
Illumination	Front/side (5)	Side only 3	Back-light 1 n/a 0
Overall R Points:____10 **Circle R Rating:**	**1 (High) 19 or more**	**(2) (Moderate) 7 – 18** **Distance factor over-ride**	**3 (Low) 6 or less** **Distance factor over-ride**

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
(1) Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (>30%)

Integrity modifying factors:
Cumulative effect of current alteration in locality/corridor: ☐ High ☐ Moderate ☒ Low ☐ n/a
Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a
Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☐ Industrial
☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

MR01 Comments

MR01 is the shrubby, flat plain of the Muskeg River. Because the only viewpoints are from the river itself, most of the landscape unit is scarcely visible.

Aerial view looking east over landscape unit MR01.

Landscape Unit Rating Form

Rating Viewpoint(s): **VP-01**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	A	O	S	R	I
HME5	3	3	3	3	2

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction 3	<15% slope; low attraction (-5)
Vegetation	High attraction, interest 5	Moderate attraction 3	Minor influence: (1); neutral: 0
Water	High attraction, interest 5	Moderate attraction 3	Minor influence: (1); neutral: 0
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence: (1); neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral: (0)
Scarcity (in region)	Rare, unique 5	Distinctive, common 3	Minor influence: (1); neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present (0)	Unharmonious -5
Overall A Points: -1 **Circle A Rating:**	**1 (High) 26 or more**	**2 (Moderate) 11-25**	**(3) (Low) 10 or less**
Vertical Relief (m):	**30-50**	**Percent Slope (%):**	**5 and less**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground < 5 km (Front) 10	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) (5)
Viewing Orientation towards LU	Focal; direct in Line of Sight (LOS) 5	Oblique; Tangential to LOS 3	Peripheral; angled away from LOS (1)
Viewing Frequency	Many opportunities 5	Some 3	Few (1)
Viewing Duration	Long 5	Moderate 3	Glimpse (1)
Overall O Points: -2 **Circle O Rating:**	**1 (High) 17 or more** **position over-ride 1**	**2 (Moderate) 8-16** **position over-ride 2**	**(3) (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**2 Mod. LS**	**3 Low LS**
3 Low LA	**2 Mod. LS**	**3 Low LS**	**(3) Low LS**

R - Landscape Risk (LR)			
Slope Class (Slope: 30-50%)	Steep 31%+ 10	Moderate 16-30% 5	Gentle 0-15% (10)
Land-Cover Diversity	Low/uniform 5	Moderate (3)	High 1 n/a 0
Topographic Diversity	Low/uniform (5)	Moderate 3	High 1 n/a 0
Colour Contrast	Low/uniform 5	Moderate 3	High 1 n/a (0)
Illumination	Front/side 5	Side only (3)	Back-light 1 n/a 0
Overall R Points: 1 **Circle R Rating:**	**1 (High) 19 or more**	**2 (Moderate) 7 – 18**	**(3) (Low) 6 or less**
Distance Over-ride		**Distance factor over-ride 2**	**Distance factor over-ride 3**
Observer Position Over-ride	**Position over-ride 1**	**Position over-ride 2**	

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
(1) Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (>30%)

Integrity modifying factors:
Cumulative effect of current alteration in locality/corridor: ☐ High ☒ Moderate ☐ Low ☐ n/a
Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a
Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☒ Industrial ☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

HME5 Comments

HME5 is the very large area east of Highway 63 and the existing Muskeg River Mine. Its low slope and limited access result in a landscape that is viewed by very few people.

Aerial view of landscape unit HME5 looking east at the southern end of the Jackpine Expansion Mining Area.

Landscape Unit Rating Form

Rating Viewpoint(s): **VP-02, VP08**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	A	O	S	R	I
HME6	3	3	3	3	2

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction 3	<15% slope; low attraction -5
Vegetation	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Water	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral: 0
Scarcity (in region)	Rare, unique 5	Distinctive, common 3	Minor influence: 1; neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present 0	Unharmonious -5
Overall A Points:______-1 **Circle A Rating:**	**1 (High) 26 or more**	**2 (Moderate) 11-25**	**3 (Low) 10 or less**
Vertical Relief (m):	**30-50**	**Percent Slope (%):**	**5 and less**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground <5 km (Front) 10	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) -5
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) 5	Oblique; Tangential to LOS 3	Peripheral; angled away from LOS 1
Viewing Frequency	Many opportunities 5	Some 3	Few 1
Viewing Duration	Long 5	Moderate 3	Glimpse 1
Overall O Points: _____-2 **Circle O Rating:**	**1 (High) 17 or more** **position over-ride 1**	**2 (Moderate) 8-16** **position over-ride 2**	**3 (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**2 Mod. LS**	**3 Low LS**
3 Low LA	**2 Mod. LS**	**3 Low LS**	**3 Low LS**

R - Landscape Risk (LR)			
Slope Class (Slope: 30-50%)	Steep 31%+ 10	Moderate 16-30% 5	Gentle 0-15% -10
Land-Cover Diversity	Low/uniform 5	Moderate 3	High 1 n/a 0
Topographic Diversity	Low/uniform 5	Moderate 3	High 1 n/a 0
Colour Contrast	Low/uniform 5	Moderate 3	High 1 n/a 0
Illumination	Front/side 5	Side only 3	Back-light 1 n/a 0
Overall R Points:____1 **Circle R Rating:**	**1 (High) 19 or more**	**2 (Moderate) 7 – 18**	**3 (Low) 6 or less**
Distance Over-ride		**Distance factor over-ride 2**	**Distance factor over-ride 3**
Observer Position Over-ride	**Position over-ride 1**	**Position over-ride 2**	

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
1 Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (> 30%)

Integrity modifying factors:

Cumulative effect of current alteration in locality/corridor: ☐ High ☒ Moderate ☐ Low ☐ n/a

Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a

Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☒ Industrial ☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

HME6 Comments

HME6 is the very large area northeast of Highway 63 and the existing Muskeg River Mine. Although it does overlap slightly with the Jackpine Expansion Mining Area, it is not visible from any identified viewpoints.

Landscape Unit Rating Form

Rating Viewpoint(s): **VP03 to VP07**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	A	O	S	R	I
HMW5	3	3	3	3	1

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction 3	<15% slope; low attraction (-5)
Vegetation	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: (0)
Water	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: (0)
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: (0)
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral: (0)
Scarcity (in region)	Rare, unique 5	Distinctive, common 3	Minor influence: 1; neutral: (0)
Land-Use Modification	Harmonious 5	Neutral; not present (0)	Unharmonious -5
Overall A Points:______-5 **Circle A Rating:**	**1 (High) 26 or more**	**2 (Moderate) 11-25**	**(3) (Low) 10 or less**
Vertical Relief (m):	**60**	**Percent Slope (%):**	**5 and less**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground <5 km (Front) 10	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) (-5)
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) 5	Oblique; Tangential to LOS 3	Peripheral; angled away from LOS (1)
Viewing Frequency	Many opportunities 5	Some 3	Few (1)
Viewing Duration	Long 5	Moderate 3	Glimpse (1)
Overall O Points: _____-2 **Circle O Rating:**	**1 (High) 17 or more** **position over-ride 1**	**2 (Moderate) 8-16** **position over-ride 2**	**(3) (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**2 Mod. LS**	**3 Low LS**
3 Low LA	**2 Mod. LS**	**3 Low LS**	**(3) Low LS**

