Part D

Environmental Impact Assessment

SOUTHERN PACIFIC
RESOURCE CORP.

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D. ENVIRONMENTAL IMPACT ASSESSMENT

This section of the STP McKay Thermal Project – Phase 2 (Phase 2) application constitutes the Environmental Impact Assessment (EIA) for Phase 2. Environmental baseline reports and impact assessments for each environmental discipline are contained in Consultant Reports (CR #1 to CR #11). This section includes STP's evaluation and summary of pertinent information from each of the Consultant Reports along with commitments to monitoring and mitigation measures relating to the environmental resources associated with Phase 2. This section also includes an evaluation and summary of the Socio-Economic Impact Assessment presented in Consultants Report #8 (CR #8). The full methodology used for the EIA is provided in Part C.

STP is currently constructing a Steam Assisted Gravity Drainage (SAGD) project on their McKay oil sands leases located in Township 91, Ranges 14 & 15, West of the 4th Meridian. The Phase 1 Project is expected to commence circulation and subsequent steam injection in the 2nd quarter of 2012. Phase 1 consists of a central processing facility (CPF), three well pads, borrow pits, water source wells, a water treatment plant, access roads and construction and operations camps. It is located on the west side of the MacKay River and was designed to produce 1,908 m^3/d (12,000 bpd) of bitumen.

The Phase 2 Project, which will have a CPF on the east side of the MacKay River, will produce an additional 3,816 m^3/d (24,000 bpd) of bitumen for approximately 25 years. The total combined bitumen production of the McKay project (Phase 1 and Phase 2) will be 5,724 m^3/d (36,000 bpd). Over the life of Phase 2 a number of well pads, borrow pits and access roads will be required to maintain production. The disturbance footprint for Phase 2 will be approximately 488.1 ha. The Phase 2 development components have been broken into the Initial Development that is required to increase production by 24,000 bpd and the Future Development required to sustain production at 36,000 bpd. The Phase 2 footprint includes:

Initial Development Footprint (ha)

- Borrow Pit #1 - 19.2
- Borrow Pit #2 - 10.2
- Borrow Pit #3 - 6.5
- CPF (includes soil and subsoil storage area) and Cogen Facility - 44.9
- Operators Camp - 2.8
- Well Pad 201 - 7.1
- Well Pad 202 - 7.9
- Well Pad 203 - 6.7

- Well Pad 204 - 4.9
- Well Pad 205 - 7.1
- Well Pad 206 - 6.8
- Well Pad 207 - 7.1
- Well Pad 208 - 7.1
- Utility and Access Corridor - 24.7

Future Development (ha)

- Borrow Pits - 92.7
- Utility and Access Corridor - 75.5
- Well Pads (x24) - 156.9

Since the environmental assessments were conducted, STP has made application to the ERCB for approval to develop a fourth pad to supply bitumen to the Phase 1 facility. This pad was originally planned as part of the Phase 2 Future Development. Due to timing of the assessments this fourth pad is assessed as a future replacement pad for Phase 2 when it is actually now a proposed pad for Phase 1. For this reason some of the areas quoted for the Phase 2 footprint are 13.9 ha more than what is listed above. This change is minor and does not impact the overall findings of the environmental assessments.

The final Terms of Reference (ToR) were issued for Phase 2 on July 22, 2011 and contained a number of conditions related to the information requirements for this EIA. These conditions from the ToR have been addressed in this section of the report and in the specific Consultant's Reports.

The Phase 2 EIA considers the following assessment scenarios:

- Baseline Case, which includes existing environmental conditions and existing projects or "approved" activities;
- Application Case, which includes the Baseline Case plus Phase 2; and
- Planned Development Case (Cumulative Effects), which includes the "Application Case", combined with past studies, existing and anticipated future environmental conditions, existing projects or activities, plus other "planned" projects or activities.

For the purposes of defining assessment scenarios, "approved" means approved by any federal, provincial or municipal regulatory authority, and "planned" means any project or activity that has been publicly disclosed prior to the issuance of the ToR or up to six months prior to the submission of the EIA report, whichever is most recent.

The EIA report has addressed impact concerns by identifying Valued Environmental Components (VECs). VECs for Phase 2 are those environmental attributes associated with the proposed development, which have been identified to be of concern either by directly-affected stakeholders, government or the professional community. VECs consider both biophysical (*i.e.*, ecosystem) and socio-economic attributes because of the broad-based definition of environmental effect as outlined both in federal and provincial legislation.

The factors used to assess the predicted environmental effects of Phase 2 are specific to the VECs for each biophysical or socio-economic component. For example, the assessment of environmental effects and determination of significance for each VEC which is population based (*e.g.*, fish, wildlife, vegetation) may not be applicable for those VECs which are not population based (*e.g.*, air quality, groundwater). This section identifies potential adverse effects and the assessment of their significance. Where possible, the determination of significance makes reference to existing standards, guidelines or recognized thresholds (*e.g.*, Alberta Ambient Air Quality Objectives).

D.1 AIR QUALITY

D.1.1 Introduction and Terms of Reference

STP conducted an assessment of air quality for the proposed Project. The following section is a summary of the Air Quality Assessment that was prepared by Millennium EMS Solutions Ltd. and is included as Consultant Report #1 (CR #1). For full details of the assessment, please refer to CR #1.

Alberta Environment issued the final ToR for Phase 2 on July 22, 2011. The specific requirements for the air quality component are provided in Section 2.5 and Section 3.1, and are as follows:

2.5 Air Emissions Management

[A] Discuss the selection criteria used, options considered, and rationale for selecting control technologies to minimize air emission and for air quality management.

[B] Provide emission profiles (type, rate and source) for the Project's operating and construction emissions including point and non-point sources and fugitive emissions. Consider both normal and upset conditions. Discuss:

- *a) odorous and visible emissions from the proposed facilities;*
- *b) annual and total greenhouse gas emissions during all stages of the Project. Identify the primary sources and provide detailed calculations;*
- *c) the intensity of greenhouse gas emissions per unit of bitumen produced;*
- *d) the Project's contribution to total provincial and national greenhouse gas emissions on an annual basis;*

e) the Proponent's overall greenhouse gas management plans;

f) amount and nature of Criteria Air Contaminants emissions;

g) the amount and nature of acidifying emissions, probable deposition patterns and rates;

h) emergency flaring scenarios (e.g., frequency and duration) and proposed measures to ensure flaring events are minimized;

i) upset condition scenarios (e.g., frequency and duration) and proposed measures to ensure upset conditions are minimized;

j) gas collection and conservation, and the applicability of vapour recovery technology;

k) applicability of sulphur recovery, acid gas re-injection or flue gas desulphurization to reduce sulphur emissions; and

l) fugitive emissions control technology to detect, measure and control emissions and odours from equipment leaks.

3.1 AIR QUALITY, CLIMATE AND NOISE

3.1.1 Baseline Information

[A] Discuss the baseline climatic and air quality conditions including:

a) the type and frequency of meteorological conditions that may result in poor air quality; and

b) appropriate ambient air quality parameters.

3.1.2 Impact Assessment

[A] Identify components of the Project that will affect air quality, and:

a) describe the potential for reduced air quality (including odours and visibility) resulting from the Project and discuss any implications of the expected air quality for environmental protection and public health;

b) estimate ground-level concentrations of appropriate air quality parameters;

c) discuss any expected changes to particulate deposition, nitrogen deposition or acidic deposition patterns;

d) identify areas that are predicted to exceed Potential Acid Input (PAI) critical loading criteria; and

e) discuss interactive effects that may occur resulting from co-exposure of a receptor to all emissions.

[D] Discuss mitigation strategies to minimize the potential impact of the Project on air quality and noise.

The air quality Local Study Area (LSA) and regional study area (RSA) were chosen based on the location of major regional industrial emission sources and the expected spread of project concentration and deposition contours. For Phase 2, maximum concentrations are expected to occur within 5 km of the main emission sources and decrease with increasing distance beyond this point. The air quality LSA is a 50 km by 50 km square centred approximately on STP's proposed Project (Figure C.2.1). The air quality RSA is about 270 km by 305 km (Figure C.2.2).

A number of potential VECs were identified during the issue scoping process as they relate to potential human or ecosystem health effects. The air quality VECs include:

- sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter ($PM_{2.5}$), hydrogen sulphide (H_2S), , specific volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs);
- ozone (O_3);
- odour and visible plumes;
- potential acid Input (PAI) and eutrophication (nitrogen deposition); and
- greenhouse gas (GHG) Emissions.

Modelling was done using the CALMET/CALPUFF model, and was conducted according to Alberta Environment (2009). The dispersion model was applied to the three assessment scenarios (baseline, application, and planned). Predictions were made over a grid of receptors as well as at specific receptors as listed in Table D.1.1 and shown in CR #1, Figure 2.3-1. Maximum points of impingement concentration in the LSA and RSA were based on modelling within the grid of receptors.

Table D.1.1 Location of Special Receptors

Receptor	Description	UTM-E [m]	UTM-N [m]	Distance to STP Phase 2[(1)] [km]
R1	Kelley McNeilly Cabin	428,998	6,286,480	18.4
R2	Damon and Sharon Wright	454,523	6,293,667	28.1
R3	Pliska Cabin A	450,384	6,294,595	23.9
R4	Pliska Cabin B	444,471	6,293,169	19.6
R5	Pliska Cabin C	422,046	6,300,401	8.1
R6	Powder Cabin A	441,048	6,316,020	16.5
R7	MacDonald Cabin B	447,034	6,316,045	21.4
R8	Powder Cabin B	441,243	6,313,727	15.2
R9	Fort McMurray	477,640	6,285,886	52.4
R10	Fort McKay	461,286	6,338,626	46.8
R11	Anzac	497,654	6,256,042	84.4
	STP Phase 1 Operations Camp	424,510	6,304,917	4.3
	STP Phase 2 Operations Camp	429,650	6,304,750	0.8

(1) Distance to STP Phase 2 Steam Boiler 1.

D.1.2 Baseline Conditions

D.1.2.1 Background Concentrations

Background concentrations must be considered in the assessment (AENV 2009a). According to guidance (AENV, 2009a), appropriate contaminant concentrations due to natural sources, and unidentified, possibly distant sources are to be used as background, and added to predicted values from the facility and nearby sources. Background concentrations of SO_2, NO_x, and $PM_{2.5}$ were obtained from the Fort Chipewyan monitoring station for the period January 2006 – December 2010, while the CO background concentration was obtained from the Fort McMurray monitoring station for the period January 2006 – December 2010. Background concentrations that were added to predictions are listed in Table D.1.2.

Table D.1.2 Ambient Background Concentrations

Parameter	90th Percentile Hourly	90th Percentile Daily	90th Percentile Monthly	50th Percentile Hourly
SO_2 (µg/m^3)	2.6	4.3	1.9	0.8
NO_x (µg/m^3))	7.5	6.2	n/a	2.4
CO (µg/m^3)	344	372(1)	n/a	n/a
$PM_{2.5}$ (µg/m^3)	5.3	4.9	n/a	1.4

(1) 90th Percentile 8-hour concentration, based on aggregation of hourly data
n/a = averaging period not assessed for constituent

D.1.2.2 Baseline Concentrations

Sulphur Dioxide

The CALPUFF model was used to estimate the concentration of SO_2 that could occur (Table D.1.7). Results of the modeling indicated that there were no exceedances of the Alberta Ambient Air Quality Objectives (AAAQOs) predicted at any location for the Baseline Case.

Nitrogen Oxides

The CALPUFF model was used to estimate the concentration of NO_x that could occur (Table D.1.8). Results of the modeling indicated that there were no exceedances of the Alberta Ambient Air Quality Objectives (AAAQOs) predicted at any location for the Baseline Case.

Carbon Monoxide

The CALPUFF model was used to estimate the concentration of CO that could occur (Table D.1.9). Results of the modeling indicated that there were no exceedances of the Alberta Ambient Air Quality Objectives (AAAQOs) predicted at any location for the Baseline Case.

Particulate Matter

The CALPUFF model was used to estimate the concentration of $PM_{2.5}$ that could occur (Table D.1.10). Results of the modeling indicate that the Canada Wide Standard for predicted $PM_{2.5}$ would be exceeded at the overall regional Maximum Point of Impingement (RSA-MPOI) for the Baseline Case. The 1-hour and 24-hour predictions also exceed the AAAQOs at the RSA-MPOI.

Hydrogen Sulphide

The CALPUFF model was used to estimate the concentration of H_2S that could occur (Table D.1.11). For the Baseline Case exceedances of the H_2S 1-hour and 24-hour AAAQO were predicted at the RSA-MPOI, stemming from emissions from the mining areas north of Fort McMurray. Exceedances of the 1-hour AAAQO were also predicted at the LSA-MPOI.

Specific Volatile Organic Compounds and Polycyclic Aromatic Hydrocarbons

No exceedances of AAAQOs were predicted with the exception of benzo(a)pyrene for the RSA-MPOI, and at Fort McMurray and Fort McKay. Exceedances of the AAAQO at the regional MPOI were predicted for benzo(a)pyrene in the Baseline Case (CR #1, Table 3.9-3).

Ozone

There is a potential for the photochemical production of surface ozone (O_3) from emissions of anthropogenic NO_x, anthropogenic VOC, and biogenic VOC compounds. The potential is greatest during summer periods characterized by high ambient temperatures (*i.e.*, above 20^oC) and stagnant weather conditions (*i.e.*, low wind speeds). Ozone formation was observed in plumes downwind of the oil sands mining area during airborne O_3 and O_3-precursor flights in summer 2002 and 2003 in relatively cool temperatures (AMEC 2004). The monitoring results suggested emissions from the key point sources in the area contributed up to an additional 60 $\mu g/m^3$ of O_3 downwind. The potential for high O_3 productions exists for a relatively small number of hours each year.

Observations of O_3 in the oil sands region have been summarized by AENV (2009b) for three-year periods from 2001 to 2007, in accordance with CWS protocol. Measurements were typically in the 50 to 57 $\mu g/m^3$ range, with no evidence of regional trends.

Odour and Visible Plumes

The predicted maximum air concentrations for chemical compounds over the five year model period are compared with established odour thresholds. As odour can be perceived within a short timespan, the air concentration used in the comparison was based on a three-minute averaging period.

The predicted 3-minute maxima for NO_2, C9-C18 aliphatics, CS_2, and acetaldehyde, which are located in the mining area of the RSA, exceed the mean odour threshold in the Baseline scenario. Hydrogen sulphide odour threshold exceedances were also predicted for the MacDonald Cabin, located in the NE corner of the LSA, and at Fort McKay. However, the frequency of these exceedances was less than 0.5%. Exceedances of the odour threshold within the LSA were confined to the NE corner, where regional operations are the primary source of odorants.

No visible plumes are expected over the LSA under baseline conditions.

Potential Acid Input

CALPUFF was used to estimate the deposition of PAI that would occur for the assessment scenarios. Precursor emissions include NO_x and SO_2. The PAI modelling assumed a regionally varying background based on Cheng (2009).

The results of CALPUFF modelling in the RSA are shown in CR #1, Table 3.6-1. The maximum predicted PAI value is approximately 3.8 keq/ha/yr in the Baseline Case.

In the LSA, the maximum predicted PAI is 0.40 keq/ha/yr in the Baseline Case. The PAI predictions are largely driven by emissions from sources beyond the LSA, as evidenced by the regional maxima in the mining area north of Fort McMurray (CR #1, Figures 3.6-1 to 3.6-3). Small incremental areas (4 ha) with deposition above 0.25 keq/ha/yr were predicted around the STP central processing facility.

Nitrogen Deposition

Deposition of nitrogen can lead to eutrophication in water bodies or changes in growth rates of terrestrial vegetation and its calculation includes both wet (removal in precipitation) and dry (direct contact with surface features) processes. In the current approach, nitrate particulate was determined to be deposited by both wet and dry processes and was directly calculated by the dispersion model. Nitrogen dioxide was assumed to be deposited by dry processes only, based on annual average predicted concentrations and a locally determined deposition velocity.

Results of the modelling indicate that the regional maximum predicted nitrogen deposition is 59 kg/ha/yr (CR #1, Table 3.7-1). The most sensitive ecosystems in the region may be affected by as little as 8 kg/ha/yr of deposited nitrogen. The area above this threshold under baseline conditions is 3,478 km^2 in the RSA and 69 km^2 in the LSA.

In the LSA, where the impacts of mine fleet NO_x emission reductions are negligible, the increases in maximum deposition and area affected are due to regional growth of SAGD facilities. The regional MPOI is in the mining area north of Fort McMurray. The LSA concentrations are influenced by sources beyond the LSA, in particular, by the mining areas to the northeast of the LSA.

D.1.3 Predicted Conditions

D.1.3.1 Project Emissions

Natural gas will be the prime fuel source for Phase 2. Some produced gas from the reservoir will be recovered and burned with the natural gas. Emissions estimates for Phase 2 were based on a production capacity of 24,000 bpd. Continuous emission sources at the proposed facility include five steam boilers, three cogeneration units, a utility boiler, and a glycol heater. Flare stacks are used for emergency only.

Emission estimates related to the recovery and processing of bitumen for the proposed Project are listed in Table D.1.3.

Emission estimates related to the construction, operation and reclamation of the proposed Project are included as Table D.1.4.

Table D.1.3 Summary of STP McKay Thermal Phase 2 Air Emissions

Point Sources															
Emission Source	**Energy Input (MW)**	**Assumed Efficiency**	**Fuel Gas Consumption Rate (sm^3/d)**	**UTM E (m)**	**UTM N (m)**	**Elevation (m ASL)**	**Stack Height (m)**	**Stack Diameter (m)**	**Exit Velocity (m/s)**	**Exit Temp (K)**	**SO_2 (t/d)**	**NO_X (t/d)**	**CO (t/d)**	**VOC (t/d)**	**$PM_{2.5}$ (t/d)**
Steam Boiler 1	100.8	80	1,073,694	428,819	6,304,902	477	34	2.03	15.24	423	0.229	0.349	1.09	5.41E-02	0.029
Steam Boiler 2	100.8	80	1,073,694	428,843	6,304,909	477	34	2.03	15.24	423	0.229	0.349	1.09	5.41E-02	0.029
Steam Boiler 3	100.8	80	1,073,694	428,870	6,304,917	477	34	2.03	15.24	423	0.229	0.349	1.09	5.41E-02	0.029
Steam Boiler 4	100.8	80	1,073,694	428,897	6,304,925	477	34	2.03	15.24	423	0.229	0.349	1.09	5.41E-02	0.029
Steam Boiler 5	100.8	80	1,073,694	428,920	6,304,932	477	34	2.03	15.24	423	0.229	0.349	1.09	5.41E-02	0.029
Cogen Unit 1	15.0	45	212,942	428,952	6,304,922	477	20	1.83	24.4	473	0.000	0.356	0.438	3.95E-03	0.005
Cogen Unit 2	15.0	45	212,942	428,961	6,304,924	477	20	1.83	24.4	473	0.000	0.356	0.438	3.95E-03	0.005
Cogen Unit 3	15.0	45	212,942	428,973	6,304,928	477	20	1.83	24.4	473	0.000	0.356	0.438	3.95E-03	0.005
Utility Boiler	5.89	80	23,628	429,026	6,304,614	477	10.1	0.76	4.04	495	0.000	0.014	0.064	3.16E-03	0.001
Glycol Heater	5.21	80	23,628	429,022	6,304,615	477	8.51	0.91	2.21	438	0.000	0.012	0.056	2.79E-03	0.001
Area Sources															
Emission Source	**NW UTM E**	**NW UTM N**	**NE UTM E**	**NE UTM N**	**SE UTM E**	**SE UTM N**	**SW UTM E**	**SW UTM N**	**Area (m^2)**	**Elevation (m ASL)**	**SO_2 (t/d)**	**NO_X (t/d)**	**CO (t/d)**	**VOC (t/d)**	**$PM_{2.5}$ (t/d)**
Process Leak Area	428.987	6304.725	429.012	6304.639	428.904	6304.608	428.880	6304.694	9968	471	0.00	0.00	0.00	0.05	0.00
Storage Leak Area	429.012	6304.747	429.157	6304.682	429.041	6304.649	429.012	6304.747	12340	471	0.00	0.00	0.00	0.02	0.00
Totals from Phase 2											1.15	2.84	6.88	0.36	0.16

Table D.1.4 Project Lifetime Construction and Operations Emissions

Contaminant	Construction Emission [t]	Operations Emissions[(1)] [t]	Reclamation Emissions [t]	Ratio of Construction to Operations [%]
SO_2	2.5	10494	2.5	**0.1**
NO_x	208	25915	208	**0.8**
CO	180	62780	180	**0.3**
VOC[(1, 2)]	10	3285	10	**0.3**
$PM_{2.5}$	28	1460	28	**1.9**

(1) Operation duration was assumed to be 25 years for calculation purposes.
(2) The definition of VOC is different between Phase 2 and MRCP. MCRP includes C2 hydrocarbons and higher, whereas the operations total from Phase 2 includes C5 and up. Therefore, the expected VOC emission ratio of Project construction to operations will be much lower than 0.3%.

D.1.3.2 Regional Emissions

Emissions within the RSA from proposed facilities including those under regulatory review were collected from various public domain documents or obtained from the operators. The data collected from these documents were based on continuous emissions that would be representative of typical operating conditions at the various facilities at full production capacity (Table D.1.5). Within the Planned Development Case (PDC) scenario, uncertainties exist about whether all facilities will proceed and whether or not all facilities would operate at full capacity concurrently. Therefore, it is likely that emission estimates in this scenario have been overestimated. The Phase 2 Project inclusion list is presented on Figure C.2.3 and in Table C.2.2.

Table D.1.5 Summary of Regional Study Area Emission Rates

Emission Scenarios	SO_2 (t/d)	NO_X (t/d)	CO (t/d)	VOC (t/d)	$PM_{2.5}$ (t/d)
Baseline Case	232	426	462	492	28
Application Case	233	428	469	492	28
PDC	269	569	692	665	35

Table D.1.6 summarizes the estimated Project emissions and compares emission totals for the three assessment scenarios.

Table D.1.6 Comparison of Baseline, Application and Planned Development Scenario Emissions

Scenario	SO_2	NO_X	CO	VOC	$PM_{2.5}$
Project Contribution only (t/d)	1.2	2.8	6.9	0.36	0.16
Baseline (t/d)	232	426	461	492	28
Application (t/d)	233	429	468	492	28
Application increase relative to Baseline (%)	*0.50*	*0.70*	*1.5*	*0.07*	*0.57*
PDC (t/d)	269	569	692	665	35
PDC increase relative to Baseline (%)	*16*	*34*	*50*	*35*	*25*

D.1.3.3 Predicted Concentrations

Sulphur Dioxide

Modelling (CALPUFF) results indicate that there are no exceedances for the AAAQOs predicted at any location in the Application Case (Table D.1.7).

The change in the RSA-MPOI values between the Baseline and Application cases was negligible. Modelling predicted a slight increase or no change in the ground-level SO_2 concentrations at special receptors locations from the Baseline Case to the Application Case. The patterns of SO_2 concentration for the 1-hour, 24-hour, monthly, and annual averages are shown on CR #1, Figures 3.2-1 to 3.2-12, respectively.

Modelling (CALPUFF) results indicate that there are no exceedances for the AAAQOs predicted at any location in the PDC (Table D.1.7), with only small increases in the RSA-MPOI. The major source of SO_2 in the LSA is from the regional mining projects located east of the LSA.

Table D.1.7 Predicted Sulphur Dioxide Concentrations

Receptor Location	Baseline Case [μg/m³]	Application Case [μg/m³]	PDC [μg/m³]	Project Only [μg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
9th Highest 1-Hour (99.9th Percentile)						
Overall Maximum (RSA-MPOI)	387	387	389	57	0.0	0.6
Local Area Maximum (LSA-MPOI)	295	295	296	57	0.0	0.5
R1 – Kelley McNeilly Cabin	81	81	85	8	0.1	4.5
R2 – Damon and Sharon Wright	195	195	196	6	0.0	0.6
R3 – Pliska Cabin A	179	179	180	9	0.0	0.5
R4 – Pliska Cabin B	134	134	134	12	0.0	0.3

Table D.1.7 Predicted Sulphur Dioxide Concentrations

Receptor Location	Baseline Case [μg/m^3]	Application Case [μg/m^3]	PDC [μg/m^3]	Project Only [μg/m^3]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
R5 – Pliska Cabin C	60	61	64	15	2.0	5.5
R6 – Powder Cabin A	106	106	107	8	0.0	0.7
R7 – MacDonald Cabin B	84	84	85	6	0.0	0.8
R8 – Powder Cabin B	83	83	85	7	0.0	2.2
R9 – Fort McMurray	66	66	84	3	0.0	27
R10 – Fort McKay	88	88	93	4	0.0	5.7
R11 – Anzac	59	59	68	3	0.0	15
STP Phase 1 Operations Camp	69	69	70	15	0.0	1.1
STP Phase 2 Operations Camp	81	81	82	34	0.0	0.7
AENV AAAQO(1)	**450**	**450**	**450**	**450**		
99th Percentile Hourly						
Overall Maximum (RSA-MPOI)	167	167	167	23	0.0	0.0
Local Area Maximum (LSA-MPOI)	85	85	88	23	0.0	0.0
Proposed LARP Level 4 Trigger(2)	94	94	94	94		
Proposed LARP Level 3 Trigger(2)	63	63	63	63		
Proposed LARP Level 2 Trigger(2)	31	31	31	31		
2nd Highest 24-Hour						
Overall Maximum (RSA-MPOI)	117	117	119	15	0.0	1.3
Local Area Maximum (LSA-MPOI)	60	60	62	15	0.0	3.3
R1 – Kelley McNeilly Cabin	32	32	34	3	0.0	7.2
R2 – Damon and Sharon Wright	54	54	56	4	0.1	3.9
R3 – Pliska Cabin A	45	45	49	4	0.0	11
R4 – Pliska Cabin B	38	38	40	4	0.0	5.3
R5 – Pliska Cabin C	26	28	29	5	8.8	11
R6 – Powder Cabin A	31	31	34	4	0.2	9.5
R7 – MacDonald Cabin B	29	29	30	4	0.5	5.3
R8 – Powder Cabin B	27	27	28	4	0.6	5.4
R9 – Fort McMurray	28	28	31	3	0.1	10
R10 – Fort McKay	29	29	32	3	0.0	12
R11 – Anzac	26	26	29	3	0.0	13
STP Phase 1 Operations Camp	26	26	27	7	0.1	6.8

Table D.1.7 Predicted Sulphur Dioxide Concentrations

Receptor Location	Baseline Case [μg/m³]	Application Case [μg/m³]	PDC [μg/m³]	Project Only [μg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
STP Phase 2 Operations Camp	28	28	29	12	0.1	6.2
AENV AAAQO(1)	**125**	**125**	**125**	**125**		
Monthly Average						
Overall Maximum (RSA-MPOI)	24	24	24	2.0	0.1	3.7
Local Area Maximum (LSA-MPOI)	12	12	14	3.9	0.6	13
R1 – Kelley McNeilly Cabin	5.8	5.9	7.1	0.1	1.5	22
R2 – Damon and Sharon Wright	11	11	12	0.2	0.6	15
R3 – Pliska Cabin A	10	10	12	0.2	0.8	15
R4 – Pliska Cabin B	9.3	9.4	11	0.3	1.6	16
R5 – Pliska Cabin C	5.6	5.8	6.8	0.3	3.4	21
R6 – Powder Cabin A	7.6	7.6	8.4	0.2	1.0	11
R7 – MacDonald Cabin B	6.7	6.8	7.6	0.1	0.6	12
R8 – Powder Cabin B	6.4	6.5	7.2	0.2	0.6	12
R9 – Fort McMurray	9.4	9.5	12	0.0	0.1	23
R10 – Fort McKay	8.4	8.4	9.4	0.1	0.2	12
R11 – Anzac	7.6	7.6	9.3	0.0	0.2	23
STP Phase 1 Operations Camp	5.4	5.6	6.5	0.3	2.8	21
STP Phase 2 Operations Camp	6.5	7.0	8.1	1.1	7.8	24
AENV AAAQO(1)	**30**	**30**	**30**	**30**		
Annual Average						
Overall Maximum (RSA-MPOI)	13	13	14	0.9	0.3	10
Local Area Maximum (LSA-MPOI)	6.2	6.3	7.4	1.7	1.0	20
R1 – Kelley McNeilly Cabin	3.2	3.3	4.0	0.1	0.9	23
R2 – Damon and Sharon Wright	6.0	6.0	7.2	0.1	0.9	20
R3 – Pliska Cabin A	5.6	5.7	6.8	0.1	1.1	22
R4 – Pliska Cabin B	4.7	4.8	5.7	0.1	1.4	23
R5 – Pliska Cabin C	3.3	3.5	4.1	0.2	4.5	24
R6 – Powder Cabin A	4.5	4.6	5.3	0.1	1.9	19
R7 – MacDonald Cabin B	3.9	4.0	4.7	0.1	1.5	20
R8 – Powder Cabin B	4.0	4.1	4.8	0.1	2.1	20
R9 – Fort McMurray	5.1	5.1	6.6	0.0	0.4	28

Table D.1.7 Predicted Sulphur Dioxide Concentrations

Receptor Location	Baseline Case [μg/m³]	Application Case [μg/m³]	PDC [μg/m³]	Project Only [μg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
R10 – Fort McKay	5.0	5.0	5.9	0.0	0.5	18
R11 – Anzac	3.8	3.8	4.8	0.0	0.3	28
STP Phase 1 Operations Camp	3.2	3.3	4.0	0.1	3.6	24
STP Phase 2 Operations Camp	4.2	4.5	5.3	0.5	9.1	27
AENV AAAQO(1)	**20**	**20**	**20**	**20**		
Proposed LARP Level 4 Trigger(2)	20	20	20	20		
Proposed LARP Level 3 Trigger(2)	13	13	13	13		
Proposed LARP Level 2 Trigger(2)	8	8	8	8		

(1) Source: AENV (2011b).
(2) Source: AENV (2011c).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Nitrogen Oxides

Modelling (CALPUFF) results indicate that there are no exceedances for the AAAQOs predicted at any location in the Application Case (Table D.1.8).

The change in the RSA-MPOI values between the Baseline and Application cases was negligible. Modelling predicted a slight increase or no change in the ground-level NO_x concentrations at special receptor locations from the Baseline Case to the Application Case. The patterns of NO_x concentration for the 1-hour and annual averages are shown on CR #1, Figures 3.3-1 to 3.3-6, respectively. The highest predicted NO_x concentrations occurred near the northeastern border of the LSA, indicating that the major source of NO_x in the LSA is from the regional mining projects located east of the LSA.

