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SHELL CANADA ENERGY

Appendix 1: JRP SIR 5 – Determination of Pierre River Mine Project Effects

Submitted to:
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REPORT

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1.0 INTRODUCTION

1.1 Overview

Shell Canada Energy (Shell) submitted the Applications and supporting Environmental Impact Assessment (EIA) for the Jackpine Mine Expansion (JME) and Pierre River Mine (PRM) Project in December 2007. As part of the regulatory process for the PRM Application, the Joint Review Panel (JRP) provided Supplemental Information Requests (SIRs) dated October 25, 2012.

In JRP SIR 5, the JRP noted that the EIA, as amended, contains sections with assessment results combined for JME and PRM. As requested in JRP SIR 5, this appendix presents the effects of PRM in isolation from JME, on all Key Indicator Resources (KIRs) identified for the PRM where this was not previously done, along with the environmental consequences for each KIR. To provide this information, an updated assessment was completed for the following components:

- Air Quality and the Effects of Air Emissions on Human and Wildlife Health, and Ecological Receptors;
- Hydrology;
- Water Quality;
- Aquatic Health;
- Fish and Fish Habitat;
- Soils and Terrain;
- Terrestrial Vegetation, Wetlands and Forest Resources;
- Wildlife and Wildlife Habitat; and
- Biodiversity.

To provide the information requested in JRP SIR 5 in a manner consistent with the EIA, updated EIA Application Case information relevant to identified KIRs was developed. This update removes JME from the assessment and represents Shell's current plans for the PRM and the exclusion of Asphaltene Energy Recovery, as outlined in the January 18, 2012 letter to the JRP. The assessment case for PRM is referred to as the 2013 PRM Application Case throughout the SIR submission. Information on PRM is also presented in the EIA and 2008 EIA Update.

The response to JRP SIR 5 was developed with consideration of the other JRP information requests, items raised by regulators and stakeholders during the regulatory process, and commitments made previously by Shell for supporting assessment work. Accounting for these items in the assessment provides a more robust assessment and maintains consistency between this response and the other information presented in the submission. Key assessment approach updates that are included in this submission include:

- Updated Base Case and Planned Development (PDC) cases: the JRP SIRs requested, among other things, an updated EIA PDC current as of June 2012. To allow a reasonable comparison between assessment case information within this submission, EIA Base Case information was also updated with a project inclusion list current to June 2012. Detailed lists of the projects included in the updated Base Case and PDC are provided in Appendix 3.1 (Section 2.4). These updated assessment cases are referred to as the 2013 Base Case and 2013 PDC in this submission.

- Updated approach to assessing forest fire and timber harvest: A key change in approach involves use of A Landscape Cumulative Effects Simulator (ALCES®) model to simulate forest fire and forest harvest information. The EIA approach to assessing forest fire and forest harvest was a topic raised by stakeholders. Landscape simulations were conducted using the ALCES® and ALCES Mapper® computer programs. The ALCES® program was used to simulate the effects of forest fire, forest harvest, and industrial development in the Regional Study Area (RSA) over a 60-year period. The ALCES Mapper® program was used to simulate the potential spatial configuration of fire and timber harvest. The revised model of burns and cutblocks was applied to the Terrestrial Resources assessment for the Pre-Industrial Case, 2013 Base Case, 2013 PRM Application Case and 2013 PDC in this submission.

Other approach changes specific to individual technical components are discussed in their respective introductory sections within this appendix: Section 2 for Air Quality and Environmental Health, Section 3 for Aquatic Resources and Section 4 for Terrestrial Resources.

2.0 AIR QUALITY AND ENVIRONMENTAL HEALTH

2.1 Introduction and Approach

This section provides the results of the 2013 PRM Application Case assessments for Air Quality and Environmental Health to inform the effects of PRM on air quality, human health risk, wildlife health risk and air emission effects on ecological receptors. To allow the development of environmental consequence ratings for these components, 2013 Base Case information has also been included.

These assessments focus on determining changes to the chemical composition of the air and the effects of these changes in air quality and deposition to the receiving environment due to PRM in isolation. Potential short-term (acute) and long-term (chronic) health risks to people and wildlife are assessed, as well as effects on ecological receptors, including aquatic and terrestrial resources.

The approaches used for these assessments are the same as those used in the EIA with the following exceptions:

- Shell has adjusted its assumptions around mine fleet emissions used in the assessment of potential acid input given the introduction of *Regulations Amending the Off-Road Compression-Ignition Engine Emission Regulations* by the Government of Canada (2011). Emissions and predictions are discussed further in Appendix 3.2.
- The Alberta Ambient Air Quality Objectives (AAAQOs) and Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (ESLs) for some compounds such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter with a mean aerodynamic diameter of 2.5 µm or smaller ($PM_{2.5}$) have been revised (ESRD 2013; TCEQ 2013) since the EIA, as presented in Appendix 3.2.
- The Jackpine Mine Expansion portion of the air quality Local Study Area (LSA) has been removed to allow for a focused assessment on PRM.
- The Human Health Risk Assessment updated the following aspects of the assessment (Appendix 3.3):
  - description of the existing conditions, including exposure and health studies;
  - problem formulation, including changes to the final list of chemicals of potential concern and revisions to the consumption rates;
  - exposure assessment, including a re-evaluation of how the physical-chemical characteristics were used to identify the non-volatile, potentially bioaccumulative chemicals; and
  - toxicity assessment, including an update of any new health-based exposure limits.

2.2 Air Quality Assessment

2.2.1 2013 Base Case Emissions

The developments included in the 2013 Base Case compared to those included in the EIA Base Case are provided in Table 2.2-1.

Table 2.2-1 Oil Sands Activities Included in the 2013 Base Case

Oil Sands Development	EIA Base Case	2013 Base Case[(a)]	Location[(b)]	
			Distance [km]	Direction
Shell Canada Energy				
Jackpine Mine - Phase 1	Yes	Yes	34	SSE
Orion EOR Project	Yes	Yes	341	SSE
Muskeg River Mine Expansion	Yes	Updated	30	S
Baytex Energy Corporation				
Cold Lake	No	Yes	380	SSE
BlackPearl Resources Inc.				
Blackrod SAGD Pilot Project	No	Yes	223	SSW
Canadian Natural Resources Limited				
Burnt Lake Pilot Project	Yes	Yes	313	SSE
Horizon Oilsands Project	Yes	Updated	23	SSW
Kirby In-Situ Oil Sands Project (Kirby North and South)	No	Yes	246	S
Primrose East In-Situ Project	Yes	Updated	314	SSE
Primrose North In-Situ Project	Yes	Updated	301	SSE
Primrose South In-Situ Project	Yes	Updated	313	SSE
Wolf Lake In-Situ Project	Yes	Updated	320	S
Cenovus Energy				
Grand Rapids SAGD Pilot Project	No	Yes	199	SW
Cenovus FCCL Ltd.				
Christina Lake Thermal Project	Yes	Updated	221	S
Foster Creek Thermal Project	Yes	Updated	281	SSE
Narrows Lake Project	No	Yes	213	S
Connacher Oil and Gas Limited				
Algar Oil Sands Project	No	Yes	158	S
Great Divide Oil Sands Project	Yes	Updated	158	S
ConocoPhillips Canada Resource Ltd.				
Surmont Pilot and Commercial SAGD Project	Yes	Updated	151	SSE
Devon Energy Corporation				
Jackfish SAGD Project	Yes	Updated	227	S
Jackfish SAGD Project 2	No	Yes	226	S
Jackfish SAGD Project 3	No	Yes	227	S
Brion Energy Corp.				
Dover Pilot Project	No	Yes	83	WSW
MacKay River Commercial Project	No	Yes	88	SSW
E-T Energy				
Poplar Creek In-Situ Pilot	No	Yes	80	S
Grizzly Oilsands				
Algar Lake SAGD Project	No	Yes	131	S
Harvest Operations Corp.				
BlackGold Oil Sands Project	No	Yes	220	S
Husky Energy Inc.				
Caribou Lake Thermal Demonstration Project	No	Yes	293	SSE
McMullen Thermal Pilot Project	No	Yes	243	SW
Sunrise Thermal Project	Yes	Yes	44	SE

Table 2.2-1 Oil Sands Activities Included in the 2013 Base Case (continued)

Oil Sands Development	EIA Base Case	2013 Base Case[a]	Location[b]	
			Distance [km]	Direction
Tucker Thermal Project	Yes	Yes	336	S
Imperial Oil Resources Ventures Ltd.				
Cold Lake In-Situ Project	Yes	Yes	334	SSE
Kearl Oil Sands Project	Yes	Yes	33	ESE
Japan Canada Oil Sands Ltd.				
Hangingstone Pilot In-Situ Project	Yes	Updated	135	S
MEG Energy Corp.				
Christina Lake Regional Project - Pilot, Phases 2and 2B	Yes	Updated	214	SSE
Laricina Energy Ltd.				
Germain Phase 1	No	Yes	173	SW
Saleski Pilot	No	Yes	150	SSW
Nexen				
Long Lake Pilot Project	Yes	Yes	131	SSE
Long Lake Commercial Project	Yes	Yes	130	SSE
Long Lake Project Phases 1 and 2	No	Yes	141	SSE
Southern Pacific Resource Corporation				
MacKay River Project	No	Yes	83	SSW
StatoilHydro Canada Ltd.				
Kai Kos Dehseh SAGD Project – Leismer and Corner 1	No	Yes	191	S
Suncor Energy Inc.				
Dover SAGD Pilot and VAPEX Pilot	Yes	Yes	57	SSW
Firebag Enhanced Thermal Solvent (ETS) Pilot Project	Yes	Yes	56	SE
Firebag SAGD Project	Yes	Updated	54	SE
Lease 86/17, Steepbank & Millennium Mines	Yes	Updated	60	S
MacKay River In-Situ and Expansion	Yes	Updated	58	SSW
Meadow Creek In-Situ	Yes	Updated	135	S
Millennium Coker Unit (MCU)	Yes	Updated	58	S
Millennium Vacuum Unit (MVU)	Yes	Updated	58	S
North Steepbank Extension Mine and Millennium Dump 9	Yes	Updated	58	S
South Tailings Pond	Yes	Updated	74	S
Upgrader Complex	Yes	Updated	58	S
Voyageur Upgrader	Yes	Updated	62	S
Fort Hills Oil Sands Project	Yes	Updated	17	SSW
Sunshine Oil Sands Ltd.				
Harper Pilot	No	Yes	140	W
West Ells SAGD Project	No	Yes	79	WSW
Syncrude Canada Ltd.				
Aurora North Mine	Yes	Yes	26	S
Aurora South Mine	Yes	Updated	39	SSE
Mildred Lake Upgrader	Yes	Yes	54	S
Total E&P Canada Ltd.				
Joslyn North Mine Project	No	Yes	33	SSW

Table 2.2-1 Oil Sands Activities Included in the 2013 Base Case (continued)

Oil Sands Development	EIA Base Case	2013 Base Case[(a)]	Location[(b)]	
			Distance [km]	Direction
Value Creation Inc.				
Terre de Grace Pilot Project	No	Yes	32	WSW
Other Industries	Yes	Updated	–	–
Communities	Yes	Updated	–	–

(a) Updated indicates that the project emissions have been revised from the EIA Base Case.

(b) Distance and direction are relative to the Pierre River Mine plant site.

– = Not applicable.

The oil sands industrial and non-industrial source emissions used in the 2013 Base Case are summarized in Table 2.2-2. Details on the emission source parameters and emission rates for the 2013 Base Case sources are presented in Appendix 3.2, Attachment A.

Table 2.2-2 Summary of 2013 Base Case Emissions

Source	Emissions Rates[(a)]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC[(b)] [t/d]	TRS[(b)] [t/d]
Shell Jackpine Mine - Phase 1	0.33	0.33	18.33	12.29	0.87	18.14	0.14
Shell Muskeg River Mine Expansion	0.61	0.61	30.73	27.03	1.61	26.80	0.13
Shell in-situ projects	0.90	0.90	1.26	0.41	0.10	0.09	0.00
Suncor Energy Inc.	62.04	90.17	161.96	101.46	11.22	213.77	2.33
Syncrude Canada Ltd.	67.12	100.12	89.49	87.69	7.63	73.84	1.75
Canadian Natural Resources Limited	20.51	25.58	65.04	44.67	3.31	158.03	2.39
Other industries[(c)]	79.86	84.80	201.46	333.33	13.29	214.88	1.08
Gas plants	2.18	2.18	18.37	5.31	0.27	0.51	0.00
Communities	0.32	0.32	2.02	–[(d)]	–[(d)]	6.12	0.00
Total	**233.88**	**305.02**	**588.67**	**612.20**	**38.28**	**712.20**	**7.82**

(a) Emissions are expressed as tonnes per stream-day (t/sd), tonnes per calendar-day (t/cd) or tonnes per day (t/d).

(b) Emissions presented for Suncor, Canadian Natural Horizon, Imperial Oil Kearl, Syncrude Aurora South, and Total Joslyn tailings ponds represent the maximum daily emission rates and vary as discussed in Appendix 3.2.

(c) The "other industries" category includes the emissions from other oil sands developments and industrial sources.

(d) Background data were added to model predictions to represent CO and $PM_{2.5}$ emissions from the communities. Therefore, community emissions of CO and $PM_{2.5}$ were not modelled. A description of the background data used is provided in the EIA, Volume 3, Appendix 3-8, Section 2.3.

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

2.2.2 2013 PRM Application Case Emissions

The detailed assessment methods used to derive the PRM emissions used in the EIA are provided in Appendix 3.2 and in the EIA, Volume 3, Appendix 3-8, Section 2. Electricity and steam requirements of PRM will be provided by two natural gas-fired 85 MW cogeneration units and four auxiliary boilers. The use of natural gas-fired cogeneration units and auxiliary boilers represents Shell's current plans for the exclusion of Asphaltene Energy Recovery from its application,. The PRM emissions are discussed in Appendix 3.2 of this submission. A summary of PRM emissions is provided in Table 2.2-3.

Table 2.2-3 Summary of Updated Emissions From Pierre River Mine

Source	Emission Rates[(a)]					
	SO_2 [t/d]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC [t/d]	TRS [t/d]
Cogeneration	0.02	4.48	2.85	0.24	0.11	–
Auxiliary boilers	0.02	1.66	2.70	0.24	0.18	–
Heaters	0.00	0.01	0.01	0.00	0.00	–
Flaring	–	–	–	–	–	–
Mine fleet	0.01	7.31	8.02	0.21	0.87	–
Mine face fugitives	–	–	–	–	6.21	0.04
Tailings pond fugitives	–	–	–	–	9.92	0.05
Plant fugitives	–	–	–	–	0.03	0.06
Tank fugitives	–	–	–	–	0.14	–
Total	**0.06**	**13.46**	**13.58**	**0.69**	**17.46**	**0.14**

(a) Emissions are expressed as tonnes per day (t/d).

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

– = No emissions.

The oil sands industrial and non-industrial source emissions used in the 2013 PRM Application Case are summarized in Table 2.2-4. Details on the parameters and emissions from the 2013 PRM Application Case sources are presented in Appendix 3.2, Attachment A.

Table 2.2-4 2013 PRM Application Case Emissions

Source	Emissions Rates[(a)]						
	Stream-day SO_2 [t/sd]	Calendar-day SO_2 [t/cd]	NO_X [t/d]	CO [t/d]	$PM_{2.5}$ [t/d]	VOC[(b)] [t/d]	TRS[(b)] [t/d]
Shell Pierre River Mine	0.06	0.06	13.46	13.58	0.69	17.46	0.14
Shell Jackpine Mine - Phase 1	0.33	0.33	18.33	12.29	0.87	18.14	0.14
Shell Muskeg River Mine Expansion	0.61	0.61	30.73	27.03	1.61	26.80	0.13
Shell in-situ projects	0.90	0.90	1.26	0.41	0.10	0.09	0.00
Suncor Energy Inc.	62.04	90.17	161.96	101.46	11.22	213.77	2.33
Syncrude Canada Ltd.	67.12	100.12	89.49	87.69	7.63	73.84	1.75
Canadian Natural Resources Limited	20.51	25.58	65.04	44.67	3.31	158.03	2.39
Other industries	79.86	84.80	201.46	333.33	13.29	214.88	1.08
Gas plants	2.18	2.18	18.37	5.31	0.27	0.51	0.00
Communities	0.32	0.32	2.02	–[(d)]	–[(d)]	6.12	0.00
Total	**233.94**	**305.08**	**602.13**	**625.78**	**38.97**	**729.65**	**7.97**

(a) Emissions are expressed as tonnes per stream-day (t/sd), tonnes per calendar-day (t/cd) or tonnes per day (t/d).

(b) Emissions presented for Suncor, Canadian Natural Horizon, Imperial Oil Kearl, Syncrude Aurora South, and Total Joslyn tailings represent the maximum daily emission rates and vary as discussed in Appendix 3.2.

(c) The "other industries" category includes the emissions from other oil sands developments and industrial sources.

(d) Background data were added to model predictions to represent CO and $PM_{2.5}$ emissions from the communities. Therefore, community emissions of CO and $PM_{2.5}$ were not modelled. A description of the background data used is provided in the EIA, Volume 3, Appendix 3-8, Section 2.3.

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

2.2.3 Assessment Results

2.2.3.1 Ambient Air Quality

The first stage of the evaluation of impacts examined the change in air emissions, within the modelling domain, that would result from the PRM. These values are summarized in Table 2.2-5 for the key air quality parameters. The respective increases in the regional emissions as a result of the PRM are estimated to be 0.02% for SO_2, 2.3% for NO_X, 2.2% for carbon monoxide (CO), 1.8% for $PM_{2.5}$, 2.5% for Volatile Organic Compounds (VOCs) and 1.9% for Total Reduced Sulphur (TRS) compounds.

Table 2.2-5 Comparison of 2013 Base Case and 2013 PRM Application Case Emissions

Descriptions	2013 Base Case	2013 PRM Application Case	Change Due to PRM[(a)] [%]
Stream-day SO_2 emissions [t/sd]	233.88	233.94	0.02
Calendar-day SO_2 emissions [t/cd]	305.02	305.08	0.02
NO_X emissions [t/d]	588.67	602.13	2.3
CO emissions [t/d]	612.20	625.78	2.2
$PM_{2.5}$ emissions [t/d]	38.28	38.97	1.8
VOC emissions [t/d]	712.20	729.65	2.5
TRS emissions [t/d]	7.82	7.97	1.9

(a) Represents change between 2013 Base Case and 2013 PRM Application Case.

Concentrations of selected air parameters (i.e., SO_2, NO_2, CO, $PM_{2.5}$, selected VOCs including benzene, selected TRS compounds including hydrogen sulphide [H_2S], selected Polycyclic Aromatic Hydrocarbon [PAH] compounds and selected trace metals) were predicted using the CALPUFF dispersion model. The 2013 Base Case and 2013 PRM Application Case ambient predictions are detailed in Appendix 3.2. The modelling results were compared to AAAQOs, National Air Quality Objectives, Canada-Wide Standards or TCEQ ESLs, where applicable. The air quality criteria used for this assessment are presented in Appendix 3.2. Some parameters (e.g., VOCs, PAHs and trace metals) can have potential effects on the health of the people and wildlife in the region. The dispersion modelling results for these compounds have been assessed in the Human Health Risk Assessment (Section 2.3).

The Lower Athabasca Regional Plan (LARP) (Government of Alberta 2012a) includes a framework for air quality management. The Lower Athabasca Region Air Quality Management Framework (Government of Alberta 2012b) sets air quality triggers and limits for NO_2 and SO_2 with guidance for long-term decision making and management. Under this framework, ambient NO_2 and SO_2 monitoring data will be evaluated annually to determine the appropriate management response. Further discussion of the air quality triggers and limits is provided in Appendix 3.1. The need for management response is triggered by measured ambient air quality data from the monitoring stations and not by modelling results. The framework states that "*while the modelling results will not be used to determine into which ambient air quality level a given area or station falls, it will be used for investigation and planning*" (Government of Alberta 2012b).

The 2013 Base Case and 2013 PRM Application Case SO_2 maximum predictions (excluding developed areas) within the Regional Study Area (RSA) and the Local Study Area (LSA) are compared in Table 2.2-6. The comparison shows that all predictions outside developed areas are below the relevant AAAQOs. There is no change in the maximum predictions due to PRM.

Table 2.2-6 Comparison of Regional Sulphur Dioxide Predictions

Parameter[(a)(b)(c)]	2013 Base Case	2013 PRM Application Case	Change Due to PRM [%]
Local Study Area			
maximum 1-hour SO_2 (excluding developed areas) [µg/m³]	82.2	82.2	0.0
maximum 24-hour SO_2 (excluding developed areas) [µg/m³]	39.5	39.5	0.0
maximum 30-day SO_2 (excluding developed areas) [µg/m³]	11.2	11.2	0.0
annual average SO_2 (excluding developed areas) [µg/m³]	4.6	4.6	0.0
Regional Study Area excluding Local Study Area			
maximum 1-hour SO_2 (excluding developed areas) [µg/m³]	276.4	276.4	0.0
maximum 24-hour SO_2 (excluding developed areas)[µg/m³]	70.6	70.6	0.0
maximum 30-day SO_2 (excluding developed areas) [µg/m³]	15.5	15.5	0.0
annual average SO_2 (excluding developed areas) [µg/m³]	10.4	10.4	0.0
Regional Study Area			
maximum 1-hour SO_2 (excluding developed areas) [µg/m³]	276.4	276.4	0.0
maximum 24-hour SO_2 (excluding developed areas) [µg/m³]	70.6	70.6	0.0
maximum 30-day SO_2 (excluding developed areas) [µg/m³]	15.5	15.5	0.0
annual average SO_2 (excluding developed areas) [µg/m³]	10.4	10.4	0.0

(a) Maximum 1-hour predictions exclude the eight highest 1-hour predictions and the maximum 24-hour predictions exclude the first highest 24-hour prediction as per the Alberta model guidelines (AENV 2009). The eight highest 1-hour predictions were included in the 30-day and annual values.

(b) Developed areas include the PRM Development Area and existing, approved and planned open pit mines and upgrading complexes within the RSA and LSA.

(c) The 1-hour, 24-hour, 30-day and annual Alberta Ambient Air Quality Objectives are 450, 125, 30 and 20 µg/m³, respectively.

The 2013 Base Case and 2013 PRM Application Case NO_2 predictions (excluding developed areas) within the LSA and RSA are compared in Table 2.2-7. The comparison shows that the 1-hour NO_2 predictions are below the AAAQO in the LSA and RSA excluding developed areas. There is an exceedance of the annual NO_2 AAAQO in the RSA; however, it is due to existing and approved projects. The change in the annual average NO_2 prediction in the RSA due to PRM is less than 1 µg/m³.

In addition to evaluating the air quality across the region, the PRM air quality assessment evaluated the ground-level concentrations of a range of compounds (i.e., SO_2, NO_2, CO, H_2S, benzene, selected VOCs, selected TRS compounds, $PM_{2.5}$, selected PAH compounds and selected trace metals) in regional communities and receptors where prolonged exposure to PRM emissions are possible. This assessment focused on those compounds that have ambient air quality criteria that can be used to evaluate the possible effects of the air emissions from the PRM on the air quality in these communities. However, not all of the parameters have air quality guidelines and standards against which the predicted concentrations could be evaluated. In such cases, the results of the modelling analyses were evaluated in the Human Health Risk Assessment (Section 2.3).

Table 2.2-7 Comparison of Regional Nitrogen Dioxide Predictions

Parameter	2013 Base Case	2013 PRM Application Case	Change Due to PRM [%]
Local Study Area			
maximum 1-hour NO_2 (excluding developed areas)[a][b] [µg/m³]	150.9	150.9	0.1
annual average NO_2 (excluding developed areas)[a] [µg/m³]	26.2	43.3	17.1
occurrences above annual AAAQO[c][d]	0	0	0
area above annual AAAQO[c] (excluding developed areas) [ha]	0	0	0
Regional Study Area excluding Local Study Area			
maximum 1-hour NO_2 (excluding developed areas)[a][b] [µg/m³]	214.2	214.2	0.0
annual average NO_2 (excluding developed areas)[a] [µg/m³]	**51.6**	**52.4**	0.8
occurrences above annual AAAQO[c][d]	1	1	0
area above annual AAAQO[c] (excluding developed areas) [ha]	1,414	1,538	125
Regional Study Area			
maximum 1-hour NO_2 (excluding developed areas)[a][b] [µg/m³]	214.2	214.2	0.0
annual average NO_2 (excluding developed areas)[a] [µg/m³]	**51.6**	**52.4**	0.8
occurrences above annual AAAQO[c][d]	1	1	0
area above annual AAAQO[c] (excluding developed areas) [ha]	1,414	1,538	125

[a] Maximum predictions exclude the eight highest 1-hour predictions as per the Alberta model guidelines (AENV 2009). The eight highest 1-hour predictions were included in the annual values.

[b] Developed areas include the PRM development area and existing, approved and planned open pit mines and upgrading complexes within the RSA and LSA.

[c] The 1-hour and annual AAAQO are 300 and 45 µg/m³, respectively. There is no 24-hour objective.

[d] The number of occurrences is based on the concentrations outside of developed areas.

Note: Bold values indicate exceedance of the applicable AAAQO.

Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

Comparisons of SO_2 concentrations in the regional communities associated with the 2013 Base Case and 2013 PRM Application Case emissions are presented in Table 2.2-8. The predictions indicate that the PRM results in a minimal change in SO_2 concentrations in all regional communities. All predictions are within the applicable AAAQOs.

Comparisons of NO_2 concentrations in the regional communities associated with the 2013 Base Case and 2013 PRM Application Case emissions are presented in Table 2.2-9. The predictions indicate that the PRM results in a minimal change in NO_2 concentrations in all regional communities. All predictions are within the applicable AAAQOs.

Comparisons of the 2013 Base Case and 2013 PRM Application Case CO, H_2S and carbon disulphide (CS_2) predictions in the regional communities are provided in Tables 2.2-10, 2.2-11 and 2.2-12, respectively. The predictions indicate that the PRM results in a minimal change in concentrations in all regional communities. All predictions are within applicable AAAQOs.

Table 2.2-8 Comparison of Sulphur Dioxide Predictions in the Regional Communities

Community	Maximum 1-Hour SO_2[(a)(b)] [µg/m³]			Maximum 24-Hour SO_2[(a)(b)] [µg/m³]			Maximum 30-Day SO_2[(a)(b)] [µg/m³]			Peak Annual Average SO_2[(a)(b)] [µg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM	2013 Base Case	2013 PRM Application Case	Change Due to PRM	2013 Base Case	2013 PRM Application Case	Change Due to PRM	2013 Base Case	2013 PRM Application Case	Change Due to PRM
Anzac	52.8	52.8	0.0	17.3	17.3	0.0	6.3	6.3	0.0	3.9	3.9	0.0
Conklin	24.4	24.4	0.0	11.2	11.2	0.0	3.5	3.5	0.0	1.6	1.6	0.0
Fort Chipewyan	17.2	17.2	0.0	9.9	9.9	0.0	2.1	2.1	0.0	0.6	0.6	0.0
Fort McKay	86.3	86.3	0.0	24.9	24.9	0.0	8.7	8.7	0.0	5.1	5.1	0.0
Fort McMurray	50.9	50.9	0.0	18.1	18.1	0.0	6.2	6.2	0.0	3.3	3.3	0.0
Janvier/Chard (IR 194)	30.8	30.8	0.0	14.7	14.7	0.0	3.8	3.8	0.0	1.8	1.8	0.0
Clearwater (IR 175)	35.0	35.0	0.0	12.0	12.0	0.0	3.3	3.3	0.0	2.2	2.2	0.0
Namur River (IR 174A)	33.6	33.6	0.0	13.3	13.3	0.0	2.8	2.8	0.0	1.3	1.3	0.0
Poplar Point (IR 201G)	27.8	27.8	0.0	14.1	14.1	0.0	3.7	3.7	0.0	1.5	1.5	0.0
Cabin A	38.8	38.8	0.1	17.4	17.4	0.0	5.2	5.2	0.0	2.3	2.3	0.0
Cabin B	29.0	29.0	0.0	14.5	14.5	0.0	4.1	4.1	0.0	2.0	2.0	0.0
Cabin C	41.7	41.8	0.1	17.3	17.3	0.0	5.2	5.2	0.0	2.3	2.3	0.0
Cabin D	46.8	46.8	0.0	18.3	18.3	0.0	5.7	5.7	0.0	2.5	2.5	0.0
Cabin E	38.8	38.8	0.0	17.1	17.2	0.0	5.1	5.1	0.0	2.7	2.7	0.0
Cabin F	44.1	44.1	0.0	16.9	16.9	0.0	5.2	5.2	0.0	2.9	2.9	0.0
Cabin G	27.8	27.8	0.0	11.7	11.7	0.0	4.6	4.6	0.0	2.6	2.6	0.0
Cabin H	49.6	49.6	0.0	19.4	19.4	0.0	5.5	5.5	0.0	3.6	3.6	0.0
Cabin I	72.5	72.5	0.0	27.4	27.4	0.0	9.2	9.2	0.0	4.2	4.2	0.0
Cabin J	100.5	100.5	0.0	47.0	47.0	0.0	12.6	12.6	0.0	6.6	6.6	0.0
Cabin K	68.3	68.3	0.0	27.9	27.9	0.0	9.5	9.5	0.0	4.8	4.8	0.0
Cabin L	54.4	54.4	0.0	22.1	22.1	0.0	7.8	7.8	0.0	3.3	3.4	0.0
Descharme Lake, SK	16.3	16.3	0.0	6.2	6.2	0.0	1.6	1.6	0.0	1.0	1.0	0.0
La Loche, SK	17.4	17.5	0.0	8.2	8.2	0.0	3.1	3.1	0.0	1.2	1.2	0.0
Oil Sands Lodge	155.2	155.2	0.0	45.1	45.1	0.0	10.8	10.8	0.0	7.1	7.1	0.0
PTI Camp	105.3	105.3	0.0	31.9	31.9	0.0	8.2	8.2	0.0	5.2	5.2	0.0

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations and the maximum 24-hour predictions exclude the first highest 24-hour concentration, as per the Alberta model guidelines (AENV 2009). The eight highest 1-hour predictions were included in the 30-day and annual values.

(b) The 1-hour, 24-hour, 30-day and annual AAAQOs are 450, 125, 30 and 20 µg/m³, respectively.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

Table 2.2-9 Comparison of Nitrogen Dioxide Predictions in the Regional Communities

Community	Maximum 1-Hour NO_2[(a)(b)] [µg/m³]			Peak Annual Average NO_2[(a)(b)] [µg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM	2013 Base Case	2013 PRM Application Case	Change Due to PRM
Anzac	77.0	77.9	0.9	7.8	7.9	0.1
Conklin	86.1	86.1	0.0	5.2	5.2	0.0
Fort Chipewyan	67.3	69.0	1.7	3.1	3.2	0.1
Fort McKay	117.4	118.4	1.1	30.0	30.2	0.2
Fort McMurray	102.6	102.7	0.1	21.5	21.6	0.1
Janvier/Chard (IR 194)	64.5	65.1	0.6	5.4	5.4	0.0
Clearwater (IR 175)	55.9	56.0	0.0	5.4	5.5	0.1
Namur River (IR 174A)	48.1	48.3	0.2	2.6	2.7	0.1
Poplar Point (IR 201G)	56.3	56.5	0.2	6.8	7.1	0.3
Cabin A	81.2	84.0	2.7	13.8	15.0	1.2
Cabin B	73.2	73.7	0.5	11.1	11.3	0.2
Cabin C	81.1	83.9	2.8	13.9	14.7	0.7
Cabin D	89.6	89.7	0.1	15.2	16.1	1.0
Cabin E	83.8	83.8	0.0	15.2	15.6	0.4
Cabin F	84.6	84.7	0.1	16.0	16.4	0.4
Cabin G	101.9	101.9	0.0	15.0	15.2	0.2
Cabin H	105.8	105.8	0.1	18.6	18.7	0.2
Cabin I	124.0	124.0	0.0	25.2	29.6	4.4
Cabin J	165.6	165.6	0.0	34.4	35.7	1.2
Cabin K	152.1	152.2	0.0	32.2	33.0	0.8
Cabin L	110.0	110.1	0.1	20.3	24.0	3.7
Descharme Lake, SK	24.0	24.0	0.0	1.7	1.8	0.0
La Loche, SK	52.2	52.4	0.2	3.7	3.8	0.0
Oil Sands Lodge	152.2	152.3	0.1	34.9	35.1	0.2
PTI Camp	97.9	98.4	0.5	25.8	26.0	0.1

(a) Maximum 1-hour predictions exclude the eight highest 1-hour concentrations, as per the Alberta model guidelines (AENV 2009). The eight highest 1-hour predictions were included in the annual values.

(b) The 1-hour and annual AAAQOs used in the EIA are 300 and 45 µg/m³, respectively. There is no 24-hour objective.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

Table 2.2-10 Comparison of Carbon Monoxide Predictions in the Regional Communities

Community	Peak 1-Hour CO[(a)(b)] [µg/m³]			Peak 8-Hour CO[(a)(b)] [µg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM	2013 Base Case	2013 PRM Application Case	Change Due to PRM
Anzac	931.9	935.5	3.6	556.9	560.5	3.7
Conklin	387.6	387.6	0.0	203.6	203.7	0.0
Fort Chipewyan	389.0	390.7	1.6	238.2	239.5	1.3
Fort McKay	1,083.9	1,102.1	18.2	648.0	665.2	17.2
Fort McMurray	3,342.2	3,342.6	0.4	1,903.1	1,903.2	0.2
Janvier/Chard (IR 194)	442.3	444.0	1.7	268.6	270.4	1.8
Clearwater (IR 175)	232.3	232.4	0.1	123.3	123.3	0.1
Namur River (IR 174A)	101.7	105.0	3.3	94.4	97.8	3.5
Poplar Point (IR 201G)	203.6	220.9	17.3	140.8	149.8	9.0
Cabin A	293.9	336.7	42.8	229.9	275.7	45.8
Cabin B	289.2	289.6	0.4	234.9	242.9	8.0
Cabin C	373.7	381.6	7.9	291.6	305.9	14.3
Cabin D	413.7	422.0	8.3	328.9	342.9	14.0
Cabin E	362.6	362.9	0.4	295.6	297.2	1.6
Cabin F	373.5	377.0	3.5	294.2	295.3	1.1
Cabin G	573.8	576.8	3.0	402.7	404.6	1.9
Cabin H	376.7	376.7	0.1	318.0	321.6	3.6
Cabin I	521.7	521.7	0.0	317.0	328.1	11.0
Cabin J	1,112.9	1,130.8	17.9	758.0	782.3	24.3
Cabin K	1,395.9	1,404.3	8.4	771.7	792.9	21.2
Cabin L	600.5	606.0	5.6	438.5	441.6	3.1
Descharme Lake, SK	46.4	46.6	0.2	25.1	26.7	1.5
La Loche, SK	510.5	512.1	1.6	294.7	295.8	1.1
Oil Sands Lodge	923.6	943.4	19.8	630.7	639.2	8.5
PTI Camp	523.8	542.0	18.2	289.2	301.9	12.7

(a) The peak concentrations include the eight highest 1-hour predictions from the model.

(b) The 1-hour and 8-hour AAAQOs are 15,000 and 6,000 µg/m³, respectively.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

Table 2.2-11 Comparison of Hydrogen Sulphide Predictions in the Regional Communities

Community	Peak 1-Hour H_2S[a][b] [µg/m³]			Peak 24-Hour H_2S[a][b] [µg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM	2013 Base Case	2013 PRM Application Case	Change Due to PRM
Anzac	1.2	1.2	0.0	0.4	0.4	0.0
Conklin	0.1	0.1	0.0	0.0	0.0	0.0
Fort Chipewyan	0.2	0.2	0.0	0.1	0.1	0.0
Fort McKay	1.3	1.3	0.0	0.5	0.5	0.0
Fort McMurray	0.5	0.5	0.0	0.2	0.2	0.0
Janvier/Chard (IR 194)	0.2	0.2	0.0	0.1	0.1	0.0
Clearwater (IR 175)	0.3	0.3	0.0	0.1	0.1	0.0
Namur River (IR 174A)	0.5	0.5	0.0	0.1	0.1	0.0
Poplar Point (IR 201G)	0.3	0.4	0.0	0.2	0.2	0.0
Cabin A	0.8	0.9	0.2	0.4	0.5	0.1
Cabin B	0.4	0.4	0.0	0.2	0.2	0.0
Cabin C	0.7	0.7	0.0	0.4	0.4	0.0
Cabin D	0.8	0.8	0.0	0.4	0.4	0.0
Cabin E	0.6	0.6	0.0	0.3	0.3	0.0
Cabin F	0.6	0.6	0.0	0.3	0.4	0.0
Cabin G	0.8	0.8	0.0	0.3	0.3	0.0
Cabin H	1.3	1.3	0.0	0.3	0.3	0.0
Cabin I	2.0	2.0	0.0	0.5	0.6	0.0
Cabin J	5.6	5.6	0.0	0.9	0.9	0.0
Cabin K	6.9	6.9	0.0	0.9	0.9	0.0
Cabin L	2.2	3.1	0.8	0.5	1.5	1.0
Descharme Lake, SK	0.1	0.1	0.0	0.0	0.0	0.0
La Loche, SK	0.1	0.1	0.0	0.0	0.0	0.0
Oil Sands Lodge	1.3	1.3	0.0	0.6	0.6	0.0
PTI Camp	3.3	3.3	0.0	0.5	0.5	0.0

[a] The peak concentrations include the eight highest 1-hour predictions from the model.

[b] The 1-hour and 24-hour AAAQOs for Hydrogen Sulphide (H_2S) are 14 and 4 µg/m³, respectively.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

Table 2.2-12 Comparison of Carbon Disulphide Predictions in the Regional Communities

Community	Peak 1-Hour CS_2 [(a)(b)] [µg/m³]			Annual Average CS_2 [(a)] [µg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM	2013 Base Case	2013 PRM Application Case	Change Due to PRM
Anzac	0.08	0.09	0.00	0.00	0.00	0.00
Conklin	0.02	0.02	0.00	0.00	0.00	0.00
Fort Chipewyan	0.05	0.05	0.00	0.00	0.00	0.00
Fort McKay	0.65	0.69	0.03	0.04	0.04	0.00
Fort McMurray	0.20	0.20	0.00	0.01	0.01	0.00
Janvier/Chard (IR 194)	0.04	0.04	0.00	0.00	0.00	0.00
Clearwater (IR 175)	0.14	0.14	0.00	0.00	0.00	0.00
Namur River (IR 174A)	0.08	0.09	0.01	0.00	0.00	0.00
Poplar Point (IR 201G)	0.21	0.24	0.03	0.01	0.01	0.00
Cabin A	0.29	0.35	0.06	0.01	0.02	0.00
Cabin B	0.32	0.32	0.00	0.01	0.01	0.00
Cabin C	0.35	0.36	0.01	0.02	0.02	0.00
Cabin D	0.43	0.44	0.01	0.02	0.02	0.00
Cabin E	0.46	0.46	0.00	0.02	0.02	0.00
Cabin F	0.47	0.47	0.01	0.02	0.02	0.00
Cabin G	0.65	0.66	0.01	0.02	0.02	0.00
Cabin H	1.11	1.11	0.00	0.04	0.04	0.00
Cabin I	0.47	0.47	0.00	0.03	0.04	0.01
Cabin J	1.24	1.25	0.01	0.06	0.07	0.01
Cabin K	1.91	1.93	0.01	0.07	0.08	0.00
Cabin L	0.60	0.70	0.10	0.03	0.05	0.02
Descharme Lake, SK	0.02	0.03	0.00	0.00	0.00	0.00
La Loche, SK	0.03	0.04	0.00	0.00	0.00	0.00
Oil Sands Lodge	0.91	0.94	0.03	0.05	0.06	0.00
PTI Camp	0.51	0.54	0.03	0.03	0.03	0.00

(a) The peak concentrations include the eight highest 1-hour predictions from the model. The eight highest 1-hour predictions were included in the annual values.

(b) The 1-hour AAAQO for Carbon Disulphide (CS_2) is 30 µg/m³.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

A comparison of the 2013 Base Case and 2013 PRM Application Case $PM_{2.5}$ predictions in the regional communities is provided in Table 2.2-13. The predictions are above the AAAQO of 30 µg/m³ at Fort McKay, Fort McMurray, Cabin J, Cabin K and the Oil Sands Lodge. These exceedances are due to existing and approved projects in the region and there is minimal increase in predicted concentrations due to PRM. For Fort McMurray, the background $PM_{2.5}$ concentration, which accounts for the community emissions, was estimated to be above 30 µg/m³.

Table 2.2-13 Comparison of $PM_{2.5}$ Predictions in the Regional Communities

Community	Maximum 24-Hour $PM_{2.5}$[a] [µg/m³]			98th Percentile 24-Hour $PM_{2.5}$[b] [µg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM [µg/m³]	2013 Base Case	2013 PRM Application Case	Change Due to PRM [µg/m³]
Anzac	17.5	17.7	0.2	12.4	12.5	0.0
Conklin	21.6	21.9	0.3	11.4	11.5	0.0
Fort Chipewyan	13.2	13.3	0.2	9.2	9.2	0.1
Fort McKay	**32.8**	**32.9**	0.1	27.7	27.8	0.2
Fort McMurray	**73.0**	**73.1**	0.1	18.6	18.6	0.0
Janvier/Chard (IR 194)	24.3	24.6	0.3	11.1	11.1	0.0
Clearwater (IR 175)	10.0	10.3	0.3	5.3	5.3	0.0
Namur River (IR 174A)	11.7	11.8	0.1	4.9	5.1	0.2
Poplar Point (IR 201G)	7.3	7.5	0.2	6.0	6.0	0.1
Cabin A	14.4	15.5	1.1	10.2	10.6	0.5
Cabin B	10.5	10.8	0.3	7.0	7.2	0.3
Cabin C	13.3	14.0	0.7	10.0	10.3	0.3
Cabin D	14.7	16.0	1.3	11.3	11.5	0.2
Cabin E	15.5	16.3	0.8	9.8	10.0	0.3
Cabin F	17.8	18.5	0.8	10.3	10.6	0.3
Cabin G	17.7	17.9	0.2	10.4	10.5	0.1
Cabin H	12.9	12.9	0.1	12.0	12.1	0.1
Cabin I	20.3	20.4	0.1	16.3	16.5	0.3
Cabin J	**37.7**	**38.2**	0.4	25.9	26.0	0.0
Cabin K	**35.8**	**36.0**	0.2	21.6	21.9	0.3
Cabin L	23.9	24.3	0.4	16.6	18.0	1.4
Descharme Lake, SK	3.7	3.8	0.0	2.6	2.6	0.0
La Loche, SK	13.4	13.4	0.0	10.0	10.0	0.0
Oil Sands Lodge	**33.0**	**33.1**	0.0	27.7	27.9	0.2
PTI Camp	22.1	22.2	0.2	15.8	15.9	0.1

[a] The maximum 24-hour predictions exclude the first highest 24-hour concentration, as per the Alberta model guidelines (AENV 2009). The 24-hour AAAQO for $PM_{2.5}$ is 30 µg/m³.

[b] The Canada-Wide Standard for Particulate Matter ($PM_{2.5}$) is 30 µg/m³ and is based on the 98th percentile 24-hour reading annually, averaged over three years (CCME 2000).

Note: Bold values indicate exceedance of the applicable AAAQO.

Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

A comparison of the 2013 Base Case and 2013 PRM Application Case benzene predictions in the regional communities is provided in Table 2.2-14. The highest 1-hour and annual benzene predictions occur in Fort McMurray and is due primarily to estimated community benzene emissions. The change due to PRM is minimal and all modelling results are below the respective AAAQOs.

Table 2.2-14 Comparison of Benzene Predictions in the Regional Communities

Community	Maximum 1-Hour Benzene[(a)] [μg/m³]			Annual Average Benzene[(a)] [μg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM [μg/m³]	2013 Base Case	2013 PRM Application Case	Change Due to PRM [μg/m³]
Anzac	1.4	1.4	0.0	0.1	0.1	0.0
Conklin	0.4	0.4	0.0	0.0	0.0	0.0
Fort Chipewyan	2.7	2.7	0.0	0.4	0.4	0.0
Fort McKay	4.4	4.4	0.0	0.7	0.7	0.0
Fort McMurray	25.3	25.3	0.0	1.5	1.5	0.0
Janvier/Chard (IR 194)	0.3	0.3	0.0	0.0	0.0	0.0
Clearwater (IR 175)	0.8	0.8	0.0	0.1	0.1	0.0
Namur River (IR 174A)	0.5	0.5	0.0	0.0	0.0	0.0
Poplar Point (IR 201G)	0.6	0.6	0.0	0.0	0.0	0.0
Cabin A	1.4	2.4	0.9	0.1	0.1	0.1
Cabin B	1.0	1.0	0.0	0.1	0.1	0.0
Cabin C	1.6	1.6	0.0	0.1	0.1	0.0
Cabin D	1.8	1.9	0.1	0.1	0.1	0.0
Cabin E	1.4	1.4	0.0	0.1	0.1	0.0
Cabin F	1.3	1.4	0.1	0.1	0.1	0.0
Cabin G	2.1	2.1	0.0	0.1	0.1	0.0
Cabin H	1.9	1.9	0.0	0.1	0.1	0.0
Cabin I	2.7	2.7	0.0	0.2	0.2	0.0
Cabin J	21.0	21.1	0.1	1.9	1.9	0.0
Cabin K	5.4	5.4	0.0	0.3	0.3	0.0
Cabin L	2.6	2.7	0.0	0.2	0.2	0.0
Descharme Lake, SK	0.1	0.1	0.0	0.0	0.0	0.0
La Loche, SK	1.4	1.4	0.0	0.3	0.3	0.0
Oil Sands Lodge	3.8	3.8	0.0	0.4	0.4	0.0
PTI Camp	7.0	7.0	0.0	0.6	0.6	0.0

(a) The maximum 1-hour predictions exclude the first eight highest 1-hour predictions. The eight highest hours are included in the annual predictions.

(b) The 1-hour and annual AAAQOs for benzene are 30 and 3 μg/m³, respectively.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values.

The air quality assessment also includes an evaluation of selected VOCs. A comparison of the 2013 Base Case and the 2013 PRM Application Case predictions for acrolein is shown in Table 2.2-15. Acrolein is the only VOC, other than benzene, with an environmental consequence higher than negligible (Table 2.2-18). For all VOCs, PRM emissions result in a small incremental effect on predicted concentrations, and all predicted VOC concentrations are within the applicable AAAQOs and other applicable criteria. The only exception is the annual acrolein prediction at the Oil Sands Lodge which is slightly above the TCEQ ESL of 0.15 μg/m³ due to other existing and approved projects in the region.

Table 2.2-15 Comparison of Acrolein Predictions in the Regional Communities

Community	Maximum 1-Hour Acrolein[a] [µg/m³]			Annual Average Acrolein[a] [µg/m³]		
	2013 Base Case	2013 PRM Application Case	Change Due to PRM [µg/m³]	2013 Base Case	2013 PRM Application Case	Change Due to PRM [µg/m³]
Anzac	0.16	0.16	0.00	0.01	0.01	0.00
Conklin	0.19	0.19	0.00	0.01	0.01	0.00
Fort Chipewyan	0.14	0.14	0.00	0.02	0.02	0.00
Fort McKay	1.32	1.34	0.02	0.13	0.13	0.00
Fort McMurray	0.86	0.86	0.00	0.07	0.07	0.00
Janvier/Chard (IR 194)	0.07	0.07	0.00	0.01	0.01	0.00
Clearwater (IR 175)	0.25	0.25	0.00	0.01	0.01	0.00
Namur River (IR 174A)	0.17	0.19	0.01	0.01	0.01	0.00
Poplar Point (IR 201G)	0.32	0.32	0.01	0.02	0.02	0.00
Cabin A	0.63	0.68	0.06	0.04	0.04	0.00
Cabin B	0.61	0.62	0.00	0.03	0.03	0.00
Cabin C	0.78	0.79	0.01	0.04	0.04	0.00
Cabin D	0.83	0.85	0.01	0.04	0.05	0.00
Cabin E	0.87	0.87	0.00	0.04	0.05	0.00
Cabin F	0.85	0.85	0.00	0.05	0.05	0.00
Cabin G	1.17	1.18	0.01	0.06	0.06	0.00
Cabin H	0.80	0.80	0.01	0.05	0.06	0.00
Cabin I	1.14	1.15	0.02	0.08	0.09	0.01
Cabin J	2.36	2.42	0.06	0.14	0.15	0.01
Cabin K	1.99	1.99	0.01	0.12	0.13	0.00
Cabin L	1.25	1.25	0.00	0.06	0.08	0.02
Descharme Lake, SK	0.04	0.04	0.00	0.00	0.00	0.00
La Loche, SK	0.17	0.17	0.00	0.03	0.03	0.00
Oil Sands Lodge	1.83	1.83	0.00	**0.16**	**0.16**	0.00
PTI Camp	0.95	0.97	0.02	0.07	0.07	0.00

(a) The maximum 1-hour predictions exclude the first eight highest 1-hour predictions. The eight highest hours are included in the annual predictions.

(b) The short-term (1-hour) and long-term (annual) TCEQ ESLs are 3.2 and 0.15 µg/m³, respectively.

Note: Some numbers are rounded for presentation purposes; therefore, it may appear that the differences do not equal the difference of the individual values. Bold values indicate an exceedance of the TCEQ ESL.

Residual Impact Classification for Ambient Air Quality

The impacts associated with changes in ambient air quality due to PRM have been evaluated using the assessment methods described in the EIA, Volume 3, Section 3.2. In general, the impacts have been described according to six criteria: direction, magnitude, geographic extent, duration, reversibility and frequency, as outlined in EIA, Volume 3, Section 1.3.6. The results of the impact classification for changes to the ambient air quality are presented in Table 2.2-16 (criteria compounds), Table 2.2-17 (TRS compounds), Table 2.2-18 (VOC compounds), Table 2.2-19 (PAH compounds) and Table 2.2-20 (trace metal compounds).

Table 2.2-16 Residual Impact Classification for Changes to the Ambient Air Quality (Criteria Compounds)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
local 1-hour SO_2	negative	negligible (0)	local (0)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (0)
local 24-hour SO_2	negative	negligible (0)	local (0)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (0)
local 30-day SO_2	negative	negligible (0)	local (0)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (0)
local annual SO_2	negative	negligible (0)	local (0)	long-term (+2)	reversible (-3)	high (+2)	negligible (+1)
local 1-hour NO_2	negative	negligible (0)	local (0)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (0)
local annual NO_2	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	high (+2)	low (+6)
regional 1-hour SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
regional 24-hour SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
regional 30-day SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
regional annual SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
regional 1-hour NO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
regional annual NO_2	negative	moderate (+10)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	moderate (+12)
community 1-hour SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 24-hour SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 30-day SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual SO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour NO_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual NO_2	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)

Table 2.2-16 Residual Impact Classification for Changes to the Ambient Air Quality (Criteria Compounds) (continued)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour CO	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	low (0)	negligible (0)
community 8-hour CO	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	low (0)	negligible (0)
community 24-hour $PM_{2.5}$	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	high (+16)

Note: Numerical scores for ranking of environmental consequences are explained in the EIA, Volume 3, Section 1.3.6.

Table 2.2-17 Residual Impact Classification for Changes to the Ambient Air Quality (Total Reduced Sulphur Compounds)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour H_2S	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)
community 24-hour H_2S	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)
community 1-hour COS	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual COS	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour CS_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual CS_2	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical scores for ranking of environmental consequences are explained in the EIA, Volume 3, Section 1.3.6.

Table 2.2-18 Residual Impact Classification for Changes to the Ambient Air Quality (Volatile Organic Compounds)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour 1,1,1-trichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,1,1-trichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour 1,1,2,2-tetrachloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,1,2,2-tetrachloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour 1,1,2-trichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,1,2-trichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour 1,1-dichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,1-dichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour 1,2-dichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,2-dichloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour 1,2-dichloropropane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,2-dichloropropane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour 1,3-butadiene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,3-butadiene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour 1,3-dichloropropene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual 1,3-dichloropropene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour acetaldehyde	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour acetone	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour acrolein	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)

Table 2.2-18 Residual Impact Classification for Changes to the Ambient Air Quality (Volatile Organic Compounds) (continued)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community annual acrolein	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)
community 1-hour benzene	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)
community annual benzene	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)
community 1-hour carbon tetrachloride	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual carbon tetrachloride	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour chlorobenzene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual chlorobenzene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour chloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual chloroethane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour chloroform	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual chloroform	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour cumene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour cyclohexane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual cyclohexane	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour ethylbenzene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour ethylene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual ethylene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour ethylene dibromide	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual ethylene dibromide	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Table 2.2-18 Residual Impact Classification for Changes to the Ambient Air Quality (Volatile Organic Compounds) (continued)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour formaldehyde	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour hexane group	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual hexane group	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour methanol	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour methyl ethyl ketone group	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual methyl ethyl ketone group	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour methylene chloride	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual methylene chloride	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour phenol	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour propylene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour propylene oxide	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual propylene oxide	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour styrene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour toluene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour trimethylbenzene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual trimethylbenzene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour vinyl chloride	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual vinyl chloride	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour xylenes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)

Note: Numerical scores for ranking of environmental consequences are explained in the EIA, Volume 3, Section 1.3.6.

Table 2.2-19 Residual Impact Classification for Changes to the Ambient Air Quality (Polycyclic Aromatic Hydrocarbons Compounds)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour pyrene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual pyrene	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour fluorenes/fluoranthenes and substitutes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual fluorenes/fluoranthenes and substitutes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour acenaphthenes/acenaphthylenes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual acenaphthenes/acenaphthylenes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour anthracenes/phenanthrenes and substitutes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual anthracenes/phenanthrenes and substitutes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour naphthalene and substitutes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual naphthalene and substitutes	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour biphenyls	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual biphenyls	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical scores for ranking of environmental consequences are explained in the EIA, Volume 3, Section 1.3.6.

Table 2.2-20 Residual Impact Classification for Changes to the Ambient Air Quality (Trace Metals)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community 1-hour aluminum	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual aluminum	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour antimony	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual antimony	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour arsenic	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual arsenic	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour barium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual barium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour beryllium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual beryllium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour cadmium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual cadmium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour chromium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour chromium VI	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual chromium VI	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour cobalt	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual cobalt	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour copper	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)

Table 2.2-20 Residual Impact Classification for Changes to the Ambient Air Quality (Trace Metals) (continued)

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
community annual copper	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour lead	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community 1-hour manganese	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual manganese	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour mercury	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual mercury	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour molybdenum	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual molybdenum	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour nickel	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual nickel	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour selenium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual selenium	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour silver	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual silver	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
community 1-hour tin	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+1)
community annual tin	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical scores for ranking of environmental consequences are explained in the EIA, Volume 3, Section 1.3.6.

By consolidating the impact measurements listed in Tables 2.2-16 to 2.2-20, it is possible to determine an overall rating of the "environmental consequence" for each of the ambient air quality parameters evaluated. Of the 130 ambient air quality parameters assessed, 120 are rated as having a "negligible" environmental consequence and eight are rated as having a "low" environmental consequence. One parameter (regional annual NO_2) was rated as moderate because the change due to the PRM was greater than 1% of the annual AAAQO of 45 µg/m³, and the maximum prediction in the RSA was higher than the annual AAAQO but lower than the National Ambient Air Quality Standard of 60 µg/m³. The maximum annual NO_2 prediction in the RSA is due to other existing and approved projects. One parameter (community 24-hour $PM_{2.5}$) was rated as high because the change due to PRM was higher than 1% of the AAAQO of 30 µg/m³ at Cabin J, and the maximum 24-hour $PM_{2.5}$ prediction at Fort McKay, Fort McMurray, Cabin J, Cabin K and the Oil Sands Lodge were higher than the AAAQO. These exceedances are due to existing and approved projects in the region and there is minimal increase in predicted concentrations due to PRM.

2.2.3.2 Acid-Forming Compounds

The deposition of sulphur and nitrogen (N) compounds can result in long-term accumulations that have been associated with the acidification of terrestrial and aquatic ecosystems. For this reason, the effects of potential emissions of NO_X and SO_2 from PRM on acid deposition in the region have been examined. The preferred assessment method for evaluating acid deposition is to determine the Potential Acid Input (PAI). This takes into account the acidification effect of sulphur and N species as well as the neutralizing effect of available base cations. The evaluation of acid-forming compounds from PRM was accomplished by predicting the regional PAI using the CALPUFF dispersion model. The evaluation of impacts that could result from acid-forming emissions is undertaken in the Air Emissions Effects on Ecological Receptors section (Section 2.5).

The assessment of PAI requires a review of the emissions of acid-forming compounds such as SO_2 and NO_X. In this assessment, as for the EIA, the PAI assessment assumes a phasing in of more stringent NO_X emission standards for mine fleets (i.e., aligning with the United States Environmental Protection Agency [U.S. EPA] Tier requirements; Government of Canada 2011) and the use of diesel fuel with sulphur content of 15 ppm or lower. The use of Tier 4 emission standards is done to provide a more realistic assessment of PAI. Because the Tier 4 emission profile has been modified for this assessment, a detailed discussion on this profile is provided in Appendix 3.2.

A summary of 2013 Base Case and 2013 PRM Application Case acid precursor emissions (i.e., SO_2 and NO_X) is provided in Table 2.2-21. The emission totals are slightly different than those shown in Tables 2.2-2 and 2.2-4 because the regional mine fleet emissions in the PAI assessment have been adjusted to reflect Tier 4 and ultra low sulphur diesel standards.

Table 2.2-21 Comparison of 2013 Base Case and 2013 PRM Application Case Acid Precursor Emissions

Parameter	2013 Base Case	2013 PRM Application Case	Change Due to Project[(a)] [%]
SO_2 emissions [t/cd][(b)]	301.29	301.34	0.02
NO_X emissions [t/d][(b)]	484.25	497.71	2.8
acid-forming compounds [t/d][(c)]	785.54	799.06	1.7

(a) Represents change between 2013 Base Case and 2013 PRM Application Case.

(b) Mine fleet NO_X emission rates based on Tier 4 emission standards (Government of Canada 2011). Mine fleet SO_2 emission rates based on 15 mg/kg diesel fuel sulphur content.

(c) Acid-forming compounds were calculated as the sum of the SO_2 and NO_X emissions.

The Alberta Acid Deposition Management Framework for managing acid deposition in Alberta delineates deposition management units into grid cells that are 1° by 1° in size (AENV 2008). A comparison of the 2013 Base Case and 2013 PRM Application Case predictions of PAI for the 20 – 1° by 1° grid cells that fall within the air modelling domain is presented in Table 2.2-22. The CALPUFF modelling results were combined with background PAI values discussed in detail in the EIA, Volume 3, Appendix 3-8, Section 2.3. The 2013 Base Case and 2013 PRM Application Case PAI predictions are provided in Appendix 3.2. Of the 20 grid cells listed, two are predicted to have PAI values in excess of the 0.25 keq/ha/yr critical load for sensitive ecosystems in both the 2013 Base Case and 2013 PRM Application Case. The exceedances are due to existing and approved projects in the region and the change due to the PRM is minimal.

Multi-stakeholder concerns regarding potential acidification in the region have led to the development of a specific acid deposition management framework (CEMA 2004) that is discussed in the Air Emissions Effects on Ecological Receptors assessment (Section 2.5). One aspect of this Cumulative Environmental Management Association (CEMA) framework is the ongoing research to develop more realistic predictions of acid deposition in the region. This ongoing research is intended to confirm whether the acid deposition levels predicted are realistic. If these predictions are realistic, it is likely that management activities will occur that will prevent acid deposition from reaching the 2013 Base Case levels presented in Table 2.2-22. These predictions are likely conservative because they assume that all projects in the region are operating continuously at maximum capacity. The PRM is located in grid cells 57°×112° and 58°×112°.

Table 2.2-22 Comparison of 2013 Base Case and 2013 PRM Application Case Potential Acid Input Predictions for 1° by 1° Grid Cells

Grid Cell Centre[a]	2013 Base Case PAI [keq/ha/yr]	2013 PRM Application Case PAI [keq/ha/yr]	Change Due to Project[b] [keq/ha/yr]
58°×113°	0.069	0.069	0.001
58°×112°	0.091	0.098	0.006
58°×111°	0.105	0.108	0.003
58°×110°	0.066	0.067	0.001
58°×109°	0.055	0.055	0.000
57°×113°	0.098	0.099	0.001
57°×112°	**0.273**	**0.282**	0.009
57°×111°	**0.302**	**0.305**	0.003
57°×110°	0.123	0.124	0.001
57°×109°	0.088	0.089	0.001
56°×113°	0.111	0.111	0.000
56°×112°	0.126	0.126	0.000
56°×111°	0.192	0.193	0.001
56°×110°	0.149	0.150	0.001
56°×109°	0.113	0.114	0.000
55°×113°	0.133	0.134	0.000
55°×112°	0.133	0.133	0.000
55°×111°	0.170	0.170	0.000
55°×110°	0.157	0.157	0.000
55°×109°	0.108	0.109	0.000

(a) The 1° by 1° grid cells are centred on the listed latitude and longitude.

(b) Although the modelling predictions in the above table have been rounded for presentation purposes, the changes between 2013 Base Case and 2013 PRM Application Case predictions were calculated directly from model outputs. Therefore, it is possible to show small changes without an apparent change in the listed predictions.

Note: Values in bold are at or above the Alberta Acid Deposition Management Framework critical load for sensitive ecosystems of 0.25 keq/ha/yr (AENV 2008).

Residual Impact Classification for Acid-Forming Compounds

The PRM air emissions will increase incremental acid deposition in the region despite the proposed mitigation measures outlined in the EIA, Volume 3, Section 3.2. However, potential impacts due to changing PAI levels in the region are best addressed using the management framework developed for use in the region by CEMA (2004). This framework incorporates the potential effects on waterbodies, soils and vegetation. The impact classification for PAI has been completed in the Air Emissions Effects on Ecological Receptors assessment (Section 2.5). The PAI results presented in the air assessment assume all nitrogen (N) is acidifying; however, the assessment of Air Emissions Effects on Ecological Receptors is based on the assumption that a portion of the N deposited is not acidifying. Details on this assessment method are provided in the EIA, Volume 3, Section 5.5.

2.2.4 Summary of Results

Of the 130 ambient air quality parameters assessed in the 2013 PRM Application Case, 120 were classified as negligible and eight were classified as having a low environmental consequence. The regional annual NO_2 prediction was rated as moderate and the community 24-hour $PM_{2.5}$ prediction was rated as high at Cabin J. The PRM emissions have little to no incremental effect on air quality at the regional community receptors, and there are no predicted occurrences above the AAAQOs or other applicable criteria for SO_2, CO, H_2S, CS_2, select VOCs, select PAHs and metals. The annual NO_2 prediction in the RSA is above the AAAQO of 45 µg/m³, and the $PM_{2.5}$ predictions are above the AAAQO of 30 µg/m³ at Fort McKay, Fort McMurray, Cabin J, Cabin K and the Oil Sands Lodge. However, these exceedances are mainly due to existing and approved projects in the region and there are minimal increases in predicted concentrations due to the PRM. The increase in PAI due to PRM air emissions was predicted to be minimal.

2.3 Human Health Risk Assessment

The 2013 Human Health Risk Assessment (HHRA) involved an evaluation of the potential health effects associated with the PRM.

The assessment methods used for the 2013 HHRA were consistent with those applied to the EIA HHRA, with a number of minor changes in the exposure and toxicity assessments. Over time, such changes are typical for HHRAs, although the changes specific to the PRM HHRA did not have a material impact on the assessment's original findings.

Overall, emissions from the PRM alone, and in combination with emissions from other sources, are not expected to result in adverse health effects in the area. The changes between the 2013 Base Case and 2013 PRM Application Case risks are generally small, suggesting that the PRM is not expected to contribute appreciably to health risks in the region.

The full HHRA update is presented in Appendix 3.3.

2.4 Wildlife Health Risk Assessment

The potential risks to terrestrial wildlife were re-assessed based on the exclusion of JME as part of the 2013 PRM Application Case. The full update of the Wildlife Health Risk Assessment (WHRA) is presented in Appendix 3.3, Attachment A.

The results of the WHRA indicate that the overall risks posed to wildlife health will be low. Therefore, no impacts to wildlife populations are expected based on estimated wildlife exposures to predicted maximum acute and chronic air concentrations or predicted soil and surface water concentrations. These conclusions are consistent with those presented in the EIA WHRA.

2.5 Air Emissions Effects on Ecological Receptors Assessment

The assessment of Air Emissions Effects (AEE) on ecological receptors evaluates the cumulative effects of air emissions from existing and approved projects and the PRM. The AEE assessment is based on comparisons of air emissions to provincial critical loads of deposition and air quality objectives that are specific to environmental health. The underlying assessment methods used in this report are the same as were used in the *May 2012 Submission of Information to the Joint Review Panel*. Additional supporting information used in the AEE assessment is presented in Appendix 3.2, Attachment B.

2.5.1 Assessment Results

2.5.1.1 Aquatic Resources

Lake Acidification

The lake acidification assessment involved comparing the lake net PAI for each lake to their critical loads. For detailed assessment methods refer to EIA, Appendix 3-13, Section 4.