R - Landscape Risk (LR)			
Slope Class (30-50%)	Steep 31%+ 10	Moderate 16-30% 5	Gentle 0-15% (-10)
Land-Cover Diversity	Low/uniform 5	Moderate 3	High 1 n/a (0)
Topographic Diversity	Low/uniform 5	Moderate 3	High 1 n/a (0)
Colour Contrast	Low/uniform 5	Moderate 3	High 1 n/a (0)
Illumination	Front/side 5	Side only 3	Back-light 1 n/a (0)
Overall R Points:____-10 **Circle R Rating:**	**1 (High) 19 or more**	**2 (Moderate) 7 – 18**	**(3) (Low) 6 or less** **nvs**
Distance Over-ride		**Distance factor over-ride 2**	**Distance factor over-ride 3**
Observer Position Over-ride	**Position over-ride 1**	**Position over-ride 2**	

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
(1) Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (> 30%)

Integrity modifying factors:

Cumulative effect of current alteration in locality/corridor: ☐ High ☐ Moderate ☒ Low ☐ n/a
Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a
Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☒ Industrial
☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

HMW5 Comments

HMW5 is the vast landscape unit above the western Athabasca River valley. With virtually no access and flat terrain, the landscape unit is visible to very few. The unit is not visible from any viewpoints used in the assessment.

Aerial view looking west with landscape unit HMW5 in the background.

Landscape Unit Rating Form

Rating Viewpoint(s): **VP-03, VP-09, VP-05**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	A	O	S	R	I
AW17	2	2	2	2	1

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction (3)	<15% slope; low attraction -5
Vegetation	High attraction, interest 5	Moderate attraction (3)	Minor influence: 1; neutral: 0
Water	High attraction, interest (5)	Moderate attraction 3	Minor influence: 1; neutral: 0
Colour	High attraction, interest 5	Moderate attraction (3)	Minor influence: 1; neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence (3)	Minor influence: 1; neutral: 0
Scarcity (in region)	Rare, unique 5	Distinctive, common (3)	Minor influence: 1; neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present (0)	Unharmonious -5
Overall A Points:______20 **Circle A Rating:**	**(1)(High) 26 or more**	**2 (Moderate) 11-25**	**3 (Low) 10 or less**
Vertical Relief (m):	**25**	**Percent Slope (%):**	**20 and less**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground <5 km (Front) (10)	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) -5
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) 5	Oblique; Tangential to LOS (3)	Peripheral; angled away from LOS 1
Viewing Frequency	Many opportunities 5	Some 3	Few (1)
Viewing Duration	Long 5	Moderate 3	Glimpse (1)
Overall O Points: _____15 **Circle O Rating:**	**1 (High) 17 or more** **position over-ride 1**	**(2)(Moderate) 8-16** **position over-ride 2**	**3 (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**(2) Mod. LS**	**3 Low LS**
3 Low LA	**2 Mod. LS**	**3 Low LS**	**3 Low LS**

R - Landscape Risk (LR)			
Slope Class (Slope: 30-50%)	Steep 31%+ 10	Moderate 16-30% (5)	Gentle 0-15% -10
Land-Cover Diversity	Low/uniform 5	Moderate (3)	High 1 n/a 0
Topographic Diversity	Low/uniform 5	Moderate (3)	High 1 n/a 0
Colour Contrast	Low/uniform 5	Moderate 3	High 1 n/a (0)
Illumination	Front/side 5	Side only (3)	Back-light 1 n/a 0
Overall R Points:____14 **Circle R Rating:**	**1 (High) 19 or more**	**(2)(Moderate) 7 – 18**	**3 (Low) 6 or less**
Distance Over-ride		**Distance factor over-ride 2**	**Distance factor over-ride 3**
Observer Position Over-ride	**Position over-ride 1**	**Position over-ride 2**	

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
(1) Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (> 30%)

Integrity modifying factors:

Cumulative effect of current alteration in locality/corridor: ☐ High ☐ Moderate ☒ Low ☐ n/a

Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a

Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☒ Industrial
☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

AW17 Comments

AW17 is the west side shore unit of the Athabasca River as it trends southwest to northeast from the Pierre River to Sled Island. The unit receives attention from river users.

Landscape Unit Rating Form

Rating Viewpoint(s): **VP-06**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	A	O	S	R	I
AW18	2	2	2	2	1

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction 3	<15% slope; low attraction -5
Vegetation	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Water	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral: 0
Scarcity (in region)	Rare, unique 5	Distinctive, common 3	Minor influence: 1; neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present 0	Unharmonious -5
Overall A Points:______20 Circle A Rating:	**1 (High) 26 or more**	**2 (Moderate) 11-25**	**3 (Low) 10 or less**
Vertical Relief (m):	**25**	**Percent Slope (%):**	**20 and less**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground < 5 km (Front) 10	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) -5
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) 5	Oblique; Tangential to LOS 3	Peripheral; angled away from LOS 1
Viewing Frequency	Many opportunities 5	Some 3	Few 1
Viewing Duration	Long 5	Moderate 3	Glimpse 1
Overall O Points: _____15 Circle O Rating:	**1 (High) 17 or more position over-ride 1**	**2 (Moderate) 8-16 position over-ride 2**	**3 (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: Use Matrix LA : LO	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**2 Mod. LS**	**3 Low LS**
3 Low LA	**2 Mod. LS**	**3 Low LS**	**3 Low LS**

R - Landscape Risk (LR)			
Slope Class (Slope: 30-50%)	Steep 31%+ 10	Moderate 16 - 30% 5	Gentle 0-15% -10
Land-Cover Diversity	Low/uniform 5	Moderate 3	High 1 n/a 0
Topographic Diversity	Low/uniform 5	Moderate 3	High 1 n/a 0
Colour Contrast	Low/uniform 5	Moderate 3	High 1 n/a 0
Illumination	Front/side 5	Side only 3	Back-light 1 n/a 0
Overall R Points:____14 Circle R Rating:	**1 (High) 19 or more**	**2 (Moderate) 7 – 18**	**3 (Low) 6 or less**
Distance Over-ride		**Distance factor over-ride 2**	**Distance factor over-ride 3**
Observer Position Over-ride	**Position over-ride 1**	**Position over-ride 2**	

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
1 Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (>30%)

Integrity modifying factors:

Cumulative effect of current alteration in locality/corridor: ☐ High ☐ Moderate ☒ Low ☐ n/a

Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a

Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☒ Industrial ☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

AW18 Comments

AW18 is the west-side shore unit where the water intake is to be located. It has a low relief section at the south and a steeper more abrupt slope at the north end. The unit is directly visible to river users, but no ground viewpoints presently have a line of sight.

Aerial view looking west over AW18 near the proposed water intake.

Looking southwest from VP07, AW18 is visible in the distance along the Athabasca River.