Modelling (CALPUFF) results indicate that there are no exceedances for the AAAQOs predicted at any location in the PDC (Table D.1.8). Decreases in concentrations were predicted in some locations as a result of the assumption that future mine fleets will be in compliance with U.S. EPA Tier 4 emission standards. As a result, PDC NO_2 predictions were also lower in Fort McKay. In the LSA, concentrations increased as a result of increased SAGD development in the area. The major source of NO_x in the LSA is from the regional mining projects located east of the LSA.

Table D.1.8 Predicted Nitrogen Dioxide Concentrations

Receptor Location	Baseline Case [µg/m³]	Application Case [µg/m³]	PDC [µg/m³]	Project Only [µg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
Total Conversion Method						
9th Highest 1-Hour (99.9th Percentile)						
Overall Maximum (RSA-MPOI)	4968	4968	4096	170	0.0	-17.5
Local Area Maximum (LSA-MPOI)	1569	1569	978	170	0.0	-37.6
R1 – Kelley McNeilly Cabin	221	221	247	26	0.0	11.6
R2 – Damon and Sharon Wright	441	441	457	21	0.0	3.5
R3 – Pliska Cabin A	387	387	426	30	0.0	10.0
R4 – Pliska Cabin B	323	323	353	34	0.0	9.4
R5 – Pliska Cabin C	221	222	266	50	0.2	20.1
R6 – Powder Cabin A	443	443	451	25	0.0	1.8
R7 – MacDonald Cabin B	552	552	552	18	0.0	0.0
R8 – Powder Cabin B	425	425	436	23	0.0	2.4
R9 – Fort McMurray	298	298	357	10	0.0	19.4
R10 – Fort McKay	1254	1254	1129	11	0.0	-10.0
R11 – Anzac	130	131	164	10	0.1	25.6
STP Phase 1 Operations Camp	238	238	269	47	0.0	13.2
STP Phase 2 Operations Camp	290	290	295	81	0.0	1.8
AENV AAAQO(1)	**300**	**300**	**300**	**300**		
Annual Average						
Overall Maximum (RSA-MPOI)	417	418	420	8	0.0	0.5
Local Area Maximum (LSA-MPOI)	74	74	65	8	0.2	-11.8
R1 – Kelley McNeilly Cabin	17	21	24	8	23.6	40.6
R2 – Damon and Sharon Wright	13	13	16	3	0.8	22.1
R3 – Pliska Cabin A	24	24	30	3	0.8	27.3
R4 – Pliska Cabin B	23	23	28	3	1.0	23.5
R5 – Pliska Cabin C	20	20	24	3	1.2	21.5
R6 – Powder Cabin A	14	14	17	3	3.9	22.6
R7 – MacDonald Cabin B	27	27	30	3	1.2	13.4
R8 – Powder Cabin B	32	32	35	3	0.7	9.9
R9 – Fort McMurray	25	25	28	3	1.3	13.3
R10 – Fort McKay	45	45	56	2	0.1	22.8

Table D.1.8 Predicted Nitrogen Dioxide Concentrations

Receptor Location	Baseline Case [μg/m³]	Application Case [μg/m³]	PDC [μg/m³]	Project Only [μg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
R11 – Anzac	11	11	15	2	0.3	35.1
STP Phase 1 Operations Camp	16	17	19	3	2.5	19.1
STP Phase 2 Operations Camp	17	19	22	6	10.9	27.9
AENV AAAQO(1)	**45**	**45**	**45**	**45**		
Ambient Ratio Method						
9th Highest 1-Hour (99.9th Percentile)						
Overall Maximum (RSA-MPOI)	281	281	257	72	0.0	-8.4
Local Area Maximum (LSA-MPOI)	166	166	134	72	0.0	-19
R1 – Kelley McNeilly Cabin	74	74	75	18	0.0	1.3
R2 – Damon and Sharon Wright	93	93	95	13	0.0	1.6
R3 – Pliska Cabin A	88	88	92	23	0.0	4.5
R4 – Pliska Cabin B	81	81	84	27	0.0	4.2
R5 – Pliska Cabin C	74	74	76	43	0.0	2.1
R6 – Powder Cabin A	94	94	94	18	0.0	0.8
R7 – MacDonald Cabin B	103	103	103	10	0.0	0.0
R8 – Powder Cabin B	92	92	93	16	0.0	1.1
R9 – Fort McMurray	78	78	85	2.8	0.0	8.6
R10 – Fort McKay	150	150	143	3.6	0.0	-4.7
R11 – Anzac	70	70	72	2	0.0	2.7
STP Phase 1 Operations Camp	75	75	76	40	0.0	1.4
STP Phase 2 Operations Camp	77	77	78	66	0.0	0.8
AENV AAAQO(1)	**300**	**300**	**300**	**300**		
99th Percentile Hourly						
Overall Maximum (RSA-MPOI)	190	190	200	68	190	190
Local Area Maximum (LSA-MPOI)	130	130	105	68	130	130
Proposed LARP Level 4 Trigger(2)	176	176	176	176		
Proposed LARP Level 3 Trigger(2)	118	118	118	118		
Proposed LARP Level 2 Trigger(2)	57	57	57	57		
Annual Average						
Overall Maximum (RSA-MPOI)	63	63	63	5.6	0.0	0.2
Local Area Maximum (LSA-MPOI)	28	28	26	5.6	0.1	-5.8

Table D.1.8 Predicted Nitrogen Dioxide Concentrations

Receptor Location	Baseline Case [µg/m³]	Application Case [µg/m³]	PDC [µg/m³]	Project Only [µg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
R1 – Kelley McNeilly Cabin	11	11	13	0.2	1.0	22
R2 – Damon and Sharon Wright	16	16	18	0.3	0.4	13
R3 – Pliska Cabin A	16	16	17	0.4	0.5	11
R4 – Pliska Cabin B	15	15	16	0.4	0.6	11
R5 – Pliska Cabin C	11	12	13	0.6	4.7	18
R6 – Powder Cabin A	17	17	18	0.4	0.6	6.5
R7 – MacDonald Cabin B	19	19	19	0.3	0.3	4.8
R8 – Powder Cabin B	16	17	18	0.4	0.7	6.5
R9 – Fort McMurray	22	22	24	0.1	0.1	10
R10 – Fort McKay	31	31	30	0.1	0.0	-2.5
R11 – Anzac	9	9	13	0.0	0.4	45
STP Phase 1 Operations Camp	13	13	14	0.5	1.3	9.7
STP Phase 2 Operations Camp	13	14	15	3.1	5.7	14
AENV AAAQO(1)	45	45	45	45		
Proposed LARP Level 4 Trigger(2)	45	45	45	45		
Proposed LARP Level 3 Trigger(2)	30	30	30	30		
Proposed LARP Level 2 Trigger(2)	15	15	15	15		

(1) Source: AENV (2011b).
(2) Source: AENV (2011c).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Carbon Monoxide

Modelling (CALPUFF) results indicate that there are no exceedances for the AAAQOs predicted at any location in the Application Case (Table D.1.9).

The change in the RSA-MPOI values between the Baseline and Application cases was negligible. Modelling predicted a slight increase or no change in the ground-level CO concentrations at special receptors locations from the Baseline Case to the Application Case. The patterns of CO concentration for the 9th highest 1-hour and 8-hour maximum are shown on CR #1, Figures 3.4-1 to 3.4-6, respectively.

Modelling (CALPUFF) results indicate that there are no exceedances for the AAAQOs predicted at any location in the PDC (Table D.1.9).

Table D.1.9 Predicted Carbon Monoxide Concentrations

Receptor Location	Baseline Case [µg/m³]	Application Case [µg/m³]	PDC [µg/m³]	Project Only [µg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
9th Highest 1-Hour						
Overall Maximum (RSA-MPOI)	5070	5070	5448	675	0.0	7.5
Local Area Maximum (LSA-MPOI)	1051	1052	1154	675	0.1	9.8
R1 – Kelley McNeilly Cabin	516	516	577	378	0.0	12
R2 – Damon and Sharon Wright	727	727	873	367	0.0	20
R3 – Pliska Cabin A	671	671	770	379	0.0	15
R4 – Pliska Cabin B	610	610	686	397	0.0	12
R5 – Pliska Cabin C	532	532	590	415	0.0	11
R6 – Powder Cabin A	721	721	820	376	0.0	14
R7 – MacDonald Cabin B	766	766	855	364	0.0	12
R8 – Powder Cabin B	698	698	781	370	0.0	12
R9 – Fort McMurray	897	897	1110	350	0.0	24
R10 – Fort McKay	1450	1450	1722	352	0.0	19
R11 – Anzac	579	579	628	348	0.0	8.5
STP Phase 1 Operations Camp	559	559	605	415	0.0	8.2
STP Phase 2 Operations Camp	588	590	653	521	0.4	11
AENV AAAQO(1)	**15,000**	**15,000**	**15,000**	**15,000**		
Maximum 8-Hour Average						
Overall Maximum (RSA-MPOI)	4573	4573	4657	685	0.0	1.8
Local Area Maximum (LSA-MPOI)	1144	1144	1192	685	0.0	4.2
R1 – Kelley McNeilly Cabin	548	548	603	387	0.0	9.9
R2 – Damon and Sharon Wright	797	797	911	391	0.0	14
R3 – Pliska Cabin A	725	725	809	400	0.0	12
R4 – Pliska Cabin B	650	651	726	409	0.0	12
R5 – Pliska Cabin C	529	533	586	420	0.8	11
R6 – Powder Cabin A	734	734	837	401	0.0	14
R7 – MacDonald Cabin B	818	818	950	383	0.0	16
R8 – Powder Cabin B	736	736	836	392	0.0	14
R9 – Fort McMurray	877	877	1077	376	0.0	23
R10 – Fort McKay	1407	1407	1607	378	0.0	14
R11 – Anzac	558	558	589	375	0.0	5.7

Table D.1.9 Predicted Carbon Monoxide Concentrations

Receptor Location	Baseline Case [μg/m³]	Application Case [μg/m³]	PDC [μg/m³]	Project Only [μg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
STP Phase 1 Operations Camp	556	557	599	425	0.2	7.6
STP Phase 2 Operations Camp	586	586	648	495	0.0	11
AENV AAAQO[(1)]	**6,000**	**6,000**	**6,000**	**6,000**		

[(1)] Source: AENV (2011b).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Particulate Matter

Results of the modeling indicate that the Canada Wide Standard and the hourly AAAQO for predicted $PM_{2.5}$ would be exceeded only at the RSA-MPOI in the Application Case (Table D.1.10). As well, 24-hour prediction exceeded the AAAQO at the RSA-MPOI and LSA-MPOIs.

The Phase 2 Project contributions to $PM_{2.5}$ concentrations are negligible to minimal in the Application Case at all locations, including the LSA-MPOI. This is evident from the patterns of the 2nd highest 24-hour $PM_{2.5}$ concentration (including secondary particulates) predicted by CALPUFF (CR #1, Figures 3.5-1 to 3.5-3).

Results of the modeling indicate that the Canada Wide Standard and the hourly AENV AAAQO for predicted $PM_{2.5}$ would be exceeded only at the regional MPOI in the PDC (Table D.1.10). As well, the AENV AAAQO 24-hour was predicted to be exceeded at the RSA and LSA MPOIs.

Table D.1.10 Predicted $PM_{2.5}$ Concentrations						
Receptor Location	**Baseline Case [µg/m³]**	**Application Case [µg/m³]**	**PDC [µg/m³]**	**Project Only [µg/m³]**	**Application Case Increase Over Baseline [%]**	**PDC Increase Over Baseline [%]**
9th Highest 1-Hour						
Overall Maximum (RSA-MPOI)	222	222	226	12	0.0	1.5
Local Area Maximum (LSA-MPOI)	72	72	77	12	0.0	6.4
R1 – Kelley McNeilly Cabin	40	40	43	6.3	0.1	7.2
R2 – Damon and Sharon Wright	46	46	52	6.3	0.0	15
R3 – Pliska Cabin A	47	47	53	6.6	0.0	13
R4 – Pliska Cabin B	45	45	49	7.2	0.0	11
R5 – Pliska Cabin C	37	38	42	7.1	2.2	13
R6 – Powder Cabin A	49	49	51	6.3	0.0	4.3
R7 – MacDonald Cabin B	57	57	64	5.8	0.0	14
R8 – Powder Cabin B	46	46	52	6.0	0.0	13
R9 – Fort McMurray	57	57	72	5.5	0.0	26
R10 – Fort McKay	75	75	75	5.5	0.0	0.0
R11 – Anzac	24	24	29	5.4	0.0	23
STP Phase 1 Operations Camp	38	38	42	7.0	0.1	9.5
STP Phase 2 Operations Camp	40	40	45	9.5	0.1	12
AENV AAAQO[(1)]	**80**	**80**	**80**	**80**		
8th Highest 24-Hour (98th Percentile)						
Overall Maximum (RSA-MPOI)	77	77	64	7.5	0.0	2.4
Local Area Maximum (LSA-MPOI)	25	25	26	7.5	0.0	17
R1 – Kelley McNeilly Cabin	13	13	14	5.0	0.0	9.2
R2 – Damon and Sharon Wright	18	18	21	5.0	0.0	14
R3 – Pliska Cabin A	17	17	20	5.0	0.4	8.6
R4 – Pliska Cabin B	16	16	19	5.1	0.0	13
R5 – Pliska Cabin C	14	14	15	5.2	0.1	5.0
R6 – Powder Cabin A	18	18	19	5.0	0.0	9.1
R7 – MacDonald Cabin B	18	18	19	5.0	0.1	12
R8 – Powder Cabin B	17	17	19	5.0	0.0	11
R9 – Fort McMurray	21	21	25	4.9	0.2	21
R10 – Fort McKay	26	26	27	4.9	0.0	4.7
R11 – Anzac	10	11	12	4.9	0.0	19

Table D.1.10 Predicted $PM_{2.5}$ Concentrations						
Receptor Location	**Baseline Case [µg/m³]**	**Application Case [µg/m³]**	**PDC [µg/m³]**	**Project Only [µg/m³]**	**Application Case Increase Over Baseline [%]**	**PDC Increase Over Baseline [%]**
STP Phase 1 Operations Camp	14	14	16	5.2	0.1	7.5
STP Phase 2 Operations Camp	16	16	17	5.8	0.1	8.1
Canada Wide Standard	**30**	**30**	**30**	**30**		
2nd Highest 24-Hour						
Overall Maximum (RSA-MPOI)	93	93	95	8.9	0.0	2.4
Local Area Maximum (LSA-MPOI)	34	34	40	8.9	0.0	17
R1 – Kelley McNeilly Cabin	20	20	21	5.2	0.0	9.2
R2 – Damon and Sharon Wright	25	25	28	5.2	0.0	14
R3 – Pliska Cabin A	25	25	27	5.2	0.4	8.6
R4 – Pliska Cabin B	23	23	26	5.4	0.0	13
R5 – Pliska Cabin C	21	21	22	5.2	0.1	5.0
R6 – Powder Cabin A	28	28	30	5.1	0.0	9.1
R7 – MacDonald Cabin B	28	28	31	5.1	0.1	12
R8 – Powder Cabin B	27	27	30	5.1	0.0	11
R9 – Fort McMurray	31	31	38	5.0	0.2	21
R10 – Fort McKay	36	36	38	5.0	0.0	4.7
R11 – Anzac	14	14	17	5.0	0.0	19
STP Phase 1 Operations Camp	21	21	22	5.5	0.1	7.5
STP Phase 2 Operations Camp	24	24	25	6.2	0.1	8.1
AENV AAAQO(1)	**30**	**30**	**30**	**30**		

(1) Source: AENV (2011b).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Hydrogen Sulphide

Modelling (CALPUFF) results indicate that there are exceedances of the AENV AAAQOs predicted at the local and regional MPOI in the Application Case (Table D.1.11).

Project sources of H_2S were low-level fugitives from the central processing facility area. Model predictions demonstrated there were no exceedances of 1-hour or 24-hour AAAQOs at or immediately beyond the Phase 2 fence line where the Phase 2 Project most influenced predictions. As shown in Table D.1.11, Phase 2's relative contribution was negligible at nearby receptors, with the exception of the Phase 2 Operations Camp where the absolute increase in predicted concentrations was small.

The patterns of H_2S concentration for the 1-hour and 24-hour maximum are shown on CR #1, Figures 3.8-1 to 3.8-6, respectively.

Results of the modeling indicate that the 1-hour and 24-hour AAAQO would be exceeded at the LSA and RSA MPOIs in the PDC (Table D.1.11). Phase 2 contribution at this location was negligible.

Table D.1.11 Predicted Hydrogen Sulphide Concentrations

Receptor Location	Baseline Case [μg/m³]	Application Case [μg/m³]	PDC [μg/m³]	Project Only [μg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
9th Highest 1-Hour						
Overall Maximum (RSA-MPOI)	128	128	165	8	0.0	29
Local Area Maximum (LSA-MPOI)	19	19	22	8	0.0	14
R1 – Kelley McNeilly Cabin	2	2	3	2.22E-02	0.0	15
R2 – Damon and Sharon Wright	5	5	6	9.87E-03	0.0	22
R3 – Pliska Cabin A	5	5	6	1.96E-02	0.0	13
R4 – Pliska Cabin B	3	3	3	3.05E-02	0.0	16
R5 – Pliska Cabin C	3	3	3	1.49E-01	0.0	5
R6 – Powder Cabin A	5	5	5	3.65E-02	0.0	15
R7 – MacDonald Cabin B	8	8	9	1.73E-02	0.0	17
R8 – Powder Cabin B	5	5	6	3.22E-02	0.0	13
R9 – Fort McMurray	3	3	4	2.88E-03	0.0	15
R10 – Fort McKay	11	11	12	4.72E-03	0.0	7
R11 – Anzac	1	1	1	1.15E-03	0.0	14
STP Phase 1 Operations Camp	4	4	4	3.80E-01	0.0	1
STP Phase 2 Operations Camp	3	5	5	3.20	52	54
AENV AAAQO(1)	**14**	**14**	**14**	**14**		
2nd Highest 24-Hour						
Overall Maximum (RSA-MPOI)	44	44	45	2	0.0	0
Local Area Maximum (LSA-MPOI)	4	4	5	2	0.0	20
R1 – Kelley McNeilly Cabin	1	1	1	4.34E-03	0.0	18
R2 – Damon and Sharon Wright	1	1	2	2.07E-03	0.1	20

Table D.1.11 Predicted Hydrogen Sulphide Concentrations

Receptor Location	Baseline Case [µg/m³]	Application Case [µg/m³]	PDC [µg/m³]	Project Only [µg/m³]	Application Case Increase Over Baseline [%]	PDC Increase Over Baseline [%]
R3 – Pliska Cabin A	1	1	1	2.98E-03	0.1	12
R4 – Pliska Cabin B	1	1	1	4.43E-03	0.0	17
R5 – Pliska Cabin C	1	1	1	3.81E-02	1.7	11
R6 – Powder Cabin A	2	2	2	7.00E-03	0.0	12
R7 – MacDonald Cabin B	2	2	2	4.20E-03	0.0	13
R8 – Powder Cabin B	1	1	2	7.33E-03	0.0	15
R9 – Fort McMurray	1	1	1	9.41E-04	0.1	21
R10 – Fort McKay	3	3	4	1.28E-03	0.0	13
R11 – Anzac	0.3	0.3	0.4	4.37E-04	0.0	15
STP Phase 1 Operations Camp	1	1	1	5.48E-02	2.9	10
STP Phase 2 Operations Camp	1	1	1	7.56E-01	27	33
AENV AAAQO[(1)]	**4**	**4**	**4**	**4**		

[(1)] Source: AENV (2011b).
Shaded Cells: AAAQOs are not applicable to predicted increases.

Volatile Organic Compounds and Polycyclic Aromatic Hydrocarbons

The chemical compounds assessed in this section have been identified as those emitted by the proposed facility that may potentially have a deleterious effect on human health if present in air in sufficient concentration, and whose concentrations are subject to AAAQOs.

Predictions of the impact of chemicals of potential concern (COPCs) at MPOI, community and receptor locations near Phase 2 are presented here and include Acetaldehyde, Benzene, Benzo(a)Pyrene, CS_2, Ethylbenzene, Formaldehyde, n-Hexane, Toluene and Xylene. Potential impacts from other COPCs are considered in the Human Health Risk Assessment (Section D.5).

Except for H_2S and benzo(a)pyrene, there were no predicted exceedances of AAAQOs of any COPC at the local MPOIs or at any of the cabin/camp receptors (CR #1, Table 3.9-1 to 3.9-9). There were predicted daily exceedances at the regional MPOI for benzo(a)pyrene.

For all COPCs, the absolute contribution of Phase 2 at locations outside the LSA was negligible. Within the LSA, the local MPOIs were largely influenced by emissions from the mining areas located to the east of the LSA. The influence of Project emissions in the LSA was negligible to small.

The only predicted exceedance in the planned development case was for benzo(a)pyrene daily exceedances at the regional MPOI and the 1-hour concentration for CS_2, located in the mining area north of Fort McMurray. Project emissions of CS_2 have negligible impact at all special receptor locations and MPOIs.

Ozone

Photochemical models can be used to predict the secondary formation of O_3 based on precursor emissions and meteorological conditions. These models have been applied to the oil sands region to determine the potential for O_3 formation due to the developments proposed for the region. Previous modelling using CALGRID (Davies and Fellin, 1999) showed an increasing trend in O_3 concentration with increasing emissions. Specifically, CALGRID results indicated that a doubling of regional NO_x emission results in a 7% increase in maximum predicted O_3 concentration. Phase 2 contributes to a 0.5% increase in regional NO_x emissions (2.8 t/d out of 569 t/d total); therefore, based on the application of CALGRID model results, Phase 2's contribution to regional O_3 would be approximately 0.02%, which is a negligible increase.

Alternatively, the approach of Fox and Kellerhaus (2008) can be used to estimate O_3 increases due to Phase 2. Using the CMAQ model, this study suggested that a 460% increase in regional NO_x emissions in the oil sands region would result in an increase of about 60% to maximum O_3 concentrations.

Both CALGRID and CMAQ result in a negligible change in regional O_3 concentrations with the addition of Phase 2.

In the planned development scenario, in which emissions of NO_x are expected to increase by 34% compared to the Baseline Case, the predicted increase of O_3 concentration would be less than 2% under the CALGRID approach or 0.06% under the CMAQ approach.

Odour

The predicted maximum air concentrations for compounds were compared with established odour thresholds. As odour can be perceived within a short time span, the air concentration used in the comparison was based on a three-minute averaging period converted from the 9th highest hourly predictions. The frequency of exceedance reported is the maximum annual frequency predicted in the five years that were modelled (CR #1, Table 3.10-1).

The predicted 3-minute maxima for NO_2, C9-C18 aliphatics, CS_2, and acetaldehyde, which are located in the mining area of the RSA, exceed the mean odour threshold in the Application Case and PDC.

Hydrogen sulphide odour threshold exceedances were also predicted for the MacDonald Cabin, located in the NE corner of the LSA, and at Fort McKay. However, the frequency of these exceedances was less than 0.5%. Exceedances of the odour threshold within the LSA are confined to the NE corner, where regional operations are the primary source of odorants. Project emissions do not contribute to new occurrences of odour at any of the special receptors or the LSA and RSA MPOIs.

Visible Plumes

Water vapour in plumes from Project combustion sources will be visible under some meteorological conditions. The CALPUFF FOG module was run with ISC extended meteorological data containing relative humidity from the Fort McMurray airport, as well as friction velocity, Monin-Obukhov length, and surface roughness length (obtained from the CALMET output file). CALPUFF was also run in PLUME mode, which allows for a visible plume to be assessed for height, length, and the frequency of occurrence.

Visible plumes were predicted to occur about one-quarter of the time, half of them in winter when the daylight hours for viewing plumes are shorter, and most of them during night-time conditions. Most visible plumes were higher than the top of the tree canopy. Most plumes were less than 1 km in length; almost all of the longest plumes were predicted to occur before sunrise or after sunset.

Potential Acid Input

The maximum predicted PAI value in the Application case is the same as that for predicted for the baseline case (approx. 3.8 keq/ha/yr) (CR #1, Table 3.6-1). The model results indicate that Phase 2 increased the area within relevant deposition isopleths by 1% or less in the RSA and by 7% in the LSA.

In the LSA, the maximum predicted PAI is 0.40 keq/ha/yr Application Case (unchanged from baseline). Small incremental areas (4 ha) with deposition above 0.25 keq/ha/yr were predicted around the STP central facility.

Potential acid input averaged over 1º latitude by 1º longitude grid cells (CR #1, Table 3.6-2 and Figures 3.6-4 and 3.6-5) indicates an increase in the grid-average deposition by approximately 11% in one grid cell (southwest corner at 56º latitude and 113º longitude) for the Application Case. The increase is a result of Phase 2 being added to an area with few existing emissions.

The provincial acid deposition management framework specifies that an exceedance of a target load at a local scale (*e.g.,* project LSA) is not to be considered to be an exceedance of an environmental objective.

In the planned development case, the maximum predicted PAI value increases to approximately 4.1 keq/ha/yr (CR #1, Table 3.6-1).

The maximum predicted PAI in the LSA increases to 0.41 keq/ha/yr for the planned development case. The PAI predictions are largely driven by emissions from sources beyond the LSA, as evidenced by the regional maxima in the mining area north of Fort McMurray (CR #1, Figures 3.6-1 to 3.6-3).

Potential acid input averaged over 1º latitude by 1º longitude grid cells (CR #1, Table 3.6-2 and Figures 3.6-4 and 3.6-5) indicates an increase from baseline across the RSA.

Nitrogen Deposition

Results of the modeling indicate that the regional maximum predicted nitrogen deposition is unchanged from baseline (59 kg/ha/yr) (CR #1, Table 3.7-1). The area above the 8 kg/ha/yr threshold is 3,492 km^2 in the RSA and 72 km^2 in the LSA (up to 5% increase from baseline).

Results of the modeling indicate that the regional maximum predicted nitrogen deposition is 5% greater than baseline (62 kg/ha/yr) (CR #1, Table 3.7-1). The area above the 8 kg/ha/yr threshold is 4,944 km^2 (42% increase from baseline) in the RSA and 152 km^2 in the LSA (120% increase from baseline). The increases in maximum deposition and area affected are due to regional growth of SAGD facilities and the mining areas to the northeast of the LSA.

Upset Conditions

It is the design intent that the Phase 2 flare stack be used as an emergency system, with any normal process vents being processed through the steam boilers. According to AENV (2009a), the impact due to emergency and upset conditions must be considered in environmental assessments for air quality.

Emergency flaring would occur in the scenario of multiple failures resulting in blockage of flow in the VRU suction. In the event of a VRU blockage the VRU gas volumes will be bypassed to the flare stack. The flaring event is concurrent with normal operations. The stack and emission parameters for the emergency flaring worst case scenario are shown in CR #1, Table 3.13-1. The maximum flow rate is 98 x 10^3 m^3/d, and the maximum duration of flaring is 4 hours.

Dispersion modelling of Project SO_2 emissions from emergency flaring was performed using CALPUFF. Regional sources and background values were included in model predictions, and the results are presented in CR #1, Table 3.13-2. The predicted maximum 1-hour SO_2 concentration is 387 μg/m^3, which is well below the hourly AAAQO for SO_2, and occurs outside of the LSA. The maximum in the LSA occurs on the eastern edge and is minimally influenced by the flaring activities. The maximum contribution from the flare is 44 µg/m^3. The increase in SO_2 concentrations at nearby camps or cabins is minimal.

D.1.4 Mitigation and Monitoring

D.1.4.1 Mitigation

In order to reduce potential impacts of Phase 2 on air quality STP will:

- design Phase 2 so there is no continuous flaring other than pilot and purge gas;
- include liquid knockout facilities, pilot/purge gas, continuous monitoring, and burner management in the emergency flare system;
- install a vapour recovery system; and
- utilize low NO_x emissions technology.

D.1.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will:

- test H_2S content in produced gas and estimating SO_2 emissions from the produced gas flow rate;
- determine GHG emissions by measuring gas composition and fuel use;
- undertake manual stack surveys as commonly required in EPEA Approvals; and
- install passive monitors to determine SO_2 and H_2S concentrations.

D.1.5 Summary of VEC

Characterization of the residual and cumulative effects of Phase 2 on air quality is presented in Table D.1.12. With mitigation, the residual and cumulative effects of the proposed Project on air quality are considered to have Low Impact, excluding cumulative PAI effects, which are estimated to have a Moderate Impact.