Lake net PAI in the 2013 Base Case ranged from 0.02 to 2.11 keq H^+/ha/y within the air modelling domain, with a mean deposition of 0.19 keq H^+/ha/yr (Attachment A). Of the 414 lakes considered in the AEE assessment, the lake net PAI was greater than the critical load at 21 lakes (Figure 2.5-1; Table 2.5-1). Lakes with critical load exceedances were generally located to the south of PRM at a mean distance of 116 km. The mean critical load of the lakes with critical load exceedances was 0.01 keq H^+/ha/yr and ranged from -0.27 to 0.23 keq H+/ha/yr. In the lakes with critical load exceedances, lake net PAI exceeded the critical load by an average (mean) of 0.15 keq H+/ha/yr and lake net PAI ranged from 0.02 to 0.44 keq H+/ha/yr above the critical load. Lakes with critical load exceedances were characterized by low major ion concentrations and low alkalinities, resulting in high acid sensitivity (Saffran and Trew 1996). Although the net inflows from the catchment areas were high at the lakes with critical load exceedances (mean flux greater than 1,000,000 L/ha/yr), high dissolved organic carbon concentrations (mean = 18.7 mg/L) and low alkalinities (mean = 4.1 mg/L) resulted in low critical loads. The mean and maximum pH of the lakes with critical load exceedances was 5.5 and 6.5, respectively.

Comparisons of critical loads with lake net PAI indicate that no additional lakes were predicted to exceed critical loads as a result of PRM activities compared to the 2013 Base Case (Table 2.5-1; Figure 2.5-1). The mean change in lake net PAI from the 2013 Base Case was less than 1% and ranged from 0 to 95%. The mean critical load exceedance among all lakes with critical load exceedances in the 2013 PRM Application Case was 0.15 keq H^+/ha/yr above the critical load and ranged from 0.03 to 0.45 keq H^+/ha/yr above the critical load (Table 2.5-1). A mean change in acid input of less than 1% is unlikely to result in a measurable change in pH in lakes. Therefore, emissions of acidifying substances from the PRM are predicted to have a negligible effect on water quality and aquatic life in these lakes.

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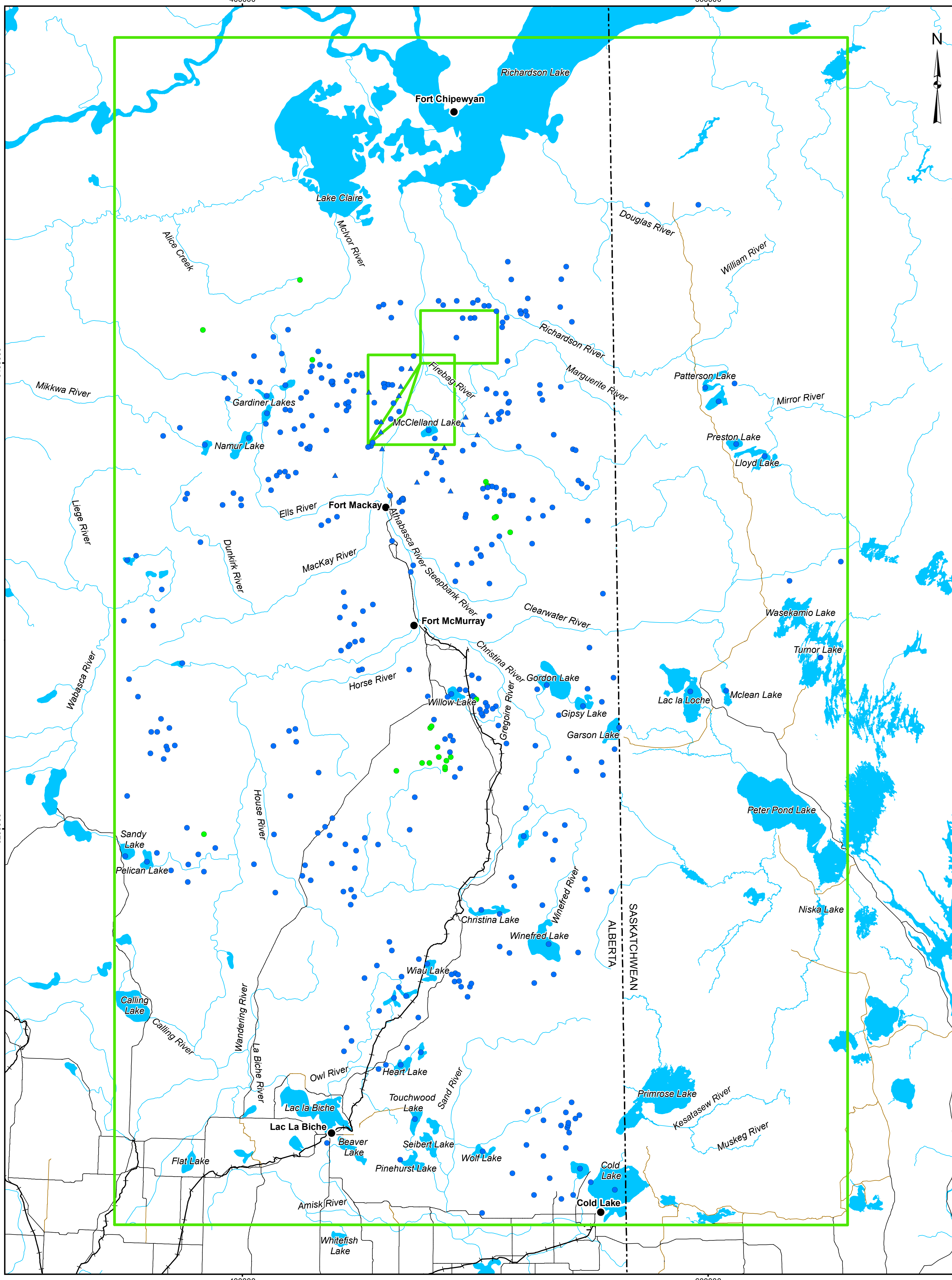


LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
- WATERCOURSE
- AIR MODELING DOMAIN
- PROVINCIAL BOUNDARY
- OPEN WATER

AQUATIC RECEPTORS AND CRITICAL LOAD EXCEEDANCES

- WATERBODY WITH NO CRITICAL LOAD EXCEEDANCE
- WATERBODY WITH CRITICAL LOAD EXCEEDANCE IN THE BASE CASE
- WATERCOURSE

50 0 50

SCALE 1:1,600,000 KILOMETRES

REFERENCE

PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC. TRANSPORTATION DATASETS OBTAINED FROM CANVEC ©

HYDROLOGY DATA OBTAINED FROM IHS ENERGY INC.

DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

WATERBODIES AND WATERCOURSES INCLUDED IN THE AIR EMISSIONS EFFECTS ASSESSMENT ON ECOLOGICAL RECEPTORS

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.	
DESIGN	BG	05 Jun 2013	SCALE AS SHOWN	REV. 0
GIS	LY	24 Oct 2013		
CHECK	CY	18 Jul 2013	**FIGURE: 2.5-1**	
REVIEW	DB	18 Jul 2013		

Table 2.5-1 Acid Input and Nitrogen Deposition Rates for Lakes with Critical Load Exceedances in the 2013 PRM Application Case

Lake Identifier[(a)]	Distance[(b)] [km]	Direction[(b)]	Gross Catchment Area [km^2]	Net Annual Inflow [L/ha/yr]	pH	Alkalinity [mg/L as $CaCO_3$]	Alkalinity [µeq/L]	Acid Sensitivity[(c)]	CL [keq H^+/ha/yr]	Lake Net PAI [keq H^+/ha/yr]		Increase in Lake Net PAI Compared to 2013 Base Case	
										2013 Base Case	2013 PRM Application Case	2013 PRM Application Case [keq H^+/ha/yr]	2013 PRM Application Case [%]
34	132	SSE	2.0	934,031	6.1	9.0	180	high	0.04	0.26	0.26	0.00	0.1
39	134	S	2.0	652,126	5.8	8.0	160	high	0.02	0.18	0.18	0.00	0.1
40	133	S	1.0	1,087,544	6.0	7.7	153	high	0.08	0.23	0.23	0.00	0.1
81	47	SE	4.3	1,174,236	6.3	5.5	110	high	0.18	0.21	0.21	0.00	0.4
82	60	SE	18	1,441,125	6.0	6.7	135	high	0.07	0.23	0.23	0.00	0.2
83	69	SE	22	1,480,408	6.4	10	203	moderate	0.19	0.21	0.21	0.00	0.2
96	91	WNW	19	744,095	5.2	2.7	53	high	-0.01	0.06	0.06	0.00	0.3
97	72	NW	13	798,008	4.3	0	0	high	-0.08	0.03	0.04	0.00	0.8
115	142	S	15	1,874,135	5.0	1.6	32	high	-0.07	0.21	0.21	0.00	0.1
116	147	S	9.0	1,207,671	4.7	0.9	19	high	-0.10	0.10	0.10	0.00	0.2
117	147	S	12	990,730	5.6	3.3	65	high	0.01	0.11	0.11	0.00	0.2
118	151	S	5.0	1,045,459	5.8	3.0	60	high	0.00	0.08	0.08	0.00	0.2
121	197	SSW	45	1,227,396	5.2	3.3	65	high	0.02	0.06	0.06	0.00	0.1
143	149	S	8.0	905,707	5.2	1.8	37	high	-0.05	0.10	0.10	0.00	0.2
144	148	S	7.0	966,871	6.5	5.3	106	high	0.03	0.08	0.08	0.00	0.2
145	152	S	3.0	1,207,760	5.9	4.1	83	high	0.02	0.09	0.09	0.00	0.2
150	60	SE	4.0	1,345,206	5.2	3.8	76	high	-0.02	0.14	0.14	0.00	0.4
178	151	S	22	1,497,922	5.2	2.1	41	high	-0.10	0.09	0.09	0.00	0.2
179	149	S	6.0	1,247,395	5.6	2.7	54	high	-0.06	0.13	0.13	0.00	0.1
464	49	SE	0.50	1,301,983	4.2	2.5	50	high	-0.27	0.17	0.17	0.00	0.4
469	44	NW	1.0	1,476,187	5.0	2.5	50	high	0.23	0.42	0.42	0.00	0.1

(a) Identifier used in Volume 3, Figure 5.5-3 of the EIA, showing lake locations.

(b) Distance and direction relative to the PRM plant site.

(c) Based on the acid sensitivity scale presented by Saffran and Trew (1996).

(d) Estimated background acid input based on measured nitrate and sulphate concentration in lakes.

Notes: CL = Critical load of acidity (critical load); PAI = potential acid input.
Grey shading indicates critical load exceedance.
Some numbers are rounded for presentation purposes; therefore, it may appear that the totals do not equal the sum of the individual values.

Episodic Acidification

Unnamed Creek 1 had the lowest alkalinity found in watercourses within 50 km of PRM (Figure 2.5-1). The alkalinity of Unnamed Creek 1 (35 mg/L or 700 µeq/L) was above the threshold value of 200 µeq/L that designates a watercourse as being acid sensitive (Boward et al. 1999) (Table 2.5-2). For the waterbodies with critical load exceedances in the 2013 Base Case, the mean and minimum predicted snowmelt pH was 3.5 and 3.1, respectively (Table 2.5-3). The mean and minimum predicted snowmelt pH among all of the waterbodies was 3.4 and 2.3, respectively (Appendix 3.5).

Under the 2013 PRM Application Case, the mean and minimum predicted snowmelt pH among waterbodies with critical load exceedances were 3.5 and 3.1, respectively (Table 2.5-3). The mean increase in acidity among lakes with critical load exceedances compared to the 2013 Base Case was 1.2 µeq H^+/L. The mean and minimum predicted snowmelt pH among all lakes in the 2013 PRM Application Case was 3.4 and 2.1, respectively (Appendix 3.5). The mean change in pH compared to the 2013 Base Case was less than 0.1 pH unit. Snowmelt pH decreased by more than 0.1 pH unit at four locations (Lakes 6, 615, 617 and 618) that were all less than 10 km from PRM. The maximum change in snowmelt pH occurred at Lake 615 (0.45 pH units) and corresponds to an increase of 5,588 µeq H^+/L in the snowmelt. The alkalinity of Lake 615 was 4,460 µeq H^+/L, so it would require less than 2 L from the lake to neutralize one litre of snowmelt.

Table 2.5-2 Alkalinity of Watercourses Within 50 km of Pierre River Mine

Station	Watershed	Alkalinity [mg/L as $CaCO_3$]	Alkalinity [µeq/L]
AB07DA0440	Muskeg River	168	3,360
AB07DA1126	Wapasu Creek	188	3,760
AB07DA1360	Calumet River	192	3,840
BC_US	Beaver Creek	95	1,900
ET1	Tributary to Firebag River	156	3,120
FR_US	Firebag River	75	1,500
IYIC-1	Iyinimin Creek	130	2,600
JC-1	Joslyn Creek	100	2,000
SHC-1	Shelley Creek	271	5,420
WQ10	Unnamed Creek 1	35	700
WQ14	Big Creek	115	2,300
WQ27	First Creek	166	3,320
WQ36	Big Creek	52	1,040
WQ49	Redclay Creek	135	2,700
WQ8	Pierre River	142	2,840

Table 2.5-3 Episodic Acidification Results for the 2013 PRM Application Case

Lake Identifier[(a)]	Potential Acid Input [keq H^+/ha/yr]		Snowmelt pH		Change in pH	Change in acidity [µeq H^+/L]
	2013 Base Case	2013 PRM Application Case	2013 Base Case	2013 PRM Application Case		
34	0.36	0.36	3.1	3.1	<0.1	-20
39	0.22	0.22	3.1	3.1	<0.1	0.48
40	0.23	0.23	3.3	3.3	<0.1	1.7
81	0.29	0.30	3.3	3.3	<0.1	8.4
82	0.23	0.23	3.5	3.5	<0.1	2.6
83	0.21	0.21	3.5	3.5	<0.1	2.6
95	0.07	0.07	3.6	3.6	<0.1	4.3
96	0.07	0.07	3.7	3.7	<0.1	1.5
97	0.07	0.07	3.7	3.7	<0.1	2.9
115	0.20	0.20	3.6	3.6	<0.1	0.84
116	0.19	0.19	3.5	3.5	<0.1	2.5
117	0.20	0.20	3.4	3.4	<0.1	2.7
118	0.16	0.16	3.5	3.5	<0.1	1.4
121	0.11	0.11	3.7	3.7	<0.1	0.074
143	0.19	0.19	3.3	3.3	<0.1	4.3
144	0.18	0.18	3.4	3.4	<0.1	2.2
145	0.19	0.19	3.5	3.5	<0.1	1.5
150	0.23	0.23	3.4	3.4	<0.1	3.6
178	0.19	0.19	3.6	3.6	<0.1	1.7
179	0.18	0.18	3.5	3.5	<0.1	2.2
437	0.09	0.09	3.9	3.9	<0.1	2.5
464	0.29	0.29	3.3	3.3	<0.1	-1.2
469	0.09	0.09	3.9	3.9	<0.1	2.7

(a) Identifier used in the EIA, Volume 3, Section 5.5.

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

Residual Impact Classification

The magnitude of the effects of PRM emissions on the acidification of lakes is predicted to be negligible (Table 2.5-4), because no additional critical load exceedances of lakes are predicted. The effects are regional in geographic extent. The effect duration is classified as long-term, corresponding to the life of the PRM. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The predicted environmental consequence of PRM on the acidification of lakes is negligible.

The magnitude of the effects of PRM emissions on episodic acidification is predicted to be negligible, because the minimum stream alkalinity (700 µeq/L) was more than double the threshold value (200 µeq/L) for designating a stream acid sensitive (Boward et al. 1999). Additionally, the lakes have sufficient alkalinity to neutralize the increase in snowmelt acidity resulting from the PRM. The effects are regional in geographic extent. The effect duration is classified as long-term, corresponding to the life of the PRM. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The predicted environmental consequence of PRM on the episodic acidification of lakes and watercourses is negligible.

Table 2.5-4 Effects Description Criteria for Lakes and Watercourses: 2013 PRM Application Case

Effect	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Chronic acidification	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
Episodic acidification	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical scores for the ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

2.5.1.2 Soil Acidification

The Terrestrial Resources Air Emissions Effects Study Area (TASA) encompassed an area of 2,012,252 ha of undisturbed soils in the 2013 Base Case. Within the TASA, 64,115 ha of soils (3%) of the undisturbed TASA had a soil net PAI above 0.17 keq H^+/ha/yr under the 2013 Base Case (Table 2.5-5; Figure 2.5-2). However, soil-series-specific critical loads were only exceeded in 9 ha (less than 0.001% of the TASA).

Based on an analysis of field data in the RSA, the TASA encompassed an area of 2,000,825 ha of undisturbed soils in the 2013 PRM Application Case. Within the TASA, 66,198 ha of soils (3% of the undisturbed TASA) had a soil net PAI greater than 0.17 keq H^+/ha/yr (Table 2.5-5; Figure 2.5-3). The area that exceeded the 0.17 keq H^+/ha/yr monitoring load increased by 2,082 ha (3%) between the 2013 Base Case and the 2013 PRM Application Case. The area of predicted soil specific critical load exceedances increased by 1 ha between the 2013 Base Case and the 2013 PRM Application Case for a total of 10 ha, or less than 0.001% of the TASA.

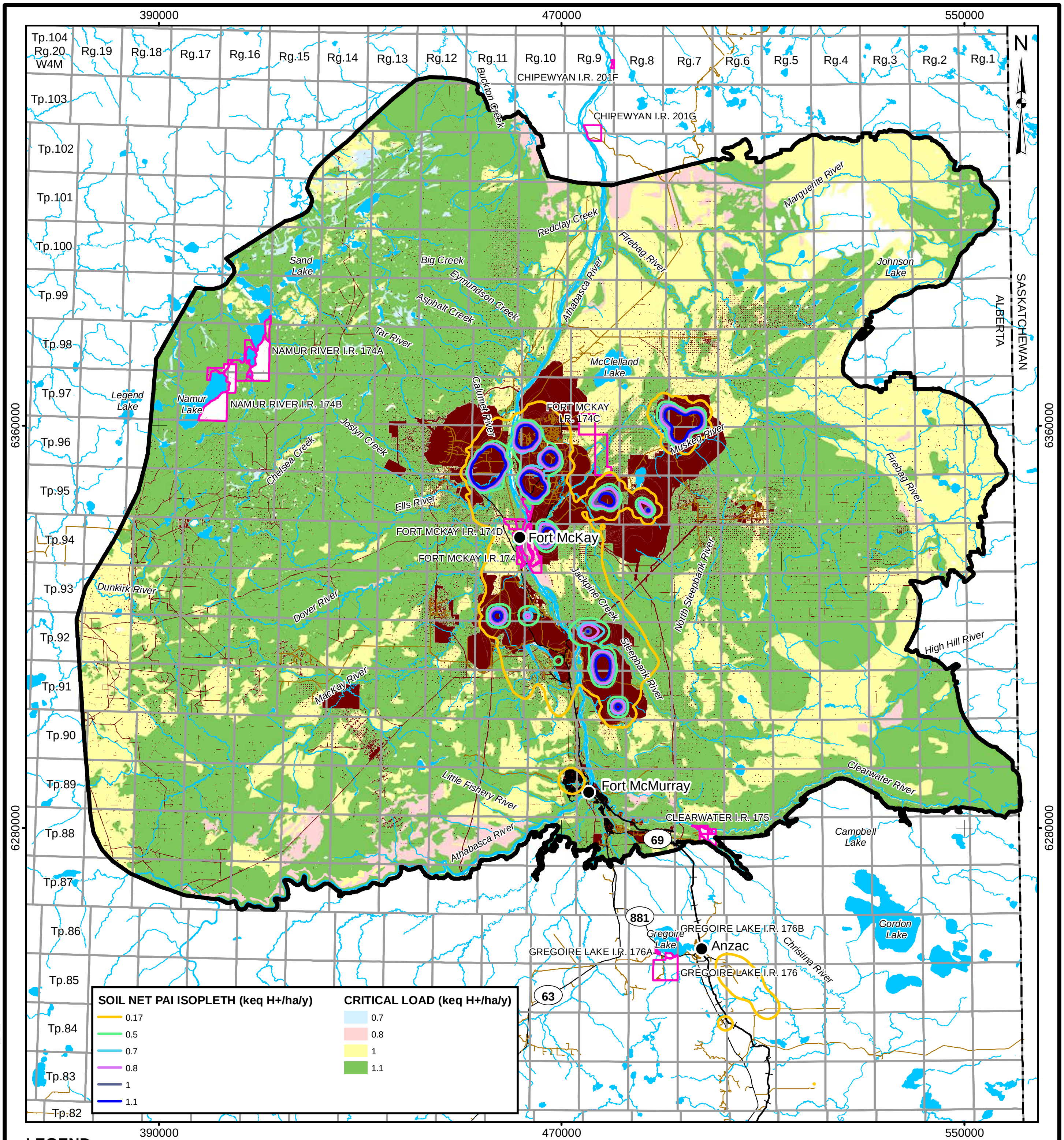
Table 2.5-5 Areas of Potential Soil Acidification in the 2013 PRM Application Case

Assessment Case	Total Area of Undisturbed Soils [ha]	Area Soil Critical Load Exceedance [ha]	Area >0.17 keq H^+/ha/yr [ha]	% TASA With Critical Load Exceedance	% TASA >0.17 keq H+/ha/yr
2013 Base Case	2,012,252	9.2	64,115	<0.001%	3%
2013 PRM Application Case	2,000,825	10	66,198	<0.001%	3%
Change	-11,426	1.0	2,082	<0.001%	0%

Notes: TASA = Terrestrial Resources Air Emissions Effects Study Area.

TASA excludes disturbed land and surface waters.

Some numbers are rounded for presentation purposes; therefore, it may appear that the values in the “Change” row do not equal the sum of the individual values.



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LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- PROVINCIAL BOUNDARY
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- OPEN WATER

DISTURBED

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

25 0 25

SCALE 1:1,100,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

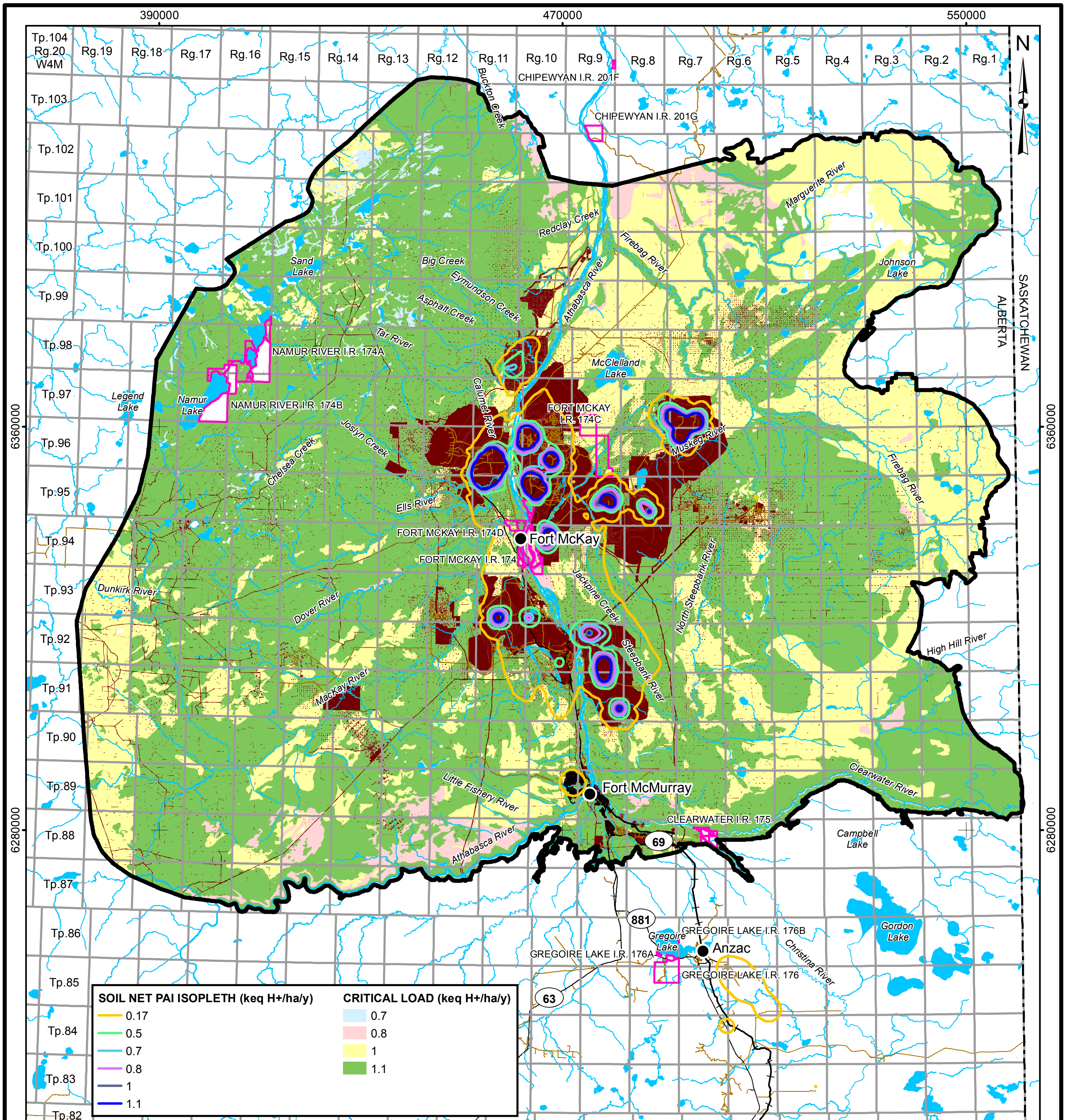
PIERRE RIVER MINE PROJECT

TITLE

POTENTIAL ACID INPUT TO SOILS IN THE TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA: 2013 BASE CASE

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.	
DESIGN	BG	25 May 2013	SCALE AS SHOWN	REV. 0
GIS	LY	18 Jul 2013	FIGURE: 2.5-2	
CHECK	CY	18 Jul 2013		
REVIEW	DB	18 Jul 2013		



LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- PROVINCIAL BOUNDARY
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- OPEN WATER

DISTURBED

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

25 0 25

SCALE 1:1,100,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

POTENTIAL ACID INPUT TO SOILS IN THE TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA: 2013 PRM APPLICATION CASE

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.
DESIGN	BG	25 May 2013	SCALE AS SHOWN REV. 0
GIS	LY	18 Jul 2013	
CHECK	CY	18 Jul 2013	FIGURE: 2.5-3
REVIEW	DB	18 Jul 2013	

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Residual Impact Classification

The magnitude of the effects of PRM emissions on the acidification of soils is predicted to be negligible (Table 2.5-6), because less than 1% of the TASA, and less than 5% of a 1° longitude by 1° latitude block, have critical load exceedances. The effect duration is classified as long-term, corresponding to the life of the PRM. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The predicted environmental consequence of PRM on the acidification of soils is negligible.

Table 2.5-6 Effects Description Criteria for Soils: 2013 PRM Application Case

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Chronic acidification of soils	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical scores for the ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

2.5.1.3 Vegetation

The vegetation assessment considers changes in the amount of total vegetated area as well as changes in woodland caribou habitat that are potentially affected by air emissions. Caribou habitat is assessed separately to assess effects on culturally important wildlife. The TASA contained 669,274 ha of woodland caribou habitat with high lichen food value in the 2013 Base Case (33% of the TASA). A total of 9.2 ha of vegetated area (less than 0.001% of the vegetated portions of the TASA) were associated with modelled soil critical load exceedances in the 2013 Base Case (Table 2.5-7; Figure 2.5-4). Burned areas dominated the potentially affected vegetation classes (61% of the total). Less than 1 ha of vegetation consisting of woodland caribou habitat (0.0001% of the vegetated TASA) was predicted to be affected by acidification in the 2013 Base Case.

Under the 2013 PRM Application Case, the TASA contained 2,000,825 ha of vegetated area and 666,959 ha (33% of the TASA) of woodland caribou habitat with high lichen food value. A total of 10 ha of vegetated area (less than 0.001% of the TASA) were in areas where the soil net PAI exceeded soil-specific critical loads (Table 2.5-7; Figure 2.5-5). The burned land class was the dominant vegetation class (65% of the total) in areas with soil-specific critical load exceedances, representing an increase of 4% from the 2013 Base Case. The exceedance area increased by 1 ha between the 2013 Base Case and the 2013 PRM Application Case, and occurred in the burn vegetation class. Less than 1 ha of woodland caribou habitat was in an area with a soil-specific critical load exceedance.

Table 2.5-7 Areas of Potential Acidification of Vegetation in the 2013 PRM Application Case

Vegetation Class	2013 Base Case		2013 PRM Application Case			
	Acid Deposition [ha]		Acid Deposition [ha]		Change from 2013 Base Case [ha]	
	>0.17	>CL	>0.17	>CL	>0.17	>CL
coniferous – jack pine	**2,026**	**0**	**2,065**	**0**	**38**	**0**
coniferous – jack pine–black spruce	**518**	**0**	**523**	**0**	**5.4**	**0**
treed bog/poor fen	**13,830**	**0.84**	**14,305**	**0.84**	**475**	**0**
subtotal	*16,375*	*0.84*	*16,893*	*0.84*	**518**	**0**
deciduous – aspen–balsam poplar	6,360	0	6,613	0	253	0
mixedwood – jack pine–aspen	**562**	**0**	**568**	**0**	**6.7**	**0**
mixedwood – aspen–white spruce	5,052	0	5,409	0	357	0
coniferous – white spruce	2,476	0	2,540	0	63	0
treed fen	14,964	0.04	15,418	0.04	454	0
subtotal	*29,413*	*0.04*	*30,547*	*0.04*	**1,134**	**0**
non–treed wetlands	6,966	0	7,160	0	194	0
cutblocks	2,042	2.7	2,152	2.7	110	0
burn	7,985	5.6	8,057	6.6	72	1.0
subtotal	*16,993*	*8.3*	*17,369*	*9.3*	**376**	**1.0**
Total Affected Area	**62,781**	**9.2**	**64,810**	**10**	**2,029**	**0.8**

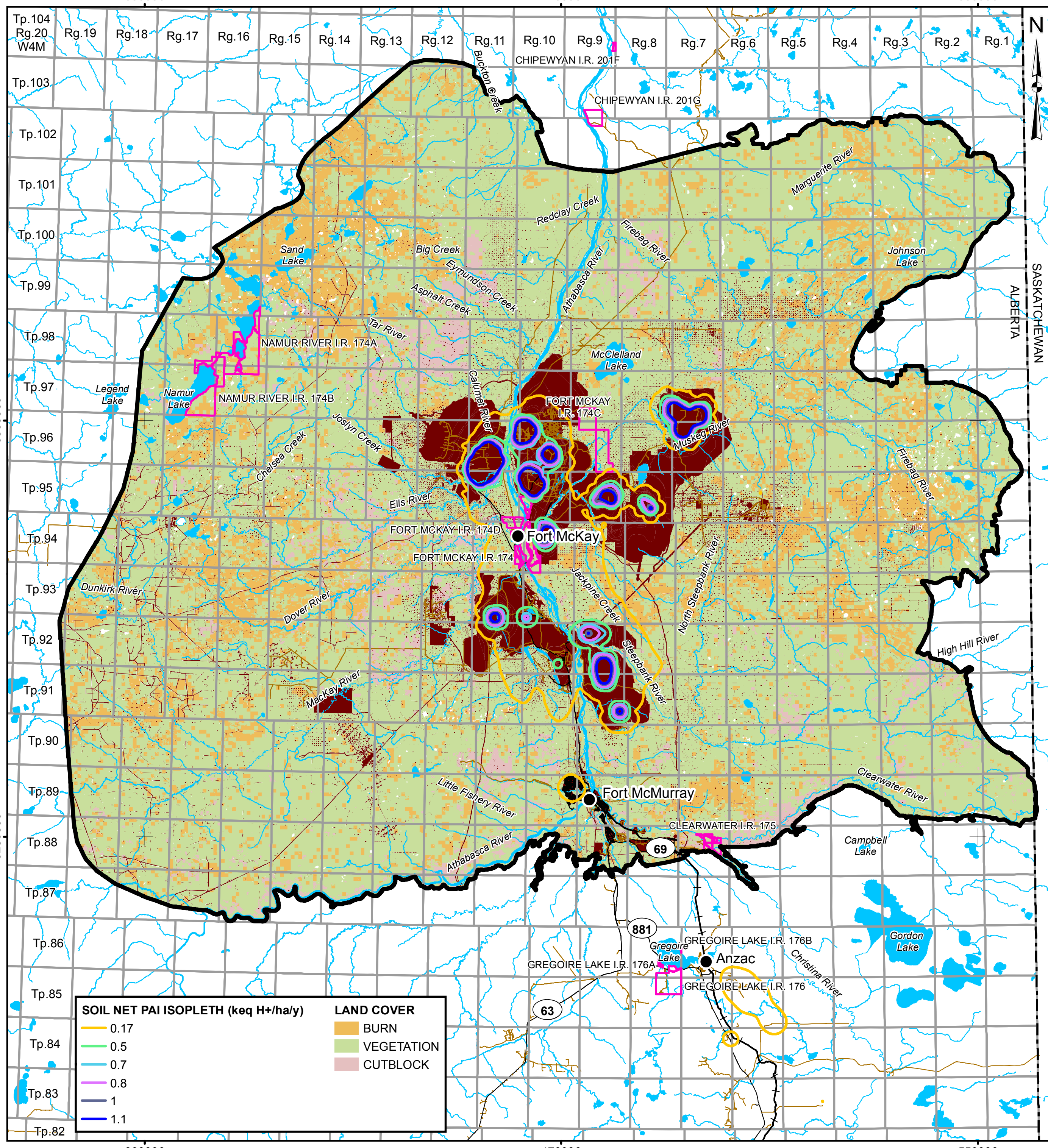
Notes: Bolding indicates vegetation associated with woodland caribou habitat (lichen).

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

>0.17 = area where soil net PAI is above 0.17 keq H^+/ha/yr.

>CL = area where soil net PAI is above soil-specific critical loads.

- = Not applicable.



LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
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- INDIAN RESERVE
- PROVINCIAL BOUNDARY
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- OPEN WATER

DISTURBED

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

25 0 25

SCALE 1:1,100,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC. DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

POTENTIAL ACID INPUT TO VEGETATION IN THE TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA: 2013 BASE CASE

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.	
DESIGN	BG	25 May 2013	SCALE AS SHOWN	REV. 0
GIS	LY	18 Jul 2013		
CHECK	CY	18 Jul 2013	FIGURE: 2.5-4	
REVIEW	DB	18 Jul 2013		

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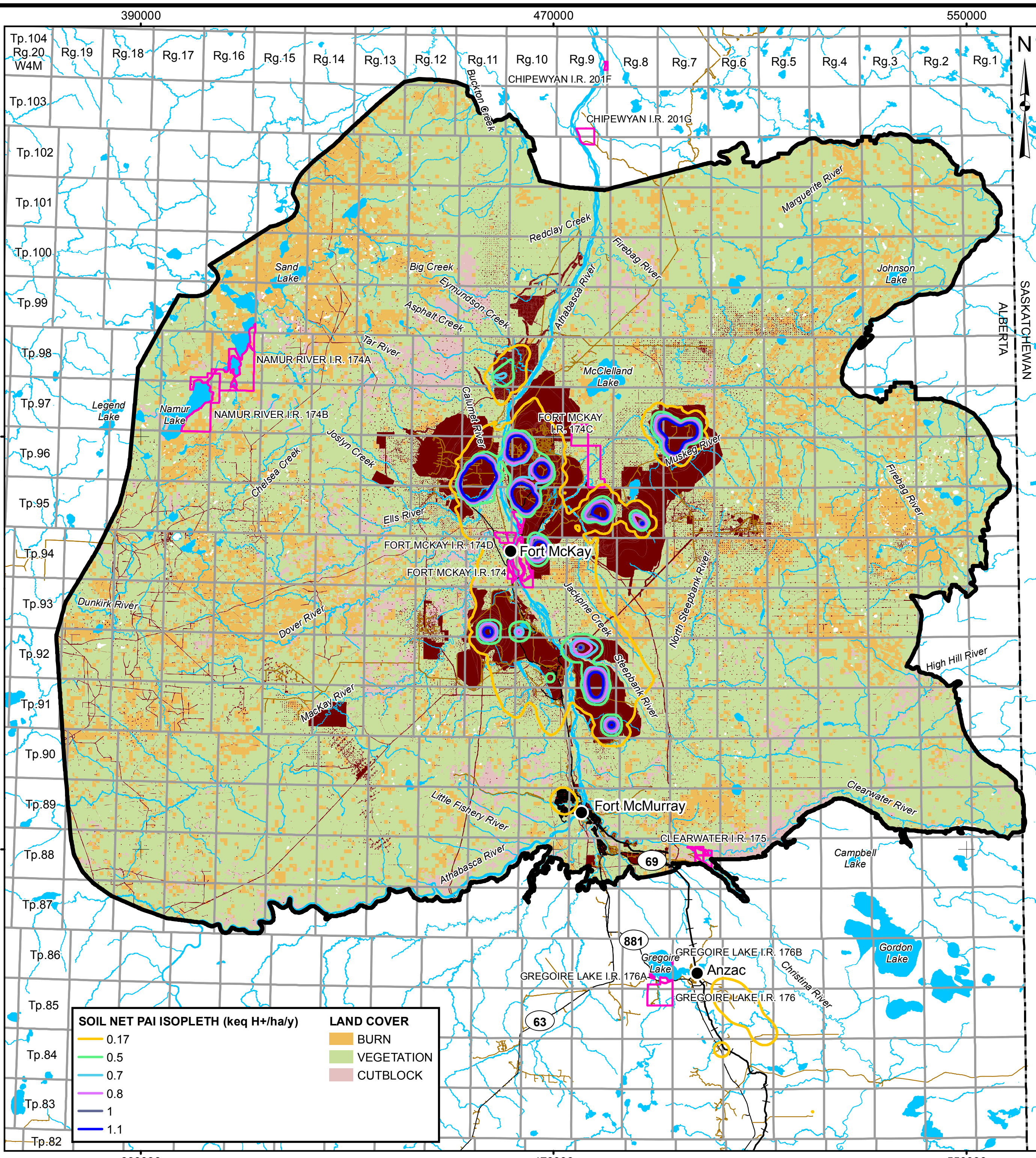

LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- PROVINCIAL BOUNDARY
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- OPEN WATER

DISTURBED

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

25 0 25

SCALE 1:1,100,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

POTENTIAL ACID INPUT TO VEGETATION IN THE TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA: 2013 PRM APPLICATION CASE

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.
DESIGN	BG	25 May 2013	SCALE AS SHOWN REV. 0
GIS	LY	18 Jul 2013	
CHECK	CY	18 Jul 2013	**FIGURE: 2.5-5**
REVIEW	DB	18 Jul 2013	

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Fumigation of Vegetation

Under the 2013 Base Case, the 20 µg/m^3 AAAQO for SO_2 (AENV 2011) was predicted to be exceeded over 32 ha of undisturbed vegetation (Table 2.5-8; Figure 2.5-6). The greatest proportion of predicted SO_2 exceedances were in the non-treed wetland vegetation class (61% of the total). The AAAQO for SO_2 was exceeded over less than 1 ha of woodland caribou habitat, which is 0.0001% of the total woodland caribou habitat in the TASA.

The amount of vegetation within the area exceeding the AAAQO between the 2013 Base Case and the 2013 PRM Application Case changed by 0.01 ha (Table 2.5-8; Figure 2.5-6). The greatest proportion of the predicted SO_2 exceedances remained in the non-treed wetlands vegetation class (61% of the total). The AAAQO for SO_2 was exceeded in less than 1 ha of woodland caribou habitat.

Under the 2013 Base Case, the 45 µg/m^3 AAAQO for NO_2 (AENV 2011) was predicted to be exceeded over an area of 2,070 ha of vegetation (0.1% of the TASA) (Table 2.5-9; Figure 2.5-7). Treed fen was the dominant vegetation class where the AAAQO was exceeded, comprising 27% of the total exceedance area. The area exceeding the AAAQO for NO_2 contained 296 ha of woodland caribou habitat, which was 0.4% of the total caribou habitat.

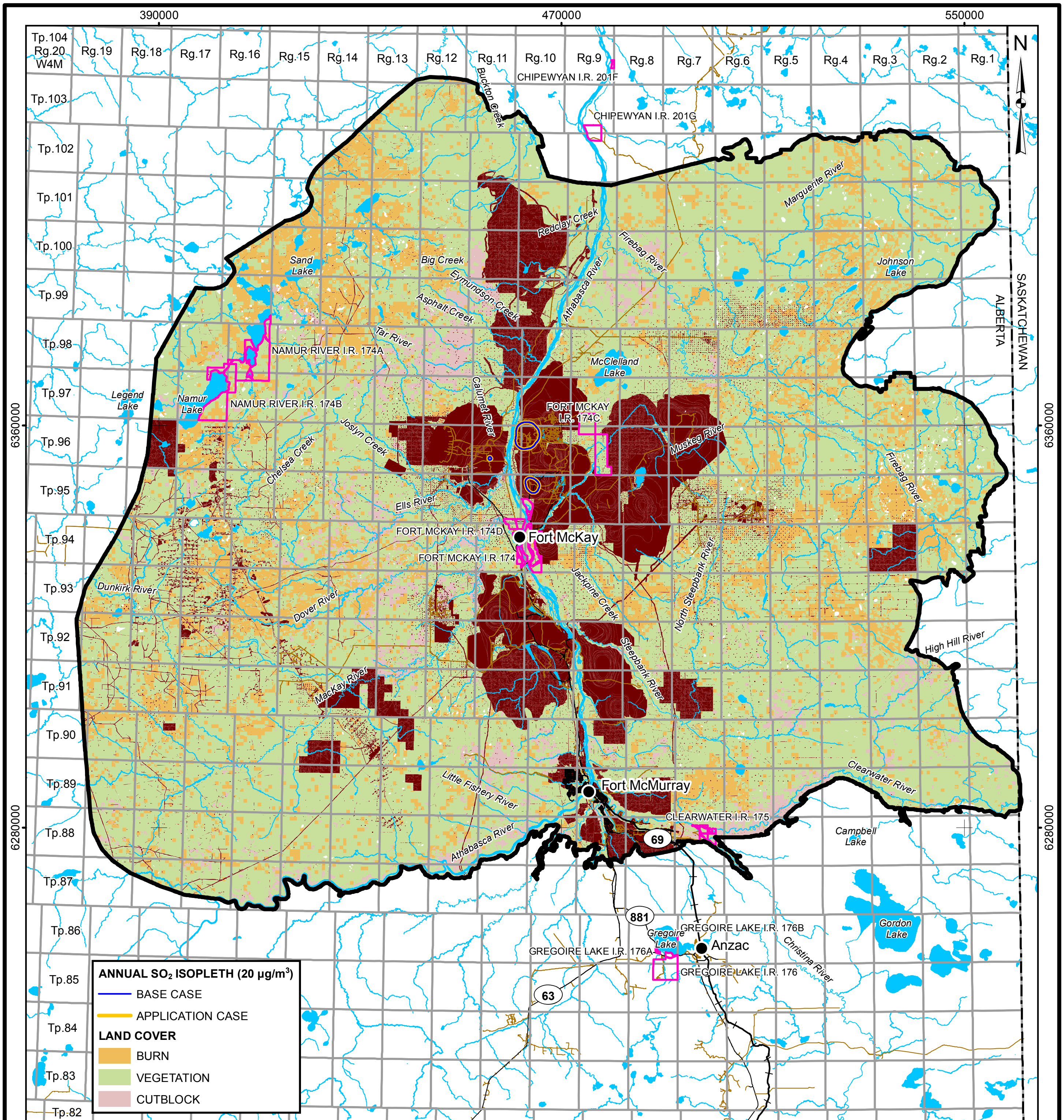
Table 2.5-8 Fumigation of Vegetation by Sulphur Dioxide in the 2013 PRM Application Case

Vegetation Class	2013 Base Case	2013 PRM Application Case	
	Exceedance Area [ha]	Exceedance Area [ha]	Change From 2013 Base Case [ha]
coniferous – jack pine	**0.84**	**0.85**	**0.01**
coniferous – jack pine–black spruce	**0**	**0**	**0**
treed bog/poor fen	**0**	**0**	**0**
subtotal	*0.84*	*0.85*	*0.01*
deciduous – aspen–balsam poplar	3.9	3.9	0.01
mixedwood – jack pine–aspen	**0**	**0**	**0**
mixedwood – aspen–white spruce	0	0	0
coniferous – white spruce	2.4	2.4	0.01
treed fen	3.4	3.4	0.01
subtotal	*9.8*	*9.8*	*0.03*
non–treed wetlands	20	20	0.02
cutblocks	1.9	1.9	0
burn	0	0	0
subtotal	*22*	*22*	*0.02*
Total Affected Area	**32**	**32**	**0.06**

Notes: Bolding indicates vegetation associated with woodland caribou habitat (lichen).

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

- = Not applicable.



LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- PROVINCIAL BOUNDARY
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- OPEN WATER

DISTURBED

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

25 0 25

SCALE 1:1,100,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

SOILS, VEGETATION AND WETLANDS RESOURCES SO_2 ISOPLETHS: 2013 BASE CASE

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.	
DESIGN	BG	25 May 2013	SCALE AS SHOWN	REV. 0
GIS	LY	18 Jul 2013		
CHECK	CY	18 Jul 2013		
REVIEW	DB	18 Jul 2013		

FIGURE: 2.5-6

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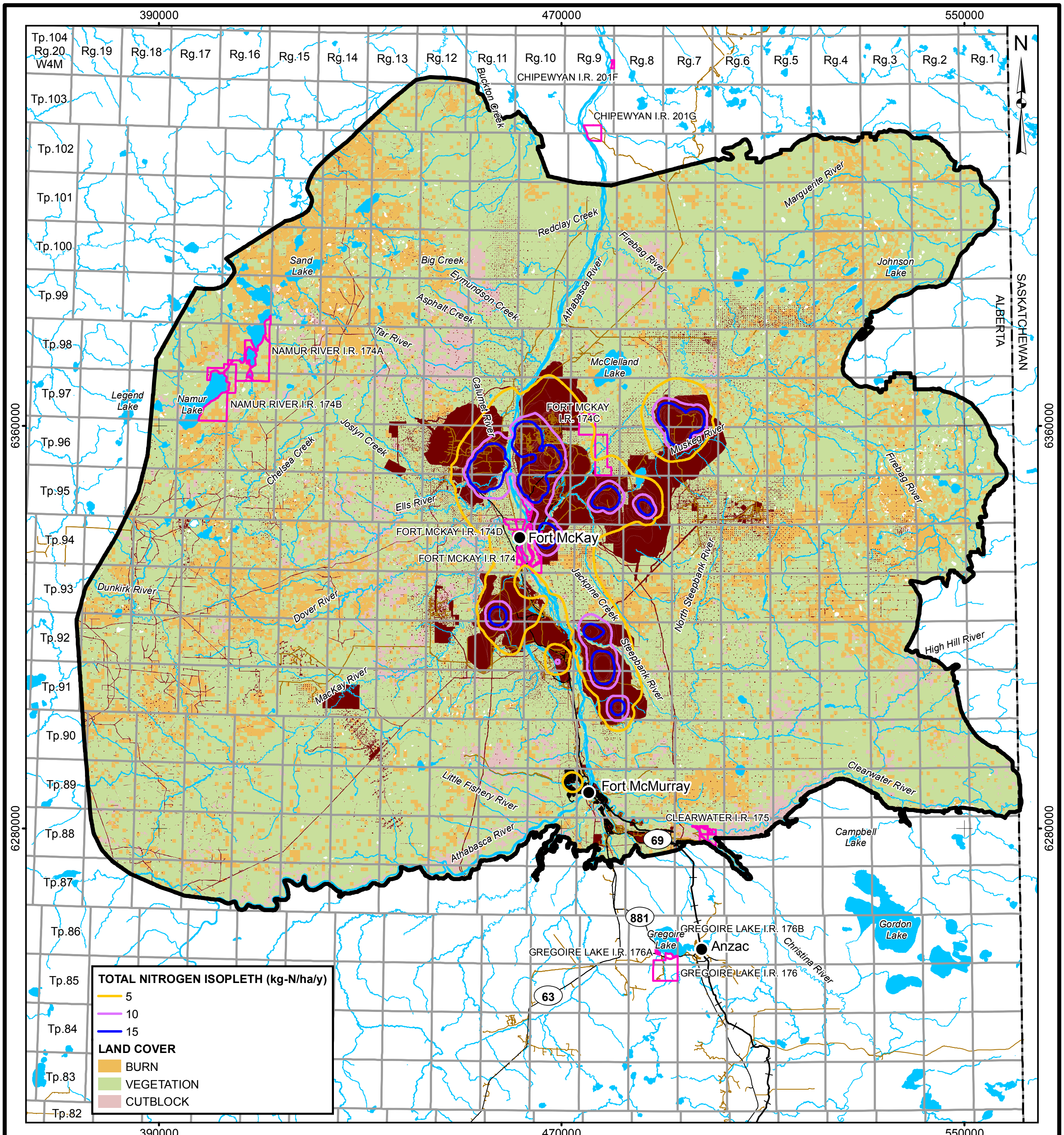

LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- PROVINCIAL BOUNDARY
- TERRESTRIAL RESOURCES REGIONAL STUDY AREA
- OPEN WATER

DISTURBED

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

25 0 25

SCALE 1:1,100,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

TOTAL NITROGEN INPUT TO VEGETATION IN THE TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA: 2013 BASE CASE

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.
DESIGN	BG	25 May 2013	SCALE AS SHOWN REV. 0
GIS	LY	18 Jul 2013	
CHECK	CY	18 Jul 2013	FIGURE: 2.5-7
REVIEW	DB	18 Jul 2013	

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Under the 2013 PRM Application Case, the 45 µg/m^3 AAAQO (AENV 2011) for NO_2 was predicted to be exceeded over 2,192 ha (0.1% of the TASA) of vegetation (Table 2.5-9; Figure 2.5-8). The area of exceedance increased by 123 ha (6%) from the 2013 Base Case. Treed fen was the dominant vegetation class within the AAAQO exceedance area and comprised 27% of the total exceedance area. The exceedance area for the NO_2 AAAQO included 305 ha of woodland caribou habitat, which is 0.05% of the total woodland caribou habitat in the TASA. The area of woodland caribou habitat with NO_2 AAAQO exceedances represents an increase of 12 ha (4%) between the 2013 Base Case and the 2013 PRM Application Case.

Table 2.5-9 Fumigation of Vegetation by Nitrogen Dioxide in the 2013 PRM Application Case

Vegetation Class	2013 Base Case	2013 PRM Application Case	
	Exceedance Area [ha]	Exceedance Area [ha]	Change From 2013 Base Case [ha]
coniferous – jack pine	**5.5**	**5.6**	**0.06**
coniferous – jack pine–black spruce	**9.7**	**10**	**0.28**
treed bog/poor fen	**278**	**289**	**12**
subtotal	*293*	*305*	12
deciduous – aspen–balsam poplar	227	265	39
mixedwood – jack pine–aspen	**3.0**	**3.0**	**0**
mixedwood – aspen–white spruce	121	122	1.2
coniferous – white spruce	135	142	6.9
treed fen	565	592	27
subtotal	*1,051*	*1,124*	74
non–treed wetlands	301	323	22
cutblocks	360	373	13
burn	66	67	1.5
subtotal	*727*	*763*	37
Total Affected Area	**2,070**	**2,192**	**123**

Notes: Bolding indicates vegetation associated with caribou habitat (lichen).

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

- = Not applicable.

Eutrophication of Vegetation

Under the 2013 Base Case, modelled total nitrogen deposition was greater than 5 kg/ha/yr in 63,605 ha of vegetated area. Nearly half of the vegetation area (47% or 29,918 ha) consisted of treed bog/poor fen or treed fen (Table 2.5-10; Figure 2.5-7). Exceedances of the 5 kg/ha/yr critical level averaged 90% of total area of critical level exceedances. Critical levels were exceeded in 17,576 ha of woodland caribou habitat (3% of total woodland caribou habitat).

Under the 2013 PRM Application Case, the critical load for total nitrogen deposition was exceeded for 72,377 ha of vegetation (4% of the TASA) of which 33,759 ha (47%) were in the treed bog/poor fen and treed fen vegetation classes (Table 2.5-10; Figure 2.5-8). The area with critical load exceedances in the 2013 PRM Application Case increased by 8,773 ha (14%) from the 2013 Base Case. Exceedances of the 5 kg/ha/yr critical load averaged 91% of the total area with total nitrogen critical load exceedances. Critical loads were exceeded in 19,724 ha of woodland caribou habitat (3% of total caribou habitat in the TASA), an increase of 2,148 ha (12%) from the 2013 Base Case.

Table 2.5-10 Eutrophication of Vegetation in the 2013 Base Case

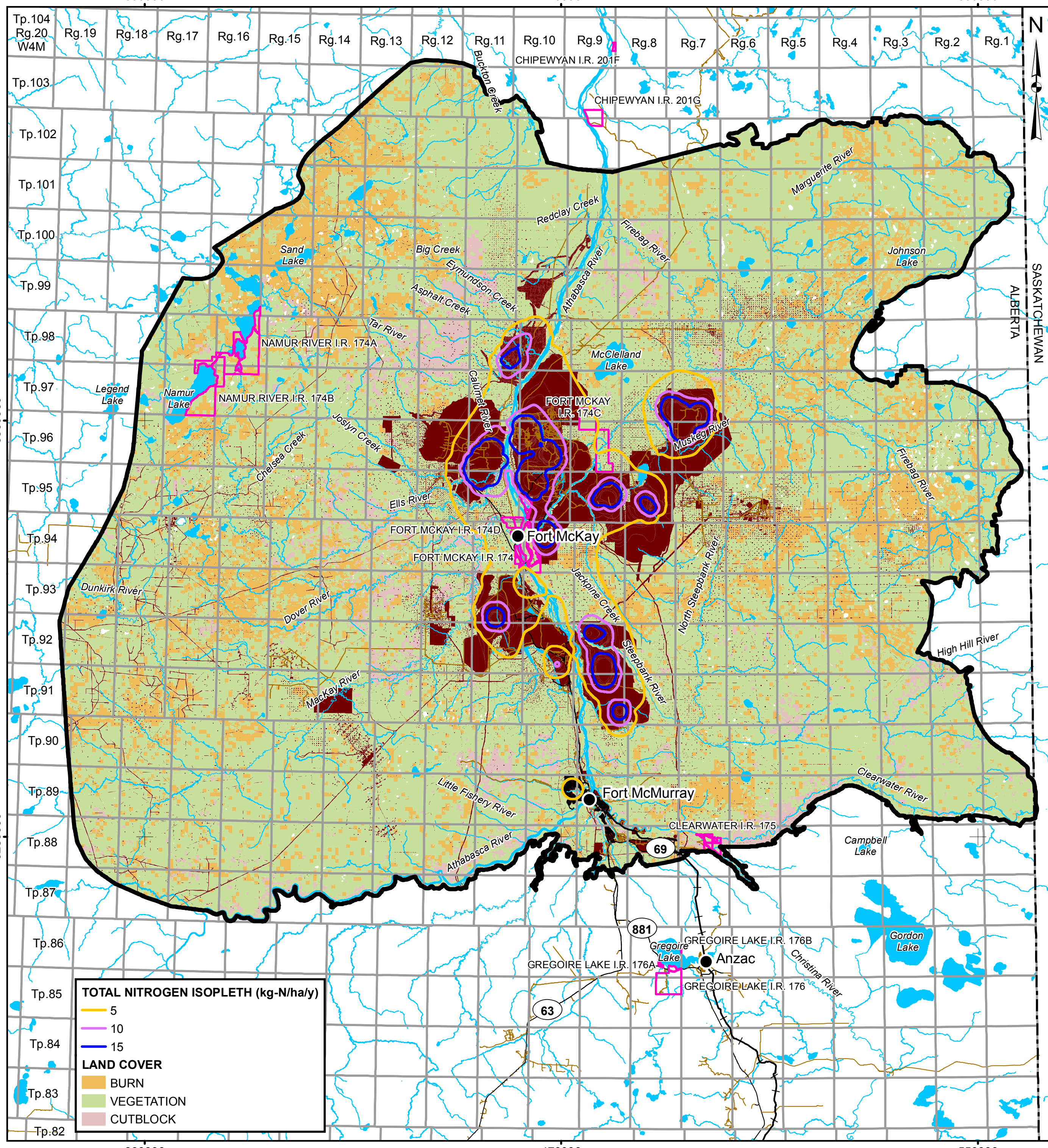
Vegetation Class	2013 Base Case				2013 PRM Application Case				
	5 kg-N/ha/yr	10 kg-N/ha/yr	15 kg-N/ha/yr	Total CL Exceedance [kg-N/ha/yr]	5 kg-N/ha/yr	10 kg-N/ha/yr	15 kg-N/ha/yr	Total CL Exceedance [kg-N/ha/yr]	Change from Total 2013 Base Case [kg-N/ha/yr]
coniferous – jack pine	**2,019**	**100**	**5.0**	**2,124**	**2,495**	**103**	**5.0**	**2,603**	**479**
coniferous – jack pine–black spruce	**224**	**15**	**0**	**240**	**234**	**15**	**0**	**249**	**9.7**
treed bog/poor fen	**13,737**	**1,075**	**93**	**14,905**	**15,271**	**1,174**	**103**	**16,547**	**1,643**
subtotal	*15,981*	*1,189*	*98*	*17,268*	*18,000*	*1,293*	*108*	*19,400*	*2,132*
deciduous – aspen–balsam poplar	5,825	555	132	6,512	6,739	601	138	7,479	967
mixedwood – jack pine–aspen	**305**	**3.0**	**0**	**308**	**321**	**3.0**	**0**	**324**	**16**
mixedwood – aspen–white spruce	4,899	309	23	5,231	5,767	390	30	6,188	957
coniferous – white spruce	2,187	192	36	2,415	2,591	207	39	2,837	421
treed fen	13,327	1,474	212	15,013	15,431	1,547	234	17,212	2,199
subtotal	*26,542*	*2,533*	*403*	*29,478*	*30,850*	*2,748*	*441*	*34,039*	*4,560*
non–treed wetlands	6,884	752	181	7,818	7,929	808	194	8,931	1,114
cutblocks	1,969	641	279	2,889	2,237	665	296	3,198	309
burn	5,897	180	75	6,152	6,546	188	75	6,809	657
subtotal	*14,750*	*1,573*	*535*	*16,859*	*16,713*	*1,660*	*565*	*18,938*	*2,080*
Total Affected Area	**57,273**	**5,296**	**1,036**	**63,605**	**65,562**	**5,701**	**1,115**	**72,377**	**8,772**

Notes: Bolding indicates vegetation associated with woodland caribou habitat (lichen).

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

CL = critical load for total nitrogen deposition.

- = Not applicable.



LEGEND

- COMMUNITY
- PAVED ROAD
- UNPAVED ROAD
- RAILWAY
- WATERCOURSE
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- PROVINCIAL BOUNDARY
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- OPEN WATER

DISTURBED

- EXISTING AND APPROVED URBAN AND INDUSTRIAL DISTURBANCE
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25 0 25

SCALE 1:1,100,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. PROVINCIAL BOUNDARY OBTAINED FROM IHS ENERGY INC.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

TOTAL NITROGEN INPUT TO VEGETATION IN THE TERRESTRIAL RESOURCES AIR EMISSIONS EFFECTS STUDY AREA: 2013 PRM APPLICATION CASE

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.
DESIGN	BG	25 May 2013	SCALE AS SHOWN REV. 0
GIS	LY	18 Jul 2013	
CHECK	CY	18 Jul 2013	**FIGURE: 2.5-8**
REVIEW	DB	18 Jul 2013	

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Residual Impact Classification

The magnitude of the effects of PRM emissions on vegetation is predicted to be negligible, because the amount of vegetation that may be affected was less than 1% of the TASA. Effect duration is classified as long-term, corresponding to the life of the PRM. The frequency of the predicted effects is classified as high (continuous) and the effects are considered reversible. The predicted environmental consequence of PRM on the acidification, fumigation and eutrophication of terrestrial vegetation is negligible (Table 2.5-11).

Table 2.5-11 Effects Description Criteria for Vegetation: 2013 PRM Application Case

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence
Acidification of vegetation	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
SO_2 fumigation	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
NO_2 fumigation	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)
Eutrophication	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)

Note: Numerical scores for the ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

2.5.2 Summary of Results

The AEE assessment evaluated the cumulative effects of air emissions from existing and approved projects and the PRM. The assessment included the chronic acidification of lakes, the episodic acidification of lakes and watercourses, the chronic acidification of soils, the chronic acidification of vegetation, the fumigation of the vegetation by NO_2 and SO_2, and the eutrophication of terrestrial vegetation by total nitrogen deposition.

Lake net PAI exceeded the critical loads of 21 lakes in the 2013 Base Case. The lakes with critical load exceedances in the 2013 Base Case had low alkalinities and were rated as acid sensitive. The effects of emissions on the acidification of lakes are predicted to be negligible, because no additional lakes had critical load exceedances in the 2013 PRM Application Case.

There was no mean change in snowmelt pH in the 2013 PRM Application Case compared to the 2013 Base Case. The effects of emissions on episodic acidification are predicted to be negligible because the minimum stream alkalinity (700 µeq/L) was more than double the threshold value (200 µeq/L) for designating a stream acid sensitive. Additionally, the lakes have sufficient alkalinity to neutralize the predicted increases in snowmelt acidity.

The area of soils that exceeded the 0.17 keq H^+/ha/yr monitoring load increased by 2,082 ha (3%) between the 2013 Base Case and the 2013 PRM Application Case. Soil-series-specific critical loads were exceeded in 9 ha in the 2013 Base Case and 10 ha in the 2013 PRM Application Case. The effects of emissions on the acidification of soils are predicted to be negligible because less than 1% of the TASA and less than 5% of a 1° longitude by 1° latitude block have predicted soil-specific critical load exceedances.

A total of 9 ha of vegetated area were associated with soil critical load exceedances in the 2013 Base Case. Less than 1 ha of vegetation consisting of woodland caribou habitat was predicted to be affected by acidification. A total of 10 ha of vegetated area were in areas where the soil net PAI exceeded soil-specific critical loads in the 2013 PRM Application Case. The exceedance area increased by 1 ha from the 2013 Base Case and less than

1 ha of woodland caribou habitat was predicted to be affected by acidification. The effects of emissions on vegetation from acidification are predicted to be negligible, because the amount of vegetation that may be affected is less than 1% of the TASA.

A total of 32 ha of undisturbed vegetation was in the area where the 20 µg/m^3 AAAQO for SO_2 concentrations was predicted to be exceeded in the 2013 Base Case and 2013 PRM Application Case, and less than 1 ha of woodland caribou habitat was in the AAAQO exceedance area. The effects of emissions on vegetation from SO_2 fumigation are predicted to be negligible, because the amount of vegetation that may be affected is less than 1% of the TASA.

The 45 µg/m^3 AAAQO for NO_2 was predicted to be exceeded in an area containing 2,070 ha of vegetation in the 2013 Base Case. The AAAQO was predicted to be exceeded in 296 ha of woodland caribou habitat. The AAAQO was predicted to be exceeded in a total of 2,192 ha of vegetation in the 2013 PRM Application Case. The area of exceedance increased by 121 ha (12 ha woodland caribou habitat) from the 2013 Base Case. The effects of emissions on vegetation from NO_2 fumigation are predicted to be negligible, because the amount of vegetation that may be affected is less than 1% of the TASA.

Modelled total nitrogen deposition was greater than 5 kg/ha/yr in 63,605 ha of vegetated area in the 2013 Base Case. Critical levels were exceeded in 17,576 ha of woodland caribou habitat in the 2013 Base Case. A total of 72,377 ha of vegetation were in the area where the critical load was exceeded for total nitrogen deposition in the 2013 PRM Application Case. The area with critical load exceedances in the 2013 PRM Application Case increased by 8,773 ha (19,724 ha woodland caribou habitat) from the 2013 Base Case. The effects of emissions on vegetation from eutrophication are predicted to be negligible, because the increase in the amount of vegetation between the 2013 Base Case and 2013 PRM Application Case is less than 1% of the TASA. The effects of emissions on woodland caribou habitat from eutrophication are predicted to be low, because the amount of woodland caribou habitat that may be affected is 3% of the total woodland caribou habitat in the TASA.

3.0 AQUATIC RESOURCES

3.1 Introduction and Approach

This section provides the results of the 2013 PRM Application Case assessments for Hydrology and Water Quality to inform the effects of PRM on human health risk and wildlife health risk. The Water Quality results have also been carried forward to an Aquatic Health assessment, as well as updates to the Fish and Fish Habitat assessment. The approaches used for these assessments are the same as those used in the EIA with the following exceptions:

- The Redclay Creek watershed has been added to the LSA to account for changes in hydrology and water quality that could occur due to the combined effects of PRM and the Teck Frontier Oil Sands Mine.
- While no appreciable water quality changes were predicted for the EIA Application Case or EIA PDC relative to the Pre-Industrial Case or EIA Base Case at Embarras, which is upstream of the Peace-Athabasca Delta (PAD), an evaluation of air quality, hydrology and water quality in the PAD was developed specifically to address issues identified by federal reviewers, and concerns expressed by potentially affected Aboriginal communities and public stakeholders. The evaluation of air quality, hydrology and water quality effects on the PAD is provided in Appendix 3.4.
- Potential impacts of aerial deposition to snowpack and snowmelt water concentrations have been raised as a potential issue in the region in recent years. Potential incremental changes to water quality resulting from aerial deposition of Polycyclic Aromatic Compounds (PACs) were evaluated using a non-steady-state, mass-balance and multi-compartment fate model to estimate the contribution of snowmelt to surface water concentrations. Similarly, a conservative mass-balance approach was developed for metals deposition. Appendix 3.5 presents this assessment and summarizes the assessment methods used to quantify the fate and transport of aerially deposited PACs and metals to the snowpack.
- Aquatic health assessments for oil sands developments have traditionally applied a combination of generic guidelines from the provincial government, the Canadian Council of Ministers of the Environment (CCME), and derivations of site-specific criteria using species sensitivity distributions. The EIA included derivations of Chronic Effects Benchmarks (CEBs), as described in Volume 4B, Appendix 4-2, Section 3. However, while these CEBs were being derived, CCME (2007) developed a refined stepwise procedure for site-specific derivations that is now preferred by regulators and provides a consistent framework for future evaluations. Appendix 3.6 presents updated CEBs that follow the approach presented in CCME (2007).