Landscape Unit Rating Form

Rating Viewpoint(s): **VP-03, VP04**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Landscape Unit Label (overall ratings from below)					
LU#	A	O	S	R	I
AE18	2	2	2	2	1

Conducted by: **Kevin Graham, Golder Associates Ltd.**

Date: **July 2007**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction 3	<15% slope; low attraction -5
Vegetation	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Water	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence: 1; neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral: 0
Scarcity (in region)	Rare, unique 5	Distinctive, common 3	Minor influence: 1; neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present 0	Unharmonious -5
Overall A Points:______20 **Circle A Rating:**	**1 (High) 26 or more**	**2 (Moderate) 11-25**	**3 (Low) 10 or less**
Vertical Relief (m):	**25**	**Percent Slope (%):**	**20 and less**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground <5 km (Front) 10	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) -5
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) 5	Oblique; Tangential to LOS 3	Peripheral; angled away from LOS 1
Viewing Frequency	Many opportunities 5	Some 3	Few 1
Viewing Duration	Long 5	Moderate 3	Glimpse 1
Overall O Points: _____15 **Circle O Rating:**	**1 (High) 17 or more** **position over-ride 1**	**2 (Moderate) 8-16** **position over-ride 2**	**3 (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**		Landscape Observability LO (across)	
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**2 Mod. LS**	**3 Low LS**
3 Low LA	**2 Mod. LS**	**3 Low LS**	**3 Low LS**

R - Landscape Risk (LR)			
Slope Class (Slope: 30-50%)	Steep 31%+ 10	Moderate 16-30% 5	Gentle 0-15% -10
Land-Cover Diversity	Low/uniform 5	Moderate 3	High 1 n/a 0
Topographic Diversity	Low/uniform 5	Moderate 3	High 1 n/a 0
Colour Contrast	Low/uniform 5	Moderate 3	High 1 n/a 0
Illumination	Front/side 5	Side only 3	Back-light 1 n/a 0
Overall R Points:____14 **Circle R Rating:**	**1 (High) 19 or more**	**2 (Moderate) 7 – 18**	**3 (Low) 6 or less**
Distance Over-ride		**Distance factor over-ride 2**	**Distance factor over-ride 3**
Observer Position Over-ride	**Position over-ride 1**	**Position over-ride 2**	

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
1 Very High	No alteration evident, very subordinate, very high landscape conformity, (0 - 1.5% alt. in LU)
2 High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 - 7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 - 18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (>30%)

Integrity modifying factors:

Cumulative effect of current alteration in locality/corridor: ☐ High ☐ Moderate ☒ Low ☐ n/a
Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a
Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☒ Industrial
☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

AE18 Comments

AE18 is the east side shore unit of the Athabasca River as it trends northeast from Pierre River. The unit receives attention from river users.

Landscape Unit Rating Form

Rating Viewpoint(s): **Canterra Bridge Crossing (Golder 2004), VP-02**

Landscape Unit Label (overall ratings from below)					
LU#	**A**	**O**	**S**	**R**	**I**
HME4.2	**2**	**2**	**2**	**2**	**2**

A: Attraction
O: Observability
S: Significance
R: Risk
I: Integrity

Conducted by: **Greg Jones, Golder Associates Ltd.**

Date: **March 2005**

Circle the most appropriate rating for each Factor of each Element below. Place overall rating for each Element in the Landscape Unit Label above. Add additional comments on side or on reverse. Note: overall ratings in each category may be influenced more strongly by one or a few factors. If so, make note of your selection rationale in the comments.

A - Landscape Attraction (LA)			
Landform	>30% slope; high attraction 10	15-30% slope; mod. attraction (3)	<15% slope; low attraction -5
Vegetation	High attraction, interest 5	Moderate attraction (3)	Minor influence: 1; neutral: 0
Water	High attraction, interest 5	Moderate attraction (3)	Minor influence: 1; neutral: 0
Colour	High attraction, interest 5	Moderate attraction 3	Minor influence (1); neutral: 0
Adjacent scenery	Enhances LU attraction 5	Moderate influence 3	Minor influence: 1; neutral (0)
Scarcity (in region)	Rare, unique 5	Distinctive, common 3	Minor influence (1); neutral: 0
Land-Use Modification	Harmonious 5	Neutral; not present (0)	Unharmonious -5
Overall A Points: ______11 **Circle A Rating:**	**1 (High) 26 or more**	**(2) (Moderate) 11-25**	**3 (Low) 10 or less**
Vertical Relief (m):	**30-50**	**Percent Slope (%):**	**5 and less**

For Landscape Attraction Factors above that are neutral or not present, assign a zero (0) rating.

0 - Landscape Observability (L0)			
Viewing Distance	Foreground/Middle ground <5 km (Front) (10)	Background 5 – 15 km (Back) 3	Seldom Seen FG/MG/BG or >15 km (Far Back) -5
Viewing Orientation towards LU	Focal; direct in Line Of Sight (LOS) 5	Oblique; Tangential to LOS 3	Peripheral; angled away from LOS (1)
Viewing Frequency	Many opportunities 5	Some (3)	Few 1
Viewing Duration	Long 5	Moderate 3	Glimpse (1)
Overall O Points: _____15 **Circle O Rating:**	**1 (High) 17 or more** **position over-ride 1**	**(2) (Moderate) 8-16** **position over-ride 2**	**3 (Low) 7 or less**

S - Landscape Significance (LS)			
Circle S Rating: **Use Matrix LA : LO**	Landscape Observability LO (across)		
Landscape Attraction LA (down)	1 High LO	2 Moderate LO	3 Low LO
1 High LA	**1 High LS**	**1 High LS**	**2 Mod. LS**
2 Moderate LA	**1 High LS**	**(2) Mod. LS**	**3 Low LS**
3 Low LA	**2 Mod. LS**	**3 Low LS**	**3 Low LS**

R - Landscape Risk (LR)			
Slope Class (Slope: 30-50%)	Steep 31%+ 10	Moderate 16-30% (5)	Gentle 0-15% -10
Land-Cover Diversity	Low/uniform 5	Moderate (3)	High 1 n/a 0
Topographic Diversity	Low/uniform 5	Moderate (3)	High 1 n/a 0
Colour Contrast	Low/uniform 5	Moderate (3)	High 1 n/a 0
Illumination	Front/side 5	Side only (3)	Back-light 1 n/a 0
Overall R Points:____17 **Circle R Rating:**	**1 (High) 19 or more**	**(2) (Moderate) 7 – 18**	**3 (Low) 6 or less**
Distance Over-ride		**Distance factor over-ride 2**	**Distance factor over-ride 3**
Observer Position Over-ride	**Position over-ride 1**	**Position over-ride 2**	

For Landscape Risk Factors above that are neutral, assign a zero (0) rating. Distant factor >5 km may lower Risk.

I - Landscape Integrity (LI)	
Circle I Rating:	
1 Very High	No alteration evident, very subordinate, very high landscape conformity, (0 -1.5% alt. in LU)
(2) High	Minimal alteration evident, subordinate, well-designed, high landscape conformity (1.6 -7%)
3 Moderate	Moderate alteration evident, dominant, moderate landscape conformity (7.1 -18% alt.)
4 Low	Intensive alteration evident, very dominant, low landscape conformity (18.1 - 30% alt.)
5 Very Low	Very intensive alteration evident, extremely dominant, very low landscape conformity (>30%)

Integrity modifying factors:
Cumulative effect of current alteration in locality/corridor: ☐ High ☒ Moderate ☐ Low ☐ n/a
Perceived ecological integrity in locality/corridor: ☒ High ☐ Moderate ☐ Low ☐ n/a
Locality influence: ☐ Urban ☐ Urban Fringe ☐ Rural, Developed ☒ Rural, Natural ☒ Industrial
☐ Recreational, Developed ☒ Recreational, Natural ☐ Backcountry ☐ Wilderness

HME4.2 Comments

HME4.2 is the Landscape Unit along the Muskeg River, extending from Township 96, Range 9 W4M to Township 94, Range 10 W4M. Although the Muskeg River is not a high-traffic river and this landscape unit is not highly visible from other travel corridors (other than one bridge crossing of the Canterra Road), some recreational traffic in the valley see foreground views of this unit with moderate frequency.