Table D.1.12 Summary of Impact Rating on Air Quality Valued Environmental Components

VEC	Nature of Potential Impact or Effect	Mitigation / Protection Plan	Type of Impact or Effect	Geographical Extent (1)	Duration (2)	Frequency (3)	Reversibility (4)	Magnitude (5)	Project Contribution (6)	Confidence Rating (7)	Probability of Occurrence (8)	Impact Rating (9)
1. NO_2 Concentration												
	Potential human health effects	see Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Negligible to Low	Negative	High	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Low to Moderate	Negative and Positive	Moderate	Medium	Low
2. SO_2 Concentration												
	Potential human health and vegetation effects	see Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Negligible to Low	Negative	High	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Low to Moderate	Negative	Moderate	Medium	Low
3. $PM_{2.5}$ Concentration												
	Potential human health effects and visibility impairment	see Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Negligible to Low	Negative	Moderate (greater uncertainty in PM secondary formation)	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Low to Moderate	Negative	Moderate	Medium	Low
4. CO Concentration												
	Potential human health effects	see Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Negligible to Low	Negative	High	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Low to Moderate	Negative	Moderate	Medium	Low
5. PAI Deposition												
	Potential acidification of sensitive soils, water bodies and vegetation	Based on management of precursors as identified in Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Low	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Moderate (>10% increase)	Negative	Low	Low	Moderate

Table D.1.12 Summary of Impact Rating on Air Quality Valued Environmental Components

VEC	Nature of Potential Impact or Effect	Mitigation / Protection Plan	Type of Impact or Effect	Geographical Extent(1)	Duration(2)	Frequency (3)	Reversibility(4)	Magnitude (5)	Project Contribution (6)	Confidence Rating(7)	Probability of Occurrence(8)	Impact Rating(9)
6. Nitrogen Deposition												
	Potential eutrophication of sensitive ecosystems	Based on management of precursors as identified in Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Low	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Moderate (>10% increase) in LSA. Variable in RSA.	Negative.	Low	Low	Moderate
7. Ozone Concentration												
	Potential human health effects	Based on management of precursors as identified in Section D.1.4.1	Application	Regional	Long	Continuous	Reversible in Long Term	Negligible to Low	Negative	High	High	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Low (<5% increase)	Negative	Low	Medium	Low
8. H_2S Concentration												
	Potential human health effects	see Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Negligible to Low	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Moderate	Negative	Low	Medium	Moderate
9. VOC, PAH and non-CAC Concentration												
	Potential human health effects	see Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Negligible to Low in percentage or absolute terms	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Continuous	Reversible in Long Term	Low to High. Typically Low in an absolute sense.	Negative	Low future (regional emissions less certain)	Medium	Low

Table D.1.12 Summary of Impact Rating on Air Quality Valued Environmental Components

VEC	Nature of Potential Impact or Effect	Mitigation / Protection Plan	Type of Impact or Effect	Geographical Extent (1)	Duration (2)	Frequency (3)	Reversibility (4)	Magnitude (5)	Project Contribution (6)	Confidence Rating (7)	Probability of Occurrence (8)	Impact Rating (9)
10. Odour												
	Potential nuisance effects	see Section D.1.4.1	Application	Local	Long	Continuous	Reversible in Long Term	Negligible to Low in percentage or absolute terms	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Occasional	Reversible in Long Term	Low to High. Typically Low in an absolute sense.	Negative	Low future (regional emissions less certain)	Medium	Low overall but moderate for specific odorants such as H_2S
11. Visibility												
	Potential aesthetic effects	none	Application	Local	Long	Occasional	Reversible in Short Term	Low	Negative	Moderate	Medium	Low
			Cumulative	Regional	Long	Occasional	Reversible in Short Term	Not Assessed	n/a	n/a	n/a	n/a

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.2 AQUATIC RESOURCES

D.2.1 Introduction and Terms of Reference

STP conducted an assessment of aquatic resources for the proposed Project. The following section is a summary of the Surface Aquatic Resources Report that was prepared by Hatfield Consultants and included as Consultants Report #2 (CR #2). For full details of the assessment please refer to CR #2.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the aquatic resource component are provided in Section 3.6 and are as follows:

3.6.1 Baseline Information

[A] Describe and map the fish, fish habitat and aquatic resources (e.g., aquatic and benthic invertebrates) of the lakes, rivers, ephemeral water bodies and other waters. Describe the species composition, distribution, relative abundance, movements and general life history parameters of fish resources. Also identify any species that are:

- *a) listed as "at Risk, May be at Risk and Sensitive" in The Status of Alberta Species (Alberta Sustainable Resource Development);*
- *b) listed in Schedule 1 of the federal Species at Risk Act;*
- *c) listed as "at risk" by COSEWIC; and*
- *d) traditionally used species.*

[B] Identify any barriers to fish passage.

[C] Describe and map existing critical or sensitive areas such as spawning, rearing, and overwintering habitats, seasonal habitat use including migration and spawning routes.

[D] Describe the current and potential use of the fish resources by aboriginal, sport or commercial fisheries.

[E] Identify the key aquatic indicators that the Proponent used to assess project impacts. Discuss the rationale for their selection.

3.6.2 Impact Assessment

[A] Describe and assess the potential impacts of the Project to fish, fish habitat, and other aquatic resources, considering:

- *a) potential habitat loss and alteration;*
- *b) potential creation of barriers to fish passage;*
- *c) potential impacts on riparian areas that could affect aquatic biological resources and productivity;*
- *d) potential increased fishing pressures in the region that could arise from the increased workforce and improved access from the Project;*
- *e) changes to benthic invertebrate communities that might affect food quality and availability for fish;*
- *f) potential increased habitat fragmentation;*

g) potential acidification; and

h) potential groundwater surface water interactions.

[B] Discuss mitigation measures to avoid or minimize potential impacts of the Project on fish, fish habitat and other aquatic resources. Clearly identify those mitigation measures that will be implemented and provide the rationale for their selection.

[C] Identify plans proposed to offset any loss in the productivity of fish habitat. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat including the development of a "No Net Loss" fish habitat objective.

3.6.3 Monitoring

[A] Describe the Proponent's current and proposed monitoring programs.

[B] Describe the monitoring programs proposed to assess any Project impacts and to measure the effectiveness of mitigation plans.

[C] Discuss the Proponent's regional monitoring activities including:

a) monitoring that will be undertaken to assist in managing environmental effects, confirm performance of mitigation measures and improve environmental protection strategies;

b) monitoring done independently by the Proponent and how these monitoring programs are consistent with other current or proposed regional monitoring programs;

c) monitoring performed in conjunction with other stakeholders, including aboriginal communities and groups; and

d) new monitoring initiatives that may be required as a result of the Project.

[D] Discuss:

a) the Proponent's plans for addressing and mitigation any environmental impacts identified in the monitoring program

b) how monitoring data will be disseminated to the public or other interested parties; and

c) how the results of monitoring programs and publicly available monitoring information will be integrated with the Proponent's environmental management system.

The aquatics LSA encompasses a portion of the upper MacKay River watershed (Figure C.2.1). The MacKay River watershed within the LSA contains the MacKay River (sixth-order stream), one fourth-order stream, and a series of third- and lower-order streams and small beaver ponds. The RSA includes the watercourses of the LSA plus the mainstem of the MacKay River downstream to its confluence the Athabasca River (Figure C.2.2). Within the RSA, the MacKay River is a sixth-order watercourse.

The VECs evaluated in the aquatic resource assessment include surface water quality and fish resources.

D.2.2 Baseline Conditions

The aquatic resources Baseline Case consists of a description of surface water quality, fish resources, aquatic habitat, (physical conditions, sediment quality, and benthic invertebrate communities), first for the watercourses within the LSA, followed by the watercourses that comprise the RSA.

The Baseline Case assumes that:

- any effects of existing projects on aquatic resources are already reflected in the data gathered to establish the baseline conditions; and
- existing projects will not cause any different effects on aquatic resources in the future.

D.2.2.1 Water Quality

The Baseline Case for surface water quality is based on surface water quality field studies undertaken in the LSA on watercourses upstream and downstream of the Phase 2 Project footprint (CR #2, Table 5). For the baseline assessment for the Phase 1 Project, all sampling was conducted during the summer season. Therefore, given the tributaries in the Phase 1 Project area of the MacKay River watershed are similar in habitat and size, the assessment for the Phase 2 Project focused on obtaining and analyzing water quality for the other seasons (*i.e.*, spring, fall, and winter). During the winter season, there were a few watercourses that were not frozen to depth; therefore, samples could only be collected at a subset of watercourses in the LSA.

Watercourses within the LSA have water quality that:

- is generally characteristic of coloured brown-water systems with a median true color level ranging from 172 TCU to 282 TCU and median concentrations of DOC ranging from 36.2 mg/L to 54.2 mg/L;
- is hard with median concentrations of $CaCO_3$ ranging from 62.2 mg/L to 153 mg/L;
- generally have circumneutral pH and pH is generally consistent across seasons;
- has high concentrations of TDS (median values ranging from 158 mg/L to 306 mg/L) and conductivity (median value ranging from 127 µS/cm to 306 µs/cm) consistent with concentrations and levels in regional baseline watercourses in the Athabasca oil sands region (RAMP 2011);
- is generally consistent median concentrations of TSS ranging from 4 mg/L to 8 mg/L;
- is classified as mesotrophic to eutrophic based on spring total phosphorus and total nitrogen concentrations (Dodds et al. 1998); and
- has ionic composition dominated by calcium and bicarbonate.

Most of the cases in which concentrations of water quality variables exceed their guidelines in the watercourses of the LSA are attributable to total and dissolved iron, total phosphorus, total Kjeldahl nitrogen, and total nitrogen (CR #2, Table 7 and Table 8). Concentrations of total iron, total phosphorus, and total nitrogen (derived from total Kjeldahl nitrogen) are generally above their water quality guidelines throughout the Athabasca oil sands region and are positively correlated with concentrations of TSS (Golder 2003, RAMP 2011). The rest of the water quality guideline exceedances in the watercourses of the LSA were occasional exceedances in concentrations of dissolved oxygen, total aluminum, total cadmium, total chromium, total manganese, and total selenium.

Concentrations of a number of water quality variables, including mercury (ultra-trace), total arsenic, almost all dissolved metals and phenols never exceeded their water quality guidelines in the watercourses of the LSA. Concentrations of naphthenic acids across watercourses were consistent with historical concentrations measured in the MacKay River watershed (RAMP 2010) and total recoverable hydrocarbons were below detection limits across all seasons in all watercourses.

D.2.2.2 Fish Resources

The Baseline Case for fish resources in the LSA was developed from:

- a review of fish resources in the MacKay River watershed, in stream orders similar to those found in the LSA, contained in the Fisheries and Wildlife Management Information System (FWMIS) database (ASRD 2011);
- fish inventory surveys conducted in support of the Phase 1 Project;
- stream crossing assessments conducted in support of the access road construction program; and
- fish inventories conducted in support of the Phase 2 Project EIA (CR #2, Table 5).

The analysis of FWMIS data indicates a high probability of first to sixth order streams containing small-bodied fish in the LSA. In addition, there is a moderate and high probability of large-bodied fish present in first to fourth order and sixth order streams, respectively. These fish species are primarily white and longnose sucker. Sportfish, primarily walleye and northern pike, have a low probability of capture in most streams with the exception of the MacKay River, which is the only sixth order stream in the LSA. The MacKay River can be expected to have a much higher probability of all types of fish and much more diverse species assemblage than the lower order streams that flow into this river.

Baseline fish inventories were conducted at ten watercourses in the LSA (CR #2, Table 5). A total of 854 fish, comprising 11 species, were captured in watercourses in the LSA (CR #2, Table 11).

The majority of fish captured were northern redbelly dace (30%), finescale dace (13%), slimy sculpin (13%), brook stickleback (11%) with fewer white sucker, lake chub, pearl dace, longnose dace, trout-perch, northern pike, and longnose sucker captured. A total of 15 fish species are documented in the MacKay River (the RSA), which is the only sixth order stream in the watershed.

While information on fish health specific to the MacKay River watershed is not available, there is some information for other watersheds in the Fort McMurray region. The majority of information on fish health comes from studies conducted in the Athabasca or Clearwater Rivers. RAMP (2009) reported that:

- mean mercury concentrations across all size classes in walleye and lake whitefish in the Athabasca River were below the Health Canada guideline for subsistence fishers indicating a negligible-low risk to human health;
- a negligible-low risk to the health of walleye and lake whitefish were identified given all metals in composite samples were below sublethal effects and no-effects criteria; and
- all tainting compounds in walleye and lake whitefish muscle tissue from the Athabasca River were below guideline concentrations indicating a negligible-low influence on fish palatability.

D.2.2.3 Physical Aquatic Habitat

Detailed physical aquatic habitat surveys were conducted in seven watercourses for Phase 2, as well as eight watercourses for the existing Phase 1 project.

The watercourses in the LSA have mostly run morphology (CR #2, Table 12). Vegetation bordering the sampled watercourses comprises grasses and shrubs with some muskeg and immature to established deciduous or mixed forest. Where beaver ponds are present large areas of vegetation have been flooded. Instream vegetation is minimal in larger watercourses, but smaller tributaries and dammed pools have high amounts of instream vegetation.

Instream cover in these watercourses is dominated by instream vegetation, substrate and large woody debris with approximately equal amounts of each and lesser amounts of small woody debris and detritus. Stream substrates are dominated by fines and organic material with lesser amounts of gravels, cobbles, and boulders.

Visual aerial observations of watercourses in the LSA made during the baseline field studies suggest that most of the watercourses have similar characteristics as those described above. In particular, beaver dams, often well-established, are frequent in the watercourses of the LSA, creating pool habitats in the upper portion of several watercourses and more defined channels in the lower portions where watercourses flow into the MacKay River.

Winter habitat quality with respect to fish overwintering was variable. Two survey sites (CR #2, Figure 5 sites SPE6 and SPE7) were in beaver pond habitat and appear to have water depth and dissolved oxygen concentrations suitable for overwintering of small-bodied fish species. Large-bodied fish species have not been documented in this type of habitat in any field studies.

Large-bodied fish species have been documented is located in Birchwood Creek (STP 2009). Concentrations of dissolved oxygen (11.2 mg/L) in Birchwood Creek in winter 2011 are well above any concentrations where chronic or acute effects would be observed in large-bodied fish species (AEP 1997).

D.2.2.4 Sediment Quality

Sediment quality data have been collected by RAMP in 2002 and 2004 at one location on the MacKay River, within the RSA and upstream of all other development in the watershed (CR #2, Table 15, RAMP 2005). Given the MacKay River consists predominantly of erosional habitat, sediment quality sampling was discontinued in the MacKay River in 2005. A summary of the existing sediment quality data for the MacKay River watershed, upstream of other development and within the RSA for the Phase 2 Project is provided in CR #2, Table 17.

D.2.2.5 Benthic Invertebrate Communities

Benthic invertebrate data have been collected by RAMP in 2010 at one reach on the MacKay River, within the RSA and upstream of other development in the watershed (CR #2, Table 15, RAMP 2011). Given the MacKay River running through the LSA is dominated by erosional habitat, the existing benthic data represents benthic communities in erosional habitat. A summary of measurement endpoint values (abundance, richness, diversity, evenness, and %EPT) for this reach is provided in CR #2, Table 18.

D.2.2.6 Fish Habitat Suitability

A number of habitat suitability index (HSI) models (Golder 2005) were applied to the LSA to assess overall habitat suitability for fish populations in the LSA. HSI models were applied to all species captured during baseline studies (CR #2, Table 14).

Based on data available, the habitat suitability models suggest that the MacKay River watershed is suitable for all life stages of fish species captured and expected, particularly brook stickleback, white sucker, finescale dace, and northern redbelly dace. Most sites show average suitability for all species assessed except the MacKay River watershed was found to have no suitable habitat for longnose dace and below average suitable habitat for slimy sculpin and pearl dace.

D.2.2.7 Acid Sensitivity

Acid-sensitive lakes occur in areas with little or no capacity to neutralize acidic deposition. This capacity is determined by basin soil characteristics (*e.g.*, soil chemistry, composition, and depth), extent and type of vegetation cover, and drainage patterns (Holowaychuk and Fessenden 1987, Lucas and Cowell 1984). Typically, these lakes occur in areas of moderate to high elevation and high relief, with severe, short-term changes in hydrology, small drainage systems, and minimal contact between drainage waters and basin soils or geologic materials.

Lakes are not present in the surface aquatic resources LSA or RSA for Phase 2. Therefore, an assessment of acid sensitivity was conducted using lakes within the Air Quality RSA (AQRSA). Acid-sensitive surface waters typically exhibit low pH (<6.5), low concentrations of all major ions (*i.e.*, specific conductance is <25 µS/cm), low organic acid concentrations (*i.e.*, DOC concentration is typically less than 3 to 5 mg/L), and low acid neutralizing capacity (*i.e.*, ANC <200 µeq/L) (Sullivan et al. 1989).In the AQRSA, there are 36 lakes that have been designated as acid-sensitive based on the characteristics of these lakes (RAMP 2011). Of the 36 lakes, Baseline Case PAI inputs for 14 of the lakes exceeded the Critical Load by approximately 0.5% to 80%. These lakes are primarily located southeast of the Phase 2 project.

D.2.3 Predicted Conditions

The surface aquatic resource issues considered in the assessment of the application and planned development cases include:

- changes in surface water quality;
- changes in fish health and fish tissue, including fish tainting; and
- alteration/loss of fish resources and aquatic habitat.

D.2.3.1 Surface Disturbance and Construction Activities

During construction, reclamation and decommissioning phases of the Phase 2 Project a number of surface disturbance and construction activities will take place within the LSA. These activities may give rise to increased sediment loading in watercourses and waterbodies. These activities may have consequent effects on water quality, aquatic habitat and fish populations and include:

- vegetation clearing and overburden stripping for access roads and utility corridor construction, borrow pit development, and well pad construction;
- management of soil stockpiles;
- dismantling of Project facilities; and
- re-grading and re-vegetation of reclamation areas.

With strict implementation of the mitigation measures summarized in Section D.2.4.1 and other measures described in detail in STP (2009), potential impacts of surface disturbance activities are predicted to be low for the following reasons:

- impacts from construction activities which have been identified as potentially adverse are mitigable using standard engineering and environmental design applications;
- potential adverse effects associated with sedimentation will be localized, that is, they will occur mainly during periods of construction and reclamation and will be confined to the immediate and downstream areas of the surface disturbance activities;
- surface run-off from active areas such as well pads and roads will be managed so erosion from surface water runoff is minimized. Ditches will be designed to avoid ponding of water along the road surface. Flows will be maintained across drainages and wetlands with the appropriate use of culverts; and
- construction of well pads and associated infrastructure will be phased with progressive reclamation in order to minimize the amount of area disturbed at any one time.

Since the residual effects of Phase 2 on surface aquatic resources through surface disturbance and construction activities are assessed as Low Impact in the LSA, these residual effects are also assessed as Low Impact for the RSA.

D.2.3.2 Instream Construction Activities

There are 28 potential watercourse crossings in the Phase 2 Project area with three crossings situated on watercourses with fish and fish habitat (CR #2, Figure 5). Direct changes and physical loss of aquatic habitat may occur during instream construction works, such as watercourse crossing sites (roads or utilities) by the direct disturbance of the streambed, banks or riparian areas. Direct habitat effects can include alteration or loss of specific habitat features, such as pools, aquatic vegetation and bed materials, that ultimately lead to loss or impairment of habitat functions, such as overwintering, spawning and rearing. The specific effects will depend on the type of habitat at the crossing site, the type of crossing method used and the timing of the construction period.

With strict implementation of the mitigation measures described in Section D.2.4.1, potential impacts of instream construction activities are predicted to be low for the following reasons:

- impacts from instream construction are mitigable using standard engineering and environmental design applications and adhering to work timing windows;
- potential adverse effects associated with sedimentation will be temporary, short-term and localized, that is, they will occur mainly during periods of construction and

reclamation and will be confined to the immediate and downstream areas of the surface disturbance activities;

- a minimum 100 m buffer will be maintained from the edge of the MacKay River and all construction activities proposed to take place; and
- a minimum 50 m buffer will be maintained from the edge of the stream bank for all other construction activities which are proposed to take place near watercourses with defined channels.

Since the residual effects of Phase 2 on surface aquatic resources through in-stream construction activities are assessed as Low Impact in the LSA, these residual effects are also assessed as Low Impact for the RSA.

D.2.3.3 Changes in Surface Water Quality

The following Project activities may negatively affect surface water quality, and may give rise to resultant changes to aquatic habitat and fish populations:

- discharge of Project-affected water to natural watercourses;
- accidental spills of hydrocarbons, chemicals and waste products used and stored within Project Development Area; and
- changes in shallow groundwater quality.

With strict implementation of the mitigation measures described in Section D.2.4.1, potential impacts to aquatic resources through changes in surface water quality and discharge of Project-affected water into natural watercourses are predicted to be low for the following reasons:

- no planned discharges of process-affected waters will take place from Phase 2;
- occasional releases from the storm water retention pond may take place, but water will always be tested prior to discharge and will only be released in strict accordance with the terms and conditions of the operating approval;
- design features, management practices, mitigation plans and emergency response procedures will minimize the potential for accidental release of substances into waterbodies or watercourses; and
- shallow groundwater quality is not expected to be significantly impacted by Project activities; therefore resultant changes to surface water are not expected.

The residual (after mitigation) effects of Phase 2 on aquatic resources due to changes in surface water quality are assessed as Low Impact in the LSA. Because the residual effects of the Phase 2

Project on surface aquatic resources through changes in surface water quality are assessed as Low Impact in the LSA, these residual effects are also assessed as Low Impact for the RSA.

D.2.3.4 Changes to Surface Water Flow Rates and Levels

Changes in stream flow can affect:

- spawning, rearing, feeding, migration and overwintering habitats of fish-bearing streams and rivers through reduced stream area and shallow depth, reducing dissolved oxygen under the ice;
- watercourse productivity and availability of food for fish (*e.g.,* benthic invertebrates); and
- the presence of macrophytes, which provide cover, spawning material or food for fish.

Changes to surface water flow rates could result from:

- surface disturbance activities altering natural run-off and drainage patterns;
- surface water withdrawal activities required to meet water requirements for the SAGD process;
- release of process affected waters to natural waterbodies; and
- changes in the amount of shallow groundwater reporting to surface water.

Potential impacts to aquatic resources through changes in surface water flow rates are predicted to be low for the following reasons:

- only small increases in surface water runoff volumes are predicted as a result of surface disturbances (Section D.6.3.3);
- no planned discharges of Project-affected waters will take place from the Phase 2 Project therefore no consequent changes to surface water flow rates are expected;
- occasional releases from the storm water retention pond may take place, but water will be released at a controlled rate in accordance with the terms and conditions of the operating approvals; and
- shallow groundwater levels are not expected to be affected by Project activities and therefore no resulting changes to surface water flow rates are expected.

The residual (after mitigation) effects of Phase 2 on surface aquatic resources due to changes in surface water flow rates are assessed as Low Impact in the LSA. Since the residual effects of Phase 2 on surface aquatic resources through changes in surface water flow rates are assessed as Low Impact in the LSA, these residual effects: are also assessed as Low Impact for the RSA.

D.2.3.5 Improved or Altered Access to Fish Bearing Waterbodies

Improved access and increased workforce in the area as a result of the Phase 2 Project could increase fishing pressure and fish harvest in local fish-bearing waterbodies and watercourses. This could, in turn, result in a decreased abundance of sportfish if fishing pressure and/or fish harvest were not appropriately managed.

While many fish populations in the RSA, particularly the MacKay River, are sensitive to angling pressure, and while the workforce may potentially catch additional fish, it is expected that the mitigation and management measures will mean that these effects of increased angling on LSA fish populations will be Low.

The residual (after mitigation) effects of Phase 2 on aquatic resources from improved or altered access to fish bearing watercourses are assessed as Low Impact in the LSA. Since the residual effects of Phase 2 on surface aquatic resources through improved or altered access to fish-bearing watercourses are assessed as Low Impact in the LSA, these residual effects are also assessed as Low Impact for the RSA given the migratory patterns of sportfish in the watershed.

D.2.3.6 Fish Health and Fish Tainting

Changes in water quality have the potential to affect the health of fish and other aquatic organisms. With implementation of the mitigation measures outlined in Section D.2.4.1, potential impacts to fish health through potential changes in water quality are predicted to be low.

The residual (after mitigation) effects of Phase 2 on fish health through changes in water quality are assessed as Low Impact in the LSA. Since the residual effects of Phase 2 on surface aquatic resources on fish health are assessed as Low Impact in the LSA, these residual effects are also assessed as Low Impact for the RSA.

D.2.3.7 Acidifying Emissions

Phase 2 will result in the release of acidifying emissions as described in the Air Quality Assessment (Section D.1).

With the exception of three lakes to the northeast of Fort McMurray, predicted PAI values at all lakes are below Alberta's CASA target level of 0.25 keq H+/ha/yr (AEP 1997) for the Baseline and Application cases.

PAI values for 14 lakes exceed critical load values, as identified in RAMP 2011, in both the Baseline and Application cases (CR #2, Table 19).

PAI in excess of 0.25 keq H+/ha/yr for the Application Case is predicted to remain the same as the Baseline Case at 6.2 km^2. This affected area represents less than 1% of the total area of the AQRSA (82,350 km2). No increases in potential for acidification are predicted to result from the Phase 2 Project within the AQRSA in the Application Case.

One lake in the Birch Mountains subregion of the acid-sensitive lakes in the air quality RSA has a predicted PAI value that exceeds the Critical Load for the Planned Development Case but not the Baseline and Application cases (CR #2, Table 19). There are no additional lakes with predicted PAI values that exceed the Alberta's CASA target level of 0.25 keq H+/ha/yr (AEP 1997) for the Planned Development Case compared to the Baseline and Application cases.

The residual (after mitigation) effects of Phase 2 in the Application Case and Planned Development Cases on surface aquatic resources through acidifying emissions are assessed as Low Impact. The residual effects of Phase 2 on surface aquatic resources from changes in acidifying emissions are assessed as Low Impact for both the Application and Planned Development Cases.

D.2.4 Mitigation and Monitoring

D.2.4.1 Mitigation

In order to reduce potential impacts of Phase 2 on aquatic resources STP will:

- require earthworks contractors to utilize and effective sediment control plan;
- implement sediment control measures such as those described in the Alberta Code of Practice for Watercourse Crossings (AENV 2000) for earthworks which take place within or in close proximity to watercourses;
- carry out surface disturbance activities in close proximity to watercourses during periods of relatively low surface runoff in late fall, winter and early spring, when possible;
- maintain a 50 m buffer between disturbance sites and watercourses except at stream crossings and diversions;
- minimize the time interval between clearing/grubbing and subsequent earthworks, particularly at or in the vicinity of watercourses or in areas susceptible to erosion;
- utilize slope grading and stabilization techniques, such as contouring slopes to produce moderate angels and ditching above the cutslope where relevant;
- utilize surface runoff collection systems to direct surface runoff from disturbed areas into settling impoundments/sumps for removal of settleable solids;
- undertake progressive disturbance and reclamation to reduce the amount of disturbed area at any given time;

- utilize interim erosion/sediment control measures until long-term protection can be effectively implemented;
- construct clear span crossings on watercourses with fish and fish habitat in accordance with the DFO Alberta Operational Statement for Clear Span Bridges;
- design and construct all watercourse crossings in compliance with the Alberta Code of Practice for Watercourse Crossings (AENV 2000);
- construct all storage tanks, except boiler feed water and source water tanks, with secondary containment and leak detection equipment to minimize the occurrence of product leaks;
- raise awareness among the STP Project workers of the existing ASRD regulations for the species found in the study area lakes; and
- discourage fishing by Project employees within the LSA.

D.2.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will:

- conduct routine audits and associated surface aquatic resources monitoring during construction periods; and
- effects monitoring will be carried out in accordance with the conditions of the EPEA approval.

D.2.5 Summary of VECs

A summary of the significance of potential impacts and effects on aquatic resource valued environmental components (VECs) for the different assessment cases is provided in Table D.2.1.

Table D.2.1 Summary of Impact Rating on Aquatic Resource Valued Environmental Components.

VEC	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent of Impact or Effect(1)	Duration of Impact or Effect(2)	Frequency of Impact or Effect(3)	Ability for Recovery from Impact or Effect(4)	Magnitude of Impact or Effect(5)	Project Contribution(6)	Confidence Rating(7)	Probability of Impact or Effect Occurrence(8)	Significance(9)
Water Quality & Fish Resources												
	Changes to water quality and aquatic habitat and resources from surface disturbance and construction activities.	see Section D.2.4.1	Application	Local	Long	Occasional	Reversible in short term	Low	Negative	High	High	Low Impact
Fish Resources												
	Changes to fish and fish habitat due to instream construction activities.	see Section D.2.4.1	Application	Local	Long	Occasional	Reversible in short term	Low	Negative	High	High	Low Impact
Water Quality												
	Changes in surface water quality.	see Section D.2.4.1	Application	Local	Long	Occasional to accidental	Reversible in short term	Low to Moderate	Negative	High	Medium	Low Impact
Fish Resources												
	Changes to surface water flow rates and levels	see Section D.2.4.1	Application	Local	Long	Occasional to seasonal	Reversible in the long term	Low	Negative	High	High	Low Impact
			Cumulative	No change from Application Case	Long	Occasional	Reversible in short term	Low	Negative	High	Medium to High	Low Impact
	Changes to fish health, including fish tainting	see Section D.2.4.1	Application	Regional	Long	Occasional to accidental	Reversible in short term	Low	Negative	High	Low	Low Impact
Water Quality												
	Changes local fish populations due to changes in angling pressure	see Section D.2.4.1	Application	Local	Long	Occasional	Reversible in short term	Low	Negative	High	High	Low Impact
Water Quality and Fisheries Resources												
	Changes to surface aquatic resources from acidifying emissions	see Section D.2.4.1	Application and Planned Development	Local and Regional	Long	Continuous	Reversible in long term	Low	Negative	Moderate	High	Low Impact

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.3 GROUNDWATER

D.3.1 Introduction and Terms of Reference

STP conducted a hydrogeological assessment for Phase 2. The following section is a summary of the Hydrogeology Assessment that was prepared by Millennium EMS Solutions Ltd. and is included as Consultant Report #3 (CR #3). For full details of the assessment, please refer to CR #3.

Alberta Environment issued the final ToR for Phase 2 on July 22, 2011. The specific requirements for the hydrogeology component are provided in Section 3.2, and are as follows:

3.2.1 BASELINE INFORMATION

[A] Provide an overview of the existing geologic and hydrogeologic setting from the ground surface down to, and including, the oil producing zones and disposal zones, and:

- *a) present regional and Project Area geology to illustrate depth, thickness and spatial extent of lithology, stratigraphic units and structural features; and*
- *b) present regional and Project Area hydrogeology describing:*
  - *i) the major aquifers, aquitards and aquicludes (Quaternary and bedrock), their spatial distribution, properties, hydraulic connections between aquifers, hydraulic heads, gradients, groundwater flow directions and velocities. Include maps and cross sections,*
  - *ii) the chemistry of groundwater aquifers including baseline concentrations of major ions, metals and hydrocarbon indicators,*
  - *iii) the potential discharge zones, potential recharge zones and sources, areas of groundwater-surface water interaction and areas of Quaternary aquifer-bedrock groundwater interaction,*
  - *iv) water well development and groundwater use, including an inventory of groundwater users,*
  - *v) the recharge potential for Quaternary aquifers,*
  - *vi) potential hydraulic connection between bitumen production zones, deep disposal formations and other aquifers resulting from Project operations,*
  - *vii) the characterization of formations chosen for deep well disposal, including chemical compatibility and containment potential, injection capacity, hydrodynamic flow regime, and water quality assessments, and*
  - *viii) the locations of major facilities associated with the Project including facilities for waste storage, treatment and disposal (e.g., deep well disposal) and describe site-specific aquifer and shallow groundwater conditions beneath these proposed facilities. Provide supporting geological information.*

3.2.2 IMPACT ASSESSMENT

[A] Describe Project components and activities that have the potential to affect groundwater resource quantity and quality at all stages of the Project.