3.2 Hydrology Assessment

The Hydrology Assessment of the RSA for the EIA Application Case for the Athabasca River was presented in EIA, Volume 4A, Section 6.4.7. The approach used to assess the effects of the PRM without JME in the RSA for the Athabasca River is the same as the approach outlined in the EIA, Volume 4A, Section 6.4.2.7. A spreadsheet-based water balance approach was used to predict the potential changes in Athabasca River flow for the 2013 PRM Application Case. The rating curve developed for the Athabasca River using measured data at the Regional Aquatics Monitoring Program station S24 was used to calculate changes in water levels for the Athabasca River at Node S24.

3.2.1 Assessment Results

The potential changes in flows and water levels in the Athabasca River under average, 10-year dry and 10-year wet hydrologic conditions were evaluated using the following hydrologic parameters discussed in the EIA, Volume 4A, Section 6.4.7.3:

- mean winter season flows and water levels (i.e., December to February);
- mean spring season flows and water levels (i.e., March to May);
- mean summer season flows and water levels (i.e., June to August); and
- mean fall season flows and water levels (i.e., September to November).

A summary of current Alberta water licence allocations, return flows, and projected annual water allocations for surface water withdrawals from the Athabasca River and its tributary watercourses are provided in Table 3.2-1 for the PRM, and existing and approved projects.

Water will be obtained from the new river intake and pumping system for the PRM operation. The maximum annual river withdrawal volume of 55 million m^3 during Stage 1 (2021 to 2031) and 45 million m^3 during Stage 2 (2032 to 2042) for PRM from the Athabasca River will be required to meet the water supply requirements for PRM with a maximum instantaneous withdrawal rate of 4.17 m^3/s. (EIA, Volume 2, Section 10).

The total peak withdrawal for 2013 Base Case oil sands developments and PRM is about 27.07 m^3/s (i.e., 22.90 m^3/s for 2013 Base Case plus 4.17 m^3/s for PRM, as shown in Table 3.2-1). The reduction in mean seasonal Athabasca River flows for the 2013 PRM Application Case due to withdrawals ranges from 2.3% (i.e., i.e., reduction of about 28.1 m^3/s) in summer to 14.7% (i.e., reduction of about 26.3 m^3/s) in winter, as shown in Table 3.2-2, based on average Athabasca River weekly flows with all flows being in the Green Zone. The reduction associated with the additional water withdrawal requirement for PRM ranges from 4.2 m^3/s (i.e., about 0.34%) in summer to 2.7 m^3/s (i.e., about 1.5%) in winter.

Under 10-year dry hydrologic conditions, the percentage reduction in the seasonal flows is higher in spring, summer and fall and lower in winter compared to average year conditions. This is because a winter withdrawal limit under the Water Management Framework for the Lower Athabasca River (AENV and DFO 2007) comes into effect more often when flows are lower under dry hydrologic conditions; it is the intent of the Framework to provide a higher level of protection during the most sensitive time periods. Under the 10-year wet hydrologic conditions, the percentage reductions in the seasonal flows are lower than average year conditions for all seasons.

Predicted changes in the maximum water levels at Node S24 are provided in Table 3.2-3. The changes in the maximum water levels were calculated based on the changes in flows and the discharge-water level rating curves for Node S24. The predicted changes in water levels at Node S24 are less than 5 cm (i.e., less than 1% of the maximum flow depth).

The effects on water level changes and flooding in the PAD due to PRM in conjunction with existing and approved developments were also evaluated. Based on the assessment detailed in Appendix 3.4, the effects for the 2013 PRM Application Case on water levels and flooding in the PAD are considered negligible.

Table 3.2-1 Annual Water Allocations From Athabasca River and Tributaries

Purpose	Existing Licences and Licence Applications for Water Allocations [dam³][(a)]						Peak Instantaneous Licence Allocations [m³/s]
	Interim Licenses	WRLIC Licenses[(b)]	WALIC Licenses[(c)]	Total Withdrawals	Return Flows	Net Water Allocations	
agricultural	24	686	56	766	0	766	n/a
commercial[(d)]	4,783	145,784	3,772	154,339	123,562	30,777	n/a
dewatering	280	35,367	0	35,647	1,293	34,354	n/a
habitat enhancement	14	1,413	0	1,427	0	1,427	n/a
industrial	4,517	36,547	53,507	94,571	2,772	91,799	n/a
irrigation	37	2,773	858	3,668	1,381	2,287	n/a
municipal	7,997	32,227	2,416	42,640	34,851	7,789	n/a
water management	0	21,590	1	21,591	2,221	19,370	n/a
other use	2	125	29	156	2	154	n/a
subtotal	*17,654*	*276,512*	*60,639*	*354,805*	*166,082*	*188,723*	*n/a*
Water Licences for Oil Sands Developments:							
2013 Base Case							
Syncrude[(e)]	0	60,441	0	60,441	0	60,441	4.17
Suncor[(f)]	0	62,825	0	62,825	38,655	24,170	3.79
Shell Muskeg River Mine[(g)]	0	0	55,100	55,100	0	55,100	3.33[(k)]
Suncor Fort Hills[(h)]	0	0	39,270	39,270	0	39,270	1.67
Canadian Natural Resources Limited Horizon[(i)]	0	0	79,320	79,320	0	79,320	3.1
Shell Jackpine Mine – Phase 1[(j)]	0	0	63,500	63,500	0	63,500	0.84[(k)]
Imperial Oil Kearl[(l)]	0	0	80,000	80,000	0	80,000	4.6
Total – Joslyn Creek[(m)]	0	0	22,000	22,000	0	22,000	1.4[(n)]
subtotal	*0*	*123,266*	*339,190*	*462,456*	*38,655*	*423,801*	*22.90*
2013 PRM Application Case							
Pierre River Mine[(o)]	0	0	55,000	55,000	0	55,000	4.17[(o)]
subtotal	0	0	55,000	55,000	0	55,000	*4.17*
Total [dam³]	**17,654**	**399,778**	**454,829**	**872,261**	**204,737**	**667,524**	**27.07**

(a) 1 dam³ = 1,000 m³.

(b) Water Licenses issued before 1999 under *Water Resources Act.*

(c) Water Licenses issued after 1999 under *Water Act*.

(d) Except oil sands mines.

(e) Syncrude License letter attached to Cumulative Environmental Management Association (CEMA) Report (Golder 2005).

(f) Suncor License letter from Alberta Environment Website.

(g) Albian License letter attached to CEMA Report (Golder 2005). Daily water withdrawal is restricted to 1.8% of Athabasca River Flow at Fort McMurray.

(h) Fort Hills License letter from Alberta Environment Website.

(i) Canadian Natural Resources Ltd. License letter from Alberta Environment Website.

(j) Shell License letter from Alberta Environment Website. For Stage 2, the mean annual water requirement will be 35.3 million m³.

(k) Jackpine Mine – Phase 1, Muskeg River Mine and Jackpine Mine Expansion would share the same water intake. The combined peak instantaneous rate of 4.72 m³/s is currently approved as part of Jackpine Mine – Phase 1, *Water Act* Licence No.186157-00-00; and as part of the Muskeg River Mine Expansion, *Water Act* License No. 00071821-01-00.

(l) Based on the EIA application documents approved by ERCB.

(m) Based on the EIA application document approved by ERCB.

(n) Based on the EIA application document approved by ERCB.

(o) For Stage 2 (2032 to 2042), the mean annual water requirement will be reduced to 45 million m³.

n/a = Not applicable.

Table 3.2-2 Changes to Athabasca River Flows in Reach 4 – 2013 PRM Application Case

Hydrologic Condition	Season	Pre-Industrial Case	2013 Base Case	2013 PRM Application Case		
		Stream flow Discharge	Stream flow Discharge	Stream flow Discharge	Change Due to Pierre River Mine	Change from Pre-Industrial Case
		[m^3/s]	[m^3/s]	[m^3/s]	[m^3/s]	[m^3/s]
Average Year	Winter	179	155	152	-2.7	-26.3
	Spring	530	506	503	-3.2	-27.2
	Summer	1,228	1,204	1,199	-4.2	-28.1
	Fall	564	540	536	-4.2	-28.1
10-Year Dry	Winter	118	105	105	0.0	-13.2
	Spring	250	231	230	-1.1	-19.7
	Summer	1,009	984	980	-4.2	-29.3
	Fall	426	402	399	-3.2	-27.0
10-Year Wet	Winter	194	172	170	-1.8	-23.9
	Spring	581	558	556	-2.5	-25.2
	Summer	1,746	1,721	1,717	-4.2	-29.2
	Fall	800	775	771	-4.2	-29.2

Notes: Data presented in the EIA, Volume 4A, Section 6.4.7.3, Table 6.4-27 is updated by including recorded flows up to 2011 and with Pre-development information retitled as "Pre-Industrial Case".

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

Table 3.2-3 Changes to the Athabasca River Flow Depths at Node S24 for the 2013 PRM Application Case

Hydrologic Condition	Season	Pre-Industrial Case	2013 Base Case	2013 PRM Application Case		
		Water Level	Water Level	Water Level	Change Due to Pierre River Mine	Change from Pre-Industrial Case
		[m amsl]	[m amsl]	[m amsl]	[m]	[m]
Average Year	Winter	225.94	225.90	225.90	0.00	-0.04
	Spring	226.56	226.52	226.52	0.00	-0.04
	Summer	227.64	227.61	227.60	-0.01	-0.04
	Fall	226.62	226.58	226.57	-0.01	-0.05
10-Year Dry	Winter	225.83	225.81	225.81	0.00	-0.02
	Spring	226.07	226.04	226.04	0.00	-0.03
	Summer	227.32	227.29	227.28	-0.01	-0.04
	Fall	226.38	226.34	226.34	0.00	-0.04
10-Year Wet	Winter	225.97	225.93	225.93	0.00	-0.04
	Spring	226.65	226.61	226.60	-0.01	-0.05
	Summer	228.32	228.29	228.28	-0.01	-0.04
	Fall	227.00	226.96	226.96	0.00	-0.04

Note: amsl = above mean sea level.

3.2.2 Summary of Results

The 2013 PRM Application Case Hydrology assessment for the Athabasca River includes an updated list of existing and approved developments and focuses on PRM, without the effects of JME. The assessment shows that flows and water levels in the 2013 PRM Application Case are similar to those described in the EIA.

3.3 Water Quality Assessment

The water quality assessment of the LSA was presented in the EIA, Volume 4A, Section 6.5.6. The assessment of water quality changes due to PRM was updated for the Pre-Industrial Case (PIC) (presented in Appendix 2, Section 2) and for the 2013 PRM Application Case. The aquatic health assessment for watercourses and waterbodies within the PRM LSA is also updated to reflect the updated water quality results and updated Chronic Effects Benchmarks (CEBs) (Appendix 3.6). Changes to water quality are further assessed for potential effects to aquatic health in Section 3.4. Predicted concentrations of individual substances were passed through a screening procedure (using the rationale and decision rules presented in the EIA, Volume 4A, Section 6.6.2.12) to identify Substances of Potential Concern (SOPCs). The SOPCs are substances that were predicted to be present at concentrations in excess of those observed under the 2013 Base Case and that also exceed relevant water quality guidelines and CEBs.

The water quality assessment of the RSA, including the Athabasca River, was presented in the EIA, Volume 4A, Section 6.5.7. For this update, the Athabasca River Model was calibrated (Appendix 3.1) and re-run for the PIC, 2013 Base Case, 2013 PRM Application Case and 2013 PDC (presented in Appendix 2, Section 3) following the assessment methods outlined in the EIA, Volume 4A, Section 6.5.2.9. Potential effects were re-assessed based on the updated project inclusion list provided in Appendix 3.1. In this update, the Golder Pit Lake Model (GPLM) was used to assess the water quality in pit lakes (Appendix 3.1).

The list of modelled water quality constituents was updated for this assessment to align with the Lower Athabasca Regional Plan (LARP) (Government of Alberta 2012). Constituents with a water quality limit in the LARP document were included in all models. Naphthenic acids model inputs and decay rates were updated based on literature that was published after submission of the EIA, and to align with the *End Pit Lake Guidance Document* (CEMA 2012). Water quality guidelines were updated to include recent updates by the Canadian Council for Ministers of the Environment (CCME 2012).

3.3.1 Assessment Results

This section presents the 2013 PRM Application Case water quality assessment. The water quality assessment considers potential changes in concentrations of constituents in watercourses and waterbodies due to effects of existing and approved developments on water quality during construction, operation and closure phases of PRM. Potential changes to water quality resulting from aerial deposition of metals and PAHs are evaluated in Appendix 3.6. This pathway was evaluated separately, owing to the preliminary nature of the assessment. An evaluation of water quality in the Peace-Athabasca Delta (PAD) is provided in Appendix 3.5. This assessment was completed to verify that the spatial boundary of the RSA was appropriate.

Pierre River Mine Local Study Area

Within the LSA, acute and chronic toxicity and tainting potential levels are predicted to be lower than guideline values, and labile naphthenic acids are predicted to be less than 1 mg/L under the 2013 PRM Application Case at all assessment nodes in all snapshots.

In this section, water quality predictions for the 2013 PRM Application Case are compared against PIC concentrations only. Comparisons are made at assessment nodes, described in Appendix 3.1. The 2013 Base Case concentrations for the small streams are identical to the PIC because there are no approved developments in the LSA.

Pierre River at the Mouth (Node PR)

In 2018, all substances predicted to exceed guidelines in the 2013 PRM Application Case are also predicted to exceed guidelines under PIC conditions. Concentrations of all substances are predicted to stay below CEBs, except for peak concentrations of cadmium and total nitrogen (Table 3.3-1). Peak concentrations of cadmium and total nitrogen are predicted to be higher than the PIC concentrations because of changes in area of lands in the watershed, which affects runoff concentrations into small streams.

A combination of watershed diversions and closed-circuiting of land areas are predicted to increase concentrations of some substance relative to PIC, in 2034 and 2042. In particular, median concentrations of beryllium and cobalt and peak concentrations of beryllium and copper are predicted to increase relative to PIC, but remain below CEBs. Peak concentrations of cobalt are predicted to exceed all screening criteria.

In the Far Future snapshot, peak concentrations of PAH Group 6 are predicted to increase relative to PIC, but remain below the CEB. This predicted increase is due to seepage of process-affected water. Peak concentrations of total nitrogen are predicted to exceed all screening criteria. This predicted increase is due to watershed diversions.

Eymundson Creek at the Mouth (Node EC)

All substances predicted to exceed guidelines in Eymundson Creek under the 2013 PRM Application Case are also predicted to exceed guidelines under PIC conditions, except for ammonia and PAH Groups 1, 2, 5, 7 and 9 in 2018 (Table 3.3-2).

In 2018, discharges of muskeg drainage and overburden dewatering are predicted to increase concentrations of some substances relative to PIC concentrations. Median concentrations of PAH Groups 1, 2, 3, 5, 7 and 9, strontium, sulphate TDS, and total phenolics and peak concentrations of ammonia, arsenic, barium, PAH Group 3, strontium and TDS are predicted to increase relative to PIC, but remain below CEBs. Median and peak concentrations of calcium and total phosphorus and peak concentrations of aluminum, cadmium, iron, PAH Groups 1, 2, 5, 7 and 9, selenium, sodium, sulphate and total phenolics are predicted to exceed all screening criteria.

In 2034 and 2042, peak concentrations of beryllium and sulphate are predicted to increase relative to the PIC, but remain below CEBs. Concentrations of all substances are predicted to stay below CEBs, except for peak concentrations of copper, lead and manganese. The increases are primarily due to diversion of the upper watershed and closed-circuiting of land areas.

In both 2052 and 2152, water quality of Eymundson Creek is assessed at the South Pit Lake, and results are presented and discussed in the pit lakes section below.

Table 3.3-1 Predicted Water Quality in Pierre River (Node PR)

Parameter	Unit	Water Quality Guideline		Chronic Effects Benchmark	Observed Natural Variation (c)	Pre-Industrial Case/2013 Base Case		2013 PRM Application Case									
		Aquatic Life (a)(b)				Median Concentration	Peak Concentration	Median Concentration					Peak Concentration				
		Acute	Chronic					2018	2034	2042	2052	2152	2018	2034	2042	2052	2152
Aluminum	mg/L	0.75	0.1	0.15	0.27 (<0.02 - 1.4) n = 11	**0.19**	**12**	**0.19**	**0.15**	**0.16**	**0.18**	**0.18**	**12**	**9.6**	**8.2**	**9.2**	**9.2**
Ammonia	mg/L	14.6	1.1	2.0	<0.05 (<0.05 - 0.82) n = 11	0.031	0.91	0.03	0.03	0.031	0.031	0.03	0.89	0.77	0.78	0.77	0.77
Antimony	mg/L	-	-	0.16	0.0009 (0.00016 - 0.0017) n = 11	0.00072	0.0014	0.00072	0.00074	0.00074	0.00074	0.00074	0.0015	0.0014	0.0014	0.0014	0.0014
Arsenic	mg/L	0.34	0.005	0.025	0.0015 (<0.0004 - 0.0067) n = 11	0.0015	**0.012**	0.0015	0.0015	0.0015	0.0014	0.0014	**0.012**	**0.0087**	**0.0087**	**0.0083**	**0.0083**
Barium	mg/L	-	-	5.8	0.044 (0.025 - 0.094) n = 11	0.058	0.45	0.059	0.061	0.061	0.058	0.058	0.45	0.4	0.37	0.4	0.4
Beryllium	mg/L	-	-	0.0053	<0.001 (<0.0001 - <0.001) n = 11	0.00017	0.00042	0.00016	0.00019	0.00019	0.00017	0.00017	0.00042	0.00057	0.00057	0.00043	0.00043
Boron	mg/L	29	1.5	1.5	0.12 (0.03 - 0.43) n = 11	0.078	0.43	0.075	0.077	0.078	0.077	0.077	0.43	0.44	0.44	0.43	0.43
Cadmium	mg/L	0.0033	0.00037	0.00025	<0.0002 (<0.0001 - <0.0002) n = 11	0.000055	**0.00041**	0.000052	0.000059	0.000061	0.000058	0.000058	**0.00049**	0.00038	0.00041	0.00038	0.00038
Calcium	mg/L	-	-	-	39 (22 - 80) n = 26	44	83	44	45	45	44	44	86	81	81	86	81
Chloride	mg/L	640	120	-	4.4 (1.9 - 9.4) n = 25	2.1	4.7	2.0	2.2	2.2	2.2	2.1	4.9	4.8	4.9	6.8	4.8
Chromium	mg/L	0.016	0.001	0.089	0.0016 (0.0005 - 0.0057) n = 11	**0.0012**	**0.034**	**0.0012**	**0.0013**	**0.0013**	**0.0012**	**0.0012**	**0.036**	**0.027**	**0.026**	**0.028**	**0.028**
Cobalt	mg/L	-	-	0.004	0.0011 (<0.0002 - 0.0085) n = 11	0.0012	0.0071	0.0012	0.0012	0.0014	0.0012	0.0012	0.0072	0.0065	0.0084	0.0066	0.0066
Copper	mg/L	0.021	0.0034	0.026	0.0017 (<0.001 - 0.006) n = 11	0.0016	**0.015**	0.0014	0.0014	0.0014	0.0014	0.0014	**0.015**	**0.016**	**0.017**	**0.015**	**0.015**
Iron	mg/L	-	0.3	1.5	1.9 (0.96 - 10) n = 11	**1.9**	**18**	**1.8**	**1.8**	**1.9**	**1.7**	**1.7**	**19**	**15**	**14**	**13**	**13**
Lead	mg/L	0.14	0.0055	0.005	0.0003 (<0.0001 - 0.001) n = 11	0.00033	**0.0071**	0.00029	0.00034	0.00036	0.0003	0.0003	**0.0071**	**0.0066**	**0.0072**	0.0065	0.0065
Lithium	mg/L	-	-	-	0.046 (0.008 - 0.099) n = 11	0.033	0.078	0.032	0.032	0.033	0.032	0.032	0.082	0.075	0.076	0.073	0.073
Manganese	mg/L	-	-	1.5	0.15 (0.057 - 4.9) n = 11	0.28	1.8	0.27	0.29	0.29	0.27	0.27	1.3	1.5	1.7	1.0	1.0
Mercury	mg/L	0.000013	0.000005	0.00005	0.0000007 (<0.0000006 - 0.0000049) n = 11	0.00000045	**0.000013**	0.00000045	0.00000045	0.00000045	0.00000045	0.00000045	**0.000015**	**0.000014**	**0.000014**	**0.000014**	**0.000014**
Molybdenum	mg/L	-	0.073	39	0.00081 (0.0001 - 0.0038) n = 11	0.00055	0.0024	0.00053	0.00058	0.0006	0.00069	0.0006	0.0029	0.0027	0.0028	0.0071	0.0027
Naphthenic Acids - Labile	mg/L	-	-	1.0	-	0	0	0	0	0	0.00032	0.00018	0	0	0	0.041	0.025
Naphthenic Acids - Refractory	mg/L	-	-	-	-	0.51	1.4	0.5	0.5	0.5	0.5	0.5	1.4	1.3	1.2	1.2	1.2
Naphthenic Acids - Total (Lower)	mg/L	-	-	-	<1 (<1 - 1) n = 31	0.25	0.82	0.25	0.25	0.25	0.25	0.25	0.81	0.78	0.78	0.78	0.78
Naphthenic Acids - Total (Upper)	mg/L	-	-	-	<1 (<1 - 1) n = 31	0.51	1.4	0.5	0.5	0.5	0.5	0.5	1.4	1.3	1.2	1.2	1.2
Nickel	mg/L	0.67	0.075	0.13	0.01 (<0.0002 - 0.016) n = 11	0.0037	0.018	0.0035	0.0038	0.0041	0.0038	0.0038	0.018	0.019	0.021	0.019	0.019
Nitrate	mg/L	124	2.9	-	<0.045 (<0.003 - 0.11) n = 26	0.033	0.27	0.031	0.033	0.032	0.032	0.032	0.28	0.25	0.25	0.25	0.25
PAH group 1	µg/L	-	0.015	0.28	<0.025 (<0.00092 - <0.04) n = 6	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 2	µg/L	-	0.018	0.28	0.025 (0.0023 - <0.04) n = 6	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 3	µg/L	-	-	0.99	0.0063 (0.00068 - <0.02) n = 6	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 4	µg/L	-	5.8	42	<0.021 (<0.00043 - <0.04) n = 6	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 5	µg/L	-	0.012	5.6	0.04 (0.031 - 0.055) n = 6	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 6	µg/L	-	-	64	<0.04 (0.0016 - <0.049) n = 6	0	0	0	0	0	0	0	0	0	0	0	0.0002
PAH group 7	µg/L	-	0.04	5.9	0.04 (0.031 - 0.06) n = 6	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 8	µg/L	-	1.1	32	0.035 (0.016 - 0.15) n = 6	0	0	0	0	0	0	0	0	0	0	0	0.00072
PAH group 9	µg/L	-	0.025	2.3	0.04 (0.015 - 0.044) n = 6	0	0	0	0	0	0	0	0	0	0	0	0
Selenium	mg/L	-	0.001	-	0.0005 (<0.0003 - 0.0015) n = 11	0.00039	**0.0027**	0.00039	0.00039	0.00039	0.00038	0.00038	**0.0028**	**0.0023**	**0.0023**	**0.0022**	**0.0022**
Silver	mg/L	0.008	0.0001	0.00022	0.00001 (0.0000035 - 0.000026) n = 11	0.000016	0.000089	0.000015	0.000015	0.000016	0.000016	0.000016	0.000092	0.000082	0.000084	0.000083	0.000083
Sodium	mg/L	-	-	-	25 (3 - 33) n = 25	13	24	13	13	13	13	13	25	23	24	23	23
Strontium	mg/L	-	-	14	0.22 (0.13 - 0.49) n = 11	0.17	0.38	0.17	0.17	0.17	0.17	0.17	0.38	0.37	0.35	0.35	0.35
Sulphate	mg/L	-	-	309	74 (2.2 - 124) n = 26	45	106	39	43	44	42	42	105	105	106	105	105
Sulphide	mg/L	-	0.009	0.002	0.016 (<0.002 - 0.041) n = 11	0.0088	**0.14**	0.0088	0.0076	0.0074	0.0082	0.0082	**0.14**	**0.11**	**0.095**	**0.1**	**0.1**

Table 3.3-1 Predicted Water Quality in Pierre River (Node PR) (continued)

Parameter	Unit	Water Quality Guideline		Chronic Effects Benchmark	Observed Natural Variation [c]	Pre-Industrial Case/2013 Base Case		2013 PRM Application Case									
		Aquatic Life [a][b]				Median Concentration	Peak Concentration	Median Concentration					Peak Concentration				
		Acute	Chronic					2018	2034	2042	2052	2152	2018	2034	2042	2052	2152
Tainting potential	TPU	-	1.0	-	-	0	0	0	0	0	0.00028	0.000025	0	0	0	0.044	0.0075
Thallium	mg/L	-	0.0008	-	<0.0001 (<0.0001 - 0.0002) n = 11	0.000036	0.00028	0.000034	0.000034	0.000034	0.000034	0.000034	0.00032	0.0003	0.00029	0.00028	0.00028
Total dissolved solids	mg/L	-	-	1000	256 (144 - 720) n = 26	243	510	234	246	249	245	245	522	442	444	427	427
Total nitrogen	mg/L	-	1.0	-	1 (0.065 - 1.9) n = 23	0.6	**3.3**	0.58	0.64	0.65	0.62	0.77	**3.8**	**3.1**	**3.2**	**3.1**	**3.9**
Total phenolics	mg/L	-	0.004	0.01	0.0074 (<0.001 - 0.029) n = 24	**0.0047**	**0.031**	0.004	**0.004**	**0.004**	**0.0041**	**0.004**	**0.031**	**0.025**	**0.021**	**0.02**	**0.02**
Total phosphorus	mg/L	-	0.05	-	0.09 (0.018 - 0.23) n = 26	**0.089**	**1.2**	**0.089**	**0.084**	**0.084**	**0.087**	**0.087**	**1.3**	**1.0**	**0.89**	**0.94**	**0.94**
Toxicity- acute	TUa	0.3	0.3	-	-	0	0	0	0	0	0	0	0	0	0	0.0032	0.0001
Toxicity- chronic	TUc	-	1.0	-	-	0	0	0	0	0	0.000075	0	0	0	0	0.011	0.00025
Uranium	mg/L	0.033	0.015	-	0.00029 (<0.0001 - 0.0018) n = 11	0.00028	0.0021	0.00028	0.00031	0.00033	0.00031	0.00031	0.0022	0.0021	0.0022	0.0022	0.0022
Vanadium	mg/L	-	-	0.034	0.0016 (<0.0002 - 0.0049) n = 11	0.0022	0.048	0.0021	0.002	0.002	0.0021	0.0021	0.05	0.038	0.038	0.037	0.037
Zinc	mg/L	0.17	0.03	0.14	0.006 (0.0031 - 0.054) n = 11	0.014	**0.1**	0.014	0.014	0.014	0.014	0.014	**0.11**	**0.094**	**0.089**	**0.094**	**0.094**

[a] – = No guideline/No data.

[b] From U.S. EPA (2002, 2003, 2009), CCME (1999, 2012) and AENV (1999), assuming a pH of 7.8, temperature of 6.7°C and hardness of 153 mg/L (reflective of on-site conditions).

[c] Observed natural variation from 1976 to 2010, based on information from the Environmental Setting Report, Water Quality Section and Alberta Environment (2010).

Note: **Bold** font indicates concentration exceeds chronic guideline for the protection of aquatic life

Table 3.3-2 Predicted Water Quality in Eymundson Creek (Node EC)

Parameter	Unit	Water Quality Guideline			Observed Natural Variation [c]	Pre-Industrial Case/2013 Base Case		2013 PRM Application Case					
		Aquatic Life [a, b]		Chronic Effects Benchmark		Median Concentration	Peak Concentration	Median Concentration			Peak Concentration		
		Acute	Chronic					2018	2034	2042	2018	2034	2042
Aluminum	mg/L	0.75	0.1	0.15	0.46 (0.03 - 18) n = 24	0.08	**3.7**	0.071	0.08	0.08	**6.4**	**2.8**	**2.8**
Ammonia	mg/L	26.8	1.59	2	<0.05 (<0.05 - 0.89) n = 24	0.03	0.78	0.29	0.03	0.03	**2.0**	0.9	0.9
Antimony	mg/L	-	-	0.157	0.0004 (0.00006 - 0.0013) n = 24	0.00075	0.0014	0.00062	0.00075	0.00075	0.0013	0.0014	0.0014
Arsenic	mg/L	0.34	0.005	0.025	0.003 (0.001 - 0.0077) n = 24	0.0014	**0.0084**	0.0011	0.0014	0.0014	**0.013**	**0.0079**	**0.0079**
Barium	mg/L	-	-	5.8	0.053 (0.023 - 0.3) n = 24	0.063	0.36	0.099	0.062	0.062	0.47	0.33	0.33
Beryllium	mg/L	-	-	0.0053	<0.001 (<0.00001 - <0.001) n = 24	0.00021	0.00068	0.00015	0.00021	0.00021	0.00057	0.00085	0.00085
Boron	mg/L	29	1.5	1.5	0.11 (0.069 - 0.15) n = 24	0.079	0.46	0.085	0.08	0.08	0.56	0.47	0.47
Cadmium	mg/L	0.0031	0.00035	0.00025	0.0002 (0.000009 - 0.00065) n = 24	0.000061	**0.00035**	0.000053	0.00006	0.00006	**0.00056**	0.00034	0.00034
Calcium	mg/L	-	-	-	39 (12 - 90) n = 25	45	81	66	44	44	186	82	82
Chloride	mg/L	640	120	-	3 (0.87 - 4) n = 25	2.3	5.1	2.5	2.3	2.3	9.2	5.1	5.1
Chromium	mg/L	0.016	0.001	0.089	0.0013 (0.0001 - 0.034) n = 24	**0.0012**	**0.025**	**0.0017**	**0.0012**	**0.0012**	**0.026**	**0.022**	**0.022**
Cobalt	mg/L	-	-	0.004	0.002 (0.00051 - 0.0085) n = 24	0.00095	0.0064	0.00074	0.00093	0.00093	0.0058	0.0064	0.0064
Copper	mg/L	0.02	0.0032	0.0256	0.0034 (0.00039 - 0.022) n = 24	0.0013	**0.019**	0.0018	0.0013	0.0013	**0.017**	**0.026**	**0.026**
Iron	mg/L	-	0.3	1.5	5 (1.2 - 19) n = 24	**1.8**	**13**	**1.5**	**1.8**	**1.8**	**15**	**12**	**12**
Lead	mg/L	0.13	0.0051	0.005	0.00088 (<0.0001 - 0.015) n = 24	0.00035	**0.0077**	0.00024	0.00035	0.00035	**0.0066**	**0.0085**	**0.0085**
Lithium	mg/L	-	-	-	0.043 (0.017 - 0.062) n = 22	0.031	0.077	0.025	0.031	0.031	0.07	0.077	0.077
Manganese	mg/L	-	-	1.455	0.28 (0.1 - 1.6) n = 24	0.28	2.5	0.26	0.28	0.28	2.3	3.7	3.7
Mercury	mg/L	0.000013	0.000005	0.00005	0.0000034 (<0.0000006 - 0.00002) n = 14	0.00000042	**0.000016**	0.0000036	0.00000042	0.00000042	**0.000017**	**0.000016**	**0.000016**
Molybdenum	mg/L	-	0.073	38.7	0.001 (0.0004 - 0.0039) n = 20	0.00061	0.003	0.0007	0.00062	0.00062	0.0031	0.003	0.003
Naphthenic Acids - Labile	mg/L	-	-	1	-	0	0	0	0	0	0	0	0
Naphthenic Acids - Refractory	mg/L	-	-	-	-	0.51	1.5	0.69	0.51	0.51	2.5	1.9	1.9
Naphthenic Acids - Total (Lower)	mg/L	-	-	-	<1 (<1 - 3) n = 31	0.26	0.89	0.35	0.26	0.26	1.2	0.99	1.0
Naphthenic Acids - Total (Upper)	mg/L	-	-	-	<1 (<1 - 3) n = 31	0.51	1.5	0.69	0.51	0.51	2.5	1.9	1.9
Nickel	mg/L	0.639	0.071	0.125	0.012 (0.00094 - 0.031) n = 24	0.0042	0.02	0.004	0.0043	0.0043	0.018	0.022	0.022
Nitrate	mg/L	124	2.93	-	<0.1 (<0.003 - 0.2) n = 25	0.031	0.24	0.035	0.03	0.03	0.23	0.24	0.24
PAH group 1	µg/L	-	0.015	0.281	<0.04 (0.0014 - 0.066) n = 16	0	0	**0.036**	0	0	**1.1**	0	0
PAH group 2	µg/L	-	0.018	0.278	<0.04 (0.0034 - 0.067) n = 16	0	0	**0.085**	0	0	**12**	0	0
PAH group 3	µg/L	-	-	0.99	<0.01 (0.00056 - 0.058) n = 16	0	0	0.0026	0	0	0.066	0	0
PAH group 4	µg/L	-	5.8	41.5	<0.04 (0.00044 - <0.04) n = 16	0	0	0.02	0	0	1.3	0	0
PAH group 5	µg/L	-	0.012	5.6	<0.04 (0.014 - 0.22) n = 16	0	0	**0.13**	0	0	**24**	0	0
PAH group 6	µg/L	-	-	64	<0.04 (0.0041 - 0.48) n = 16	0	0	0	0	0	0	0	0
PAH group 7	µg/L	-	0.04	5.9	0.04 (0.01 - 0.21) n = 16	0	0	**0.15**	0	0	**35**	0	0
PAH group 8	µg/L	-	1.1	32	0.04 (0.01 - 0.78) n = 16	0	0	0.0073	0	0	0.37	0	0
PAH group 9	µg/L	-	0.025	2.3	<0.04 (0.01 - 0.24) n = 16	0	0	0.02	0	0	**5.3**	0	0
Selenium	mg/L	-	0.001	-	0.0007 (0.00018 - 0.0021) n = 24	0.00038	**0.0019**	0.00035	0.00038	0.00038	**0.0026**	**0.0019**	**0.0019**
Silver	mg/L	0.0076	0.0001	0.00022	0.000035 (0.0000018 - 0.00097) n = 16	0.000015	0.00009	0.000015	0.000014	0.000014	0.000085	0.000085	0.000085
Sodium	mg/L	-	-	-	18 (7.9 - 25) n = 25	12	24	11	12	12	36	26	26
Strontium	mg/L	-	-	14.1	0.21 (0.072 - 0.32) n = 20	0.17	0.37	0.21	0.17	0.17	0.66	0.39	0.39
Sulphate	mg/L	-	-	309	80 (9.4 - 122) n = 25	48	114	59	50	50	453	136	136
Sulphide	mg/L	-	0.005	0.002	0.015 (<0.002 - 0.053) n = 20	**0.0062**	**0.05**	**0.0056**	**0.0061**	**0.0061**	**0.04**	**0.04**	**0.04**
Tainting potential	TPU	-	1	-	-	0	0	0	0	0	0	0	0
Thallium	mg/L	-	0.0008	-	0.0001 (0.000002 - 0.00054) n = 24	0.000031	0.00029	0.00004	0.000031	0.000031	0.00023	0.00028	0.00028
Total dissolved solids	mg/L	-	-	1,000	273 (146 - 436) n = 21	259	462	296	261	261	660	481	481
Total nitrogen	mg/L	-	1	-	0.97 (0.21 - 3.4) n = 25	0.68	**3.1**	0.86	0.68	0.68	**2.8**	**3.1**	**3.1**

Table 3.3-2 Predicted Water Quality in Eymundson Creek (Node EC) (continued)

Parameter	Unit	Water Quality Guideline		Chronic Effects Benchmark	Observed Natural Variation [c]	Pre-Industrial Case/2013 Base Case		2013 PRM Application Case					
		Aquatic Life [a, b]				Median Concentration	Peak Concentration	Median Concentration			Peak Concentration		
		Acute	Chronic					2018	2034	2042	2018	2034	2042
Total phenolics	mg/L	-	0.004	0.01	0.007 (0.003 - 0.026) n = 21	0.0039	**0.023**	**0.0095**	0.0039	0.0039	**0.039**	**0.025**	**0.025**
Total phosphorus	mg/L	-	0.05	-	0.25 (0.037 - 0.61) n = 25	**0.07**	**0.9**	**0.083**	**0.07**	**0.07**	**1.0**	**0.73**	**0.73**
Toxicity- acute	TUa	0.3	0.3	-	-	0	0	0	0	0	0	0	0
Toxicity- chronic	TUc	-	1	-	-	0	0	0	0	0	0	0	0
Uranium	mg/L	0.033	0.015	-	0.0008 (0.00017 - 0.0026) n = 24	0.00033	0.0022	0.00035	0.00033	0.00033	0.0021	0.0022	0.0022
Vanadium	mg/L	-	-	0.0338	0.0024 (<0.0002 - 0.074) n = 24	0.0018	0.04	0.0014	0.0018	0.0018	0.043	0.037	0.037
Zinc	mg/L	0.163	0.03	0.138	0.013 (0.002 - 0.1) n = 24	0.013	**0.094**	0.014	0.013	0.013	**0.087**	**0.091**	**0.091**

[a] – = No guideline/No data.

[b] From U.S. EPA (2002, 2003, 2009), CCME (1999, 2012) and AENV (1999), assuming a pH of 7.4, temperature of 5.1°C and hardness of 144 mg/L (reflective of on-site conditions).

[c] Observed natural variation from 1976 to 2010, based on information from the Environmental Setting Report, Water Quality Section and Alberta Environment (2010).

Notes: **Bold** font indicates concentration exceeds chronic guideline for the protection of aquatic life.

Big Creek at the Mouth (Node BC)

In all snapshots, all substances in Big Creek that are predicted to exceed guidelines under the 2013 PRM Application Case are also predicted to exceed guidelines under PIC conditions (Table 3.3-3).

In 2018, Big Creek was assessed at the mouth of Big Creek. In this snapshot, median and peak concentrations of chromium and peak concentrations of arsenic and barium are predicted to increase relative to PIC, but remain below CEBs. Median concentrations of aluminum and total phosphorus and peak concentrations of cadmium, iron, selenium, total phenolics and vanadium are predicted to exceed all screening criteria. Concentrations of aluminum, iron and total phosphorus remain within the range of natural variation for the watershed. The increases are mainly due to watershed diversions, which incorporate natural lands with slightly different runoff chemistry.

In 2034 and 2042, a combination of watershed diversions and impoundment of Big Creek are predicted to increase median concentrations of aluminum, chromium, sulphate, total phosphorus and vanadium relative to the PIC. The act of impounding water tends to increase median concentrations but decrease peak concentrations due to longer residence times. Median concentrations of aluminum and total phosphorus are predicted to exceed all screening criteria, but remain within the range of natural variation within the watershed.

In 2052 and 2152, watershed diversions are predicted to increase concentrations of some substances relative to PIC. In particular, peak concentrations of beryllium, copper and sulphate are predicted to increase, but remain below CEBs. Peak concentrations of calcium, manganese and total nitrogen are predicted to exceed all screening criteria in at least one of the 2052 or 2152 snapshots.

South Redclay Lake (Node RCL)

Because South Redclay Lake does not exist in the PIC, the 2013 PRM Application Case concentrations are compared to PIC concentrations at the mouth of Redclay and Big creeks, which will ultimately report to that lake (Table 3.3-4).

In 2018, Redclay Creek assessment node is located at the mouth of Redclay Creek, just upstream of the Redclay Creek – Athabasca River confluence. After construction of the South Redclay Lake in other snapshots, this node was located at South Redclay Lake. In 2018, neither Shell PRM, nor Teck Frontier projects will affect Redclay Creek.

In all snapshots after 2018, the 2013 PRM Application Case median concentrations are predicted to increase relative to PIC conditions because of the longer residence time in lakes relative to streams. The impoundment of water tends to increase median concentrations because of two factors: First, the additional evaporation in the lake leads to increased concentrations, and second, high loading during pulse events, whether natural or anthropogenic, remain within the lake rather than being washed downstream. In contrast, the longer residence times tend to reduce peak concentrations because lakes attenuate high loadings during pulse events. In all snapshots, all substances predicted to exceed guidelines are also predicted to exceed guidelines under PIC, except for median concentrations of aluminum, chromium, cobalt and total nitrogen.

Table 3.3-3 Predicted Water Quality in Big Creek (Node BC)

Parameter	Unit	Water Quality Guideline		Chronic Effects Benchmark	Observed Natural Variation [(c)]	Pre-Industrial Case/2013 Base Case		2013 PRM Application Case									
		Aquatic Life[(a, b)]				Median Concentration	Peak Concentration	Median Concentration					Peak Concentration				
		Acute	Chronic					2018	2034	2042	2052	2152	2018	2034	2042	2052	2152
Aluminum	mg/L	0.75	0.1	0.15	0.13 (0.018 - 9) n = 41	**0.12**	**3.9**	**0.17**	**0.24**	**0.24**	**0.1**	0.097	**8.1**	**0.71**	**0.71**	**2.8**	**3.0**
Ammonia	mg/L	18.32	1.27	2	<0.05 (<0.05 - 1.4) n = 41	0.031	0.73	0.032	0.0082	0.0082	0.03	0.03	0.71	0.1	0.1	0.85	0.86
Antimony	mg/L	-	-	0.157	0.0007 (0.000057 - 0.0017) n = 41	0.00076	0.0013	0.00075	0.00072	0.00072	0.00076	0.00076	0.0013	0.00091	0.00091	0.0013	0.0013
Arsenic	mg/L	0.34	0.005	0.025	0.00078 (<0.0004 - 0.041) n = 41	0.0014	**0.0095**	0.0015	0.0013	0.0013	0.0014	0.0014	**0.018**	0.0026	0.0026	**0.0083**	**0.0087**
Barium	mg/L	-	-	5.8	0.07 (0.026 - 0.54) n = 41	0.062	0.36	0.065	0.062	0.062	0.062	0.062	0.56	0.11	0.11	0.32	0.32
Beryllium	mg/L	-	-	0.0053	<0.001 (<0.0001 - <0.001) n = 41	0.00021	0.00065	0.00019	0.00018	0.00018	0.00021	0.00021	0.00057	0.00029	0.00029	0.00079	0.00079
Boron	mg/L	29	1.5	1.5	0.07 (0.03 - 0.14) n = 41	0.08	0.41	0.078	0.087	0.087	0.08	0.08	0.66	0.28	0.28	0.41	0.41
Cadmium	mg/L	0.0037	0.0004	0.00025	<0.0002 (<0.000005 - 0.0004) n = 41	0.000065	0.00032	0.000074	0.000065	0.000065	0.000066	0.000063	**0.00067**	0.00017	0.00017	0.00029	0.00031
Calcium	mg/L	-	-	-	52 (25 - 92) n = 60	45	80	45	40	40	44	44	79	49	49	89	80
Chloride	mg/L	640	120	-	1.3 (<0.1 - 3) n = 60	2.3	4.9	2.2	2.2	2.2	2.3	2.3	4.7	2.9	2.9	4.8	5.0
Chromium	mg/L	0.016	0.001	0.089	0.001 (0.00045 - 0.017) n = 41	**0.0013**	**0.024**	**0.0015**	**0.0015**	**0.0015**	**0.0012**	**0.0013**	**0.036**	**0.005**	**0.005**	**0.018**	**0.021**
Cobalt	mg/L	-	-	0.004	0.0004 (<0.0002 - 0.012) n = 41	0.001	0.0061	0.001	0.001	0.001	0.00097	0.00096	0.0066	0.0039	0.0039	0.0058	0.0058
Copper	mg/L	0.023	0.0037	0.0256	0.001 (0.0004 - 0.019) n = 41	0.0014	**0.018**	0.0017	0.0024	0.0024	0.0014	0.0013	**0.017**	**0.0068**	**0.0068**	**0.02**	**0.022**
Iron	mg/L	-	0.3	1.5	1 (0.073 - 25) n = 40	**1.8**	**14**	**1.9**	**1.8**	**1.8**	**1.8**	**1.8**	**21**	**3.5**	**3.5**	**12**	**12**
Lead	mg/L	0.16	0.0063	0.005	0.0002 (<0.0001 - 0.0095) n = 41	0.00036	**0.0069**	0.00038	0.00044	0.00044	0.00036	0.00036	**0.0068**	0.0022	0.0022	**0.007**	**0.007**
Lithium	mg/L	-	-	-	0.03 (0.011 - 0.063) n = 41	0.032	0.073	0.03	0.029	0.029	0.031	0.031	0.072	0.035	0.035	0.071	0.075
Manganese	mg/L	-	-	1.455	0.24 (0.032 - 4.2) n = 40	0.29	2.4	0.26	0.26	0.26	0.28	0.28	2.2	0.74	0.74	3.1	3.1
Mercury	mg/L	0.000013	0.000005	0.00005	<0.0000006 (<0.0000006 - 0.0000076) n = 41	0.00000042	**0.000015**	0.0000005	0.0000011	0.0000011	0.00000044	0.00000042	**0.000015**	0.0000046	0.0000046	**0.000015**	**0.000015**
Molybdenum	mg/L	-	0.073	38.7	0.0004 (<0.0001 - 0.002) n = 41	0.00061	0.0026	0.00054	0.0006	0.0006	0.00063	0.00062	0.0025	0.00092	0.00092	0.0024	0.0028
Naphthenic Acids - Labile	mg/L	-	-	1	-	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Refractory	mg/L	-	-	-	-	0.51	1.4	0.5	0.57	0.57	0.52	0.51	1.4	0.83	0.83	1.7	1.7
Naphthenic Acids - Total (Lower)	mg/L	-	-	-	<1 (<1 - 3) n = 60	0.26	0.79	0.25	0.3	0.3	0.26	0.26	0.89	0.57	0.57	0.87	0.86
Naphthenic Acids - Total (Upper)	mg/L	-	-	-	<1 (<1 - 3) n = 60	0.51	1.4	0.5	0.57	0.57	0.52	0.51	1.4	0.83	0.83	1.7	1.7
Nickel	mg/L	0.735	0.082	0.125	0.0036 (<0.0002 - 0.029) n = 41	0.0042	0.018	0.0039	0.0046	0.0046	0.0044	0.0043	0.017	0.0072	0.0072	0.018	0.02
Nitrate	mg/L	124	2.93	-	0.1 (<0.003 - 0.3) n = 60	0.033	0.23	0.037	0.026	0.026	0.032	0.032	0.23	0.055	0.055	0.23	0.23
PAH group 1	µg/L	-	0.015	0.281	<0.04 (<0.00022 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 2	µg/L	-	0.018	0.278	<0.04 (0.00075 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 3	µg/L	-	-	0.99	<0.01 (0.00022 - <0.01) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 4	µg/L	-	5.8	41.5	<0.04 (<0.00032 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 5	µg/L	-	0.012	5.6	0.04 (0.0013 - 0.051) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 6	µg/L	-	-	64	<0.04 (0.0012 - 0.1) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 7	µg/L	-	0.04	5.9	<0.04 (0.00045 - 0.051) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 8	µg/L	-	1.1	32	<0.04 (0.0044 - 0.15) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 9	µg/L	-	0.025	2.3	<0.04 (0.0033 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
Selenium	mg/L	-	0.001	-	<0.0004 (<0.0002 - 0.003) n = 41	0.00039	**0.0022**	0.00041	0.00034	0.00034	0.00039	0.00039	**0.0035**	0.00066	0.00066	**0.0018**	**0.0018**
Silver	mg/L	0.01	0.0001	0.00022	0.00001 (0.0000009 - 0.00011) n = 41	0.000015	0.000081	0.000016	0.000014	0.000014	0.000015	0.000015	0.000098	0.000029	0.000029	0.000078	0.000084
Sodium	mg/L	-	-	-	12 (2 - 25) n = 60	13	23	13	12	12	13	13	23	16	16	24	24
Strontium	mg/L	-	-	14.1	0.17 (0.1 - 0.44) n = 41	0.17	0.38	0.17	0.16	0.16	0.17	0.17	0.41	0.19	0.19	0.38	0.38
Sulphate	mg/L	-	-	309	47 (1.4 - 170) n = 58	49	109	46	57	57	51	50	105	75	75	122	122
Sulphide	mg/L	-	0.007	0.002	0.0075 (<0.002 - 0.8) n = 46	**0.0072**	**0.062**	**0.0075**	0.00005	0.00005	0.0066	0.0065	**0.067**	0.0035	0.0035	**0.047**	**0.05**

Table 3.3-3 Predicted Water Quality in Big Creek (Node BC) (continued)

Parameter	Unit	Water Quality Guideline		Chronic Effects Benchmark	Observed Natural Variation [c]	Pre-Industrial Case/2013 Base Case		2013 PRM Application Case									
		Aquatic Life[a, b]				Median Concentration	Peak Concentration	Median Concentration					Peak Concentration				
		Acute	Chronic					2018	2034	2042	2052	2152	2018	2034	2042	2052	2152
Tainting potential	TPU	-	1	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Thallium	mg/L	-	0.0008	-	<0.0001 (<0.0001 - 0.0002) n = 41	0.000034	0.00026	0.000036	0.000034	0.000034	0.000034	0.000033	0.00024	0.000086	0.000086	0.00025	0.00028
Total dissolved solids	mg/L	-	-	1000	255 (140 - 452) n = 59	256	448	246	248	248	261	260	430	286	286	450	463
Total nitrogen	mg/L	-	1	-	0.76 (<0.2 - 3.2) n = 56	0.68	**2.6**	0.63	0.68	0.68	0.68	0.85	**2.5**	**1.1**	**1.1**	**2.4**	**3.4**
Total phenolics	mg/L	-	0.004	0.01	0.003 (<0.001 - 0.022) n = 57	**0.004**	**0.024**	**0.0044**	0.0002	0.0002	**0.0041**	0.004	**0.036**	0.0036	0.0036	**0.024**	**0.024**
Total phosphorus	mg/L	-	0.05	-	0.079 (0.027 - 1.5) n = 57	**0.074**	**0.94**	**0.086**	**0.1**	**0.1**	**0.072**	**0.071**	**1.4**	**0.25**	**0.25**	**0.83**	**0.86**
Toxicity- acute	TUa	0.3	0.3	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Toxicity- chronic	TUc	-	1	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Uranium	mg/L	0.033	0.015	-	0.0002 (<0.0001 - 0.0014) n = 41	0.00032	0.002	0.00029	0.00034	0.00034	0.00034	0.00033	0.002	0.00072	0.00072	0.0021	0.0021
Vanadium	mg/L	-	-	0.0338	0.001 (<0.0002 - 0.042) n = 41	0.0019	0.035	0.0022	0.0032	0.0032	0.0018	0.0018	0.061	0.012	0.012	0.035	0.035
Zinc	mg/L	0.188	0.03	0.138	0.006 (0.0022 - 0.17) n = 41	0.013	**0.089**	0.012	0.012	0.012	0.013	0.013	**0.092**	**0.044**	**0.044**	**0.086**	**0.089**

[a] – = No guideline/No data.

[b] From U.S. EPA (2002, 2003, 2009), CCME (1999, 2012) and AENV (1999), assuming a pH of 7.7, temperature of 6.8°C and hardness of 174 mg/L (reflective of on-site conditions).

[c] Observed natural variation from 1976 to 2010, based on information from Shell (2007) and Alberta Environment (2010).

Notes: **Bold** font indicates concentration exceeds chronic guideline for the protection of aquatic life.

Table 3.3-4 Predicted Water Quality in South Redclay Lake (Node RCL)

Parameter	Unit	Water Quality Guideline Aquatic Life [a, b]		Chronic Effects Benchmark	Observed Natural Variation[c]	Pre-Industrial Case/2013 Base Case [d]		2013 PRM Application Case									
								Median Concentration					Peak Concentration				
		Acute	Chronic			Median Concentration	Peak Concentration	2018	2034	2042	2052	2152	2018	2034	2042	2052	2152
Aluminum	mg/L	0.75	0.1	0.15	0.07 (0.006 - 9) n = 91	0.038 - 0.12	**2.1 - 3.9**	0.037	**0.27**	**0.27**	**0.22**	**0.22**	**1.3**	**0.92**	**0.92**	**0.71**	**0.71**
Ammonia	mg/L	25.7	1.55	2	<0.05 (<0.05 - 1.4) n = 91	0.031 - 0.045	0.73 - 0.86	0.046	0.0034	0.0034	0.0044	0.0044	0.82	0.041	0.041	0.055	0.055
Antimony	mg/L	-	-	0.157	0.0007 (<0.0002 - 0.0018) n = 89	0.00058 - 0.00076	0.0012 - 0.0013	0.00058	0.001	0.001	0.00067	0.00067	0.0012	0.0012	0.0012	0.00076	0.00076
Arsenic	mg/L	0.34	0.005	0.025	0.0004 (<0.0002 - 0.041) n = 91	0.00024 - 0.0014	0.00098 - 0.0095	0.00024	0.0012	0.0012	0.00087	0.00087	0.00096	0.0015	0.0015	0.0012	0.0012
Barium	mg/L	-	-	5.8	0.051 (0.013 - 0.54) n = 91	0.039 - 0.062	0.087 - 0.36	0.039	0.081	0.081	0.051	0.051	0.088	0.098	0.098	0.07	0.07
Beryllium	mg/L	-	-	0.0053	<0.001 (<0.001 - <0.001) n = 65	0.00021 - 0.0005	0.00065 - 0.0007	0.0005	0.00068	0.00068	0.00031	0.00031	0.00069	0.00083	0.00083	0.00037	0.00037
Boron	mg/L	29	1.5	1.5	0.1 (0.03 - 0.17) n = 91	0.08 - 0.11	0.16 - 0.41	0.11	0.19	0.19	0.1	0.1	0.22	0.32	0.32	0.19	0.19
Cadmium	mg/L	0.005	0.0005	0.00025	<0.0002 (<0.000005 - 0.0004) n = 71	0.000065 - 0.000089	0.00014 - 0.00032	0.000088	0.00019	0.00019	0.000078	0.000078	0.00015	**0.0003**	**0.0003**	0.00013	0.00013
Calcium	mg/L	-	-	-	-	42 - 45	80 - 102	42	61	61	41	41	97	72	72	50	50
Chloride	mg/L	640	120	-	2 (<0.1 - 3.1) n = 111	2.3 - 2.6	4.9 - 9.4	2.6	4.1	4.1	2.6	2.6	9.3	4.9	4.9	3.2	3.2
Chromium	mg/L	0.016	0.001	0.089	<0.0008 (<0.0008 - 0.039) n = 91	0.00066 - 0.0013	**0.0025 - 0.024**	0.00066	**0.0027**	**0.0027**	**0.0014**	**0.0014**	**0.0026**	**0.0047**	**0.0047**	**0.0024**	**0.0024**
Cobalt	mg/L	-	-	0.004	-	0.00013 - 0.001	0.0006 - 0.0061	0.00014	0.0008	0.0008	0.00069	0.0007	0.00062	0.0014	0.0014	0.0015	0.0015
Copper	mg/L	0.031	0.0048	0.0256	<0.001 (0.0002 - 0.019) n = 91	0.0006 - 0.0014	0.0017 - 0.018	0.0006	0.0025	0.0025	0.0018	0.0018	0.0017	0.0038	0.0038	0.0029	0.0029
Iron	mg/L	-	0.3	1.5	1.4 (0.073 - 26) n = 90	**1.1 - 1.8**	**8.8 - 14**	**1.1**	**2.5**	**2.5**	**1.6**	**1.6**	**9.4**	**3.9**	**3.9**	**2.8**	**2.8**
Lead	mg/L	0.236	0.0092	0.005	0.0001 (<0.0001 - 0.0095) n = 91	0.00011 - 0.00036	0.00074 - 0.0069	0.0001	0.00054	0.00054	0.00038	0.00038	0.0006	0.001	0.001	0.00098	0.00098
Lithium	mg/L	-	-	-	-	0.032 - 0.048	0.073 - 0.076	0.048	0.058	0.058	0.033	0.033	0.076	0.074	0.074	0.041	0.041
Manganese	mg/L	-	-	1.455	0.26 (0.032 - 2.8) n = 88	0.27 - 0.29	2.4 - 3.1	0.27	0.5	0.5	0.32	0.32	3.4	1.1	1.1	0.76	0.76
Mercury	mg/L	0.000013	0.000005	0.00005	<0.0000006 (<0.0000006 - 0.00001) n = 93	0.0000003 - 0.00000042	0.0000015 - 0.000015	0.0000003	0.0000011	0.0000011	0.0000008	0.0000008	0.0000011	0.0000019	0.0000019	0.0000018	0.0000018
Molybdenum	mg/L	-	0.073	38.7	0.0002 (<0.0001 - 0.002) n = 91	0.000096 - 0.00061	0.00049 - 0.0026	0.000097	0.00045	0.00045	0.00038	0.00038	0.00046	0.00059	0.00059	0.0005	0.0005
Naphthenic Acids - Labile	mg/L	-	-	1	-	0	0	0	0	0	0	0	0	0	0	0	0
Naphthenic Acids - Refractory	mg/L	-	-	-	-	0.51 - 0.52	1.1 - 1.4	0.52	0.9	0.9	0.59	0.59	1.1	1.1	1.1	0.76	0.76
Naphthenic Acids - Total (Lower)	mg/L	-	-	-	-	0.26 - 0.26	0.77 - 0.79	0.027	0.28	0.28	0.22	0.22	0.6	0.56	0.56	0.42	0.42
Naphthenic Acids - Total (Upper)	mg/L	-	-	-	-	0.51 - 0.52	1.1 - 1.4	0.52	0.9	0.9	0.59	0.59	1.1	1.1	1.1	0.76	0.76
Nickel	mg/L	0.95	0.106	0.125	0.0018 (<0.0002 - 0.029) n = 91	0.00085 - 0.0042	0.0024 - 0.018	0.00083	0.0041	0.0041	0.0032	0.0032	0.0024	0.0052	0.0052	0.0042	0.0042
Nitrate	mg/L	124	2.93	-	-	0.014 - 0.033	0.16 - 0.23	0.015	0.046	0.046	0.027	0.027	0.16	0.085	0.085	0.044	0.044
PAH group 1	µg/L	-	0.015	0.281	<0.04 (<0.00022 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 2	µg/L	-	0.018	0.278	<0.04 (<0.00023 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 3	µg/L	-	-	0.99	<0.01 (<0.00012 - <0.01) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 4	µg/L	-	5.8	41.5	<0.04 (<0.00032 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 5	µg/L	-	0.012	5.6	<0.04 (0.0015 - 0.1) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 6	µg/L	-	-	64	<0.04 (<0.0015 - 0.1) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 7	µg/L	-	0.04	5.9	<0.04 (0.0099 - 0.051) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 8	µg/L	-	1.1	32	<0.04 (0.01 - 0.15) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
PAH group 9	µg/L	-	0.025	2.3	<0.04 (0.00071 - <0.04) n = 19	0	0	0	0	0	0	0	0	0	0	0	0
Selenium	mg/L	-	0.001	-	<0.0004 (<0.0002 - 0.008) n = 91	0.0002 - 0.00039	**0.0015 - 0.0022**	0.0002	0.00045	0.00045	0.00029	0.00029	**0.0014**	0.00061	0.00061	0.00047	0.00047
Silver	mg/L	0.017	0.0001	0.00022	0.0000086 (0.0000009 - 0.00011) n = 92	0.0000088 - 0.000015	0.000051 - 0.000081	0.0000088	0.000016	0.000016	0.000012	0.000012	0.000047	0.00002	0.00002	0.000017	0.000017
Sodium	mg/L	-	-	-	-	13 - 13	23 - 26	13	19	19	12	12	26	22	22	15	15
Strontium	mg/L	-	-	14.1	0.19 (0.086 - 0.44) n = 91	0.17 - 0.25	0.38 - 0.52	0.25	0.33	0.33	0.22	0.22	0.52	0.41	0.41	0.27	0.27
Sulphate	mg/L	-	-	309	66 (1.4 - 209) n = 109	49 - 82	109 - 195	82	120	120	71	71	199	139	139	83	83
Sulphide	mg/L	-	0.005	0.002	0.008 (<0.002 - 0.14) n = 92	**0.0061 - 0.0072**	**0.033 - 0.062**	**0.0061**	0	0	0	0	**0.029**	0.0013	0.0013	0.0016	0.0016

Table 3.3-4 Predicted Water Quality in South Redclay Lake (Node RCL) (continued)

Parameter	Unit	Water Quality Guideline		Chronic Effects Benchmark	Observed Natural Variation[c]	Pre-Industrial Case/2013 Base Case [d]		2013 PRM Application Case									
		Aquatic Life [a, b]				Median Concentration	Peak Concentration	Median Concentration					Peak Concentration				
		Acute	Chronic					2018	2034	2042	2052	2152	2018	2034	2042	2052	2152
Tainting potential	TPU	-	1	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Thallium	mg/L	-	0.0008	-	-	0.000014 - 0.000034	0.00011 - 0.00026	0.000013	0.000046	0.000046	0.000036	0.000036	0.00011	0.000081	0.000081	0.000067	0.000067
Total dissolved solids	mg/L	-	-	1000	264 (140 - 690) n = 110	256 - 298	448 - 658	299	424	424	274	274	652	474	474	304	304
Total nitrogen	mg/L	-	1	-	0.7 (<0.2 - 3.2) n = 107	0.68 - 0.7	**2.2 - 2.6**	0.7	**1.1**	**1.1**	0.72	0.81	**2.1**	**1.3**	**1.3**	0.89	0.99
Total phenolics	mg/L	-	0.004	0.01	0.003 (<0.001 - 0.022) n = 107	0.003 - 0.004	**0.022 - 0.024**	0.0031	0	0	0.0001	0.0001	**0.021**	0.0018	0.0018	0.0018	0.0018
Total phosphorus	mg/L	-	0.05	-	0.088 (0.007 - 2.2) n = 109	**0.07 - 0.074**	**0.39 - 0.94**	**0.07**	**0.14**	**0.14**	**0.1**	**0.1**	**0.37**	**0.18**	**0.18**	**0.14**	**0.14**
Toxicity- acute	TUa	0.3	0.3	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Toxicity- chronic	TUc	-	1	-	-	0	0	0	0	0	0	0	0	0	0	0	0
Uranium	mg/L	0.033	0.015	-	-	0.00001 - 0.00032	0.000075 - 0.002	0.00001	0.00023	0.00023	0.0002	0.0002	0.000055	0.00036	0.00036	0.00035	0.00035
Vanadium	mg/L	-	-	0.0338	0.0006 (<0.0002 - 0.042) n = 91	0.00025 - 0.0019	0.0022 - 0.035	0.00025	0.0033	0.0033	0.0021	0.0021	0.0023	0.0061	0.0061	0.0046	0.0046
Zinc	mg/L	0.243	0.03	0.138	0.0085 (<0.003 - 0.17) n = 90	0.0078 - 0.013	**0.079 - 0.089**	0.0078	0.027	0.027	0.014	0.014	**0.078**	**0.051**	**0.051**	0.025	0.025

(a) – = No guideline/No data.

(b) From U.S. EPA (2002, 2003, 2009), CCME (1999, 2012) and AENV (1999), assuming a pH of 7.4, temperature of 4.6°C and hardness of 230 mg/L (reflective of on-site conditions).

(c) Observed natural variation at Redclay Creek from 1976 to 2010, based on information from the Environmental Setting Report, Water Quality Section and Alberta Environment (2010).

(d) Predicted concentrations at Big Creek and Redclay Creek.

Notes: **Bold** font indicates concentration exceeds chronic guideline for the protection of aquatic life.

In 2034 and 2042, median concentrations of antimony, manganese, strontium, sulphate and TDS and median and peak concentrations of barium, beryllium, chromium, cobalt and vanadium are predicted to increase relative to PIC, but remain below CEBs. Median concentration of aluminium, calcium, iron, sodium, total nitrogen and total phosphorus are predicted to exceed all screening criteria. The increases are primarily due to diversion of Big Creek and Redclay Creek to South Redclay Lake.

In 2052 and 2152, median concentrations of antimony, barium, chromium and manganese, and median and peak concentrations of cobalt and vanadium are predicted to increase relative to PIC, but remain below CEBs. Median concentrations of aluminum, iron and total phosphorus are predicted to exceed all screening criteria. The increases are primarily due to diversion of Big Creek and Redclay Creek into South Redclay Lake.

Pit Lakes

Predicted concentrations of all modelled constituents in pit lakes for 2052 and in Far Future 2152 are shown in Table 3.3-5 and discussed below.