View of HME 4.2 from Canterra Road crossing.

View of HME 4.2 from downstream of the Muskeg River bridge

Aerial view of HME4.2 facing southwest (Muskeg River Mine External Tailings Disposal Area in background at right).

2 REFERENCES

RDI (Resource Design Inc.). 2003. Visual Landscape System for Planning and Managing Aesthetic Resources. Prepared for the Cumulative Environmental Management Association, Sustainable Ecosystems Working Group, Cultural and Historic Resources Subgroup.

Shell (Shell Canada Limited). 2005. Muskeg River Mine Expansion Project Application and Environmental Impact Assessment. Submitted to Alberta Energy and Utilities Board and Alberta Environment. Prepared by Golder Associates Ltd. and Nichols Applied Management. Volume 1, 2, 3 and 4. Fort McMurray, AB. Submitted April, 2005.

APPENDIX 5-8

VISUAL RESOURCES
VISIBLE PLUME MODELLING INFORMATION

TABLE OF CONTENTS

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LIST OF TABLES

1 PLUME ANALYSIS METHODS

1.1 STEAM PLUMES

The height of the visible "steam plumes" can be calculated using methodologies recommended for the evaluation of plumes from cooling towers (Hanna et al. 1982; Wrigley and Slawson 1975). The following equations give the height of the steam plume (Z_p) above the top of the stack. The first equation is for calm conditions (wind speeds less than 1 m/s), while the second is for windy conditions. The terms used in these formulae are described in Table 1.

$$Z_p = 9 \times R_0 \times \left[\left(\frac{q_{p_0} + q_{L_0}}{q_s - q_e} \right)^{1/2} - 1 \right] \qquad \text{calm conditions}$$

$$Z_p = 3.6 \times R_0 \times \left(\frac{W_0}{U} \right)^{1/2} \left[\left(\frac{q_{p_0} + q_{L_0}}{q_s - q_e} \right)^{1/2} - 1 \right] \qquad \text{windy conditions}$$

In the above formulas, q_e and q_s are derived from the following relationships:

$$q_s = \frac{\varepsilon \times e_s}{P}$$

$$q_e = RH \times q_s$$

$$\varepsilon = R_d / R_v$$

$$e_s = e_0 \times \exp\left[\frac{L}{R_v} \times \left(\frac{1}{T_d} - \frac{1}{T} \right) \right]$$

Table 1 Parameters Used to Calculate Visible Plume Heights

Parameter	Value	Units	Description	Reference
R_0	–	m	initial plume radius	–
W_0	–	m/s	stack exit velocity	–
q_{p_0}	–	g/g	plume specific humidity	–
q_{L_0}	0.001	g/g	initial specific humidity of liquid water in the plume	Stull (1989)
q_s	0.000692	g/g	saturation specific humidity of the environment	calculated
q_e	0.000520	g/g	specific humidity of the environment	calculated
ε	0.622	–	ratio of the gas constants for dry air and water vapour	Stull (1989)
e_s	0.1057	kPa	saturation vapour pressure	calculated
e_0	0.611	kPa	vapour pressure at reference temperature	Stull (1989)
L	2.50×106	J/kg	latent heat of vaporization at 0°C	Stull (1989)
R_v	461.5	J/(K×kg)	gas constant for water vapour	Stull (1989)
R_d	287.1	J/(K×kg)	gas constant for dry air	Stull (1989)
T_d	273.15	K	reference temperature	–
P	–	kPa	hourly barometric pressure	Fort McMurray Airport
RH	–	–	hourly relative humidity	Fort McMurray Airport
U	–	m/s	hourly wind speed	Fort McMurray Airport
T	–	K	hourly ambient temperature	Fort McMurray Airport

The visible plume heights were calculated for every hour of one year of meteorological data (i.e., 1995). The results of the visible plume calculations are presented in Volume 5, Section 8.5, based on the source characteristics for the natural gas-fired and asphaltene-fired cogeneration units.

1.2 COOLING TOWER PLUMES

1.2.1 Seasonal/Annual Cooling Tower Impact Model

Due to the high moisture content, plumes from cooling towers are often visible. In addition, cooling tower plumes may touch the ground and cause fogging or icing under certain meteorological conditions. The dimension of these visible plumes and the likelihood of observing ground-level fogging or icing will vary depending on the characteristics of the cooling tower, atmospheric conditions and the time of year. The height of the visible cooling tower plume and the likelihood of ground-level fogging and icing were predicted using the Seasonal/Annual Cooling Tower Impact (SACTI) computer model. The assessment of visible plumes is presented in the Visual Aesthetics section (Volume 5, Section 8.5).

The SACTI model predicts seasonal and annual impacts of the vapour plume, fogging, icing, shadowing and drift deposition from natural and mechanical draft cooling towers. The SACTI model was developed by Argonne National Laboratory and the University of Illinois. The model development was supported by Electric Power Research Institute (EPRI) through interagency agreement with the U.S. Department of Energy (Policastro et al. 1994).

The SACTI model is a one-dimensional integral plume model. The main advantage of the SACTI model is its advanced theoretical development and extensive model validation using experimental data from studies in the United States and Europe. An extensive database on cooling tower plumes was analyzed to assist in the development of the theoretical assumptions. Other data, not used in the model development, was used for independent model verification (Policastro et al. 1994).

The SACTI model is able to predict visible plume rise within a factor of 2.0 in 75% of the field study cases, and visible plume length within a factor of 2.5 in 70% of cases. For laboratory data, the mean error in trajectory or rise predictions is 20%, and the mean error in dilution predictions is 30%. For one-dimensional integral models, these are considered to be state of the art levels of predictive accuracy (Carhart and Policastro 1991).

The SACTI modelling system meets the requirements of most regulatory bodies in the United States, and has been applied for many cooling tower projects in the United States and throughout the world (ANL 2005, website).

The parameters used for the Project cooling towers are presented in Table 2. Since the Project cooling towers are similar to the one assessed in the Muskeg River Mine Expansion Environmental Impact Assessment (EIA) (Shell 2005), the same parameters were used for this assessment.

Table 2 Parameters Used in the Seasonal/Annual Cooling Tower Impact Model

Parameter	Description
Cooling Tower Parameters	
type	mechanical induced draft hybrid fluid
number of cells	18
configuration	2×9
length of each cell	35.2 m
width of each cell	7.9 m
height of each cell	6.7 m
total heat rejection rate	175 GJ/h
total tower input air flow rate	3,904 kg/s
effective exit diameter	17.82 m
Meteorological Parameters	
wind speed - wind direction - dry bulb temperature	2003 - Albian Mine Site WBEA station (CASA 2005, website)
relative humidity	2003 - Fort McKay WBEA station (CASA 2005, website)

1.2.2 Seasonal/Annual Cooling Tower Impact Meteorology

The SACTI model requires one year of hourly meteorological data to calculate seasonal and annual plume characteristics. The Albian Mine Site air monitoring station operated by the Wood Buffalo Environmental Association (WBEA) is the closest station to the Project (9.4 km from the Jackpine Expansion Mining Area (JEMA) plant site and 27.8 km from the Pierre River Mining Area (PRMA) plant site) and provides the most appropriate on-site meteorological data. Therefore, wind speed, wind direction and dry bulb temperature parameters were gathered from the Albian Mine Site station.