[B] Describe the nature and significance of the potential Project impacts on groundwater with respect to:

- *a) inter-relationship between groundwater and surface water in terms of both ground water and surface water quantity and quality;*
- *b) implications for terrestrial or riparian vegetation, wildlife and aquatic resources including wetlands;*
- *c) changes in groundwater quality and quantity and flow;*
- *d) conflicts with other groundwater users, and proposed resolutions to these conflicts;*
- *e) potential implications of seasonal variations; and*
- *f) groundwater withdrawal for Project operations, including any expected alterations in the groundwater flow regime during and following Project operations.*

[C] Discuss mitigation strategies to minimize the potential impact of the Project on hydrogeology.

The hydrogeology LSA includes a buffer around the proposed Phase 2 Project area (Figure C.2.1). The LSA is intended to include the extent of the Phase 2 Project related impacts beyond which the potential effects of Phase 2 are expected to be non-detectable.

The RSA defined for the hydrogeology assessment extends between townships 87 and 94 and range 19 East to the Athabasca River (Figure C.2.2). The RSA boundaries were selected based on major hydrologic-hydrogeologic features, such as the Athabasca River, which is a regional groundwater discharge feature and was selected as the southern and eastern boundary. The RSA also includes sufficient distances where measureable effects associated with the Phase 2 Project are not anticipated, but where residual effects from Phase 2 have potential to interact cumulatively with the residual effects of other projects.

Components of the Phase 2 Project that have been identified as having the potential to affect groundwater resources include:

- groundwater withdrawal;
- operation of surface facilities; and
- steaming and production.

Potential impacts were assessed for the following resources;

- surface water bodies and wetland areas;
- shallow drift aquifers;
- Empress Aquifer; and
- Grand Rapids Aquifers.

D.3.2 Baseline Conditions

The baseline study was completed based on a review of publically available information and Project specific information obtained by STP. Key information sources include the following:

- hydrogeological environmental assessment submitted for Phase 1 (STP 2009);
- groundwater supply evaluations in support of groundwater diversion applications for Phase 1 (MEMS 2009; 2011a);
- hydrogeology portions of Environmental Impact Assessments for the Dover Commercial Project (Dover Operating Corp. 2010), Athabasca Oil Sands Corp. (AOSC) MacKay River Commercial Project (AOSC 2009) and Petro-Canada MacKay River Expansion (2005);
- Alberta Research Council (ARC) and Alberta Geological Survey (AGS) reports on regional geology and hydrogeology;
- water well driller's reports and chemical analyses in Alberta Environment's Groundwater Information Centre database (AENV 2011);
- hydrogeological information obtained for this assessment; and
- water diversion license information from the AENV Authorization/Approval database.

In addition, a proprietary well log database was used to determine formation tops, total formation thickness and thickness of key stratigraphic units.

The region is underlain by an unconformable sequence of Quaternary, Cretaceous and Devonian sediments on the Precambrian crystalline basement (CR #3, Figure 2). Regional Quaternary deposits are divided into two units; undifferentiated drift deposits that blanket the region and buried channel deposits. Cretaceous units include the La Biche, Viking and Joli Fou of the Colorado Group and the Grand Rapids, Clearwater and McMurray formations of the Mannville Group. Devonian units present in the RSA include the Woodbend, Beaverhill Lake and Elk Point groups; of these the Beaverhill and Woodbend Groups subcrop beneath the pre-Cretaceous unconformity (CR #3, Figure 4). There are bitumen deposits in the Cretaceous McMurray Formation, which are the subject of the SAGD operations assessed herein. A description of the geological units within the RSA and LSA is provided in CR #3, Section 4.2.

Regional aquifers include the Empress Formation, the Cretaceous Viking, Grand Rapids 3, 4 and 5 sands and the Devonian Beaverhill Lake - Cooking Lake aquifer system (CR #3, Figure 2). Within the RSA the permeable portions of the undifferentiated glacial drift and water saturated portions of the McMurray aquifer are interpreted as forming only localized aquifers. The Base of Groundwater Protection is established at an elevation of 287 masl at Phase 2 (ERCB 2011) and the Clearwater Formation is identified as the deepest protected groundwater unit. Thus key units from a hydrogeological point of view that underlie the Phase 2 Project are the Quaternary glacial drift, buried channels and the Grand Rapids Formation. Other units were not considered in detail as they are either below the Base of Groundwater Protection or do not underlie the Phase 2 Project.

D.3.2.1 Undifferentiated Drift Aquifer/Aquitard

The undifferentiated drift within the HLSA consists of predominantly clay till with intervals of sand, which is referred to as the Undifferentiated Drift Aquifer/Aquitard. Characteristics of the drift are as follows:

- hydraulic conductivity of the shallow sand is 1×10^{-6} to 4×10^{-5} m/s and groundwater flow rates are approximately 4 m per year;
- hydraulic conductivity of the clay till deposit is 3.3×10^{-8} to 2.3×10^{-7} m/s and groundwater flow rates are approximately 0.1 m per year;
- shallow groundwater flow within the HLSA is anticipated to be generally towards the MacKay River with a slight downward gradient;
- water table is typically found at depths of 3 m or less and is occasionally above the ground surface;
- groundwater quality and type is predominately calcium bicarbonate however the dominant cation is frequently a mixture of calcium- sodium- magnesium and some sulphate-dominated waters are also present; and
- TDS concentrations within the LSA range from 137 to 855 mg/L and within the RSA are generally less than 1,000 mg/L; however concentrations of over 8,000 mg/L have been measured within the undifferentiated drift (Petro Canada 2005).

D.3.2.2 Empress Aquifer

The Empress Formation is located at the base of buried bedrock channels within the HRSA including the MacKay and Birch Channels. The Empress Formation forms an aquifer with a thickness of up to 31 m along the thalweg of the MacKay Channel within the HLSA.

Three water supply wells (WSWs) have been completed by STP within the MacKay Channel. WSW1 (at 08-08-91-14-W4M), WSW2 (at 16-08-91-14-W4M) and WSW3 (at 15-08-91-14-W4M). Observation wells are installed at two of these locations within the Empress Formation, and in sand intervals within the overlying undifferentiated drift. Constant rate pump tests have identified higher horizontal hydraulic conductivity in the channel thalweg (up to 5.0×10^{-4} m/s) than at the margins of the channel deposits (*i.e.*, 4.8×10^{-5} m/s). The storativity was calculated as 2.6×10^{-4} for the MacKay Channel Empress Aquifer.

Information from wells within the Birch Channel and Thickwood Channels indicates comparable aquifer characteristics and a similar pattern of higher hydraulic conductivities along the thalweg was also observed in the Birch Channel (Petro-Canada 2005).

During the pumping tests completed by STP, the MacKay Channel Empress Aquifer demonstrated confined aquifer behaviour with no drawdown observed in the shallower sand units. Geological mapping and pumping test responses indicate a hydraulic connection between the MacKay Channel Empress Aquifer and the Grand Rapids Sand 5 aquifer.

A comparison of water level measurements within the Empress Formation and the overlying glacial drift indicate a downward vertical gradient (CR #3, Figure 17). The average vertical gradient is 0.04 m/m. Limited hydraulic head measurements are available for the Empress Aquifer and indicate generally higher heads in the Birch and Thickwood Channels with the exception of measurements in 93-12-W4M which are the lowest within the Birch-MacKay Channel network and suggest groundwater flow towards the northeast. The average groundwater flow rate within the MacKay Channel Empress Formation is estimated at 36 m per year.

The groundwater within the MacKay Channel Empress aquifer is of sodium bicarbonate type with a TDS from 780 to 1,160 mg/L (CR #3, Appendix B, Table B2).

D.3.2.3 Grand Rapids Aquifer/Aquitard

The Grand Rapids Formation is a regional aquifer (Bachu et al. 1993). Within the HRSA the Grand Rapids 3, 4 and 5 sand units form individual aquifers separated by intervals of shale. The Grand Rapids Formation in its entirety is referred to as the Grand Rapids aquifer/aquitard to reflect the variable behaviour of this unit. Characteristics of the Grand Rapids include:

- hydraulic conductivity of Grand Rapids 4 was found to be 6×10^{-5} m/s which is slightly higher than the value reported by AOSC (2009) of 7×10^{-6} m/s;
- hydraulic conductivity of Grand Rapids 3 is reported to average 1×10^{-5} m/s (AOSC 2009);
- the mean hydraulic conductivity for the Grand Rapids 5 Sand is 9×10^{-7} m/s;
- a upward hydraulic gradient with the hydraulic head in the Grand Rapids 4 Aquifer roughly 20 m higher than in the Grand Rapids 5 Aquifer; and
- in the HLSA the groundwater is of sodium-bicarbonate type with the Grand Rapids 4 having a TDS of 1,180 mg/L and the Grand Rapids 5 approximately 2,100 mg/L in sand within the HLSA which is higher overall than other measurements within the HRSA, which range up to 1,340 mg/L at 01-23-093-017-W4M (AOSC 2009).

D.3.2.4 Clearwater Aquitard

The Clearwater Formation is considered a regional aquitard (Bachu et al. 1993) and is continuous across the HRSA. Characteristics of the Clearwater Aquitard are as follows:

- minimum thickness of 45 m within the HLSA;
- mean hydraulic conductivity reported to be 5.0 x 10^{-9} (Petro-Canada 2005) to 5.4 x 10^{-7} m/s (Hackbarth and Nastasa 1979); and
- non-saline groundwater of sodium bicarbonate-chloride type, although other areas have reported sodium bicarbonate-sulphate type water and some saline groundwater with TDS up to 5,700 mg/L (Petro-Canada 2005).

D.3.2.5 Wabiskaw/McMurray Aquitard and Basal McMurray Aquifer

The Wabiskaw and McMurray are primarily bitumen saturated within the HRSA. As a result these units are anticipated as having a low hydraulic conductivity and are considered an aquitard. Only thin water-saturated zones of limited lateral extent are identified at the base of the McMurray Formation which could form local aquifers.

The McMurray Formation water quality is saline, of sodium-chloride type water and with reported TDS from 5,480 to over 10,000 mg/L (Petro-Canada 2005, AOSC 2009).

D.3.2.6 Beaverhill Lake Aquifer/Aquitard

The uppermost Devonian units are mapped as the Beaverhill Lake Group which is regionally interpreted as an aquifer (Bachu et al. 1993). Characteristics are as follows:

- low conductivities and tests in the HRSA indicate hydraulic conductivities in the Beaverhill Lake Group of 5 x 10^{-9} to 10^{-10} m/s (Hackbarth and Nastasta 1979);
- a review of available geophysical logs indicated a generally tight sequence, with no evidence of reefs; and
- groundwater is expected to be saline with TDS ranging from 7,000 to 11,000.

D.3.2.7 Groundwater Flow System

Groundwater flow within aquifers above the pre-Cretaceous unconformity is expected to be driven by physiography, with recharge in upland areas and flow towards topographic lows. The Birch Mountains and Thickwood Hills are expected to form areas of recharge with groundwater movement predominantly downwards and away from these topographic features. The Athabasca River is a regional groundwater discharge area for most Cretaceous units and the Devonian Waterways Formation, which subcrops along much of the river valley. Groundwater flow within the MacKay Plain is therefore expected to be generally eastward towards the Athabasca river valley. Higher hydraulic heads are observed within the Birch and Thickwood Channels underlying or adjacent to the upland areas and lower hydraulic heads are found in the Birch Channel towards the Athabasca River, which is consistent with this interpretation.

Generally downward hydraulic gradients are observed; however this is attributed to alternating high and low permeability layers in combination with the topographic relief (Hackbarth and Nastasa 1979), which restricts groundwater movement downward, resulting in the dominance of lateral groundwater flow.

Groundwater flow within the Undifferentiated Drift Aquifer/Aquitard is also expected to be topographically driven, but the result of more subtle changes in topography. Small areas that are topographically elevated could form localized areas of recharge with flow towards nearby topographic lows or into nearby surface water bodies. The overall result is a more complex pattern of hydraulic heads reflecting the local topography and shorter flow paths than those anticipated in the Cretaceous and Upper Devonian units.

D.3.2.8 Groundwater Use

A total of 164 water well records are on file with AENV within the RSA. Of these records, roughly one third are for observation or monitoring wells and another third are for industrial wells. Only 22 records were identified for domestic wells and the use of the remaining wells is unknown. The nearest domestic water well is approximately 13 km to the west of the Phase 2 Project. Active groundwater production from the Empress Formation within the RSA is occurring at licensed Suncor wells located in Township 93 Range 12. Suncor's allocations from the Empress Formation total 1,213,904 m^3 annually. STP has a license for Phase 1 in the amount of 419,750 m^3 annually from the Empress Formation. No other withdrawals appear to be currently allocated from the Empress Formation within the RSA.

D.3.3 Predicted Conditions

The valued environmental components (VECs) for hydrogeology are water quantity (water levels) and/or water quality. The assessment evaluates the following;

- effects of the groundwater withdrawals on water quantity;
- effects of the surface facilities on water quality; and
- effects of the production and injection wells on water quality.

D.3.3.1 Groundwater Withdrawal

The water demands for Phase 2 include start-up and make-up water for steam generation, sanitary and potable water. The estimated water demand for make-up water is 4,000 m^3/d for the first two years during start up and 1,708 m^3/d for steady state operations (Section B.7.1). A review of potential groundwater sources was undertaken in accordance with the Water Conservation and Allocation Guideline for Oilfield Injection (AENV 2006) in which non-saline groundwater use for enhanced oil recovery is to be reduced or eliminated. Saline groundwater is frequently considered the most feasible alternative to non-saline groundwater use, however, it is not readily available or practically accessible in the RSA.

STP plans to obtain water for Phase 2 from the Empress Formation. The Suncor Dover and MacKay Projects have approved withdrawals from the Birch Channel which began in 1984. The STP Phase 1 Project has an approved withdrawal from the MacKay Channel that is anticipated to begin production in 2012. AOSC's MacKay River Pilot Project was scheduled to begin producing groundwater from the Grand Rapids 4 and 5 Aquifers in 2010, although it is noted that no approvals have been issued yet for groundwater withdrawals. The withdrawal schedule and aquifers used by each of these projects is summarized in Table D.3.1.

Table D.3.1 Groundwater Production Schedule within the RSA (m^3/day) for Baseline and Application Cases

Project		Suncor Dover and MacKay	AOSC MacKay River Pilot Project	STP - Phase 1	STP - Phase 2
Aquifer Unit		Empress	Grand Rapids 4 and 5	Empress	Empress
Case	Baseline	✓	✓	✓	
	Application	✓	✓	✓	✓
Start Date	End Date				
Oct-84	Sep-92	212			
Oct-92	Sep-95	907			
Oct-95	Sep-00	1487			
Oct-00	Sep-02	480			
Oct-02	Sep-06	1480			
Oct-06	Sep-09	1735			
Oct-09	Mar-10	5200			
Apr-10	Dec-10	4000	65		
Jan-11	Dec-11	4000	245		
Jan-12	Dec-12	4000	218	1060	
Jan-13	Dec-13	4000	201	882	
Jan-14	Dec-14	4000	180	596	4000

Table D.3.1 Groundwater Production Schedule within the RSA (m^3/day) for Baseline and Application Cases

Project		Suncor Dover and MacKay	AOSC MacKay River Pilot Project	STP - Phase 1	STP - Phase 2
Jan-15	Dec-15	4000		596	4000
Jan-16	May-35	4000		596	1708
Apr-35	Dec-41			596	1708
Jan-42	Dec-46			202	

Pumping of groundwater from a water supply well causes the formation pressure to decrease. This decrease in pressure spreads outwards over time as a cone of pressure in the potentiometric surface. The reduction in formation pressure could reduce available production for other wells that are completed in the same formation and could also alter seepage from or discharge to hydraulically-connected surface water bodies or other aquifers.

A numerical groundwater flow model was prepared to complete the assessment of potential impacts due to groundwater production from the Empress Formation. The model was developed using the finite difference code of United States Geological Survey (USGS) MODFLOW (McDonald and Harbaugh 1988) and the Visual MODFLOW interface developed by Schlumberger Water Services (2010). A complete description of the conceptual model, numerical model construction and calibration is included in CR #3, Appendix C.

For the Empress Aquifer the model of the Baseline Case predicted a maximum drawdown of 6 m at the STP source wells and 13 m at the Suncor source wells. For the Application case the maximum drawdown in the Empress Formation near the STP source wells is 16 m and 15 m near the Suncor source wells. Percent reduction in groundwater level is calculated as 14% at the STP source wells and 7% at the Suncor source wells. Potential effects of withdrawal on groundwater quantity in the Empress Formation are rated as Low Impact.

For the Grand Rapids Aquifers the model of the Baseline Case predicted a drawdown of 1.5 m for the Grand Rapids 5 Aquifer and 3 m for the Grand Rapids 4 Aquifer. For the Application Case the model predicted a 3 m drawdown for the Grand Rapids 5 Aquifer and 6 m for the Grand Rapids 4 Aquifer. The percent reduction in groundwater level associated with the Phase 2 Project production is therefore 3 % for the Grand Rapids 5 Aquifer and 6 % for the Grand Rapids 4 Aquifer. Potential effects of withdrawal on groundwater quantity in the Grand Rapids Aquifers are rated as Low Impact.

Shallow drift aquifers are understood to be of limited extent and therefore drawdown impacts would be transmitted through the low permeability clay rich materials. For the Baseline Case drawdowns in the base of the drift, vary from 0 to 6 m near STP up to 13 m near Suncor. The extent of the drawdown cone (based on the 1 m drawdown contour interval) is approximately 10 km to the west of STP, 15 km to the south and extending northeast towards Suncor. For the Application Case the model predicted a maximum drawdown of 15 m near STP and 14 m at Suncor. The percent change in drawdown could be of high magnitude in the area immediately around STP, whereas at Suncor the incremental increase in drawdown due to Project effects is likely low. The only groundwater wells indicated completed within the surficial drift for domestic use are Suncor wells where Project effects are anticipated to be low. Overall, the potential effects of groundwater withdrawals on groundwater quantity in the shallow drift aquifers are rated as Low Impact.

The hydraulic head elevation of the Grand Rapids 4 Aquifer, which is the uppermost aquifer unit at STP, is 458 masl (CR #3, Appendix B, Table B1) near the MacKay River relative to a river elevation of about 450 masl. This indicates a hydraulic relationship which is consistently observed between the MacKay River and the groundwater units (*i.e.*, shallow drift, the Grand Rapids 4 and 5 Aquifers and the Empress Aquifer), where the groundwater units have higher hydraulic heads compared to the river and are therefore providing recharge to the river.

An estimate of the flux change for MacKay River was made using an average drawdown of 3 m for the Baseline Case simulation and 7 m for the Application Case. Groundwater flux to the MacKay River is calculated as 0.01 m^3/s for the Baseline Case and 0.003 m^3/s for the Application Case. Thus the groundwater units are expected to continue to provide recharge to the MacKay River at a reduced rate. Relative to the mean seasonal flow of the MacKay River, which is 2.46 m/s (nhc 2011), the baseline recharge represents only 0.5% and any reduction in this amount would be quantitatively negligible. Potential Project effects related to groundwater withdrawals on water quantity in surface water bodies and wetland areas were rated as Low Impact.

Planned Development Case

The numerical groundwater model used in the assessment of groundwater withdrawals (CR #3, Section 5.1.2) was used to complete the cumulative effects assessment.

The planned development case includes anticipated withdrawals associated with anticipated projects in addition to those included in the Application Case. Planned projects include Athabasca Oil Sands Corporation's MacKay Commercial Project (AOSC 2009), the Dover Central Pilot Project and the Dover Commercial Project (Dover 2010). The MacKay Commercial Project is proposing to utilize groundwater from the Empress Aquifer to the south of the Phase 2 Project beginning in 2012. The Dover Central Pilot Project intends to use a water supply from the Grand Rapids 3 Aquifer and Empress Formation beginning in 2013. The Dover

Commercial Project application concluded that the groundwater diversion identified for the Pilot Project would also be utilized, so no additional withdrawals have been assigned for this project (Dover 2010). The withdrawal schedule and aquifers used by these planned projects is summarized in Table D.3.2.

Table D.3.2 Groundwater Production Schedule within the HRSA (m^3/day) for Planned Development Case

Project		AOSC MacKay River Commercial Project	Dover Central Pilot Project	
Aquifer Unit		Empress	Grand Rapids 3	Empress
Start Date	End Date			
Jan-12	Dec-12	320		
Jan-13	Aug-13	320	541	
Sep-13	Jun-14	1955	541	
Jul-14	Dec-14	5800	541	
Jan-15	May-15	4800	541	
Jun-15	Jun-15	4800	3382	4559
Jul-15	Nov-15	3500	3382	4559
Dec-15	May-16	3500	3382	1266
Jun-16	Jun-59	3500	3382	
Jul-59	Jun-63		3382	

In the Empress Aquifer the maximum predicted drawdown was 24 m near the STP wells and 16 m at the Suncor wells and occurred after the cessation of pumping at the Suncor projects in 2035. The increased drawdown in the area of Phase 2 is mainly the result of additional production from the AOSC MacKay River Commercial Project which plans to withdraw a minimum of 3,500 m^3/day from the Empress Aquifer to the south of STP from 2014 to 2059. The percent reduction in groundwater level is calculated as 26 % near the STP source wells and 10 % at the Suncor source wells. Cumulative effects related to effects of groundwater withdrawals on groundwater quantity (water levels) in the Empress Aquifer are rated as moderate.

In the Grand Rapids Aquifers the maximum predicted drawdown was 6 m for the Grand Rapids 5 Aquifer and 11 m for the Grand Rapids 4 Aquifer. The percent reduction in groundwater level is therefore 9 % for the Grand Rapids 5 Aquifer and 17 % for the Grand Rapids 4 Aquifer. Cumulative effects related to effects of groundwater withdrawals on groundwater quantity in the Grand Rapids Aquifers are rated as Low Impact.

Predicted drawdown in the base of the drift is noticeably greater in extent in the planned case as a result of production at the Dover Central Project. Maximum drawdown will vary from 0 to 24 m near STP and up to 15 m near Suncor. The only groundwater wells identified as completed within the surficial drift for domestic use are Suncor wells; the cumulative effects to these wells are anticipated to be low. Cumulative effects related to effects of groundwater withdrawals on groundwater quantity in the shallow drift aquifers are rated as Low Impact.

Assuming that the baseline conditions at STP are a reasonable approximation of the regional conditions, an average drawdown of 12 m was assumed for the Planned Development Case. Using this assumption the groundwater flux to the MacKay River is calculated as -0.02 m^3/s. This indicates the potential for a shift in the hydraulic relationship between the MacKay River and underlying groundwater units with the MacKay River now supplying recharge to the groundwater units. Relative to the mean seasonal flow of the MacKay River, which is 2.46 m/s (nhc 2011), this loss (-0.02 m^3/s) from the MacKay River is negligible. Cumulative effects related to effects of groundwater withdrawals on water quantity in surface water bodies and wetland areas are rated as Low Impact.

D.3.3.2 Surface Facilities

Application Case

As a result of the best management practices and material handling methods outlined in Part B.5, there should be no possibility of potential effects to shallow groundwater quality, except through upset conditions, *i.e.*, accidental spills or leaks. Accidental releases may allow fluids to seep into the ground where they could alter shallow groundwater quality.

The CPF is located in an area that is anticipated to have intervals of sand underlain by clay rich deposits. Groundwater flow rates are anticipated to be variable; up to four metres per year within the sands, but generally slow within the clay rich deposits. It is expected that the sand will be removed and/or covered with compacted material which will reduce infiltration and allow runoff control to the storm water pond, which would facilitate the control of any surface contamination. With mitigation, application case effects are rated as Low Impact.

Planned Development Case

Project effects associated with surface facilities are evaluated as local in extent and therefore a cumulative effects assessment is not required for these components.

D.3.3.3 Production and Injection Wells

Application Case

Thermal changes along the well bore of the injection wells have the potential to locally alter groundwater chemistry in non-saline aquifers due to the response of geologic materials to heating along the well bore. In addition, potential accidental releases due to casing failure have the potential to impact groundwater quality of non-saline aquifers underlying Phase 2.

Dissolution of minerals resulting in increased concentrations of dissolved arsenic in the area of a thermal plume has been comprehensively investigated in the Cold Lake area (Canadian Natural Resources Ltd. (CNRL) 2006, CNRL 2009, Imperial Oil Limited 2009, and Fennell 2008) and these studies demonstrate the following;

- naturally occurring arsenic in the glacial deposits is mobilized (from minerals to water) by the change in the thermal regime caused by heat released into the glacial deposits from in-situ steam processes;
- concentrations of arsenic within tills in the Cold Lake area range up to 14 mg/kg (Andriashek 2000, Andriashek 2003)
- Arsenic moves with the groundwater flow, but with a retardation factor of approximately 1.6 (*i.e.*, 60% the distance that groundwater would move in the same time) due to sorption and mineral precipitation reactions;
- Arsenic concentrations are attenuated to background down gradient as the thermal regime returns to ambient temperature;
- velocity of groundwater flow is a major factor in the distance of movement down gradient; however the ultimate control lies with the temperature; and
- the operative distance for attenuation in the field is less than 400 m.

A till sample from 6 m beneath the Phase 1 CPF was found to have an arsenic concentration of 11 mg/kg, which is comparable to the concentrations measured in the Cold Lake tills. Baseline groundwater concentrations of arsenic have been measured within the undifferentiated drift, the Empress Formation, and the Grand Rapids sands in the HLSA and range up to 0.009 mg/L in the Empress Formation. Based on this information, there is potential for elevated arsenic concentrations to occur within non-saline aquifers underlying Phase 2 that could extend approximately 250 m from the injection well within the Empress Formation. Groundwater monitoring will be implemented to enable detection of any effects to groundwater quality in non-saline aquifers. Potential Project effects related to operation of the production/injection wells on groundwater quality are rated as Low Impact.

Industry best practices and regulatory requirements associated with the production and injection wells relate to their construction, operating pressures and operational monitoring (Section B.4). As a result of these measures, casing failure and leakage into a non-saline aquifer during operations should not occur. Therefore it is determined that there is no potential Project impact on groundwater quality in non-saline aquifers.

Planned Development Case

Project effects associated with injection and production wells are evaluated as local in extent and therefore a cumulative effects assessment is not required.

D.3.4 Mitigation and Monitoring

D.3.4.1 Mitigation

In order to reduce the potential impact to groundwater resources STP will:

- develop a spill response plan to mitigate effects in the event of upset conditions;
- develop a groundwater monitoring program to and enable early detection of any effects to groundwater quality and quantity;
- implement a Groundwater Response Plan in the case that monitoring identifies a change in groundwater quality; and
- in the event of a material change in water levels implement mitigative actions such as: reducing pumping rates in one or more of the water source wells, adding more source wells to modify the drawdown distribution, completing water source wells in other aquifer units or utilizing alternative water sources.

D.3.4.2 Monitoring

In order to monitor the effectiveness of the mitigation measures STP will:

- monitor water quality in non-saline aquifer units, *i.e.*, shallow drift aquifers, Grand Rapids Aquifers and the Empress Aquifer in locations near well pads; and
- monitor water levels in the water source wells in addition to monitoring wells installed within the shallow drift aquifers, Grand Rapids Aquifers and Empress Aquifer.

D.3.5 Summary of VECs

A summary of the significance of potential impacts and effects on valued environmental components (VECs) for the different assessment cases is provided in Table D.3.3.

Table D.3.3 Summary of Impact Ratings on Groundwater Valued Environmental Components

VEC	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent of Impact or Effect[1]	Duration of Impact or Effect[2]	Frequency of Impact or Effect[3]	Ability for Recovery from Impact or Effect[4]	Magnitude of Impact or Effect[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Impact or Effect Occurrence[8]	Significance[9]
1. Groundwater Quantity												
Empress Aquifer	Groundwater Withdrawals	Section D.3.4.1	Application	Regional	Residual	Continuous	Reversible – long term	Low	Negative	Moderate	High	Low Impact
			CEA	Regional	Residual	Continuous	Reversible – long term	Moderate	Negative	Moderate	High	Moderate Impact
Surface Water Bodies and Wetlands			Application	Regional	Residual	Continuous	Reversible – long term	Negligible	Negative	Low	Medium	Low Impact
			CEA	Regional	Residual	Continuous	Reversible – long term	Negligible	Negative	Low	Medium	Low Impact
Shallow Drift Aquifers			Application	Regional	Residual	Continuous	Reversible – long term	Low	Negative	Low	Medium	Low Impact
			CEA	Regional	Residual	Continuous	Reversible – long term	Low	Negative	Low	Medium	Low Impact
Grand Rapids Aquifers			Application	Regional	Residual	Continuous	Reversible – long term	Low	Negative	Moderate	Medium	Low Impact
			CEA	Regional	Residual	Continuous	Reversible – long term	Moderate	Negative	Moderate	Medium	Low Impact
2. Groundwater quality												
Shallow Drift Aquifers	Surface Facilities	Section D.3.4.1	Application	Local	Long-term	Occasional	Reversible – long term	Moderate	Negative	Moderate	Medium	Low Impact
			CEA	Not evaluated due to local extent of Project effects.								
Shallow Drift Aquifers	Production and Steaming	Section D.3.4.1	Application	Local	Long-term	Isolated	Reversible – long term	Low	Negative	Moderate	Medium	Low Impact
			CEA	Not evaluated due to local extent of Project effects.								
Surface Water Bodies and Wetlands			Application	Neutral	NA	NA	NA	NA	NA	Moderate	NA	No Impact
			CEA	Not evaluated due to local extent of Project effects.								
Empress Aquifer			Application	Local	Long-term	Isolated	Reversible – long term	Low	Negative	Moderate	Medium	Low Impact
			CEA	Not evaluated due to local extent of Project effects.								
Grand Rapids Aquifers			Application	Local	Long-term	Isolated	Reversible – long term	Low	Negative	Moderate	Medium	Low Impact
			CEA	Not evaluated due to local extent of Project effects.								

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.4 Historical Resources

D.4.1 Introduction

STP conducted an assessment of historical resources for the proposed Project. The following section is a summary of the Historical Resource Impact Assessment (HRIA) that was prepared by Stantec. The full HRIA was submitted under separate cover to Alberta Culture and Community Services.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the historical resource component are provided in Section 4.0 and are as follows:

4.0 Historic Resources

4.1.1 Baseline Information

[A] Provide a brief overview of the regional historical resources setting including a discussion of the relevant archaeological, historic and paleontological records.