Table 3.3-5 Predicted Water Quality in Pit Lakes

Constituent	Units	North Pit Lake		South Pit Lake - Up Stream Cell		South Pit Lake - Down Stream Cell	
		Initial 2052	Far Future 2152	Initial 2052	Far Future 2152	Initial 2052	Far Future 2152
Aluminum	mg/L	**0.9**	**0.18**	**1.3**	**0.27**	**1.5**	**0.27**
Ammonia - N	mg/L	0.068	0.022	0.019	0.0054	0.0024	0.00066
Antimony	mg/L	0.00061	0.0008	0.00092	0.00094	0.00054	0.00095
Arsenic	mg/L	0.0017	0.002	0.002	0.0023	0.0015	0.0023
Barium	mg/L	0.088	0.085	0.1	0.093	0.096	0.093
Beryllium	mg/L	0.00035	0.0003	0.00049	0.00033	0.0004	0.00034
Boron	mg/L	0.23	0.14	0.63	0.27	0.36	0.28
Cadmium	mg/L	0.00023	0.00012	**0.00048**	0.00023	0.00035	0.00023
Calcium	mg/L	43	49	42	52	41	52
Chloride	mg/L	14	9.8	41	26	24	26
Chromium	mg/L	**0.0027**	**0.0016**	**0.0038**	**0.0019**	**0.0038**	**0.002**
Cobalt	mg/L	0.0016	0.0017	0.0018	0.0023	0.0016	0.0023
Copper	mg/L	0.0027	0.0019	**0.0036**	0.0022	**0.0035**	0.0022
Iron	mg/L	**2.5**	**3.2**	**1.9**	**3.3**	**1.9**	**3.3**
Lead	mg/L	0.0011	0.00044	0.0015	0.00052	0.0017	0.00052
Lithium	mg/L	0.031	0.039	0.042	0.046	0.026	0.047
Manganese	mg/L	0.23	0.41	0.14	0.43	0.097	0.43
Mercury	mg/L	0.000004	0.0000012	**0.0000089**	0.0000016	**0.0000066**	0.0000016
Molybdenum	mg/L	0.043	0.012	**0.15**	0.039	**0.083**	0.04
Naphthenic Acids - Labile	mg/L	0.22	0.0041	0.12	0.0019	0.035	0.0032
Naphthenic Acids - Refractory	mg/L	4.1	1.3	12	3.3	7.4	3.5
Naphthenic Acids - Total (Lower)	mg/L	2.9	0.83	9.3	2.3	5.4	2.4
Naphthenic Acids - Total (Upper)	mg/L	4.3	1.3	13	3.3	7.4	3.5
Nickel	mg/L	0.0053	0.005	0.0066	0.0058	0.0059	0.0058
Nitrate	mg/L	0.059	0.05	0.079	0.046	0.08	0.046
PAH Group 1	ppb	0.0036	0.000063	0.0042	0.000048	0.0039	0.000041
PAH Group 2	ppb	0.017	0.00024	**0.027**	0.00033	**0.025**	0.00033
PAH Group 3	ppb	0.009	2.8E-29	0.0074	1.6E-15	0.014	1.8E-15

Table 3.3-5 Predicted Water Quality in Pit Lakes (continued)

Constituent	Units	North Pit Lake		South Pit Lake - Up Stream Cell		South Pit Lake - Down Stream Cell	
		Initial 2052	Far Future 2152	Initial 2052	Far Future 2152	Initial 2052	Far Future 2152
PAH Group 4	ppb	0.00056	0.000026	0.00028	0.0000044	0.000082	0.0000011
PAH Group 5	ppb	0.0023	0.000062	0.0013	0.000014	0.00039	0.000004
PAH Group 6	ppb	0.0055	0.00015	0.013	0.00023	0.007	0.00024
PAH Group 7	ppb	0.007	0.00019	0.0059	0.000075	0.0031	0.000044
PAH Group 8	ppb	0.018	0.00051	0.02	0.00025	0.015	0.00019
PAH Group 9	ppb	0.0044	0.000083	0.0041	0.000039	0.0029	0.000027
Selenium	mg/L	0.00053	0.00066	0.00073	0.0008	0.0005	0.00081
Silver	mg/L	0.000026	0.000019	0.000051	0.000027	0.000037	0.000027
Sodium	mg/L	31	17	81	30	50	30
Strontium	mg/L	0.29	0.19	0.48	0.25	0.4	0.25
Sulphate	mg/L	47	51	71	55	53	55
Sulphide	mg/L	0.004	0.0003	0.0014	0.00004	0.00013	0.0000035
Tainting Potential	mg/L	0.06	0.017	0.018	0.013	0.0053	0.004
Thallium	mg/L	0.000046	0.000042	0.000054	0.000041	0.000054	0.000042
Total Dissolved Solids	mg/L	300	287	474	351	347	354
Total Nitrogen	mg/L	**1.2**	0.95	**2.0**	**1.1**	**1.4**	**1.2**
Total Phenolics	mg/L	0.0013	0.0002	0.0004	0.000018	0.000036	0.0000016
Total Phosphorus	mg/L	**0.1**	**0.092**	**0.12**	**0.1**	**0.12**	**0.11**
Toxicity - Acute	TUa	0.22	0.0012	0.19	0.00067	0.082	0.0004
Toxicity - Chronic	TUc	0.34	0.0018	0.21	0.00085	0.07	0.00033
Uranium	mg/L	0.00069	0.00062	0.0012	0.00061	0.00094	0.00062
Vanadium	mg/L	0.0043	0.003	0.0072	0.0042	0.006	0.0042
Zinc	mg/L	0.014	0.016	0.016	0.017	0.014	0.017

Notes: Bold font indicates concentration exceeds chronic guideline for the protection of aquatic life.

Similar to the EIA, pit lakes are predicted to be low in key constituents such as labile naphthenic acids, chronic and acute toxicity, tainting potential and TDS. Concentrations of most constituents in the two pit lakes are predicted to remain below aquatic life guidelines or within natural variation at the time of initial discharge and 100 years post-closure.

Concentrations of aluminum, cadmium, chromium, copper, iron, mercury, molybdenum, PAH Group 2, total nitrogen and total phosphorus are predicted to exceed guidelines in one or more pit lakes. Predicted exceedances in 2052 are in some cases due to high concentrations in Athabasca River water that will be used to fill the pit lakes. Since the Athabasca River water is known to be high in the particulate fraction of several metals, as described below, considerable settling and reduction in concentrations can be expected as the pit lakes fill. During the filling period, settling of total metals was not accounted for in this modelling; therefore, concentrations of these constituents are anticipated to be lower than predicted.

Similar to the EIA, labile naphthenic acids are predicted to be below 1 mg/L at the time of initial discharge and beyond for both of the pit lakes. In 2052 and 2152, refractory naphthenic acids are predicted to be higher in the pit lakes compared to the values predicted in the EIA because of the updated assumptions regarding refractory naphthenic acids concentrations in mine waters. Refractory naphthenic acids were previously assigned to 30%

of total naphthenic acids in process-affected waters with no decay, whereas the updated modelling assigned 75% with a 23-year half life. Thus, the pit lakes with longer residence times (South Pit Lake Upstream Cell) decrease more from 2052 to 2152 in concentrations of refractory naphthenic acids than other lakes. Due to the inclusion of an inert fraction in the calculation of total naphthenic acids, concentrations of total naphthenic acids are predicted to be higher in the updated results compared with predictions in the EIA in both pit lakes.

Athabasca River

Predicted water quality concentrations in the Athabasca River are presented for downstream of Redclay Creek in Table 3.3-6 and at Embarras in Table 3.3-7. The results for all assessment cases indicate that developments in the Oil Sands Region will not appreciably change the levels of acute and chronic toxicity, tainting potential or labile and refractory naphthenic acids in the Athabasca River at either assessment node.

Model results for the 2013 Base Case indicate that median and peak concentrations of aluminum, chromium, cobalt, iron and total phosphorus, as well as peak concentrations of cadmium, copper, mercury, lead, PAH Group 5, silver, sulphide, total nitrogen, total phenolics and zinc are predicted to exceed chronic guidelines for the protection of aquatic life in all snapshots. Constituents that are predicted to exceed guidelines under the 2013 Base Case snapshots are also predicted to do so under PIC conditions. The high background levels are generally associated with high total suspended solids from upstream of Fort McMurray and occur mostly during the spring season, consistent with the findings of Glozier et al. (2009).

The 2013 PRM Application Case results indicate that predicted effects on water quality in the Athabasca River are the same as those described in 2013 Base Case.

The environmental evaluation of potential surface water and sediment quality changes to the PAD (Appendix 3.4) indicated that changes due to PRM in conjunction with existing and approved developments would be negligible. This conclusion was based on a number of lines of evidence, including a literature review of existing studies, an analysis of data from those studies and the model results for the Athabasca River described above. Because effects on water and sediment quality were predicted to be negligible upstream of and within the PAD, the spatial extent of the aquatics RSA was verified to be appropriate. Based on this assessment, the effects for the 2013 PRM Application Case on surface water and sediment quality in the PAD are also considered negligible.

Table 3.3-6 Predicted Water Quality in Athabasca River at the Mouth of Redclay Creek

Parameter	Unit	Water Quality Guideline		Chronic Effect Benchmarks	Natural Variation Observed [c]	Pre-Industrial Case		2013 Base Case									
		Aquatic Life[a][b]				Median Concentration	Peak[d] Concentration	2018		2034		2042		2052		2152	
		Acute	Chronic					Median	Peak [d]	Median	Peak [d]	Median	Peak [d]	Median	Peak [d]	Median	Peak [d]
Aluminum	mg/L	0.75	0.1	0.15	0.88 (0.02 - 21) n = 136	**0.91**	**17**	**0.9**	**17**	**0.9**	**17**	**0.9**	**17**	**0.9**	**17**	**0.9**	**17**
Ammonia	mg/L	9.81	0.67	2	<0.05 (0.02 - 0.47) n = 146	0.042	0.18	0.048	0.2	0.05	0.21	0.05	0.21	0.051	0.21	0.049	0.2
Antimony	mg/L	-	-	0.157	0.000063 (0.000032 - 0.001) n = 124	0.00008	0.00027	0.0001	0.0003	0.0001	0.0003	0.00011	0.0003	0.00012	0.0003	0.00011	0.0003
Arsenic	mg/L	0.34	0.005	0.025	0.00082 (0.0003 - 0.0085) n = 165	0.0007	0.0031	0.0007	0.0031	0.0007	0.0031	0.0007	0.0031	0.0007	0.0031	0.0007	0.0031
Barium	mg/L	-	-	5.8	0.063 (0.042 - 0.53) n = 162	0.073	0.1	0.074	0.104	0.073	0.104	0.073	0.104	0.074	0.104	0.074	0.104
Beryllium	mg/L	-	-	0.0053	0.000065 (<0.000003 - 0.01) n = 136	0.0001	0.0009	0.0001	0.0009	0.0001	0.0009	0.0001	0.0009	0.0001	0.0009	0.0001	0.0009
Boron	mg/L	29	1.5	1.5	0.029 (0.015 - 0.052) n = 135	0.039	0.078	0.047	0.089	0.048	0.093	0.05	0.104	0.053	0.12	0.05	0.099
Cadmium	mg/L	0.0026	0.00031	0.00025	0.000032 (<0.000002 - 0.0005) n = 122	0.00009	**0.00039**	0.00011	**0.0004**	0.00011	**0.0004**	0.00011	**0.0004**	0.00012	**0.00041**	0.00012	**0.00041**
Calcium	mg/L	-	-	-	31 (21 - 60) n = 212	31	54	32	56	32	55	32	55	32	55	32	54
Chloride	mg/L	640	120	-	10 (1.3 - 54) n = 210	13	54	14	57	14	58	14	57	14	58	14	57
Chromium	mg/L	0.016	0.001	0.089	0.0019 (<0.00003 - 0.027) n = 167	**0.0025**	**0.011**	**0.0026**	**0.011**	**0.0026**	**0.011**	**0.0026**	**0.011**	**0.0026**	**0.011**	**0.0026**	**0.011**
Cobalt	mg/L	-	-	0.004	0.00056 (0.000044 - 0.01) n = 166	0.00081	0.007	0.00088	0.007	0.00088	0.007	0.00088	0.007	0.00088	0.007	0.00087	0.007
Copper	mg/L	0.017	0.0028	0.0256	0.0015 (0.00046 - 0.017) n = 167	0.0019	**0.012**	0.002	**0.012**	0.002	**0.012**	0.002	**0.012**	0.002	**0.012**	0.0019	**0.012**
Iron	mg/L	-	0.3	1.5	0.77 (0.066 - 17) n = 144	**0.85**	**9.5**	**0.9**	**9.5**	**0.9**	**9.5**	**0.9**	**9.4**	**0.9**	**9.5**	**0.9**	**9.5**
Lead	mg/L	0.103	0.004	0.005	0.00048 (0.000052 - 0.018) n = 136	0.0012	**0.023**	0.0012	**0.022**	0.0012	**0.023**	0.0012	**0.022**	0.0012	**0.022**	0.0012	**0.022**
Lithium	mg/L	-	-	-	0.0078 (0.002 - 0.023) n = 134	0.0092	0.016	0.0097	0.017	0.0097	0.017	0.0098	0.017	0.0099	0.017	0.0099	0.017
Manganese	mg/L	-	-	1.455	0.044 (0.0045 - 0.5) n = 168	0.033	0.29	0.039	0.29	0.038	0.29	0.038	0.29	0.038	0.29	0.034	0.29
Mercury	mg/L	0.000013	0.000005	0.00005	<0.000012 (<0.000000035 - 0.0001) n = 124	0.0000041	**0.000012**	0.0000046	**0.000013**	0.0000047	**0.000013**	0.0000048	**0.000013**	0.0000047	**0.000013**	0.0000044	**0.000012**
Molybdenum	mg/L	-	0.073	38.7	0.00069 (0.00014 - 0.015) n = 164	0.0011	0.0032	0.0018	0.0051	0.002	0.0057	0.0021	0.0066	0.0028	0.0099	0.0025	0.0073
Naphthenic acids - labile	mg/L	-	-	1	-	0.000	0.00	0.021	0.123	0.029	0.16	0.035	0.19	0.039	0.21	0.039	0.2
Naphthenic acids - refractory	mg/L	-	-	-	<1 (<0.004 - 3) n = 113	0.11	0.49	0.16	0.59	0.17	0.62	0.19	0.7	0.22	0.81	0.22	0.79
Naphthenic acids - total	mg/L	-	-	-	<1 (<0.004 - 3) n = 113	0.11	0.49	0.19	0.67	0.21	0.76	0.23	0.86	0.26	1.0	0.26	1.0
Nickel	mg/L	0.547	0.061	0.125	0.0018 (0.00003 - 0.044) n = 168	0.0037	0.016	0.0039	0.016	0.0038	0.016	0.0039	0.016	0.0039	0.016	0.0037	0.016
Nitrate	mg/L	124	2.93	-	0.1 (<0.001 - 0.6) n = 218	0.08	0.75	0.1	0.77	0.1	0.77	0.1	0.77	0.11	0.77	0.079	0.75
PAH group 1	µg/L	-	0.015	0.281	<0.01 (0.0013 - 0.088) n = 28	0	0.000	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001
PAH group 2	µg/L	-	0.018	0.278	<0.01 (0.0029 - 0.1) n = 28	0.000	0.005	0.001	0.005	0.001	0.005	0.001	0.005	0.001	0.005	0.001	0.005
PAH group 3	µg/L	-	-	0.99	<0.01 (0.00075 - 0.026) n = 28	0	0.011	0	0.011	0	0.011	0	0.011	0	0.011	0	0.011
PAH group 4	µg/L	-	5.8	41.5	<0.01 (0.00052 - <0.04) n = 28	0	0.001	0	0.002	0	0.001	0	0.001	0	0.001	0	0.001
PAH group 5	µg/L	-	0.012	5.6	<0.01 (0.005 - 0.65) n = 28	0.003	**0.017**	0.005	**0.017**	0.005	**0.017**	0.005	**0.017**	0.005	**0.017**	0.004	**0.016**
PAH group 6	µg/L	-	-	64	<0.04 (0.0011 - <0.049) n = 11	0	0.001	0	0.001	0	0.001	0	0.002	0	0.002	0	0.002
PAH group 7	µg/L	-	0.04	5.9	<0.01 (<0.01 - 0.43) n = 28	0.002	0.006	0.003	0.008	0.003	0.009	0.003	0.009	0.003	0.010	0.003	0.009
PAH group 8	µg/L	-	1.1	32	<0.01 (0.0084 - 0.21) n = 28	0.003	0.13	0.004	0.13	0.004	0.13	0.004	0.13	0.004	0.13	0.004	0.13
PAH group 9	µg/L	-	0.025	2.3	<0.01 (0.009 - 0.42) n = 28	0.001	0.004	0.001	0.004	0.001	0.004	0.001	0.004	0.002	0.004	0.001	0.004
Selenium	mg/L	-	0.001	-	0.0003 (0.000079 - 0.0014) n = 163	0.00022	0.00078	0.00025	0.00079	0.00025	0.00079	0.00025	0.00079	0.00026	0.00079	0.00023	0.00078
Silver	mg/L	0.0056	0.0001	0.00022	0.00001 (<0.0000005 - 0.00014) n = 124	0.000006	**0.00013**	0.000008	**0.00012**	0.000008	**0.00012**	0.000009	**0.00012**	0.000009	**0.00012**	0.000008	**0.00012**
Sodium	mg/L	-	-	-	13 (6.4 - 53) n = 209	17	45	18	49	18	49	18	50	18	52	18	51
Strontium	mg/L	-	-	14.1	0.21 (0.12 - 0.39) n = 135	0.26	0.45	0.26	0.45	0.26	0.45	0.26	0.45	0.26	0.46	0.26	0.45
Sulphate	mg/L	-	-	309	24 (4 - 67) n = 208	26	59	29	74	29	74	29	75	30	77	27	61
Sulphide	mg/L	-	0.014	0.002	0.004 (<0.001 - 0.22) n = 118	0.003	**0.083**	0.003	**0.083**	0.003	**0.083**	0.003	**0.083**	0.003	**0.083**	0.003	**0.083**
Tainting potential	TPU	-	1	-	-	0.00	0.0	0.023	0.33	0.036	0.43	0.043	0.52	0.051	0.55	0.052	0.47
Thallium	mg/L	-	0.0008	-	0.000034 (0.0000023 - 0.00037) n = 127	0.00004	0.00024	0.00004	0.00024	0.00004	0.00024	0.00004	0.00024	0.00004	0.0002	0.00004	0.00024
Total dissolved solids	mg/L	-	-	1000	178 (86 - 560) n = 180	185	320	194	354	194	352	195	356	197	362	192	339
Total nitrogen	mg/L	-	1	-	0.49 (<0.2 - 2.9) n = 192	0.7	**1.7**	0.7	**1.7**	0.7	**1.7**	0.8	**1.7**	0.8	**1.7**	0.7	**1.7**
Total phenolics	mg/L	-	0.004	0.01	0.003 (<0.001 - 0.05) n = 181	0.0027	**0.008**	0.0027	**0.008**	0.0027	**0.008**	0.0027	**0.008**	0.0027	**0.008**	0.0027	**0.0079**

Table 3.3-11 Predicted Water Quality in Athabasca River at the Mouth of Redclay Creek (continued)

Parameter	Unit	Water Quality Guideline		Chronic Effect Benchmarks	Natural Variation Observed [c]	Pre-Industrial Case		2013 Base Case									
		Aquatic Life[a][b]				Median Concentration	Peak[d] Concentration	2018		2034		2042		2052		2152	
		Acute	Chronic					Median	Peak [d]	Median	Peak [d]	Median	Peak [d]	Median	Peak [d]	Median	Peak [d]
Total phosphorus	mg/L	-	0.05	-	0.041 (0.015 - 1.8) n = 209	**0.053**	**0.6**	**0.055**	**0.59**	**0.054**	**0.6**	**0.055**	**0.59**	**0.054**	**0.59**	**0.054**	**0.59**
Toxicity- acute	TUa	0.3	0.3	-	-	0.017	0.12	0.019	0.13	0.019	0.13	0.02	0.13	0.021	0.14	0.02	0.13
Toxicity- chronic	TUc	-	1	-	-	0.007	0.053	0.019	0.114	0.022	0.13	0.023	0.14	0.025	0.15	0.018	0.1
Uranium	mg/L	0.033	0.015	-	0.0004 (0.0002 - 0.0022) n = 131	0.00052	0.00086	0.00054	0.00086	0.00053	0.00086	0.00054	0.00087	0.00054	0.00086	0.00053	0.00086
Vanadium	mg/L	-	-	0.0338	0.002 (0.00014 - 0.028) n = 190	0.002	0.021	0.0026	0.021	0.0027	0.021	0.0027	0.021	0.0027	0.021	0.0021	0.021
Zinc	mg/L	0.14	0.03	0.138	0.0054 (0.00088 - 0.13) n = 164	0.01	**0.038**	0.011	**0.038**	0.011	**0.038**	0.011	**0.038**	0.011	**0.038**	0.011	**0.038**

(a) - = No guideline / no data.

(b) From U.S. EPA (2002, 2003a, 2009), CCME (1999, 2012) and AENV (1999), assuming a pH of 8, temperature of 10°C and hardness of 120 mg/L (which are reflective of average conditions in the Athabasca River).

(c) Based on information from Golder (2000, 2001, 2002), RAMP (2005) and from Alberta Environment WDS stations: AB07DA0820\0850\0860\0870\0970\0980\1550 (AENV 2010).

(d) Peak concentrations represent 99.91 percentile values calculated from a model dataset containing more than 16,000 data points; with the exception of acute toxicity, which is a daily peak, concentrations are shown as four-day average concentrations.

Note: **Bold** value indicate that the predicted concentration exceeds the chronic guideline for the protection of aquatic life.

Table 3.3-7 Predicted Water Quality in Athabasca River at Embarras

Parameter	Unit	Water Quality Guideline Aquatic Life[(a)(b)]		Chronic Effect Benchmarks	Natural Variation Observed [(c)]	Pre-Industrial Case		2013 Base Case									
								2018		2034		2042		2052		2152	
		Acute	Chronic			Median Concentration	Peak[(d)] Concentration	Median	Peak [(d)]	Median	Peak [(d)]	Median	Peak [(d)]	Median	Peak [(d)]	Median	Peak [(d)]
Aluminum	mg/L	0.75	0.1	0.15	0.84 (<0.01 - 8.2) n = 75	**0.86**	**16**	**0.86**	**16**	**0.86**	**16**	**0.86**	**16**	**0.86**	**16**	**0.86**	**16**
Ammonia	mg/L	9.81	0.67	2	0.03 (<0.01 - 1) n = 197	0.042	0.2	0.047	0.19	0.048	0.18	0.048	0.18	0.049	0.19	0.048	0.18
Antimony	mg/L	-	-	0.157	0.00012 (0.00005 - <0.0008) n = 42	0.00013	0.0021	0.00013	0.0022	0.00014	0.0022	0.00014	0.0022	0.00014	0.0022	0.00014	0.0021
Arsenic	mg/L	0.34	0.005	0.025	0.0009 (<0.0001 - 0.018) n = 79	0.0011	0.0031	0.0011	0.0031	0.0011	0.0031	0.0011	0.0031	0.0011	0.0031	0.0011	0.0031
Barium	mg/L	-	-	5.8	0.066 (<0.001 - 0.27) n = 73	0.069	0.099	0.07	0.099	0.069	0.099	0.07	0.099	0.07	0.099	0.07	0.099
Beryllium	mg/L	-	-	0.0053	0.0002 (0.000017 - 0.0012) n = 55	0.0001	0.0008	0.0001	0.0008	0.0001	0.0008	0.0001	0.0008	0.0001	0.0008	0.0001	0.0008
Boron	mg/L	29	1.5	1.5	0.027 (<0.01 - 0.14) n = 49	0.038	0.08	0.045	0.082	0.046	0.085	0.047	0.093	0.05	0.11	0.049	0.093
Cadmium	mg/L	0.0026	0.00031	0.00025	0.00014 (0.000019 - 0.0026) n = 39	0.0002	**0.00064**	0.00021	**0.00072**	0.00021	**0.00073**	0.00021	**0.00073**	0.00022	**0.00075**	0.00022	**0.0007**
Calcium	mg/L	-	-	-	31 (<1 - 60) n = 263	30	53	31	54	31	53	31	53	31	53	31	53
Chloride	mg/L	640	120	-	12 (<0.5 - 65) n = 263	13	53	14	55	14	56	14	55	14	56	14	56
Chromium	mg/L	0.016	0.001	0.089	0.003 (0.00061 - 0.016) n = 101	**0.0044**	**0.013**	**0.0045**	**0.013**	**0.0045**	**0.013**	**0.0045**	**0.013**	**0.0045**	**0.013**	**0.0044**	**0.013**
Cobalt	mg/L	-	-	0.004	0.001 (0.00016 - 0.006) n = 76	0.00079	0.0068	0.00085	0.0068	0.00085	0.0068	0.00085	0.0068	0.00086	0.0068	0.00084	0.0068
Copper	mg/L	0.017	0.0028	0.0256	0.0024 (<0.0002 - 0.012) n = 104	**0.0043**	**0.012**	**0.0044**	**0.012**	**0.0044**	**0.012**	**0.0044**	**0.012**	**0.0044**	**0.012**	**0.0043**	**0.012**
Iron	mg/L	-	0.3	1.5	1 (<0.001 - 12) n = 93	**1.6**	**9.3**	**1.7**	**9.3**	**1.7**	**9.3**	**1.7**	**9.3**	**1.7**	**9.3**	**1.6**	**9.3**
Lead	mg/L	0.103	0.004	0.005	0.0012 (<0.0001 - 0.026) n = 73	0.0023	**0.023**	0.0023	**0.023**	0.0023	**0.023**	0.0023	**0.023**	0.0023	**0.023**	0.0023	**0.023**
Lithium	mg/L	-	-	-	0.007 (0.0039 - 0.054) n = 44	0.0088	0.015	0.0092	0.016	0.0093	0.016	0.0094	0.016	0.0095	0.016	0.0097	0.016
Manganese	mg/L	-	-	1.455	0.048 (<0.001 - 0.3) n = 102	0.062	0.29	0.069	0.29	0.068	0.29	0.068	0.28	0.068	0.28	0.064	0.28
Mercury	mg/L	0.000013	0.000005	0.00005	0.0000055 (<0.0000006 - 0.00005) n = 34	0.0000043	**0.000012**	0.0000046	**0.000012**	0.0000047	**0.000012**	0.0000048	**0.000012**	0.0000047	**0.000012**	0.0000045	**0.000011**
Molybdenum	mg/L	-	0.073	38.7	0.0008 (0.00034 - 0.007) n = 73	0.001	0.0031	0.0016	0.0043	0.0018	0.005	0.002	0.0057	0.0027	0.0091	0.0026	0.0079
Naphthenic acids - labile	mg/L	-	-	1	-	0.000	0.00	0.016	0.092	0.024	0.13	0.029	0.16	0.036	0.19	0.039	0.19
Naphthenic acids - refractory	mg/L	-	-	-	0.15 (0.053 - <1) n = 10	0.15	0.58	0.19	0.64	0.21	0.68	0.23	0.7	0.27	0.85	0.28	0.85
Naphthenic acids - total	mg/L	-	-	-	0.15 (0.053 - <1) n = 10	0.15	0.58	0.22	0.68	0.25	0.77	0.27	0.83	0.31	1.0	0.33	1.0
Nickel	mg/L	0.547	0.061	0.125	0.0037 (<0.0002 - 0.038) n = 77	0.0036	0.016	0.0037	0.016	0.0037	0.016	0.0037	0.016	0.0038	0.016	0.0037	0.016
Nitrate	mg/L	124	2.93	-	0.034 (<0.001 - 0.49) n = 263	0.082	0.7	0.1	0.71	0.1	0.71	0.1	0.71	0.1	0.71	0.085	0.69
PAH group 1	µg/L	-	0.015	0.281	<0.01 (<0.01 - <0.1) n = 16	0	0.000	0	0.001	0	0.001	0	0.001	0	0.001	0	0.001
PAH group 2	µg/L	-	0.018	0.278	<0.01 (<0.01 - <0.1) n = 16	0	0.005	0.001	0.005	0.001	0.005	0.001	0.005	0.001	0.005	0.001	0.005
PAH group 3	µg/L	-	-	0.99	<0.01 (0.003 - <0.2) n = 16	0	0.011	0	0.011	0	0.011	0	0.011	0	0.011	0	0.011
PAH group 4	µg/L	-	5.8	41.5	<0.01 (<0.01 - <0.1) n = 16	0	0.001	0	0.002	0	0.001	0	0.001	0	0.001	0	0.001
PAH group 5	µg/L	-	0.012	5.6	<0.01 (0.007 - <0.1) n = 16	0.003	**0.016**	0.004	**0.016**	0.005	**0.016**	0.005	**0.016**	0.005	**0.016**	0.004	**0.016**
PAH group 6	µg/L	-	-	64	<0.04 n = 1	0	0.001	0	0.001	0	0.001	0	0.001	0	0.002	0	0.001
PAH group 7	µg/L	-	0.04	5.9	<0.01 (<0.01 - <0.1) n = 16	0.002	0.005	0.002	0.007	0.002	0.008	0.003	0.008	0.003	0.009	0.003	0.008
PAH group 8	µg/L	-	1.1	32	<0.01 (0.009 - 0.18) n = 16	0.003	0.12	0.004	0.12	0.004	0.12	0.004	0.12	0.004	0.12	0.004	0.12
PAH group 9	µg/L	-	0.025	2.3	<0.01 (<0.01 - <0.1) n = 16	0.001	0.006	0.002	0.007	0.002	0.007	0.002	0.007	0.002	0.007	0.002	0.006
Selenium	mg/L	-	0.001	-	<0.0002 (<0.0001 - 0.0009) n = 78	0.00022	0.00076	0.00024	0.00076	0.00024	0.00076	0.00024	0.00077	0.00025	0.00077	0.00023	0.00076
Silver	mg/L	0.0056	0.0001	0.00022	0.000029 (0.0000016 - 0.0007) n = 35	0.00001	**0.00012**	0.000012	**0.00012**	0.000012	**0.00012**	0.000012	**0.00012**	0.000012	**0.00012**	0.000012	**0.00012**
Sodium	mg/L	-	-	-	15 (<1 - 55) n = 263	16	43	17	47	17	48	17	48	18	50	18	50
Strontium	mg/L	-	-	14.1	0.19 (0.11 - 0.3) n = 44	0.24	0.44	0.24	0.44	0.24	0.44	0.24	0.44	0.24	0.44	0.24	0.44
Sulphate	mg/L	-	-	309	23 (<0.5 - 62) n = 263	24	57	26	65	26	65	26	66	27	67	24	59
Sulphide	mg/L	-	0.014	0.002	<0.005 (<0.001 - 0.02) n = 85	0.004	**0.083**	0.004	**0.083**	0.004	**0.083**	0.004	**0.083**	0.004	**0.083**	0.004	**0.083**
Tainting potential	TPU	-	1	-	-	0.000	0.0	0.018	0.25	0.031	0.37	0.037	0.42	0.049	0.48	0.053	0.48
Thallium	mg/L	-	0.0008	-	0.000098 (0.0000065 - 0.00027) n = 43	0.00005	0.00023	0.00005	0.00023	0.00005	0.00023	0.00005	0.00023	0.00005	0.0002	0.00005	0.00023
Total dissolved solids	mg/L	-	-	1000	170 (16 - 450) n = 251	180	314	187	337	187	337	188	340	190	344	186	328
Total nitrogen	mg/L	-	1	-	0.57 (<0.01 - 3) n = 244	0.7	**1.6**	0.7	**1.6**	0.7	**1.6**	0.7	**1.6**	0.8	**1.6**	0.7	**1.6**

Table 3.3-7 Predicted Water Quality in Athabasca River at Embarras (continued)

Parameter	Unit	Water Quality Guideline		Chronic Effect Benchmarks	Natural Variation Observed [c]	Pre-Industrial Case		2013 Base Case									
		Aquatic Life[a][b]				Median Concentration	Peak[d] Concentration	2018		2034		2042		2052		2152	
		Acute	Chronic					Median	Peak [d]	Median	Peak [d]	Median	Peak [d]	Median	Peak [d]	Median	Peak [d]
Total phenolics	mg/L	-	0.004	0.01	<0.001 (<0.001 - 0.042) n = 175	0.0027	**0.0078**	0.0027	**0.0077**	0.0027	**0.0077**	0.0027	**0.0077**	0.0027	**0.0077**	0.0027	**0.0077**
Total phosphorus	mg/L	-	0.05	-	0.049 (0.004 - 0.75) n = 262	**0.053**	**0.57**	**0.054**	**0.57**	**0.054**	**0.57**	**0.054**	**0.57**	**0.054**	**0.57**	**0.054**	**0.57**
Toxicity- acute	TUa	0.3	0.3	-	-	0.017	0.12	0.019	0.13	0.019	0.13	0.019	0.13	0.02	0.13	0.02	0.13
Toxicity- chronic	TUc	-	1	-	-	0.007	0.053	0.016	0.096	0.019	0.11	0.02	0.12	0.022	0.13	0.018	0.1
Uranium	mg/L	0.033	0.015	-	0.0004 (<0.0001 - 0.003) n = 101	0.00049	0.00081	0.0005	0.00082	0.0005	0.00082	0.00051	0.00082	0.00051	0.00082	0.0005	0.00082
Vanadium	mg/L	-	-	0.0338	0.0018 (0.00026 - 0.02) n = 266	0.0019	0.02	0.0024	0.02	0.0024	0.02	0.0025	0.02	0.0025	0.02	0.002	0.02
Zinc	mg/L	0.14	0.03	0.138	0.0063 (0.00053 - 0.054) n = 252	0.011	**0.037**	0.011	**0.037**	0.011	**0.037**	0.011	**0.037**	0.011	**0.037**	0.011	**0.037**

[a] - = No guideline / no data.

[b] From U.S. EPA (2002, 2003a, 2009), CCME (1999, 2012) and AENV (1999), assuming a pH of 8, temperature of 10°C and hardness of 120 mg/L (which are reflective of average conditions in the Athabasca River).

[c] Based on information from Golder (2000, 2001, 2002), RAMP (2005) and from Alberta Environment WDS stations: AB07DA0010\0040\0060\0080\0250 (AENV 2010).

[d] Peak concentrations represent 99.91 percentile values calculated from a model dataset containing more than 16,000 data points; with the exception of acute toxicity, which is a daily peak, concentrations are shown as four-day average concentrations.

Note: **Bold** value indicate that the predicted concentration exceeds the chronic guideline for the protection of aquatic life.

3.3.2 Summary of Results

Within the LSA, acute and chronic toxicity and tainting potential levels are predicted to be lower than guideline values, and labile naphthenic acids are predicted to be less than 1 mg/L under the 2013 PRM Application Case at all assessment nodes. In general, concentrations of most substances are changed relative to the EIA because the model was recalibrated using the most up-to-date observed data, but those changes did not alter the conclusions of the EIA.

The assessment of water quality for the 2013 PRM Application Case for the Athabasca River was based on the re-calibrated ARM and included updated input sources. The conclusion of negligible changes to water quality concentrations in the Athabasca River in the 2013 PRM Application Case is consistent with the EIA conclusions.

Changes to water quality are further assessed for potential effects to aquatic health in Section 3.4, and to human and wildlife health in Sections 2.3 and 2.4, respectively.

3.4 Aquatic Health

This section presents an aquatic health assessment for the effects of the PRM, separated from those of the JME. It also compares the 2013 PRM Application Case to the PIC.

The Aquatic Health assessment builds upon the water quality predictions presented in Section 3.3. It evaluates potential impacts to aquatic health as a result of any Substances of Potential Concern (SOPCs) that are expected to significantly increase in concentration for the 2013 PRM Application Case relative to the PIC. The project assessment scenarios include the PIC and 2013 PRM Application Case.

Aquatic health, in the context of this assessment, refers to health of aquatic biota including fish and benthic invertebrates. The aquatic health assessment considers the potential effects on fish and benthic invertebrates due to changes in water quality from the PRM and other existing developments.

The aquatic health assessment methods were generally consistent with those outlined in the EIA, Volume 4A, Section 6.6.2. Briefly, the assessment methods involved the following:

- **Water Quality Effects –** Potential changes to water quality in local waterbodies, streams and pit lakes in the LSA were predicted using dynamic water quality modelling following the assessment methods described in Section 3.3 and the EIA, Volume 4, Appendix 4-2. The water quality predictions are presented in Section 3.3 of this Appendix. For the 2013 PRM Application Case, SOPCs were identified using the rationale and decision rules presented in the EIA, Volume 4A, Section 6.6.2.12, which requires that substances both exceed CEBs (Appendix 3.1, Section 2.8.3, Table 2.8-6) and increase by greater than 10% relative to the PIC concentrations. Environmental consequences associated with the individual SOPCs that met these two criteria were then evaluated by considering comparison to, and the toxicological basis of, the CEBs, and the effects classification scheme described in Appendix 3.1, Section 2.8.3.

- **Fish Tissue Effects –** Potential changes to fish tissue metal concentrations in the assessed rivers, streams and pit lakes within the LSA, were estimated by multiplying predicted median metal concentrations in water by parameter-specific Bioaccumulation Factors (BAFs). The only exception to this approach was for selenium, for which a non-linear model was used (discussed below). Only those parameters for which toxicological benchmarks could be reliably developed for depiction of the bioaccumulation pathway were considered (see Appendix 3.1, Section 2.8.3). Predicted fish tissue metal concentrations were compared to toxicological benchmarks that have been shown in laboratory studies to cause sublethal effects in fish; the benchmarks derived in the EIA, Volume 4, Section 6.6.2.12, Table 6.6-1 were applied here, with the exception of selenium. The environmental consequences associated with fish tissue metals concentrations predicted to exceed their respective toxicological benchmarks were evaluated using an approach similar to that for Water Quality Effects.

The aquatic health effects assessment (water quality effects and fish tissue effects) was conducted for the 2013 PRM Application Case versus the PIC. Aquatic health effects were assessed for small streams (combined assessment for Pierre River, Redclay Creek, Big Creek and Eymundson Creek) and pit lakes. For pit lakes, no comparison to the PIC was made because pit lakes were not present in the study area prior to development.

3.4.1 Assessment Results

3.4.1.1 Small Streams

Water Quality Assessment

For each SOPC the worst-case peak concentration that was identified in Section 3.3 of this assessment was selected from the watercourses in the LSA (Table 3.4-1). This concentration was assumed to apply to the entire LSA, regardless of the watercourse in which the exceedance was predicted to occur. As such, it was carried forward to the aquatic health assessment and was assumed to apply to Pierre River, Redclay Creek, Big Creek and Eymundson Creek.

Comparison of peak calcium, lithium, and sodium concentrations to SWQMF screening values suggested that the predicted concentrations of these substances were not of concern for maintaining aquatic health. Therefore, these substances were not retained as SOPCs.

A key consideration in the small streams assessment was the frequency of exceedance of the CEBs. Frequency of exceedance tables for SOPCs in each stream and snapshot are presented in Appendix 2, Attachment A.

Table 3.4-1 Substances Carried Forward to the 2013 PRM Application Case (Small Streams)

Parameter	Unit	Chronic Effects Benchmark	Pre-Industrial Case Peak Concentration	2013 PRM Application Case Peak Concentration	Snapshot	Watercourse
Aluminum	mg/L	0.15	3.9	8.1	2018	Big Creek
Cadmium	mg/L	0.00021	0.00032	0.00067	2018	Big Creek
Calcium	mg/L	1,000[(a)]	80	186	2018	Eymundson Creek
Cobalt	mg/L	0.004	0.0061	0.0084	2042	Pierre River
Copper	mg/L	0.0256	0.018	0.026	2034 and 2042	Eymundson Creek
Iron	mg/L	1.5	14	21	2018	Big Creek
Lead	mg/L	0.005	0.0069	0.0085	2034 and 2042	Eymundson Creek
Lithium	mg/L	2.5[(a)]	0.073	0.074	2037 and 2042	Redclay Creek
Manganese	mg/L	1.455	2.4	3.7	2034 and 2042	Eymundson Creek
Naphthenic acids – labile	mg/L	1	0	0.041	2052	Pierre River
Naphthenic acids – refractory	mg/L	19	1.4	2.5	2018	Eymundson Creek
Naphthenic acids – total	mg/L	1 or 19[(b)]	1.4	2.5	2018	Eymundson Creek
PAH group 1	µg/L	0.281	0	1.1	2018	Eymundson Creek
PAH group 2	µg/L	0.278	0	12	2018	Eymundson Creek
PAH group 5	µg/L	5.6	0	24	2018	Eymundson Creek
PAH group 7	µg/L	5.9	0	35	2018	Eymundson Creek
PAH group 9	µg/L	0.025	0	5.3	2018	Eymundson Creek
Selenium	mg/L	0.001[(a)]	0.0022	0.0035	2018	Big Creek
Sodium	mg/L	200[(a)]	23	36	2018	Eymundson Creek
Sulphate	mg/L	309 to 743	109	453	2018	Eymundson Creek
Total nitrogen	mg-N/L	-	2.6	3.9	2152	Pierre River
Total phenolics	mg/L	0.01	0.024	0.039	2018	Eymundson Creek
Total phosphorus	mg-P/L	-	0.94	1.4	2018	Big Creek
Vanadium	mg/L	0.0338	0.035	0.061	2018	Big Creek

(a) SWQMF screening value (Government of Alberta), used in place of a CEB.

(b) Either CEB may apply, see discussion in text.

Note: An evaluation of each substance is provided in more detail below.

- = No CEB for a given parameter.

Whole Effluent Toxicity

Levels of chronic and acute toxicity in Pierre River, and Redclay, Big and Eymundson creeks are predicted to be below the guidelines recommended by Alberta Environment and Sustainable Resource Development (AEP 1995) throughout the active life of PRM and into the Far Future (see Section 3.3). These guidelines represent no-effects thresholds for sensitive aquatic organisms. Achievement of acute and chronic guidelines provides confidence that aquatic health in these watercourses will be protected from the cumulative effects of SOPCs.

Metals

In the LSA, metals carried forward to the assessment included aluminum, cadmium, cobalt, copper, iron, lead, manganese, and vanadium. These parameters are expected to increase in small streams because of outflow from the pit lakes, groundwater seepages, and upstream diversions in the watershed. Baseline concentrations of total metals in most LSA headwaters, especially in Redclay Creek, are high relative to other waters in the Oil Sands Region. The elevated values in these LSA watercourses are thought to represent natural background levels for their respective drainages, and the erosion of polymetallic black shales in the Birch Mountain region (Dufresne et al. 1996) is a possible source of heterogeneity in background levels among watersheds. The elevated total metals concentrations are associated with high particulate loads in the samples; strong positive correlations are observed between Total Suspended Solids (TSS) and total metals in these watercourses.

The strong linkage between particulate matter and concentrations of total metals in watercourses has significant implications for the toxicity assessment of these substances, especially for those substances that are natural components of the mineral matrices found in the TSS mixture. Analysis of water chemistry data from the study area suggest that a large proportion of the total metals measured in the LSA watercourses is bound to suspended particles (primarily silts and clays, which have a high surface area for sorption and binding with metals). Particulate-bound metals are less available to aquatic organisms relative to dissolved metals, whereas the majority of literature-based studies of metal toxicity emphasize dissolved or highly bioavailable exposures. In the absence of detailed fractionation of samples between freely dissolved and bound/sorbed/complexed forms, the comparison of total concentrations provided a conservative starting point, but this approach is likely to overstate the actual biologically meaningful exposures.

An additional layer of conservatism in the modelled predictions is the assumption that only natural sources of particulate metals will settle and be removed from the water column in the small streams of the LSA. Given that none of the mine-related water sources currently exist for the PRM, the level of detail required to accurately model their fate processes cannot be estimated with certainty. Therefore, the conservative approach is to assume that these particulate metals will remain in suspension and contribute to the load in all downstream nodes. This approach has been shown to generate conservative predictions. In Shell's *October 15, 2012 Letter to the Joint Review Panel and Appendix B: Surface Water Model Validation Report,* Shell compared model predictions for the Muskeg River Mine Expansion EIA that used similar models and assessment methods to the PRM EIA were compared with measured values at two points in the Muskeg River, after the mine was approved and operational, and approximately five years after those predictions were made. This model validation study demonstrated that the model matched or over predicted actual concentrations for all modelled constituents. Specifically, aluminum was slightly over predicted, cadmium was over predicted by an order of magnitude (owing to improvements in analytical methods), iron predictions matched actual concentrations, and strontium was over predicted by a factor of two over the entire frequency curve.

Each of the metals identified as SOPCs (aluminum, cadmium, calcium, cobalt, copper, iron, lead, manganese, selenium and vanadium) are discussed in further detail below, in the context of water quality implications for aquatic health. Selenium was only assessed as part of the fish tissue assessment based on rationale provided in Appendix 3.1, Section 2.8.3.1.

Aluminum

Predicted peak aluminum concentrations are considerably higher than the CEB of 0.15 mg/L for all four watercourses and snapshots. The maximum peak concentration predicted for the 2013 PRM Application Case is 8.1 mg/L in Big Creek in the 2018 snapshot, which is 2.1 times that of the PIC peak concentration (i.e., 3.9 mg/L). Total aluminum concentrations are naturally high in watercourses located in the LSA, especially for Big Creek, which exhibited a maximum measured concentration of 51.1 mg/L in the spring months between 2006 and 2007 (EIA, Volume 3, Appendix F). Most of the variability in aluminum concentrations can be explained by the particulate load. Plots of total aluminum versus TSS for each watercourse (i.e., Pierre River, and Eymundson, Big and Redclay creeks) produced correlation coefficients for aluminum versus TSS concentrations that ranged from 0.57 to 0.85. The peak median total aluminum concentration was 18.2 mg/L, whereas the peak median concentration of dissolved aluminum was only 0.17 mg/L (EIA, Volume 3, Appendix F). A very large proportion of total aluminum would be associated with the particulate phase and therefore much less bioavailable to aquatic life relative to the forms of dissolved aluminum for which the CCME guideline has been derived.

The behavior and fate of aluminum in freshwater systems is highly complex and dependent on several variables. Aluminum toxicity is known to be influenced by pH, and the CEB derivation was limited to studies with pH representative of conditions in the LSA. However, aluminum can also react and form complexes with various ions (e.g., chloride, fluoride, sulphate, nitrate and phosphate), as well as dissolved organic carbon (ATSDR 2008; Wilson 2012), which may serve to reduce the bioavailability and subsequent toxicity to aquatic organisms in receiving water containing these substances. Inorganic monomeric aluminum species (i.e., dissolved or labile aluminum) are considered the most toxic forms of aluminum (Wilson 2012). Organic and complexed aluminum is less available and therefore less toxic to aquatic life.

In contrast to the bioavailability-limited aluminum forms discussed above, all of the studies included in the CEB derivation used relatively soluble and available forms of aluminum (i.e., inorganic aluminum salts) in the test treatments; these studies also did not distinguish between dissolved and total aluminum. The exact form of the aluminum released to small streams in the LSA is unknown, and the degree to which it is associated with particulates to which it would complex into more insoluble and unavailable forms is also uncertain. However it is expected that a significant fraction of aluminum would be associated with particulates and complexed. Therefore, the CEB based on laboratory studies with highly soluble aluminum is conservative, yielding a benchmark likely to be substantially lower than the concentration that could cause responses in aquatic organisms.

Based on the above, although predicted total aluminum concentrations are above the CEB, such exceedances largely reflect the influence of increased contributions of particulate matter, and fail to account for organic and complexed fractions of non-particulate aluminum. Association with particulates and complexation would lead to overall low bioavailability of aluminum to aquatic organisms, limiting the actual chronic effects. Consideration of these factors suggests that the potential for chronic effects is of low-magnitude in small streams of the LSA, classification with respect to other considerations (geographic extent, duration, frequency and reversibility) is discussed in the summary below.

Cadmium

The maximum peak concentration of cadmium is 0.67 µg/L, which is predicted for Big Creek in 2018 and is associated with overburden dewatering at project commencement. Measured baseline concentrations of total cadmium in watercourses located in the LSA were elevated, with the highest concentration (2.0 µg/L) observed in Big Creek in summer (EIA, Volume 3, Appendix F, Table F-33).

Although maximum predicted concentrations are above the lower bound of the CEB range (0.25 µg/L) for some of the watercourses, and slightly above the upper bound of the CEB range (0.62 µg/L) in one snapshot, bioavailability of cadmium is dependent on a range of abiotic conditions, such as hardness, alkalinity, pH and dissolved organic matter. Cadmium tends to partition to particulate matter and dissolved organic matter, upon entering the aquatic system, reducing concentrations of the free ion in the water column and thereby lowering its bioavailability (Jonnalagadda and Rao 1993). High dissolved solids and organic matter concentrations may reduce toxicity both through sorption to surfaces and/or complexation of free ions with suspended matter.

Peak concentrations that exceed the lower bound of the CEB and exceed the upper bound in one snapshot may be indicative of an occasional, short-term potential for chronic effects to aquatic life in small streams. However, frequency of exceedance of the CEB was low (lower than 5%) for all streams and snapshots. The PIC peak concentrations were also predicted to exceed this lower range in multiple streams of the LSA, which suggests that cadmium is naturally elevated. These considerations, combined with the site-specific factors limiting cadmium bioavailability, indicate that change in the potential for chronic effects on aquatic health would be negligible.

Cobalt

Predicted peak concentrations of total cobalt were above the CEB in the 2018, 2052 and 2152 Application Case snapshots; however, median predicted cobalt concentrations did not exceed the CEB. The 2013 PRM Application Case peak concentrations for total cobalt did not exceed the PIC peak concentrations by greater than 20% and the frequency of exceedance was very low in all watercourses (lower than 8%). Average measured baseline concentrations for total cobalt were 0.004 mg/L, consistent with predicted peak concentrations in the 2034 and 2042 snapshots. As such, predicted changes to the concentrations of total cobalt represent a negligible change in the potential for chronic effects on aquatic health.

Copper

The 2013 PRM Application Case predicted peak concentrations of total copper exceed the 0.0256 mg/L CEB by only a small amount in the 2034 and 2042 snapshots (i.e., 0.026 mg/L peak concentration of total copper). There is a very low predicted frequency of exceedance in all watercourses for all snapshots (lower than 1%). The 2013 PRM Application Case peak total copper concentration is 1.4 times that of the PIC concentration (0.018 mg/L) but is considerably lower than the maximum concentration measured in baseline monitoring of 0.26 mg/L.

As specified in the Appendix 3.6, as water hardness increases, the toxicity of copper decreases. Given the hard water conditions of the LSA (median hardness is 143 mg/L), combined with the very low frequency of exceedance, predicted changes to the concentrations of total copper represent a negligible potential for chronic effects on aquatic health.

Iron

Predicted peak iron concentrations in the LSA for the 2013 PRM Application Case are 1.5 times greater than for the PIC (i.e., 21 mg/L versus 14 mg/L respectively); however, median concentrations for the PIC and 2013 PRM Application Case are similar (i.e., 1.8 to 1.9 mg/L). Similar to aluminum, measured background concentrations of total iron in watercourses located in the LSA were elevated, with the highest concentration observed in Big Creek in winter (908 mg/L) (EIA, Volume 3, Appendix F, Table F-33). These observations suggest naturally occurring localized elevations in iron chemistry that are unlikely to be associated with ecological impairment due to PRM. Although the predicted total iron concentrations for the PIC and 2013 PRM Application Case are well above the 1.5 mg/L CEB, the likelihood of adverse effects on aquatic health is uncertain, because the total iron concentrations in the watercourses would be associated with suspended sediments (particulate matter), and therefore have low bioavailability.

Based on water quality modelling results for the 2013 PRM Application Case and the PIC, iron is expected to continue to be primarily present in particulate forms with more limited bioavailability to aquatic biota. It is expected that LSA waterbodies will be well oxygenated for most of the year, when iron will exist as insoluble and relatively non- toxic ferric iron, which, as stated in Appendix 3.6, is expected to have low bioavailability. Thus, the peak increase from the PIC to the 2013 PRM Application Case, which is not seen for median concentrations is unlikely to represent an ecological significant change to iron exposure. This means that the potential for chronic effects would be, at most, of low-magnitude in small streams of the LSA. Rating with respect to other considerations (geographic extent, duration, frequency, reversibility) is discussed in the summary below.

Lead

Peak total lead concentrations (0.0085 µg/L) predicted for the 2013 PRM Application Case are 1.2 times those of the PIC peak concentration and occasionally exceed the CEB (0.005 µg/L). However, there was a very low frequency of exceedance (lower than 1%) and median concentrations met the CEBs in all snapshots and watercourses. Although the peak concentrations suggest a potential for temporary conditions which could cause slight impairment of aquatic health in Big Creek and Eymundson Creek, under almost all conditions lead concentrations are expected to be below the CEB.

The low frequency of exceedance and low magnitude of CEB exceedance indicates that predicted concentrations of total lead represent a negligible change in the potential for chronic effects on aquatic health.

Manganese

Peak concentrations of total manganese for the 2013 PRM Application Case were 1.5 times the PIC peak concentrations, and were above the CEB of 1.455 mg/L in one or more snapshots for each watercourse (i.e., Pierre River, and Big, Eymundson and Redclay creeks). However, the frequency of exceedance was very low, with predicted concentrations exceeding the CEB less than 3% of the time for most watercourses and snapshots, with a higher exceedance of 14.8% in Redclay Creek for snapshot 2018, which was associated with muskeg and overburden dewatering during this time.

Measured background concentrations of total manganese in watercourses located in the LSA were similar to those predicted for the 2013 PRM Application Case, with the peak median concentration observed in Eymundson Creek in winter (8.4 mg/L) (EIA, Volume 3, Appendix F, Table F-31). Considering the similarity of the 2013 PRM Application Case to measured baseline conditions and the low frequency of exceedance, predicted concentrations of manganese represent a negligible change in the potential for chronic effects on aquatic health.

Vanadium

Predicted peak concentrations of total vanadium for the 2013 PRM Application Case are 1.7 times those of the PIC (total vanadium 2013 PRM Application Case 0.061 mg/L versus PIC 0.035 mg/L). The PIC and the 2013 PRM Application Case peak concentrations exceed the CEB of 0.0338 mg/L; however, the frequency of exceedance for all snapshots and watercourses (i.e., Pierre River, Big, Eymundson and Redclay creeks) is lower than 1%.

Measured background concentrations of total vanadium were an average of 0.015 mg/L and peak concentration of 0.57 mg/L. Considering the very low frequency of exceedance low magnitude of peak exceedance above the

PIC and CEB (less than 2-fold), predicted concentrations of total vanadium manganese represent a negligible change in the potential for chronic effects on aquatic health.

Summary of Potential Effects of Metals

For the metals that screened into the water quality assessment for the 2013 PRM Application Case, aluminum and iron are predicted to increase over time and to be sustained above CEBs due to upstream diversions in the watershed and outflow from the pit lakes. These elevated concentrations are associated with increased particulate matter rather than to dissolved-phase contributions to the water column. The potential for chronic effects associated with these changes is, therefore, rated as being low in magnitude high in frequency and local in geographical extent. Duration is rated as long-term, because the predicted increases are projected to occur during closure and after final reclamation is complete. These ratings are integrated in the Effects Classification in Section 3.4.1.2 resulting in an environmental consequence rating of low.

For the remaining metals (cadmium, copper, cobalt, lead, manganese and vanadium), conservative assumptions in the water quality predictions combined with median predicted concentrations that meet the CEBs, and a low frequency of exceedance of the CEBs for all small streams and snapshots, collectively indicate that the potential for aquatic health effects from these metals is negligible (i.e., environmental consequence is negligible).

Naphthenic Acids

As described in Appendix 3.6, the toxicity of total Naphthenic Acids (NA) mixtures depends on the relative proportions of labile and refractory NAs with an increase in the labile fraction increasing acute and chronic toxicity. As a result, separate CEBs were developed for labile NAs (1 mg/L) and refractory NAs (19 mg/L).

Predicted peak concentrations of labile and refractory NAs met their respective screening thresholds for all model snapshots in all of the small streams in the study area. However, predicted peak concentrations of total NAs exceeded the 1 mg/L threshold and were higher than PIC concentrations in multiple snapshots for Big Creek and Eymundson Creek, with highest peak concentrations of 2.5 mg/L NA.

Although predicted maximum peak concentrations of total NAs exceeded 1 mg/L in Big Creek and Eymundson Creek, the total NA mixtures would be composed of a large proportion of refractory NAs. The water quality predictions indicate negligible fractions of labile NAs in any of the snapshots for these waterbodies meaning that use of the threshold based on labile-dominated NAs is not appropriate; instead, the threshold for the refractory fraction of 19 mg/L based on studies of aged mixtures is more appropriate. In this regard, the predicted maximum peak total concentrations of NAs (i.e., 2.5 mg/L) are well below the threshold for refractory NAs.

Overall, predicted changes in NA concentrations represent a negligible change in the potential for chronic effects on aquatic health in small streams of the LSA because:

- the scenarios for which concentrations of NAs increase over time yield low concentrations relative to toxicity thresholds;
- the predicted concentrations of labile NAs fall far below the threshold for toxicity (1 mg/L) in the most sensitive species and relevant endpoint identified in chronic testing to date;
- the concentrations of total NAs (labile and refractory) in PRM scenarios fall below the approximate threshold for toxicity identified in aged oil sands process-affected waters from similar developments; and

- predicted toxicity values from whole effluent toxicity testing suggest a negligible effect on aquatic biota.

Polycyclic Aromatic Hydrocarbons

For small streams in the LSA, the Polycyclic Aromatic Hydrocarbons (PAHs) carried forward for the 2013 PRM Application Case included PAH Groups 1, 2, 5, 7 and 9. Peak concentrations of these PAH Groups were predicted to exceed their respective CEBs in Eymundson Creek for the 2018 snapshot only. These elevated PAH concentrations for 2018 are associated with PRM commencement activities, which will include a discharge of muskeg drainage and overburden dewatering to a watercourse that reports to Eymundson Creek. These waters will be drained continuously, with rates increasing during the open-water season (April to October). Following overburden removal, this discharge will no longer occur; consequently, peak PAH concentrations are predicted to meet CEBs for the 2034 snapshot (maximum muskeg dewatering) and future snapshots.

The potential effects on aquatic health for these individual PAH groups are discussed below. For all groups, important considerations which tend to mitigate the potential effects of predicted peak concentrations include the following:

- *Conservative Model Assumptions* – During the 2013 PRM Application Case represented by the 2018 snapshot, drainage waters will be retained in polishing ponds prior to discharge, and this retention is not accounted for in the water quality model. The PAHs are hydrophobic and are expected to sorb strongly to organic carbon in suspended sediments (discussed further below). Therefore, retention in polishing ponds is expected to result in removal of non-dissolved PAHs from the water column, prior to water discharge. Once drainage waters are discharged to Eymundson Creek, sorption to particulates followed by sedimentation is expected to continue, further reducing water column PAH concentrations, and this process was not accounted for in the water quality model. Thus, the predicted peak concentrations of PAH groups for the 2018 snapshot are likely overestimates because they do not account for sorption and sedimentation removal of PAHs in polishing ponds and in the aquatic receiving environment.

- *Overestimate of Bioavailable Fraction* – The model predictions were for total PAH concentrations as opposed to dissolved concentrations. It has been well-established, especially for organic compounds, that dissolved concentrations more properly represent the bioavailable fraction relative to total concentrations. Because they are hydrophobic, PAHs have a tendency to sort to dissolved organic carbon (e.g., humic acids) and particulate organic carbon in the water column, limiting the fraction of chemical that is truly dissolved and bioavailable. In contrast, the toxicity studies that were included in the CEB derivations in Appendix 3.6 and the target lipid model of McGrath and DiToro (2009) are based primarily on studies examining exposure to dissolved concentrations of PAHs. Thus, comparison of total PAH concentrations to these CEBs is likely to overestimate exposure to the bioavailable fraction, resulting in overestimation of potential effects to aquatic health.

Polycyclic Aromatic Hydrocarbon Groups 1, 5, 7 and 9

For PAH Groups 1, 5, 7 and 9, predicted peak concentrations in Eymundson Creek for the 2018 snapshot are approximately two to six fold above the corresponding CEB for each PAH Group (the groupings are described in Appendix 3.6). In all cases the median predicted concentrations are well below the CEBs, suggesting negligible potential for adverse effects under normal predicted conditions for this snapshot. The predicted frequency of exceedance for these PAH groups is also low (0% to 10.9%) for the 2018 snapshot. Considering the conservative model assumptions and overestimate of the bioavailable fraction, exceedances are only expected under maximum worst-case conditions that would rarely, if ever, apply to the PRM. Also, these predicted worst-case exceedances only occur for the 2018 snapshot, meaning that this limited potential for adverse effects only exists during this project phase. Several factors, including median concentrations that are well below CEBs, a low frequency of exceedance, the likely overestimate of peak concentrations, and reversibility, collectively indicate negligible incremental risk to aquatic health from these PAH groups under almost all conditions. The potential for low magnitude effects on aquatic health under worst-case conditions would be transitory.

The potential for chronic effects associated changes in concentrations of these PAH Groups are, therefore, rated as being low in magnitude, short-term and low in frequency, local in geographical extent, and reversible. These ratings are integrated in the Effects Classification in Section 3.4.1.2 resulting in an environmental consequence rating of negligible.

Polycyclic Aromatic Hydrocarbon Group 2

For PAH Group 2, the predicted peak concentration (12 µg/L) exceeded the CEB (0.278 µg/L) by approximately 43-fold for the 2018 snapshot in Eymundson Creek. Although the predicted median concentration was well below the CEB, the, high degree of exceedances of the peak concentrations and somewhat higher frequency of exceedance (27%) relative to the other PAH groups, suggests some low potential for adverse effects on aquatic health from peak concentrations of this PAH group. The PAH Group 2 represents high molecular weight PAHs including a variety of substitute chrysenes, anthracenes and pyrenes. The CEB was based on the concentration of 7,12-dimethylbenzanthracene estimated to protect 95% of species using the target lipid model of McGrath and DiToro (2009). Aquatic toxicity data for non-phototoxic effects for the PAHs included in Group 2 are limited, but the available information confirms a potential for sublethal and lethal effects near the predicted peak concentrations including:

- a Lowest Observed Effect Concentration (LOEC) of 12.5 µg/L 7,12-dimethylbenzanthracene for reproductive effects in Japanese medaka (summarized in McGrath and DiToro 2009);
- a 4-day LC50 (lethal concentration to 50% of organisms) of 10 µg/L for benz(a)anthracene toxicity to *Daphnia pulex* (Trucco et al. 1983); and
- decreased population growth in blue-green algae at 5 µg/L (Bastian and Toetz 1982).

Although peak concentrations and bioavailability of PAH Group 2 are likely overestimates (based on the considerations above) the magnitude of overestimation is uncertain. Worst-case peak concentration predictions are similar to known toxicity thresholds and are well above the CEB, suggesting a potential for adverse effects on aquatic health.

Given that the CEB is still met most of the time for the 2018 snapshot and that the peak concentrations would occur only occasionally, it can be concluded that emissions of PAH Group 2 from PRM pose a potential effect on aquatic health that is of low magnitude. This effect would be limited spatially (i.e., only in Eymundson Creek), short-term, of moderate frequency and reversible (i.e., a potential for exceeding peak concentrations only during overburden dewatering at project commencement). These ratings are integrated in the Effects Classification in Section 3.4.1.2 resulting in an environmental consequence rating of low.

Sulphate

Alberta does not have freshwater aquatic life water quality guidelines for sulphate, but the CEB range of 309 to 743 mg/L has been proposed using the recently finalized British Columbia water quality guidelines document for sulphate (Meays and Nordin 2013) using hardness conditions relevant to the PRM (moderately hard to hard water conditions).

The predicted 2013 PRM Application Case peak concentration of sulphate is 4.2 times greater than the PIC peak concentration (453 mg/L 2013 PRM Application Case concentration versus 109 mg/L PIC concentration). The 2013 PRM Application Case peak concentration exceeds the lower bound of the CEB range for sulphate of 309 mg/L only in the 2018 snapshot for Eymundson Creek. All other 2013 PRM Application Case snapshots and watercourses are predicted to be below the CEB. The frequency of exceedance in Eymundson Creek for the 2018 snapshot was very low (1%). Baseline data indicate an average sulphate concentration of 79.4 mg/L, with a peak concentration of 679 mg/L. The predicted 2013 PRM Application Case peak concentration of sulphate is well below the measured baseline peak concentration (453 mg/L 2013 PRM Application Case peak concentration versus 679 mg/L measured baseline peak concentration).

Based on the above, although there is a predicted exceedance of the sulphate CEB, this exceedance is limited to one snapshot and one watercourse, with a low frequency of occurrence. As such, predicted changes to the concentrations of sulphate for the 2013 PRM Application Case represent a negligible change in the potential for chronic effects on aquatic health.

Nutrients

Because watercourses in the LSA are relatively nutrient-rich, they are less sensitive to nutrient inputs relative to oligotrophic watercourses. Changes in nutrient concentrations in watercourses in the LSA have been evaluated in terms of the potential for eutrophication relative to PIC and 2013 PRM Application Case conditions.

The potential for eutrophication has been assessed primarily based on changes in total phosphorus concentrations; algal productivity is most likely to be limited by phosphorus, and national trigger levels have been established for this indicator substance (CCME 2004; Wetzel 2001). Under the PIC, total phosphorus concentrations were frequently measured in the eutrophic range and sometimes in the hyper-eutrophic range for this nutrient (Vollenweider and Kerekes 1982), which is common in aquatic systems across Eastern Alberta (ESRD 2012). Although the cited references for classification of hyper-eutrophication are intended to apply to lakes, they do give a general indication for streams in the LSA. This trophic status is not expected to change based on predicted changes in median phosphorus concentrations. Therefore, negligible effects on aquatic biota are expected in these watercourses under the 2013 PRM Application Case snapshots.

Because phosphorus and nitrogen contribute to nutrient enrichment in aquatic systems, it is possible that predicted increases in total nitrogen may lead to some nutrient enrichment; however, trophic values are not well established for nitrogen and less is known about the relationship between this nutrient and enrichment effects, relative to phosphorus. Environmental responses from simulated changes in total nitrogen concentrations have uncertainty, but are believed to be negligible in the LSA under the 2013 PRM Application Case snapshots. This conclusion is mainly based on the predicted lack of toxic effects from increased concentrations of ammonia, rather than the potential for nutrient enrichment, because phosphorus is expected to be the primary nutrient limiting algal growth.

Total Phenolics

The frequency of exceedance for total phenolics for all snapshots was between 0% and 8%, with one exception; the 2018 snapshot for Eymundson Creek was 0.039 mg/L, which was over three times the CEB (0.01 mg/L) and with a 48% frequency of exceedance. Peak concentrations of total phenolics in the PIC and 2013 PRM Application Case are above the chronic aquatic life guideline (0.004 mg/L) on a regional geographic extent, at a low magnitude and high frequency. The 2013 PRM Application Case peak concentration of total phenolics is 1.6 times the peak concentration of the PIC (0.024 mg/L PIC versus 0.039 mg/L 2013 PRM Application Case).