One of the most important parameters that determines the condensation of the moisture in the cooling tower plume is the relative humidity of the surrounding atmosphere. However, relative humidity is not measured at the Albian Mine Site station; therefore, data from the Fort McKay WBEA station was used. The Fort McKay WBEA station is located 15.9 km from the JEMA plant site and 38.4 km from the PRMA plant site; therefore, the relative humidity at the Fort McKay station is representative of the relative humidity at the Project.

In addition to hourly parameters, SACTI also requires twice daily mixing height values. Twice daily (morning and afternoon) mixing heights were calculated from the observed surface wind speeds following the Benkley and Schulman (1979) and Randerson (1984) formulations.

The SACTI model also requires monthly average daily solar insolation and monthly clearness index parameters for each month (Table 3). The values for these parameters are gathered from the long-term average values recommended for the Edmonton station in the SACTI manual (EPRI 1987). This is representative of solar insolation at the Project.

Table 3 Monthly Meteorological Parameters Used in the Seasonal/Annual Cooling Tower Impact Model

Parameter[(a)]	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
average daily insolation [MJ/m²]	3.72	7.36	13.05	17.27	21.29	21.45	22.00	17.10	12.46	7.86	4.64	2.76
monthly clearness index	0.53	0.59	0.64	0.58	0.57	0.52	0.56	0.52	0.52	0.53	0.56	0.48

(a) Based on Edmonton station data.

The SACTI model requires the determination of up to five characteristic wind directions to optimize the program runtime. The number and value of characteristic wind directions were determined based on the precision that is required in the results and the orientation of the cooling tower structure. To obtain the highest directional precision, five categories were selected specific to the Project cooling tower structure orientation. The characteristic wind directions and associated wind sector array used in this assessment are presented in Table 4.

Table 4 Characteristic Wind Sectors Used in the Seasonal/Annual Cooling Tower Impact Model

Parameter	Description
characteristic wind sectors	(1) 346° - (2) 8.5° - (3) 31° - (4) 53.5° - (5) 76°
array of characteristic wind direction sector pattern to cover all 36 sectors[(a)]	2 - 3 - 4 - 5 - 4 - 3 - 2 - 1 - 2 - 3 - 4 - 5 - 4 - 3 - 2 - 1

(a) First array element is for north. Order is given in clockwise direction.

2 RESULTS

Two categories of visible effects have been assessed for the Project. The first deals with the visible plumes from large combustion sources (i.e., cogeneration units) and cooling towers at the Project. During the coldest months of the year, moisture in the cogeneration unit plumes can condense and become visible. The dimension of these visible "steam plumes" will vary depending on the atmospheric conditions and the time of year. The second category of visibility effect is the haze associated with secondary aerosols (nitrates and sulphates), oxides of nitrogen, soot and airborne particles. These compounds could appear as either a light or dark haze, depending on the distance and relative position of the viewer to the Project.

2.1 PLUME CHARACTERISTICS

The visible plume heights were calculated for every hour of one year of meteorological data used for the air quality assessment, using the approach discussed in Section 1.1 of this Appendix. The results of the visible plume calculations are presented in Tables 5 and 6 based on the source characteristics for the natural gas-fired and asphaltene-fired cogeneration units. The results indicate that the plumes could reach heights of 239 m, under certain meteorological conditions.

The visible plumes from the Project are not expected to be a concern for ground-level fog on local roadways due to the high exit velocities from the cogeneration units (between 20 and 23 m/s). At this high velocity, the plumes would tend to rise directly up from the stacks and would not descend to ground level for several kilometres. At these distances, the moisture in the plume will have dispersed and will not be visible.

Table 5 Likelihood of Various Visible "Steam Plume" Heights From Natural Gas-Fired Cogeneration Units

Month	Height of the Visible Plume[(a)(b)] [m]					
	Maximum	99th Percentile	95th Percentile	90th Percentile	75th Percentile	50th Percentile
January	139	118	90	73	48	0
February	132	116	85	70	43	0
March	198	135	72	52	31	8
April	107	70	41	31	21	9
May	54	41	27	20	11	3
June	53	31	23	19	12	4
July	45	41	32	26	14	6
August	67	49	36	28	16	6
September	61	49	34	22	10	1
October	239	101	67	52	31	0
November	147	101	84	69	39	0
December	163	127	85	71	37	0
Annual	**239**	**102**	**67**	**47**	**21**	**3**

(a) The heights presented in the table do not include the natural gas-fired cogeneration unit exhaust stack height of 40 m.

(b) Only "steam plumes" that occur during the daylight hours were considered to be visible. Plumes that occurred at night were assigned a visible height of 0 m.

Table 6 Likelihood of Various Visible "Steam Plume" Heights From Asphaltene-Fired Cogeneration Units

Month	Height of the Visible Plume[(a)(b)] [m]					
	Maximum	99th Percentile	95th Percentile	90th Percentile	75th Percentile	50th Percentile
January	136	115	87	72	49	0
February	129	113	85	68	42	0
March	193	135	70	51	30	8
April	104	67	40	29	20	8
May	52	40	26	19	10	3
June	51	30	22	18	12	4
July	43	39	30	25	13	6
August	65	47	34	27	15	5
September	59	47	32	21	9	0
October	233	98	65	51	30	0
November	143	98	82	67	39	0
December	159	124	84	70	39	0
Annual	**233**	**99**	**65**	**46**	**20**	**2**

(a) The heights presented in the table do not include the asphaltene-fired cogeneration unit exhaust stack height of 150 m.

(b) Only "steam plumes" that occur during the daylight hours were considered to be visible. Plumes that occurred at night were assigned a visible height of 0 m.

The visible plumes from the cooling towers were determined using the approach discussed in Section 1.2 of this Appendix. The maximum visible plume height was predicted to be 120 m while the average height was 69 m.

2.2 HAZE CHARACTERISTICS

The second type of visible impact is related to the regional haze resulting from the airborne concentrations of secondary aerosols (sulphates and nitrates), oxides of nitrogen, soot and airborne particles. The haze is measured as an extinction coefficient. The extinction coefficient (b_{ext}) is an optical measure of the reduction in light resulting from the combination of compounds that take up water (hygroscopic) and those that cannot (non-hygroscopic). The formula can be written as follows:

$$b_{ext} = b_{S,N} \times f(RH) + b_{dry}$$

In the above formula, $b_{S,N}$ is the extinction coefficient for sulphates and nitrates at 0% relative humidity, $f(RH)$ is the relative humidity adjustment factor and b_{dry} is the extinction coefficient for non-hygroscopic compounds. The b_{dry} term is a combination of light scattering due to fine and coarse particulate matter, organic carbon, soil and Rayleigh scattering, as well as the light absorption due to elemental carbon. The extinction coefficient for each compound is computed as the product of its air concentration (in $\mu g/m^3$) and extinction efficiency (in m^2/g).

The Project is estimated to increase regional emissions by 7.88 t/cd of sulphur dioxide (SO_2), 12.19 t/d of oxides of nitrogen (NO_X) and 0.44 t/d of $PM_{2.5}$. These are 2.8, 2.5 and 1.4% of the Application Case regional emissions totals as shown in Table 7. Furthermore, the SO_2 and NO_X emissions do not form aerosols directly, rather they interact with other airborne compounds (primarily ammonium) and produce secondary particulates (ammoniated sulphate and nitrate). Therefore, some fraction of the SO_2 and NO_X emissions will not result in any effect on regional visibility. When the above factors are considered, the visibility effects predicted from the Project are not expected to result in a significant deterioration of visibility in the region as the result of haze production.