[B] Describe and map known historic resources sites in the Project Area, considering:

- *a) site type and assigned Historic Resources Values (HRVs); and*
- *b) existing site specific Historical Resources Act requirements (if applicable).*

[C] Provide an overview of previous Historical Resources Impact Assessment (HRIAs) that have been conducted within the Project Area, including:

- *a) a description of the spatial extent of previous assessments relative to the Project Area, noting any assessment gap areas; and*
- *b) a summary of Historical Resources Act requirements and/or clearances that have been issued for the Project to date (if applicable).*

[D] Identify locations within the Project Area that are likely to contain previously unrecorded historic resources. Thoroughly describe the methods used to identify these areas.

4.1.2 Impact Assessment

[A] Describe Project components and activities that have the potential to affect historic resources at all stages of the Project.

[B] Describe the nature and significance of the potential Project impacts on historical resources, considering:

- *a) effects on historic resources site integrity; and*
- *b) implications for the interpretation of the archaeological, historic and paleontological records.*

[C] Discuss mitigation measures that can be used to minimize impacts on historical resources. Clearly identify those mitigation measures that will be implemented and provide rationale for their selection.

In Alberta, historical resources are protected under the Alberta *Historical Resources Act,* and are defined as Precontact, Historic, and paleontological sites and their contents. Cultural landscapes and traditional use sites may also be associated with historical resources. Due to the fact that Precontact archaeological, Historical, paleontological and traditional land use sites represent discrete episodes of past activities, they are non-renewable and, therefore, are susceptible to alteration or removal by modern industrial development. Precontact and historic archaeological resources are comprised of residues of past cultures or societies. Although the cultural entities responsible for deposition of the archaeological material are unavailable for observation, the preserved context and associations in which the remains functioned can reveal many clues about past human behaviour, adaptations and relationships to the natural world. The key to the interpretation of these resources, however, is in their pattern of cultural deposition, which is extremely fragile, ephemeral and the product of unique processes and conditions of preservation. Consequently, once they are disturbed, they cannot be replaced, re-created or restored. Due to the nature of their origin and preservation, archaeological resources are finite in quantity. As a result, archaeological resources are increasingly susceptible to destruction and depletion through natural and cultural disturbances.

The assessment of Historical Resources included:

- review of existing records;
- creation of a predictive model; and
- ground reconnaissance.

D.4.2 Baseline Conditions

The Phase 2 Project is location within Borden Blocks HfPa and HfPb. No previously recorded archaeological sites are located within these Borden Blocks. No historic or paleontological sites have been previously recorded within proximity of Phase 2. There are no Sections with Historic Resources Values (HRVs) within proximity of Phase 2.

To determine the relative ranking of terrain features in terms of potential to identify precontact historical resources, a predictive model was developed using Geographic Information Systems (GIS) technology. Overall the footprint for the initial development is located on areas of low and low to moderate potential although some areas of high potential are present. Although the predictive model served as a guide to focus the investigation, field archaeologists were not restricted to the model; the model does not reflect the presence of smaller areas of good potential, such as knolls, due to the scale and nature of the databases used. As such, archaeologists used judgment based on experience and in field observations, as well as the predictive model, to select areas of assessment.

The ground reconnaissance consisted of a pedestrian traverse and intensive visual examination of fortuitous exposures and a shovel testing program within targeted areas with archaeological potential within the Phase 2 Project area. Areas targeted for assessment included landforms associated with bodies of water in addition to elevated, well-drained landforms.

All fortuitous exposures such as seismic lines, game trails, erosional surfaces and tree throws were examined for cultural materials. Visual inspection of these areas was considered adequate for assessing the presence of near surface cultural remains. Excavation of shovel tests (n=194), each approximately 40 cm X 40 cm, was conducted in areas of limited exposure or in areas deemed to have potential for buried cultural deposits.

D.4.3 Predicted Conditions

During the course of the assessment, no archaeological, historic or paleontological sites were located and no previously recorded sites were revisited. Therefore, it is recommended that STP be granted *Historical Resources Act* clearance for the proposed STP McKay Thermal Project – Phase 2 initial development footprint (Figure A.1.3).

D.4.4 Mitigation and Monitoring

In order to reduce potential impacts of Phase 2 on historic resources STP will:

- apply to ACCS for clearance to develop new facilities, as required;
- undertake mitigation recommended by ACCS; and
- notify ACCS if a historic resource not previously identified is encountered during construction of Project facilities.

D.4.5 Summary

During the course of the assessment, no archaeological, historic or paleontological sites were located and no previously recorded sites were revisited. Therefore, it is recommended that STP be granted *Historical Resources Act* clearance for the proposed STP McKay Thermal Project – Phase 2 initial development.

D.5 Human and Wildlife Health

D.5.1 Introduction and Terms of Reference

STP conducted a human health risk assessment for Phase 2. The following section is a summary of the Human Health Risk Assessment (HHRA) that was prepared by Intrinsik Environmental Sciences Inc. (Intrinsik) and included as Consultants Report #5 (CR #5). For full details of the assessment please refer to CR #5.

Intrinsik also conducted a Screening Level Wildlife Risk Assessment (SLWRA) for the proposed project. The following summary also includes select information from the SLWRA included as Appendix F of CR #5.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the human health component are provided in Section 6.0 and potential effects of air quality on wildlife are in Section 3.7.2:

6.0 PUBLIC HEALTH AND SAFETY

6.1 Public Health

[A] Describe those aspects of the Project that may have implications for public health or the delivery of regional health services. Determine quantitatively whether there may be implications for public health arising from the Project.

[B] Document any health concerns raised by stakeholders during consultation on the Project.

[C] Document any health concerns identified by aboriginal communities or groups resulting from impacts of existing development and of the Project specifically on their traditional lifestyle and include an aboriginal receptor type in the assessment.

[D] Describe the potential health impacts resulting from higher regional traffic volumes and the increased risk of accidental leaks and spills.

[E] Discuss mitigation strategies to minimize the potential impact of the Project on human health.

6.2 Public Safety

[A] Describe those aspects of the Project that may have implications for public safety. Determine whether there may be implications for public safety arising from the Project. Specifically:

- *a) describe the Proponent's emergency response plan, including public notification protocol and safety procedures, to minimize adverse environmental effects, including emergency reporting procedures for spill containment and management;*
- *b) document any safety concerns raised by stakeholders during consultation on the Project;*
- *c) describe how local residents will be contacted during an emergency and the type of information that will be communicated to them;*
- *d) describe the existing agreements with area municipalities or industry groups such as safety cooperatives, emergency response associations, regional mutual aid programs and municipal emergency response agencies; and*
- *e) describe the potential safety impacts resulting from higher regional traffic volumes.*

3.7.2 Wildlife Impact Assessment

[A] Describe and assess the potential impacts of the Project to wildlife and wildlife habitats, considering:

e) potential effects on wildlife resulting from changes to air and water quality, including both acute and chronic effects to animal health;

This HHRA describes the nature and significance of the potential short-term (*i.e.*, acute) and long-term (*i.e.*, chronic) health risks posed to people exposed to the Chemicals of Potential Concern (COPCs) emitted or released from the Phase 2 Project. The HHRA examines the potential health risks attributable to Phase 2 in combination with existing, approved and planned emission sources in the region. The SLWRA addresses the same components with respect to effects on wildlife.

The HHRA and SLWRA focused on the potential health risks associated with chemical concentrations in the LSA and RSA which are consistent with the Air Quality Study areas (Section D.1 and CR #1)

Health was raised as one of the key issues of concern, with residents in the area indicating that they are concerned about an overall deterioration in air quality, water quality and traditional food quality (*i.e.*, fish and game). This concern is addressed in this HHRA, specifically as it relates to potential health effects associated with air and water quality changes.

The HHRA assessed both short and long term health risks associated with the chemicals emitted from Phase 2 and the SLWRA assessed both short and long term health risks to wildlife. The two exposure durations used can be described as follows:

- acute where the exposure extends over a time period covering minutes to a day; and
- chronic where the exposure occurs continuously or regularly over extended periods, lasting for periods of months to years, and possibly extending over an entire lifetime.

Although the operational life of Phase 2 is expected to be 25 years, the HHRA assumed that the chemical emissions attributable to Phase 2 would continue for a period of 80 years. The assumption of 80 years coincides with a person's assumed lifespan (Health Canada 2009a).

D.5.2 Assessment Approach

In 2010, Alberta Health and Wellness (AHW) developed what was intended to be a step-by-step process for undertaking focused HHRA of in situ oil sands developments. The intent was that applicants would be able to make certain modifications to the approach typically adopted for risk assessments in order to reduce the level of complexity and shorten the regulatory review period.

In order for an in situ project to qualify for a focused HHRA, Phase 2 needs to meet a number of conditions, namely:

- there must be a recent Environmental Impact Assessment (EIA) available that can be used as a partial surrogate for the proposed project;
- this surrogate EIA must contain relevant Baseline, Application and Planned Development assessment cases and contain a comprehensive HHRA applicable to the proposed project; and,
- there must be sufficient and applicable regional environmental (*i.e.*, measured) data available in the region of the proposed project.

The Phase 2 Project meets the requirements and is located in close proximity to the following three SAGD projects:

- Petro-Canada/Suncor MacKay River Expansion Project (Petro-Canada 2007);
- proposed AOSC MacKay River Commercial Project (AOSC 2009); and
- proposed Dover Commercial Project (DOC 2010).

Phase 2 will utilize similar well-established in situ technology currently proposed for the Dover and AOSC commercial facilities, and approved for the Suncor MacKay River Expansion facility. AHW and STP determined that Phase 2 meets the conditions and criteria required to proceed to a focused HHRA. In consultation with AHW a detailed work plan was developed (CR #5, Appendix G). This approved work plan outlines the information requirements and scope of work required for the focused HHRA.

The potential health risks associated with Phase 2 emissions were examined using a conventional risk assessment paradigm. The risk assessment paradigm is consistent with those developed by Health Canada (1995; 2009a), the Canadian Council of Ministers of the Environment (CCME 2006), and the US Environmental Protection Agency (US EPA 2005). This approach has been endorsed by a number of provincial regulatory authorities in the past, including Alberta Environment, Alberta Health and Wellness, and the Alberta Energy Resources and Conservation Board (ERCB).

The risk assessment paradigm for both the HHRA and SLWRA involves the following steps (CR #5, Figure 3.1):

- Problem Formulation: identification of the COPCs associated with Project emissions, characterization of people potentially ‘at risk’ and identification of relevant exposure pathways.
- Exposure Assessment: quantification of the potential amount or dose of each COPC that could be received by humans through all relevant exposure pathways. Exposure

pathways assessed include air inhalation as well as exposures via soil, water, plants, berries, wild game and fish.

- Toxicity Assessment: identification of potential adverse health effects associated with exposure to each of the COPCs, the conditions under which these effects are observed and determination of the maximum safe dose of the chemical for sensitive individuals following exposure for a prescribed period (*i.e.*, identification of acute and chronic exposure limits for the COPCs).
- Risk Characterization: comparison of estimated exposures (identified in the exposure assessment) with exposure limits (identified during the toxicity assessment) to identify potential health risks for the different assessment cases, as well as discussion of sources of uncertainties and how these were addressed.

D.5.2.1 Problem Formulation

Identification of Chemicals of Potential Concern

The COPCs for Phase 2 were identified through the development of a comprehensive inventory of chemicals that could be emitted by the Phase 2 Project and to which people might be exposed. Development of the initial chemical inventory considered both possible Project air emissions and water releases.

The selection of COPCs for this Project also took into consideration whether or not sufficient toxicological information is available to assess the potential health risks; and, the availability of chemical surrogates to represent any of the substances or groups of substances for which limited toxicological information is available.

Only Project emissions or releases resulting in potential changes to environmental quality were considered as COPCs within the HHRA. As Phase 2 will not release any chemicals into groundwater or surface water, the COPCs for the HHRA were based on air emissions only.

The COPCs that were included in the HHRA are listed in CR #5, Appendix A and for the SLWRA in CR #5, Table F-7. In general the COPCs include:

- polycyclic aromatic hydrocarbons (PAH);
- petroleum hydrocarbon (PHC) fractions;
- reduced sulfur compounds (RSCs);
- volatile organic carbons (VOCs); and
- criteria air contaminants (CAC).

All of the COPCs emitted to air from Phase 2 were evaluated using a toxic potency screen in order to determine which COPCs would most likely pose a potential health hazard and contribute the majority of the total toxic potential of the air emissions. A number of screening methods can be used to narrow a list of chemicals for further analysis. These include:

- using the COPCs' emission rates and exposure limits to determine their relative toxic potencies;
- identifying COPCs viewed as a concern by regulatory authorities for the oil sands region; and
- identifying those COPCs for which elevated risks were predicted in previous HHRAs.

Identification and Characterization of Receptors

The HHRA was structured to characterize the potential health risks to people who reside in the area over the long-term or use the LSA for traditional (*e.g.*, hunting and gathering) or recreational (*e.g.*, fishing and snowmobile) activities.

Twelve discrete locations within the RSA were selected for consideration in the HHRA (CR #5, Figure 3.2). Of these twelve locations, two are worker camps (*i.e.*, Phase 1 and Phase 2), as workers will be residing in local housing camps within the principal development area during both construction and operation phases. Most of the discrete receptor locations are cabins located within the LSA, while two community locations (*i.e.*, Fort McMurray and Fort McKay) are found outside the LSA. In addition to the discrete locations, the air quality assessment evaluated three MPOIs or maximum ground level air concentrations. These include the RSA-MPOI and two LSA-MPOI locations (*i.e.*, fence line MPOI and local MPOI).

The general types of individuals who were evaluated in the HHRA include:

- **LSA-MPOI:** includes the fence line MPOI and local MPOI and includes people who may be present at the locations where the highest COPC concentration could occur.
- **Residents**: This group of locations represents known aboriginal or urban communities within the study area (*i.e.*, Fort McKay and Fort McMurray). It was assumed that these individuals live permanently in the area, and practice a lifestyle that involves a high level of consumption of local country foods, garden vegetables and traditional plants.
- **Cabins**: includes individuals who may use the cabins located near the Phase 2 Project area as a temporary shelter while engaged in activities such as hunting, fishing or trapping. Although the exact frequency of use is not documented, for the purposes of the HHRA, it was assumed that these individuals use these cabins on a regular basis for several months per year.

- **Workers**: this group includes STP workers staying at camps (*i.e.*, Phase 1 and Phase 2) during both construction and operation phases.

It was assumed that temporary visitors would only be near Phase 2 on a short-term (acute) basis, and that they could be exposed to concentrations equivalent to the LSA MPOI along the Phase 2 Project boundary (*i.e.*, fence line) or within the LSA. Inhalation of the COPCs emitted from Phase 2 to the air was deemed to be the only potential exposure pathway for this group.

Potentially chronically exposed individuals residing in the RSA include additional exposure pathways and include both aboriginals and non-aboriginal people. All age classes (life stages) were considered in a multiple pathway exposure assessment. The five receptor life stages that were included in the HHRA are consistent with Health Canada guidance (Health Canada 2009a):

- infant (0 to 6 months = 0.5 years);
- toddler (7 months to 4 years = 4.5 years);
- child (5 to 11 years = 7 years);
- adolescent (12 to 19 years = 8 years); and
- adult (20 to 80 years = 60 years).

For the assessment of carcinogens, a “composite individual” who represents all life stages (*e.g.*, from infant to adult) was used to represent cumulative exposure over an 80-year lifetime.

D.5.2.2 Exposure Assessment

The following exposure pathways were included in this HHRA (CR #5, Figure 3.3 and 3.4):

- inhalation of air;
- inhalation of dust;
- ingestion of soil (inadvertent);
- ingestion of water;
- ingestion of local above-ground plants (including fruit and vegetables);
- ingestion of local below-ground plants (root vegetables);
- ingestion of local traditional plants (Labrador tea and cattail);
- ingestion of local fish;
- ingestion of local wild game;
- ingestion of water while swimming;
- dermal contact with water; and

- dermal contact with soil.

Inhalation Assessment

Inhalation exposure estimates were based on the results of the air dispersion modeling that was described in Section D.1 and CR #1 and focused on those COPCs identified in the toxic potency screening (CR #5, Appendix A). Predicted air concentrations were presented over different averaging periods (*e.g.*, 10-minute, 1-hour, 8-hour, 24-hour and annual) to allow for the assessment of both acute and chronic health risks. In addition, predicted air concentrations were presented for various assessment cases (*i.e.*, Base Case, Application Case and PDC) to characterize risks from Phase 2 in combination with existing, approved and proposed sources.

Multiple Exposure Pathway Assessment

For the assessment of exposure pathways other than inhalation, physical and chemical screening was performed to identify COPCs emitted from Phase 2 that may deposit to the surrounding terrestrial environment and possibly persist or accumulate in sufficient quantities for people to be exposed via soil, food and water pathways (CR #5, Table 3-7).

Environmental Media Concentrations

Ambient measurements in the area of Phase 2 were included where available to characterize the background or ambient concentrations of COPCs in environmental media. When measured data were not available or analytical results were equivalent or below analytical method detection limits, exposure models were used to predict environmental media concentrations.

D.5.2.3 Toxicity Assessment

The toxicity assessment involves having an understanding of the critical toxicological effects that can result from exposure to the COPCs and the condition in which these effects might occur. Such information is generally obtained from published scientific studies conducted in animals or humans under controlled experimental conditions, or observations from human epidemiological studies that examine the relationship between adverse effects and exposure to individual chemicals or groups of chemicals.

When evaluating the toxicological potential for a substance in relation to health, consideration must be given to the dose to which a person is exposed, as the dose determines the type and potentially the severity of any adverse effects that may be observed. In addition, consideration must be given to the route of exposure (*i.e.*, inhalation, oral, or dermal), as the route of exposure influences absorption, distribution and excretion of the toxicant. Specifically, it is the amount of the substance that is absorbed and reaches the toxicological target in the organism that determines the probability of an adverse effect occurring. Substances may differ greatly with respect to the dosage required to result in an adverse effect, as well as in the mechanism(s) by which the adverse effects are elicited.

Two categories of COPCs were assessed based upon their mechanism of toxicity: threshold and non-threshold COPCs. Threshold substances are generally those that require that a certain level of exposure (or minimum dose) be exceeded before toxic effects occur. In general, threshold substances are non-carcinogenic (*i.e.,* non-cancer causing), but there are some chemicals that demonstrate a mode of carcinogenicity that has a threshold. For threshold substances, it is necessary to evaluate the available information to identify effect-levels at which either no effects are observed (*e.g.,* a no-observed-adverse-effect level [NOAEL] or a no-observed-effect level [NOEL]) or adverse effects are first observed (*e.g.,* a lowest observed adverse effect level [LOAEL] or lowest observed effect level [LOEL]).

Non-threshold substances are carcinogens capable of producing cancer through one or more of a number of possible mechanisms (*e.g.,* mutagenicity, cytotoxicity, inhibition of programmed cell death, mitogenesis [uncontrolled cell proliferation] and immune suppression) that, in theory, do not require the exceedance of a threshold (US EPA OSW 2005). In general, carcinogenic potency data from animals or human epidemiological studies were evaluated by jurisdictional authorities. From these data sets, Unit Risks (URs) or Slope Factors (SFs) are identified, which are in turn used to develop applicable exposure limits (risk specific doses or risk specific concentrations).

Exposure Limits

Exposure limits (also known as toxicological reference values or TRVs) that have been developed by scientific and/or regulatory agencies aimed at the protection of human health were identified for each of the COPCs on both an acute and chronic basis.

Separate assessments were completed for both the acute and chronic exposure scenarios in recognition of the fact that the toxic response produced by chemicals and the target tissues affected can change, depending on whether exposure is short term or long term.

For the purposes of the HHRA, reliance was placed on exposure limits developed by regulatory or reputable scientific agencies as criteria (*i.e.,* objectives, guidelines or standards) for the protection of air quality and human health. By definition, exposure limits may include standards, guidelines, objectives, reference concentrations or doses, cancer risk estimates, etc. that have been derived for the protection of human health.

Chemical Mixtures

Given that chemical exposures rarely occur in isolation, the potential health effects associated with mixtures of the COPCs were assessed in the HHRA. In accordance with Health Canada guidance, additive interactions were assumed for the HHRA (Health Canada 2009a). Additive interactions apply most readily to chemicals that are structurally similar, act toxicologically through similar mechanisms or affect the same target tissue in the body (*i.e.*, share commonality in effect) (Health Canada 2009a).

Potential additive interactions were identified for specific COPCs that may cause:

- eye irritation;
- nasal irritation;
- respiratory irritation; and
- kidney toxicity.

D.5.2.4 Risk Characterization

This final step of the risk assessment involves comparing estimated exposures (identified in the exposure assessment) with exposure limits (identified in the toxicity assessment) to determine potential health risks for the different assessment cases.

Non-Cancer Risks

Risk quotient (RQ) values were calculated by comparing the predicted levels of exposure for the non-carcinogenic COPCs to their respective exposure limits (CR #5, Appendix B) that have been developed by regulatory and scientific authorities. Interpretation of the RQ values is as follows:

- RQ ≤ 1.0: Indicates that the estimated exposure is less than or equal to the exposure limit (*i.e.*, the assumed safe level of exposure). RQ values less than or equal to 1.0 are associated with negligible health risks, even in sensitive individuals given the level of conservatism incorporated in the derivation of the exposure limit and exposure estimate.
- RQ > 1.0: Indicates that the exposure estimate exceeds the exposure limit. This suggests an elevated level of risk, the significance of which must be balanced against the high degree of conservatism incorporated into the risk assessment (*i.e.*, the margin of safety is reduced but not removed entirely).

Cancer Risks

Health Canada (2009a) specifies that carcinogens be assessed on an incremental basis, and mandate an "acceptable" incremental lifetime cancer risk (ILCR) of 1.0 in 100 000. For the purposes of this assessment, ILCR estimates have been determined for Phase 2 alone as well as the incremental contribution of the future emission sources. The future scenario was calculated by subtracting the Baseline case from the PDC and represents the cumulative increase in exposures over Baseline. Interpretation of these ILCR values was based on comparison of the ILCR associated with Phase 2 and future scenario against the Health Canada (2009a) de minimus risk level of 1.0 in 100 000 (*i.e.*, one extra cancer case in a population of 100 000 people).

Interpretation of the ILCR values proceeded as follows:

- ILCR ≤ 1.0: Denotes an incremental lifetime cancer risk that is below the benchmark ILCR of 1.0 in 100,000 (*i.e.*, within the accepted level of risk set by Alberta Environment and Health Canada).
- ILCR > 1.0: Indicates an incremental lifetime cancer risk that is greater than the de minimus risk level of 1.0 in 100,000, the interpretation of which must consider the conservatism incorporated into the assessment.

Wildlife Health

The risk characterization step of the SLWRA for inhalation exposure involved comparing maximum predicted COPC air concentrations for each of the assessment cases to wildlife inhalation toxicological reference values (TRVs). Hazard quotient (HQ) values were then calculated by dividing the predicted contaminant concentration in air by the available TRV.

Interpretation of the predicted HQ values was as follows:

- HQ ≤ 1: estimated maximum exposure is less than the associated TRV, indicating that risks to wildlife are negligible for the COPC.
- HQ >1: estimated maximum exposure is greater than the associated TRV, indicating that potential wildlife health effects may exist.

Maximum predicted COPC soil and surface water concentrations was compared of to soil quality guidelines (CR #5, Table F-13) and surface water quality guidelines (CR #5, Table F-14). Where maximum predicted concentrations did not exceed soil quality guidelines (SQGs) or surface water quality guidelines (SWQG), it was assumed that potential risks to wildlife would be negligible. Where maximum predicted COPC concentrations exceed SQGs or SWQGs, it was assumed that potential wildlife health effects may exist and the potential health risks were discussed further.

D.5.3 Predicted Conditions

D.5.3.1 Acute Inhalation Results

With the exception of SO_2, all acute RQ values were less than 1 (CR #5 Table 4-1 to 4-4), suggesting a low probability of adverse health effects attributable to air emissions. In general, the predicted RQ values for the Application Case were identical to those predicted in the Baseline Case, indicating that Phase 2 emissions are expected to have a negligible impact on predicted health risks.

The predicted 10-minute and 1-hour SO_2 RQ values exceed health-based exposure limits only at the LSA-MPOI and two cabin locations (*i.e.*, R2 and R3) in the Baseline, Application and PDC. All other RQ values for SO_2 are less than 1.0. Phase 2 is not expected to increase the likelihood of the SO_2 acute exposure limits being exceeded at the LSA-MPOI.

D.5.3.2 Facility Upset Flaring Event: Acute Inhalation Assessment

Comparison of the predicted hourly maximum concentrations of the Application Case to the upset scenario indicates that there are no differences, indicating that an emergency flaring event is not discernable from normal operations.

D.5.3.3 Chronic Inhalation Results

Chronic inhalation risks were evaluated for the cabin, resident and worker groups only. The MPOI location was not evaluated on a chronic basis since it is intended to reflect worst-case exposure to a transient, hypothetical person who might be in the area when worst case emissions and meteorological conditions are occurring. As such, the chronic inhalation pathway is not considered relevant to the LSA-MPOI.

Non-Carcinogens

The results of the non-carcinogenic assessment are expressed as risk quotients (RQs). All chronic RQ values were less than 1 (CR #5, Table 4-10 to 4-12), suggesting that the predicted long-term air concentrations of the COPCs are not expected to result in adverse health effects. The predicted RQ values for the Baseline and Application Cases were generally very similar. This suggests that the contributions of Phase 2 with respect to air emissions will likely have a negligible impact on health.

Carcinogens

All predicted ILCR values were predicted to be less than 1 in 100,000 for the Application and Planned Development Cases, indicating that the incremental contributions from Phase 2 and

Future emission sources are associated with an essentially negligible degree of risk (CR #5, Table 4-13 to 4-15).

Wildlife Chronic Inhalation

The chronic inhalation assessment evaluates the potential health risks associated with continuous exposure to predicted maximum annual average air concentrations. With the exception of NO_2 for mammalian wildlife, predicted chronic inhalation HQ values did not exceed 1 (*i.e.*, predicted exposures were less than the exposure limits) for all of the assessment cases (*i.e.*, Baseline Case, Application Case and PDC) for mammalian and avian wildlife receptors (CR #5, Table F-12).

HQ values for chronic inhalation exposure to NO_2 in mammals were predicted to be greater than 1 under all assessment cases (*i.e.*, Baseline Case, Application Case, and PDC) at the local maximum point of impact (L-MPOI) and at Fort McKay. The resulting HQ value predicted for the local MPOI was 1.1 and for R10, 1.2 under all assessment cases for both locations. All other locations predicted HQs of less than 1.0. The lack of increase between the Baseline Case and the Application Case for the LSA-MPOI and for R10 indicates that Phase 2 is not a significant contributor to the annual NO_2 concentrations.

The overall conclusion of the chronic inhalation assessment is that the predicted maximum annual average air concentrations for all COPCs would pose negligible to low inhalation health risks to mammalian and avian wildlife in the region.

D.5.3.4 Chronic Multiple Pathway Results

As in the chronic inhalation assessment, separate assessments were completed for non-carcinogenic and carcinogenic exposures in the multiple pathway assessment to reflect the different approaches used in calculating and interpreting the risk estimates. Predicted health risks are expressed as RQs for the non-carcinogenic COPCs and as ILCRs for the carcinogenic COPCs. Risk quotients are presented for the Baseline, Application and PDC, while ILCRs are provided only for the two incremental scenarios (*i.e.*, Project and Future).

Non-Carcinogen Results

All multiple pathway RQ values for the Baseline, Application and PDC for the resident, cabin and worker groups were less than 1.0. Risk quotients for the non-carcinogenic COPCs are provided for the most sensitive life stage for the resident group (CR #5, Table 4-16), and for the adult life stage only for the worker group (CR #5, Table 4 17). For all of the COPCs, negligible changes in RQ value were predicted between the Baseline and Application Cases, indicating that the incremental change associated with Phase 2 is negligible. Overall, the potential for adverse non-carcinogenic health impacts is anticipated to be low.

Carcinogen Results

All ICLR values were less than 1.0, indicating that Phase 2 and the Future sources (in the PDC) are associated with negligible degrees of incremental cancer risks (*i.e.*, less than 1 in 100,000) for the resident, cabin and worker receptor group.

D.5.3.5 Mixture Results

Acute Inhalation Mixture Results

Acute RQ values were less than 1.0 for the eye and nasal irritant mixtures at all locations, with the exception of the LSA-MPOI, where RQ values slightly exceeded 1.0 (i.e., RQ value = 1.1) for both eye and nasal irritants in the PDC only. Both mixture groups are comprised of the same chemical components, namely acrolein, acetaldehyde, and formaldehyde. The lack of exceedances at all cabin, residential and worker locations indicates that the risk of eye and nasal effects occurring as a result of the combined exposure to COPCs is negligible for these groups (CR #5, Table 4-20 to 4-23).

Chronic Inhalation Mixture Results

The chronic inhalation assessment mixture results for the various groups of individuals were evaluated. As people are unlikely to be located at locations where the MPOI may occur, the MPOI was not included in the chronic mixtures assessment. All chronic inhalation mixture RQ values were less than 1.0 (CR #5, Table 4-25, Table 4-26 and Table 4-27), indicating that the risk of additive effects occurring as a result of the combined exposure to COPCs with common chronic toxicological endpoints is low.

Chronic Multiple Exposure Pathway Mixture Results

The chronic multiple pathway mixture results for the resident and worker groups were evaluated (CR #5, Table 4-28). As no mixtures for carcinogenic endpoints were identified, all results presented in these tables are for non-carcinogenic endpoints only. The RQ values for the renal toxicants mixture for both groups were less than 1.0 in all cases, indicating that the additive risk of renal toxicity is negligible. There are no apparent differences between the Baseline and Application Case risks, indicating that Phase 2 will have a negligible impact on the risks to renal impacts.

D.5.3.6 Wildlife Chronic Soil and Surface Water Ingestion

Chronic risk estimates associated with ingestion exposure pathways were based on comparison of predicted maximum soil concentrations to relevant SQGs. All predicted soil concentrations were below their respective SQGs for all COPCs (CR #5, Table F-13), and therefore it was concluded that predicted long-term soil concentrations would not adversely impact terrestrial wildlife populations in the study area.

D.5.4 Mitigation and Monitoring

D.5.4.1 Mitigation

In order to reduce potential impacts of Phase 2 on human and wildlife health STP will:

- undertake measures to mitigate potential impacts to air quality (Section D.1.4.1);
- undertake measures to mitigate potential impacts to aquatic resources (Section D.2.4.1); and
- undertake measures to mitigate potential impacts to groundwater (Section D.3.4.1).

D.5.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will:

- undertake monitoring of air quality (Section D.1.4.2);
- undertake monitoring of aquatic resources (Section D.2.4.2); and
- undertake monitoring of groundwater quality (Section D.3.4.2).