The PIC peak concentration is more than twice the CEB, and the average measured baseline concentration of total phenolics is 0.01 mg/L, reinforcing that phenols naturally occur in aquatic environments, particularly those in the proximity of late-successional boreal forests, which are dominated by plants with high tissue levels of phenolic compounds (CCME 1999; Dobbins et al. 1987). While it is possible that some fraction of the naturally occurring phenolics are due to the presence of erodible McMurray Formation, the elevated total phenolics concentrations in surface waters of the LSA are thought to be attributed mainly to the decomposition of vegetation.

Based on the above, although there is a moderate predicted exceedance of the total phenolics CEB, this low-level exceedance occurs mainly in the 2018 snapshot for Eymundson Creek and represents a negligible to low increase in the potential for chronic effects on aquatic health that wold be reversible, and is limited in duration and spatial extent. These considerations are integrated in the Effects Classification in Section 3.4.1.2 resulting in an environmental consequence rating of negligible.

Fish Tissue Assessment

Fish tissue metal concentrations in the small streams of the LSA were predicted to be below toxicological benchmarks for all substances considered with the exception of chromium (Table 3.4-2).

The estimated chromium tissue concentration for the 2013 PRM Application Case (1.04 mg/kg ww) is approximately two times the toxicological benchmark (0.58 mg/kg ww). The chromium benchmark is based on a muscle concentration that resulted in no significant effect (No Observed Effect Concentration [NOEC]) to survival of rainbow trout (Jarvinen and Ankley 1999).

Muscle concentrations in excess of the NOEC value will not necessarily result in detrimental effects. Moreover, the 2013 PRM Application Case water concentration predictions are conservative because they are for total concentrations rather than the bioavailable dissolved fraction, and the BAF used to estimate the tissue concentration was originally derived for human health purposes and is therefore conservatively applied to aquatic health assessment.

Given that the predicted value was conservatively derived and the exceeded benchmark is a NOEC value, the exceedance of the tissue toxicological benchmark likely overstates the potential for aquatic health effects from chromium accumulation. The predicted benchmark exceedance is considered unlikely to translate into ecologically significant effects to fish and therefore represents a negligible to low increase in the potential for chronic effects on aquatic health. Any effect would be local in scale, long-term and of high frequency (i.e., continuous accumulation), but reversible. These considerations are integrated in the Effects Classification in Section 3.4.1.2 resulting in an environmental consequence rating of low.

Table 3.4-2 Predicted Changes in Fish Tissue Concentrations Under the 2013 PRM Application Case (Small Streams)

Parameter	Tissue-based Toxicological Benchmarks[a] [mg/kg ww]	Bioconcentration Factor	Pre-Industrial Case		2013 PRM Application Case	
			Predicted Maximum Median Concentration in Water [mg/L]	Predicted Fish Tissue Concentration [mg/kg ww]	Predicted Maximum Median Concentration in Water [mg/L]	Predicted Fish Tissue Concentration [mg/kg ww]
Aluminum	20	1.7	0.19	0.3	0.27	0.5
Antimony	30	40	0.00076	0.03	0.0010	0.04
Arsenic	6.1	114	0.0015	0.17	0.0015	0.17
Cadmium	0.6	377	0.00009	0.03	0.00019	0.07
Chromium	0.58	385	0.0013	0.5	0.0027	**1.04**
Copper	3.4	243	0.0016	0.39	0.0025	0.61
Lead	4	38	0.00036	0.014	0.00054	0.021
Mercury	0.5	126,654	0.0000005	0.06	0.0000011	0.14
Nickel	0.82	39	0.0042	0.16	0.0046	0.18
Selenium[b]	20	lotic model[c]	0.00039	8.1[d]	0.00045	8.3[d]
Vanadium	0.41	62	0.0022	0.14	0.0033	0.2
Zinc	60	536	0.014	8	0.027	14

(a) Toxicological benchmarks are from Jarvinen and Ankley (1999) unless otherwise noted.

(b) Toxicological benchmark and estimated fish tissue concentrations are expressed as mg/kg dw in egg and ovary tissue (DeForest et al. 2011).

(c) Tissue selenium concentration was estimated using the lotic model developed by Orr et al. (2012).

(d) Dry weight estimate.

Note: **Bold** value exceeds toxicological benchmark.

3.4.1.2 Effects Classification for Small Streams

Activities associated with the 2013 PRM Application Case are predicted to cause changes in water quality in the LSA. Potential effects on aquatic health were evaluated in consideration of two potential effects pathways:

- direct effects occurring as a result of predicted changes to water quality; and
- indirect effects related to dietary consumption and possible accumulation of substances in fish tissue.

As discussed in Section 3.4.1.1 whole effluent acute and chronic toxicity levels in the LSA are predicted to be below guideline levels throughout the life of the PRM and into the Far Future.

The effects classification for the small streams 2013 PRM Application Case is presented in Table 3.4-3.

Table 3.4-3 Effects Classification for Aquatic Health – 2013 PRM Application Case, Small Streams

Parameter	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Toxic units	negative	negligible	N/A	N/A	N/A	N/A	negligible
Aluminum Iron	negative	low (+5)	local (+2)	long-term (+2)	high (+2)	reversible (-3)	low (+6)
Cadmium Copper Cobalt Lead Manganese Vanadium	negative	negligible	n/a	n/a	n/a	n/a	negligible
Naphthenic acids	negative	negligible	n/a	n/a	n/a	n/a	negligible
PAH Groups 1, 5, 7 and 9	negative	negligible-to-low (+5)	local (0)	short-term (0)	low (0)	reversible (-3)	negligible (+2)
PAH Group 2	negative	low (+5)	local (0)	short-term (0)	medium (+1)	reversible (-3)	negligible (+3)
Sulphate	negative	negligible	n/a	n/a	n/a	n/a	negligible
Nutrients	negative	negligible	n/a	n/a	n/a	n/a	negligible
Total phenolics	negative	negligible-to-low (+5)	local (0)	short-term (0)	low (0)	reversible (-3)	negligible (+2)
Fish Tissue (chromium)	negative	low (+5)	local (0)	long-term (+2)	high (+2)	reversible (-3)	low (+6)

Note: Numerical scores for ranking of environmental consequence are explained in EIA, Volume 3, Section 1.3.6.
n/a = Not applicable.

For multiple metals (cadmium, copper, cobalt, lead, manganese and vanadium), as well as sulphate, peak concentrations were predicted to exceed their respective CEBs, but predicted median concentrations met the CEBs for all watercourses and snapshots, and the frequency of exceedance of the CEB was very low. Given that the peak value predictions corresponded to the 99.91 percentile, or a one-day in three-year frequency of occurrence, and given the degree of conservatism in water quality predictions (i.e., overestimates of bioavailability inherent in the use of total metals concentrations), the magnitude of effect for these substances was considered to be negligible, and additional effects classification was not warranted. A similar conclusion was reached for NAs based on labile and refractory NAs meeting their respective CEBs, and the expectation that total NAs, being comprised primarily of the refractory fraction, will meet the CEB for this fraction. The predicted nutrient concentrations were not expected to change the trophic status of small streams in the LSA.

Aluminum and iron were predicted to have a low magnitude effect in the LSA. The evaluations of these substances were necessarily conservative because the details of chemical speciation, complexation and interaction with known toxicity modifying factors were not quantified. However, for both of these substances, the association with the particulate phase of the water column is likely to yield substantially lower bioavailability and toxicity than if the substances were present in dissolved form. Additionally, the models used to predict future concentrations have been confirmed to generate conservative predictions. As discussed in the preceding paragraph, benchmarks were applied to peak predicted concentrations that would occur rarely. Considering the magnitude, duration and spatial extent of the predicted changes to the concentrations of these substances during closure and after final reclamation is complete, it is unlikely that changes to the concentrations of these selected substances will be sufficient to affect the resistance or resilience of the ecosystems. Therefore, a rank of reversible was assigned to each of these substances and the effects classification resulted in an overall environmental consequence classification of low.

For PAHs, conservatively estimated peak concentrations were predicted to exceed their respective CEBs only for the 2018 snapshot, whereas predicted median concentrations met the CEBs for all watercourses and snapshots. For PAH groups 1, 5, 7 and 9, the consideration of median concentrations, low frequency of exceedance of CEBs, and limited duration of peak concentrations exceeding CEBs, collectively resulted in an overall environmental consequence classification of negligible. For PAH Group 2, peak concentrations were relatively high compared to the CEB, and frequency of exceedance of the CEB was higher (approximately 30%). These findings suggest a low-magnitude potential for chronic effects that is temporary in duration, and reversible. These considerations resulted in an overall classification of negligible based on the classification criteria described in the EIA, Volume 4a, Section 6.6.2.12 surface water quality assessment.

For total phenolics, the incremental change predicted for small streams relative to the PIC was low, suggesting that phenolics are naturally occurring in small streams of the LSA. The CEB was exceeded at a low level mainly in the 2018 snapshot for Eymundson Creek; the low potential for effects is considered to be reversible, and limited in duration and spatial extent. As such, predicted changes to the concentrations of total phenolics for the 2013 PRM Application Case were expected to result in negligible overall environmental consequence.

Concentrations of substances in fish tissues are also predicted to remain below screening toxicological benchmarks, with the possible exception of chromium. However, as discussed above, the magnitude of potential aquatic health effects as a result of chromium are expected to be low, given that the tissue benchmark is protective and the predicted total concentration of chromium may overestimate the bioavailable fraction.

Based on the effects criteria, concentrations of individual substances received negligible to low ratings for environmental consequence (Table 3.4-3). Of the individual substances considered in the assessment, changes in the concentrations of aluminum and iron in water, and chromium in fish tissue were deemed to be of low consequence to aquatic health, while all others were deemed to be negligible.

Potential effects resulting from elevated levels of these parameters may be over-estimated, because of the conservative assumptions used to complete the assessment. These substances are strongly influenced by site-specific factors that mediate bioavailability and toxicity. It was not possible to fully account for all factors that mediate speciation and aquatic toxicity of these substances using the screening water quality guidelines or CEBs. In many cases, the baseline concentrations at or above the CEBs, combined with the presence of a viable baseline aquatic community, indicate that CEBs may overstate the potential for adverse effects. When all lines of evidence are considered together, including predicted acute and chronic toxicity levels, as well as predicted changes to sediment quality, water quality and fish tissue metal concentrations, potential changes to aquatic health resulting from PRM are expected to be negligible to low for small streams in the LSA.

3.4.1.3 Pit Lakes

The capability of the pit lakes to support aquatic life, and the potential for aquatic health effects from pit lakes water discharge, was evaluated in consideration of predicted water and fish tissue quality in each pit lake, both when the lakes begin discharging to the environment, and in the Far Future.

Individual substances that were identified as having the potential to affect aquatic health in the pit lakes were identified in Section 3.3. For each substance identified as having the potential to affect aquatic life, the worst-case concentrations were selected from the pit lakes in the LSA (Table 3.4-4). These maximum values were carried forward to the 2013 PRM Application Case assessment.

Table 3.4-4 Substances Carried Forward to the 2013 PRM Application Case (Pit Lakes)

Parameter	Unit	Chronic Effects Benchmark (CEB)	Predicted Peak Concentrations in Water			
			2052	Pit Lake	2152	Pit Lake
Cadmium	µg/L	0.25 to 0.62	0. 48	South Pit Lake (upstream cell)	0.47	South Pit Lake (upstream cell)
Lithium	mg/L	2.5[(a)]	-	-	0.039	North Pit Lake
Naphthenic acids – labile	mg/L	1.0	0.22	North Pit Lake	0.0041	North Pit Lake
Naphthenic acids – refractory	mg/L	19	12	South Pit Lake (upstream cell)	3.5	South Pit Lake (downstream cell)
Naphthenic acids – total	mg/L	1 or 19[(b)]	12.6	South Pit Lake (upstream cell)	3.5	South Pit Lake (downstream cell)
Sodium	mg/L	200[(a)]	81	South Pit Lake (upstream cell)	30	South Pit Lake (downstream cell)

(a) SWQMF screening value.

(b) Either CEB may apply, see discussion in text.

Note: An evaluation of each substance is provided in more detail below.

- = Lack of data or CEBs for a given parameter.

As with the small streams assessment, comparison to the SWQMF screening values for calcium, lithium and sodium suggested that the predicted peak concentrations of these substances were not of concern for aquatic health and they were not retained as SOPCs for the pit lakes assessment.

Water Quality Assessment

Whole Effluent Toxicity

Levels of acute and chronic toxicity in the pit lakes were predicted to be below the 0.3 TU_a and 1 TU_c threshold recommended by Alberta Environment and Sustainable Resource Development (AEP 1995). These predictions apply to the time of discharge to the receiving environment and also into the Far Future. As acute and chronic toxicity predictions account for synergistic interactions among individual substances, these results provide a high level of confidence that the pit lakes will be able to support aquatic life.

Cadmium

Cadmium concentrations are predicted to increase due to direct input of process-affected water and/or process-affected seepage from the reclaimed landscape or high concentrations in Athabasca River water used for pit lakes filling. The maximum predicted peak concentration of cadmium is 0.48 µg/L, for the upstream cell of the South Pit Lake in the 2052 snapshot; this value is within the CEB range of 0.25 to 0.62 µg/L. Baseline measurements indicate that total cadmium is naturally elevated in some watercourses of the LSA with maximum observed concentrations of 3.65 µg/L. Although maximum predicted concentrations are within the CEB range, cadmium partitioning behavior in natural systems can mitigate against toxicity. Cadmium tends to partition to particulate matter and dissolved organic matter upon entering the aquatic system, reducing concentrations of the free ion in the water column and thereby lowering its bioavailability (Jonnalagadda and Rao 1993).

Peak concentrations that fall within the CEB range may be indicative of a potential for low-level chronic effects in aquatic life of the pit lakes. However, measured and predicted peak concentrations of cadmium were also predicted to exceed this lower range in multiple streams of the LSA, suggesting that the waters used to fill the pit lakes would also be a natural source of elevated cadmium. As with cadmium in small streams, these considerations, combined with the factors discussed above which would limit cadmium bioavailability, suggest that the overall magnitude of effect on aquatic health in pit lakes would be negligible.

Naphthenic Acids

Predicted concentrations of labile and refractory NAs met their respective screening thresholds for all model snapshots for pit lakes. Predicted concentrations of total NAs exceeded the 1 mg/L benchmark for the 2052 and 2152 snapshots with a highest concentration of 12.6 mg/L. However, this 1 mg/L benchmark is unlikely to provide an accurate representation of the threshold for chronic effects for total NAs, because ageing of the NA mixtures results in removal of labile fractions and a reduction in toxicity (Holowenko et al. 2002).

Following PRM closure and in the Far Future, the total NA concentrations in pit lakes would be composed of primarily refractory NAs, as indicated by the ranges of predicted labile NAs (0.0019 to 0.22 mg/L) relative to the ranges of predicted refractory NAs (1.3 to 12.5 mg/L). Thus, use of the threshold based on labile-dominated NAs is not appropriate; instead, the threshold for the refractory fraction of 19 mg/L based on studies of aged mixtures is more relevant to site conditions. The range of predicted total NA concentrations is below the benchmark for refractory NAs and therefore predicted NA concentrations in pit lakes are expected to have a negligible effect on aquatic biota in pit lakes.

Fish Tissue Assessment

Predicted fish tissue concentrations in all pit lakes were projected to be below the toxicological benchmarks for all assessed substances, with the exception of chromium, mercury and vanadium (Table 3.4-5).

Table 3.4-5 Predicted Changes in Fish Tissue Concentrations Under the 2013 PRM Application Case (Pit Lakes)

Parameter	Predicted Concentrations in Water [mg/L]		Tissue-Based Toxicological Benchmark[a] [mg/kg ww]	Bioconcentration Factor	Predicted Fish Tissue Concentration [mg/kg ww]	
	2052	2152			2052	2152
Aluminum	1.5	0.27	20	1.7	2.6	0.46
Antimony	0.00092	0.00095	30	40	0.037	0.038
Arsenic	0.002	0.0023	6.1	114	0.22	0.27
Cadmium	0.00048	0.00023	0.6	377	0.18	0.09
Chromium	0.0038	0.002	0.58	385	**1.5**	**0.8**
Copper	0.0036	0.0022	3.4	243	0.9	0.53
Lead	0.0017	0.00052	4	38	0.06	0.02
Mercury	0.0000089	0.0000016	0.5	126,654	**1.13**	0.2
Nickel	0.0066	0.0058	0.82	39	0.26	0.23
Selenium[b]	0.00073	0.00081	20	lentic model[c]	16.0[d]	16.4[d]
Vanadium	0.0072	0.0042	0.41	62	**0.45**	0.26
Zinc	0.016	0.017	60	536	9	9

(a) Toxicological benchmarks are from Jarvinen and Ankley (1999) unless otherwise noted.

(b) Toxicological benchmark and estimated fish tissue concentrations are expressed as mg/kg dw in egg and ovary tissue (DeForest et al. 2011).

(c) Tissue selenium concentration was estimated using the lentic model developed by Orr et al. (2012).

(d) Dry weight estimate.

Note: **Bold** numbers exceeds toxicological benchmark.

Chromium

The maximum estimated tissue concentration of chromium in the pit lakes is 1.5 mg/kg ww (South Pit Lake in 2052), which is approximately 2.5 times the toxicological benchmark (0.58 mg/kg ww). The chromium benchmark is based on a muscle concentration that resulted in no significant effect (NOEC) to survival of rainbow trout (Jarvinen and Ankley 1999). Given that the predicted value was conservatively derived and the exceeded benchmark is a NOEC value, the exceedance of the tissue toxicological benchmark likely overstates the potential for aquatic health effects from chromium accumulation. The predicted benchmark exceedance is considered unlikely to translate into ecologically significant effects to fish and therefore represents a negligible to low increase in the potential for chronic effects on aquatic health. Any effect would be local in scale, long-term and of high frequency (i.e., continuous accumulation), but reversible. These considerations are integrated in the Effects Classification in Section 3.4.1.4 resulting in an environmental consequence rating of low.

Mercury

The maximum estimated tissue concentration of mercury in the pit lakes was 1.13 mg/kg ww, just over twice the toxicological benchmark (0.5 mg/kg ww). This predicted maximum concentration is marginally above the IC_{20} threshold of 1 mg/kg ww based on the most sensitive endpoint of available data (i.e., before application of the safety factor; refer to Appendix 3.6). As discussed in Appendix 3.6, the available toxicity data for mercury in fish tissue from the literature is highly variable but the magnitude and frequency of adverse responses in fish appears to increase at concentrations close to 1.0 mg/kg ww total mercury. There is uncertainty in the likelihood of adverse effects at concentrations below 1 mg/kg ww; therefore, a CEB of half this value was selected as being sufficiently protective of fish in the LSA. Comparison to benchmarks derived by other authors (Beckvar et al. 2005; EVS 1999; Sandheinrich and Wiener 2011; Wiener and Spry 1996) indicated that the value of 0.5 mg/kg ww was in alignment with the work of others.

The maximum predicted concentrations of mercury in fish are at levels where there is potential for small increases (0-20%) in the risk of chronic effects on survival, reproduction and growth in sensitive fish species based on the CEB developed here and thresholds developed by other authors. Accordingly, it was concluded that predicted mercury concentrations represent a low increase in the potential for chronic effects on aquatic health that is local in scale, long-term and of high frequency (i.e., continuous accumulation), but reversible. These considerations are integrated in the Effects Classification in Section 3.4.1.4 resulting in an environmental consequence rating of low.

Vanadium

The maximum estimated tissue concentration of vanadium in the pit lakes is 0.45 mg/kg ww, which is marginally above the toxicological benchmark of 0.41 mg/kg ww derived from Jarvinen and Ankley (1999). The toxicological benchmark for vanadium is based on an approximate 60% reduction (compared to control) in final body weight for juvenile rainbow trout with a carcass tissue concentration of 2.05 mg/kg dw (Hilton and Bettger 1988). This tissue concentration is equivalent to 0.41 mg/kg ww when converted using a dry weight to wet weight conversion factor of 0.2. In the same study, there was no effect on survival up to a carcass tissue concentration of 5.33 mg/kg ww.

The predicted tissue concentration exceeds the benchmark by a relatively small degree (1.1), but is based on a significant response size for a chronic endpoint (60% reduction in growth). Therefore, the exceedance of the tissue benchmark was interpreted to be indicative of a low increase in the potential for chronic effects on aquatic health that is local in scale, long-term and of high frequency (i.e., continuous accumulation), but reversible.

These considerations are integrated in the Effects Classification in Section 3.4.1.4 resulting in an environmental consequence rating of low.

3.4.1.4 Effects Classification for Pit Lakes

Activities associated with the 2013 PRM Application Case are predicted to influence water quality in pit lakes, affecting their ability to support aquatic life after Closure, and the potential for discharged water to affect aquatic health in receiving streams. Potential effects on aquatic health after Closure were evaluated in consideration of two potential effects pathways:

- direct effects occurring as a result of predicted changes to water quality; and
- indirect effects related to dietary consumption and possible accumulation of substances in fish tissue.

The effects classification for the 2013 PRM Application Case and pit lakes is presented in Table 3.4-6.

Whole effluent acute and chronic toxicity levels in the PRM pit lakes are predicted to be below guideline levels at Closure and into the Far Future.

Table 3.4-6 Effects Classification for Aquatic Health – 2013 PRM Application Case, Pit Lakes

Parameter	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental Consequence
Toxic units	negative	negligible	n/a	n/a	n/a	n/a	negligible
Cadmium	negative	negligible	n/a	n/a	n/a	n/a	negligible
Naphthenic acids	negative	negligible	n/a	n/a	n/a	n/a	negligible
Fish tissue quality (chromium, mercury, vanadium	negative	low (+5)	local (0)	long-term (+2)	high (+2)	reversible (-3)	low (+6)

Note: Numerical scores for ranking of environmental consequence are explained in EIA, Volume 3, Section 1.3.6.
n/a = Not applicable.

For cadmium and NAs, magnitude of potential aquatic health effects was considered to be negligible and additional effects classification was not warranted. In the case of cadmium, the highest predicted pit lakes concentration fell below the hardness-adjusted CEB indicating negligible likelihood of effects once site-specific conditions were accounted for. For NAs the conclusion was based on labile and refractory NAs meeting their respective CEBs, and the expectation that total NAs, being comprised primarily of the refractory fraction, will meet the CEB for this fraction.

Concentrations of substances in fish tissues are predicted to remain below toxicological benchmarks, with the possible exception of chromium, mercury and vanadium. The magnitude of the tissue benchmark exceedances for these metals reflect a conservative assessment because the predicted total concentrations of metals in water overestimate the fraction that is bioavailable for accumulation in fish tissue. As a result, the potential magnitude of effects for accumulation of these metals in fish tissue was considered low. In light of the magnitude, duration and spatial extent of the predicted water quality changes during Closure and after final reclamation is complete, it is unlikely that changes will be sufficient to affect the resistance or resilience of the ecosystems. Therefore, as per the classification criteria described in the surface water quality assessment in the EIA, Volume 5, Section 4.12.2.3 of, a rank of reversible was assigned to each of these substances.

Based on the Effect Classification approach described in the surface water quality assessment in the EIA, Volume 5, Section 4.12.2.3, concentrations of individual substances received negligible to low ratings for environmental consequence (Table 3.4-6). When all lines of evidence are considered together, including predicted acute and chronic toxicity levels, as well as predicted changes to sediment quality, water quality and fish tissue metal concentrations, the PRM pit lakes are expected to be able to support viable aquatic ecosystems, and discharged waters are not anticipated to impair aquatic health in receiving streams.

3.4.1.5 Prediction Confidence

Residual effects predictions for aquatic health in the LSA are based upon conservative modelling and multiple lines of evidence, including predicted levels of whole effluent chronic and acute toxicity, predicted concentrations of individual substances in water and fish tissue, and changes to sediment quality. Results of uncertainty analyses indicate that the water quality predictions are robust, particularly with respect to whole effluent toxicity (see EIA, Volume 4B, Appendix 4-2). The greatest uncertainties relate to the partitioning, degradation, and/or speciation of these substances in the environment, as opposed to uncertainty in the total concentrations observed in Project media. As a result, confidence in the overall predictions to aquatic health is moderate to high.

3.4.2 Summary of Results

Activities associated with the 2013 PRM Application Case are predicted to influence water quality in receiving watercourses and waterbodies and in pit lakes. Potential effects on aquatic health were evaluated in consideration of two potential effects pathways:

- direct effects occurring as a result of predicted changes to water quality; and
- indirect effects related to dietary consumption and possible accumulation of substances in fish tissue.

Concentrations of individual substances received negligible to low ratings for environmental consequence. When all lines of evidence are considered together, including predicted acute and chronic toxicity levels, as well as predicted changes to sediment quality, water quality and fish tissue metal concentrations, PRM pit lakes are expected to be able to support viable aquatic ecosystems, and discharged waters are not anticipated to impair aquatic health in receiving streams.

3.5 Fish and Fish Habitat

A bridge and a water intake structure on the Athabasca River will be constructed for PRM. This infrastructure is described in the EIA, Volume 4A, Section 6.7.7.2. The assessment conclusions from the EIA Application Case associated with this infrastructure remain unchanged for the 2013 PRM Application Case.

With the exception of impacts to flows and water quality of the Athabasca River, the impacts to local watercourses and waterbodies are separate for PRM and JME. Accordingly, the hydrology and water quality assessments in the EIA Application Case for the PRM LSA, with the exception of the Athabasca River, are not influenced by JME development. Therefore, reassessment of impacts to fish and fish habitat for streams other than the Athabasca River within the PRM LSA was not required. An assessment is provided for the Athabasca River omitting effects due to the JME development.

3.5.1 Assessment Results

The assessment of changes in flows and water quality in the Athabasca River for the EIA Application Case was provided in the EIA, Volume 4A, Section 6.7.7.2. Negligible changes to water quality in the Athabasca River are predicted under the 2013 PRM Application Case as described in Section 3.4 of this Appendix, and therefore, the conclusions from the EIA remain unchanged.

A majority of the flow changes assessed in the EIA Application Case were due to the development of PRM because JME will rely on existing water allocations for a majority of the JME water supply. The effects of PRM to fish and fish habitat and the Athabasca River without JME would remain unchanged from the EIA Application Case due to the consideration of the Water Management Framework for the Lower Athabasca River (AENV and DFO 2007). The proportion of flow reduction in the Athabasca River caused by PRM in the 2013 PRM Application Case are low as described in Section 3.2 of this Appendix, ranging from 0.34% in the summer to 1.5% in the winter. However, regardless of the magnitude of diversion, PRM would be subject to the withdrawal restrictions in the Water Management Framework, which are designed to minimize the duration and frequency of potential cumulative habitat effects, and protect the aquatic ecosystem and associated fisheries of the Athabasca River. Shell has committed to meeting water withdrawal restrictions associated with the Water Management Framework. This includes a commitment to reducing water withdrawals to zero under winter low-flow conditions within the “red zone” as defined by the Water Management Framework, and as proposed and agreed upon by Shell in the Phase 2 recommendations for the framework that are currently under consideration (Ohlson et al. 2010). As a result, the effects to fish and fish habitat in the Athabasca River under the 2013 PRM Application Case due to PRM water withdrawals are negligible.

3.5.2 Summary of Results

Based on the mitigations in place in the form of the Water Management Framework to manage cumulative water withdrawals from the Athabasca River and the updated assessment on water quality for the 2013 PRM Application Case, the effects to Fish and Fish Habitat due to PRM are negligible and remain unchanged from the conclusions presented in the EIA Application Case.

4.0 TERRESTRIAL RESOURCES

4.1 Introduction and Approach

This section presents the 2013 PRM Application Case assessment focused on PRM, without JME, in combination with existing and approved developments as of June 2012. To allow the development of environmental consequence ratings for Terrestrial Resources components, 2013 Base Case information has also been included. The Terrestrial Resources sections of the EIA (Volume 5, Sections 7.1 to 7.6) provided Soils and Terrain; Terrestrial Vegetation, Wetlands and Forest Resources; Wildlife and Wildlife Habitat; and Biodiversity assessments for JME and PRM in combination with existing and approved regional developments.

The objective of the Soils and Terrain assessment (Section 4.2) is to predict the potential effects associated with the construction, operation and final reclamation of PRM and the existing and approved developments on terrain units, soil and soil quality.

The objective of the Terrestrial Vegetation, Wetlands and Forest Resources assessment (Section 4.3) is to predict the potential effects associated with the construction, operations and final reclamation of PRM on plant communities and species (i.e., economic forests, rare plants, rare and special plant communities, traditional use plants and Key Indicator Resources [KIRs]).

The objective of the Wildlife and Wildlife Habitat assessment (Section 4.4) is to predict the potential effects associated with the construction, operations and final reclamation of PRM on wildlife abundance, wildlife habitat, and wildlife movement for KIRs including species at risk. Effects on wildlife health were discussed previously in Section 2.4.

The objective of the Biodiversity assessment (Section 4.5) is to predict the potential effects associated with the construction, operations and final reclamation of PRM on species-level, ecosystem-level and landscape-level biodiversity. An updated biodiversity assessment was not specifically requested in JRP SIR 7 but is provided to explicitly tie together the interacting effects of the PRM on fish, vegetation and wildlife at the species, ecosystem, and landscape levels.

The approaches used for these assessments are the same as the approaches used in the EIA with the following exceptions:

- Species at Risk are incorporated as Key Indicator Resources (KIRs) into the wildlife assessment, building from the work previously submitted in the *May 2011, Submission of Information to the Joint Review Panel*, Appendix 2, Federally Listed Species at Risk Assessment, Appendix B.
- The ALCES® model was used to simulate forest fire and harvest information. Landscape simulations were conducted using the ALCES® and ALCES Mapper® computer programs. The ALCES® program was used to simulate the effects of fire, timber harvest, and industrial development in the RSA over a 60-year period. The ALCES Mapper® program was used to simulate the potential spatial configuration of fire and timber harvest. The revised model of burns and cutblocks was applied to the Terrestrial Resources assessment for the 2013 Base Case and 2013 PRM Application Case in this appendix.
- Direct and indirect effects due to groundwater drawdown are delineated. With the exception of landscape fragmentation analysis conducted for the LSA, the biodiversity effects analyses are based on the direct effects of the PRM's disturbance footprint in addition to the indirect effects of groundwater drawdown.

- Updated Alberta Biodiversity Monitoring Institute (ABMI), Alberta Conservation Management Information System (ACIMS), and Fisheries and Wildlife Management Information System were incorporated into the updated assessment of the effects of the PRM.
- An updated disturbance layer was applied to all components of the terrestrial assessment, and was incorporated into predictive models. Updated linear feature data were obtained from the Government of Alberta in February 2013. Access features including roads and cutlines were updated as of October 2010 and May 2011 (depending on the location in the RSA). Updates are based on interpretation of linear features from satellite imagery. Pipelines and well site updates were obtained from IHS Energy in February 2013 and are current as of November 2012. Within the LSA, both linear and non-linear disturbances were updated by Golder Associates Ltd. (Golder) based on August 2011 high-resolution satellite imagery.
- Forest stands at Closure are considered to be 80 years old (*May 2011, Submission of Information to the Joint Review Panel*, Appendix 2, Federally Listed Species at Risk Assessment, Appendix B). Eighty years represents the estimated time required for the development of mature forest on the reclaimed landscape, and is a more appropriate time frame upon which to compare vegetation, wildlife and biodiversity values in the reclaimed landscape against the EIA Base Case values (EIA, Volume 5, Section 7.2.3). However, this represents a change from the EIA (Volume 5, Section 7.2.3) for habitat suitability modelling, in which stand ages of original wildlife KIRs were assigned using mine progression diagrams to represent stand ages at the point in time at which Closure occurs (i.e., 2070), and therefore resulted in closure landscape much younger than that used for habitat suitability modelling here. The assumptions regarding stand age at Closure were changed from those used in the EIA because mature forest stands at Closure represent a more appropriate time frame for the assessment of long-term PRM effects. Robust ecological communities and processes will take time to develop on the closure landscape.

  Detailed information on approach modifications is provided in Appendix 3.1 (Section 2.8).

4.2 Soils and Terrain Assessment

The effects of PRM and JME combined with existing and approved projects on soils and terrain were assessed in the EIA, Volume 5, Section 7.3 through 7.5. This response assesses soils and terrain effects related to PRM excluding JME.

4.2.1 Assessment Results

A total of 23,129 ha of soil and terrain units are mapped for the LSA for the 2013 Base Case. The PRM will result in a development area of 11,742 ha. The loss or alteration of terrain units due to the PRM for the LSA is shown in Table 4.2-1. The net changes in terrain units in the RSA due to the PRM are shown in Table 4.2-2. The net changes comprise less than 1% of the RSA.

The specific soil units, their extent, and the soil units affected in the LSA due to the PRM are shown in Table 4.2-3. Pedogenic soil profiles cannot be directly replaced through reclamation, and therefore naturally occurring soil series are lost due to the PRM development. However, the loss of upland and some wetlands soil types will be mitigated through reclamation.

The specific soil units, their extent, and the soil units affected in the RSA due to the PRM are shown in Table 4.2-4.

Table 4.2-1 Loss or Alteration of Terrain Units in the Local Study Area

Terrain Unit (Symbol)	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure [(a)]		Net Change due to Pierre River Mine	
	Area [ha]	% of LSA	Area [ha]	% of Resource	Area [ha]	% of Resource	Area [ha]	% of Resource
Bog (B)	605	3	-433	-72	172	28	-433	-72
Fen (N)	3,986	17	-2,785	-70	1,201	30	-2,785	-70
Shallow Fen (Ns)	100	<1	-78	-78	21	21	-78	-79
Fluvial (F)	1,448	6	-578	-40	870	60	-578	-40
Glaciofluvial (Fg)	8,703	38	-3,799	-44	4,905	56	-3,799	-44
Glaciofluvial/Moraine (Fg/M)	463	2	-180	-39	283	61	-180	-39
Glaciolacustrine (Lg)	2,732	12	-1,109	-41	1,623	59	-1,109	-41
Moraine (M)	4,276	18	-2,485	-58	1,791	42	-2,485	-58
subtotal (terrain units)	*22,314*	*96*	*-11,447*	*-51*	*10,867*	*49*	*-11,447*	*-51*
Reconstructed Landforms	0	0	0	n/a	11,252	n/a	11,252	0
South Redclay Lake	0	0	0	n/a	491	n/a	491	0
Disturbed	503	2	-239	-48	263	52	-239	-48
Water	313	1	-56	-18	256	82	-56	-18
subtotal (other)	*815*	*4*	*-295*	*-36*	*12,263*	*1,505*	*11,447*	*1,404*
Total	**23,129**	**100**	**-11,742**	**-51**	**23,129**	**100**	**0**	**0**

(a) Closure scenario includes reclamation of the PRM development areas.

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

Table 4.2-2 Loss or Alteration of Terrain Units in the Regional Study Area

Terrain Unit (Symbol)	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[(a)]		Net Change due to Pierre River Mine	
	Area [ha]	% of RSA	Area [ha]	% of Resource	Area [ha]	% of Resource	Area [ha]	% of Resource
Bog (B)	144,525	6	0	0	144,525	100	0	0
Fen (N)	445,797	20	-594	-<1	445,203	100	-594	-<1
Shallow Fen (Ns)	323,151	14	-1,812	-1	321,339	99	-1,812	-<1
Fluvial (F)	114,175	5	-3,401	-3	110,774	97	-3,401	-3
Glaciofluvial (Fg)	283,627	12	-5,314	-2	278,313	98	-5,314	-2
Glaciofluvial/Moraine (Fg/M)	36,431	2	0	0	36,431	100	0	0
Glaciolacustrine (Lg)	162,924	7	-3	-<1	162,921	100	-3	-<1
Moraine (M)	368,539	16	-86	-<1	368,453	100	-86	-<1
Aeolian (A)	69,996	3	-3	-<1	69,993	100	-3	-<1
subtotal (terrain units)	*1,949,166*	*85.6*	*-11,213*	*-1*	*1,937,952*	*99*	*-11,213*	*-<1*
Reconstructed Landforms	0	0	0	n/a	11,252	n/a	11,252	n/a
South Redclay Lake	0	0	0	n/a	490	n/a	490	n/a
Rough broken/rock	82,415	4	-213	-<1	82,202	100	-213	-<1
Disturbed	186,349	8	-237	-<1	186,113	100	-237	-<1
Water	53,309	2	-79	-<1	53,230	100	-79	-<1
Indian Reserves	6,137	<1	0	0	6,137	100	0	0
subtotal (other)	*328,211*	*14*	*-529*	*-<1*	*339,424*	*103*	*11,213*	*3*
Total	**2,277,376**	**100**	**-11,742**	**-<1**	**2,277,376**	**100**	**0**	**0**

(a) Closure scenario includes reclamation of the PRM development areas.

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

n/a = Not applicable.

Table 4.2-3 Loss or Alteration of Soils in the Local Study Area

Soil Series, Reclaimed Soils and Non-Soils	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[a]		Net Change due to Pierre River Mine	
	Area [ha]	% of LSA	Area [ha]	% of Resource	Area [ha]	% of Resource	Area [ha]	% of Resource
Mineral Soils								
Algar Lake (ALG)	188	1	-86	-46	101	54	-86	-46
Algar Lake-pt (ALGpt)[b]	76	<1	-31	-41	45	59	-31	-41
Bitumount-pt (BMTpt)[b]	868	4	-551	-63	317	37	-551	-63
Darough (DAR)	20	<1	-17	-85	3	15	-17	-83
Wanham-aapt (WHMaapt)[b]	27	<1	-24	-89	3	11	-24	-88
Chateh (CHT)	687	3	-280	-41	407	59	-280	-41
Chateh-zr (CHTzr)[b]	163	1	-66	-40	97	60	-66	-41
Chateh-ptzr (CHTptzr)[b]	69	<1	-24	-35	45	65	-24	-35
Dover (DOV)	1,357	6	-482	-36	875	64	-482	-36
Dover-gl (DOVgl)[b]	69	<1	-24	-35	45	65	-24	-35
Dover-cogl (DOVcogl)[b]	91	<1	-91	-100	0	0	-91	-100
Firebag (FIR)	221	1	-158	-71	63	29	-158	-72
Fort (FRT)	4,244	18	-2,463	-58	1,781	42	-2,463	-58
Fort-gl (FRTgl)[b]	25	<1	-16	-64	9	36	-16	-63
Livock (LVK)	345	1	-142	-41	203	59	-142	-41
Mamawi (MMW)	467	2	-188	-40	280	60	-188	-40
Mamawi-pt (MMWpt)[b]	30	<1	-30	-100	0	0	-30	-99
McMurray (MMY)	411	2	-7	-2	404	98	-7	-2
Mildred (MIL)	6,696	29	-2,634	-39	4,062	61	-2,634	-39
Mildred-gl (MILgl)[b]	108	<1	-58	-54	50	46	-58	-54
Mildred-zz (MILzz)[b]	237	1	-76	-32	161	68	-76	-32
Namur (NAM)	435	2	-285	-66	150	34	-285	-65
Namur-gl (NAMgl)[b]	105	<1	-68	-65	36	34	-68	-65
Norberta (NOR)	12	<1	-8	-67	4	33	-8	-65
Peavine (PEA)	546	2	-297	-54	249	46	-297	-54
Steepbank (STP)	6	<1	-6	-100	0	0	-6	-97
Sutherland (SUT)	106	<1	-30	-28	76	72	-30	-28
Sutherland-gl (SUTgl)[b]	12	<1	-8	-67	4	33	-8	-65
subtotal (mineral soils)	*17,623*	*76*	*-8,150*	*-46*	*9,472*	*54*	*-8,150*	*-46*
Organic Soils								
Albian (ALB)	702	3	-610	-87	93	13	-610	-87
Hartley (HLY)	18	0	-17	-94	1	6	-17	-96
Hartley (HLYxs)[b]	81	0	-61	-75	20	25	-61	-75
McLelland (MLD)	1,014	4	-824	-81	190	19	-824	-81
McLelland –xc (MLDxc)[b]	1,370	6	-765	-56	605	44	-765	-56
McLelland-xs (MLDxs)[b]	900	4	-586	-65	313	35	-586	-65
Mikkwa-aa (MKWaa)[b]	81	<1	-79	-98	2	2	-79	-97
Muskeg (MUS)	151	1	-137	-91	14	9	-137	-91
Muskeg-xc (MUSxc)[b]	267	1	-148	-55	119	45	-148	-55
Muskeg-xs (MUSxs)[b]	106	<1	-69	-65	37	35	-69	-65
subtotal (organic soils)	*4,691*	*20*	*-3,296*	*-70*	*1,394*	*30*	*-3,296*	*-70*
Reconstructed Landforms	0	0	0	n/a	11,252	n/a	11,252	n/a

Table 4.2-3 Loss or Alteration of Soils in the Local Study Area (continued)

Soil Series, Reclaimed Soils and Non-Soils	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[(a)]		Net Change due to Pierre River Mine	
	Area [ha]	% of LSA	Area [ha]	% of Resource	Area [ha]	% of Resource	Area [ha]	% of Resource
South Redclay Lake	0	0	0	n/a	490	n/a	490	n/a
Disturbed	503	2	-239	-48	263	52	-239	-48
Water	313	1	-56	-18	256	82	-56	-18
subtotal (other)	*815*	*4*	*-295*	*-36*	*12,263*	*1,505*	*11,447*	*1,404*
Total	**23,129**	**100.0**	**-11,742**	**-51**	**23,129**	**100**	**0**	**0**

(a) Closure scenario includes reclamation of the PRM development areas.

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

n/a = Not applicable.

Pt = Peaty – an organic horizon (>17% organic carbon) which is > 10 cm thick, aa=Not modal soil correlation area, zr= Regosolic, gl= Gleyed – poor drainage and periodic reduction, co= Coarse – greater than 10% coarse fragments or one textural group coarser than modal, xs= Sand at 30 to 99 cm, xc= Clay at 30 to 99 cm, zz= Atypical subgroup.

Table 4.2-4 Loss or Alteration of Soils in the Regional Study Area

Soil Series, Reclaimed Soils and Non-Soils	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[a]		Net Change due to Pierre River Mine	
	Area [ha]	% of RSA	Area [ha]	% of Resource	Area [ha]	% of Resource	Area [ha]	% of Resource
Mineral Soils								
Algar Lake	42,044	2	-<1	-<1	42,043	100	-<1	-<1
Bitumount	37,996	2	-762	-2	37,234	98	-762	-2
Buckton	31,739	1	0	0	31,739	100	0	0
Dover	50,801	2	0	0	50,801	100	0	0
Firebag	60,364	3	0	0	60,364	100	0	0
Fort	1,821	<1	0	0	1,821	100	0	0
Gipsy	6,291	<1	0	0	6,291	100	0	0
Horse River	23,544	1	0	0	23,544	100	0	0
Joslyn	66,208	3	-2	-<1	66,206	100	-2	-<1
Kearl	3,870	<1	0	0	3,870	100	0	0
Kinosis	49,429	2	0	0	49,429	100	0	0
Legend	126,228	6	0	0	126,228	100	0	0
Livock	36,431	2	0	0	36,431	100	0	0
Marguerite	69,996	3	-3	-<1	69,993	100	-3	-<1
McMurray	53,535	2	-776	-1	52,759	99	-776	-1
Mildred	171,159	8	-4,082	-2	167,077	98	-4,082	-2
Namur	60,640	3	-2,625	-4	58,015	96	-2,625	-4
Ruth Lake	12,286	1	-470	-4	11,816	96	-470	-4
Steepbank	120,129	5	-86	-<1	120,043	100	-86	<1
Surmont	11,180	<1	0	0	11,180	100	0	0
subtotal (mineral soils)	*1,035,692*	*45*	*-8,807*	*-1*	*1,026,885*	*99*	*-8,807*	*-1*
Organic Soils								
Bayard	14,616	1	0	0	14,616	100	0	n/a
Conklin	57,922	3	-14	-<1	57,907	100	-14	-<1
Gregoire	19,342	1	0	0	19,342	100	0	0
Hartley	152,844	7	-541	-<1	152,303	100	-541	-<1
McLelland	145,313	6	-117	-<1	145,196	100	-117	-<1
Mikkwa	125,183	5	0	0	125,183	100	0	0
Mariana	138,616	6	-1,082	-1	137,533	99	-1,082	-<1
Muskeg	227,947	10	-463	-<1	227,484	100	-463	-1
Wabasca	31,692	1	-189	-1	31,502	99	-189	-<1
subtotal (organic soils)	*913,474*	*40*	*-2,406*	*-<1*	*911,067*	100	*-2,406*	*-<1*
Reconstructed Landforms	0	0	0	n/a	11,252	n/a	11,252	n/a
South Redclay Lake	0	0	0	n/a	490	n/a	490	n/a
rough broken/rock	82,415	4	-213	-<1	82,202	100	-213	-<1
Disturb	186,349	8	-237	-<1	186,113	100	-237	-<1
Water	53,309	2	-79	-<1	53,230	100	-79	-<1
Indian Reserves[a]	6,137	<1	0	0	6,137	100	0	0
subtotal (other)	*328,211*	*14*	*-529*	*-<1*	*339,424*	*103*	*11,213*	*3*
Total	**2,277,376**	**100**	**-11,742**	**-<1**	**2,277,376**	**100**	**0**	**0**

[a] Closure scenario includes reclamation of the PRM development areas.

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

n/a = Not applicable.

The extent of soil loss or alteration due to PRM in the LSA is summarized in Table 4.2-5. The PRM will result in the loss or alteration of 8,150 ha (46% of the resource) of mineral soils and 3,296 ha (70% of the resource) of organic soils. A total of 295 ha (36% of the resource) of non-native soil landscape components (i.e., reclaimed soils, water, disturbed) will also be altered due to the PRM.

Changes to soil units due to PRM account for 1% (11,742 ha) of the RSA (Table 4.2-6).

Table 4.2-5 Summary of Predicted Changes to Soils in the Local Study Area

Soil Type	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[(a)]		Net Change due to Pierre River Mine	
	Area [ha]	**% of LSA**	**Area [ha]**	**% of Resource**	**Area [ha]**	**% of Resource**	**Area [ha]**	**% of Resource**
Mineral soils	17,623	76	-8,150	-46	9,473	54	-8,150	-46
Organic soils	4,691	20	-3,296	-70	1,394	30	-3,296	-70
subtotal (soils)	*22,314*	*96*	*-11,447*	*-51*	*10,867*	*49*	*-11,447*	*-51*
Reconstructed Landforms	0	0	0	n/a	11,251	n/a	11,251	n/a
South Redclay Lake	0	0	0	n/a	490	n/a	490	n/a
Disturbed	503	2	-239	-48	263	52	-239	-48
Water	313	1	-56	-18	256	82	-56	-18
subtotal (other)	*815*	*4*	*-295*	*-36*	*12,262*	*1,504*	*11,447*	*1,404*
Total	**23,129**	**100**	**-11,742**	**-51**	**23,129**	**100**	**0**	**0**

(a) Closure scenario includes reclamation of the PRM development areas.

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

n/a = Not applicable.

Table 4.2-6 Summary of Predicted Changes to Soils in the Regional Study Area

Soil Type	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[(a)]		Net Change due to Pierre River Mine	
	Area [ha]	**% of RSA**	**Area [ha]**	**% of Resource**	**Area [ha]**	**% of Resource**	**Area [ha]**	**% of Resource**
Mineral soils	1,035,692	45	-8,807	-1	1,026,885	99	-8,807	-1
Organic soils	913,474	40	-2,406	-<1	911,067	100	-2,406	-<1
subtotal (soils)	*1,949,166*	*86*	*-11,213*	*-1*	*1,937,952*	*99*	*-11,213*	*-1*
Reconstructed Landforms	0	0	0	n/a	11,251	n/a	11,251	n/a
South Redclay Lake	0	0	0	n/a	491	n/a	491	n/a
Rough broken/rock	82,415	4	-213	-<1	82,202	100	-213	-<1
Disturbed	186,349	8	-237	-<1	186,113	100	-237	-<1
Water	53,309	2	-79	-<1	53,230	100	-79	-<1
Indian Reserves	6,137	<1	0	0	6,137	100	0	0
subtotal (other)	*328,211*	*14*	*-529*	*-<1*	*339,424*	*103*	*11,213*	3
Total	**2,277,376**	**100**	**-11,742**	**-1**	**2,277,376**	**100**	**0**	**0**

(a) Closure scenario includes reclamation of the PRM development areas.

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

n/a = Not applicable.

Changes to forestry capability within the LSA are summarized in Table 4.2-7. An increase in land capability is predicted for forestry Class 1 (high capability; 351 ha or 239% of the resource) and Class 3 (low capability; 5,369 ha or 203% of the resource) in the LSA at Closure. A decrease is predicted for Class 4 (conditionally productive; 9,195 ha or 80% of the resource), Class 5 (non-productive; 2,738 ha or 55% of the resource) and Class 2 (moderate capability; 2,694 ha or 88% of the resource) (Table 4.2-7).

Changes to forestry capability within the RSA are summarized in Table 4.2-8. The total changes due to the PRM account for 1% of the RSA.

Table 4.2-7 Forestry Capability Changes Following Reclamation in the Local Study Area

Forest Land	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[(a)]		Net Change due to Pierre River Mine	
Capability Class	Area [ha]	% of LSA	Area [ha]	% of Resource	Area [ha]	% of Resource	Area [ha]	% of Resource
1 (high)	147	1	-2	-1	351	239	204	139
2 (moderate)	3,048	13	-1,539	-50	2,694	88	-354	-12
3 (low)	2,641	11	-1,307	-49	5,369	203	2,728	103
4 (conditionally productive)	11,512	50	-5,137	-45	9,195	80	-2,317	-20
5 (non-productive)	4,965	21	-3,461	-70	2,738	55	-2,228	-45
subtotal	*22,314*	*96*	*-11,447*	*-51*	*20,347*	*91*	*-1,967*	*-9*
Water[(b)]	313	1	-56	-18	2,519	805	2,206	706
Disturbed	503	2	-239	-48	263	52	-239	-48
subtotal (other)	*815*	*4*	*-295*	*-36*	*2,782*	*341*	*1,967*	*241*
Total	**23,129**	**100**	**-11,742**	**-51**	**23,129**	**100**	**0**	**0**

(a) Closure scenario includes reclamation of the PRM development areas.

(b) Includes South Redclay Lake.

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

Table 4.2-8 Forestry Capability Changes Following Reclamation in the Regional Study Area

Forest Land Capability Class	2013 Base Case		Loss/Alteration due to Pierre River Mine		Closure[(a)]		Net Change due to Pierre River Mine	
	Area [ha]	% of RSA	Area [ha]	% of Resource	Area [ha]	% of Resource	Area [ha]	% of Resource
1 (high)	58,790	3	-2	-<1	58,016	99	-773	-1
2 (moderate)	265,824	12	-1,539	-1	264,525	100	-1,299	-<1
3 (low)	168,847	7	-1,307	-1	169,284	100	437	<1
4 (conditionally	466,385	20	-5,137	-1	466,117	100	-268	-<1
5 (non-productive)	1,071,736	47	-3,461	-<1	1,073,659	100	1,923	<1
subtotal	*2,031,581*	*89*	*-11,447*	*-1*	*2,031,601*	*100*	*20*	*<1*
Water[(b)]	53,309	2	-56	-<1	53,286	100	-23	-<1
Disturb	192,487	8	-239	-<1	192,489	100	3	<1
subtotal (other)	*245,795*	*11*	*-295*	*-<1*	*245,775*	*100*	*-20*	*-<1*
Total	**2,277,376**	**100**	**-11,742**	**-1**	**2,277,376**	**100**	**0**	**0**

(a) Closure scenario includes reclamation of the PRM development areas.

(b) Includes South Redclay Lake.

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

Residual Impact Classification

The PRM will result in changes to soils in the LSA. This is due to changes in the area of organic and mineral soils as a result of the construction of the PRM. Before reclamation, 8,150 ha (46% of the resource) of mineral soils and 3,926 (70% of the resource) organic soils will be lost or altered due to the PRM. At Closure, however, it is predicted that mineral and organic soil loss or alteration due to PRM will be mitigated through reclamation including 11,251 ha (49% of the LSA) of reconstructed landforms. After reclamation, it is predicted that there will be a 490 ha permanent decrease of soil area due to construction of South Redclay Lake. The permanent loss of soils after reclamation is predicted to be a negative, moderate environmental consequence in the LSA (Table 4.2-9), which is a change from the EIA where the environmental consequence was a negative, high environmental consequence. The PRM is predicted to have a negligible consequence at the RSA level, which is the same as in the EIA.

Table 4.2-9 Residual Impact Classification for Soils in the Local Study Area and Regional Study Area

Parameter	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSAs)	Environmental Consequence (RSA)
Soils								
permanent loss	negative	low (+5)	local (0)	long-term (+2)	irreversible (+3)	high (+2)	moderate (+12)	negligible
Land Capability for Forestry								
equivalent capability for forestry	positive	low (+5)	local (0)	long-term (+2)	n/a	high (+2)	low (+9)	negligible

Note: Numerical scores for ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.
n/a = Reversibility is not applicable when the direction of change is positive.

The soils impact classification relies on the ability of the planned reclamation program to return an equivalent land capability for forestry. The reclaimed soils are predicted to provide a higher average land capability for forestry as compared to 2013 Base Case conditions (Table 4.2-6). Therefore, the residual forestry capability impact is rated as a positive direction, low environmental consequence in the LSA, and a negligible environmental consequence at the RSA level (Table 4.2-9), which remains unchanged from the EIA.

4.2.2 Summary of Results

The 2013 PRM Application Case assessment for soils and terrain includes an updated list of existing, approved and planned developments and focuses on PRM, without effects of JME. Soil loss or alteration before reclamation is classified as having high environmental consequence in the LSA and a negligible environmental consequence in the RSA.

At Closure, however, it is predicted that mineral and organic soil loss or alteration due to the PRM will be mitigated through reclamation. After reclamation, it is predicted that there will be a permanent decrease of 490 ha of soils mostly due to construction of South Redclay Lake. This permanent loss of soils after reclamation will result in a moderate environmental consequence in the LSA and a negligible consequence in the RSA.

The reclaimed soils are predicted to provide a higher average land capability for forestry as compared to 2013 Base Case conditions. Therefore, the residual land capability for forestry impact is rated as a positive direction, low environmental consequence in the LSA, and a negligible environmental consequence in the context of the RSA.

4.3 Terrestrial Vegetation, Wetlands and Forest Resources Assessment

The effects of PRM and JME combined with existing and approved projects on terrestrial vegetation, wetlands and forest resources were assessed in the EIA, Volume 5, Sections 7.1 through 7.6. The basis on which each KIR was assessed is described in the EIA, Volume 3, Section 1.3.6.1 and 1.3.6.2. As outlined in the *Terrestrial Environmental Setting Report for the Jackpine Mine Expansion & Pierre River Mine Project* (Section 3.3.6; Golder 2007b), KIRs are used to describe and assess the economical, cultural and ecological importance of plant communities. The KIRs are assessed based on either the PRM's direct effects (i.e., footprint), or direct and indirect effects (i.e., footprint and drawdown) combined. In general, upland vegetation is directly affected by the PRM footprint, while wetlands are subjected to both direct and indirect effects.

Because the scale, data sources and mapping methods differ between the RSA (i.e., Regional Land Cover Classes [RLCCs]) and the LSA (i.e., Alberta Vegetation Inventory ecosite phases, Albert Wetlands Inventory wetlands types and other land cover types), direct comparisons between the results presented for the RSA and the LSA cannot be made. The datasets used for mapping and modelling the LSA and the RSA must be appropriate for the scale of each area. The size of the study area to be analyzed determines what scale is appropriate for use in the analyses. To obtain the most meaningful results, an appropriate scale must be chosen. As a general rule, the smaller the study area is, the finer the detail in the dataset, and conversely, the larger the study area, the more coarse the dataset. The LSA-level data are not appropriate for use at the RSA level. The fine details in LSA scale datasets would be lost when the results are summarized at the RSA scale.

Combining the RSA and LSA datasets can introduce inconsistencies into analyses and modelling. In addition, the introduction of highly detailed information at the RSA scale can cause technical problems during data preparation, analysis, and modelling. Because of the difference in scale, the LSA and RSA each use a different set of land classifications, which leads to different mapping due to the inclusion or exclusion of fine details/divisions. Therefore, the mapping and the area numbers for the LSA and RSA are not directly comparable, and the area numbers for the LSA and RSA will be slightly different.

4.3.1 Assessment Results

4.3.1.1 Direct and Indirect Losses/Alterations From Vegetation Clearing in the Local Study Area

The LSA is 23,129 ha and is located within the Central Mixedwood and Athabasca Plain Natural Subregions (Figure 4.3-1). Construction and operation of the PRM will result in clearing 11,742 ha (51%) of the LSA. The changes in terrestrial vegetation, wetlands and forest resources in the LSA at Closure are detailed in Table 4.3-1 and are summarized as follows:

- Terrestrial upland vegetation will increase from 2,240 ha (10% of the LSA) at the 2013 Base Case to 4,037 ha (180% of resource; 17% of the LSA) in the Central Mixedwood portion at Closure. In the Athabasca Plain portion, terrestrial vegetation will increase from 6,805 ha (29% of the LSA) at the 2013 Base Case to 9,533 ha (140% of resource; 41% of the LSA) at Closure.
- Wetlands, excluding burned wetlands, (BUw) will decrease from 4,541 ha (20% of the LSA) at the 2013 Base Case to 1,878 ha (41% of resource; 8% of the LSA) at Closure, a decrease of 2,663 ha (59% of resource) from the 2013 Base Case.
- Miscellaneous vegetation types will decrease from 7,530 ha (33% of the LSA) at the 2013 Base Case to 4,488 ha (60% of resource; 19% of the LSA) at Closure.
- Waterbodies and sand will increase from 312 ha (1% of the LSA) at the 2013 Base Case to 2,516 ha (807% of resource; 11% of the LSA) at Closure.

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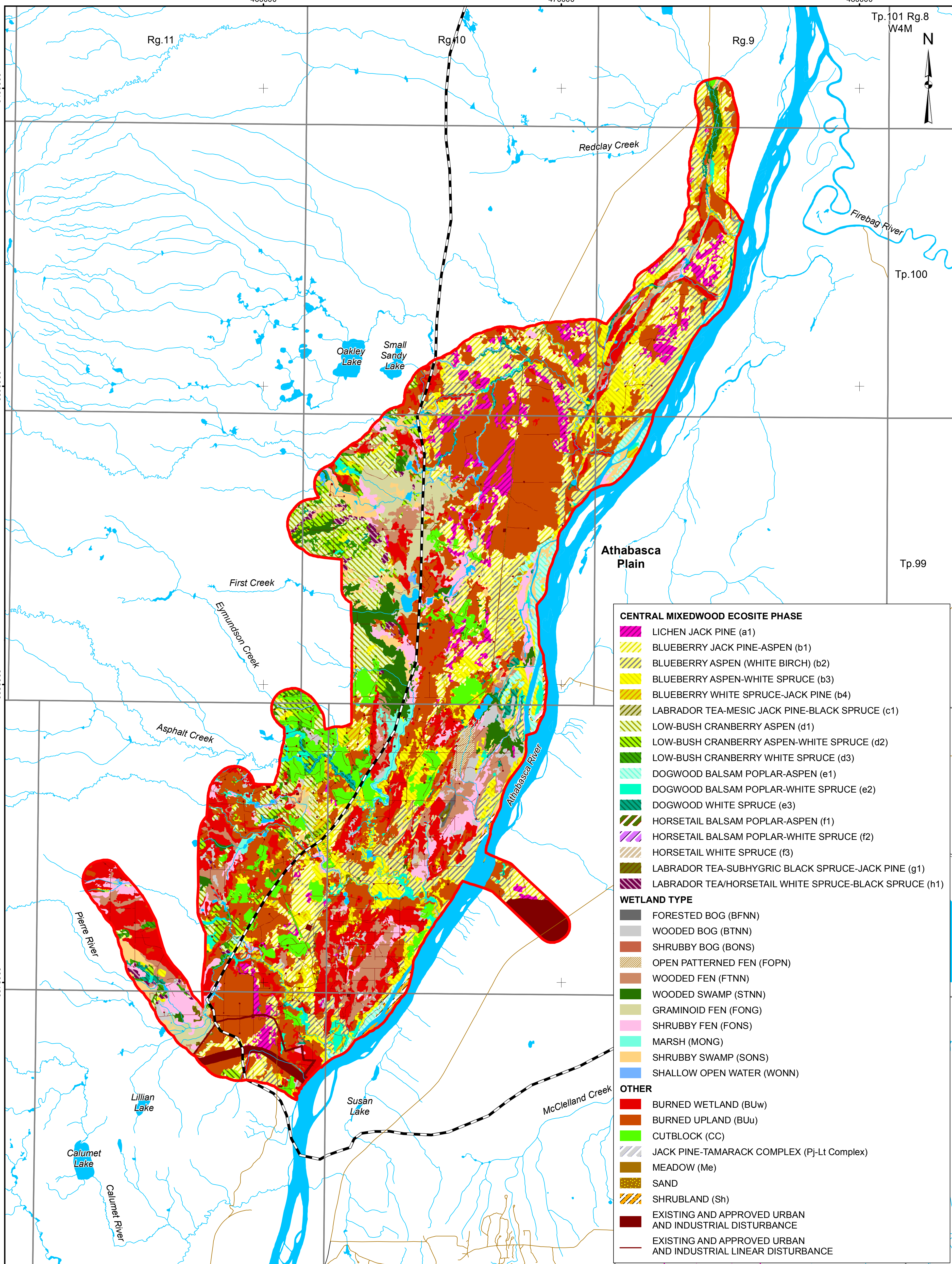

LEGEND

- PAVED ROAD
- UNPAVED ROAD
- WATERCOURSE
- INDIAN RESERVE
- NATURAL SUBREGION
- PIERRE RIVER MINE LOCAL STUDY AREA
- OPEN WATER

ATHABASCA PLAIN (CANADIAN SHIELD) ECOSITE PHASE

- BEARBERRY JACK PINE (a1)
- CANADA BUFFALO-BERRY-GREEN ALDER JACK PINE-ASPEN-WHITE BIRCH (b1)
- CANADA BUFFALO-BERRY-GREEN ALDER ASPEN (b2)
- CANADA BUFFALO-BERRY-GREEN ALDER ASPEN-WHITE SPRUCE-BLACK SPRUCE (b3)
- CANADA BUFFALO-BERRY-GREEN ALDER WHITE SPRUCE-BLACK SPRUCE-JACK PINE (b4)
- LABRADOR TEA-MESIC JACK PINE-BLACK SPRUCE (c1)
- WILLOW/HORSETAIL ASPEN-WHITE BIRCH-BALSAM POPLAR (e1)
- WILLOW/HORSETAIL ASPEN-WHITE SPRUCE-BLACK SPRUCE (e2)
- WILLOW/HORSETAIL WHITE SPRUCE-BLACK SPRUCE (e3)
- LABRADOR TEA-SUBHYGRIC BLACK SPRUCE-JACK PINE (g1)

4 0 4

SCALE 1:125,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013. ALBERTA NATURAL SUBREGION DATA OBTAINED FROM ALBERTA NATURAL HERITAGE INFORMATION CENTRE.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT

PIERRE RIVER MINE PROJECT

TITLE

DISTRIBUTION OF LAND COVER TYPES IN THE TERRESTRIAL LOCAL STUDY AREA – 2013 BASE CASE

Shell Canada Limited

PROJECT	13-1346-0001		FILE No.	
DESIGN	AD	26 Apr 2013	SCALE AS SHOWN	REV. 0
GIS	CH	20 Jun 2013		
CHECK	CY	18 Jul 2013	FIGURE: 4.3-1	
REVIEW	DB	18 Jul 2013		

Table 4.3-1 Ecosite Phases and Wetlands Types to be Cleared and Reclaimed in the Local Study Area

Terrestrial Vegetation, Wetlands and Forest Resources KIRs[a]	Map Code	Description	2013 Base Case[b]		Direct Loss/Alteration due to Pierre River Mine		Indirect Loss/Alteration due to Surficial Aquifer Drawdown from Pierre River Mine		Loss/Alteration due to Pierre River Mine Direct and Indirect Effects[b]		Closure[c]		Net Change due to Pierre River Mine[d]	
			Area [ha]	% of LSA[b]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]
Central Mixedwood Natural Subregion Ecosite Phases														
4,9	a1	lichen jack pine	7	<1	-7	-100	n/a	n/a	-7	-100	56	818	49	718
3,5,8,9	b1	blueberry jack pine-aspen	125	<1	-83	-67	n/a	n/a	-83	-67	151	121	26	21
3,9	b2	blueberry aspen (white birch)	37	<1	-14	-39	n/a	n/a	-14	-39	143	386	106	286
3,5,9	b3	blueberry aspen-white spruce	115	<1	-51	-45	n/a	n/a	-51	-45	332	289	217	189
3,5,9	b4	blueberry white spruce-jack pine	101	<1	-72	-71	n/a	n/a	-72	-71	29	29	-72	-71
9	c1	Labrador tea-mesic jack pine-black spruce	5	<1	-5	-99	n/a	n/a	-5	-99	958	20,404	953	20,304
3,5,9	d1	low-bush cranberry aspen	873	4	-363	-42	n/a	n/a	-363	-42	1,405	161	532	61
3,5,9	d2	low-bush cranberry aspen-white spruce	468	2	-247	-53	n/a	n/a	-247	-53	425	91	-42	-9
3,5,9	d3	low-bush cranberry white spruce	208	<1	-71	-34	n/a	n/a	-71	-34	137	66	-71	-34
1,3,5,9	e1	dogwood balsam poplar-aspen	7	<1	-6	-88	n/a	n/a	-6	-88	48	660	41	560
1,3,5,9	e2	dogwood balsam poplar-white spruce	97	<1	-30	-31	n/a	n/a	-30	-31	113	117	17	17
1,3,5,9	e3	dogwood white spruce	74	<1	-51	-69	n/a	n/a	-51	-69	179	243	106	143
1	f1	horsetail balsam poplar-aspen	2	<1	-2	-100	n/a	n/a	-2	-100	0	0	-2	-100
3,9	f2	horsetail balsam poplar-white spruce	<1	<1	-<1	-100	n/a	n/a	-<1	-100	0	0	-<1	-100
9	f3	horsetail white spruce	4	<1	-2	-62	n/a	n/a	-2	-62	1	38	-2	-62
9	g1	Labrador tea-subhygric black spruce-jack pine	11	<1	-<1	-4	n/a	n/a	-<1	-4	10	96	-<1	-4
1,5,9	h1	Labrador tea/horsetail white spruce-black spruce	107	<1	-58	-54	n/a	n/a	-58	-54	49	46	-58	-54
		central mixedwood ecosite phases subtotal	*2,240*	*10*	*-1,065*	*-48*	*n/a*	*n/a*	*-1,065*	*-48*	*4,037*	*180*	*1,798*	*80*
Athabasca Plain Natural Subregion Ecosite Phases														
4,5,9	a1	bearberry jack pine	772	3	-294	-38	n/a	n/a	-294	-38	689	89	-83	-11
3,5,9	b1	Canada buffalo-berry-green alder jack pine-aspen-white birch	1,654	7	-595	-36	n/a	n/a	-595	-36	1,065	64	-590	-36
3,5,9	b2	Canada buffalo-berry-green alder aspen	1,939	8	-676	-35	n/a	n/a	-676	-35	2,055	106	117	6
3,5,9	b3	Canada buffalo-berry-green alder aspen-white spruce-black spruce	1,227	5	-634	-52	n/a	n/a	-634	-52	1,258	102	30	2
3,5,9	b4	Canada buffalo-berry-green alder white spruce-black spruce-jack pine	451	2	-206	-46	n/a	n/a	-206	-46	248	55	-203	-45
9	c1	Labrador tea-mesic jack pine-black spruce	23	<1	-8	-36	n/a	n/a	-8	-36	1,133	4,905	1,110	4,805
n/a	d1	Labrador tea-subhygric black spruce-jack pine	34	<1	-23	-69	n/a	n/a	-23	-69	2,105	6,265	2,072	6,165
1,3,5,9	e1	willow/horsetail aspen-white birch-balsam poplar	319	1	-29	-9	n/a	n/a	-29	-9	292	92	-27	-8
1,3,5,9	e2	willow/horsetail aspen-white spruce-black spruce	224	<1	-126	-56	n/a	n/a	-126	-56	209	93	-15	-7
1,3,5,9	e3	willow/horsetail white spruce-black spruce	159	<1	-61	-38	n/a	n/a	-61	-38	480	302	321	202
9	Pj-Lt Complex	jack pine-tamarack complex	4	<1	-4	-100	n/a	n/a	-4	-100	0	0	-4	-100
		Athabasca plain ecosite phases subtotal	*6,805*	*29*	*-2,655*	*-39*	*n/a*	*n/a*	*-2,655*	*-39*	*9,533*	*140*	*2,728*	*40*
Wetlands Types														
6	BFNN	forested bog	17	<1	-16	-92	-1	-6	-17	-97	1	8	-16	-92
2,6	BONS	shrubby bog	1	<1	-<1	-100	0	0	-<1	-100	0	0	-<1	-100
6	BTNN	wooded bog	347	1	-186	-54	-128	-37	-314	-91	172	50	-175	-50
1,2,6	FONG	graminoid fen	810	4	-661	-82	-86	-11	-746	-92	149	18	-661	-82
1,2,6	FONS	shrubby fen	963	4	-513	-53	-210	-22	-724	-75	450	47	-513	-53
1,2,6,7,9	FOPN	open patterned fen	67	<1	-54	-81	-13	-19	-67	-100	13	19	-54	-81
1,2,6,8	FTNN	wooded fen	1,042	5	-748	-72	-178	-17	-926	-89	295	28	-748	-72
1,2	MONG	marsh	140	<1	-104	-74	-36	-26	-140	-100	146	104	6	4
1,2,8	SONS	shrubby swamp	495	2	-221	-45	-37	-8	-258	-52	275	55	-221	-45
1,5,9	STNN	wooded swamp	590	3	-239	-41	-210	-36	-449	-76	351	59	-239	-41
2	WONN	shallow open water	69	<1	-42	-62	-<1	-<1	-43	-62	27	38	-42	-62
		wetlands types subtotal	*4,541*	*20*	*-2,785*	*-61*	*-900*	*-20*	*-3,684*	*-81*	*1,878*	*41*	*-2,663*	*-59*

Table 4.3-1 Ecosite Phases and Wetlands Types to be Cleared and Reclaimed in the Local Study Area (continued)

Terrestrial Vegetation, Wetlands and Forest Resources KIRs[(a)]	Map Code	Description	2013 Base Case[(b)]		Direct Loss/Alteration due to Pierre River Mine		Indirect Loss/Alteration due to Surficial Aquifer Drawdown from Pierre River Mine		Loss/Alteration due to Pierre River Mine Direct and Indirect Effects[(b)]		Closure[(c)]		Net Change due to Pierre River Mine [(d)]	
			Area [ha]	% of LSA[(b)]	Area [ha]	% of Resource[(f)]	Area [ha]	% of Resource[(f)]	Area [ha]	% of Resource[(f)]	Area [ha]	% of Resource[(f)]	Area [ha]	% of Resource[(f)]
Miscellaneous Vegetation Types														
1,9	BUu	burn upland	5,065	22	-2,533	-50	n/a	n/a	-2,533	-50	2,533	50	-2,533	-50
1,6	BUw	burn wetlands[(g)]	2,345	10	-1,616	-69	-294	-13	-1,910	-81	728	31	-1,616	-69
1	Me	meadow	9	<1	-2	-20	n/a	n/a	-2	-20	7	80	-2	-20
1,2	Sh	shrubland	110	<1	-3	-3	n/a	n/a	-3	-3	108	97	-3	-3
n/a	Sh1	reclaimed shrubland type 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	413	n/a	413	n/a
n/a	Sh2	reclaimed shrubland type 2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	699	n/a	699	n/a
		miscellaneous vegetation types subtotal	*7,530*	*33*	*-4,154*	*-55*	*-294*	*-4*	*-4,448*	*1,513*	*4,488*	*60*	*-3,042*	*-201*
Non-Vegetation Types														
n/a	lake	lake[(h)]	83	<1	-51	-61	n/a	n/a	-51	-61	2,041	2,447	1,957	2,347
n/a	littoral zone	littoral zone	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	254	n/a	254	n/a
n/a	river	river	180	<1	-2	-1	n/a	n/a	-2	-1	178	99	-2	-1
1	sand	sand	48	<1	-5	-10	n/a	n/a	-5	-10	43	90	-5	-10
		non-vegetation types subtotal	*312*	*1*	*-58*	*-19*	*n/a*	*n/a*	*-58*	*-19*	*2,516*	*807*	*2,205*	*707*
Disturbances														
9	CC	cutblock	931	4	-606	-65	n/a	n/a	-606	-65	325	35	-606	-65
1[(i)]	DIS	disturbance	771	3	-420	-54	n/a	n/a	-420	-54	351	46	-420	-54
		disturbances subtotal	*1,702*	*7*	*-1,026*	*-60*	*n/a*	*n/a*	*-1,026*	*-60*	*676*	*40*	*-1,026*	*-60*
Total			**23,129**	**100**	**-11,742**	**-51**	**-1,193**	**-5**	**-12,935**	**-56**	**23,129**	**100**	**n/a**	**n/a**

(a) Numbers in each row indicate that the ecosite phases and wetlands types have the potential to contain the following Key Indicator Resources (KIRs): 1) riparian communities (if within 100 m of water), 2) high rare plant potential, 3) high traditional plant potential, 4) lichen jack pine communities, 5) old growth, 6) peatlands, 7) patterned fens, 8) rare and special plant communities and 9) productive forest.