Table 7 Summary of Application Case Emissions in the Oil Sands Region

Source	Emission Rates[a]		
	SO_2 [t/cd]	NO_X [t/d]	$PM_{2.5}$ [t/d]
Project and Updated Jackpine Mine – Phase 1	8.21	30.52	1.31
Shell in-situ sources	0.90	1.26	0.10
Albian Sands	0.61	31.68	1.61
Suncor	84.72	112.14	9.26
Syncrude	100.12	89.49	7.63
Canadian Natural	21.14	69.29	3.96
Petro-Canada Oil Sands	1.73	26.74	0.72
other industries[b]	62.07	116.03	6.85
gas plants	2.18	16.76	0.26
communities	0.26	1.62	–[c]
Total[d]	**281.94**	**495.55**	**31.69**

(a) Emissions are expressed as tonnes per calendar-day (t/cd) or tonnes per day (t/d).

(b) The "other industries" category includes the emissions from other oil sands developments and industrial sources.

(c) Background data were added to model predictions to represent $PM_{2.5}$ emissions from the communities. Therefore, community emissions of $PM_{2.5}$ were not modelled.

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

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4 ABBREVIATIONS

°C	Temperature in degrees Celsius
%	Percent
EIA	Environmental Impact Assessment
EPRI	Electric Power Research Institute
g/g	Gram per gram
GJ/h	Gigajoule per hour
i.e.	That is
JEMA	Jackpine Expansion Mining Area
J/kg	Joules per kilogram
K	Degrees kelvin
kg/s	Kilogram per second
km	Kilometre
kPa	Kilopascals
m	Metre
m^2/g	Square metres per gram
m/s	Metres per second
MJ/m^2	Megajoule per square metre
NO_X	Oxides of nitrogen (NO, NO_2) (gas), or all nitrogen species (e.g., NO_X, N_2O, N_3O)
$PM_{2.5}$	Particulate matter with nominally smaller than 2.5 µm in diameter
PRMA	Pierre River Mining Area
SACTI	Seasonal/Annual Cooling Tower Impact
SO_2	Sulphur dioxide
t/cd	Tonnes per calendar day
t/d	Tonnes per day
WBEA	Wood Buffalo Environmental Association
$\mu g/m^3$	Micrograms per cubic metre

5 GLOSSARY

Insolation Patterns	The amount of solar radiation received by the earth.
Mixing Height	The depth of surface layer in which atmospheric mixing of emissions occurs.
Solar Insolation	The measure of solar energy received on a given surface area in a given time.
Visual Aesthetics	The study of the psychological responses to appearances.

APPENDIX 5-9

URBAN POPULATION IMPACT MODEL

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1 INTRODUCTION

This appendix addresses:

- selected observations regarding population growth in the Regional Municipality of Wood Buffalo (RMWB);
- the Urban Population Impact Model developed by Regional Issues Working Group (RIWG); and
- the performance of this model in view of actual population estimates.

Definitions

Definitions of terms applicable to this appendix are provided below.

Wood Buffalo Region means the area within the borders of the RMWB and includes the RMWB and the reserves within its borders.

The *Regional Municipality of Wood Buffalo* is a municipality in northeastern Alberta. It was created in 1995 by amalgamating the City of Fort McMurray and Improvement District 18.

The *Urban Service Area* of the RMWB is a planning area, roughly coincident with Fort McMurray.

Population includes all people in the region, except people on short-term assignments and those living in camps.

The *urban population* of the RMWB is the population of Fort McMurray and the nearby bedroom communities of Saprae Creek and Gregoire Lake Estates. The urban population refers to the permanent population and does not include work camps.

The *Urban Population Impact Model* is a demographic model of Fort McMurray and the nearby bedroom communities of Saprae Creek and Gregoire Lake Estates. It was developed in 1997 by Nichols Applied Management on behalf of the RIWG and the RMWB.

2 SELECTED OBSERVATIONS

Construction and especially operations of oil sands facilities are main drivers of urban population growth in the RMWB. A number of general observations regarding the population growth of the urban population are detailed below.

Historical Growth

There are many ways to count the population of the Wood Buffalo region and there are two main sources for population data:

- the municipal census conducted by the RMWB; and
- the national census conducted by Statistics Canada.

The RMWB has conducted municipal census in 1999, 2000, 2002, 2004, 2005 and 2006. The RMWB conducted a count in 2007, but the results were not public in November 2007 when this study was finalized. Statistics Canada conducts its census once every five years, with the last one being in 2006. The two sources have several differences in terms of definition of population and methodology. The main difference is that the Statistics Canada census counts people where they reside normally, while the RMWB municipal census counts them where they are found. In view of the high proportion of people working in the region, but maintaining their primary residence elsewhere, the Statistics Canada estimates have been smaller than the most comparable municipal census.

The RMWB census counted 79,800 people in the region for 2006, while the Statistics Canada census places the population at 51,496. The difference lies in the camp populations and people living in hotels. For most purposes, the RMWB census provides a more appropriate picture of the population in the region and Alberta Municipal Affairs uses RMWB census population estimates in its Official Population List.

Table 1 presents the RMWB census numbers and indicates the average annual growth rate for the 1999 to 2006. Table 1 indicates the growth rates range from -1.5% for Fort Chipewyan to +34.6% for “other”. Interpreting changes in population data for small communities must be viewed with a degree of uncertainty, because even small enumeration issues can lead to relatively large swings in the count. The population estimates for the larger centres are less susceptible to survey administration-related issues. The information in Table 1 shows that the population of Fort McMurray (excluding people in campgrounds and hotels) grew with an average rate of 7.8%, while the estimate of people in campgrounds and hotels grew by 27.3%.

Table 1 Population Growth Rates

Community	1999	2000	2002	2004	2005	2006	Rate 1999 to 2006 [%]
Fort McMurray (excl hotels/campgrounds)	36,452	41,712	46,723	55,121	58,150	61,735	7.8
Saprae Creek	509	659	603	624	754	728	5.2
Gregoire Lake Estates	163	206	184	206	180	285	8.3
Draper	47	60	84	141	148	118	14.1
Anzac	397	446	548	647	685	711	8.7
Conklin	215	219	213	210	242	338	6.7
Janvier	207	185	143	112	141	218	0.7
Fort Chipewyan	1,020	1,036	1,012	1,146	744	915	-1.5
Fort McKay	262	399	186	218	104	536	10.8
Other	7	167	11	n/a	n/a	56	34.6
Homeless	n/a	n/a	n/a	n/a	232	405	n/a
Fort McMurray hotels/campgrounds	424	444	517	990	2,601	2,301	27.3
Work Camps	3,568	5,903	8,063	7,678	9,178	10,442	16.6
Total	43,271	51,436	58,287	67,093	73,159	78,788	8.9
First Nations Reserves	n/a	n/a	n/a	n/a	n/a	1,018	n/a
Total RMWB plus FN Reserves	n/a	n/a	n/a	n/a	n/a	79,806	n/a

Source: RMWB census, various years.

n/a = Not available.

Notes: The 2006 RWMB census is the first municipal census that presents an estimate for people living on First Nations reserves. People living on reserves live in the Wood Buffalo region, but not in the RMWB, as reserves are not part of a municipality.