D.5.5 Summary

The chemical emissions from Phase 2 are not expected to result in adverse health effects in the region. For most of the COPCs, the magnitude of the differences in predicted health risks between the Baseline and Application Cases is negligible. The key findings of the HHRA are as follows:

- Acute Inhalation Assessment - The potential short-term health risks associated with Phase 2 and other emissions sources were evaluated through the comparison of predicted air concentrations (10-minute, 1-hour, 8-hour or 24-hour) against health-based exposure limits. Overall, there were minimal changes between the Baseline and Application Cases, indicating that Phase 2 emissions are not anticipated to have an impact on human health in the area;
- Chronic Inhalation Assessment - Predicted risks associated with continuous, long-term inhalation of the COPCs were evaluated through the comparison of predicted annual average air concentrations with health-based exposure limits. No exceedances of health-based exposure limits were predicted in the chronic inhalation assessment. All incremental lifetime cancer risks were predicted to be less than 1.0 in 100,000, indicating that the cancer risks associated with Phase 2 are essentially negligible; and

- Chronic Multiple Pathway Assessment - The potential long-term health risks associated with exposure to the COPCs via multiple pathways of exposure were evaluated for permanent and seasonal residents in the area. In all instances, potential risks were determined to be negligible. All incremental lifetime cancer risks associated with exposure via multiple pathways of exposure were predicted to be less than 1.0 in 100,000, suggesting that the cancer risks associated with Phase 2 are negligible.

The results of the SLWRA indicate that the overall risks posed to wildlife health will be negligible. Therefore, no impacts to wildlife populations are expected based on estimated wildlife exposures to predicted maximum acute and chronic air concentrations and predicted maximum soil and surface water concentrations. The confidence in the prediction is high since highly conservative assumptions were applied in the SLWRA.

D.6 HYDROLOGY

D.6.1 Introduction and Terms of Reference

STP conducted an assessment of hydrology for the Phase 2 Project. The following section is a summary of the Hydrology Assessment that was prepared by Northwest Hydraulic Consultants and included as Consultant Report #6 (CR #6). For full details of the assessment, please refer to CR #6.

Alberta Environment issued the final ToR for Phase 2 on July 22, 2011. The specific requirements for the hydrology component are provided in Section 3.3, and are as follows:

3.3 HYDROLOGY

3.3.1 Baseline Information

[A] Describe and map the surface hydrology in the Project Area.

[B] Identify any surface water users who have existing approvals, permits or licenses.

3.3.2 Impact Assessment

[A] Describe the extent of hydrological changes that will result from disturbances to groundwater and surface water movement:

a) include changes to the quantity of surface flow, water levels and channel regime in watercourses (during minimum, average and peak flows) and water levels in waterbodies;

b) assess the potential impact of any alterations in flow on the hydrology and identify all temporary and permanent alterations, channel realignments, disturbances or surface water withdrawals;

> c) *discuss the effect of these changes on hydrology (e.g., timing, volume, peak and minimum flow rates, river regime and lake levels), including the significance of effects for downstream watercourses; and*
>
> d) *identify any potential erosion problems in watercourses resulting from the Project.*

[B] Describe impacts on other surface water users resulting from the Project. Identify any potential water use conflicts.

[C] Discuss the impact of low flow conditions and in-stream flow needs on water supply and water and wastewater management strategies.

[D] Discuss mitigation strategies to prevent or minimize the potential impact of the Project on hydrology.

The LSA used for the hydrology assessment is defined as the land of potential development and surrounding areas which may be affected by direct runoff from the Phase 2 Project (Figure C.2.1). The RSA focuses on these lands, as well as the area in which stream flows and water levels could be affected by the Phase 2 Project (Figure C.2.2). The RSA is limited to this area, as potential impacts to the MacKay River downstream of this area are anticipated to be negligible.

The proposed Project lies within the Central Mixedwood subregion of the Boreal Forest, in the MacKay River watershed along the mainstem of the MacKay River, near the mouth of Thickwood (Birchwood) Creek.

Phase 2 may potentially affect a number of VECs related to hydrology, including:

- runoff volumes and streamflows;
- water levels and surface areas; and
- channel morphology and sediment concentrations.

D.6.2 Baseline Conditions

The baseline data collection and review included:

- seasonal measurements of water levels, widths, depths, and velocities at eight sites within the LSA over a three year period to quantify local flow characteristics (CR #6, Figure 12, Table 7);
- record hourly water level fluctuations from June 2010 to July 2011 at five sites;
- regional climatic characteristics such as air temperature, precipitation, and evaporation (CR #6, Section 2.2);

- regional hydrology characteristics including an assessment of flows in the streams which drain the RSA as well as an analysis of runoff and flows from gauges in the vicinity of the RSA (CR #6, Section 2.3);
- local hydrology data including hydrography, snow depths and densities, water levels and streamflow (CR #6, Section 2.3); and,
- streamflow and water level simulations using the Hydrologic Simulation Program – FORTRAN (HSPF) (CR #6, Section 3.2.1).

D.6.2.1 Surface Disturbances

Existing and approved developments within the LSA include the existing STP McKay Thermal Project – Phase 1 and the access road to Phase 1. There are other minor sources of disturbances within the LSA such as cutlines for seismic exploration and access for oil and gas extraction. These types of activities are wide spread in the region and any hydrologic effects of such minor disturbances will be reflected in the regional historical streamflow data presented in the baseline hydrology study. Table D.6.1 summarizes the extent of the spatial disturbances within the individual watersheds.

Table D.6.1 Summary of Existing and Approved Disturbance Areas

Watershed	Plant Site Area (ha)	Camp Area (ha)	Well Pad Area (ha)	Water Well Area (ha)	Soil Storage Area (ha)	Borrow Pit Area (ha)	Access Corridor (ha)	Total Disturbed Area (ha)	Percentage of Watershed Disturbed (%)
M05	15.7	6.6	13.3		15.1	18.5	7.5	76.7	16.9%
M07				0.2				0.2	0.0%
M08				0.8			3.0	3.9	4.2%
M09		2.5	7.8		7.7		5.0	23.0	20.0%
M10					0.9		0.5	1.4	5.6%
M12				0.1			4.3	4.4	15.2%
M14							13.4	13.4	3.1%
B01							6.8	6.8	1.1%
MacKay River (direct)	0.1	0.1					6.4	6.6	
Birchwood							6.8	6.8	0.0%
MacKay River (below LSA)	15.8	9.2	21.2	1.2	23.7	18.5	46.7	136.4	

The surface disturbances for the existing Project are located where they do not disturb any identified streams with defined channels. Run-off from the plant site and well pads is collected and stored, with release only occurring once water quality objectives are met. Run-off from access corridors and borrow pits is also collected, either in ditches or pits, and either evaporates or seeps into the ground. Run-off co-efficients for the other surface disturbances may be equal to or lower than the natural environment, but water quality is expected to be similar to natural conditions.

D.6.2.2 Water Supply

The Phase 1 Project uses groundwater to make steam for injection into the oil bearing formation; smaller volumes are also used for domestic purposes at the CPF and campsites. All water used for the Phase 1 Project is obtained from a local deep groundwater aquifer.

D.6.2.3 Runoff Volumes and Streamflows

Surface disturbances from existing and approved developments can cause changes to surface runoff characteristics of the natural environment. Specifically, changes in surface drainage patterns and changes in the runoff coefficients can affect the runoff volumes, peak flow rates, and timing of peak flows in the local streams. Water levels in ponds and wetlands may also be affected. Changes in runoff volumes were estimated assuming a worst case condition of the disturbed areas being directly connected to the drainage networks in the watersheds and that the estimated runoff coefficients for each disturbance type are applicable for all runoff events (Table D.6.2). The impacts of the existing and approved development were assessed by adjusting runoff parameters to reflect the effects of development.

The largest change in runoff volume occurs in watershed M12, which is estimated to have an increase in runoff volume of about 18% as a result of the access corridor area in this small watershed. The worst case change in runoff volume in watershed M09 is estimated to be an increase of about 12% resulting from the access corridor, soil storage and camp areas. Worst case change in runoff volumes in the other local watersheds are in the order of 5% or less. The change in runoff volumes in the MacKay River below the LSA boundary due to the total surface disturbance is expected to be negligible, about 0.013% of the runoff volume.

Table D.6.2 Summary of Changes in Runoff Volumes Due to Existing and Approved Surface Disturbances

Watershed	Total Drainage Area (ha)	Percentage of Watershed Disturbed (%)	Worst Case Change in Runoff Volume (%)	Average Change in Runoff Volume (%)	Average Change in 2-Year Peak Flow (%)	Average Change in 2-Year Minimum Flow (%)
M05	453.0	16.9%	-1.0%	6.0%	5.1%	-18.0%
M07	467.2	0.0%	0.0%			
M08	92.5	4.2%	4.4%			
M09	115.2	20.0%	11.7%	9.0%	8.0%	48.1%
M10	25.3	5.6%	6.7%	5.6%	6.4%	19.5%
M12	28.9	15.2%	18.2%			
M14	430.3	3.1%	3.8%	3.2%	3.4%	0.6%
B01	611.5	1.1%	1.4%	1.1%	1.3%	7.6%
MacKay River (direct)	395,422.9		0.002%			
Birchwood Cr.	21,831.3	0.0%	0.038%			
MacKay River (below LSA)	395,422.9		0.013%			

HSPF modelling was used to make a more detailed process-based assessment of the hydrologic effects of the existing and approved developments relative to pre-development conditions. The calibrated model was validated by comparison with the local flow data collected during 2010 and 2011, and by comparison with the Water Survey of Canada recorded flows for Beaver River above Syncrude for years 1975 through 2010. The Beaver River watershed is about 165 km^2 which is comparable in size to Birchwood Creek and Tributary M20, the larger tributaries of the MacKay River.

HSPF simulations on the effects of existing and approved development were carried out at the outlets to six local watersheds, M05, M09, M10, M14, B01 and B02, which would be most affected by the proposed Project. Runoff volumes, peak flows and minimum flows for the existing and approved development were compared to the values for pre-development in order to evaluate the effects of the existing development.

The effects of existing and approved development on runoff volumes were greatest for watershed M09 with an overall average increase of 9.0% over pre-development conditions. Runoff volume increases were less apparent in wet years but more noticeable in dry years.

The change in magnitude in 2-year peak flow due to existing and approved development was also greatest in watershed M09, with a predicted increase of 8.0%. There were no perceptible changes in the timing of peak flows. Changes in magnitude of annual minimum flow rates appear to be large in some of the watersheds because they are relative to very small flows. In most of the watersheds the net effect will be less years with zero flow. The predicted changes in runoff volumes, peak flows and minimum flows in these small tributaries will be imperceptible in the larger Birchwood Creek or MacKay River as a result of the much higher flow volumes in these streams.

D.6.2.4 Water Levels and Surface Areas

Annual peak water levels and surface areas of streams may change slightly due to the effects of existing development on annual peak flows. These changes will be imperceptible compared to natural variability. Minimum water levels and surface areas may be slightly higher due to increased minimum flows; however, zero flows will still occur in most of these small watersheds.

D.6.2.5 Channel Morphology and Sediment Concentrations

Sediment concentrations in streams have the potential to increase due to increases in streamflow or from sediment introduced to the stream from disturbances. Sediment concentrations in the streams in the LSA do not appear to have increased due to changes in the surface runoff characteristics. The changes in the flow regime due to surface disturbances from existing development are very small in most cases and would not have a perceptible effect on sediment concentrations.

D.6.3 Predicted Conditions

The following section provides a summary of the potential impacts to the hydrological VECs due to surface disturbance and water use.

D.6.3.1 Surface Disturbances

<u>Application Case</u>

The proposed Project has a total disturbance area of 502 ha and overlaps twenty-three watersheds (Table D.6.3). The greatest percentage area of disturbance due to the proposed Project occurs in watershed B02, a small watershed of 59 ha, where 31% of the area will be disturbed. Drainage control around the disturbed areas will be utilized in order to reduce the potential for impacts due to these surface disturbances (CR #6, Figure 23).

Table D.6.3 Summary of Surface Disturbances of the Proposed Project by Watershed

Watershed	Plant Site Area (ha)	Camp Area (ha)	Well Pad Area (ha)	Borrow Pit Area (ha)	Access Corridor (ha)	Total New Disturbed Area (ha)	Water-shed Area (ha)	Percentage of Watershed Newly Disturbed (%)	Percentage of Watershed Disturbed in Total (%)
M01			14.6		4.2	18.8	129	14.6	14.6
M03			9.5		3.6	13.1	85	15.4	15.4
M04			5.9		0.7	6.6	295	2.2	2.2
M05			4.7	15.5	6.7	26.9	453	5.9	22.9
M06			8.2		5.1	13.3	1,946	0.7	0.7
M07			0.0		4.7	4.7	467	1.0	1.0
M08			9.9		3.4	13.3	92	14.4	18.6
M09			1.6		0.5	2.1	115	1.8	21.8
M10			5.6		0.9	6.4	25	25.4	31.0
M11			0.2		4.6	4.9	269	1.8	1.8
M12			3.8			3.8	29	13.3	28.5
M13			5.6		6.0	11.6	108	10.7	10.7
M14			28.9	45.0	15.5	89.5	430	20.8	23.9
M15			2.8		3.5	6.3	338	1.9	1.9
M17			2.2		1.9	4.1	232	1.8	1.8
M18			4.6		2.0	6.7	79	8.4	8.4
M19			0.5	18.7	3.2	22.3	212	10.5	10.5
M20			13.4		7.6	21.0	30,935	0.1	0.1
M21			4.3		1.0	5.3	267	2.0	2.0
MacKay River (direct)			29.6	6.5	5.9	42.0	395,423	0.0	0.0
B01	45.0	2.8	33.1	42.0	16.3	139.2	611	22.8	23.9
B02			13.4		5.1	18.6	59	31.4	31.4
Birchwood Creek (direct)			15.8	1.1	4.5	21.4	21,831	0.0	0.0
Birchwood Creek (at mouth)	45.0	2.8	62.3	43.1	25.9	179.1	21,831	0.0	0.0
MacKay River (below LSA)	45.0	2.8	218.4	128.7	107.0	502.0	395,423	0.0	0.0

Phase 2 will use the existing access road so no new crossings of the MacKay River are required. However, the utility corridors for future well pads will cross some streams with defined channels. There are five crossings of streams with defined channels proposed for Phase 2. Field data collected on these channels at nearby locations indicate that Tributaries M03, M06, M15 and M20 are likely not navigable because they are either too small, have debris blockages or beaver dams. Birchwood Creek will require further evaluation and submission to Transport Canada in order to determine navigability but was previously deemed non navigable upstream at the existing access road crossing.

Planned Development Case

There are no other planned developments within the hydrology LSA except for a short length of the access road and a few well pads associated with the Athabasca Oil Sands Corp. (AOSC) MacKay River SAGD Project. No additional stream crossings are anticipated within the hydrology LSA and the effect of the additional surface disturbances on runoff volumes and peak flows is expected to be undetectable.

The cumulative impact of projects in the hydrology RSA was considered; however, there are no other activities in the hydrology RSA which were not already included in the assessment within the LSA. There are other existing and planned SAGD developments within the Mackay River watershed; however, the cumulative impact of these developments on the MacKay River is expected to be similar to the predicted impacts in the RSA for the Application Case, which is very small. These projects are similar in nature so the relative disturbances to other tributaries to the MacKay River are expected to be similar.

D.6.3.2 Water Supply

Application Case

Phase 2 will use the same local deep groundwater source as Phase 1 to supply water. The use of local deep groundwater is not expected to have a measureable effect on flows within the MacKay River relative to the natural flow variability (Section D.3).

Runoff from the plant site will be collected in a storm water pond. The runoff volume stored in the storm water pond may be used for process water. The mean annual runoff volume from the plant site is estimated to be about 117,000 m^3 (45 ha x 0.6 x 435 mm). This is the amount of runoff water which could potentially be diverted on an annual basis for process water if sufficient storage is available to capture the runoff when it occurs.

Planned Development Case

There are no currently active licences for surface water withdrawals within the RSA other than an existing licence to withdrawal water from the Phase 1 stormwater retention pond.

D.6.3.3 Runoff Volumes and Streamflows

Application Case

The effect of development on runoff volumes in each individual watershed depends on the proportions of the watershed that are used for plant sites, camps, well pads, borrow pits and utility corridors. Borrow pits will tend to reduce runoff volumes and flood peaks because water is not released from these areas. Utility corridors and camps will tend to increase both runoff volumes and flood peaks due to the reduction in vegetation and the addition of less permeable surfaces. The plant site and well pads will tend to reduce the flood peaks because the runoff is detained before being discharged to the natural environment.

The changes in runoff volumes summarized in Table D.6.4 include the effects of the existing disturbances combined with all proposed future Phase 2 development. Changes in runoff volumes were estimated assuming a worst case condition of the disturbed areas being directly connected to the drainage networks in the watersheds and that the estimated runoff coefficients for each disturbance type are applicable for all runoff events. The impacts of the existing surface disturbance and proposed surface disturbance were assessed by adjusting runoff parameters to reflect the effects of development.

Table D.6.4 Summary of Changes in Runoff Volumes Due to Surface Disturbances

Watershed	Total Drainage Area (ha)	Total Disturbed Area (ha)	Worst Case Change in Runoff Volume (%)	Average Change in Runoff Volume (%)	Average Change in 2-Year Peak Flow (%)	Average Change in 2-Year Minimum Flow (%)
M01	129	18.8	-7.3%			
M03	85	13.1	-6.1%			
M04	295	6.6	-1.7%			
M05	453	103.6	-3.6%	3.3%	2.5%	-11.7%
M06	1,946	13.3	-0.10%			
M07	467	4.9	1.3%			
M08	92	17.2	-1.9%			
M09	115	25.1	10.9%	8.3%	7.0%	49.6%
M10	25	7.9	-11.0%	-8.6%	-10.5%	21.5%
M11	269	4.9	2.0%			
M12	29	8.2	4.9%			
M13	108	11.6	1.6%			
M14	430	102.8	-9.0%	-8.9%	-8.8%	-25.6%

Table D.6.4 Summary of Changes in Runoff Volumes Due to Surface Disturbances

Watershed	Total Drainage Area (ha)	Total Disturbed Area (ha)	Worst Case Change in Runoff Volume (%)	Average Change in Runoff Volume (%)	Average Change in 2-Year Peak Flow (%)	Average Change in 2-Year Minimum Flow (%)
M15	338	6.3	0.45%			
M17	232	4.1	0.03%			
M18	79	6.7	-2.7%			
M19	212	22.3	-7.2%			
M20	30,935	21.0	-0.01%			
M21	267	5.3	-1.1%			
MacKay River (direct)	395,423	48.6	-0.01%			
B01	611	146.0	-13.9%	3.0%	3.1%	43.3%
B02	59	18.6	-12.1%	-8.8%	-11.9%	21.8%
Birchwood Creek (direct)	21,831	29.9	-0.01%			
Birchwood Creek (at mouth)	21,831	194.5	-0.43%			
MacKay River (below LSA)	395,423	646.9	-0.05%			

HSPF modelling was used to make a more detailed process-based assessment of the hydrologic effects of Phase 2 relative to pre-development conditions. The effects of this development scenario on runoff volumes were greatest for watershed M14 with an average decrease of 8.9% from pre-development conditions. Runoff volume decreases were more apparent in wet years. The change in magnitude in 2-year peak flows due to existing and approved development was greatest in watershed B02, with a predicted decrease of 11.9%. The simulations predicted some small changes in the timing of peak flows; typically the peaks occurred slightly earlier. Percentage changes in magnitude of annual minimum flow rates appear to be large in some of the watersheds because they are relative to very low flows. In most of the watersheds the net effect will be less years with zero flow.

The predicted changes in runoff volumes, peak flows and minimum flows in these small tributaries will be imperceptible in the downstream Birchwood Creek and MacKay River due to the much greater flows in these streams.

Planned Development Case

There are no other planned developments within the hydrology LSA except for a short length of the access road and a few well pads associated with the Athabasca Oil Sands Corp. (AOSC) MacKay River SAGD Project. The effect of the additional surface disturbances on runoff volumes and peak flows is expected to be undetectable and the impact is predicted to be Low.

The cumulative impact of projects in the hydrology RSA was considered; however, there are no other activities in the hydrology RSA which were not already included in the assessment within the LSA. There are other existing and planned SAGD developments within the Mackay River watershed; however, the cumulative impact of these developments on the MacKay River is not expected to be greater than the impact of the Application Development Case within the RSA, which is very small. These projects are similar in nature so the relative disturbances to other tributaries to the MacKay River are expected to be similar.

The development of the AOSC MacKay River SAGD Project to the south will increase the hydrologic impacts in some of the smaller tributaries of the Mackay River and Birchwood Creek but these impacts will still be minimal and imperceptible in the downstream Birchwood Creek and MacKay River due to the much higher flow volumes in these watercourses.

D.6.3.4 Water Levels and Surface Areas

Application Case

Annual peak water levels and surface areas in the streams may change slightly due to changes in annual peak flow. These changes will be imperceptible compared to natural variability. Minimum water levels and surface areas may be slightly higher due to increased minimum flows; however, zero flows will still occur in most of these small watersheds.

Levels in small waterbodies created by beaver dams are controlled by the height of the beaver dams rather than by inflow volumes therefore small changes in streamflows are not expected to affect the water levels and surface areas of these features. The impact is predicted to be Low.

Planned Development Case

Since it is predicted that there will be negligible impact to surface runoff volumes due to surface disturbances there will also be negligible impact to water levels and surface areas. The impact is predicted to be Low.

D.6.3.5 Channel Morphology and Sediment Concentrations

Application Case

Sediment concentrations in streams have the potential to increase due to increases in streamflow or from sediment introduced to the stream from disturbances. Sediment concentrations in the streams in the LSA are not expected to increase due to changes in the surface runoff characteristics because in most cases the runoff volume will not increase. In watersheds where increases in runoff may occur, changes in the flow regime due to surface disturbances are very small and would not have a perceptible impact the sediment concentrations. The impact is predicted to be Low.

Planned Development Case

Other projects in the RSA will be developed in a manner that reduces the potential for changes to channel morphology and sediment concentrations therefore there it is predicted that there will be Low Impact to channel morphology and sediment concentrations for the PDC. The impact is predicted to be Low.

D.6.4 Mitigation and Monitoring

D.6.4.1 Mitigation

In order to reduce potential impacts of Phase 2 on hydrology STP will:

- maintain existing drainage patterns and prevent water from being transferred from one watershed to another by using drainage control structures such as culverts and ditches;
- maintain vegetative buffers between disturbance areas and watercourses with defined channels
- utilize sediment control during construction where runoff may potentially flow directly into watercourse with defined channels.
- control runoff from well pads and prevent runoff from entering watercourses with defined channels.
- direct run-on from upstream of well pads and plant site around the disturbances and back into their original pathways; and
- reclaim surface disturbances once they are no longer required.

D.6.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will:

- conduct routine visual inspections to ensure that the access road drainage culverts are working as intended to maintain the natural surface drainage patterns;
- conduct sediment monitoring during the construction of stream channel crossings to ensure that sediment from construction sites does not adversely impact the downstream channels; and
- record water volumes used or pumped from the stormwater retention pond.

D.6.5 Summary of VEC

A summary of the significance of potential impacts and effects on hydrology valued environmental components (VECs) for the different assessment cases is provided in Table D.6.5.

Table D.6.5 Summary of Impact Rating on Hydrology Valued Environmental Components

VEC	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent[(1)]	Duration[(2)]	Frequency[(3)]	Reversibility[(4)]	Magnitude[(5)]	Project Contribution[(6)]	Confidence Rating[(7)]	Probability of Occurrence[(8)]	Impact Rating[(9)]
1. Runoff Volumes and Streamflows												
	Changes to runoff volume, peak flows, and low flows	see Section D.6.4.1	Application	Local	Long-term	Periodic	Reversible in long term	Low	Negative	High	High	Low
			Cumulative	Local	Long-term	Periodic	Reversible in long term	Low	Negative	High	High	Low
2. Water Levels and Surface Areas												
	Changes in water levels and surface area due to streamflow changes	see Section D.6.4.1	Application	Local	Long-term	Periodic	Reversible in long term	Low	Negative	High	High	Low
			Cumulative	Local	Long-term	Periodic	Reversible in long term	Low	Negative	High	High	Low
3. Channel Morphology and Sediment Concentration												
	Changes in channel shape and sediment concentration due to flow changes and crossing construction	see Section D.6.4.1	Application	Local	Long-term	Periodic	Reversible in long term	Low	Negative	High	Low	Low
			Cumulative	Local	Long-term	Periodic	Reversible in long term	Low	Negative	High	Low	Low

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.7 NOISE

D.7.1 Introduction and Terms of Reference

STP conducted an assessment of noise impacts for the Phase 2 Project. The following section is a summary of the Noise Impact Assessment (NIA) that was prepared by aci Acoustical Consultants Inc. included as Consultants Report #7 (CR #7). For full details of the assessment please refer to CR #7.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the NIA are provided in Section 3.1 of the ToR and are as follows:

3.1.2 Impact Assessment

[C] Summarize the results of the noise assessment conducted for the ERCB, and:

- *a) identify the nearest receptor used in the assessment; and*
- *b) discuss the design, construction and operational factors to be incorporated into the Project to comply with the ERCB's Directive 38: Noise Control.*

[D] Discuss mitigation strategies to minimize the potential impact of the Project on air quality and noise.

The purpose of the work was to generate a computer noise model of Phase 2 under Baseline Case and Application Case conditions and to compare the resultant sound levels to the Alberta Energy Resources Conservation Board (ERCB) permissible sound level (PSL) guidelines (Directive 038 on Noise Control, 2007) as well as the Alberta Utilities Commission (AUC) Rule 012 on Noise Control. The computer noise modeling was conducted using the CADNA/A (version 4.1.137) software package. The calculation method used for noise propagation follows the International Standards Organization (ISO) 9613-2. All receiver locations were assumed as being downwind from the source(s).

The computer noise modeling results were calculated in two ways. First, sound levels were calculated at the theoretical 1,500 m receiver locations (CR #7, Figure 2). Second, sound levels were calculated using a 20 m x 20 m receptor grid pattern within the entire study area. This provided color noise contours for easier visualization and evaluation of the results.

There are no major roadways nearby and there are no existing industrial facilities within 5 km of the Phase 2 lease boundary. In addition, there are no residents or Trappers' Cabins within at least 5 km of the Phase 2 lease area. Topographically, the land in the area has a general downward slope into the MacKay River from the CPF and the well pads (maximum elevation change of approximately 40 m). The land is covered with field grasses, trees and bushes (as observed through aerial photos). As such, the level of vegetative sound absorption is considered moderate.

D.7.2 Baseline Conditions

D.7.2.1 Permissible Sound Levels

The documents which relate to the PSLs for the NIA are the ERCB Directive 038 on Noise Control (2007) and the AUC Rule 012 on Noise Control. Both documents set the PSL at the receiver location based on population density and relative distances to heavily traveled road and rail (CR #7, Table 1). In all instances, there is a Basic Sound Level (BSL) of 40 dBA for the night-time (night-time hours are 22:00 – 07:00) and 50 dBA for the day-time (day-time hours are 07:00 – 22:00). Note that for this location, none of the adjustments to the PSL apply. Finally, both documents specify that new or modified facilities must meet a PSL-Night of 40 dBA at 1,500 m from the facility fence-line if there are no closer dwellings. As such, the PSLs at a distance of 1,500 m are a L_{eq}Night of 40 dBA and a L_{eq}Day of 50 dBA.

D.7.2.2 Baseline Case Results

Due to the lack of residential receptors or existing industrial noise sources in the surrounding area, baseline noise monitoring was not conducted. This conforms with the requirements of the ERCB Directive 038 and AUC Rule 012.

The Baseline Case includes the noise sources associated with the Phase 1 CPF and well pads. The modeled noise levels at the theoretical 1,500 m receptor locations are under the PSLs with the Phase 1 noise combined with the 35 dBA ASL (CR #7, Table 2). In addition, the noise levels resulting from the Phase 1 equipment alone (*i.e.*, no ASL) are more than 5 dBA below the PSL at all but one location.

In addition to the broadband A-weighted (dBA) sound levels, the modeling results at the theoretical 1,500 m receptor locations indicated C-weighted (dBC) sound levels will be less than 20 dB above the dBA sound levels at most locations (CR #7, Table 3). As specified in ERCB Directive 038 and AUC Rule 012, if the dBC – dBA sound levels are less than 20 dB, the noise is not considered to have a low frequency tonal component. For those locations with dBC – dBA values above 20, the modeling indicates that the possibility exists for a low frequency tonal component. However, both ERCB Directive 038 and AUC Rule 012 have additional requirements related to the 1/3 octave band sound pressure levels to have an identified low frequency tonal component. Sound level data for the various noise sources is only available in 1/1 octave band resolution. As such, a specific low frequency tonal component cannot be determined. The modeling does indicate that the dominant source of the low frequency noise is the gas turbine exhaust from the CoGen units. Noise from this equipment tends to have a more broadband low frequency content with no specific tones.

D.7.3 Predicted Conditions

Application Case

Noise modeling for the Application Case included the baseline case conditions plus all noise sources associated with the Phase 2 development. Although there are no specific construction noise level limits detailed by ERCB Directive 038, there are general recommendations for construction noise mitigation (Section D.7.4). Noise sources associated with operation of the Phase 2 facility include equipment on the CPF and well pads (CR #7, Appendix I).

Results of the Application Case noise modeling are presented in Table D.7.1. The modeled noise levels at the theoretical 1,500 m receptor locations were found to be under the PSLs with the Phase 1 and Project noise combined with the 35 dBA ASL. In addition, the noise levels resulting from Phase 1 and Phase 2 equipment alone (*i.e.*, no ASL) are more than 5 dBA below the PSL at most of the theoretical receptor locations.