(b) For the purposes of this assessment, each land cover type is assumed to be 100% of resource at 2013 Base Case.

(c) Loss/alteration due to the PRM combines direct effects due to site clearing (PRM footprint) and indirect effects due to surficial aquifer drawdown within the LSA, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed.

(d) Closure scenario includes reclamation of the PRM development areas. Values presented in this table do not include indirect effects due to surficial aquifer drawdown, as drawdown will occur primarily during the life of PRM. Drawdown effects on wetlands types surrounding pit lakes may extend to Closure. At Closure combined direct and indirect effects are predicted to cause an additional loss of 978 ha (22% of resource) of wetlands, 899 ha (16% of resource) of peatlands and 67 ha (100% of resource) of patterned fens.

(e) Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure. Net change is a value upon which the environmental consequence is assessed at Closure.

(f) % of resource is calculated as a percentage of 2013 Base Case area.

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

(h) Includes a South Redclay Lake and planned littoral zones bordering pit lakes at Closure.

(i) Disturbed riparian communities include cutlines/trails and inactive well sites.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

n/a = Not applicable.

4.3.1.2 Direct and Indirect Losses/Alterations From Vegetation Clearing in the Regional Study Area

The RLCCs that will be cleared and reclaimed within the RSA areas are summarized in Table 4.3-2. Less than 1% of the RSA of each of the regional terrestrial, wetlands, miscellaneous and disturbance RLCCs in the RSA will be cleared for PRM. The Closure, Conservation and Reclamation (CC&R) Plan (EIA, Volume 2, Section 20.1) describes the land cover types that will be reclaimed after PRM completion using LSA-scale mapping. Within the PRM footprint portion of the RSA, the Closure land cover types were correlated with RLCCs for the RSA to determine the area of each RLCC following reclamation (Golder 2007b). Following reclamation of PRM, the RSA landscape will have a net increase in terrestrial RLCCs (5,126 ha). There will be a net decrease in wetlands by 6,792 ha (less than 1% of the RSA).

4.3.1.3 Overview of Indirect Effects due to Changes in Hydrogeology and Hydrology

The LSA and RSA were assessed for effects to vegetation due to changes in surface water hydrology in the EIA, due to PRM dewatering of the surficial aquifers (i.e., surficial aquifer drawdown). The drawdown isopleths presented in Figure 7.5-2 of the EIA (Volume 5, Section 7.5) conservatively represent the anticipated extent of dewatering effects for PRM and were thus used in this assessment. The areal extent of wetlands and burned wetlands (BUw) potentially affected by surficial aquifer drawdown from PRM within the LSA is 1,193 ha (Table 4.3-3). Outside of the LSA, the RSA contains an additional 988 ha of wetlands and burned wetlands (BUw) potentially affected by surficial aquifer drawdown due to PRM. Dewatering drawdown isopleths of 0.1 m and 1 m (Figure 4.3-2) were originally presented in the EIA, Volume 4A, Section 6.1.2.

The potential effects due to drawdown on wetlands include reductions in water levels and alterations to moisture regimes that may lead to a shift in species composition (e.g., more shrubs and trees) transitioning towards terrestrial vegetation communities (LaChance and Lavoie 2004; Strack et al. 2006). A second effect could be an increase in the nutrient levels within peatlands due to peat decomposition (Price et al. 2005). The indirect effects of surficial aquifer drawdown are predicted to have the potential to cause negative effects to the following KIRs during construction and operations: wetlands (including peatlands and patterned fens), riparian communities, areas of high rare plant potential, and the rare and special plant community - river alder/ostrich fern.

Effects of surficial aquifer drawdown on uplands vegetation and productive (i.e., of economic importance) forests are considered negligible because precipitation and surface water runoff infiltration into soils are the predominant water sources for uplands vegetation and forest resources (December 2009 Jackpine Mine, Supplemental Information, Volume 2, Appendix B). Therefore, drawdown is not predicted to affect the following KIRs and vegetation resources: terrestrial vegetation, lichen jack pine communities, old growth forest, productive forests, areas of high traditional use plant potential, and the sparsely vegetated slope rare and special plant community (EIA, Volume 5, Section 7.3.3). The deep and well-established root systems of trees are expected to compensate for the effects of moderate fluctuations in water levels (Murphy et al. 2009). In addition, increasing soil drainage is a common method of improving boreal soil conditions to increase forestry yields. Augmented drainage of muskeg soils increases soil aeration and raises substrate temperatures, leading to increased tree biomass (Prévost et al. 1999). Therefore, drawdown is not predicted to negatively affect old growth and productive forests during the life of the PRM.

Table 4.3-2 Regional Land Cover Class Changes in the Regional Study Area

Regional Land Cover Class	2013 Base Case[(a)]		Loss/Alteration due to Pierre River Mine[(a)(b)]		Closure[(a)(c)]		Net Change due to Pierre River Mine[(d)]	
	Area [ha]	% of RSA[(e)]	Area [ha]	% of Resource[(f)]	Area [ha]	% of Resource[(f)]	Area [ha]	% of Resource[(f)]
Terrestrial Vegetation								
coniferous jack pine	166,332	7	-349	-<1	166,251	7	-81	-<1
coniferous jack pine−black spruce	40,054	2	0	0	44,228	2	4,173	10
coniferous white spruce	52,386	2	-622	-1	52,302	2	-84	-<1
deciduous aspen−balsam poplar	178,067	8	-506	-<1	179,418	8	1,351	<1
mixedwood aspen−jack pine	39,033	2	0	0	39,147	2	114	<1
mixedwood aspen−white spruce	144,759	6	-1,643	-1	144,411	6	-348	-<1
terrestrial vegetation subtotal	*620,630*	*27*	*-3,120*	*-<1*	*625,757*	*27*	*5,126*	*<1*
Wetlands								
non-treed wetlands	241,110	11	-2,512	-1	240,492	11	-618	-<1
treed bog/poor fen	423,855	19	-2,380	-<1	421,900	19	-1,955	-<1
treed fen	230,369	10	-5,014	-2	226,151	10	-4,218	-2
wetlands subtotal	*895,334*	*39*	*-9,906*	*-1*	*888,543*	*39*	*-6,792*	*-<1*
Miscellaneous								
burn	396,125	17	-426	-<1	395,993	17	-132	-<1
water[(g)]	52,526	2	-52	-<1	54,743	2	2,217	4
miscellaneous subtotal	*448,651*	*20*	*-478*	*-<1*	*450,736*	*20*	*2,085*	*<1*
Disturbances								
cutblock	100,160	4	0	0	100,160	4	0	0
disturbance	212,601	9	-420	-<1	212,181	9	-420	-<1
disturbances subtotal	*312,761*	*14*	*-420*	*-<1*	*312,341*	*14*	*-420*	-<1
Total	**2,277,376**	**100**	**-13,924**	**-<1**	**2,277,376**	**100**	**n/a**	**n/a**

(a) Includes burns and cutblocks as modelled by ALCES.

(b) Loss/alteration combines direct effects due to site clearing (PRM footprint) and indirect effects due to surficial aquifer drawdown within the RSA, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed. Excluding indirect effects due to surficial aquifer drawdown there is a total loss/alteration of -11,742 ha within the RSA.

(c) Closure scenario includes reclamation of the PRM development areas. Values presented in this table do not include indirect effects due to surficial aquifer drawdown, as drawdown will occur primarily during the life of PRM. Drawdown effects on wetlands types surrounding pit lakes may extend to Closure. At Closure combined direct and indirect effects are predicted to cause an additional loss of 1,881 ha (less than 1% of resource) of wetlands and 301 ha (less than 1% of resource) of miscellaneous land cover types (due to loss of burned wetlands [BUw] and shallow open water [WONN], Table 4.3-3).

(d) Net change is calculated as the difference between the 2013 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

(e) For the purposes of this assessment, each RLCC is assumed to be 100% of resource at 2013 Base Case.

(f) % of resource is calculated as a percentage of 2013 Base Case area; the areas of this column are not additive.

(g) Closure values include a planned compensation lake (South Redclay Lake) as described in the EIA, Volume 2, Section 20 and the EIA, Appendix 4-4, Section 1.4.1 and planned littoral zones bordering pit lakes and South Redclay Lake.

n/a = Not applicable; PRM = Pierre River Mine.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Basel Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

Table 4.3-3 Wetlands Potentially Affected by Surficial Aquifer Drawdown Within the Regional Study Area

Map Code	Description	Loss/Alteration Due to Surficial Aquifer Drawdown			
		Inside LSA [ha]	Outside LSA [ha]	Total [ha]	% LSA
BFNN[a]	forested bog	-1	-5	-6	-<1
BTNN[a]	wooded bog	-128	-280	-408	-2
BONS[a]	shrubby bog	0	0	0	0
BUw[a]	burn wetlands	-294	-<1	-295	-1
FONG[a]	graminoid fen	-86	-34	-120	-<1
FONS[a]	shrubby fen	-210	-238	-449	-2
FOPN[a]	open patterned fen	-13	0	-13	-<1
FTNN[a]	wooded fen	-178	-370	-548	-2
MONG	marsh	-36	0	-36	-<1
SONS	shrubby swamp	-37	-18	-55	-<1
STNN	wooded swamp	-210	-37	-248	-1
WONN	shallow open water	-<1	-6	-6	-<1
Total		**-1,193**	**-988**	**-2,182**	**-9**

[a] Peatland. Total amount of peatlands affected by drawdown is 909 ha.

Note: 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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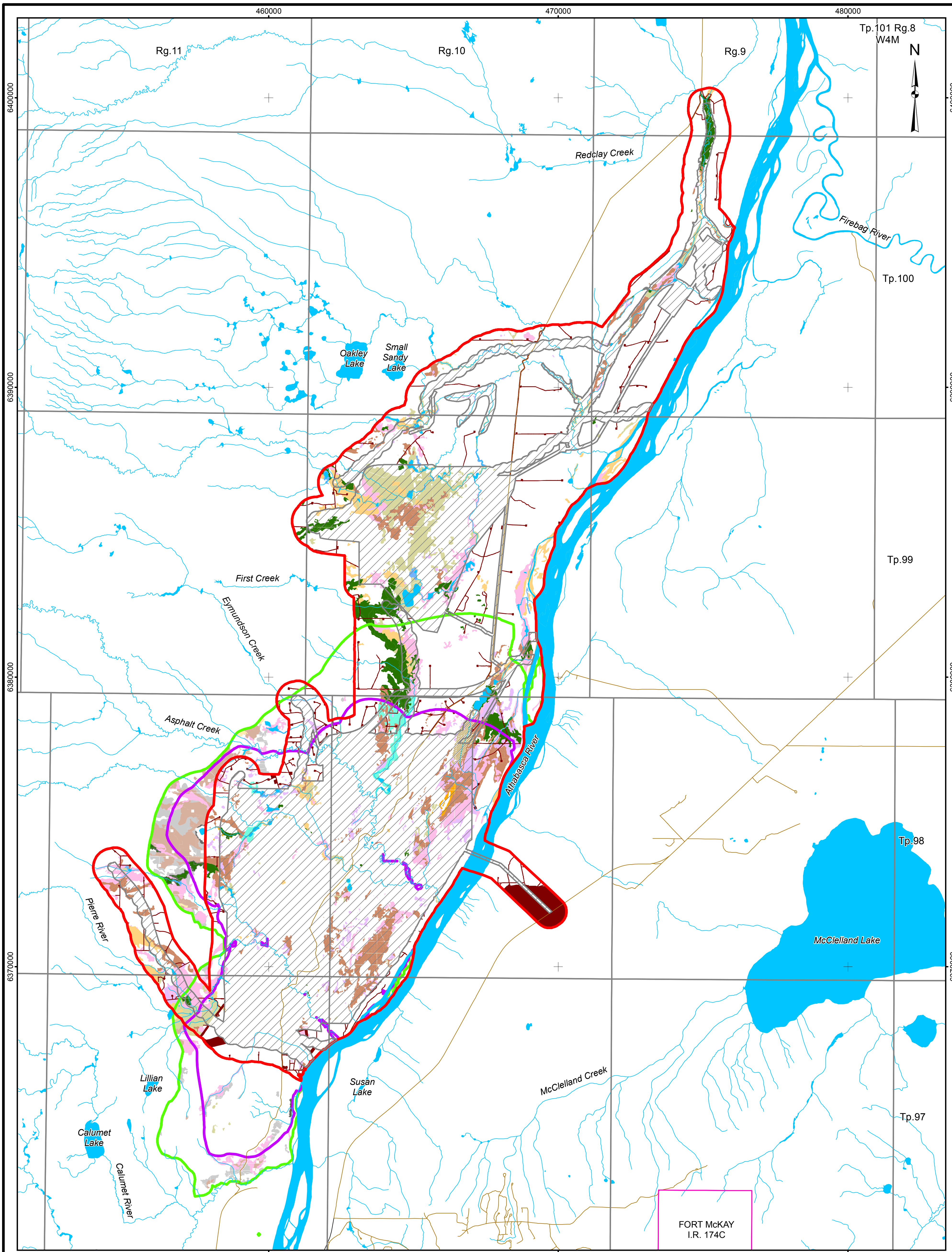

LEGEND

- PAVED ROAD
- UNPAVED ROAD
- WATERCOURSE
- INDIAN RESERVE
- PIERRE RIVER MINE LOCAL STUDY AREA
- PROJECT FOOTPRINT
- OPEN WATER

DISTURBED

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

SURFICIAL AQUIFER DRAWDOWN ISOPLETH

- 0.1 m
- 1 m

WETLAND TYPE

- FORESTED BOG (BFNN)
- WOODED BOG (BTNN)
- SHRUBBY BOG (BONS)
- OPEN PATTERNED FEN (FOPN)
- WOODED FEN (FTNN)
- WOODED SWAMP (STNN)
- GRAMINOID FEN (FONG)
- SHRUBBY FEN (FONS)
- MARSH (MONG)
- SHRUBBY SWAMP (SONS)
- SHALLOW OPEN WATER (WONN)

4 0 4
SCALE 1:125,000 KILOMETRES

REFERENCE

ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2013.
DATUM: NAD83 PROJECTION: UTM ZONE 12N

PROJECT
PIERRE RIVER MINE PROJECT

TITLE
WETLANDS POTENTIALLY AFFECTED BY SURFICIAL AQUIFER DRAWDOWN IN AND NEAR THE TERRESTRIAL LOCAL STUDY AREA

Shell Canada Limited

PROJECT		13-1346-0001	FILE No.	
DESIGN	AD	26 Apr 2013	SCALE AS SHOWN	REV. 0
GIS	SB	24 Jun 2013		
CHECK	CY	18 Jul 2013	**FIGURE: 4.3-2**	
REVIEW	DB	18 Jul 2013		

Construction and operations have the potential to increase dust production which can affect nearby vegetation. Drawdown is not expected to cause an increase in dust production.

Surficial aquifer levels at Closure will be similar to EIA Base Case levels after reclamation (EIA, Volume 4A, Section 6.3). The vegetation alterations due to drawdown are predicted to persist for the aforementioned negatively impacted KIRs after Closure, except for riparian communities, which are naturally adapted to fluctuations in water levels (Luke et al. 2007). Although drawdown effects are predicted to continue near the pit lakes, the recovery of the hydrology is predicted to be accompanied by natural succession towards wetland vegetation communities over time.

4.3.1.4 Key Indicator Resources and Vegetation Resources Residual Impact Classification

In the following sections, PRM effects, residual impacts and environmental consequences during construction and operations include the combined effects of the PRM footprint (i.e., direct effects) and drawdown (i.e., indirect effects). The PRM effects, residual impacts and environmental consequences at Closure are first discussed for direct effects alone, because surficial aquifer levels at Closure will be similar to EIA Base Case levels after reclamation (EIA, Volume 4A, Section 6.3). For comparison, the additional influence that drawdown might have on Closure environmental consequences is also given.

Terrestrial Vegetation (Uplands)

In the 2013 Base Case, terrestrial vegetation (uplands) occupies a total of 39% (Central Mixedwood Natural Subregion plus Athabasca Plain Natural Subregion subtotals) of the LSA (Table 4.3-1). The PRM is predicted to cause a loss of 3,720 ha (41% of resource) of terrestrial vegetation (uplands) in the LSA during construction and operations. The impact is negative and high in magnitude, and the overall environmental consequence for uplands in the LSA is moderate during construction and operations. This environmental consequence is negligible in the RSA with a decrease of terrestrial vegetation of less than 1% of resource during construction and operations.

As a result of the PRM, there is a shift in vegetation community structure in the LSA at Closure. At Closure, terrestrial vegetation (uplands) will occupy 13,571 ha (150% of resource), representing a net increase of 4,526 ha (50% of resource) within the LSA (Table 4.3-1). Within the RSA, the PRM will result in a net increase of terrestrial vegetation by less than 1% of resource at Closure (Table 4.3-2). Therefore, the PRM is expected to have a high and positive environmental consequence at the LSA scale, and a negligible and positive environmental consequence at the RSA scale at Closure. Assessing PRM effects alone results in a high and positive environmental consequence for terrestrial communities in the LSA instead of a moderate positive environmental consequence as reported in the EIA.

Lichen Jack Pine Communities

A total of 779 ha (3%) of the lichen jack pine (a1) ecosite phase (Central Mixedwood Natural Subregion plus Athabasca Plain Natural Subregion subtotals: a1 ecosite phase is called Lichen-jack pine in the Central Mixedwood, and called bearberry jack pine in the Athabasca Plain, but are equivalent) has been mapped within the PRM LSA (Table 4.3-1). Lichen jack pine communities will decrease by 301 ha (39% of resource) in the LSA during construction and operations. Lichen jack pine communities at the RSA scale are associated with the coniferous jack pine RLCC and will decrease by less than 1% of resource (Table 4.3-2). The PRM is predicted to have a negative and moderate environmental consequence on lichen jack pine communities in the LSA and a negligible environmental consequence in the RSA during construction and operations. At Closure, a net decrease of 34 ha (4% of resource) is predicted for lichen jack pine communities compared to the 2013 Base Case in the LSA. At Closure, the PRM will result in a net decrease of less than 1% of coniferous jack pine RLCC communities in the RSA. Therefore, assessing the effects of PRM alone, at Closure a negative and negligible environmental consequence within the LSA is predicted instead of a positive and negligible environmental consequence as reported in the EIA. At the RSA scale, assessing the effects of PRM alone results in a negative and negligible environmental consequence, which is the same as in the EIA.

Riparian Communities

Riparian communities represent vegetation assemblages adjacent to streams and waterbodies whose structure and function are influenced by, or dependent upon, this aquatic association. There is both a spatial and functional component to mapping riparian communities. At the LSA scale, riparian communities are identified as those vegetation types with the potential to support a riparian ecosystem and occur within 100 m of a watercourse. Burns and low impact disturbances are also considered to have conditional riparian potential. Areas with conditional riparian potential are considered riparian if the underlying pre-baseline ecosite phases had riparian potential. Areas within the 100 m buffer that are initially considered as riparian are removed if they are smaller than 1,000 m^2, or if they are not immediately adjacent (i.e., more than 5 m) to a waterbody or watercourse. Other polygons that may have been fragmented by low impact disturbance, (i.e., cutlines/trails and inactive well sites), but did occur within a riparian zone remained as riparian habitat. Other polygons that may have been fragmented by high impact disturbance, such as roads, were re-classified as non-riparian, even when they occurred within a riparian zone. Additional details are presented in the *Terrestrial Environmental Setting Report for the Jackpine Mine Expansion & Pierre River Mine Project* (Golder 2007b).

In the 2013 Base Case, a total of 2,487 ha (11% of the LSA) of riparian communities were mapped within the LSA (Table 4.3-4). Combined direct and indirect effects will cause a net decrease of 1,566 ha (63% of resource) in riparian communities in the LSA during PRM construction and operations (Table 4.3-4). The environmental consequence for riparian communities during construction and operations is predicted to be negative and high within the LSA, and not applicable, too small an area to map separately at the RSA scale, in the RSA (EIA, Volume 5, Section 7.5). In the RSA, riparian communities are not mapped for the predicted reclamation landscape; therefore, Closure riparian communities are not identified at the RSA scale.

At Closure, the reclaimed landscape will have 2,384 ha (96% of resource) of riparian communities, a net decrease of 103 ha (4% of resource) over the 2013 Base Case. Riparian communities are adapted to fluctuating water levels (Luke et al. 2007) and are not expected to have permanent effects at Closure for most wetlands types, when surficial aquifer levels will have returned to near 2013 Base Case levels. The Closure landscape includes riparian communities unaffected by development and new reclaimed riparian communities around South Redclay Lake, pit lakes, littoral zones and shrubland reclamation types (EIA Volume 5, Appendices 5-1 and 5-2) near streams and waterbodies. The PRM is predicted to have a negative and low environmental consequence for riparian communities in the LSA at Closure, which differs from the positive and negligible environmental consequence predicted for riparian communities in the EIA. As indicated in the previous paragraph, in the RSA, riparian communities are not mapped in the predicted reclamation landscape; therefore, Closure riparian communities are not identified at the RSA scale.

Table 4.3-4 Riparian Communities in the Local Study Area

Riparian Map Code	Description	2013 Base Case		Loss/Alteration due to Pierre River Mine Direct and Indirect Effects[(a)]		Closure[(b)]		Net Change due to Pierre River Mine[(c)]	
		Area [ha]	% of LSA[(d)]	Area [ha]	% of Resource[(e)]	Area [ha]	% of Resource[(e)]	Area [ha]	% of Resource[(e)]
Central Mixedwood Natural Subregion Ecosite Phases									
e1	dogwood balsam poplar-aspen	3	<1	-2	-66	4	166	2	66
e2	dogwood balsam poplar-white spruce	54	<1	-20	-38	25	47	-29	-53
e3	dogwood white spruce	59	<1	-43	-73	69	118	10	18
f1	horsetail balsam poplar-aspen	2	<1	-2	-100	0	0	-2	-100
h1	Labrador tea/horsetail white spruce-black spruce	8	<1	-3	-38	4	51	-4	-49
	central mixedwood ecosite phase subtotal	*125*	*<1*	*-70*	*-56*	*102*	*82*	*-23*	*-18*
Athabasca Plain Natural Subregion									
e1	willow/horsetail aspen-white birch-balsam poplar	227	<1	-11	-5	213	94	-14	-6
e2	willow/horsetail aspen-white spruce-black spruce	135	<1	-73	-54	67	50	-68	-50
e3	willow/horsetail white spruce-black spruce	76	<1	-38	-50	252	330	176	230
	Athabasca plain ecosite phases subtotal	*439*	*2*	*-122*	*-28*	*532*	*121*	*93*	*21*
Wetlands Types									
FONG	graminoid fen	355	2	-323	-91	79	22	-276	-78
FONS	shrubby fen	375	2	-283	-76	134	36	-241	-64
FOPN	open patterned fen	32	<1	-32	-100	0	0	-32	-100
FTNN	wooded fen	173	<1	-147	-85	33	19	-140	-81
MONG	marsh	88	<1	-88	-100	7	8	-81	-92
SONS	shrubby swamp	247	1	-122	-49	128	52	-119	-48
STNN	wooded swamp	163	<1	-129	-79	63	39	-100	-61
	wetlands types subtotal	*1,432*	*6*	*-1,123*	*-78*	*443*	*31*	*-989*	*-69*

Table 4.3-4 Riparian Communities in the Local Study Area (continued)

Riparian Map Code	Description	2013 Base Case		Loss/Alteration due to Pierre River Mine Direct and Indirect Effects[(a)]		Closure[(b)]		Net Change due to Pierre River Mine[(c)]	
		Area [ha]	% of LSA[(d)]	Area [ha]	% of Resource[(e)]	Area [ha]	% of Resource[(e)]	Area [ha]	% of Resource[(e)]
Miscellaneous Vegetation Types									
BUu	burn upland	118	<1	-70	-60	50	42	-68	-58
BUw	burn wetlands[(f)]	202	<1	-161	-80	53	26	-149	-74
Me	meadow	2	<1	-2	-90	<1	22	-1	-78
Sh	shrubland	105	<1	-3	-3	100	95	-5	-5
Sh1	reclaimed shrubland 1	n/a	n/a	n/a	n/a	386	n/a	386	n/a
Sh2	reclaimed shrubland 2	n/a	n/a	n/a	n/a	668	n/a	668	n/a
	miscellaneous vegetation types subtotal	*427*	*2*	*-236*	*-55*	*1,258*	*295*	*831*	*195*
Non-Vegetation Types									
sand	sand	48	<1	-5	-10	43	90	-5	-10
	non-vegetation types subtotal	*48*	*<1*	*-5*	*-10*	*43*	*90*	*-5*	*-10*
Disturbances									
DIS[(g)]	disturbance	15	<1	-9	-61	5	30	-11	-70
	disturbances subtotal	*15*	*<1*	*-9*	*-61*	*5*	*30*	*-11*	*-70*
Total		**2,487**	**11**	**-1,566**	**-63**	**2,384**	**96**	**-103**	**-4**

(a) Loss/alteration due to the PRM combines direct effects due to site clearing (PRM footprint) and indirect effects due to surficial aquifer drawdown within the LSA, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed.

(b) Closure scenario includes reclamation of the PRM development areas.

(c) Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

(d) For the purposes of this assessment, each land cover type is assumed to be 100% of resource at 2013 Base Case.

(e) % of resource is calculated as a percentage of 2013 Base Case area; the values of this column are not additive.

(f) Burn areas with conditional riparian potential are considered riparian if the underlying pre-baseline ecosites had riparian potential.

(g) Disturbed riparian communities include cutlines/trails and inactive well sites.

n/a = Not applicable, PRM = Pierre River Mine.

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

Old Growth Forest

The age of old growth was assessed based on the stand type; black spruce, white spruce, tamarack and balsam fir stands were considered old growth at 140 years, jack pine stands at 120 years, and deciduous and mixedwood stands at 100 years. Old growth forest accounts for 1,141 ha (5%) of the LSA in the 2013 Base Case (Table 4.3-5). The PRM will result in the removal of 448 ha (40% of resource) of the old growth forest during construction and operations. Old growth forest lost during construction and operation of the PRM will not return within the 80-year closure time frame because development of old growth requires 100 years or more.

Table 4.3-5 Old Growth Forests in the Local Study Area

Old Growth	2013 Base Case		Loss/Alteration due to Pierre River Mine Direct and Indirect Effects[a]	
	Area [ha]	% of LSA	Area [ha]	% of Resource[b]
timber productive old growth[c]	1,128	5	-448	-40
non-productive old growth[d]	13	0	0	0
Total	**1,141**	**5**	**-448**	**-40**

[a] Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case, a value upon which the Environmental consequence is assessed. Net change between the 2013 Base Case and Closure is assumed to be the same and is not shown.

[b] % of resource is calculated as a percentage of 2013 Base Case area, the areas of this column are not additive.

[c] Aspen, jack pine, balsam poplar and white spruce leading stands.

[d] Tamarack and black spruce leading stands.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

For each RLCC in Table 4.3-6, the amount of old growth forest in the RSA was determined using the mid-point values from an age class variability assessment based on the dominant tree type (Andison 2003). Based on the mid-point ages assigned to each RLCC, the estimated amount of old growth forest potential area in the RSA is 295,513 ha (13% of the RSA; Table 4.3-6). As a result of PRM activities, the amount of old growth potential area is predicted to decrease by 448 ha (less than 1% of resource).

During construction and operations and at Closure, the PRM is expected to have a negative and high environmental consequence for old growth forests in the LSA. Within the RSA, the environmental consequence is negative and negligible. This ranking differs from the negative and low environmental consequences for old growth in the LSA in the EIA.

Table 4.3-6 Old Growth Forests in the Regional Study Area

Regional Land Cover Classes	Forest Type (Old Growth Range)[a]	Estimated Occurrence of Old Growth in the RSA [%][b]	2013 Base Case: Total Class Area in the RSA[c]	Estimated 2013 Base Case Old Growth in the RSA		Loss/Alteration due to the Pierre River Mine[d]	
			[ha]	[ha]	% of RSA	[ha]	% of Resource[e]
Forested Cover Type							
coniferous jack pine	pine dominant (16% to 36%)	26	166,332	43,246	2	-<1	-<1
coniferous jack pine–black spruce	pine dominant (16% to 36%)	26	40,054	10,414	<1	-88	-<1
coniferous white spruce	white spruce dominant (10% to 34%)	22	52,386	11,525	<1	-72	-<1
deciduous aspen–balsam poplar	hardwood dominant (14% to 42%)	28	178,067	49,859	2	-95	-<1
mixedwood aspen–jack pine	mixedwood dominant (16% to 38%)	27	39,033	10,539	<1	-19	-<1
mixedwood aspen–white spruce	mixedwood dominant (16% to 38%)	27	144,759	39,085	2	-173	-<1
treed bog/poor fen	black spruce dominant (12% to 28%)	20	423,855	84,771	4	0	0
treed fen	black spruce dominant (12% to 28%)	20	230,369	46,074	2	-<1	-<1
Total		**n/a**	**1,274,855**	**295,513**	**13**	**-448**	**-<1**

(a) Based on percent ranges of overmature dominant tree species derived from computer modelling of historic patterns in seral stage variation over time (Andison 2003).

(b) Based on mid-point of the percent range of the overmature age class values in Andison (2003).

(c) Includes burns and cutblocks as modelled by ALCES.

(d) Values generated by correlating the amount of loss/alteration of old growth in each LSA vegetation type to the corresponding regional land cover class. These values are used to assess environmental consequence before and after reclamation.

(e) % of resource is calculated as a percentage of 2013 Base Case area, the areas of this column are not additive.

n/a = Not applicable, PRM = Pierre River Mine.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

Wetlands (Including Peatlands and Patterned Fens)

As shown in Table 4.3-1, within the LSA, wetlands are broadly defined as swamps, marshes, shallow open water and peatlands. Peatlands can be delineated to include bogs, fens and burned wetlands (BUw). In addition, fens can be separated into patterned fens, which include the open patterned fen (FOPN) wetlands type in the LSA. Within the RSA, wetlands are represented by the following RLCCs: non-treed wetlands, treed bog/poor fen and treed fen. Peatlands cannot be differentiated using RSA-scale LANDSAT mapping.

Within the LSA, wetlands (including peatlands, patterned fens), and burned wetlands (BUw) occupy 6,886 ha (30% of the LSA) in the 2013 Base Case (Table 4.3-1). Loss/alteration as a result of the PRM combines direct effects due to site clearing (PRM footprint) and indirect effects from surficial aquifer drawdown within the LSA. Wetlands (-3,684 ha) and burned wetlands (-1,910 ha) will decrease by 5,595 ha (81% of resource) in the LSA due to direct and indirect effects of the PRM during construction and operations. Peatlands (3,247 ha: forested bog [BFNN], shrubby bog [BONS], wooded bog [BTNN], graminoid fen [FONG], shrubby fen [FONS], open patterned fen [FONG], wooded fen [FTNN]), including burned wetlands (BUw, 2,345 ha), occupy 5,592 ha (24% of the LSA) in the 2013 Base Case and will decrease by 4,704 ha (84% of resource) due to direct and indirect effects of the PRM during construction and operations (peatlands are further discussed in JRP SIR 46, Appendix 3.0, Table 46-1). A total of 67 ha of patterned fens were mapped within the LSA in the 2013 Base Case. Due to direct and indirect effects during construction and operations, there will be a 100% loss of patterned fens. During construction and operations, the PRM is expected to have a negative and high environmental consequence for wetlands (including peatlands and patterned fens) in the LSA.

Within the LSA, wetlands (-2,785 ha; including peatlands and patterned fens) and burned wetlands (BUw; -1,616 ha) will decrease by 4,280 ha (62% of resource) from 2013 Base Case to Closure due to direct effects of the PRM (Table 4.3-1). In the LSA, a net decrease of 3,784 ha (68% of resource) of peatlands, including burned wetlands (BUw), and a net decrease of 54 ha (81% of resource) of patterned fens is predicted from the 2013 Base Case to Closure due to direct effects of the PRM (JRP SIR 46, Appendix 3.0, Table 46-1). The 13 ha of patterned fen present at Closure that was absent during construction and operations is considered recovered due to the dissipation of effects of surficial aquifer drawdown. At Closure, marsh and swamp wetlands types are expected to be reclaimed. However, peatland reclamation techniques are currently being researched. Peatlands cleared during construction cannot currently be reclaimed, and are considered permanently lost.

Wetlands account for 895,334 ha (39%) of the RSA (Table 4.3-2). The PRM will result in a loss of 9,906 ha (1% of resource) of wetlands (including peatlands) in the RSA resulting in a negligible environmental consequence in the RSA during construction and operations. The PRM will result in a net decrease of 6,792 ha (less than 1% of resource) of wetlands (including peatlands) in the RSA from 2013 Base Case to Closure. At the RSA scale, area and percentages for peatlands and patterned fens are not assessed individually, because wetlands classification used at the RSA scale is too coarse to differentiate peatlands and patterned fens separately from other wetlands. The finer scale Alberta Vegetation Inventory (AVI) data that allows for peatlands and patterned fens to be mapped separately at the LSA scale are not available for the entire area of the RSA. Further discussion on assessing peatlands and patterned fens in the RSA is provided in the JRP SIR 46.

At Closure, the PRM direct effects on wetlands (including peatlands and patterned fens) are expected to have a negative and high environmental consequence at the LSA scale, and a negligible environmental consequence at the RSA scale, and will not change the environmental consequence assessed for wetlands (including peatlands and patterned fens) in the EIA.

Surficial aquifer drawdown will occur primarily during the life of the PRM; however, drawdown effects on wetlands types surrounding South Redclay Lake and pit lakes may extend to Closure. At Closure, indirect effects are predicted to cause an additional loss of 1,193 ha (17% of resource) of wetlands (Table 4.3-3). Within wetlands in the LSA, indirect effects of drawdown are predicted to cause an additional loss of 909 ha (16% of resource) of peatlands including burned wetlands (Table 4.3-3). Within peatlands, including burned wetlands (BUw), in the LSA, indirect effects of drawdown are predicted to cause an additional loss of 13 ha (19% of resource) of patterned fens (Table 4.3-3). Including drawdown at Closure results in a loss of wetlands and burned wetlands of 79% of resource, a loss of peatlands and burned wetlands of 84% of resource, and a loss of patterned fens of 100% of resource, in the LSA. There is no change to the environmental consequences due to the incorporation of surficial aquifer drawdown at Closure.

Productive Forests

In the LSA, productive forests are assessed using the Timber Productivity Rating (TPR) from AVI for all mapped vegetation polygons in the LSA. To predict TPR in the Closure scenario, a TPR rank is required for each ecosite phase and wetlands type found within the LSA (EIA, Volume 5, Section 7.5.2, Table 7.5-20). Timber productivity ratings were reclassified for areas affected by the PRM by determining the median 2013 Base Case rank based on a scale of good, medium, fair, unproductive, non-treed and non-vegetated (EIA, Volume 5, Section 7.5.2, Table 7.5-20).

Vegetation classes at the RSA level were classified as either ‘productive’ or ‘unproductive’. Black spruce and tamarack dominated stands are not typically harvested for timber and were considered to be unproductive. Burned areas at the RSA level were excluded from the productive forest land base even though portions of the burned areas may be productive; however information on what types of vegetation occur within the burned areas is not available at the RSA scale. As a result, the burn land cover class was assigned an “unknown” productivity class.

Productive forests in the RSA include the following classes:

- coniferous jack pine;
- coniferous jack pine−black spruce;
- coniferous white spruce;
- deciduous aspen−balsam poplar;
- mixedwood aspen−jack pine;
- mixedwood aspen−white spruce; and
- regenerating cutblock.

During construction and operations, 6,475 ha (45% of resource) of productive forest will be lost/altered by the PRM within the LSA (Table 4.3-7). Within the RSA, the PRM will affect 3,120 ha (less than 1% of resource) of productive forests, 132 ha (less than 1% of resource) of burns and 8,490 ha (less than 1% of resource) of unproductive forests during construction and operations (Table 4.3-8). Environmental consequences are negative and moderate in the LSA, and negative and negligible in the RSA during PRM construction and operations.

From 2013 Base Case to Closure, the largest increase in productive forest within the LSA is predicted for stands rated as medium, and productive forest will have an overall increase of 1,993 ha (14% of resource). Most of these changes are the result of converting 2013 Base Case wetlands types to upland terrestrial vegetation types at Closure. At Closure, RSA productive forests are predicted to increase 5,126 ha (less than 1%) over 2013 Base Case conditions, due to reclamation to terrestrial upland communities. Unproductive forests are predicted to decrease by 4,995 ha (less than 1%) and areas with unknown productivity (i.e., burns) are predicted to decrease by less than 1%. The net increase in productive forest from 2013 Base Case to Closure will result in the same positive and moderate environmental consequence as reported in the EIA. Within the RSA, overall changes in productive forest result in the same positive and negligible environmental consequence as reported in the EIA Application Case.

Annual Allowable Cut (AAC) can be estimated from the Mean Annual Increment (MAI). A detailed description of MAI analysis assessment methods can be found in the EIA (Volume 5, Section 7.5). Estimates of MAI for the 2013 Base Case, 2013 PRM Application Case and Closure landscapes are shown in Tables 4.3-9 and 4.3-10.

The estimates of MAI are totalled on a cover type basis for all productive stands to arrive at Long Run Sustained Yield Average (LRSYA) estimates for the LSA. These estimates also include calculations of incidental fibre. The 2013 Base Case mature stand MAI has been applied to the predicted Closure landscape, 80 years after the end of operations. The mature stand MAI is appropriate, as it applies to stands greater than 70 years of age.

At Closure, productive forest types that support merchantable timber are predicted to increase. This results in a net increase in LRSYA as an estimate of AAC in the LSA. For coniferous fibre, the predicted LRSYA increases from 7,388 to 8,207 m^3/yr, an increase of 11% of resource (Table 4.3-9). The deciduous LRSYA increases from 13,135 to 13,240 m^3/yr, an increase of less than 1% of resource (Table 4.3-10).

Table 4.3-7 Timber Productivity in the Local Study Area

Timber Productivity Rating Description	2013 Base Case		Loss/Alteration due to Pierre River Mine [(a)]		Closure [(b)]		Net Change due to Pierre River Mine[(c)]	
	Area [ha]	% of LSA	Area [ha]	% Resource[(d)]	Area [ha]	% Resource[(d)]	Area [ha]	% Resource[(d)]
Productive Forest								
good	6,922	30	-3,270	-47	6,696	97	-226	-3
medium	7,367	32	-3,129	-42	9,732	132	2,366	32
fair	146	<1	-76	-52	<1	0	-146	-100
productive forest subtotal	*14,435*	*62*	*-6,475*	*-45*	*16,429*	*114*	*1,993*	*14*
Unproductive Landbase								
unproductive[(d)]	8,515	37	-5,238	-62	875	10	-7,640	-90
non-treed[(e)]	179	<1	-29	-16	3,564	1,996	3,385	1,896
non-vegetated[(f)]	<1	<1	0	0	2,262	1,498,759	2,262	1,498,659
unproductive landbase subtotal	*8,694*	*38*	*-5,267*	*-61*	*6,701*	*77*	*-1,993*	-23
Total[(g)]	**23,129**	**100**	**-11,742**	**-51**	**23,129**	**100**	**n/a**	**n/a**

(a) Loss/alteration due to the PRM is due to direct effects of site clearing, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed.

(b) Closure scenario includes reclamation of the PRM development areas.

(c) Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure. Net change is a value upon which the environmental consequence is assessed at Closure.

(d) % of resource is calculated as a percentage of 2013 Base Case area.

(e) Includes unproductive stands, disturbance, black spruce and tamarack dominated stands, and unproductive treed wetlands.

(f) Non-treed types include non-treed terrestrial and wetlands types (EIA, Volume 5, Section 7.5-2, Table 7.5-20).

g) Non-vegetated types include water types and sand.

(h) Pierre River Mine LSA or footprint.

n/a = Not applicable.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

Table 4.3-8 Productive Forests Within the Regional Study Area

Timber Productivity	2013 Base Case[a]		Loss/Alteration due to the Pierre River Mine[b]		Closure[a][c]		Net Change due to the Pierre River Mine[d]	
	[ha]	% of RSA[e]	[ha]	% of Resource[f]	[ha]	% of Resource[f]	[ha]	% of Resource[f]
potentially productive	720,790	32	-3,120	-<1	725,916	101	5,126	<1
unproductive land and water	1,160,462	51	-8,490	-<1	1,155,467	160	-4,995	-<1
unknown (burns)	396,125	17	-132	-<1	395,993	55	-132	-<1
Total	**2,277,376**	**100**	**-11,742**	**-<1**	**2,277,376**	**100**	n/a	**n/a**

(a) Includes burns and cutblocks as modelled by ALCES.

(b) Loss/alteration is the value upon which the environmental consequence is assessed at 2013 PRM Application Case.

(c) Closure scenario includes reclamation of the PRM development areas.

(d) Net change is calculated as the difference between the 2013 Base Case and closure, a value upon which the environmental consequence is assessed.

(e) For the purposes of this assessment, each productive forest category is assumed to be 100% of resource at 2013 Base Case.

(f) % of resource is calculated as a percentage of 2013 Base Case area; the areas of this column are not additive.

n/a = Not applicable, PRM = Pierre River Mine.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

Table 4.3-9 Coniferous Mean Annual Increment for the Local Study Area

Predominant Forest Cover Types	2013 Base Case		Loss/Alteration due to Pierre River Mine			Closure[(a)]		Net Change due to Pierre River Mine[(b)]		
	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	% of Resource [(c)]	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	% of Resource[(c)]
total merchantable deciduous	1,891	26	-748	-10	-40	1,886	26	-5	-<1	-<1
total merchantable coniferous	4,715	64	-2,102	-28	-45	5,498	74	783	11	17
total merchantable mixedwood	782	11	-337	-5	-43	823	11	41	<1	5
total merchantable regenerating cutblocks[(d)]	0	0	0	0	0	0	0	0	0	0
total merchantable	7,388	100	-3,187	-43	-43	8,207	111	819	11	11
total non-merchantable[(e)]	607	8	-361	-5	-59	973	197	365	5	60
long run sustained yield average	**7,388**	**100**	**-3,187**	**-43**	**43**	**8,207**	**111**	**819**	**11**	**11**

(a) Closure scenario includes reclamation of the PRM development areas.

(b) Net change due is calculated as the difference between the 2013 Base Case and Closure.

(c) % of resource is calculated as a percentage of 2013 Base Case area; the areas of this column are not additive.

(d) Cutblocks within the LSA were greater than 95% cleared according to AVI data; therefore, timber volume in cutblocks is assumed to be negligible.

(e) Unproductive forest (black spruce and tamarack stands) does not contribute to the net merchantable land base or Long Run Sustained Yield Average (LRSYA) and is included in the table for comparative purposes only.

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

Table 4.3-10 Deciduous Mean Annual Increment for the Local Study Area

Predominant Forest Cover Types	2013 Base Case		Loss/Alteration due to Pierre River Mine			Closure[(a)]		Net Change due to Pierre River Mine[(b)]		
	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	% of Resource [(c)]	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	Total MAI [m^3/yr]	% of 2013 Base Case LRSYA	% of Resource[(c)]
total merchantable deciduous	10,153	77	-4,000	-30	-39	10,097	77	-55	-<1	-<1
total merchantable coniferous	1,065	8	-493	-4	-46	1,217	9	152	1	14
total merchantable mixedwood	1,917	15	-872	-7	-45	1,926	15	9	<1	<1
total merchantable regenerating cutblocks[(d)]	0	0	0	0	0	0	0	0	0	0
total merchantable	13,135	100	-5,365	-41	-41	13,240	101	105	<1	<1
total non-merchantable[(e)]	242	2	-140	-1	-58	459	3	217	2	90
long run sustained yield average	**13,135**	**100**	**-5,365**	**-41**	**-41**	**13,240**	**101**	**105**	**<1**	**<1**

(a) Closure scenario includes reclamation of the PRM development areas.

(b) Net change due is calculated as the difference between the 2013 Base Case and Closure.

(c) % of resource is calculated as a percentage of 2013 Base Case area; the areas of this column are not additive.

(d) Cutblocks within the LSA were greater than 95% cleared according to AVI data; therefore, timber volume in cutblocks is assumed to be negligible.

(e) Unproductive forest (black spruce and tamarack stands) does not contribute to the net merchantable land base or Long Run Sustained Yield Average (LRSYA) and is included in the table for comparative purposes only.

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

PRM = Pierre River Mine.

Rare Plant Occurrences

Potential effects to rare plants in the LSA and RSA are assessed by quantifying changes in area of land cover types and RLCCs ranked as "high" for rare plant potential, and by changes in rare and special plant communities (i.e., river alder/ostrich fern and sparsely vegetated slope). Although PRM also affects rare plant occurrences, the magnitude of effects to rare plant occurrences cannot be quantified, partly because the number of rare plants outside of surveyed sites cannot be quantified and therefore, the overall effects on individual rare plants as a % of resource cannot be calculated. Residual impacts are assessed for areas of high rare plant potential and the rare and special plant communities.

A total of 231 rare plant occurrences (i.e., rare plants as defined by ACIMS tracking and watch lists, as well as other less known species that are currently unranked by ACIMS) were identified within the LSA (ACIMS 2012) (Table 4.3-11). Of these 231 occurrences, there are 2 vascular, 5 bryophyte and 224 lichen species (Table 4.3-11). The lichen flora of Alberta in particular is poorly known, especially in the north and eastern portions of the province (Goward 2011, pers. comm.). Thus, while some lichen species may be rare or new to the province, it is likely that many of them could be common within the region. Based on recorded rare plant occurrences, a total of 189 rare plant occurrences are predicted to be permanently lost due to the direct and indirect effects of the PRM, resulting in a total of 42 rare plant occurrences remaining at Closure. Of that total, direct effects result in the loss of 180 rare plant occurrences and surficial aquifer drawdown results in the loss of nine additional rare plant occurrences. An additional 242 rare plant occurrences were noted in the RSA (202 from ACIMS [2012] and 40 from ABMI [2013]). Drawdown outside the LSA results in a loss of three additional rare plant occurrences in the RSA (Table 4.3-11).

A total of 3,698 ha of high rare plant potential areas were mapped within the LSA at 2013 Base Case (Table 4.3-12). Combined direct and indirect effects will result in a decrease of 2,907 ha (79% of resource) in high rare plant potential areas in the LSA during construction and operations (Table 4.3-12). At Closure, high rare plant potential areas are predicted to occupy 1,462 ha, representing a net decrease of 2,237 ha (60% of resource) (Table 4.3-12). Surficial aquifer drawdown will only be experienced during the life of the PRM; however, the effects may extend to Closure such that at Closure combined direct and indirect effects of drawdown outside the PRM footprint are predicted to cause a net decrease in high rare plant potential areas of 2,797 ha (76% of resource). The PRM will alter 7,526 ha (2% of resource) of high rare plant potential within the RSA during construction and operations (Table 4.3-13). There will be a net decrease of 4,836 ha (1% of the RSA) from 2013 Base Case to Closure, within the RSA.

Due to direct and indirect effects combined, during PRM construction and operations the PRM will have a negative and high environmental consequence on high rare plant potential in the LSA, and a negative and low environmental consequence in the RSA. At Closure, the direct and indirect effects of the PRM on areas of high rare plant potential are predicted to have a negative and high environmental consequence at the LSA scale, and a negative and low environmental consequence at the RSA scale. There is no change in environmental consequence for high rare plant potential in the LSA, as compared to the EIA; however, the low environmental consequence in the RSA is a change compared to the negligible environmental consequence noted in the RSA in the EIA for a combined high rare plant potential, rare plant occurrence, and rare and special plant community KIR.

Table 4.3-11 Total Number of Rare Species Occurrences Documented in the Local Study Area

Species Group	Species Occurrences[a]									
	2013 Base Case	Direct Loss due to Pierre River Mine	Indirect Loss due to Pierre River Mine	Net Direct and Indirect Loss due to Pierre River Mine[a]		Closure[b]	Other Occurrences Reported in the RSA-ACIMS[c]	Other Occurrences Reported in the RSA ABMI[d]	Additional Indirect Loss Due to Drawdown in the RSA	
	Occurrences	Occurrences	Occurrences[e]	Occurrences	% of Resource[f]	Occurrences			Occurrences	% of Resource[g]
vascular	2	-1	0	-1	-50	1	41	13	0	n/a
bryophyte	5	-4	0	-4	-80	1	28	19	0	n/a
lichen	224	-175	-9	-184	-82	40	133	8	-3	**-<1**
Total	**231**	**-180**	**-9**	**-189**	**-82**	**42**	**202**	**40**	**-3**	**-<1**

(a) Number of rare plant occurrences is based on survey data in the LSA and historical data from ACIMS.

(b) Closure scenario includes reclamation of the PRM development areas.

(c) Numbers of rare vascular plant occurrences within the RSA is based on historical data from the Alberta Conservation Information Management System (ACIMS 2012).

(d) Additional rare plant occurrences within the Regional Study Area (RSA) from Alberta Biodiversity Monitoring Institute (ABMI) are based on raw data from ABMI inventories (2007 -2011). ABMI cautions that their datasets are intended for use in large regional areas and does not recommend analyses using ABMI datasets with fewer than 50 points. The PRM RSA contains 40 ABMI data points and results should be interpreted with caution. The ABMI is not designed to survey very uncommon elements as large-scale systematic sampling designs are not an optimal strategy for sampling highly patchy or uncommon resources; ABMI recommends that data on rare or under-represented species should be analyzed and interpreted cautiously.

(e) Number of rare plants lost is due to drawdown effects only.

(f) % of resource is calculated as a percentage of rare plant occurrences in the LSA; the numbers of this column are not additive.

(g) % of resource is calculated as percentage of rare plant occurrences in the LSA and RSA combined; the numbers of this column are not additive.

Note: Rare plant species found in the LSA were updated using ACIMS (2012) and data from the EIA. Species no longer listed as rare (tracked, watched or unranked) were removed from the data set, resulting in some differences between the table and data from the EIA.

PRM = Pierre River Mine.

Table 4.3-12 Rare Plant Potential in the Local Study Area

Rare Plant Potential	2013 Base Case	Direct Loss/ Alteration due to Pierre River Mine		Indirect Loss/Alteration due to drawdown from Pierre River Mine		Loss/Alteration due to Pierre River Mine Direct and Indirect Effects[(a)]		Closure[(b)]		Net Change due to Pierre River Mine[(c)]	
	Area [ha]	Area [ha]	% of Resource[(d)]	Area [ha]	% of Resource[(d)]	Area [ha]	% of Resource[(d)]	Area [ha]	% of Resource[(d)]	Area [ha]	% of Resource[(d)]
high	3,698	-2,347	-63	-560	-15	-2,907	-79	1,462	40	-2,237	-60
moderate	15,727	-7,682	-49	-504	-3	-8,187	-52	12,397	79	-3,331	-21
low	3,703	-1,713	-46	-129	-3	-1,841	-50	9,271	250	5,567	150
Total[(e)]	**23,129**	**-11,742**	**-51**	**-1,193**	**-5**	**-12,935**	**-56**	**23,129**	**100**	**n/a**	**n/a**

(a) Loss/alteration due to the PRM combined direct effect due to site clearing (PRM footprint) and indirect effects due to surficial aquifer drawdown within the LSA, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed.

(b) Closure scenario includes reclamation of the PRM development areas.

(c) Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

(d) % of resource is calculated as a percentage of 2013 Base Case area; the values of this column are not additive.

(e) Pierre River Mine LSA or footprint.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

n/a = Not applicable.

Table 4.3-13 Rare Plant Potential in the Regional Study Area

RSA Rare Plant Potential	2013 Base Case[a]		Loss/Alteration due to Pierre River Mine[a][b]		Closure[a][c]		Net Change due to Pierre River Mine[d]	
	Area [ha]	% of RSA[e]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]
high	471,479	21	-7,526	-2	466,643	99	-4,836	-1
moderate	1,165,558	28	-3,155	-<1	1,167,678	100	2,119	<1
low	640,339	51	-3,243	-<1	643,056	100	2,717	<1
Total	**2,277,376**	**100**	**-13,924**	-<1	**2,277,376**	**n/a**	**n/a**	**n/a**

(a) Includes burns and cutblocks as modelled by ALCES.

(b) Loss/alteration combines direct effects due to site clearing (PRM footprint) and indirect effects due to surficial aquifer drawdown within the RSA, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed. Excluding indirect effects due to surficial aquifer drawdown there is a total loss/alteration of -11,742 ha within the RSA.

(c) Closure scenario includes reclamation of the PRM development areas. Values presented in this table do not include indirect effects due to surficial aquifer drawdown, as drawdown will occur primarily during the life of PRM. Drawdown effects on wetlands types surrounding pit lakes may extend to Closure. At Closure combined direct and indirect effects are predicted to cause an additional loss of 1,467 ha, 708 ha and 6 ha (less than 1% of resource) of high, moderate and low rare plant potential areas, respectively.

(d) Net change is calculated as the difference between the 2013 Base Case and Closure, a value upon which the environmental consequence is assessed.

(e) For the purposes of this assessment, each rare plant potential category is assumed to be at 100% of resource at 2013 Base Case.

(f) % of resource is calculated as a percentage of 2013 Base Case area; the areas of this column are not additive.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

n/a = Not applicable.

Two occurrences of a river alder/ostrich fern, and one occurrence of a sparsely vegetated slope rare and special plant community are reported within the northern and northeastern part of the LSA. These three occurrences of rare and special plant communities occur outside the PRM footprint and drawdown area; therefore, they are not expected to be affected by PRM or drawdown (EIA, Volume 5, Section 7.5.2). The PRM is not predicted to affect rare and special plant communities during construction and operations, and at Closure within the LSA. Potential direct and indirect effects to the rare and special plant communities are not expected within the RSA; therefore, an environmental consequence is not applicable. The lack of an effect on the river alder/ostrich fern and sparsely vegetated slope rare and special plant communities is a change compared to the environmental consequence for rare and special plant communities assigned in the EIA (i.e., negative and high environmental consequence). The EIA environmental consequences were negative and high based on combined effects assessments of high rare plant potential, and three rare and special plant communities that included the lenticular patterned fen within the JME LSA (EIA, Volume 5, Section 7.5.2).

Traditional Use Plants

In the LSA, the PRM will alter 3,316 ha (41% of resource) of the high traditional use plant potential during construction and operations due to direct effects. Indirect effects are not predicted to affect areas of high traditional use plant potential (Table 4.3-14). In the LSA, direct and indirect effects of PRM combined are predicted to alter 6,207 ha (65% of resource) of the moderate traditional use plant potential and 3,412 ha (62% of resource) of low traditional use plant potential during construction and operations (Table 4.3-14). In the RSA, the PRM will cause loss/alteration of 2,771 ha (less than 1% of resource) of the high traditional use plant potential, 7,820 ha (1% of resource) of the moderate traditional use plant potential, and 3,333 ha (less than 1% of resource) of the low traditional use plant potential during construction and operations (Table 4.3-15). The PRM will result in a negative and moderate environmental consequence to high traditional use plant potential areas in the LSA during construction and operations (Table 4.3-17). In the RSA, the PRM results in a negative and negligible environmental consequence to high traditional use plant potential areas during construction and operations (Table 4.3-17).

At Closure, high traditional use plant potential areas are predicted to occupy 8,566 ha (106% of resource) in the LSA, an increase of 489 ha (6% of resource), while moderate traditional use plant potential areas will decrease by 3,310 ha (35% of resource) (Table 4.3-14). Low traditional use plant potential areas will increase by 2,821 ha (51% of resource) over the 2013 Base Case. In the RSA at Closure, after reclamation, moderate traditional use plant potential areas are predicted to decrease by 2,132 ha (less than 1% of resource), while high and low traditional use plant potential areas are expected to increase by 1,034 ha (less than 1% of resource) and 1,098 ha (less than 1% of resource) over the 2013 Base Case (Table 4.3-15). At Closure, the PRM is expected to have a positive and low environmental consequence for high traditional use plant potential at the LSA scale, and a positive and negligible environmental consequence at the RSA scale. Including drawdown at Closure will not change environmental consequences for high traditional use plant potential. The 2013 PRM Application Case environmental consequences represent a change from the environmental consequences as assessed in the EIA Application Case.

Table 4.3-14 Traditional Use Plant Potential in the Local Study Area

Traditional Plant Potential	2013 Base Case	Direct Loss/Alteration due to Pierre River Mine		Indirect Loss/Alteration due to Drawdown from Pierre River Mine		Loss/Alteration due to Pierre River Mine Direct and Indirect Effects[a]		Closure[b]		Net Change due to Pierre River Mine[c]	
	Area [ha]	Area [ha]	% of Resource[d]	Area [ha]	% of Resource[d]	Area [ha]	% of Resource[d]	Area [ha]	% of Resource[d]	Area [ha]	% of Resource[d]
high	8,077	-3,316	41	0	0	-3,316	-41	8,566	106	489	6
moderate	9,529	-5,397	57	-810	-9	-6,207	-65	6,219	65	-3,310	-35
low	5,523	-3,029	55	-383	-7	-3,412	-62	8,344	151	2,821	51
Total[e]	**23,129**	**-11,742**	**51**	**-1,193**	**-5**	**-12,935**	**-56**	**23,129**	**100**	**n/a**	**n/a**

[a] Loss/alteration due to the PRM combined direct effect due to site clearing (PRM footprint) and indirect effects due to surficial aquifer drawdown within the LSA, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed.

[b] Closure scenario includes reclamation of the PRM development areas.

[c] Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

[d] % of resource is calculated as a percentage of 2013 Base Case area; the values in this column are not additive.

[e] Pierre River Mine LSA.

n/a = Not applicable, PRM = Pierre River Mine.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

Table 4.3-15 Traditional Use Plant Potential in the Regional Study Area

Regional Study Area Rare Plant Potential	2013 Base Case[a]		Loss/Alteration due to Pierre River Mine[a][b]		Closure[a][c]		Net Change due to Pierre River Mine [d]	
	Area [ha]	% of RSA[e]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]	Area [ha]	% of Resource[f]
high	414,244	18	-2,771	-<1	415,278	100	1,034	<1
moderate	1,090,403	48	-7,820	-1	1,088,271	100	-2,132	-<1
low	772,729	34	-3,333	-<1	773,827	100	1,098	<1
Total	**2,277,376**	**100**	**-13,924**	**-<1**	**2,277,376**	**n/a**	**n/a**	**n/a**

(a) Includes burns and cutblocks as modelled by ALCES.

(b) Loss/alteration combines direct effects due to site clearing (PRM footprint) and indirect effects due to surficial aquifer drawdown within the RSA, and at 2013 PRM Application Case is the value upon which the environmental consequence is assessed. Excluding indirect effects due to surficial aquifer drawdown there is a total loss/alteration of -11,742 ha within the RSA.