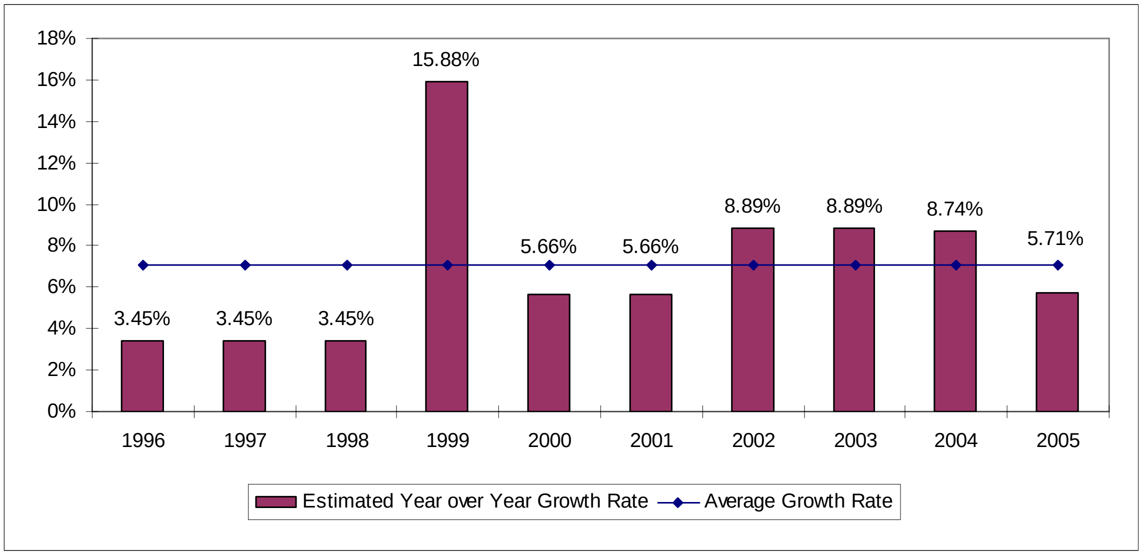
Other means living outside established urban and rural communities.

Variable Growth Rates

Most the people in the region live in the urban areas of Fort McMurray and its nearby bedroom communities of Saprae Creek and Gregoire Lake Estates. Together, these communities (including the people counted in camp grounds and hotels) account for 65,059 or 95% of the estimated 68,346 population in the municipality (excluding people in work camps and living on reserve).

Figure 1 shows the annual growth rates of the urban population and indicates that the growth rate is variable from year to year. The estimated growth rate in 2005 is estimated at 5.7% as compared to 8.7% the year previous and the seven-year average of 6.8%.

Figure 1 Urban Population Growth Rates



Notes: Pertains to population of Fort McMurray, Saprae Creek and Gregoire Lake Estates and includes people living in hotels and campgrounds in the urban area.
Growth rates for 1996 to 1999 are the average annual growth rate for 1996 to 1999.
Growth rates for 2000 and 2001 are the average annual growth rate for 2001 to 2002.
Growth rates for 2002 and 2003 are the average annual growth rate for 2003 to 2004.

Sources: RMWB census 1999, 2000, 2002, 2004, 2005 and 2006. Statistics Canada census 1996.

Declining Growth Rates During Peak Construction Periods

The impact of construction periods is reduced as the population grows. The average annual growth rate of the population of Fort McMurray by period was:

- 38.5% in the period of 1963 to 1968, when the Suncor base plant was built;
- 21.4% in the 1978 to 1979 period during the construction of the Syncrude base plant; and
- 8.25% in 1999 to 2006 during the construction of the Shell Muskeg River Mine, Suncor Millennium mine and Syncrude UE1.

Declining Number of Workers per Barrel of Synthetic Crude Oil Output

Technological advances and economies of scale are changing the productivity of oil sands plants, as expressed as the number of people required to produce a barrel of synthetic crude oil. One integrated mine and upgrader facility has increased its output per worker from an estimated 19,000 barrels of synthetic crude oil (SCO) per worker in early stages of operation to a current output of about 30,000 barrels per worker. Another operator building a greenfield integrated mining/upgrader facility plans on a SCO output of about 36,000 barrels per worker.

Reasons for the increased productivity per worker pertain to both changes in technology and scale, including:

- changing from bucketwheel to truck and shovel mining;
- the introduction of hydrotransportation; and
- production growth by means of expansion projects that can draw on existing infrastructure and workforce functions.

Changing Operations Models

Operators of new projects that are remote from Fort McMurray have started to use operations camps to reduce worker travel times and to ensure worker health and safety. In May 2007, Suncor has an operations camp at its Firebag site and the Imperial Oil Kearl and Synenco Northern Lights projects are on record as including operations camps. The worker health and safety concerns brought forward to support operations camps apply to an increasing number of planned developments that are located more than 1.5 hours driving time from Fort McMurray. These oil sands operations include:

- Husky Sunrise;
- EnCana Borealis;
- Shell Pierre River Mining Area; and
- Synenco Northern Lights Project.

Operations camps tend to be linked to moving workers in and out of the region by plane. Conceived as fly-in/fly-out operations that marshal workers in Edmonton or elsewhere outside the RMWB, the camps will reduce the impact of projects that use them on the urban population in the RMWB.

3 URBAN POPULATION IMPACT MODEL

In 1997 the RIWG recognized that the cumulative growth of the oil sands industry would have a significant impact on the urban population of Wood Buffalo region. The RIWG commissioned the Urban Population Impact Model with a view to facilitate the planning of the RMWB, school boards and other agencies. This model goes well beyond the simple extrapolation of historic growth trends in that it:

- is driven by the construction and especially the operations employment of individual oil sands projects;
- recognizes the spin-off jobs implied by oil sands industry expansion and the jobs created in the general economy by means of regional multipliers;
- incorporates demographic forces, such as the aging of the existing population;
- recognizes house and commercial building activity that supports the population expansion as an explicit impact on the population; and
- models explicitly the net in-migration into the RMWB.

The Urban Population Impact Model is driven by individual oil sands projects, it allows for updated forecasts every time a new project enters the public discussion and the regulatory process.

3.1 MODEL REVISION

Over the years, the Urban Population Impact Model has undergone several revisions, incorporating a number of different considerations as discussed below.

Structural Change

Fort McMurray attracts more and more diversified services as it grows. Examples abound in the general economy and include big box stores, increased number of restaurants and large grocery stores. The evidence is more mixed in the industrial sector, including:

- consistent issues from local area contractors in obtaining work on the large projects, especially those run by large multi-national contracting firms; and
- an expansion of the municipal and environmental engineering sector.

Construction Period

The oil sands industry has sustained a high level of investment since 1996. The level of investment has been much larger then anticipated. For example, work done by the National Oil Sands Task Force in 1995 was premised on $25 billion in investment over 25 years. In reality, the investment to date in new facilities has exceeded this estimate by a wide margin. This change in the level of investment has been well documented and subject to review at oil sands project regulator hearings in 2006.

The higher than expected level of investment has resulted in a high level of construction activity in the Wood Buffalo region that has been sustained over nine years and is expected to continue through to the early years of the next decade. This, in turn, has increased the weight of the impact of construction on population relative to the assumptions made when the model was initially configured.

A survey conducted by Nichols Applied Management on behalf of RIWG (Nichols Applied Management 2003) also has provided additional information on the economic behaviour of camp dwellers. The survey found that camp dwellers, on average, spend $108/week in Fort McMurray for goods and services, with the hospitality industry being the main beneficiary.