Table D.7.1 Application Case Modeled Sound Levels

Receptor (1,500m From Project)	ASL-Night (dBA)	Application Case L_{eq}Night (dBA)	ASL + Application Case L_{eq}Night (dBA)	PSL-Night (dBA)	Compliant
R_01	35.0	25.6	35.5	40.0	YES
R_02	35.0	24.3	35.4	40.0	YES
R_03	35.0	28.4	35.9	40.0	YES
R_04	35.0	29.3	36.0	40.0	YES
R_05	35.0	31.0	36.5	40.0	YES
R_06	35.0	35.5	38.3	40.0	YES
R_07	35.0	36.4	38.8	40.0	YES
R_08	35.0	32.0	36.8	40.0	YES
R_09	35.0	29.1	36.0	40.0	YES
R_10	35.0	29.0	36.0	40.0	YES
R_11	35.0	31.1	36.5	40.0	YES
R_12	35.0	34.5	37.8	40.0	YES
R_13	35.0	32.1	36.8	40.0	YES
R_14	35.0	32.0	36.8	40.0	YES
R_15	35.0	32.5	36.9	40.0	YES
R_16	35.0	29.6	36.1	40.0	YES
R_17	35.0	31.4	36.6	40.0	YES
R_18	35.0	31.3	36.5	40.0	YES
R_19	35.0	29.2	36.0	40.0	YES

Table D.7.1 Application Case Modeled Sound Levels					
Receptor (1,500m From Project)	**ASL-Night (dBA)**	**Application Case L_{eq}Night (dBA)**	**ASL + Application Case L_{eq}Night (dBA)**	**PSL-Night (dBA)**	**Compliant**
R_20	35.0	31.8	36.7	40.0	YES
R_21	35.0	33.6	37.4	40.0	YES
R_22	35.0	37.9	39.7	40.0	YES
R_23	35.0	31.6	36.6	40.0	YES
R_24	35.0	30.6	36.3	40.0	YES
R_25	35.0	26.6	35.6	40.0	YES
R_26	35.0	26.9	35.6	40.0	YES

In addition to the broadband A-weighted (dBA) sound levels, the modeling results at the theoretical 1,500 m receptor locations indicated C-weighted (dBC) sound levels will be less than 20 dB above the dBA sound levels at most locations, as shown in Table D.7.2. Similar to the Baseline Case, some locations have dBC – dBA sound levels greater than 20 dB. Again, the dominant low frequency noise sources are the gas turbine exhaust stacks. These tend not to be specifically tonal in nature. They tend to have a more broadband low frequency quality. In addition, there are no residential receptors nearby to express concerns for the low frequency noise.

Table D.7.2 Application Case Modeled dBA and dBC Sound Levels				
Receptor (1,500m From Project)	**Application Case L_{eq}Night (dBA)**	**Application Case L_{eq}Night (dBC)**	**dBC - dBA**	**Tonal**
R_01	25.6	48.1	22.5	POSSIBLE
R_02	24.3	44.0	19.7	NO
R_03	28.4	47.7	19.3	NO
R_04	29.3	51.4	22.1	POSSIBLE
R_05	31.0	52.7	21.7	POSSIBLE
R_06	35.5	55.7	20.2	POSSIBLE
R_07	36.4	58.5	22.1	POSSIBLE
R_08	32.0	50.7	18.7	NO
R_09	29.1	48.0	18.9	NO
R_10	29.0	47.8	18.8	NO
R_11	31.1	50.1	19.0	NO
R_12	34.5	52.9	18.4	NO

Table D.7.2 Application Case Modeled dBA and dBC Sound Levels

Receptor (1,500m From Project)	Application Case L_{eq}Night (dBA)	Application Case L_{eq}Night (dBC)	dBC - dBA	Tonal
R_13	32.1	51.4	19.3	NO
R_14	32.0	51.4	19.4	NO
R_15	32.5	51.3	18.8	NO
R_16	29.6	46.7	17.1	NO
R_17	31.4	50.7	19.3	NO
R_18	31.3	47.5	16.2	NO
R_19	29.2	46.0	16.8	NO
R_20	31.8	49.2	17.4	NO
R_21	33.6	51.3	17.7	NO
R_22	37.9	54.9	17.0	NO
R_23	31.6	49.3	17.7	NO
R_24	30.6	50.3	19.7	NO
R_25	26.6	47.7	21.1	POSSIBLE
R_26	26.9	49.3	22.4	POSSIBLE

Planned Development Case

Noise modeling for the PDC was not conducted as there are no other industrial facilities, other than well pads, planned within 1.5 km of the Phase 2 Project.

D.7.4 Mitigation and Monitoring

D.7.4.1 Mitigation

The results of the noise modeling indicated that no additional operation factors need to be incorporated into the Phase 2 Project and specific additional noise mitigation measures are not required. In accordance with ERCB's Directive 38, STP will utilize the following measures to mitigate potential impacts due to construction noise:

- conduct construction activity between the hours of 07:00 and 22:00;
- advise nearby residents of significant noise-causing activities and the Projects construction schedule;
- ensure all internal combustion engines are fitted with appropriate muffler systems;
- take advantage of acoustical screening from existing on-site buildings to shield dwellings from construction equipment noise; and

- limiting vehicle speeds, at all times, in the Project Area.

D.7.4.2 Monitoring

As per ERCB Directive 038, post-commissioning noise monitoring is not required. If, however, a noise complaint is filed with the ERCB or STP, STP will conduct a comprehensive sound level survey in accordance with the requirements of ERCB Directive 038.

D.7.5 Summary

The results of the noise modeling indicated Baseline Case noise levels associated with Phase 1 (with the average ambient sound level of 35 dBA included) will be below the ERCB Directive 038 PSL of 40 dBA L_{eq}Night for all surrounding theoretical 1,500 m receptors. The noise levels without the ASL were more than 5 dBA below the PSL at all but one location.

The Application Case noise levels associated with Phase 1 and Phase 2 (with the average ambient sound level of 35 dBA included) will be below the ERCB Directive 038 PSL of 40 dBA L_{eq}Night for all surrounding theoretical 1,500 m receptors. The noise levels without the ASL are modeled to be more than 5 dBA below the PSL at most locations.

For both the Baseline Case and Application Case, the dBC – dBA sound levels are projected to be less than 20 dB at most locations. There are some locations, however with values greater than 20 dB, resulting in the possibility of low frequency tonal noise. The dominant low frequency noise sources are the gas turbine exhaust stacks. These tend not to be specifically tonal in nature. They tend to have a more broadband low frequency quality. As such, the possibility of a low frequency tonal component (as specified by ERCB Directive 038 and AUC Rule 012) is low.

D.8 Socio-Economic Assessment

D.8.1 Introduction and Terms of Reference

STP conducted a socio-economic assessment for the Phase 2 Project. The following section is a summary of the Soci-Economic Impact Assessment (SEIA) that was prepared by Nichols Applied Management and included as Consultants Report #8 (CR #8). For full details of the assessment please refer to CR #8.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the SEIA are provided in Section 7.0 of the ToR and are as follows:

7.1 Baseline Conditions

[A] Describe the existing socio-economic conditions in the region and in the communities in the region.

[B] Describe factors that may affect existing socio-economic conditions including:

a) population changes;

b) workforce requirements for the Project, including a description of when peak activity periods will occur;

c) planned accommodations for the workforce for all stages of the Project;

d) the Proponent's policies and programs regarding the use of regional and Alberta goods and services;

e) the project schedule; and

f) the overall engineering and contracting plan for the Project.

7.2 Impact Assessment

[A] Describe the effects of construction and operation of the Project on:

a) housing;

b) availability and quality of health care services;

c) local and regional infrastructure and community services;

d) recreational activities;

e) hunting, fishing, trapping and gathering; and

f) First Nations and Métis (e.g., traditional land use and social and cultural implications).

[B] Describe the socio-economic effects of any construction camp required for the Project and identify:

a) its location;

b) the number of workers it is intended to house;

c) whether the camp will service the Project only or other clients;

d) the length of time the camp will be in service; and

e) describe what services will be provided in the camp (e.g., security, recreation and leisure, medical services).

[C] Describe the need for additional Crown land to manage the effects in [A] and [B].

[D] Discuss plans to work with First Nation and Métis communities and groups, other local residents and businesses regarding employment, training needs and other economic development opportunities arising from the Project.

[E] Provide the estimated total Project cost, including a breakdown for engineering and project management, equipment and materials, and labour for both construction and operation stages. Indicate the percentage of expenditures expected to occur in the region, Alberta, Canada outside of Alberta, and outside of Canada.

[F] Discuss mitigation strategies to minimize the potential impact of the Project on socioeconomic conditions in the region and communities in the region.

The SEIA addresses the human environment with and without the Phase 2 Project. The key socio-economic issues considered in the analysis fall into the following categories:

- employment effects;
- regional and provincial economic benefits;
- population effects;
- effects on regional infrastructure and services; and
- traditional land use effects.

The SEIA covers the life of the Phase 2 Project from construction through to the end of operations. It will concentrate on the time between 2013 and 2017, reflecting that:

- on-site construction for Phase 2A of Phase 2 is expected to take place between early 2013 and mid 2015, with Phase 2B to be built between mid 2014 and mid 2016; and
- Project operations are expected to begin in mid to late 2015 with Phase 2A and ramp up as Phase 2B comes on stream in 2016. The first full year of combined operations will be 2017.

The RSA boundaries for the SEIA are the same as those of the Regional Municipality of Wood Buffalo (RMWB) (Figure C.2.2). Particular attention is paid to Fort McMurray, the urban centre of the RMWB and the hub of the commercial and public services directly affected by Phase 2. Where appropriate, the SEIA will consider Project effects beyond the study area. For example, the SEIA considers Project effects on the Alberta and Canadian economies.

D.8.2 Baseline Conditions

D.8.2.1 Economic and Fiscal Assessment

The primary economic driver of the region is development of the oil sands. Most oil sands industrial activity is north of Fort McMurray near Fort McKay, but more recent developments are also taking place to the south of Fort McMurray, notably near Anzac and Conklin. The oil sands facilities are supported by a range of contractor and support services, most of which are located in the urban service area of Fort McMurray.

Other economic activities in the region include forestry, tourism and outdoor recreation, mineral exploration, commercial fishing, outfitting, hunting, and trapping. The region also supports a number of traditional economic activities, such as subsistence hunting, trapping and plant gathering. All of these activities are supported by a range of contracting and other service providers in the areas of transportation, construction, logistics, wholesale and retail trade.

The estimated unemployment rate in the Wood Buffalo-Cold Lake region was 5.7% in July 2011. This is above both the unemployment rate of 4.7% in July 2010 and the estimated 5.5% June 2011 unemployment rate for the province (E&I July 2011).

In addition to the resident workforce of the RSA, there are approximately 25,000 mobile workers living primarily in camps, but also in hotels, motels and campgrounds throughout the region (RMWB 2010). The use of mobile workers is standard practice in the construction and operation of heavy industrial projects and these workers are likely to continue to be present in the RSA for the foreseeable future.

Unemployment rates tend to be higher among Aboriginal people compared with the rest of the population. In July 2011, unemployment among off-reserve Aboriginal people in Alberta was about 13.7%. The corresponding estimate for the areas outside Edmonton and Calgary was 12.9% (E&I 2011). Employment and unemployment on reserves in the region is a fluid situation. An analysis conducted by the Athabasca Tribal Council (ATC) indicates unemployment rates on reserves in the region range from 38% to 54%, which is well above the Alberta off-reserve rates (ATC 2006). Generally, the relatively lower levels of unemployment are found among the First Nations north of Fort McMurray and located closer to the well-established oil sands mining facilities.

Strong economic growth in the region is reflected in family incomes, as shown in Table D.8.1.

Table D.8.1 Median Family Income – 2008

	Couple Family	Lone-Parent Family	Persons Not in Census Families
	CAD $		
Alberta	94,170	41,170	33,150
Fort McMurray	167,870	60,970	71,220
Anzac	163,650	71,800	55,520
Fort McKay	104,890	23,840	29,260
Conklin	80,420	28,150	40,690
Fort Chipewyan	80,010	25,600	25,760

Source: Statistics Canada 2010a

D.8.2.2 Traditional Land and Culture

Aboriginal peoples in the region have been engaged in traditional activities such as hunting, fishing, and gathering for thousands of years. While traditional land use remains essential to Aboriginal culture, it has changed. The traditional culture of Aboriginal communities in the RSA is affected by a number of external influences, similar to those impacting Aboriginal communities elsewhere in Canada, including:

- increased use of traditional lands for non-traditional purposes, whether it be resource development such as oil sands development in the Wood Buffalo region or diamond mining in the Northwest Territories, or increased agricultural development and encroaching urbanization in other parts of the country,
- education initiatives that limit the learning of traditional knowledge values and practices, and
- increased access to other cultural influences through advancements in technology (*e.g.*, satellite, internet, cell phones).

D.8.2.3 Population

The most recent population estimate from the 2010 municipal census indicates a regional population of 104,340. The RMWB's population can be divided into the following categories (RMWB 2010d):

- those occupying owned or rented dwellings, often referred to as the resident population; and
- those occupying camp-based or other temporary dwellings such as area hotels, motels and campgrounds, often referred to as the non-resident population.

The urban and rural communities of the Wood Buffalo region differ from one another in terms of their demographic characteristics and their integration into the regional wage economy. Table D.8.2 provides a summary of some key differences between urban and rural communities.

Table D.8.2 Selected Differences Between Urban and Rural Communities

Selected Indicators	Urban Communities	Rural Communities
Labour Force Participation Rate	83%	62%
Unemployment Rate	3.7%	16.5%
Persons Employed in Selected Oil Sands Industry and Related Occupations (as percent of total labour force)	43%	32%
Median Family Income	$109,546	$65,853
Aboriginal Identity Population (as percent of total population)	9%	71%
Persons Aged 19 Years or Less (as percent of total population)	27%	34%

Note: Persons employed in selected oil sands industry and related occupations are defined here as those employed in the mining and oil and gas extraction, construction, and utilities industries.
Source: Statistics Canada, 2006 Census; Nichols Applied Management.

Not all rural communities in the Wood Buffalo region are alike. Anzac, for example, stands out as a rural community that is increasingly integrated into the oil sands economy. The participation of its population in the labour force and other key indicators of involvement are generally closer to urban levels than to the rural average.

Since 1999, the non-resident population has grown from under 4,000 to nearly 25,000 in 2010. Over 23,300 workers live in work camps, or lodges, in the outlying rural communities, whereas the remaining 1,500 people primarily live in hotels, motels and campgrounds in, or near, the urban service area. Most of the workforce camps in the RMWB are temporary construction camps, but there are an increasing number of permanent operations camps both north and south of Fort McMurray. As oil sands operations move farther from the RMWB urban service area, additional permanent operations lodges are being established in light of health, safety and worker efficiency considerations.

However, the proliferation of camps in the region has raised concerns, including their effect on policing, emergency and health services, as well as municipal infrastructure (*e.g.*, water, wastewater, and solid waste). Both the Athabasca Oil Sands Area (AOSA) Comprehensive Regional Infrastructure Sustainability Plan (CRISP) and the Draft Municipal Development Plan (MDP) incorporate language of consolidating camp locations and developing housing and transportation systems to allow at least the operations workers within commuting distance of Fort McMurray to make the transition from camp to community living.

Based on the industry's growth plans and limiting the analysis to only those projects that are under construction or have regulatory approval in the spring of 2011, the resident population in the urban service area is expected to grow by approximately 4% annually, reaching nearly 99,000 by 2017. Some additional population is likely to accrue to the rural communities in the RSA, especially if land and planning constraints faced by these communities are resolved.

D.8.2.4 Housing

High rates of population growth in the region, along with a lack of available land and the high costs of development, have contributed to a housing shortage and high house prices in Fort McMurray. The average price for single family dwellings more than doubled between 2003 and 2008 before dropping in 2009 in response to the economic recession. House prices began increasing again in 2010, rising to levels comparable with 2008. Preliminary figures for early 2011 indicate that house prices have continued to climb in Fort McMurray, reaching over $740,000 as of July 2011 (FMREB 2011).

Price and availability of rental accommodations has also been an issue in Fort McMurray. Rental rate increases have moderated in Fort McMurray in recent years, but rents remain the highest among all urban centres in Alberta (*e.g.*, they are twice as high as Edmonton) (CR #8, Figure 5.2).

Many rural communities in the RMWB are also experiencing housing pressures as a result of:

- community members returning, often from Fort McMurray, to avoid high housing prices there;
- a young population and early family formation; and
- housing policies and funding allocations by Aboriginal Affairs and Northern Development Canada (AANDC) that do not tend to respond quickly to changing situations.

The housing needed to accommodate Baseline Case population growth is estimated at 1,300 units for the period between 2011 and 2017. This level of annual demand is above the number of annual housing starts in 2010 (769 units) but below the average annual housing starts experienced in the region over the last five years (1,415 units).

This estimate implies an average of 2.8 people per dwelling and does not account for any unmet housing demand as of 2010. The actual number of housing units might vary based on the number of people per dwelling, which is an amalgam of single-family houses and multifamily units. Housing availability and affordability are expected to remain a concern in the near term.

D.8.2.5 Social Infrastructure

Social infrastructure includes a diverse range of human services and infrastructure including health, education, social, policing and emergency services.

From the late 1990s until 2008, rapid population growth in the region, often in the range of 6% to 9% annually, led to increased demands on social infrastructure. Available resources often did not keep pace with this growth leading to increased strains and pressure on regional service providers. In response, government and industry have increased funding for social infrastructure as well as introduced new planning processes and initiatives to alleviate the pressures of rapid growth and to enhance the quality of life of local residents.

The non-resident population, primarily camp-based workers, in the region has grown exponentially over the past decade, placing increased demands on regional social infrastructure, including health services, rural policing and emergency response; recreational facilities; and social services. The enhancement and expansion of in-camp amenities and services has helped to reduce some of these demands, but concerns remain as the regional camp population is anticipated to exceed 30,000 during much of the forecast period.

With the increase in oil sands development, Fort McMurray has grown from a relatively small, isolated northern town with few amenities into one of Alberta's larger urban centres. This transition means that service providers in Fort McMurray have to increasingly address complex social issues more often associated with urban communities, including social isolation, reduced community cohesion, increased homelessness, crime and traffic. The affect on Aboriginal residents is further compounded by the social stressors associated with departure from traditional pursuits and culture.

A significant challenge faced across social infrastructure areas is the shortage of appropriately skilled labour. Both public sector agencies and private sector companies have experienced difficulties attracting workers as a result of:

- the high cost of living (*e.g.*, housing costs);
- stressful working conditions for existing staff coping with staff shortages for various disciplines; and
- the RSA's remote location (*e.g.*, limited professional development opportunities).

Oil sands development will lead to increases in population that will in turn require additional social infrastructure in the RSA. The increase in demand for social infrastructure will require additional facilities, programming and staffing, some of which has been quantified in Table D.8.3.

Table D.8.3 Additional Social Infrastructure Required by 2017[1]

Assessment Cases	Police Services *(No. of Officers)*[2]	Emergency Services *(No. of Staff*[3]	Health Services *(No. of Physicians)*[4]	Education *(No. of Teachers)*[5]	Social Services *(No. of Staff)*[6]
Base Case[7]	46	43	20	191	9
Application Case ***(Project Effect Only)***	0.2	0.2	0.1	0.7	0.04
Planned Development Case[7]	28	26	12	116	6

Notes:
(1) Urban service area only
(2) Number of RCMP officers (full-time equivalents)
(3) Number of fire and ambulance personnel (full-time equivalents)
(4) Number of full-registered physicians
(5) Number of licensed teachers (full-time equivalents)
(6) Number of Neighbourhood and Community Development Branch (RMWB) staff (full-time equivalents)
(7) Additional social infrastructure required over and above existing levels
(8) Additional social infrastructure required over and above Application Case assumptions in 2017

D.8.2.6 Municipal Infrastructure and Services

Like other municipalities, the RMWB is responsible for:

- planning residential growth;
- providing sufficient quality water, wastewater and solid waste facilities and services;

- planning, building, operating, and maintaining arterial roads;
- delivering selected emergency and social services; and
- ensuring adequate recreation facilities.

The RMWB has been experiencing demand for services and municipal infrastructure as the population of the municipality grows. At the same time, development of the region's oil sands has provided the RMWB with increased financial ability to respond to these growth pressures. Property assessment in the Rural Service Area of the RMWB, which consists mostly of oil sands industry facilities, grew on average by 24% per year from $6.6 billion in 2005 to $24.1 billion in 2011. The rural nonresidential (oil sands) assessment currently contributes over 90% of the RMWB's property tax revenue.

The municipality still has some concerns with meeting infrastructure and service demands, including:

- the relatively higher costs of providing infrastructure in the RMWB as compared to municipalities in the southern half of the province. These cost concerns are offset by recent and expected increases in the RMWB's rural non-residential assessment base; and
- reduced management capacity within the municipality as a result of staff attraction and retention difficulties. The RMWB has a number of initiatives in place to address staff recruitment and retention, including a housing allowance, relocation assistance and house equity protection.

The long-term ability of the RMWB to finance critical infrastructure projects, carry increased debt load and maintain operating services will depend upon future municipal tax revenue from oil sands development coming on stream as planned. The RMWB's Fiscal Management Strategy 2011 to 2014, states that the rural nonresidential taxation class "will have a tax burden that provides the municipality with a balanced budget while taking into account other taxation classes" (RMWB 2011c).The assessment in the Rural Service Area of the RMWB will expand further as projects currently under construction come on stream and additional projects are sanctioned and built.

Additional population under the Base Case will require additional investment in municipal infrastructure and services. The RMWB has undertaken a number of planning studies and is investing in infrastructure and service capacity expansion. The Government of Alberta has provided assistance on some of these projects.

In more general terms, the RMWB anticipates much of the population growth under the Base Case assumptions and has put in place a long-term capital program worth $3.1 billion for the period between 2011 and 2017 (RMWB 2011c).

D.8.2.7 Transportation

Highway 63 is the primary roadway throughout the RSA, connecting southward with the wider provincial road network. Secondary Highway 881, which intersects with Highway 63 roughly 20 km south of Fort McMurray, serves as the other highway connection within the RSA.

Traffic volumes over the last five years have increased by approximately 8.4% per year on the segment of highway 63 between Fort McMurray and the AOSTRA road intersection. In 2010, the traffic volume between Fort McMurray and the AOSTRA road intersection recorded by Alberta Transportation was 20,630 AADTs (average annual daily traffic [two-way vehicle movements]). A recent Traffic Impact Assessment (TIA) examined the intersection of Highway 63 and the AOSTRA road and determined that the aforementioned intersection does not currently provide an adequate level of service during the peak hours of 6:15 to 7:15 am and 5:15 to 6:15 pm (Stantec 2009).

While traffic safety is a concern for many residents, both Highway 63 and Highway 881 continue to have collision rates below the provincial average for comparable roadways (CR #8, Table 8.1). For example, the 2009 collision rate for the highway segment between Fort McMurray and the AOSTRA road is 51% of the provincial average for that roadway type.

Base Case traffic levels will continue to increase, as a result of continued construction and operations of oil sands activities, related indirect activities supporting industry, as well as general population growth in the study area. Traffic volumes on Highway 63 between Fort McMurray and the AOSTRA road turnoff are expected to rise by 33% from 20,630 AADT in 2010 to 27,335 AADT in 2020. This estimate is based on the traffic volumes associated with the long term operations of oil sands projects which access Highway 63. Traffic may peak above 27,335 AADT during the forecast period due to temporary construction activity. The AOSA CRISP highlights the need to expand the transportation network north of Fort McMurray and suggests additional north-south highway corridor crossing the Clearwater River east of Fort McMurray and bus-based rapid transit north of Fort McMurray. If implemented, these developments would decrease the traffic numbers on Highway 63 between Fort McMurray and AOSTRA Road.

Traffic volume on the AOSTRA road is also expected to increase from the 580 AADT observed in 2010 to approximately 860 AADT in 2020. The AOSTRA road is an industry road and therefore traffic volumes fluctuate with the construction and operations activity at oil sands

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facilities along the road and the estimates presented above may change as companies adjust the timing of projects and workforce housing and transportation strategies.

D.8.3 Predicted Conditions

D.8.3.1 Economic and Fiscal Assessment

Income Effects

Total capital expenditure during construction by Phase 2 is estimated at $1.14 billion. Construction capital expenditures include wages and salaries paid to construction workers, professional engineering and environmental services, and the direct purchase of goods and services, such as equipment modules and structural elements. Table D.8.4 provides a breakdown of the estimated construction expenditure by region, based on published supply ratios by industry, discussions with local service contractors, information provided by STP, and the past experiences of similar projects in the region (Alberta Finance, 2011).

Table D.8.4 Construction Expenditure by Region

Expenditures	RSA	Other Alberta	Other Canada	Foreign	Total
	[$ millions]				
Engineering	-	40	15	-	**55**
Labour	20	205	200	-	**425**
Materials/Equipment	-	260	100	300	**660**
Total	**20**	**505**	**315**	**300**	**1,140**
Total [%]	**2**	**44**	**28**	**26**	**100**

– Not significant.
Note: Totals may not add to 100% due to rounding.

Once operational, Phase 2 will incur costs in the form of ongoing drilling and sustaining capital expenditure. These expenditures include wages and salaries for drilling/completions contractors, as well as pipeline, well pad, road and plant related materials and equipment required to maintain the designed productive capacity of the plant. Sustaining capital and ongoing drilling expenditures will begin in 2016 and average $50 million per year over the life Phase 2. More than three-quarters of the annual sustaining capital and ongoing drilling expenditures will accrue to Alberta suppliers, reflecting the supply capabilities of the Alberta drilling and pad and pipeline construction sectors.

Once fully constructed, the annual operations expenditure related to Phase 2, excluding fuel and utilities, will average approximately $81 million. These costs are in addition to the sustaining capital and ongoing drilling expenditures of approximately $50 million.

Table D.8.5 provides a breakdown, by region, of the annual operations expenditure based on published supply ratios by industry (Alberta Finance, 2011).

Table D.8.5 Operations Expenditure by Region

Expenditures	RSA	Other Alberta	Other Canada	Foreign	Total
	[$ millions]				
Labour	1	19	6	-	**26**
Materials/Equipment	-	39	6	10	**55**
Total	2	58	12	10	**81**
Total [%]	2	72	15	12	**100**

– Not significant.
Note: Totals may not add to 100% due to rounding.

The total (direct, indirect and induced) GDP impact of operating, ongoing drilling, and sustaining capital expenditures are estimated at $110 million annually. The total labour income effect of operating, sustaining capital, and ongoing drilling expenditures for Phase 2 is estimated at $60 million annually. The estimates represent an average annual impact over the life of the project and are based on published multipliers (Alberta Finance 2011).

Project Fiscal Effects

Phase 2 contributes property taxes to the RMWB, oil sands royalties to the provincial government and corporate taxes to the provincial and federal government. Project tax and royalty payments expand the ability of the different levels of government to fund programs and initiatives in the RSA and elsewhere.

The amount of municipal taxes that will be paid in relation to Phase 2 is uncertain, as both the actual assessment of the facility and the tax rates in effect when it becomes operational are unknown. A preliminary estimate of the municipal tax payment related to Phase 2 is $2.6 million in 2017, when the project is fully operational. Over the life of Phase 2, assuming that the 2010 municipal tax rates remain in effect and a discount rate of 8%, the present value in 2011 of the municipal taxes paid in relation to Phase 2 is approximately $28.2 million.

Once Phase 2 is operational, royalties will be paid to the provincial government. Future royalty payments are subject to uncertainty as they are directly related to the prevailing market price of oil, the Canadian-US dollar exchange rate, and the differential between light and heavy crude oil. Production costs, including fuel, also impact the calculation of royalties. The Phase 2 Project is estimated to result in approximately $550 million (NPV 2011) being paid in royalties over the life of the project.

STP will also pay provincial and federal corporate income taxes on revenue derived from Phase 2. Under the same assumptions described above and assuming the present tax framework applies over the life of the project, STP will pay approximately $150 million and $225 million (NPV 2011) in provincial and federal corporate income taxes, respectively over the life of the project.

These provincial fiscal benefits are not net of potential costs to the province of social and physical infrastructure investment driven by oil sands industry expansion, including Phase 2. The CRISP outlines the requirement of provincially funded infrastructure in the Athabasca Oil Sands area, which includes the RSA, as bitumen production increases (CRISP 2010). Most of the bitumen royalties are paid by projects in the RSA.

Project Employment Effects

The construction of Phase 2 will create work in fabrication shops and construction yards outside of the RSA, mostly in the Edmonton area. The total off-site construction is estimated to be 525 person years during the 2012 to 2016 period. Figure 2.3 shows that the off-site workforce is expected to peak at approximately 220 workers during 2013 given the assumed construction schedule.

Construction of Phase 2 is expected to require 1,295 person years on-site during the 2013 to 2016 period In addition to the construction of the central facility, there will be initial drilling and completions activity which is expected to generate an additional 100 person years of employment between 2013 and 2017. All together and under the assumed schedule, the construction of the plants, field facilities and the drilling of wells will create close to 1,395 person years of on-site employment over the five-year construction period, with a peak of roughly 500 in 2014 (CR #8, Figure 2.2). The construction of Phase 2 will create work in fabrication shops and construction yards outside of the RSA, mostly in the Edmonton area. The total off-site construction is estimated to be 525 person years during the 2012 to 2016 period. The total direct employment effect of construction of Phase 2, including the on- and off-site workforces, initial drilling and engineering is estimated at 2,220 person-years. The total direct, indirect and induced employment effect is estimated at 3,870 person-years over the construction period.

Once fully operational, Phase 2 is expected to increase the total workforce of the STP McKay Thermal Project by 51 positions, from 63 to 114 positions. Approximately 70% of these full-time positions are expected to be STP employees with the balance staffed by contractors. During the operational phase of the project, there will be continuous drilling activities to ensure the productive capacity of each phase is maintained throughout the life of the project. Ongoing drilling activity and associated field construction for Phase 2 is expected to employ approximately 70 person years of labour annually on-site. This estimate is an annual average as the actual volume of drilling will vary from year to year and be performed primarily in the winter months. In addition to the permanent operations employment, Phases 1 and 2 will collectively employ between 100 and 220 contractors for approximately two weeks every year for scheduled turnarounds. Some of the activities related to the operation of Phase 2 will be performed off-site. For example, well pad equipment will be fabricated in production facilities in the greater Edmonton area. This employment is expected to average between 5 and 10 person years of employment annually over the life of the project. The total direct employment effect of operating Phase 2, including the regular operations workforce, the ongoing maintenance workforce and ongoing drilling activities is estimated at 121 full-time equivalent positions. The total direct, indirect and induced employment is estimated at 400 person years annually.

D.8.3.2 Traditional Land Use

Additional land disturbance and population growth associated with approved and proposed oil sands projects will diminish opportunities for traditional pursuits in the region and place increasing stress on traditional culture. However, it will also enhance a number of the benefits associated with development including increased wage opportunities, support for TLU and TEK studies, as well as support for cultural retention and historical preservation initiatives.