(c) Closure scenario includes reclamation of the PRM development areas. Values presented in this table do not include indirect effects due to surficial aquifer drawdown, as drawdown will occur primarily during the life of PRM. Drawdown effects on wetlands types surrounding pit lakes may extend to Closure. At Closure, indirect effects are predicted to cause an additional loss of 1,503 ha and 678 ha (less than 1% of resource) of moderate and low traditional plant potential areas, respectively.

(d) Net change is calculated as the difference between the 2013 Base Case and Closure, a value upon which the environmental consequence after reclamation is assessed.

(e) For the purposes of this assessment, each traditional plant potential category is assumed to be at 100% of resource at 2013 Base Case.

(f) % of resource is calculated as a percentage of 2013 Base Case area; the areas of this column are not additive.

n/a = Not applicable.

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

Loss/alteration and net change numbers might not match between the LSA and RSA because of the use of different datasets at 2013 Base Case for the LSA and RSA. Different datasets are used to provide spatially appropriate data sets for analysis and modelling within each study area.

Dust

Existing disturbances (i.e., roads, wellpads and developments) in the 2013 Base Case were buffered by 50 m within the LSA to create a dust effect zone covering 929 ha (4% of resource) of the total vegetated area in the LSA (22,358 ha, 97% of the LSA) (Table 4.3-16). Additional dust effects will occur during the construction and operation phases from mining and vehicular activities in the mine pit, roads and infrastructure. Along with remaining 2013 Base Case disturbances not under the PRM footprint, dust affects 1,444 ha (6% of resource) in the 2013 PRM Application Case during construction and operations, which represents an increase in dust-affected vegetation from the 2013 Base Case of 515 ha (2% of resource). The effects of dust on vegetation are thus expected to be negative (i.e., an increase in dust) and low in magnitude within the LSA during construction and operations.

The effects of dust are local and sources of dust will only be present for the life of the PRM. Effects are considered reversible, and at Closure there will be no effects of dust due to the PRM, because mining operations will be complete. However, 381 ha of dust sources present at 2013 Base Case that were outside of the PRM footprint will remain at Closure, resulting in a net decrease of 552 ha (2% of resource) of dust-affected vegetation from 2013 Base Case to Closure. The environmental consequences of dust effects to vegetation are thus predicted to be positive (indicating a reduction in the amount of area affected by dust) and low.

Residual Impact Classification for Terrestrial Vegetation, Wetlands and Forest Resources

The residual effects of the PRM on terrestrial vegetation, wetlands and forest resources in the LSA during the construction and operations phase of the PRM are provided in Table 4.3-17. Of the 10 KIRs and vegetation resources (i.e., component criteria) assessed, based on either the PRM's direct effects (i.e., footprint) or direct and indirect effects (i.e., footprint and drawdown), PRM construction and operations are predicted to have negative effects on nine KIRs and vegetation resources, and no effect on rare and special plant communities. High negative environmental consequences are associated with loss/alteration to riparian, old growth, wetlands (including peatlands and patterned fens), and high rare plant potential.

The residual environmental consequences of direct effects of the PRM at Closure are shown in Table 4.3-18. Four KIRs and vegetation resources will experience a positive change, and lichen jack pine communities will experience a negative and negligible change as a result of direct effects due to the PRM at Closure in the LSA. The PRM has no effect on rare and special plant communities at Closure. Direct effects due to the PRM will result in negative and low environmental consequences for riparian communities, and negative and high environmental consequences for three KIRs and vegetation resources at Closure in the LSA, including old growth forest, wetlands (including peatlands and patterned fens), and high rare plant potential. Drawdown of the surficial aquifer occurs primarily during the life of the PRM. Additional indirect effects due to surficial aquifer drawdown around pit lakes at Closure will not change the predicted environmental consequences for KIRs and vegetation resources within the LSA or RSA.

Table 4.3-16 Areas Potentially Affected by Dust in the Local Study Area

Map Code	Description	2013 Base Case Total	2013 Base Case		2013 PRM Application Case		Loss/Alteration due to Pierre River Mine[a]		Closure		Net Change	
		Area [ha]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]
Central Mixedwood Natural Subregion Ecosite Phases												
a1	lichen jack pine	7	<1	6	0	0	-<1	-6	0	0	-<1	-6
b1	blueberry jack pine-aspen	125	8	6	5	4	-3	-3	3	2	-6	-4
b2	blueberry aspen (white birch)	37	1	3	2	6	1	3	<1	<1	-<1	-2
b3	blueberry aspen-white spruce	115	6	5	14	12	8	7	7	6	1	<1
b4	blueberry white spruce-jack pine	101	8	8	6	6	-2	-2	2	2	-6	-6
c1	Labrador tea-mesic jack pine-black spruce	5	0	0	<1	1	<1	1	3	62	3	62
d1	low-bush cranberry aspen	873	34	4	54	6	20	2	24	3	-10	-1
d2	low-bush cranberry aspen-white spruce	468	25	5	35	8	10	2	15	3	-10	-2
d3	low-bush cranberry white spruce	208	9	4	19	9	9	4	6	3	-4	-2
e1	dogwood balsam poplar-aspen	7	0	0	<1	5	<1	5	0	0	0	0
e2	dogwood balsam poplar-white spruce	97	10	10	12	13	2	3	7	7	-3	-3
e3	dogwood white spruce	74	2	2	7	9	5	7	3	4	2	2
f2	horsetail balsam poplar-white spruce	0	0	0	0	0	0	0	0	0	0	0
f3	horsetail white spruce	4	0	0	0	0	0	0	0	0	0	0
g1	Labrador tea-subhygric black spruce-jack pine	11	<1	8	2	16	<1	8	<1	8	-<1	-<1
h1	Labrador tea/horsetail white spruce-black spruce	107	1	1	8	7	7	6	1	1	0	0
central mixedwood ecosite phase subtotal		*2,237*	*106*	*5*	*164*	*7*	*59*	*3*	*72*	*3*	*-34*	*-2*

Table 4.3-16 Areas Potentially Affected by Dust in the Local Study Area (continued)

Map Code	Description	2013 Base Case Total	2013 Base Case		2013 PRM Application Case		Loss/Alteration due to Pierre River Mine[a]		Closure		Net Change	
		Area [ha]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]
Athabasca Plain Natural Subregion												
a1	bearberry jack pine	772	48	6	63	8	14	2	19	2	-29	-4
b1	Canada buffalo-berry-green alder jack pine-aspen-white birch	1,654	84	5	143	9	58	4	42	3	-42	-3
b2	Canada buffalo-berry-green alder aspen	1,939	106	5	139	7	33	2	40	2	-66	-3
b3	Canada buffalo-berry-green alder aspen-white spruce-black spruce	1,227	66	5	85	7	20	2	24	2	-42	-3
b4	Canada buffalo-berry-green alder white spruce-black spruce-jack pine	451	13	3	35	8	22	5	4	<1	-9	-2
c1	Labrador tea-mesic jack pine-black spruce	23	2	9	2	9	<1	<1	5	20	3	11
d1	Labrador tea-subhygric black spruce-jack pine	34	4	11	<1	1	-3	-10	4	10	-<1	-<1
e1	willow/horsetail aspen-white birch-balsam poplar	319	1	<1	9	3	8	2	<1	<1	-1	-<1
e2	willow/horsetail aspen-white spruce-black spruce	224	10	4	10	4	<1	<1	1	<1	-9	-4
e3	willow/horsetail white spruce-black spruce	159	4	2	14	9	11	7	5	3	2	<1
Pj-Lt Complex	jack pine-tamarack complex	4	0	0	0	0	0	0	0	0	0	0
Athabasca plain ecosite phases subtotal		*6,805*	*338*	*5*	*500*	*7*	*162*	*2*	*143*	*2*	*-195*	*-3*

Table 4.3-16 Areas Potentially Affected by Dust in the Local Study Area (continued)

Map Code	Description	2013 Base Case Total	2013 Base Case		2013 PRM Application Case		Loss/Alteration due to Pierre River Mine[a]		Closure		Net Change	
		Area [ha]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]
Wetlands Types												
BFNN	forested bog	17	<1	4	<1	3	-<1	-<1	0	0	-<1	-4
BONS	shrubby bog	1	0	0	0	0	0	0	0	0	0	0
BTNN	wooded bog	347	15	4	28	8	13	4	6	2	-9	-2
FONG	graminoid fen	810	8	<1	21	3	13	2	4	<1	-4	-<1
FONS	shrubby fen	963	16	2	62	6	45	5	10	1	-6	-<1 -<1
FOPN	open patterned fen	67	2	3	9	13	7	10	0	0	-2	-3
FTNN	wooded fen	1,042	32	3	49	5	16	2	13	1	-20	-2
MONG	marsh	140	6	4	9	6	3	2	2	1	-4	-3
SONS	shrubby swamp	495	10	2	24	5	14	3	3	<1	-7	-1
STNN	wooded swamp	590	11	2	47	8	36	6	6	1	-5	-<1
WONN	shallow open water	69	<1	<1	3	4	3	4	<1	<1	0	0
	wetlands types subtotal	*4,541*	*101*	2	*252*	*6*	*150*	*3*	*44*	<1	*-57*	-1
Miscellaneous Vegetation Types												
BUu	burn upland	5,065	250	5	350	7	100	2	74	1	-175	-3
BUw	burn wetlands	2,345	91	4	103	4	12	<1	30	1	-61	-3
Me	meadow	9	<1	<1	<1	7	<1	7	<1	<1	0	0
Sh	shrubland	110	0	0	<1	<1	<1	<1	0	0	0	0
	miscellaneous vegetation types subtotal	*7,530*	*341*	*5*	*455*	*6*	*114*	*2*	*104*	1	*-237*	-3
Non-Vegetation Types												
lake	lake(g)	83	0	0	3	3	3	3	0	0	0	0
river	river	180	0	0	8	4	8	4	0	0	0	0
sand	sand	48	0	0	4	8	4	8	0	0	0	0
	non-vegetation types subtotal	*312*	*0*	*0*	*14*	*5*	*14*	*5*	*0*	0	*0*	0

Table 4.3-16 Areas Potentially Affected by Dust in the Local Study Area (continued)

Map Code	Description	2013 Base Case Total	2013 Base Case		2013 PRM Application Case		Loss/Alteration due to Pierre River Mine[a]		Closure		Net Change	
		Area [ha]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]	Area [ha]	% of Resource[b]
Disturbances												
CC	cutblock	931	43	5	58	6	15	2	17	2	-25	-3
	disturbances subtotal	*931*	*43*	5	*58*	6	*15*	*2*	*17*	2	*-25*	-3
Total		**22,358**	**929**	**4**	**1,444**	**6**	**515**	**2**	**381**	**2**	**-548**	**-2**

(a) Net change due to the PRM is calculated as the difference between 2013 Base Case and 2013 PRM Application Case, and is a value upon which the environmental consequence is assessed.

(b) % of resource is calculated as a percentage of 2013 Base Case area; the values in this column.

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

Table 4.3-17 Residual Impact Classification for the Pierre River Mine Effects on Terrestrial Vegetation, Wetlands and Forest Resources in the Local Study Area: 2013 PRM Application Case - During Construction and Operations

Component Criteria	Direction	Magnitude[(a)]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)[(b)]
terrestrial vegetation (uplands)[(c)]	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	low (0)	moderate (+14)	negligible
lichen jack pine communities[(c)]	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	low (0)	moderate (+14)	negligible
riparian communities[(d)]	negative	high (+15)	local (0)	long-term (+2)	reversible/ irreversible (0)	low (0)	high (+17)	n/a
old growth forests[(c)]	negative	high (+15)	local (0)	long-term (+2)	reversible/ irreversible (0)	low (0)	high (+17)	negligible
wetlands (including peatlands and patterned fens)[(d)]	negative	high (+15)	local (0)	long-term (+2)	reversible/ irreversible (0)	low (0)	high (+17)	negligible
high rare plant potential[(d)]	negative	high (+15)	local (0)	long-term (+2)	irreversible (+3)	low (0)	high (+20)	low
rare and special plant communities[(d)]	neutral	n/a (0)	n/a (0)	n/a (0)	n/a (0)	low (0)	n/a (0)	n/a
productive forests[(c)]	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	low (0)	moderate (+14)	negligible
high traditional use plants potential[(d)]	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	low (0)	moderate (+14)	negligible
dust[(c)]	negative	low (+5)	local (0)	medium-term (+1)	n/a	moderate (+1)	low (+7)	n/a

(a) The magnitude of the residual impact is based on percent of resource at 2013 Base Case.

(b) RSA Environmental Consequence magnitude is based on percent of RSA resource.

(c) Assessed based on direct effects.

(d) Assessed based on direct and indirect effects.

n/a = Not applicable.

Note: Numerical scores for ranking of environmental consequence are explained in EIA, Volume 3, Section 1.3.6.

Table 4.3-18 Residual Impact Classification for Pierre River Mine Effects on Terrestrial Vegetation, Wetlands and Forest Resources in the Local Study Area: Closure

Component Criteria	Direction	Magnitude[a]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)[b]
terrestrial vegetation (uplands)[c]	positive	high (+15)	local (0)	long-term (+2)	n/a	low (0)	high (+17)	negligible
lichen jack pine communities[c]	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	low (0)	negligible (+4)	negligible
riparian communities[d]	negative	low (+5)	local (0)	long-term (+2)	irreversible/ reversible (0)	low (0)	low (+7)	n/a
old growth forests[c]	negative	high (+15)	local (0)	long-term (+2)	irreversible/ reversible (0)	low (0)	high (+17)	negligible
wetlands (including peatlands and patterned fens)[d]	negative	high (+15)	local (0)	long-term (+2)	irreversible/ reversible (0)	low (0)	high (+17)	negligible
high rare plant potential	negative	high (+15)	local (0)	long-term (+2)	irreversible (+3)	low (0)	high (+20)	low
rare and special plant communities[d]	neutral	n/a (0)	n/a (0)	n/a (0)	n/a (0)	low (0)	n/a (0)	n/a
productive forests[c]	positive	moderate (+10)	local (0)	long-term (+2)	n/a	low (0)	moderate (+12)	negligible
high traditional use plants potential[d]	positive	low (+5)	local (0)	long-term (+2)	n/a	low (0)	low (+7)	negligible
dust[a]	positive	low (+5)	local (0)	long-term (+2)	n/a	low (0)	low (+7)	n/a

(a) Residual impact magnitude is based on percent of Resource at 2013 Base Case.

(b) RSA Environmental Consequence magnitude is based on percent of resource in the RSA.

(c) Assessed based on direct effects.

(d) Assessed based on direct and indirect effects.

n/a = Not applicable.

Note: Numerical scores for ranking of environmental consequence are explained in EIA, Volume 3, Section 1.3.6.

4.3.2 Summary of Results

The 2013 PRM Application Case Terrestrial Vegetation, Wetlands and Forest Resources assessment includes an updated list of existing, approved and planned developments, simulated forest fire and forest harvest information, and focuses on PRM, without the effects of JME.

A loss of 3,720 ha (41% of resource) of terrestrial vegetation (uplands) will occur in the LSA during PRM construction and operations. The environmental consequence for terrestrial uplands in the LSA is moderate during construction and operations. This environmental consequence is negligible in the RSA with the loss of less than 1% of terrestrial vegetation during construction and operations. At Closure, terrestrial vegetation (uplands) will increase to 150% of resource, representing a net increase of 4,526 ha (50% of resource) within the LSA. The PRM will result in net increase of less than 1% of terrestrial vegetation in the RSA at Closure. Therefore, the PRM is expected to have a high, positive environmental consequence at the LSA scale, and a negligible, positive environmental consequence at the RSA scale at Closure. Assessing PRM effects alone results in a high positive (% of resource) environmental consequence for terrestrial vegetation communities instead of a low positive (% LSA) environmental consequence as reported in the EIA.

During construction and operations the PRM is predicted to have a negative and moderate environmental consequence on lichen jack pine communities in the LSA. The environmental consequence is negligible in the RSA during construction and operations. At Closure, the PRM will result in net decrease of less than 1% of lichen jack pine communities in the RSA. Therefore, assessing the effects of PRM alone results in a negative and negligible environmental consequence at the LSA scale at Closure (based on % of resource) instead of a positive and negligible environmental consequence as reported in the EIA (based on % LSA). At the RSA scale, assessing the effects of PRM alone results in a negative and negligible environmental consequence, the same as in the EIA.

The environmental consequence for riparian communities during PRM construction and operations is predicted to be negative and high within the LSA. The PRM is predicted to have a negative and low environmental consequence for riparian communities in the LSA at Closure, which differs from the positive, negligible environmental consequence predicted for riparian communities in the EIA, due to assessing the effects of PRM separately from the effects of JME. In the RSA, riparian communities in the reclaimed landscape are not mapped; therefore, Closure riparian communities were not identified at this scale.

Old growth forest lost during construction and operation of PRM will not return within the 80-year closure time frame because development of old growth requires 100 years or more. During construction and operations and at Closure PRM is expected to have a negative and high environmental consequence for old growth forests in the LSA. This prediction differs from the negative and low environmental consequence predicted for old growth forests in the LSA in the EIA, which included JME and was based on % of LSA rather than % of resource. Within the RSA, the environmental consequence is negative and negligible. This assessment will not change the environmental consequences for old growth in the RSA as compared to the EIA.

During construction and operations PRM is expected to have a negative and high environmental consequence in the LSA for wetlands (including peatlands and patterned fens). At Closure, PRM direct effects on wetlands (including peatlands and patterned fens) are expected to have a negative and high environmental consequence at the LSA scale. Surficial aquifer drawdown will occur primarily during the life of the PRM; however, drawdown effects on wetlands types surrounding pit lakes may extend to Closure. At Closure, indirect effects are predicted to cause an additional loss of 1,193 ha (17% of resource) of wetlands and burned wetlands (BUw) in the LSA. Assessing peatlands, including burned wetlands (BUw), separately results in a loss of 909 ha (16% of resource). Assessing patterned fens separately, indirect effects of drawdown are predicted to cause an additional loss of 13 ha (19% of resource) of patterned fens resulting in a 100% loss of patterned fens in the LSA during construction and operations.

As discussed in the response to JRP SIR 46, peatlands and patterned fens are not differentiated at the RSA level, due to the coarser scale of mapping. The finer scale of AVI data that allows for peatlands and patterned fens to be mapped separately at the LSA scale is not available for the entire area of the RSA. At Closure, a negligible environmental consequence at the RSA scale is predicted for the direct and indirect effects of the PRM, and will not change the environmental consequence assessed for wetlands (including peatlands and patterned fens) in the EIA. There will be no change to the environmental consequences due to the incorporation of surficial aquifer drawdown at Closure for both the LSA and RSA.

Environmental consequences for productive forests are negative and moderate in the LSA, and negative and negligible in the RSA during construction and operations. The net increase in productive forests from 2013 Base Case to Closure is positive and moderate at the LSA scale. This assessment will not change the environmental consequence for productive forests in the LSA compared to the EIA. Within the RSA, overall changes in productive forests result in the same positive and negligible environmental consequence as reported in the EIA.

Due to combined direct and indirect effects during construction and operations, PRM will have a negative and high environmental consequence on high rare plant potential within the LSA, and a negative and low environmental consequence for this KIR in the RSA. At Closure, PRM is predicted to have a negative and high environmental consequence at the LSA scale and a negative and negligible environmental consequence at the RSA scale due to direct effects on high rare plant potential. Incorporation of surficial aquifer drawdown at Closure does not change environmental consequences due to PRM, and there is no change in environmental consequence for high rare plant potential as compared to the EIA.

The PRM is not predicted to affect rare and special plant communities within the LSA and RSA during construction and operations or at Closure; therefore, the PRM is predicted to have no effect on rare and special plant communities. An environmental consequence was not assigned to rare and special plant communities.

The PRM will result in a negative and moderate environmental consequence to high traditional use plant potential areas in the LSA during construction and operations, with no additional effects due to drawdown. In the RSA, PRM results in a negative and negligible environmental consequence to high traditional use plant potential areas during construction and operations, and there is no change to environmental consequence compared to the EIA. At Closure, the PRM is expected to have a positive and low environmental consequence for high traditional use plant potential at the LSA scale. This ranking is a change from the negative and negligible environmental consequence assigned to high traditional use plant potential in the EIA. A positive and negligible environmental consequence was assigned at the RSA scale, which does not change the environmental consequence as assessed in the EIA.

The effects of dust on vegetation are expected to be negative and low within the LSA during construction and operations. The effects of dust are local and sources of dust will only be present for the life of the PRM. Effects are considered reversible, and at Closure there will be no effects of dust due to PRM, because mining operations will be complete. Some 2013 Base Case disturbances not affected by the PRM footprint, and thus not actively reclaimed, might continue to produce dust at Closure. Overall the effects of PRM on vegetation due to dust are positive, i.e., there are less dust sources and less dust, and low at Closure.

Ten KIRS and vegetation resources were assessed in the 2013 PRM Application Case. Nine KIRs and vegetation resources are predicted to have negative effects during construction and operations while neutral effects are predicted for rare and special plant communities. In the LSA, high negative environmental consequences are associated with riparian communities, old growth forests, loss/alteration to wetlands (including peatlands and patterned fens), and high rare plant potential.

At Closure, six KIRs and vegetation resources assessed will experience a net positive change (terrestrial vegetation, productive forests, high traditional use plants and effects of dust), negative and negligible change (lichen jack pine communities), or no change (rare and special plant communities) as a result of direct effects due to the PRM in the LSA. Direct effects due to the PRM will result in negative effects for the remaining four KIRs and vegetation resources with environmental consequences that are low or high.

4.4 Wildlife and Wildlife Habitat Assessment

This assessment considers the effects of the PRM, in combination with existing and approved projects, on wildlife Key Indicator Resources (KIRs) including federally listed Species at Risk (SAR) that may be affected by development in the PRM LSA. The combined effects of the JME, PRM and existing and approved developments on wildlife were assessed in the EIA (Volume 5, Section 7.3.4). The EIA, as amended, originally assessed the effects of JME and PRM on the abundance, habitat and movement of wildlife KIRs, which were selected based on robust selection rationale (EIA, Volume 3, Section 1.3.5). Estimated effects on those species were extrapolated to assess the effects of JME and PRM on other wildlife species, including federally listed SAR. The effects of JME and PRM on wildlife abundance, habitat and movement were explicitly assessed for relevant federally listed wildlife SAR in the *May 2011 Submission of Information to the Joint Review Panel, Appendix 2*. The effects of development on wildlife movement were not previously explicitly assessed for Canadian toad, barred owl, black-throated green warbler and western toad, but are assessed for the 2013 PRM Application Case (Section 4.4.1.3).

The effects of the PRM on woodland caribou habitat were not previously assessed because woodland caribou are virtually absent from the LSA and are therefore unlikely to be affected by habitat changes as a result of the PRM. The PRM LSA is outside of provincially and federally recognized woodland caribou range, with the closest range (i.e., the Red Earth range) 12 km from the PRM footprint. The West Side of the Athabasca River range is 33 km away from the PRM footprint. The Richardson range also occurs in the RSA, but on the opposite (east) side of the Athabasca River.

4.4.1 Assessment Results

4.4.1.1 Wildlife Abundance

The effects of the PRM on wildlife abundance were assessed in the EIA, Volume 5, Appendix 5-4 and the Species at Risk assessment in the *May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2* in such a way as to be precautionary and result in a conservative assessment. There are no predicted effects to the abundance of Eskimo curlew and northern leopard frog because these species have not been recorded in the RSA in recent times. After reclamation, the magnitude of the effects of the PRM on wildlife abundance will be negligible in magnitude and environmental consequence at the RSA and LSA scales for all affected species, excepting bison and woodland caribou.

The available evidence suggests the regional abundances of little brown myotis, northern myotis, peregrine falcon, red knot, western toad, whooping crane and wood bison are not likely to be limited by habitat in the RSA (Appendix 2 of this submission, Section 3.4.3.1). As such, the abundances of these species are unlikely to be affected by habitat changes due to PRM and other planned developments in the RSA. Habitat loss in northern breeding grounds may be affecting the abundance of Canada warbler and common nighthawk (Appendix 2, Section 3.4.3.1). It is probable that the abundances of horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail are also not limited by habitat within the RSA (Appendix 2, Section 3.4.3.1). However, because sufficient uncertainty exists for these species, the potential effects of habitat loss on abundance were considered (Appendix 2, Section 3.4.3.1).

Woodland caribou are virtually absent from the PRM LSA, and provincially recognized herd boundaries do not overlap with the PRM LSA. The closest herds on the west side of the Athabasca River are the Red Earth range 12 km west of the LSA and the West Side of the Athabasca River (WSAR) range 33 km southwest of the LSA.

The development of PRM may indirectly affect woodland caribou abundance by displacing wolves and alternate prey (i.e., moose, deer) out of the LSA into woodland caribou ranges during construction and operations, and through the production of early seral habitat attractive to moose, white-tailed deer and beaver after reclamation.

The displacement of wolves and alternate prey species from the PRM LSA into adjacent habitats during construction and operations may adversely affect caribou. White-tailed deer are much more prevalent in upland habitats in summer and winter (Latham et al. 2013), but the overall abundance of deer in peatland habitats preferred by caribou has been shown to be increasing (Latham et al. 2011). Moose are more prevalent in upland habitats in winter, but appear to prefer peatlands in summer (Latham et al. 2013). Beaver appear to be more common in caribou ranges than in adjacent upland habitats (Latham et al. 2013). Wolves have been shown to generally select habitat that is selected by primary prey species, which include moose, deer and beaver (Latham et al. 2013). In general, wolves show avoidance of habitat preferred by woodland caribou, although pack-specific exceptions occur (Latham et al. 2013). Therefore, displaced deer, moose and beaver may increase population densities in habitat adjacent to the LSA, and may increase within woodland caribou ranges. Displaced wolves may or may not be able to hunt effectively on existing adjacent territories due to inter-pack aggression, but the overall wolf population density may nonetheless increase due to increased prey density (Mech and Boitani 2003). Increases in wolf population densities pose a threat to woodland caribou (Latham et al 2011).

Forest fragmentation due to oil and gas, forestry and other developments creates early seral vegetation communities that are thought to support higher densities of ungulates such as moose and white-tailed deer (Reittie and Messier 1998; Wittmer et al. 2007). Deer are at the northern end of their range in the Oil Sands Region and historical populations tended to be small and localized (Smith 1993). However, white-tailed deer have been expanding their range and increasing in number in northeastern Alberta during the last 5 to 10 years (Latham et al. 2011). Largely as a result of increasing white-tailed deer populations, wolf populations are also increasing in northeastern Alberta, and increasing wolf populations pose a threat to woodland caribou abundance (Latham et al. 2011). The development of PRM will not contribute to increased early seral habitat during construction and operations, but will result in a temporary increase in early seral communities after reclamation until freshly established vegetation communities mature over time.

The combined effects of displaced alternate prey populations during construction and operations and increased forage for moose and deer in young reclaimed habitats after reclamation of PRM and other planned developments are likely to result in increased alternate prey and wolf population densities. However, the limited size of the PRM footprint relative to the size of woodland caribou ranges is predicted to result in an effect that is low magnitude at the LSA scale, and negligible magnitude at the RSA scale.

Residual Impact Classification for Wildlife Abundance

The environmental consequences of PRM on wildlife abundance at the LSA and RSA scales are similar to those previously assessed for PRM and JME combined (EIA, Volume 5; *May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2*) (Table 4.4-1). To be conservative, the magnitude of net effects to regional populations of Canada warbler, common nighthawk, horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail were estimated as equivalent to the magnitude of the habitat loss effects within the RSA for the 2013 PRM Application Case prior to reclamation. As a result, the RSA scale environmental consequence of the 2013 PRM Application Case before Closure on the abundance of Canada warbler, common nighthawk, horned grebe, rusty blackbird, wolverine and yellow rail increases from negligible

(*May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2*) to low (Table 4.4-1), although the LSA scale environmental consequences are unchanged.

For wood bison abundance, the environmental consequences of the Pierre River Mine are predicted to be low at the LSA and RSA scale during construction and operations, as increased access due to the PRM could potentially result in a decline in wood bison abundance due to unregulated hunting. Restrictions limiting traffic to project personnel will be instituted on the access road to the PRM to mitigate the potential effects of increased hunting due to increased access.

Effects to little brown myotis and northern myotis habitat were not previously assessed because they were not listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) until February 2012 (COSEWIC 2012a,b), but they are assessed here. Site clearing will occur in the winter, when little brown myotis and northern myotis are in hibernacula. No hibernacula have been identified in the Oil Sands Region (Barclay 2012, pers. comm.). Therefore, site clearing will not result in mortality events for little brown myotis and northern myotis. However, they may be affected by sensory disturbance during non-winter months, which may result in an environmental consequence of the PRM on abundance that is low at the LSA scale and negligible at the RSA scale.

Woodland caribou are virtually absent from the PRM LSA, and provincially recognized herd boundaries do not overlap with the PRM LSA. However, the combined effects of displaced alternate prey populations during construction and operations, and increased forage for moose and deer in young reclaimed habitats after reclamation of PRM and other planned developments are likely to result in increased alternate prey and wolf population densities. Due to the limited size of the PRM footprint relative to the size of woodland caribou ranges, the environmental consequence of this effect on woodland caribou abundance is predicted be low at the LSA scale, and negligible at the RSA scale.

Reclamation of terrain features and vegetation communities is predicted to result in the recovery of wildlife populations that experienced declines due to construction and operations of the PRM. Species that vacated all or part of the LSA during construction and operations are expected to utilize reclaimed areas to satisfy requirements for forage and shelter, thereby facilitating wildlife population growth. As the landscape develops after reclamation, the magnitude of the effects of the PRM on wildlife abundance will be negligible in magnitude and environmental consequence at the LSA and RSA scales for all KIRs.

Table 4.4-1 Residual Impact Classification for the Pierre River Mine on Wildlife Abundance: 2013 PRM Application Case During Construction and Operations

Potential Effects and Key Indicator Resources	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)
Interactions of Wildlife with Infrastructure								
Canadian toad, barred owl	negative	low (+5)	local (0)	medium-term (+1)	reversible (-3)	moderate (+1)	negligible (+4)	negligible
moose, Canada lynx, fisher, beaver, black bear	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	moderate (+1)	negligible (+5)	negligible
black-throated green warbler	negative	low (+5)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	low (+7)	negligible
western toad	negative	low (+5)	local (0)	medium-term (+1)	reversible (-3)	moderate (+1)	negligible (+4)	negligible
wolverine	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	moderate (+1)	negligible (+5)	negligible
Canada warbler, common nighthawk, horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, yellow rail	negative	low (+5)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	low (+7)	negligible
peregrine falcon, red knot, whooping crane	negative	low (+5)	beyond regional (+2)	medium-term (+1)	reversible (-3)	moderate (+1)	low (+6)	negligible
Increased Predation, Hunting and Trapping								
beaver, black bear, Canada lynx, fisher, moose, wolverine, woodland caribou	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)	negligible
wood bison	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)	low
Direct Mortality due to Site Clearing								
moose, black bear, Canada lynx, fisher, beaver	negative	negligible (0)	regional (+1)	medium-term (+1)	reversible (-3)	low (0)	negligible (-1)	negligible
Canadian toad, barred owl	negative	low (+5)	local (0)	medium-term (+1)	reversible (-3)	low (0)	negligible (+3)	negligible
western toad	negative	low (+5)	local (0)	medium-term (+1)	reversible (-3)	low (0)	negligible (+3)	negligible
wolverine	negative	negligible (0)	regional (+1)	medium-term (+1)	reversible (-3)	low (0)	negligible (0)	negligible
Removal of Nuisance Wildlife								
black bear, beaver	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	moderate (+1)	negligible (+5)	negligible
Increased Vehicle-Wildlife Collisions								
Canadian toad, moose, black bear, Canada lynx, barred owl, fisher, beaver	negative	low (+5)	local to regional (0 to +1)	long term (+2)	reversible (-3)	low (0)	negligible (+4 to +5)	negligible
black-throated green warbler	negative	low (+5)	beyond regional (+2)	long term (+2)	reversible (-3)	low (0)	low (+6)	negligible
western toad	negative	low (+5)	local (0)	long term (+2)	reversible (-3)	low (0)	negligible (+4)	negligible
wolverine	negative	low (+5)	regional (+1)	long term (+2)	reversible (-3)	low (0)	negligible (+5)	negligible
Canada warbler, common nighthawk, horned grebe, olive-sided flycatcher, peregrine falcon, red knot, rusty blackbird, short-eared owl, whooping crane, yellow rail	negative	low (+5)	beyond regional (+2)	long term (+2)	reversible (-3)	low (0)	low (+6)	negligible

Table 4.4-1 Residual Impact Classification for the Pierre River Mine on Wildlife Abundance: 2013 PRM Application Case During Construction and Operations (continued)

Potential Effects and Key Indicator Resources	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)
Sensory Disturbance								
barred owl	negative	negligible (0)	local (0)	medium-term (+1)	reversible (-3)	high (+2)	negligible (0)	negligible
moose, Canada lynx, fisher	negative	negligible (0)	regional (+1)	short-term (0)	reversible (-3)	high (+2)	negligible (0)	negligible
black bear	negative	low (+5)	regional (+1)	short-term (0)	reversible (-3)	high (+2)	negligible (+5)	negligible
black-throated green warbler	negative	low (+5)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	low (+7)	negligible
peregrine falcon, red knot, whooping crane	neutral	n/a	n/a	n/a	n/a	n/a	negligible (0)	negligible
western toad	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	low (0)	negligible (+4)	negligible
wolverine	negative	low (+5)	regional (+1)	medium-term (+1)	reversible (-3)	high (+2)	low (+6)	negligible
Canada warbler, common nighthawk, horned grebe, little brown myotis, northern myotis, olive-sided flycatcher, rusty blackbird, short-eared owl, yellow rail	negative	low (+5)	beyond regional (+2)	medium-term (+1)	reversible (-3)	high (+2)	low (+7)	negligible
Net Change due to Pierre River Mine								
Canadian toad, barred owl	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	moderate (+1)	negligible (+5)	negligible
moose, Canada lynx, fisher, beaver, black bear, woodland caribou	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)	negligible
black-throated green warbler	negative	low (+5)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	low (+8)	negligible
western toad	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	low (0)	negligible (+4)	negligible
little brown myotis, northern myotis, olive-sided flycatcher, peregrine falcon, red knot, short-eared owl, whooping crane	negative	low (+5)	beyond regional (+2)	long term (+2)	reversible (-3)	low (0)	low (+6)	negligible
wolverine	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)	negligible
wood bison	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)	low
Canada warbler, common nighthawk, horned grebe, rusty blackbird, yellow rail	negative	low (+5)	beyond regional (+2)	long term (+2)	reversible (-3)	low (0)	low (+6)	low

Note: Numerical scores for the ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

n/a = Not applicable because these are migratory species and although their use of habitat during migration may be affected by sensory disturbance, there are no predicted effects on abundance as a result of sensory disturbance.

4.4.1.2 Wildlife Habitat

The effects of PRM on wildlife habitat were assessed in the EIA and the Species at Risk Assessment in the *May 2011, Submission of Information to the Joint Review Panel, Appendix 2*. Changes to Eskimo curlew, northern leopard frog, peregrine falcon, red knot and whooping crane habitat due to the PRM are not assessed. Eskimo curlew, northern leopard frog and red knot do not breed in northeastern Alberta and no historical data on these species within the Oil Sands Region are available. Peregrine falcons are likely migratory in the Oil Sands Region because typical breeding habitat (i.e., high cliffs over waterbodies) is not present in the RSA and no eyries have been documented to date. Whooping cranes in the Oil Sands Region breed exclusively in the northern portion of Wood Buffalo National Park in the Northwest Territories. None of these species is likely to be sensitive to the availability of migratory (i.e., staging) habitat within the LSA or RSA.

Effects to little brown myotis and northern myotis habitat were not previously assessed because they were not listed by COSEWIC until February of 2012 (COSEWIC 2012a,b), but they are assessed here through the quantification of changes to foraging and roosting habitat.

Woodland caribou are virtually absent from the LSA, and are therefore also unlikely to be sensitive to the availability of habitat within the LSA. However, the effects of the PRM to potential woodland caribou habitat are assessed at the request of the JRP in response to JRP SIRs 35a and 40a (Appendix 4) because caribou previously occurred in the LSA.

Residual Impact Classification for Wildlife Habitat During Construction and Operations

The assessed environmental consequences of PRM on wildlife habitat during construction and operations are similar to those previously assessed (EIA and *May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2*).

The environmental consequences of habitat loss for site clearing during operations are high at the LSA scale for all affected species during construction and operations prior to Closure (Table 4.4-2), as stated in the EIA and *May 2011, Submission of Information to the Joint Review Panel* Species at Risk Assessment. The removal of the effects of JME to the 2013 Base Case results in changes to the environmental consequences for the indirect effects of habitat loss before Closure for some KIRs. Specifically, the predicted decline of high suitability habitat due to the indirect effects of sensory disturbance and surficial aquifer drawdown during operations at the LSA scale change from the *May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2* as follows:

- from a low environmental consequence in the Species at Risk Assessment to high for common nighthawk, horned grebe, short-eared owl, wood bison and yellow rail in the 2013 PRM Application Case; and
- from a moderate environmental consequence in the Species at Risk Assessment to high for olive-sided flycatcher in the 2013 PRM Application Case.

The net environmental consequence of the PRM during construction and operations was previously assessed for wolverine and wood bison habitat as low at the RSA scale (*May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2*). However, the removal of the effects of JME reduced the environmental consequences of potential habitat loss to negligible for both KIRs (Table 4.4-2).

Table 4.4-2 Residual Impact Classification for the Pierre River Mine on Wildlife Habitat: 2013 PRM Application Case During Construction and Operations

Potential Effects and Key Indicator Resources	Direction	Magnitude[a]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)
Direct Effects (Site Clearing)								
barred owl	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	high (+2)	high (+16)	low
Canadian toad	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	high (+2)	high (+16)	low
beaver, black bear	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
Canada lynx, fisher, moose	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	low
black-throated green warbler	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	low
western toad	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	high (+2)	high (+16)	negligible
wolverine, wood bison	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
woodland caribou	negative	high (+15)	regional (+1)	long-term (+2)	reversible/irreversible (0)	high (+2)	high (+20)	negligible
Canada warbler, common nighthawk, horned grebe, little brown myotis, northern myotis, olive-sided flycatcher, short-eared owl, yellow rail	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	negligible
rusty blackbird	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible/irreversible (0)	high (+2)	high (+21)	low
Indirect Effects (Sensory Disturbance and Surficial Aquifer Drawdown)								
fisher	negative	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)	negligible
barred owl	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	high (+2)	low (+6)	negligible
beaver	neutral	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)	negligible
Canadian toad	negative	low (+5)	local (0)	long-term (+2)	reversible (-3)	high (+2)	low (+6)	negligible
Canada lynx, moose	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)	negligible
black bear	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
black-throated green warbler	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	negligible
western toad	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	high (+2)	high (+16)	negligible
wolverine, wood bison, woodland caribou	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
Canada warbler, common nighthawk, horned grebe, little brown myotis, northern myotis, olive-sided flycatcher, rusty blackbird, short-eared owl, yellow rail	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	negligible
Net Change from PRM								
barred owl, Canadian toad	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	high (+2)	high (+16)	low
beaver, black bear	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
Canada lynx, fisher, moose	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	low
black-throated green warbler	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	low

Table 4.4-2 Residual Impact Classification for the Pierre River Mine on Wildlife Habitat: 2013 PRM Application Case During Construction and Operations (continued)

Potential Effects and Key Indicator Resources	Direction	Magnitude[(a)]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)
western toad	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	high (+2)	high (+16)	low
wolverine, wood bison	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
Canada warbler, common nighthawk, little brown myotis, northern myotis, olive-sided flycatcher, short-eared owl	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	negligible
horned grebe	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	low
woodland caribou	negative	high (+15)	regional (+1)	long-term (+2)	reversible/irreversible (0)	high (+2)	high (+20)	negligible
rusty blackbird, yellow rail	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible/irreversible (0)	high (+2)	high (+21)	low

(a) Magnitude is defined through habitat suitability modelling (Appendix 3.7).

Note: Numerical scores for the ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

Some wildlife species are dependent upon wetlands, including peatlands. For example, rusty blackbird, yellow rail, and woodland caribou are all associated with peatlands. However, rusty blackbird (COSEWIC 2006) and yellow rail (COSEWIC 2009) are also associated with non-peatland wetlands types, and woodland caribou will utilize upland stands rich in lichen (COSEWIC 2002; Jones 2007). Therefore, the partial reversibility of the effects of habitat change for these species is classified as "reversible/irreversible".

Little brown myotis and northern myotis use mixedwood and coniferous forests for foraging and roosting habitat (ASRD and ACA 2009; Crampton and Barclay 1998). During construction and operations, the areal extent of mixedwood and coniferous forests is reduced resulting in a magnitude and environmental consequence of habitat loss that is high at the LSA scale and negligible at the RSA scale (Section 4.3.1).

The effects of PRM on potential woodland caribou habitat are assessed as having a negative high environmental consequence during construction and operations at the LSA scale, and a negligible environmental consequence at the RSA scale (Table 4.4-2).

Residual Impact Classification for Wildlife Habitat at Closure

The removal of the effects of JME results in changes to the environmental consequences for the effects of habitat loss at Closure for some wildlife KIRs in the LSA (Table 4.4-3). Specifically, the effects of the PRM at Closure change as follows:

- from a positive and high environmental consequence in the EIA (Volume 5, Section 7.5.3) to negative and high for black-throated green warbler after Closure for the 2013 PRM Application Case;
- from a negative and low environmental consequence in the Species at Risk Assessment (*May 2011 Submission of Information to the Joint Review Panel*, *Appendix 2*) to negative and high for common nighthawk after Closure for the 2013 PRM Application Case;
- from a negative and high environmental consequence in the Species at Risk Assessment (*May 2011 Submission of Information to the Joint Review Panel*) to positive and high for horned grebe after Closure for the 2013 PRM Application Case; and
- from a positive and high environmental consequence in the EIA (Volume 5, Section 7.5.3) to negative and low for moose and fisher after Closure for the 2013 PRM Application Case.

The changes in the environmental consequences of the effects of the PRM on high suitability black-throated green warbler habitat are due to the large areal extent of burns in the LSA in the 2013 Base Case. The black-throated green warbler Resource Selection Function (RSF) model shows increases in habitat suitability with increased landscape diversity and the presence of forest stands over 90 years of age. The mature forest in the LSA at Closure is less diverse than the patchwork of burns and forest of various seral stages that is present in the 2013 Base Case. In addition, all stands are assumed to be 80 years of age, and therefore are younger than those predicted to be high suitability for black-throated green warbler.

For common nighthawk, the change in environmental consequence from negative and low (*May 2011, Submission of Information to the Joint Review Panel*) to negative and high after Closure is due to the large proportion of burns in the LSA in the 2013 Base Case as a result of the Richardson Fire in 2011 (Section 4.1), in comparison to the mature forest stands that dominate the LSA at Closure. Burns are generally high suitability habitat for common nighthawk, while mature forest stands are not (COSEWIC 2007).

The environmental consequence of the effects of PRM at Closure for horned grebe change from negative and high in the Species at Risk Assessment (*May 2011 Submission of Information to the Joint Review Panel*) to positive and high due to the addition of South Redclay Lake and graminoid marsh (MONG) in the north of the LSA.

The change in the environmental consequences for moose and fisher habitat is related to a change in the assessment method for representing the Closure scenario in modelling. Closure and reclamation is considered as 80 years after the completion of mining. Eighty years represents the estimated time required for the development of mature forest on the reclaimed landscape, and is therefore an appropriate time frame upon which to compare vegetation, wildlife and biodiversity values in the reclaimed landscape against the 2013 Base Case values. However, this approach represents a change from the EIA (Volume 5, Section 7.5.3) in which stand ages for habitat suitability modelling of original wildlife KIRs were assigned using mine progression diagrams to represent stand ages at the point in time at which closure occurs (i.e., 2070), and therefore resulted in a much younger landscape. This change in assumption related to stand ages at Closure did not change the magnitude and direction of the effect of the PRM on wildlife KIRs, with the exception of moose and fisher. For moose and fisher habitat, this approach resulted in the habitat suitability model suggesting a negative high and negative moderate magnitude effect at Closure, respectively, rather than the positive high magnitude effect predicted in the EIA.

The effect of stand age highlights the sensitivity of moose (Serrouya and D'Eon 2002) and fisher (Jones and Garton 1994) habitat selection to this variable. In the reclaimed landscape, natural disturbance and succession processes will occur, stand ages will cycle naturally over time, and patches of young forest will re-occur, which the habitat suitability modelling does not represent. The shift in the landscape from wetlands to upland habitats that are preferred by moose (e.g., James et al. 2004) and fisher (Weir and Corbould 2010), as well as the increase in shrubland habitats preferred by moose (e.g., Stewart et al. 2010), is predicted to result in positive changes to the LSA for these species. However, habitat suitability model predictions are based on a moment in time, and do not represent long-term stand dynamics or changes to site capability. They do not capture the positive changes for moose and fisher site capability that are predicted based on the ecology of these species. Therefore, environmental consequences for changes to habitat after Closure for moose and fisher were reduced to negative and low at the LSA scale (Table 4.4-3).

Table 4.4-3 Residual Impact Classification for Effects to Wildlife Habitat: 2013 PRM Application Case at Closure

Key Indicator Resources	Direction	Magnitude[(a)]	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)[(d)]
beaver	positive	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
Canada lynx, Canadian toad	positive	moderate (+10)	local to regional (0 to +1)	long-term (+2)	reversible (-3)	high (+2)	moderate (+11 to +12)	negligible
black bear	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	moderate (+1)	low (+6)	negligible
barred owl	negative	high (+15)	local (0)	long-term (+2)	reversible/irreversible (0)	high (+2)	low[(b)] (+19)	negligible
fisher, moose	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low[(c)] (+17)	negligible
black-throated green warbler	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	negligible
Canada warbler	positive	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	low
horned grebe, little brown myotis, northern myotis, olive-sided flycatcher	positive	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	negligible
wolverine	positive	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
woodland caribou	positive	high (+15)	regional (+1)	long-term (+2)	reversible/irreversible (0)	high (+2)	high (+20)	negligible
rusty blackbird	negative	moderate (+10)	beyond regional (+2)	long-term (+2)	reversible/irreversible (0)	high (+2)	high (+16)	negligible
western toad	negative	high (+15)	local (0)	long-term (+2)	reversible (-3)	high (+2)	high (+16)	negligible
wood bison	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	high (+17)	negligible
short-eared owl	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	negligible
common nighthawk	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	high (+18)	low
yellow rail	negative	high (+15)	beyond regional (+2)	long-term (+2)	reversible/irreversible (0)	high (+2)	high (+21)	negligible

(a) Magnitude is defined through habitat suitability modelling (Appendix 3.7).

(b) The environmental consequence for barred owl habitat is considered low because, although habitat loss is high in magnitude at 80 years post closure and reclamation, the reclamation landscape has the potential to develop barred owl habitat over 100 years or more.

(c) The environmental consequences for fisher and moose habitat is considered low because, although habitat loss is high in magnitude at 80 years post closure and reclamation, this is due to the sensitivity of these species to the age class of forest stands. Habitat suitability will vary with natural stand dynamic processes.

(d) The magnitude of effects at the RSA scale was predicted using the change in high and moderate-high suitability habitat from the 2013 Base Case to Closure in the LSA as a percentage of the high and moderate-high suitability habitat present at the 2013 Base Case in the RSA.

Note: Numerical scores for the ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

The environmental consequences of the effects of PRM at Closure at the RSA scale were assessed as being from negligible to low for all KIRs in the EIA and the *May 2011, Submission of Information to the Joint Review Panel* Species at Risk Assessment. The assessed environmental consequences at the RSA scale decrease from low in the *May 2011, Submission of Information to the Joint Review Panel, Appendix 2* Species at Risk Assessment for western toad and wood bison to negligible for the 2013 PRM Application Case, and increase for common nighthawk from negligible to low.

Little brown myotis and northern myotis use mixedwood and coniferous forests for foraging and roosting habitat (ASRD and ACA 2009; Crampton and Barclay 1998). Mixedwood and coniferous forests increase after reclamation. This increase results in a magnitude and environmental consequence of habitat change due to PRM for little brown myotis and northern myotis that are positive and high at the LSA scale, and negligible at the RSA scale (Section 4.3.1).

After reclamation, the environmental consequence of PRM on woodland caribou habitat is predicted to be positive and high due to the large decrease in burned areas, the increase in ecosite phases rich in lichen, such as blueberry aspen-white spruce (b3) and Labrador tea-mesic jack pine-black spruce (c1), and the reclamation of disturbances present in the 2013 Base Case. As stated in Section 4.4.1.1, woodland caribou are unlikely to be affected by PRM because woodland caribou are virtually absent from the LSA.

4.4.1.3 Wildlife Movement

The effects of PRM on wildlife movement were assessed in the EIA and the Species at Risk Assessment (*May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2*). The effects of PRM on wildlife movement were not previously explicitly assessed for Canadian toad, barred owl, black-throated green warbler and western toad, but are assessed for the 2013 PRM Application Case. The effects of PRM on the movement of woodland caribou are not assessed because they are virtually absent from the LSA.

Residual Impact Classification for Wildlife Movement

The assessed environmental consequences are negative and negligible at the LSA and RSA scales for Canadian toad, barred owl and black-throated green warbler during operations because Canadian toads are not wide ranging and terrestrial disturbance is unlikely to impede the movement of birds (Table 4.4-4). Environmental consequences of PRM on movement for little brown myotis and northern myotis are also negative and negligible, as terrestrial disturbance is unlikely to impede the movement of these small flying mammals. For all other wildlife KIRs and SAR that may be affected, the assessed environmental consequences before reclamation are unchanged from that previously assessed, and range from negligible for all avian species and western toad, to low for terrestrial mammals (EIA; 2008 EIA Update; *May 2011, Submission of Information to the Joint Review Panel*). The environmental consequence will be low for terrestrial mammals because wildlife passageways will be provided under the Athabasca River bridge in the PRM LSA to provide for north-south wildlife movement along the Athabasca River, and wildlife movements across the RSA outside of the LSA have not been blocked.

Table 4.4-4 Residual Impact Classification of the Pierre River Mine on Wildlife Movement: 2013 PRM Application Case During Construction and Operations

Potential Effects and Key Indicator Resources	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)
Wildlife Movement During Operations								
Canadian toad, barred owl	negative	negligible (0)	local (0)	long-term (+2)	reversible (-3)	high (+2)	negligible (+1)	negligible
black-throated green warbler	negative	negligible (0)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	negligible (+3)	negligible
beaver	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)	low
moose, black bear, Canada lynx, fisher	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)	low
western toad	negative	negligible (0)	local (0)	long-term (+2)	reversible (-3)	high (+2)	negligible (+1)	negligible
Canada warbler, common nighthawk, horned grebe, little brown myotis, northern myotis, olive-sided flycatcher, rusty blackbird, short-eared owl, yellow rail	negative	negligible (0)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	negligible (+3)	negligible
wolverine, wood bison	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)	low
Wildlife Movement After Closure								
Canadian toad, barred owl	positive	negligible (0)	local (0)	long-term (+2)	reversible (-3)	high (+2)	negligible (+1)	negligible
beaver	positive	negligible (0)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	negligible (+2)	negligible
black-throated green warbler	positive	negligible (0)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	negligible (+3)	negligible
moose, black bear, Canada lynx, fisher	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)	negligible
western toad	positive	negligible (0)	local (0)	long-term (+2)	reversible (-3)	high (+2)	negligible (+1)	negligible
Canada warbler, common nighthawk, horned grebe, little brown myotis, northern myotis, olive-sided flycatcher, rusty blackbird, short-eared owl, yellow rail	positive	negligible (0)	beyond regional (+2)	long-term (+2)	reversible (-3)	high (+2)	negligible (+3)	negligible
wolverine, wood bison	negative	low (+5)	regional (+1)	long-term (+2)	reversible (-3)	high (+2)	low (+7)	negligible

Note: Numerical scores for the ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

At Closure, the assessed environmental consequences of PRM on movement of Canadian toad, barred owl, black-throated green warbler and western toad are positive and negligible at the LSA and RSA scales due to the removal of disturbances that are present in the 2013 Base Case (Table 4.4-4). For all other wildlife KIRs and SAR that may be affected, the assessed environmental consequences at Closure range from positive and negligible for little brown myotis, northern myotis, avian species and western toad, to negative and low for terrestrial mammals, again due to the removal of disturbances that are present in the 2013 Base Case. The negative and low environmental consequences at Closure for terrestrial mammals (i.e., moose, black bear, Canada lynx, fisher and wolverine) at the LSA scale are due to the creation of the large South Redclay Lake to the north end of the LSA and large pit lakes to the south end of the LSA. The addition of the lakes results in a change to the environmental consequence of PRM on wolverine and wood bison movement from positive and low (*May 2011, Submission of Information to the Joint Review Panel*), to negative and low at the LSA scale, and negligible at the RSA scale (Table 4.4-4).

4.4.2 Summary of Results

The 2013 PRM Application Case Wildlife assessment includes a more recent list of existing and approved developments, simulated forest fire and forest harvest information, and focuses on PRM, without the effects of JME. The effects of JME and PRM on wildlife abundance, habitat and movement were assessed in the EIA and the Species at Risk Assessment (*May 2011, Submission of Information to the Joint Review Panel Appendix 2*).

The environmental consequences of PRM on wildlife abundance at the LSA and RSA scales are similar to those previously assessed for JME and PRM combined (EIA and *May 2011, Submission of Information to the Joint Review Panel*). There are no predicted effects to the abundance of Eskimo curlew and northern leopard frog because these species have not been recorded in the RSA. Effects to little brown myotis and northern myotis habitat were not previously assessed because they were not listed by COSEWIC until February of 2012 (COSEWIC 2012a, 2012b). Net effects to wildlife abundance during construction and operations result in negative environmental consequences that are negligible for Canadian toad, barred owl, caribou and western toad, and low for all other KIRs at the LSA scale. The effects on caribou abundance at the LSA scale is predicted to be negligible because caribou are currently virtually absent from the LSA. After reclamation, the environmental consequences of PRM on wildlife abundance will be negligible in magnitude and environmental consequence at the RSA and LSA scales for all affected species.

The available evidence suggests the regional abundances of little brown myotis, northern myotis, peregrine falcon, red knot, western toad, whooping crane and wood bison are not limited by habitat in the RSA (Appendix 2, Section 3.4.3.1). As such, the abundances of these species are unlikely to be affected by habitat changes due to PRM and other planned developments in the RSA.

Habitat loss in northern breeding grounds may be affecting the abundance of Canada warbler and common nighthawk (Appendix 2, Section 3.4.3.1). It is probable that the abundances of horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail are not limited by habitat within the RSA (Appendix 2, Section 3.4.3.1). However, because sufficient uncertainty exists for these species, the potential effects of habitat loss on abundance were considered (Appendix 2, Section 3.4.3.1). Therefore, to be precautionary, the magnitude of effects to regional populations of Canada warbler, common nighthawk, horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail were estimated as equivalent to the magnitude of the habitat loss effects within the RSA for the 2013 PRM Application Case prior to reclamation. As a result, the RSA scale environmental consequence of the 2013 PRM Application Case before

Closure on the abundance of Canada warbler, common nighthawk, horned grebe, rusty blackbird and yellow rail increases from negligible (*May 2011, Submission of Information to the Joint Review Panel*) to low (Table 4.4-1).

Changes to Eskimo curlew, northern leopard frog, peregrine falcon, red knot and whooping crane habitat due to PRM are not assessed. Eskimo curlew, northern leopard frog and red knot do not breed in northeastern Alberta and no historical data on these species within the Oil Sands Region are available. Peregrine falcons are likely migratory in the Oil Sands Region because typical breeding habitat (i.e., high cliffs over waterbodies) is not present in the RSA and no eyries have been documented to date. Whooping cranes in the Oil Sands Region breed exclusively in the northern portions of Wood Buffalo National Park in the Northwest Territories. None of these species is likely to be sensitive to the availability of migratory (i.e., staging) habitat within the LSA or RSA.

The environmental consequences of habitat loss during operations are high for all affected species during operations and before Closure at the LSA scale, and range from negligible to low at the RSA scale, as stated in the EIA and Species at Risk Assessment (EIA and *May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2*). The removal of the effects of JME and updates to the 2013 Base Case results in changes to the environmental consequences for the indirect effects of habitat loss before Closure for some KIRs. Specifically, the predicted decline of high suitability habitat due to the indirect effects of sensory disturbance and surficial aquifer drawdown during operations at the LSA scale change from the *May 2011, Submission of Information to the Joint Review Panel* as follows:

- from a low environmental consequence in the Species at Risk Assessment to high for common nighthawk, horned grebe, short-eared owl, wood bison and yellow rail in the 2013 PRM Application Case; and
- from a moderate environmental consequence in the Species at Risk Assessment to high for olive-sided flycatcher in the 2013 PRM Application Case.

In addition, the net environmental consequence of the PRM during construction and operations was previously assessed for wolverine and wood bison habitat as low at the RSA scale (*May 2011, Submission of Information to the Joint Review Panel*, *Appendix 2*). However, the removal of the effects of JME reduced the environmental consequences of habitat loss to negligible (Table 4.4-2).

The PRM is predicted to cause a decline in foraging and roosting habitat for little brown myotis and northern myotis which results in environmental consequences that are high at the LSA scale and negligible at the RSA scale during operations.

Although woodland caribou are virtually absent from the LSA, effects to potential habitat of these species are assessed at the request of the response to JRP SIRs 35a and 40a (Appendix 4) because caribou previously occurred in the LSA. The effects of PRM on potential woodland caribou habitat are assessed as having a negative high environmental consequence prior to reclamation at the LSA scale, and a negligible environmental consequence at the RSA scale.

The removal of the effects of JME results in changes to the environmental consequences for the effects of habitat at Closure for some wildlife KIRs in the LSA (Table 4.4-3). Specifically, the effects of the PRM at Closure change as follows:

- from a positive and high environmental consequence in the EIA (Volume 5, Section 7.5.3) to a negative and high for black-throated green warbler after Closure for the 2013 PRM Application Case;

- from a negative and low environmental consequence in the Species at Risk Assessment (*May 2011 Submission of Information to the Joint Review Panel*, *Appendix 2*) to negative and high for common nighthawk after Closure for the 2013 PRM Application Case;
- from a negative and high environmental consequence in the Species at Risk Assessment (*May 2011 Submission of Information to the Joint Review Panel*) to positive and high for horned grebe after Closure for the 2013 PRM Application Case; and
- from a positive and high environmental consequence in the EIA (Volume 5, Section 7.5.3) to negative and low for moose and moderate for fisher after Closure for the 2013 PRM Application Case.

The environmental consequences of the effects of PRM at Closure at the RSA scale were assessed as being from negligible to low for all KIRs and SAR in the EIA and the *May 2011, Submission of Information to the Joint Review Panel* Species at Risk Assessment. The assessed environmental consequences at the RSA scale decrease from low in the *May 2011, Submission of Information to the Joint Review Panel* Species at Risk Assessment for western toad and wood bison to negligible for the 2013 PRM Application Case, and increase for common nighthawk from negligible to low.

Little brown myotis and northern myotis use mixedwood and coniferous forests for foraging and roosting habitat (ASRD and ACA 2009; Crampton and Barclay 1998). Mixedwood and coniferous forests increase after reclamation. This increase results in a magnitude and environmental consequence of habitat change due to PRM for little brown myotis and northern myotis that are positive and high at the LSA scale, and negligible at the RSA scale (Section 4.3.1).

After reclamation, the environmental consequence of PRM on woodland caribou habitat is predicted to be positive and high due to the large decrease in burned areas, the increase in ecosite phases rich in lichen, such as blueberry aspen-white spruce (b3) and Labrador tea-mesic jack pine-black spruce (c1), and the reclamation of disturbances present in the 2013 Base Case. As stated in Section 4.4.1.1, woodland caribou are unlikely to be affected by PRM because woodland caribou are virtually absent from the LSA.

The assessed environmental consequences of the PRM on wildlife movement are negative and negligible at the LSA and RSA scales for Canadian toad, barred owl and black-throated green warbler during operations (Table 4.4-4). Environmental consequences of PRM on movement for little brown myotis and northern myotis are also negative and negligible. For all other wildlife KIRs and SAR that may be affected, the assessed environmental consequences before reclamation are unchanged from that previously assessed, and range from negligible for all avian species and western toad to low for terrestrial mammals (EIA; 2008 EIA Update; *May 2011, Submission of Information to the Joint Review Panel*). The environmental consequence will be low for terrestrial mammals because wildlife passageways will be provided under the Athabasca River bridge in the PRM LSA to provide for north-south wildlife movement along the Athabasca River.

At Closure, the assessed environmental consequences of PRM on movement of Canadian toad, barred owl, black-throated green warbler and western toad are positive and negligible at the LSA and RSA scales (Table 4.4-4). For all other wildlife KIRs and SAR that may be affected, the assessed environmental consequences at Closure range from positive and negligible for little brown myotis, northern myotis, avian species and western toad, to negative and low for terrestrial mammals. The negative and low environmental consequences at Closure for terrestrial mammals (i.e., moose, black bear, Canada lynx, fisher and wolverine) at the LSA scale are due to the creation of the large South Redclay Lake to the north end of the LSA and large pit lakes to the south end of the LSA. This increase in the areal extent of lakes results in a change to the environmental consequence of PRM on wolverine and wood bison movement from positive and low (*May 2011, Submission of Information to the Joint Review Panel*), to negative and low at the LSA scale, and negligible at the RSA scale (Table 4.4-4).

4.5 Biodiversity Assessment

The combined effects of the JME and PRM, in combination with existing and approved regional developments, on biodiversity were assessed in the EIA (Volume 5, Section 7.5.6). This assessment considers the effects of the PRM, without JME, in combination with existing and approved developments. The biodiversity assessment is provided to explicitly tie together the interacting effects of the PRM on fish, vegetation and wildlife at the species, ecosystem and landscape levels.

It is expected that biodiversity will be lost or altered during construction, operation and reclamation of the PRM. The loss or alteration of biodiversity at the species, ecosystem and landscape levels is assessed herein using a Geographic Information System (GIS)-based approach. This approach uses the estimated number of affected species, populations and communities; the areas of disturbance associated with PRM and their arrangement; and the variation and fragmentation of different land cover classes, types and categories in the study areas to assess the effects of PRM on biodiversity. The assessment places an emphasis on the ecosystem and landscape levels of biodiversity.

Biodiversity has been assessed for the 2013 PRM Application Case using the same assessment methods as described in Volume 5, Section 7.5.6 of the EIA, where appropriate. With the exception of FRAGSTATS analysis conducted for the LSA, the biodiversity effects analyses are based on the direct effect of the PRM's disturbance footprint, as well as the indirect effect of groundwater drawdown. It was not possible to incorporate groundwater drawdown into the raster (i.e., cells in a grid) data layer used for FRAGSTATS. The components that make up the disturbance footprint are listed in Appendix 3.1, Section 2.4.

As previously explained in Section 4.3, direct comparisons between the results presented for the RSA and the LSA cannot be made due to differences in scale, data sources and mapping methods between the two study areas. The reclaimed landscape is based on the CC&R Plan (EIA, Volume 5, Appendix 5-2, as amended), which provides a description of activities required to reclaim the area disturbed by the PRM. Reclamation efforts will include progressive reclamation of areas not required for ongoing activities.

4.5.1 Assessment Results

Species-level biodiversity effects of the PRM are addressed in the EIA, Volume 4A, Section 6.7.6 for fish, and in Sections 4.3.1 and 4.4.1 of this submission for vegetation and wildlife, respectively. Potential effects to these resources are summarized below.

Fish and Fish Habitat

The potential effects associated with PRM activities were evaluated for fish habitat, fish abundance, fish diversity and fish habitat diversity. Once mitigation and compensation were taken into account for valid linkages, all residual effects were considered to have no environmental consequence (EIA, Volume 4A, Tables 6.7-20, 6.7-21 and 6.7-22).

Terrestrial Vegetation, Wetlands and Forest Resources

The analysis of potential linkages indicates that the loss or alteration of terrestrial vegetation, wetlands and forest resources are primarily due to site clearing during the construction and operations phases of the PRM. Of the three species-level KIRs assessed at the LSA scale, a negative residual effect with a high environmental consequence is predicted for high rare plant potential, and a moderate environmental consequence is predicted for high traditional use plant potential (Table 4.3-17). The residual effect of dust is predicted to be negative, with a low environmental consequence in the LSA. The residual effects have a low (high rare plant potential) and negligible (high traditional use plant potential) environmental consequence at the RSA scale. An environmental consequence is not applicable for dust at the RSA scale.

At Closure, the environmental consequence for high rare plant potential remains the same as during construction and operations at the LSA scale (i.e., negative high; Table 4.3-18). For high traditional use plant potential and dust, the environmental consequence becomes a positive low in the LSA at Closure. The residual effects have a negative low (high rare plant potential) or positive negligible (high traditional use plant potential) environmental consequence in the RSA. An environmental consequence at the RSA scale is not applicable for dust.

Wildlife and Wildlife Habitat

The net change of the potential effects of the PRM assessed during construction and operations are predicted to have negative residual effects on wildlife abundance, with a negligible environmental consequence for three wildlife KIRs (Canadian toad, barred owl and western toad; Table 4.4-1) at the LSA and RSA scales. Negative residual effects on wildlife abundance, with low environmental consequence, are predicted for the remaining wildlife KIRs at the LSA scale. At the RSA scale, construction and operations of the PRM are expected to have a negative low environmental consequence on the abundance of five KIRs (Canada warbler, common nighthawk, horned grebe, rusty blackbird and yellow rail), and a negative high environmental consequence for woodland caribou (Table 4.4-1). Environmental consequences are predicted to be negligible in the RSA for the remaining KIRs. At Closure, populations are expected to recover, resulting in a negligible environmental consequence of the residual effects of the PRM on the abundance of all wildlife KIRs at both the LSA and RSA scales.