The implications to the urban population impact model are:

- changes in the attention paid to the number of construction workers in the region; and
- changes in the multiplier used to calculate induced jobs to account for the evidence from the camp survey.

Operations Camps

There is one operations camp in existence and several others planned as of May 2007. This is a structural change in the way some oil sands facilities are operated as compared to the traditional model in which all operations workers resided in the region, mostly in Fort McMurray.

The implications for the Urban Population Impact Model are that it:

- includes the capability to indicate whether or not a project includes an operations camp; and
- allows for an estimate of the percentage of operations camp workers residing in the region as compared to elsewhere.

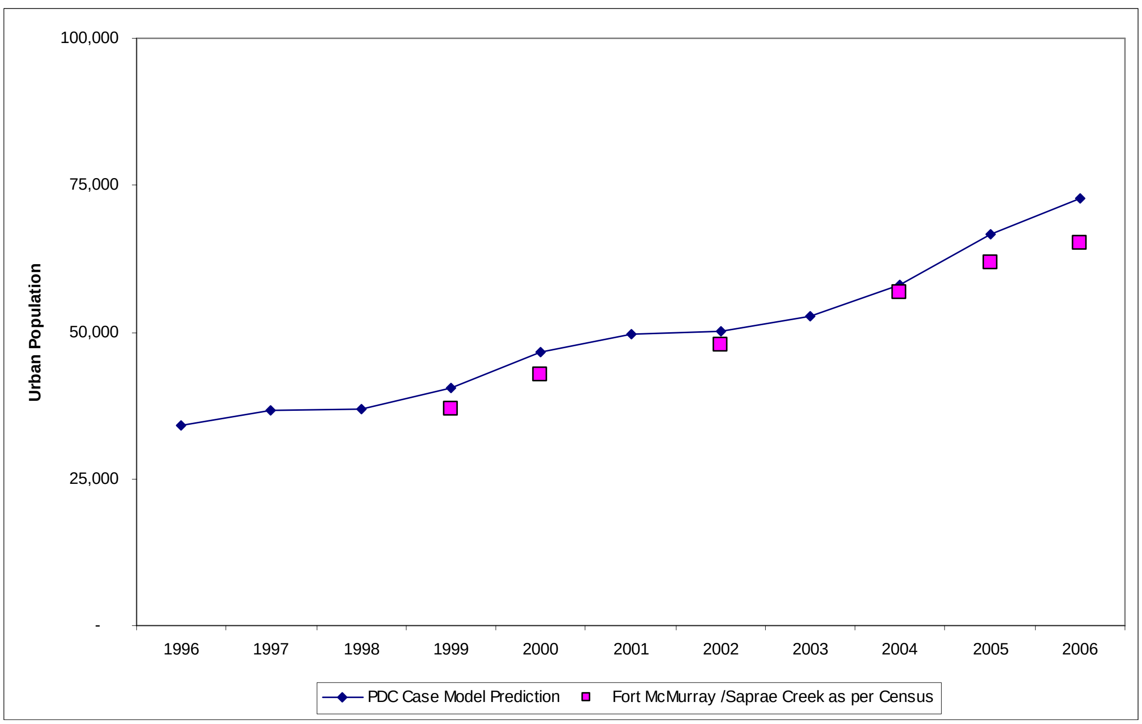
3.2 MODEL PERFORMANCE

Calibrating the Urban Population Impact Model

The output of the Urban Population Impact Model is tested against actual population counts when they become available. As discussed in Section 2 and following the practice of Alberta Municipal Affairs and Housing Official Population List, the Urban Population Impact Model uses the municipal census counts for calibration purposes.

Figure 2 shows the forecasted urban population of the region and the actual population as measured by the municipal census in various years. Figure 2 indicates that the model, as configured in 1997 and periodically updated to reflect new projects, yields population estimates that are very close to the population numbers as actually counted as part of the 1999, 2000, 2002 and 2004 Municipal Census. The Urban Population Impact Model forecasts were marginally high relative to the 2005 and 2006 Municipal Census results.

Figure 2 Model Performance



In early November 2007 when this report was prepared, the 2007 Municipal Census results were not yet available. In light of the marginally high forecast for both 2005 and 2006, the Urban Population Model may require some adjustment to the model if the 2007 count indicates a year-over-year growth rate than experienced in recent years.

The model performance was also tested against the number of school-aged children in the urban population. The model has consistently over-estimated the number of children relative to the actual school enrolments, suggesting that in-migrants are younger and have fewer children than assumed in the model.

Model Forecast

The Urban population impact model forecasts that the urban population of Wood Buffalo may reach 101,000 in 2009, 116,600 in 2015 and 125,500 in 2020. This forecast implies an average annual growth rate of 7% over the five year period starting in 2007. It uses the Planned Development Case (PDC) assumptions, noting that additional projects may come forward and that some projects in the PDC may be delayed or cancelled for a variety of reasons.

3.3 SIMPLE EXTRAPOLATIONS

The historical evidence provides an indication of the population growth that may be expected over the next years, considering that:

- oil sands industry expansion is expected to continue into the second decade of this century; and
- investment levels are expected to be at least as high, but likely higher than experienced since 1996.

The RMWB Planning Department has developed a number of growth scenarios based on growth patterns experienced in recent years. These scenarios consist of population projections based on 6%, 9% and 12% average annual growth. The 9% scenario is in line, but marginally higher than the average historical (1999 – 2006) growth rate of the total RWMB as shown in Table 1. The information in that table also indicates that the 9% growth rate is about 1.2 percentage points higher than the average growth rate of the population of Fort McMurray (excluding hotels and campgrounds) in the 1999 to 2006 period. Table 2 presents the 9% growth scenario and shows that the urban area reaches almost 100,000 people by 2011.

Table 2 Regional Municipality of Wood Buffalo – 9% Growth Scenario

Year	Urban Area	RMWB Excluding Camps	RMWB Including Camps
2006 (actual)	64,441	69,368	79,810
2007	70,241	75,611	86,993
2008	76,562	82,416	94,822
2009	83,453	89,834	103,356
2010	90,964	97,919	112,658
2011	99,150	106,731	122,798

Source: Gordon, 2006.

An extrapolation model is the most appropriate for those future years in which oil sands industry investment is of a similar order-of-magnitude as experienced over the years that were used to establish the trend. However, it should be used with caution in future years, because:

- the compounding effect suggests increasingly large population increases; and
- the historical evidence of no population growth in the 1985 to 1995 period suggests no or at best limited population growth when oil sands industry investment is limited.

The extrapolation model can act as a corroboration of the Urban Population Impact Model in the near-term when continued oil sands investment is highly likely. However for the period beyond 2012, when levels of oil sands industry investment is subject to much uncertainty, extrapolating from recent past experience yield different results than the urban impact model.

Comparing the results of the 9% growth scenario with those generated by the Urban Population Impact Model is complicated by the fact that the RMWB 9% growth scenario presents an estimate of population in May of each year, as it uses the municipal census results as its basis. The Urban Population Impact Model presents a December 31 estimate, suggesting that the most appropriate comparison is between the 2012 estimate using the RMWB 9% scenario (108,073) and the 2011 estimate using the Urban Population Impact Model (109,862). This comparison suggest that although the methodologies are very different, both the RMWB 9% scenario and the Urban Population Impact Model yield very similar five-year urban population estimates.