During construction and operations, the net change of the potential effects of the PRM are predicted to have negative residual effects on habitat for all assessed KIRs, with a high environmental consequence at the LSA scale (Table 4.4-2). At the RSA scale, construction and operations of the PRM are expected to have a negligible environmental consequence on the habitat of 11 KIRs and a low environmental consequence for nine KIRs (barred owl, Canadian toad, Canada lynx, western toad, Canada warbler, common nighthawk, horned grebe, rusty blackbird and yellow rail, Table 4.4-2). Because black-throated green warbler population trends indicate that they may be declining to extirpation in the RSA and that the decline may be associated with breeding habitat loss (Appendix 2, Section 4.2.3.6), the environmental consequence for black throated green warbler at the RSA scale is conservatively predicted to be high. At Closure, negative residual effects to habitat are predicted for barred owl, black bear, black-throated green warbler, common nighthawk, fisher, moose, rusty blackbird, western toad, wood bison, short-eared owl and yellow rail (Table 4.4-3). At the LSA scale, the environmental consequence of these residual effects are predicted to be high for these KIRs, with the exception of a low environmental consequence for barred owl, fisher and moose, and a negligible environmental consequence for black bear. At the RSA scale, the negative residual effect of the PRM on wildlife habitat is predicted to be negligible for all KIRs except common nighthawk; the residual effect for common nighthawk is expected to have a low environmental consequence.

Construction and operations of the PRM are predicted to have negative residual effects on the movement of all KIRs (Table 4.4-4). At the LSA scale, environmental consequences are expected to be negligible for most KIRs, but low for beaver, black bear, Canada lynx, fisher, moose, wolverine and wood bison. At the RSA scale, the environmental consequences are predicted to remain unchanged from the EIA and the SAR Assessment for all KIRs. At Closure, positive residual effects are predicted for all KIRs except the wide-ranging species (i.e., black bear, Canada lynx, fisher, moose, wolverine and wood bison; Table 4.4-4). Negative residual effects to black bear, Canada lynx, fisher, moose, wolverine and wood bison are predicted to have environmental consequences of low at the LSA scale and negligible at the RSA scale.

4.5.1.1 Ecosystem-Level Biodiversity Impact Analysis

At the ecosystem level of biodiversity, effects of the PRM are evaluated by considering changes in area of land cover types (i.e., ecosite phase, wetlands type or other land cover type) in the LSA, and RLCCs in the RSA ranked high, moderate or low for biodiversity potential. Biodiversity potential represents the relative contribution of a land cover type or RLCC to the overall biological diversity of an area. Both direct (i.e., PRM footprint) and indirect (i.e., groundwater drawdown) effects are assessed in this subsection. Specific details and assessment methods are provided in the *Biodiversity Environmental Setting Report for the Jackpine Mine Expansion & Pierre River Mine Project* (Golder 2007).

Biodiversity Potential in the Local Study Area

Effects of the PRM on land cover types in the LSA are presented according to biodiversity potential in Figure 4.5-1 and Table 4.5-1, and are summarized according to rank as follows:

- During construction and operations, areas ranked high for biodiversity potential will decrease by 1,391 ha (80%; Table 4.5-1). This reduction in high biodiversity potential areas will be primarily due to the loss of 926 ha (89%) of wooded fen (FTNN) which accounts for 66% of the total high biodiversity loss. Reclamation will restore 22% of the high biodiversity losses, after which residual loss will comprise 1,016 ha (58% relative to the 2013 Base Case; Figure 4.5-1, Table 4.5-1). Where soil is removed or disturbed, such as by construction of open pits, plant facilities or access roads, the reclaimed landscape is conservatively assumed to not support peatland wetlands types (i.e., FOPN, FTNN) that existed before being disturbed. However, disturbances that do not alter the soil, such as seismic lines, could support similar wetlands types at Closure.
- Areas ranked moderate for biodiversity potential decrease by 2,162 ha (77%) due to construction and operations (Table 4.5-1). Most of the area of moderate biodiversity potential land cover types affected consist of 746 ha (92%) of graminoid fen (FONG), 724 ha (75%) of shrubby fen (FONS), and 449 ha (76%) of wooded swamps (STNN), which together comprise 89% of the total moderate biodiversity potential loss (Table 4.5-1). At Closure, there will be a net increase of 1,267 ha (45%) in moderate biodiversity potential areas relative to the 2013 Base Case (Figure 4.5-1, Table 4.5-1). This increase is mainly due to the addition of lakes (including two pit lakes and South Redclay Lake) to the landscape. Data are not currently available to determine if these reclaimed water types will have an equivalent level of biodiversity, 80 years post-reclamation, to natural water types. Shell will continue its participation in CEMA and other multi-stakeholder groups to research and refine assumptions regarding pit lakes development. Monitoring

and adaptive management are considered to be appropriate strategies for dealing with the uncertainties associated with pit lakes development. Other moderate-ranked land cover types are expected to increase in spatial extent at Closure. The largest increases are to willow/horsetail white spruce-black spruce (Athabasca Plain e3) and littoral zones (specific to the Closure landscape), which increase by 321 ha and 254 ha, respectively. Blueberry aspen (white birch) (b2) and dogwood white spruce (Central Mixedwood e3) will also increase in the LSA at Closure.

- Low biodiversity potential areas will decrease 9,383 ha (51%) due to construction and operations (Table 4.5-1). The majority of low biodiversity potential land cover types affected consist of 2,533 ha of burned upland (BUu) and 1,910 ha of burned wetlands (BUw), which together account for 47% of the low biodiversity potential loss (Table 4.5-1). Reclamation will restore 50% of the low biodiversity losses, after which residual loss will comprise 251 ha (1% relative to the 2013 Base Case; Figure 4.5-1, Table 4.5-1) in the LSA at Closure.

Figure 4.5-1 Change in Biodiversity Potential in the Local Study Area From 2013 Base Case to Closure

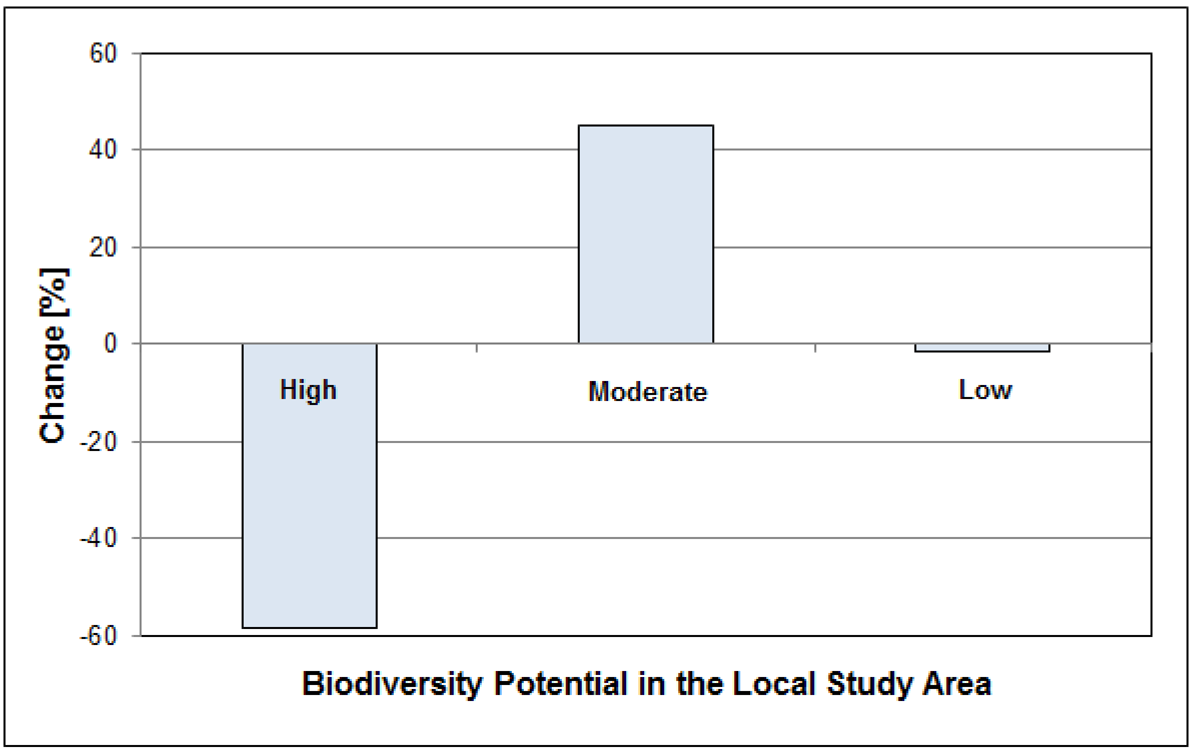

Table 4.5-1 Change in Biodiversity Potential in the Local Study Area

Natural Subregion[a]	Land Cover Type		2013 Base Case	Direct and Indirect Loss/Alteration due to Pierre River Mine[b]		Closure	Net Change due to Pierre River Mine[c]	
			Area [ha]	Area [ha]	% of Resource[d]	Area [ha]	Area [ha]	% of Resource[d]
High Biodiversity Potential								
AP/CM	FOPN	open patterned fen	67	-67	-100	13	-54	-81
AP/CM	FTNN	wooded fen	1,042	-926	-89	295	-748	-72
AP/CM	MONG	marsh	140	-140	-100	146	6	4
AP/CM	SONS	shrubby swamp	495	-258	-52	275	-221	-45
		subtotal	*1,745*	*-1,391*	*-80*	*728*	*-1,016*	*-58*
Moderate Biodiversity Potential								
CM	b2	blueberry aspen (white birch)	37	-14	-39	143	106	286
CM	e3	dogwood white spruce	74	-51	-69	179	106	143
CM	f1	horsetail balsam poplar-aspen	2	-2	-100	0	-2	-100
CM	f2	horsetail balsam poplar-white spruce	<1	-<1	-100	0	-<1	-100
CM	f3	horsetail white spruce	4	-2	-62	1	-2	-62
AP	e3	willow/horsetail white spruce-black spruce	159	-61	-38	480	321	202
AP/CM	BFNN	forested bog	17	-17	-97	1	-16	-92
AP/CM	BONS	shrubby bog	<1	-<1	-100	0	-<1	-100
AP/CM	FONG	graminoid fen	810	-746	-92	149	-661	-82
AP/CM	FONS	shrubby fen	963	-724	-75	450	-513	-53
AP/CM	STNN	wooded swamp	590	-449	-76	351	-239	-41
AP/CM	WONN	shallow open water	69	-43	-62	27	-42	-62
AP/CM	lake	lake[e]	83	-51	-61	2,041	1,957	2,347
AP/CM	littoral zone	littoral zone[f]	n/a	n/a	n/a	254	254	n/a
		subtotal	*2,810*	*-2,162*	*-77*	*4,077*	*1,267*	*45*

Table 4.5-1 Change in Biodiversity Potential in the Local Study Area (continued)

Natural Subregion[(a)]	Land Cover Type		2013 Base Case	Direct and Indirect Loss/Alteration due to Pierre River Mine[(b)]		Closure	Net Change due to Pierre River Mine[(c)]	
			Area [ha]	Area [ha]	% of Resource[(d)]	Area [ha]	Area [ha]	% of Resource[(d)]
Low Biodiversity Potential								
CM	a1	lichen jack pine	7	-7	-100	56	49	718
CM	b1	blueberry jack pine-aspen	125	-83	-67	151	26	21
CM	b3	blueberry aspen-white spruce	115	-51	-45	332	217	189
CM	b4	blueberry white spruce-jack pine	101	-72	-71	29	-72	-71
CM	c1	Labrador tea-mesic jack pine-black spruce	5	-5	-99	958	953	20,304
CM	d1	low-bush cranberry aspen	873	-363	-42	1,405	532	61
CM	d2	low-bush cranberry aspen-white spruce	468	-247	-53	425	-42	-9
CM	d3	low-bush cranberry white spruce	208	-71	-34	137	-71	-34
CM	e1	dogwood balsam poplar-aspen	7	-6	-88	48	41	560
CM	e2	dogwood balsam poplar-white spruce	97	-30	-31	113	17	17
CM	g1	Labrador tea-subhygric black spruce-jack pine	11	0	-4	10	-<1	-4
CM	h1	Labrador tea/horsetail white spruce-black spruce	107	-58	-54	49	-58	-54
AP	a1	bearberry jack pine	772	-294	-38	689	-83	-11
AP	b1	Canada buffalo-berry-green alder jack pine-aspen-white birch	1,654	-595	-36	1,065	-590	-36
AP	b2	Canada buffalo-berry-green alder aspen	1,939	-676	-35	2,055	117	6
AP	b3	Canada buffalo-berry-green alder aspen-white spruce-black spruce	1,227	-634	-52	1,258	30	2
AP	b4	Canada buffalo-berry-green alder white spruce-black spruce-jack pine	451	-206	-46	248	-203	-45
AP	c1	Labrador tea-mesic jack pine-black spruce	23	-8	-36	1,133	1,110	4,805
AP	d1	Labrador tea-subhygric black spruce-jack pine	34	-23	-69	2,105	2,072	6,165
AP	e1	willow/horsetail aspen-white birch-balsam poplar	319	-29	-9	292	-27	-8
AP	e2	willow/horsetail aspen-white spruce-black spruce	224	-126	-56	209	-15	-7
AP	Pj-Lt	jack pine-tamarack complex	4	-4	-100	0	-4	-100
AP/CM	BTNN	wooded bog	347	-314	-91	172	-175	-50

Table 4.5-1 Change in Biodiversity Potential in the Local Study Area (continued)

Natural Subregion[a]	Land Cover Type		2013 Base Case	Direct and Indirect Loss/Alteration due to Pierre River Mine[b]		Closure	Net Change due to Pierre River Mine[c]	
			Area [ha]	Area [ha]	% of Resource[d]	Area [ha]	Area [ha]	% of Resource[d]
AP/CM	BUu	burn upland	5,065	-2,533	-50	2,533	-2,533	-50
AP/CM	BUw	burn wetlands	2,345	-1,910	-81	728	-1,616	-69
AP/CM	Me	meadow	9	-2	-20	7	-2	-20
AP/CM	Sh	shrubland	110	-3	-3	108	-3	-3
AP/CM	Sh1	reclaimed shrubland type 1[f]	n/a	n/a	n/a	413	413	n/a
AP/CM	Sh2	reclaimed shrubland type 2[f]	n/a	n/a	n/a	699	699	n/a
AP/CM	River	river	180	-2	-1	178	-2	-1
AP/CM	Sand	sand	48	-5	-10	43	-5	-10
AP/CM	Cutblock	cutblock	931	-606	-65	325	-606	-65
AP/CM	DIS	disturbance[g]	771	-420[h]	-54	351	-420	-54
		subtotal	*18,575*	*-9,383*	*-51*	*18,324*	*-251*	*-1*
Total[i]			**23,129**	**-12,935**	**-56**	**23,129**	**n/a**	**n/a**

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

(b) Loss/alteration combines direct effects due to site clearing (PRM footprint) and indirect effects due to groundwater drawdown; this is the value upon which the environmental consequence before reclamation is assessed.

(c) Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure; this is the value upon which the environmental consequence at Closure is assessed.

(d) This column is calculated as a percentage of 2013 Base Case area; the areas are not additive.

(e) Includes pit lakes and the South Redclay Lake at Closure.

(f) These land cover types are specific to the Closure landscape and are described in the CC&R Plan (EIA, Volume 5, Appendix 5-2, as amended).

(g) Includes urban, industrial and other human disturbances in the LSA.

(h) This is the total amount of previously disturbed areas that fall within the PRM footprint; this value will be different than what is reported in Table 4.5-4 because different datasets are used for the different analyses.

(i) Total LSA or footprint and groundwater drawdown in the LSA.

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.

Biodiversity Potential in the Regional Study Area

Effects of the PRM on RLCCs in the RSA are presented according to biodiversity potential in Figure 4.5-2 and Table 4.5-2, and are summarized according to rank as follows:

- During construction and operations, high biodiversity potential areas will decrease by 7,526 ha (2%) (Table 4.5-2). Non-treed wetlands and treed fen RLCCs will decrease by 1% (2,512 ha) and 2% (5,014 ha), respectively. At Closure, there will be an overall decrease in high biodiversity potential areas of 4,836 ha (1%) (Figure 4.5-2, Table 4.5-2). This decrease is mostly due to the loss of treed fens (4,218 ha) relative to the 2013 Base Case (Table 4.5-2).
- Moderate biodiversity potential areas will decrease by 4,697 ha (less than 1%) during construction and operations (Table 4.5-2). Each RLCC is affected by 1% or less of its total area compared to the 2013 Base Case. At Closure, there will be a net decrease of less than 1% (55 ha) in moderate biodiversity potential areas (Figure 4.5-2, Table 4.5-2). Water and mixedwood aspen−jack pine are the only moderate-ranked RLCCs that will increase at Closure relative to the 2013 Base Case. The large increase in the water RLCC is due to the addition of littoral zones, the pit lakes, and South Redclay Lake at Closure (Table 4.5-2).
- During construction and operations, low biodiversity potential areas will decrease by 1,701 ha (less than 1%) (Table 4.5-2). The cutblock and coniferous jack pine-black spruce RLCCs will not be affected by the PRM footprint. At Closure, there will be a net increase of 4,892 ha (less than 1%) of low-ranked areas relative to the 2013 Base Case (Figure 4.5-2, Table 4.5-2). Coniferous jack pine−black spruce comprises the majority of this gain (4,173 ha) in low biodiversity potential areas (Table 4.5-2).

Figure 4.5-2 Change in Biodiversity Potential in the Regional Study Area from 2013 Base Case to Closure

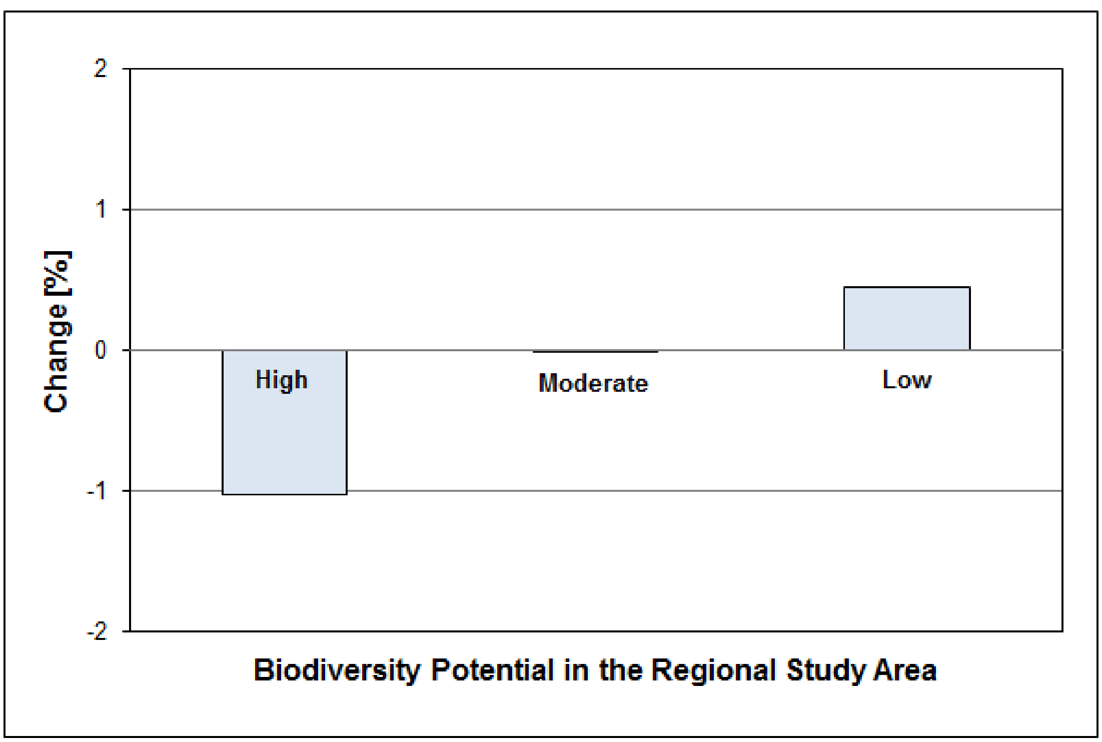

Table 4.5-2 Change in Biodiversity Potential in the Regional Study Area

Regional Land Cover Class	2013 Base Case	Direct and Indirect Loss/Alteration due to Pierre River Mine[(a)]		Closure	Net Change due to Pierre River Mine[(b)]	
	Area [ha]	Area [ha]	% of Resource[(c)]	Area [ha]	Area [ha]	% of Resource[(c)]
High Biodiversity Potential						
non-treed wetlands	241,110	-2,512	-1	240,492	-618	-<1
treed fen	230,369	-5,014	-2	226,151	-4,218	-2
subtotal	*471,479*	*-7,526*	*-2*	*466,643*	*-4,836*	*-1*
Moderate Biodiversity Potential						
coniferous white spruce	52,386	-622	-1	52,302	-84	-<1
mixedwood aspen−jack pine	39,033	0	0	39,147	114	<1
mixedwood aspen-white spruce	144,759	-1,643	-1	144,411	-348	-<1
treed bog/poor fen	423,855	-2,380	-<1	421,900	-1,955	-<1
water[(d)]	52,526	-52	-<1	54,743	2,217	4
subtotal	*712,559*	*-4,697*	*-<1*	*712,504*	*-55*	*-<1*
Low Biodiversity Potential						
burn	396,125	-426	-<1	395,993	-132	-<1
coniferous jack pine	166,332	-349	-<1	166,251	-81	-<1
coniferous jack pine-black spruce	40,054	0	0	44,228	4,173	10
deciduous aspen−balsam poplar	178,067	-506	-<1	179,418	1,351	<1
cutblock	100,160	0	0	100,160	0	0
disturbance[(e)]	212,601	-420[(f)]	-<1	212,181	-420	-<1
subtotal	*1,093,338*	*-1,701*	*-<1*	*1,098,230*	*4,892*	*<1*
Total[(g)]	**2,277,376**	**-13,924**	**-<1**	**2,277,376**	**n/a**	**n/a**

(a) Loss/alteration combines direct effects due to site clearing (PRM footprint) and indirect effects due to groundwater drawdown; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure; this is the value upon which the environmental consequence at Closure is assessed.

(c) This column is calculated as a percentage of 2013 Base Case area; the areas are not additive.

(d) Includes littoral zones, pit lakes and South Redclay Lake at Closure.

(e) Includes urban, industrial and other human disturbances in the RSA.

(f) This is the total amount of previously disturbed areas that fall within the PRM footprint.

(g) Total RSA or footprint and groundwater drawdown in the RSA.

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.

4.5.1.2 Landscape-Level Biodiversity Impact Analysis

At the landscape level of biodiversity, effects of the PRM are assessed by considering changes in heterogeneity and degree of fragmentation within the LSA and RSA. Landscape heterogeneity is a measure of landscape composition, similarity and arrangement based on patch type (i.e., land cover types in the LSA and RLCCs in the RSA). Fragmentation relates to how categories (e.g., natural, non-forested and riparian) are portioned on the landscape. Specific details and assessment methods are provided in the *Biodiversity Environmental Setting Report for the Jackpine Mine Expansion & Pierre River Mine Project* (Golder 2007).

Heterogeneity in the Local Study Area

The effects on landscape heterogeneity in the LSA due to the PRM were measured by changes in the size, number and distribution of land cover type patches and land cover categories (e.g., terrestrial, wetlands and water). The results are presented in Table 4.5-3 and Table 4.5-4 and are summarized as follows:

- During construction and operations, patch richness will decrease by four land cover types (11%; Table 4.5-3). At Closure, there will be a net decrease in patch richness of one land cover type compared to the 2013 Base Case. Some land cover types will be lost and not reclaimed (e.g., horsetail balsam poplar-aspen [f1], horsetail balsam poplar-white spruce [f2], shrubby bog [BONS], jack pine-tamarack complex [Pj-Lt]), whereas others not present in the 2013 Base Case will be added to the Closure landscape (i.e., littoral zone and reclaimed shrubland types 1 and 2) (Table 4.5-1).
- Shannon's Evenness Index (SHEI) (i.e., a measure of the evenness, or homogeneity, of the landscape) will decrease 27% between the 2013 Base Case and 2013 PRM Application Case (Table 4.5-3). At Closure, SHEI will be 4% greater than that in the 2013 Base Case. This increase indicates that the Closure landscape will be more even compared to the 2013 Base Case due to a more pronounced decrease in dominance of a few land cover types at Closure (e.g., burns and wooded fen [FTNN]) relative to the increased dominance of other land cover types (e.g., Labrador tea–mesic jack pine–black spruce [c1] and lakes) (Table 4.5-1).
- During construction and operations, 3,725 ha (41%) of the terrestrial land cover category and 2,785 ha (61%) of the wetlands cover category will be disturbed. The burn and water land cover categories will decrease by 56% (4,149 ha) and 19% (58 ha), respectively (Table 4.5-4).
- The PRM will result in a net increase of 5,633 ha (61%) to the terrestrial land cover category from 2013 Base Case to Closure (Table 4.5-4). This increase is primarily due to increases in Labrador tea-subhygric black spruce-jack pine (Athabasca Plain d1), Labrador tea–mesic jack pine–black spruce (c1) and reclaimed shrublands (Table 4.5-1).
- Wetlands in the LSA will decrease by 2,663 ha (59%) from 2013 Base Case to Closure as a result of the PRM (Table 4.5-4). This decrease is primarily due to losses of wooded fen (FTNN), which cannot be reclaimed with current technologies (Table 4.5-1).
- The PRM will result in a net increase of 2,205 ha (707%) to the water land cover category from 2013 Base Case to Closure (Table 4.5-4). This increase is due to the addition of the pit lakes and South Redclay Lake to the Closure landscape (Table 4.5-1).
- At Closure, there will be a net decrease of 1,026 ha (60%) to disturbed areas in the LSA. Disturbances that were already present in the 2013 Base Case, which underlay the PRM footprint, will also be reclaimed (Table 4.5-4).

Table 4.5-3 Change in Patch Richness and Shannon's Evenness Index in the Local Study Area

Landscape Metric	2013 Base Case	Loss/Alteration due to Pierre River Mine[(a)]		Closure	Net Change due to Pierre River Mine[(b)]	
		Change in Parameter	% Change		Change in Parameter	% Change
patch richness (PR)	38	-4	-11	37	-1	-3
Shannon's evenness index (SHEI)	0.78	-0.21	-27	0.81	0.03	4

(a) Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change is calculated as the difference between the 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

Note: Table comparable to Table 5 in the EIA, Volume 5, Appendix 5-3. Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Table 4.5-4 Change in Area of Land Cover Categories in the Local Study Area

Land Cover Category	2013 Base Case	Loss/Alteration due to Pierre River Mine[(a)]		Closure	Net Change due to Pierre River Mine[(b)]	
	Area [ha]	Area [ha]	% of Resource[(c)]	Area [ha]	Area [ha]	% of Resource[(c)]
burn	7,410	-4,149	-56	3,261	-4,149	-56
disturbed[(d)]	1,702	-1,026[(d)]	-60	676	-1,026	-60
terrestrial	9,165	-3,725	-41	14,798	5,633	61
water	312	-58	-19	2,516	2,205	707
wetlands	4,541	-2,785	-61	1,878	-2,663	-59
Total[(f)]	**23,129**	**-11,742**	**-51**	**23,129**	**n/a**	**n/a**

(a) Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change is calculated as the difference between the 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

(c) This column is calculated as a percentage of 2013 Base Case area; the areas are not additive.

(d) Includes cutblocks, urban, industrial and other human disturbances within the LSA.

(e) This is the total amount of previously disturbed areas that fall within the PRM footprint; this value will be different than what is reported in Table 4.5-1 because different datasets are used for the different analyses.

(f) Total LSA or footprint.

Note: Table comparable to Table 6 in the EIA, Volume 5, Appendix 5-3. 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.

Fragmentation in the Local Study Area

The LSA fragmentation analysis identified changes in natural, disturbed, forested, non-forested, old growth and riparian areas due to the PRM. A summary of results according to analysis category is presented below.

Natural and Disturbed Areas

Land cover types were grouped into categories of natural and human disturbed areas to examine fragmentation of natural patches by disturbance. The results are provided in Table 4.5-5 and are discussed below:

- Natural areas will decrease by 10,716 ha (50%) relative to the 2013 Base Case due to construction and operations. After reclamation, there will be a net increase of 1,026 ha (5%) relative to the 2013 Base Case as disturbed areas are converted to natural land cover types (Table 4.5-5).

- The number of natural area patches will decrease by 133 patches (40%) due to construction and operations. At Closure, there will be a net decrease of 273 patches (82%) relative to 2013 Base Case conditions because the landscape will be less dissected by human disturbances and natural areas will be more contiguous. Median patch size will increase by 2.3 ha (149%) during construction and operations, but will decrease by 0.4 ha (24%) relative to the 2013 Base Case, with a very high variability (Table 4.5-5), at Closure.
- The mean nearest neighbour distance between natural patches will increase by 6.1 m (61%) due to construction and operations. At Closure, the mean nearest neighbour distance between natural patches will increase by 1.7 m (17%) relative to the 2013 Base Case due to reclamation and natural regeneration creating more contiguous patches (Table 4.5-5).
- The total core area of natural area patches will decrease by 7,995 ha (57% of 2013 Base Case core area) as a result of habitat lost during construction and operations. At Closure, 4,954 ha (36%) of core area in natural patches will be gained (Table 4.5-5).
- Total edge between natural and disturbed patches will decrease by 38% due to the addition of PRM infrastructure to the landscape. At Closure, total edge will decrease by 65% relative to 2013 Base Case conditions because existing disturbance that fell within the PRM footprint will also be reclaimed (Table 4.5-5).

Table 4.5-5 Change in Natural and Disturbed Areas in the Local Study Area

Landscape Metric	Category	2013 Base Case	Loss/Alteration due to Pierre River Mine[a]		Closure	Net Change due to Pierre River Mine[b]	
			Change in Parameter	% Change		Change in Parameter	% Change
class area [ha]	natural	21,427	-10,716	-50	22,453	1,026	5
	human disturbed	1,702	10,716	630	676	-1,026	-60
number of patches	natural	332	-133	-40	59	-273	-82
	human disturbed	65	-38	-58	137	72	111
median patch size [ha]	natural	1.6	2.3	149	1.2	-0.4	-24
	human disturbed	0.3	0.1	24	0.6	0.3	97
patch size coefficient of variation [%]	natural	748	-446	-60	749	2	<1
	human disturbed	675	-171	-25	366	-309	-46
nearest neighbour mean [m]	natural	10.0	6.1	61	11.7	1.7	17
	human disturbed	183.6	-11.5	-6	253.2	69.6	38
nearest neighbour standard deviation [m]	natural	6.8	16.8	247	13.4	6.6	97
	human disturbed	315.5	-101.9	-32	271.1	-44.4	-14
total core area[c] [ha]	natural	13,920	-7,995	-57	18,874	4,954	36
total edge [km]	natural/human disturbed interface	1,001	-384	-38	352	-650	-65

(a) Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change is calculated as the difference between the 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

(c) Total core area was calculated using a 100-m buffer inside the perimeter of natural areas.

Note: Table comparable to Table 13 in the EIA, Volume 5, Appendix 5-3. Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Forested and Non-Forested Areas

Natural land cover types were grouped into forested and non-forested areas to examine fragmentation of these patches. The results are provided in Table 4.5-6 and are discussed below:

- During construction and operations, forested areas will decrease by 4,908 ha (44%) and non-forested areas will decrease by 5,808 ha (56%). At Closure, forested areas will increase 3,349 ha (30%) relative to the 2013 Base Case as a result of reclamation activities. Consequently, the Closure landscape will have a net decrease of 2,324 ha (22%) in non-forested natural areas (Table 4.5-6).
- The number of forested area patches decreases by 69%, from 1,491 patches in the 2013 Base Case to 460 patches at Closure (Table 4.5-6). The number of non-forested area patches decreases by 42%, from 786 patches in the 2013 Base Case to 457 patches at Closure. These decreases are indicative of some of the smaller patches being reconnected or replaced with larger reclaimed patches. However, overall median patch size will decrease on the reclaimed landscape compared to the 2013 Base Case because the reclaimed patches within the PRM footprint will be smaller relative to the 2013 Base Case patches. Both forested and non-forested areas will have a more variable patch size in the Closure landscape (107% and 65% increase relative to the 2013 Base Case, respectively).
- The total core area within both forested and non-forested patches will decrease due to fragmentation and habitat loss caused by construction and operations (45% and 60%, respectively) (Table 4.5-6). At Closure, there will be a net increase in the total core area of both forested and non-forested patches relative to the 2013 Base Case (133% and 21%, respectively). Forested patches experience a larger increase in total core area because the PRM footprint will be reclaimed or will regenerate with a greater amount of forested land cover types (Table 4.5-1).

Table 4.5-6 Change in Forested and Non-Forested Areas in the Local Study Area

Landscape Metric	Category	2013 Base Case	Loss/Alteration due to Pierre River Mine[(a)]		Closure	Net Change due to Pierre River Mine[(b)]	
			Change in Parameter	% Change		Change in Parameter	% Change
class area [ha]	forested	11,041	-4,908	-44	14,390	3,349	30
	non-forested	10,387	-5,808	-56	8,063	-2,324	-22
number of patches	forested	1,491	-788	-53	460	-1,031	-69
	non-forested	786	-236	-30	457	-329	-42
median patch size [ha]	forested	0.2	0.1	36	0.1	-0.1	-45
	non-forested	1.0	-0.4	-40	1.0	-0.1	-5
patch size coefficient of variation [%]	forested	877	-455	-52	1,818	942	107
	non-forested	413	-70	-17	682	269	65
nearest neighbour mean [m]	forested	25.9	7.0	27	33.2	7.4	28
	non-forested	23.3	20.3	87	37.5	14.3	61
nearest neighbour standard deviation [m]	forested	39.2	7.3	19	58.8	19.7	50
	non-forested	68.6	24.7	36	69.2	0.6	<1
total core area[(c)] [ha]	forested	2,995	-1,342	-45	6,986	3,991	133
	non-forested	2,595	-1,548	-60	3,141	547	21

(a) Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change is calculated as the difference between the 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

(c) Total core area was calculated using a 100-m buffer inside the perimeter of natural areas.

Note: Table comparable to Table 14 in the EIA, Volume 5, Appendix 5-3. Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Old Growth Forest

The size and proximity of old growth forest patches in the LSA was analyzed to examine patch fragmentation. The results are provided in Table 4.5-7 and are discussed below:

- Reclaimed forests will be 80 years old in the Closure landscape and will not yet have reached the old growth stage (Schneider 2002). Models do not account for aging of younger undisturbed forests in the LSA. Therefore, the fragmentation results of old growth forests at Closure are the same as for the 2013 PRM Application Case during construction and operations. However, the Closure landscape is predicted to have the capability to develop old growth forest.
- As a result of construction and operations, 448 ha (39%) of old growth forest will be lost (Table 4.5-7). Disturbance will reduce the number of old growth patches by 115. Median patch size is 0.5 ha for both the 2013 Base Case and Closure; however, patch size will be less variable (13%) at Closure. The mean distance between patches of old growth increases 31%, from 77.7 m in the 2013 Base Case to 101.5 m in the Closure landscape, and is expected to remain unchanged within the Closure time frame of 80 years. Total core area is reduced by 20 ha (37%) at Closure relative to the 2013 Base Case (Table 4.5-7).

Table 4.5-7 Change in Old Growth Forest in the Local Study Area

Landscape Metric	2013 Base Case	Loss/Alteration due to Pierre River Mine[a]	Closure[b]	Net Change due to Pierre River Mine[c]	
				Change in Parameter	% Change
class area [ha]	1,142	-448	693	-448	-39
number of patches	398	-115	283	-115	-29
median patch size [ha]	0.5	<0.1	0.5	<0.1	5
patch size coefficient of variation [%]	257	-33	224	-33	-13
nearest neighbour mean [m]	77.7	23.8	101.5	23.8	31
nearest neighbour standard deviation [m]	163.2	77.5	240.7	77.5	47
total core area[d] [ha]	53	-20	33	-20	-37

(a) Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Reclaimed forests will not become old growth within the 80-year time frame of reclamation, so the value for the 2013 PRM Application Case is carried forward to Closure.

(c) Net change is calculated as the difference between the 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

(d) Total core area was calculated using a 100-m buffer inside the perimeter of natural areas.

Note: Table comparable to Table 16 in the EIA, Volume 5, Appendix 5-3. Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Riparian Areas

Fragmentation (i.e., size, variability and proximity) of riparian patches was also examined in the LSA. The results are provided in Table 4.5-8 and are discussed below:

- During construction and operations, 1,320 ha of riparian vegetation (53%) will be removed within the LSA. The number of patches will increase by 2%, whereas median patch size and patch size variability will both decrease by 16% and 19%, respectively. The mean distance between patches will increase by 106.2 m (97% relative to 2013 Base Case conditions), due to fragmentation by disturbances associated with the PRM (Table 4.5-8).
- At Closure, there will be a predicted net loss of 103 ha (4%) of riparian areas (Table 4.5-8). This net loss is predicted because the PRM footprint will be reclaimed or will regenerate with a greater amount of land cover types that do not have riparian potential (e.g., Labrador tea–mesic jack pine–black spruce [c1], Labrador tea-subhygric black spruce-jack pine (Athabasca Plain d1) than land cover types that do have riparian potential (e.g., shrubland types) (Table 4.5-1).

Table 4.5-8 Change in Riparian Areas in the Local Study Area

Landscape Metric	2013 Base Case	Loss/Alteration due to Pierre River Mine[(a)]		Closure	Net Change due to Pierre River Mine[(b)]	
		Change in Parameter	% Change		Change in Parameter	% Change
class area [ha]	2,486	-1,320	-53	2,384	-103	-4
number of patches	100	2	2	125	25	25
median patch size [ha]	6.5	-1.1	-16	2.9	-3.6	-55
patch size coefficient of variation [%]	171	-32	-19	288	117	68
mean nearest neighbour [m]	109.8	106.2	97	123.6	13.8	13
nearest neighbour standard deviation [m]	279.9	14.2	5	176.5	-103.4	-37

(a) Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change is calculated as the difference between the 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

Notes: Table comparable to Table 15 in the EIA, Volume 5, Appendix 5-3. Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Heterogeneity in the Regional Study Area

The effects on landscape heterogeneity in the RSA were measured by changes in areas of land cover categories (e.g., terrestrial, wetlands and water). These changes illustrate the effects of the PRM on general landscape patterns in the RSA. The results are presented in Table 4.5-9 and are summarized as follows:

- Terrestrial RLCCs will decrease by 3,120 ha (less than 1%) due to construction and operations of the PRM. Reclamation will result in a net increase of 5,126 ha (less than 1%) of terrestrial RLCCs in the RSA from 2013 Base Case to Closure (Table 4.5-9). This increase results primarily from an increase in the coniferous jack pine−black spruce land cover class (Table 4.5-2).
- Construction and operations of the PRM will result in a decrease of 9,906 ha (1%) to wetland RLCCs. Wetlands in the RSA will decrease by 6,792 ha (less than 1%) overall from 2013 Base Case to Closure as a result of the PRM (Table 4.5-9). The largest decrease will occur to treed fens, followed by treed bog/poor fens (Table 4.5-2). These two RLCCs are mainly composed of peatland land cover types, which cannot be reclaimed with current technologies.
- The burn and disturbance land cover categories decrease by a similar amount (426 ha and 420 ha, respectively) due to construction and operations of the PRM. Net change due to the PRM remains the same for the disturbance category (420 ha). Burns in the RSA will decrease by 132 ha (less than 1%) overall from the 2013 Base Case to Closure as a result of the PRM (Table 4.5-9).
- The water land cover category comprises the smallest proportion (less than 1%) of the overall change during construction and operations of the PRM. However, relative to the proportion available in the 2013 Base Case, net change due to the PRM is greatest for this category due to the addition of the pit lakes and South Redclay Lake to the Closure landscape (Table 4.5-9).

Table 4.5-9 Change in Area of Land Cover Categories in the Regional Study Area

Land Cover Category	2013 Base Case	Loss/Alteration due to Pierre River Mine[a]		Closure	Net Change due to Pierre River Mine[b]	
	Area [ha]	Area [ha]	% of Resource[c]	Area [ha]	Area [ha]	% of Resource[c]
burn	396,125	-426	-<1	395,993	-132	-<1
disturbed[d]	312,761	-420[e]	-<1	312,341	-420	-<1
terrestrial	620,630	-3,120	-<1	625,757	5,126	<1
water	52,526	-52	-<1	54,743	2,217	4
wetlands	895,334	-9,906	-1	888,543	-6,792	-<1
Total[f]	**2,277,376**	**-13,924**	**-<1**	**2,277,376**	**n/a**	**n/a**

(a) Loss/alteration combines direct effects due to site clearing (PRM footprint) and indirect effects due to groundwater drawdown; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change due to the PRM is calculated as the difference between 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

(c) This column is calculated as a percentage of 2013 Base Case area; the areas are not additive.

(d) Includes urban, industrial and other human disturbances in the RSA.

(e) This is the total amount of previously disturbed areas that fall within the PRM footprint.

(f) Total RSA or footprint and groundwater drawdown in the RSA.

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.

Fragmentation in the Regional Study Area

The RSA fragmentation analysis identified changes in natural, disturbed, forested and non-forested areas. Other landscape-level metrics were not calculated as the change due to the PRM at the scale of the LSA would result in virtually no change at the RSA scale. A summary of results is presented in Table 4.5-10 and is discussed below:

- Natural areas will decrease by 13,504 ha (less than 1%) due to construction and operations. At Closure, natural areas will experience a net increase of 420 ha (less than 1%). This increase is the result of disturbed areas, which existed in the 2013 Base Case, being reclaimed to natural land cover types (Table 4.5-10).
- Forested areas will decrease by 10,513 ha (less than 1%) due to construction and operations, with a net decrease of 1,047 ha (less than 1%) from 2013 Base Case to Closure (Table 4.5-10). The 1,467 ha (less than 1%) net increase in non-forested areas will mainly result from some of the forested RLCCs (e.g., treed bog/poor fen) disturbed by the footprint being replaced with non-forested RLCCs (e.g., water) in the Closure landscape (Table 4.5-2).

Table 4.5-10 Change in Natural, Disturbed, Forested and Non Forested Areas in the Regional Study Area

Land Cover Category	2013 Base Case	Loss/Alteration due to Pierre River Mine[(a)]		Closure	Net Change due to Pierre River Mine[(b)]	
	Area [ha]	Area [ha]	% of Resource[(c)]	Area [ha]	Area [ha]	% of Resource[(c)]
natural	1,964,616	-13,504	-<1	1,965,036	420	<1
disturbed[(d)]	312,761	-420[(e)]	-<1	312,341	-420	-<1
forested	1,274,855	-10,513	-<1	1,273,807	-1,047	-<1
non-forested	689,761	-2,990	-<1	691,228	1,467	<1

(a) Loss/alteration is calculated as the difference between the 2013 Base Case and 2013 PRM Application Case; this is the value upon which the environmental consequence before reclamation is assessed.

(b) Net change is calculated as the difference between the 2013 Base Case and Closure; this is the value upon which the environmental consequence after reclamation is assessed.

(c) This column is calculated as a percentage of 2013 Base Case area; the areas are not additive.

(d) Includes cutblocks, urban, industrial and other human disturbances within the RSA.

(e) This is the total amount of previously disturbed areas that fall within the PRM footprint.

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

Residual Impact Classification for Biodiversity During Construction and Operations

After construction, operation and reclamation of the PRM, the changes in biodiversity result in residual effects. The residual effects may vary for each effect criteria, depending on the time period (i.e., before or after reclamation) and level of biodiversity (i.e., species, ecosystem or landscape) being assessed (Table 4.5-11). The biodiversity species-level residual effect classification draws directly upon the Terrestrial Vegetation, Wetlands and Forest Resources, and Wildlife and Wildlife Habitat residual effects (Sections 4.3.1 and 4.4.1, respectively). The PRM is predicted to have no environmental consequences on Fish and Fish Habitat (Section 4.5.1.1), so fish are not considered further. The ecosystem- and landscape-level residual effect classifications are based on the changes discussed in Sections 4.5.1.2 and 4.5.1.3.

Table 4.5-11 Residual Effects to Biodiversity in the Local and Regional Study Areas due to the 2013 PRM Application Case

Biodiversity Criteria	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Environmental Consequence (LSA)	Environmental Consequence (RSA)
During Construction and Operations								
species-level effects	negative	moderate (+10)	beyond regional (+2)	long-term (+2)	reversible/ irreversible (0)	high (+2)	high (+16)	negligible
ecosystem-level effects	negative	high (+15)	local (0)	long-term (+2)	irreversible (+3)	low (0)	high (+20)	negligible
landscape-level effects	negative	high (+15)	regional (+1)	long-term (+2)	irreversible (+3)	high (+2)	high (+23)	negligible
Closure								
species-level effects	negative/ positive	moderate (+10)	regional (+1)	long-term (+2)	reversible/ irreversible (0)	high (+2)	moderate (+15)	negligible
ecosystem-level effects	negative	moderate (+10)	local (0)	long-term (+2)	irreversible (+3)	low (0)	moderate (+15)	negligible
landscape-level effects	negative	high (+15)	regional (+1)	long-term (+2)	reversible (-3)	low (0)	moderate (+15)	negligible

Note: Numerical scores for ranking of environmental consequence are explained in the EIA, Volume 3, Section 1.3.6.

During construction and operations, the overall magnitude of the residual effect of the PRM at the species-level of biodiversity is considered negative and moderate at the LSA scale because most of the negative residual effects to KIRs have either low or high magnitude. Although the geographic extent of negative residual effects to vegetation KIRs are considered local in geographic extent, most effects are beyond regional for wildlife KIRs. Therefore, the overall residual effect at the species-level is considered to be beyond regional. The majority of the residual effects to vegetation and wildlife KIRs are long-term in duration and occur with high frequency. Residual effects to vegetation and wildlife KIRs are mostly reversible, with some irreversible or partially reversible (i.e., reversible/irreversible), resulting in an overall partial reversibility of effects at the species-level.

The overall magnitude of the residual effect of construction and operations on the ecosystem-level of biodiversity in the LSA is scored as high because the negative changes to high, moderate and low biodiversity potential areas are all predicted to be greater than 20% (Table 4.5-1). The residual effect is considered to be local in geographic extent because the majority of losses to high biodiversity potential areas occur to the wooded fen (FTNN) wetlands type, which is very common in the region. However, the high biodiversity potential fens that are lost in the LSA cannot be reclaimed with current technologies if the soil has been disturbed. For this reason, the overall residual effect was scored as irreversible. The residual effect is also considered to be long-term in duration and low in frequency. The effect occurs with low frequency because continual losses to ecosystem-level biodiversity potential will be balanced by continual gains due to reclamation of disturbances.

At the landscape level, changes in heterogeneity and fragmentation metrics are highly variable and range from negligible to high in magnitude. The overall magnitude of the residual effect of construction and operations to landscape-level biodiversity is scored as high because most of the changes are greater than 20%. The residual effect is considered to be regional in geographic extent, long-term in duration, and irreversible. The frequency is considered to be high because residual effects to landscape-level biodiversity can potentially be a continual process over the life of the PRM.

Overall, negative high environmental consequences are predicted in the LSA for all levels of biodiversity (i.e., species, ecosystem or landscape). Negative negligible environmental consequences are predicted in the RSA. Although some predicted residual effects in the LSA extend into the RSA and beyond (e.g., barriers to movement for wide-ranging species), the small size of the LSA relative to the RSA (approximately 1%) lessens these effects.

Residual Impact Classification for Biodiversity At Closure

The residual effects of the PRM on vegetation and wildlife KIRs are fairly evenly split between positive and negative effects at Closure. The overall magnitude of the residual effect of the PRM at the species-level of biodiversity is considered moderate because most of the negative residual effects to KIRs fell into either the low or high magnitude categories. All negative residual effects to vegetation KIRs are considered local in geographic extent; however, the criterion varies for wildlife KIRs. Most residual effects are either regional or beyond regional for wildlife KIRs, with some local. Overall, the residual effect at the species-level was considered to be regional. All residual effects were considered to be long-term for vegetation and wildlife KIRs. The majority of species-level residual effects also occur with high frequency at Closure. Negative residual effects to wildlife KIRs are mostly reversible, whereas effects to species-level vegetation KIRs are irreversible, resulting in an overall partial reversibility of effects at the species-level.

The overall magnitude of the residual effect on the ecosystem-level of biodiversity after reclamation of the PRM is scored as moderate because the net change to both high and moderate biodiversity potential areas will be greater than 20% (i.e., high magnitude; Table 4.5-1), and the net change in low biodiversity potential areas is less than 10% (i.e., low magnitude; Table 4.5-1). The residual effect is also considered to be local in geographic extent, long-term in duration, irreversible, and low in frequency as previously described for residual effects before reclamation.

At the landscape level, changes in heterogeneity and fragmentation metrics are highly variable and range from negligible to high in magnitude. The overall magnitude of the residual effect of PRM to landscape-level biodiversity at Closure is scored as high because most of the changes are greater than 20%. The residual effect is considered to be regional in geographic extent and long-term in duration. The residual effect is also considered to be reversible because the reclamation of pre-existing disturbances in the LSA will reconnect fragmented natural areas. The frequency is considered to be low after reclamation.

Overall, negative moderate environmental consequences are predicted in the LSA for species, ecosystem or landscape levels of biodiversity. Negligible environmental consequences are predicted in the RSA for species, ecosystem or landscape levels of biodiversity. Some predicted residual effects in the LSA extend into the RSA and beyond, but the small size of the LSA relative to the RSA (approximately 1%) make these effects less substantial at the larger regional scale. Some of the species-level residual effects will be positive.

4.5.2 Summary of Results

The 2013 PRM Application Case Biodiversity assessment includes existing and approved developments as of June 2012, simulated forest fire and forest harvest information, and focuses on the PRM without the effects of the JME. During construction and operation of the PRM, overall negative residual effects with high environmental consequence are predicted at all levels of biodiversity in the LSA (Table 4.5-11). Negligible environmental consequences are predicted in the RSA. Although some predicted residual effects in the LSA extend into the RSA and beyond (e.g., barriers to movement for wide-ranging species), the small size of the LSA relative to the RSA (approximately 1%) makes these effects less substantial at the RSA scale. At Closure, overall residual effects with moderate environmental consequences are predicted at all levels of biodiversity in the LSA (Table 4.5-11). Negligible environmental consequences are also expected in the RSA at Closure. Some of the species-level residual effects will be positive. In the EIA, the combined effects on all levels of biodiversity resulted in a prediction of a negative high environmental consequence in the combined PRM and JME LSAs and a negligible environmental consequence in the RSA at Closure.

5.0 ASSESSMENT SUMMARY

Appendix 1 presents the response to JRP SIR 5, which requested assessment results for PRM alone, in isolation from JME, for specific sections of the EIA. The revised assessment, referred to as the 2013 PRM Application Case, concluded that the findings for all components were the same as in the EIA, with the exception of specific KIRs within the Terrestrial Vegetation, Wetlands and Forest Resources Assessment, the Wildlife and Wildlife Habitat Assessment, and the Biodiversity Assessment.

The following sections provide conclusions by component for the 2013 PRM Application Case.

Air Quality

Of the 130 ambient air quality parameters assessed in the 2013 PRM Application Case, 120 are classified as negligible environmental consequence and eight were classified as having a low environmental consequence. The regional annual NO_2 prediction was rated as moderate environmental consequence and the community 24 hour Particular Matter up to 2.5 micrometers in size ($PM_{2.5}$) prediction was rated as high environmental consequence at Cabin J. The PRM air emissions have little to no incremental effect on air quality at the regional community receptors, and there are no predicted occurrences above the Alberta Ambient Air Quality Objectives (AAAQOs) or other applicable criteria for sulfur dioxide (SO_2), carbon monoxide (CO), hydrogen sulfide (H_2S), carbon disulfide (CS_2), select volatile organic compounds (VOCs), select polycyclic aromatic hydrocarbons (PAHs) and metals. There are AAAQO exceedances of nitrogen dioxide (NO_2) at the RSA scale, and $PM_{2.5}$, at five receptor locations; however, these exceedances are mainly due to existing and approved projects in the region and there are minimal increases in predicted concentrations due to the PRM.

Environmental Health

Overall, air emissions from PRM alone, and in combination with air emissions from other sources, are not expected to result in adverse human health effects in the area. The changes between the 2013 Base Case and the 2013 PRM Application Case for human health risks are generally small, suggesting that PRM is not expected to contribute appreciably to health risks in the region. Based on this, the exclusion of the JME does not alter the assessment results or the conclusions originally presented in the Human Health Risk Assessment (HHRA) of the EIA.

The results of the Screening Level Wildlife Health Risk Assessment (SLWHRA) indicate that the overall risks posed to wildlife health will be low. Therefore, no impacts to wildlife populations are expected based on estimated wildlife exposures to predicted maximum acute and chronic air concentrations or predicted soil and surface water concentrations. These conclusions are consistent with those presented in the WHRA of the EIA.

The air emissions effects assessment for the 2013 PRM Application Case considered the results of PAI on aquatic and soil receptors, ground-level concentrations of SO_2 and NO_2 on vegetation, and terrestrial eutrophication from increased nitrogen deposition. The environmental consequences for all parameters were predicted to be negligible, the same as in the EIA.

Hydrology

The 2013 PRM Application Case Hydrology assessment for the Athabasca River includes an updated list of existing and approved developments and focuses on PRM, without the effects of JME. The assessment shows that flows and water levels in the 2013 PRM Application Case are similar to those described in the EIA.

Water Quality

Within the LSA, acute and chronic toxicity and tainting potential levels are predicted to be lower than guideline values, and labile naphthenic acids are predicted to be less than 1 mg/L under the 2013 PRM Application Case at all assessment nodes. In general, concentrations of most substances are changed relative to the EIA because the model was recalibrated using the most up-to-date observed data, but those changes did not alter the conclusions of the EIA.

The assessment of water quality for the 2013 PRM Application Case for the Athabasca River was based on the re-calibrated ARM and included updated input sources. The conclusion of negligible changes to water quality concentrations in the Athabasca River in the 2013 PRM Application Case is consistent with the EIA conclusions.

Changes to water quality are further assessed for potential effects to aquatic health in Section 3.4 of Appendix 1, and to human and wildlife health in Sections 2.3 and 2.4 of Appendix 1, respectively.

Aquatic Health

Activities associated with the 2013 PRM Application Case are predicted to influence water quality in receiving watercourses and waterbodies and in pit lakes. Potential effects on aquatic health were evaluated in consideration of two potential effects pathways:

- direct effects occurring as a result of predicted changes to water quality; and
- indirect effects related to dietary consumption and possible accumulation of substances in fish tissue.

Concentrations of individual substances received negligible to low ratings for environmental consequence. When all lines of evidence are considered together, including predicted acute and chronic toxicity levels, as well as predicted changes to sediment quality, water quality and fish tissue metal concentrations, PRM pit lakes are expected to be able to support viable aquatic ecosystems, and discharged waters are not anticipated to impair aquatic health in receiving streams.

Fish and Fish Habitat

Based on the mitigations in place in the form of the Water Management Framework to manage cumulative water withdrawals from the Athabasca River and the updated assessment on water quality for the 2013 PRM Application Case, the effects to Fish and Fish Habitat due to PRM are negligible and remain unchanged from the conclusions presented in the EIA. All other fish and fish habitat effects for PRM are unchanged from the EIA Application Case and are offset through the planned development of compensation habitat in South Redclay Lake as described in the Draft No Net Loss Plan (Golder 2012).

Soils and Terrain

Before reclamation, soil loss or alteration is classified as having a high environmental consequence in the LSA and a negligible environmental consequence in the RSA. After reclamation, it is predicted that there will be a permanent decrease of soils mostly due to the construction of South Redclay Lake which results in a moderate environmental consequence in the LSA and a negligible consequence in the RSA. The residual forestry capability impact is rated as a positive direction, low environmental consequence in the LSA, and a negligible environmental consequence in the RSA. These environmental consequences are unchanged from the EIA.

Terrestrial Vegetation, Wetlands and Forest Resources

Ten KIRS and vegetation resources were assessed in the 2013 PRM Application Case. Nine KIRs and vegetation resources are predicted to have negative effects during construction and operations, while neutral effects are predicted for the remaining KIR, rare and special plant communities in the LSA. In the LSA, high negative environmental consequences are associated with riparian communities, old growth forests, loss/alteration to wetlands (including peatlands and patterned fens), and high rare plant potential.

At Closure, six KIRs and vegetation resources will experience a net positive change (terrestrial vegetation, productive forests, high traditional use plants and effects of dust), negative and negligible change (lichen jack pine communities), or neutral and negligible change (rare and special plant communities) as a result of direct effects due to PRM in the LSA. Direct effects due to PRM will result in negative effects for the remaining four KIRs and vegetation resources with environmental consequences that are low or high. Additional indirect effects of PRM due to groundwater drawdown at Closure will not cause changes to the predicted environmental consequences for KIRs within the LSA and RSA.

A brief summary of the conclusions for each KIR and vegetation resource and a comparison with EIA conclusions follows.

The environmental consequence for uplands is moderate in the LSA and negligible in the RSA during construction and operations. At Closure, PRM is expected to have a high, positive environmental consequence at the LSA scale and a negligible, positive environmental consequence at the RSA scale. Assessing PRM effects alone results in a high positive (% of resource) environmental consequence for terrestrial upland communities instead of a low positive (% LSA) environmental consequence as reported in the EIA.

The PRM is predicted to have a negative and moderate environmental consequence on lichen jack pine communities in the LSA during construction and operations. The environmental consequence is negligible in the RSA during construction and operations. At Closure, the PRM is expected to have a negative, negligible environmental consequence at the LSA scale (based on % of resource) instead of a positive and negligible environmental consequence as reported in the EIA (based on % LSA). At the RSA scale at Closure, assessing the effects of PRM alone results in a negative and negligible environmental consequence for lichen jack pine communities, the same as in the EIA.

The environmental consequence for riparian communities during PRM construction and operations is predicted to be negative and high within the LSA. The PRM is predicted to have a negative low environmental consequence for riparian communities in the LSA at Closure, which differs from the positive negligible environmental consequence predicted for riparian communities in the EIA due to changes in the Closure and Reclamation Plan. Riparian communities are not mapped at the RSA scale for the predicted reclamation landscape, as explained in Section 4.3 of Appendix 1; therefore, Closure riparian communities are not identified at the RSA scale.

During construction and operations and at Closure, PRM is expected to have a negative, high environmental consequence for old growth forests in the LSA. This prediction differs from the negative and low environmental consequence predicted for old growth forests in the LSA in the EIA, which included JME and was based on % of LSA rather than % of resource. Within the RSA, the environmental consequence is negative and negligible, both during construction and operations and at Closure. This assessment will not change the environmental consequences for old growth in the RSA as compared to the EIA.

During construction and operations, PRM is expected to have a negative, high environmental consequence in the LSA for wetlands (including peatlands and patterned fens). At Closure, direct effects of the PRM on wetlands (including peatlands and patterned fens) are expected to have a negative and high environmental consequence at the LSA scale. As discussed in the response to JRP SIR 46, peatlands and patterned fens are not differentiated at the RSA level. Both during construction and operations and at Closure, a negligible environmental consequence at the RSA scale is predicted for PRM, and will not change the environmental consequence assessed for wetlands (including peatlands and patterned fens) in the EIA.

Environmental consequences on economic forests are negative and moderate in the LSA, and negative and negligible in the RSA during construction and operations and at Closure. This assessment will not change the environmental consequence for productive forests in the LSA compared to the EIA. Within the RSA, overall changes in economic forest result in the same positive and negligible environmental consequence as in the EIA.

Due to direct and indirect effects combined, during construction and operations PRM will have a negative, high environmental consequence on high rare plant potential within the LSA, and a negative, negligible environmental consequence for this KIR in the RSA. At Closure, the effects of PRM on high rare plant potential are predicted to result in a negative and high environmental consequence at the LSA scale and a negative, negligible environmental consequence at the RSA scale. These environmental consequences are unchanged from the EIA.

During construction and operations, the PRM will result in a negative and moderate environmental consequence to high traditional use plant potential areas in the LSA and a negative and negligible environmental consequence in the RSA. At Closure, the PRM is predicted to have a positive and low environmental consequence for high traditional use plant potential at the LSA scale. A positive and negligible environmental consequence was assigned for high traditional use plant potential at the RSA scale at Closure, which does not change the environmental consequence as assessed in the EIA.

The effects of dust on vegetation are expected to be negative and low within the LSA. At Closure, there will be no effects of dust due to the PRM, as mining operations will be complete and, overall, dust effects to vegetation will be positive (i.e., there are fewer dust sources), and low at Closure

Wildlife and Wildlife Habitat

The environmental consequences of PRM on wildlife abundance at the LSA and RSA scales are similar to those previously assessed in the EIA and for SAR in the May 2011, Submission of Information to the Joint Review Panel, Appendix 2. After reclamation, the environmental consequences of the PRM on wildlife abundance will be negligible in magnitude and environmental consequence at the RSA and LSA scales for all affected species.

Although it is probable that the abundances of horned grebe, olive-sided flycatcher, rusty blackbird, short-eared owl, wolverine and yellow rail are not limited by habitat within the RSA, enough uncertainty exists that the potential effects of habitat loss on abundance were considered. To be conservative, the magnitude of effects to regional populations of these species were estimated as equivalent to the magnitude of the habitat loss effects within the RSA for the 2013 PRM Application Case prior to reclamation. As a result, the RSA scale environmental consequence of the 2013 PRM Application Case before Closure on the abundance of horned grebe, rusty blackbird and yellow rail increase from negligible in the May 2011, Submission of Information to the Joint Review Panel to low in this submission.

The environmental consequences of habitat loss during operations are high for all affected species during operations and before Closure at the LSA scale, as stated in the EIA and the May 2011, Submission of Information to the Joint Review Panel, Appendix 2, Species at Risk Assessment. The removal of the effects of JME and other updates, as discussed above, results in changes to the environmental consequences for the indirect effects of habitat before Closure for some species at risk. Specifically, the predicted decline of high suitability habitat due to the indirect effects of sensory disturbance and surficial aquifer drawdown during operations changes:

- from a low environmental consequence in the Species at Risk Assessment to high for common nighthawk, horned grebe, short-eared owl, wood bison and yellow rail in the 2013 PRM Application Case; and
- from a moderate environmental consequence in the Species at Risk Assessment to high for olive-sided flycatcher in the 2013 PRM Application Case.

The net environmental consequence of PRM during operations was previously assessed for wolverine and wood bison habitat as low at the RSA scale (May 2011, Submission of Information to the Joint Review Panel). However, the removal of the effects of JME reduced the environmental consequence of potential habitat loss to negligible for both KIRs.

The effects of PRM on potential wood bison and woodland caribou habitat are assessed as having a negative high environmental consequence prior to reclamation at the LSA scale, and a negligible environmental consequence at the RSA scale.

The removal of the effects of JME results in changes to the environmental consequences for the effects of the PRM on habitat at Closure for some KIRs. Specifically, the effects of the PRM at Closure were assessed as follows:

- from a positive and high environmental consequence in the EIA (Volume 5, Section 7.5.3) to a negative and high for black-throated green warbler after Closure for the 2013 PRM Application Case;
- from a negative and low environmental consequence in the Species at Risk Assessment (May 2011 Submission of Information to the Joint Review Panel, Appendix 2) to negative and high for common nighthawk after Closure for the 2013 PRM Application Case;
- from a negative and high environmental consequence in the Species at Risk Assessment (May 2011 Submission of Information to the Joint Review Panel) to positive and high for horned grebe after Closure for the 2013 PRM Application Case; and
- from a positive and high environmental consequence in the EIA (Volume 5, Section 7.5.3) to negative and low for moose and moderate for fisher after Closure for the 2013 PRM Application Case.

At the RSA scale, the environmental consequences of the effects of PRM on habitat at Closure are unchanged from the EIA and the May 2011, Submission of Information to the Joint Review Panel, Appendix 2, Species at Risk Assessment, and remain negligible to low for all assessed species. After reclamation, the environmental consequence of PRM on woodland caribou habitat is predicted to be positive and high.

During operations, the assessed environmental consequences for wildlife movement are negative and negligible at the LSA and RSA scales for Canadian toad, barred owl and black-throated green warbler. Environmental consequences of the PRM on movement for little brown myotis and northern myotis are also negative and negligible at the LSA and RSA scales. For all other wildlife KIRs and species at risk that may be affected, the assessed environmental consequences before reclamation are unchanged from those previously assessed, and range from negligible for all avian species and western toad to low for terrestrial mammals.

At Closure, the assessed environmental consequences of PRM on movement of Canadian toad, barred owl, black-throated green warbler and western toad are positive and negligible at the LSA and RSA scales. For all other wildlife KIRs and SAR that may be affected, the assessed environmental consequences at Closure range from positive and negligible for little brown myotis, northern myotis, and avian species to negative and low for terrestrial mammals. The negative and low environmental consequences at Closure for terrestrial mammals (i.e., moose, black bear, Canada lynx, fisher and wolverine) at the LSA scale are due to the creation of South Redclay Lake at the north end of the LSA and large pit lakes at the south end of the LSA. This results in a change to the environmental consequence of PRM on wolverine movement from positive and low (May 2011, Submission of Information to the Joint Review Panel), to negative and low at the LSA scale (Table 4.4 4). The negligible effects at the RSA scale in the EIA remain unchanged in this assessment.

Biodiversity

During construction and operations, the environmental consequences for all levels of biodiversity in the LSA are predicted to be high, the same as the EIA. After reclamation, the environmental consequences for all levels of biodiversity in the LSA are predicted to be moderate, whereas the EIA was rated high. Negligible environmental consequences to biodiversity are predicted in the RSA both during construction and operations and after reclamation, the same as the EIA.

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