D.8.3.3 Population

<u>Application Case</u>

Resident population growth associated with Phase 2 will largely accrue to the urban service area beginning in 2013, the start of on-site construction. Phase 2's peak population effect is just over 420 and will occur in 2015 when on-site construction and operations employment overlap. Once on-site construction is complete and full operations are underway, the long-term resident population effect of Phase 2 is approximately 75 people.

The effect of Phase 2 on the Wood Buffalo resident population is limited during both the construction and operations phases by its onsite lodge-based approach.

<u>Planned Development Case</u>

Under the PDC the long-range population growth trend of the urban population of the RMWB is expected to be 6% per year, reaching approximately 114,500 by 2017. This is 16% higher than the Baseline Case.

Most newcomers to the region take up residence in Fort McMurray and its bedroom communities. However, in recent years urban population growth has spilled over to some rural communities in the vicinity of the urban service area, driven mainly by the presence of new subdivisions in these communities. Future growth among the region's smaller rural communities is anticipated as a result of cumulative development in the region. Most of this growth is expected among communities in close proximity to the urban service area, such as Anzac.

Population projections are open to uncertainty and should be treated as estimates only. A number of factors could affect population growth including changes in the timing and size of individual projects, additional projects being brought forward, future technological advances in oil sands construction and operation, and the potential emergence of new communities in the region.

D.8.3.4 Housing

<u>Application Case</u>

Phase 2 will have a negligible impact on the urban area housing market. The permanent housing need associated with the long-term population effects of Phase 2 is estimated at about 27 dwelling units over and above the units needed under Base Case assumptions. The use of an operations camp will reduce the housing requirement associated with Phase 2 by about 80 dwelling units.

<u>Planned Development Case</u>

The population forecast for the PDC is estimated to generate housing demand for about 2,100 additional dwelling units by 2020, above Base Case assumptions.

D.8.3.5 Social Infrastructure

<u>Resident Population</u>

Phase 2 will have a small effect on social infrastructure in-line with its effect on the resident population. The effects of Phase 2 on social infrastructure will begin with the start of on-site construction in 2013. During the overlap of construction and operations hiring in 2015, when population effects are most pronounced, Phase 2 will create demand for social infrastructure higher than the long-term average identified in Table D.8.3, in line with Phase 2's population effect (see CR #8, Section 4.3.1.2).

Responsible authorities are aware of anticipated future growth and have been carrying out planning initiatives in anticipation of this growth (*e.g.*, LARP, AOSA CRISP, RMWB MDP). It is imperative that these planning initiatives be properly resourced and carried out in a timely manner so as to avoid socio-economic pressures associated with growth.

Rural Communities

Rural communities will also experience increased demand for social infrastructure resulting from oil sands development primarily through:

- Urban population growth that has spilled over to some rural communities. Most of this growth is expected among communities in close proximity to the urban service area. Growth in many of the smaller communities is somewhat constrained by the limited residential and commercial opportunities.
- Associated social changes that development brings to many Aboriginal communities. Many Aboriginal community members need, and will likely continue to need, assistance in managing these changes. This assistance is likely to be needed in different forms for different people. Some will need programs to help keep their children in school, while others will need counselling for a range of social issues, including addictions (see CR #8 Section 3).

Non-Resident Population

Growth in the nonresident population, primarily camp-based workers, is also expected to affect demand for social infrastructure in the region. Many effects are mitigated by camp distances from Fort McMurray, restrictions on personal vehicles allowed on-site and available camp services (*e.g.*, health, recreation).

Facility Related Effects

Oil sands projects are large-scale industrial projects that often require specialized emergency responder capabilities. While emergency and medical services are available on-site, oil sands projects in the region also increase the potential for industrial accidents and emergencies that could in turn place demands on emergency and health services in the region.

A primary concern for policing services in the region is traffic issues related mainly to the construction of oil sands projects. Construction-related traffic will increase traffic volumes on the regional road network (see CR #8, Section 8). Because of the extended construction period for these projects, these increased traffic volumes will lead to the need for increased policing resources to monitor traffic safety and respond to traffic collisions.

D.8.3.6 Municipal Infrastructure and Services

Application Case

Phase 2 will have limited or no effect on municipal services. The project will provide its own water and sewer services and the associated infrastructure, including camps. The resident population effect associated with Phase 2, estimated at approximately 75 people over the long term, will have a negligible effect on the region's municipal infrastructure above the forecasted Base Case.

Planned Development Case

The PDC population forecast calls for the regional population to reach 114,500 by 2017. Planning and investment currently underway assumes population levels in line with the population estimate associated with the PDC.

While the planned oil sands developments assumed in the PDC will drive further population growth, nonresidential assessment will also grow, thus expanding the RMWB's ability to pay for municipal services and infrastructure.

D.8.3.7 Transportation

Application Case

It is expected that construction workers will travel during shift rotations from their point of origin to the project site via a combination of commercial flights to Fort McMurray and private vehicles. During peak construction in the 2013 to 2014 period, Phase 2 is expected to temporarily contribute approximately 350 AADT to Highway 63 and the AOSTRA road. This represents an increase of 1.7% and 60% over current volumes on Highway 63 and the AOSTRA road respectively.

During operations, the majority of operations workers will be flown in and out of the Fort McMurray airport and bussed to site during shift rotations. Phase 2 is expected to generate approximately 40 AADT on both Highway 63 and the AOSTRA road.

Planned Development Case

AOSTRA road is the access road to a substantial number of planned in situ projects. Production levels from projects using AOSTRA road may increase from the current 30,000 bpd to over 300,000 bpd.

Traffic volumes on Highway 63 are driven primarily by oil sands mine developments further north than the AOSTRA road intersection. The most current (2010) data available suggests that of the 10,300 vehicles counted on Highway 63 prior to the AOSTRA road intersection, 10,070, or 98% of the traffic, continued north to oil sands project further along the highway. Development of the oil sands north of the AOSTRA road is expected to continue in the PDC, resulting in long run operations related traffic volumes of approximately 27,375 AADT in 2020. Traffic may peak above 27,375 AADT during the forecast period due to temporary construction activity. The AOSA CRISP addresses this increase in traffic volume and indicates the need for a number of road infrastructure improvements, including additional north-south highways to the east and the west of Highway 63 north of Fort McMurray.

Traffic volume on the AOSTRA road is expected to be 920 AADT in 2020. This volume will all pass through the intersection of Highway 63 and the AOSTRA road which has already been identified as operating below the level of service criteria established by Alberta Transportation during peak hours (Stantec 2009). The timing of future projects on the AOSTRA road is uncertain and the forecast traffic volumes will change as project timelines shift and new projects come forward.

D.8.4 Mitigation and Monitoring

D.8.4.1 Mitigation

In order to reduce the potential impacts on housing, transportation, municipal infrastructure and social infrastructure STP will:

- house construction workers associated with Phase 2 in on-site camps and if, during peak periods, the on-site accommodation needs exceed availability open camps near the project site will be used;
- have a dedicated on-site operations camp;
- offer in-camp services to mitigate the effects of its camp-based workforce on regional service providers, including:
- basic first responder medical capability on site during operations and onsite medical response during construction;
- onsite security staff during construction; and
- recreational opportunities.
- provide onsite water supply and wastewater treatment system;
- employ a fly-in-fly-out program and bussing operations workers from the Fort McMurray Airport to the project site during operations;
- schedule construction truck traffic (including oversized loads), commodity deliveries and material deliveries during off-peak hours;
- lead a TIA Industry Group, in updating a Traffic Impact Assessment and a Functional Planning Review as per Alberta Transportation’s guidelines
- become a member of the OSDG and therefore be supportive of OSDG efforts to work with municipal and provincial planners and home builders to facilitate the timely development of residential land and dwellings;

- be open to working with the Government of Alberta and other stakeholders as the AOSA CRISP moves forward with implementation;
- put in place additional project-related measures to mitigate effects on regional social infrastructure, including:
- developing and implementing an emergency response plan which includes the required personnel, procedures and equipment resources (*e.g.*, vehicles, fire response, medical response, and rescue);
- maintaining explicit and enforced camp and workplace policies with regards to the use of alcohol, drugs, and illegal activities; and
- providing employees with access to the company's confidential employee assistance plan, which provides support for families and individuals who may experience difficulty dealing with personal, family, or work-life issues that can affect one's health and well-being.
- support local community initiatives (*e.g.,* financial and in-kind contributions to social groups, education institutions, and health care providers), where appropriate; and
- cooperate with service providers, government, and industry to assist in addressing effects of its project and oil sands development in general by:
- communicating its development and operational plans with the appropriate agencies; and
- working with the provincial and municipal governments on the implementation of relevant planning initiatives, where appropriate (*e.g.,* LARP, AOSA CRISP, RMWB's MDP).

In order to enhance the positive and minimize the adverse effects of Phase 2 on traditional land use and culture STP will:

- undertake progressive reclamation, giving priority to lands of Aboriginal importance, whenever possible;
- discourage camp residents from fishing, hunting, and driving recreational vehicles on traditional lands;
- promote cultural diversity awareness to STP employees and contractors regarding respect for traditional resource users, traplines, cabins, trails and equipment;
- provide access to trappers and traditional users across the project area;
- compensate trappers directly affected by the project, according to industry standards;
- consider entering into beneficial agreements with First Nations whose traditional land uses are directly affected by the project;

- participate in regional multi-stakeholder planning and research initiatives that incorporate consideration for the long-term sustainability of effective traditional land use; and
- continue to work with Aboriginal communities in the region to ensure that their concerns with respect to traditional land use and culture are continually considered during project planning and operation.

D.8.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will continue to consult with main stakeholders. No other monitoring other than ongoing consultation is required.

D.8.5 Summary

Phase 2 will create positive economic and fiscal effects on the Socio-Economic Regional Study Area (RSA) consisting of the RMWB and the nearby First Nation communities. Phase 2 will create 300 person years of engineering employment, 2,220 person years of construction employment, 51 operations positions and 70 person years of employment for ongoing drilling. STP will also pay municipal property taxes, provincial and federal corporate income tax and provincial royalties.

The effects of Phase 2 on many regional services and infrastructure will be muted due to the continued use by STP of construction and operations strategies that rely on on-site work camps, supported during operations by a fly-in-fly-out (FIFO) worker commute program. The long-term resident population effect of Phase 2, estimated at around 75 people, will have a marginal effect on regional services and infrastructure. In addition, various mitigation and management measures are and will be taken by STP to address the effects of its project and oil sands development in general.

D.9 Soil Resources

D.9.1 Introduction and Terms of Reference

STP conducted an assessment of soil resources for the Phase 2 Project. The following section is a summary of the Soil Assessment that was prepared by Millennium EMS Solutions Ltd. and included as Consultants Report #9 (CR #9). For full details of the assessment please refer to CR #9.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the soil resource component are provided in Section 3.9 and are as follows:

3.9.1 Baseline Information

[A] Describe and map the terrain and soils conditions in the Project Area.

[B] Describe and map soil types in the areas that are predicted in 3.1.2[A]d) to exceed Potential Acid Input (PAI) critical loading criteria.

3.9.2 Impact Assessment

[A] Describe Project activities and other related issues that could affect soil quality (e.g., compaction, contaminants) and:

- *a) indicate the amount (ha) of surface disturbance from plant, field (pads, pipelines, access roads), aggregate and borrow sites, construction camps, drilling waste disposal and other infrastructure-related construction activities;*
- *b) discuss the relevance of any changes for the local and regional landscapes, biodiversity, productivity, ecological integrity, aesthetics and future use;*
- *c) identify the potential acidification impact on soils and discuss the significance of predicted impacts by acidifying emissions; and*
- *d) describe potential sources of soil contamination.*

[B] Discuss:

- *a) the environmental effects of proposed drilling methods on the landscape and surficial and bedrock geology;*
- *b) the potential for changes in the ground surface during steaming and recovery operations (e.g., ground heave and/or subsidence) and their environmental implications; and*
- *c) the potential impacts caused by the mulching and storage of woody debris considering, but not limited to vulnerability to fire, degradation of soil quality, increased footprint, etc.*

[C] Discuss mitigation strategies to minimize the potential impact of the Project on soils or terrain.

3.10.3 Monitoring

[A] Describe the Proponent's current and proposed monitoring programs.

[B] Describe the monitoring programs proposed to assess any Project impacts and to measure the effectiveness of mitigation plans.

[C] Discuss the Proponent's regional monitoring activities including:

- *a) monitoring that will be undertaken to assist in managing environmental effects, confirm performance of mitigation measures and improve environmental protection strategies;*
- *b) monitoring done independently by the Proponent and how these monitoring programs are consistent with other current or proposed regional monitoring programs;*
- *c) monitoring performed in conjunction with other stakeholders, including aboriginal communities and groups; and*
- *d) new monitoring initiatives that may be required as a result of the Project.*

[D] Discuss:

a) the Proponent's plans for addressing and mitigation any environmental impacts identified in the monitoring program

b) how monitoring data will be disseminated to the public or other interested parties; and

c) how the results of monitoring programs and publicly available monitoring information will be integrated with the Proponent's environmental management system.

The LSA for the soils and terrain baseline study was selected to allow for the evaluation of soils and terrain that may be potentially impacted as a result of the development of Phase 2 (Figure C.2.1). The RSA consists of an area delineated on the basis of potential regional effects to soils, including those related to existing and planned activities in the area and to regional air emissions from Phase 2 in combination with adjacent existing, approved and future planned oil sands operations (Figure C.2.2).

Baseline soil data was used to determine the potential environmental effects that Phase 2 may have on soil resources in the survey and proposed development areas, and to assist in preparation of a Conservation and Reclamation Plan with appropriate site mitigation and monitoring activities designed to achieve reclamation success. The soil resource valued environmental components (VECs) chosen for the assessment include:

- soil quality;
- soil biodiversity; and
- terrain.

D.9.2 Baseline Conditions

The LSA and RSA boundaries for Phase 2 are within Soil Correlation Area (SCA) 20, which consists dominantly of low-relief till with extensive areas of poorly drained peatlands (Pedocan 1993). Upland areas within SCA 20 are dominated by Luvisols, with significant inclusions of Brunisols, Regosols and Gleysols. Nearly level to depressional landscapes are dominated by Organic soils.

Regional Study Area

The baseline soil units within the RSA are listed in Table D.9.1 and shown in CR #9, Figure 6 and the dominant soil series summarized in Table D.9.1.The baseline soil map for the RSA was developed through the use of the following information sources:

- satellite imagery of the region;
- surficial geology map of the region (Pawley 2011);
- ecosite phase shapefile data for Phase 2 vegetation RSA (CR #10); and,

- soil mapping information available from other baseline soil surveys within the region, including the adjacent *Soils Inventory of the Alberta Oils Sands Environmental Research Program – Study Area* (AOSERP) (Turchenek and Lindsay 1982).

Table D.9.1 Soil Series Within The RSA And Estimated Extent

Map Unit	Area (ha)	% of RSA	Map Unit Count
ALG/CHT	7,989.6	10.0	2,621
ALG/DOV	4,274.3	5.4	525
DOV	9,032.1	11.3	599
HRR	836.2	1.1	44
HRR/LVK	314.3	0.4	4
HRR/MNS	106.3	0.1	12
LVK	908.8	1.1	75
LVK/WHM	1,553.0	2.0	299
MIL	2,096.0	2.6	4,398
MLD	466.7	0.6	383
MMY	1,970.1	2.5	188
MMY/MMW	290.8	0.4	60
MNS/WHM	967.4	1.2	344
MRN	37,701.2	47.4	4,529
MUS	9,061.2	11.4	3,368
ZDL	1,315.1	1.7	81
ZWA	727.9	0.9	133
TOTALS	**79,611**	**100**	**17,659**

Local Study Area

Morphological and analytical data from the following sources were utilized in assessing the base-line soil and terrain conditions within the LSA:

- 902 inspection sites and 66 sampled profiles with lab analysis located within or adjacent to the LSA;
- baseline soil interpretations from the Application for the Proposed STP McKay Thermal Project – Phase 1 (Consultant Report #9)(STP 2008);
- soil profile and chemistry data from the AOSERP document were consulted (Turchenek and Lindsay 1981); and

- soil profile information from Alberta Soil Names (AG30SNF) and Soil Layer (AG30SLF) files from AGRASID version 3.0 (ASIC 2001, Brierley et al. 2006).

A total of 1,072 soil inspection sites have been recorded within or adjacent to the LSA to date, including 66 soil profiles sampled. Of that total, 902 were located within the LSA, which covers the area where soils may potentially be impacted by the Project (CR #9, Figure 2). There were two levels of soil survey intensity completed within the LSA: survey intensity level (SIL) 2 (majority of lease area including the Future Development footprint with one inspection for every 5-15 ha) (MSWG 1981), and survey intensity levels greater than one inspection per 1 ha (SIL1) on the Initial Development footprint as required for a Pre-Disturbance Assessment (AENV 2009).

At each inspection site the soil profile was investigated to a depth of approximately 100 cm for upland soils, while Organic soils were investigated to mineral contact or a maximum depth of 220 cm.

Samples of one or more soil horizons or layers were collected at 62 of the soil inspection sites located within and adjacent to the LSA. Grab samples collected aimed to represent common soils in the area and to identify specific characteristics of such soils.

Soil information within the LSA was analyzed in order to understand the relationship between soil types, vegetation and terrain patterns. Thirty-three representative soil series and variants (CR #9, Table 4) were organized into 30 soil map units (SLMs) representing common soil patterns found in the LSA. The 30 soil map units include two non-soil map units (ZDL – disturbed lands and ZWA – water bodies).

D.9.2.1 Thickness of Soil Layers

Litter material, topsoil, surface peat and subsoil layers were defined based on The Canadian System of Soil Classification – Third Edition (SCWG 1998). Topsoil, surface peat, and upper subsoil layers were defined as follows:

- topsoil (TS) – Ae, Ahe and AB horizons, including gleyed (g) and weakly gleyed (gj) versions of these horizons;
- surface litter/peat – under forested vegetation the surface litter is commonly comprised of L, F, and H layers (L- forest litter; F – fibric; and H – humic) and in organic landscapes, peat profiles are differentiated by degree of decomposition (Of, Om, and Oh layers); and

- upper subsoil (US) – all types of B horizons (Bm, Bt, BA), plus gleyed (g) and weakly gleyed (gj) versions of them (as defined by SCWG 1998), were considered to be part of the upper subsoil.

All soil data collected within or adjacent to the LSA was analyzed to determine average thicknesses of soil layers for the soil map units. The results are listed in Table D.9.2 and shown in CR #9, Figure 7.

Table D.9.2 Soil Layer Thicknesses By SLM

Map Unit (SLM)	Thickness (cm)			
	Litter/Peat	Topsoil	Topsoil Lift Thickness(1)	Upper Subsoil
ALG20/L1	10	10	20	40
CHT21/L1	25	5	30	30
DOKM9/U1l	10	15	25	40
DOLV2/U1l	5	15	20	45
DOLV9/U1l	5	15	20	45
HRLV2/U1l	10	15	25	40
HRLV18/U1h	10	15	25	40
KME9/U1l	10	10	20	40
LVK18/U1l	5	15	20	40
MIL18/L3	5	15	20	45
MIL5/H1m	5	15	20	45
MLD1m-G/O1	55	5	-	20
MLD1m-G/O3	60	-	-	15
MLD1m/O1	75	-	-	-
MLD1m/O3	85	-	-	-
MLD1f/O1	75	-	-	-
MLD2m/O1	120	-	-	-
MMY2/SC2	10	5	15	0
MMY9/SC1l	10	5	15	0
MNS20/L1	15	10	25	50
MRN1m-G/O1	55	5	-	20
MRN1m/O1	85	-	-	-
MRN1f/O1	80	-	-	-
MUS2m/O1	145	-	-	-
MUS2f/O1	130	-	-	-

Table D.9.2 Soil Layer Thicknesses By SLM				
	Thickness (cm)			
Map Unit (SLM)	Litter/Peat	Topsoil	Topsoil Lift Thickness[(1)]	Upper Subsoil
WHM20/L1	10	10	20	40

(1) Topsoil Lift Thickness includes the mineral A horizon plus the litter/surface organic layer. In mineral soils this is the salvage depth for the topsoil material.

D.9.2.2 Forest Soil Capability Classification

Land capability for the LSA has been catalogued by rating the SLMs according to the *Land Capability Classification System for Forest Ecosystems in the Oil Sands* (LCCS) (CEMA 2006).

Forest soil capabilities were determined for SLMs (*i.e.*, DOKM9/U1l) through amalgamation of individual soil series ratings of dominant (>50%), co-dominant (>30%) and significant soils (>10%) estimated to occur in each SLM. The predominant limitations to soils within the LSA include moderately acidic to acidic soil pH values throughout the soil profiles (subclass V), massive subsoil structure and firm consistence (subclass D), poor drainage (subclass W), and/or rapid drainage (subclass X).

Distribution of final land capability classes within the LSA and Phase 2 footprint are provided in Table D.9.3 and are shown on CR #9, Figure 8.

Table D.9.3 Extent Of Forested Soil Capability In The LSA and Phase 2 Footprint						
	LCCS Ratings Classes					Totals (ha)
Area	Class 2 (ha)	Class 3 (ha)	Class 4 (ha)	Class 5 (ha)	Not Rated[(1)] (ha)	
LSA	877.5	1,084.4	369.9	2,780.0	623.5	5,735
Initial Development	90.7	4.8	7.9	49.8	<0.01	153.2
Future Development	75.1	47.2	23.8	200.7	2.0	348.8

(1) Not rated: Undifferentiated Gleysolic soils and water bodies (ZGWA); undifferentiated mineral soils on inclined to steep, single-slope landforms with high relief (ZUN); disturbed lands (ZDL); and water bodies (ZWA).

Classes 3 and 5 are most extensive within the LSA, accounting for 18.9% and 48.5% of the LSA area respectively. Class 5 lands were the most common within the Phase 2 Project footprint covering between 32.5 to 80.0% of the footprint depending on the development stage. Class 2 soils accounted for 21.5 to 59.2% of the footprint, with Initial Development containing the largest distribution of Class 2 soils.

D.9.2.3 Reclamation Suitability

Reclamation suitability ratings provide information that is useful for making soil handling recommendations, and guidance as to soil types that may present challenges for reclamation. Reclamation suitability was assessed for the topsoil (TS; *i.e.*, A horizons) and upper subsoil (US; *i.e.*, B horizons), horizons for soils in the LSA. This assessment followed the *Soil Quality Criteria Relative to Disturbance and Reclamation Guidelines* as specified for the Northern Forest Region of Alberta (SQCWG 1987). SLM ratings for the LSA are listed in Table D.9.4 and the suitability ratings for topsoil and upper subsoil are displayed in CR #9, Figure 9 & 10.

Table D.9.4 Reclamation Suitability Ratings For Soil Landscape Models In The LSA

Map Unit (SLM)	Ratings		Comments
	TS(1)	US(2)	
ALG20/L1	G-F	P	TS – slightly acidic pH, slightly low saturation %, fine textures US – mainly fine textures
CHT21/L1	G-F	F-P	TS – slightly acidic pH, slightly low saturation %, fine textures US – mainly fine textures
DOKM9/U1l	G-F	P	TS – slightly acidic pH, slightly low saturation %, fine textures US – mainly fine textures
DOLV2/U1l	G-F	F-P	TS – slightly acidic pH, slightly low saturation %, fine textures US – mainly fine textures
DOLV9/U1l	G-F	F-P	TS – slightly acidic pH, slightly low saturation %, fine textures US – mainly fine textures
HRLV2/U1l	G-F	F	TS – slightly acidic pH, slightly low saturation %, fine & coarse textures US – moderately fine texture
HRLV18/U1h	G-F	F	TS – slightly acidic pH, slightly low saturation %, fine & coarse textures US – moderately fine texture
KME9/U1l	G-F	P	TS – slightly acidic pH, slightly low saturation %, fine textures US – mainly fine textures
LVK18/U1l	F	F	TS – slightly acidic pH, slightly low saturation %, fine & coarse textures US – moderately fine texture
MIL18/L3	P-F	P	TS – slightly acidic pH, and coarse textures US – coarse texture
MIL5/H1m	P-F	P	TS – slightly acidic pH, and coarse textures US – coarse texture
MLD1m-G/O1	O	O	TS – Organic, not rated US – slightly alkaline pH and moderately fine texture
MLD1m-G/O3	O	O	TS – Organic, not rated US – slightly alkaline pH and moderately fine texture

Table D.9.4 **Reclamation Suitability Ratings For Soil Landscape Models In The LSA**			
Map Unit (SLM)	**Ratings**		**Comments**
	TS[(1)]	**US[(2)]**	
MLD1m/O1	O	O	TS – Organic, not rated US – slightly alkaline pH and moderately fine texture
MLD1m/O3	O	O	TS – Organic, not rated US – slightly alkaline pH and moderately fine texture
MLD1f/O1	O	O	TS – Organic, not rated US – slightly alkaline pH and fine textures
MLD2m/O1	O	O	Organic > 1.0 m
MMY2/SC2	G-F	G-F	TS – slightly acidic pH, slightly low saturation %, moderately coarse or fine textures US – moderately fine texture
MMY9/SC1l	G-F	G-F	TS – slightly acidic pH, slightly low saturation %, moderately coarse or fine textures US – moderately fine texture
MNS20/L1	G-F	G-F	TS – slightly acidic pH and moderately fine textures US – slightly alkaline pH and moderately fine texture
MRN1m-G/O1	O	F	TS – Organic, not rated US – slightly alkaline pH and moderately fine textures in component soils
MRN1m/O1	O	F	TS – Organic, not rated US – slightly alkaline pH and moderately fine textures in component soils
MRN1f/O1	O	P	TS – Organic, not rated US – slightly alkaline pH and fine textures in component soils
MUS2m/O1	O	O	Organic >1.0 m
MUS2f/O1	O	O	Organic >1.0 m
WHM20/L1	G-F	F	TS – low saturation % and coarse or moderately fine textures US – slightly alkaline pH and moderately fine textures
ZGWA20/SC1l	NR[(3)]	NR[(3)]	Undifferentiated Gleysolic soils and water bodies – not rated
ZUN18/I3h	NR[(3)]	NR[(3)]	Undifferentiated mineral soils on inclined to steep, single-slope landforms with high relief – not rated
ZDL	NR[(3)]	NR[(3)]	Disturbed lands – not rated
ZWA	NR[(3)]	NR[(3)]	Water bodies – not rated

(1) TS – Topsoil is defined as the A horizon material (Ahe, Ae, Aegj, Aeg, AB)
(2) US – Upper subsoil is defined as the B horizon (Bm, Bt, Btgj, Btg, BA)
(3) NR – Soil Landscape Model not rated for reclamation suitability.

D.9.2.4 Erosion Risk Assessment

Soil erosion by wind or water can affect soil profiles and distribution of soils in the landscape. In areas where vegetation has been cleared and the soil surface disturbed, the risk of erosion generally increases.

Erosion via wind and water was evaluated for the dominant or co-dominant soils of all Soil Models in the LSA. Wind erosion risk ratings are adapted from the *Wind Erosion Risk – Alberta* (Coote and Pettapiece 1989), and water erosion risk ratings were adapted from *Water Erosion Risk – Alberta* (Tajek and Coote 1985).

Within the LSA the risk of water erosion is typically low to moderate as the soil surface is currently well protected by tree and understory cover. However, one SLM (ZUN18/I3h) contains significant coarse textured soils and relatively steep slopes resulting in moderate to high water erosion risk.

Significant tree and understory cover and an extensive litter layer results in minimal exposure of surface soil material to wind throughout the study area. A majority of the soil series in the region have a low potential for soil erosion via wind (Pedocan 1993).

D.9.2.5 Soil Sensitivity - Acidification

Soil sensitivity to acid deposition is the most commonly used system to rate the ability of soils to offset acidic inputs. Soils within the LSA and RSA were rated for sensitivity to acid deposition based on the following resources:

- Critical Loads of Acid Deposition on Soils in the Athabasca Oil Sands Region, Alberta (Abboud et al. 2002); and
- Recommendations for the Acid Deposition Management Framework for the Oil Sands Region of Northeastern Alberta (CEMA 2004).

Acid deposition values from the 50-Year critical loads for Mid-CV case were adapted from Abboud et al. (2002) to rate the soils within the RSA and LSA. The Mid-CV case critical load scenario is the lowest critical load determined for 50% of the difference between the starting and literature-based values for base saturation, base cation to aluminum (BC: Al) ratio or base cation to hydrogen (BC: H) ratio over a 50-year period (Abboud et al. 2002).

Assigned acid deposition ratings for all dominant or co-dominant soils of the RSA and LSA are listed in CR #9, Table 16. Acid sensitivity ratings for the LSA and RSA are displayed in CR #9, Figure 13A-B.

The potential for soil acidification on a soil type is assessed through comparison of the modelled PAI isopleths (CR #1, Section 3.6) against the critical loads assigned to particular soil map units. Based on a review of the cumulative case PAI isopleths for Phase 2 there are no PAI isopleths that contain values that trigger critical load exceedances for the soils within the LSA or the RSA (CR #9, Figure 13). The largest cumulative PAI isopleths (worst case) within the RSA were a point source location (AOSC MacKay River North Oil Sands Facility) with a PAI of 0.25 keq/ha/yr, and the most sensitive soil recorded in the RSA contains a PAI critical load of 0.4 keq/ha/yr. Soil acidification via atmospheric deposition is not expected to be a potential impact that will result in an environmental effect on the soil resources within the LSA or RSA.

D.9.3 Predicted Conditions

Activities that may impact the soil resource and associated terrain as a result of Project and existing, planned, and approved development:

- soil salvage and handling – salvage of all required soil materials in the proposed disturbance areas as well as construction on (padding over); or salvage of organic materials may result in effects to soil quality;
- soil stockpiling – stockpiling of salvaged soil materials during the construction of Phase 2, both short term and long term, results in potential for soil erosion issues and effects to soil productivity;
- development of Project infrastructure – includes creation of well pads, roads, borrow pits that require site contouring and creation of padded areas may result in environmental effects to soil quality and terrain;
- operational activities – day to day operations that may result in effects to soil through accidental releases; and
- progressive reclamation – activities including recontouring, soil handling and replacement, and pad removal on organic landforms may result in effects to the reclaimed soil profiles and terrain.

The analysis of soil quality VEC considers changes that may occur in soil physical, chemical and biological properties and soil quantity due to soil profile disturbance, erosion and accidental releases. The potential effect to soil biodiversity VEC will be discussed in terms of the effects of Phase 2 on the spatial distribution of soil patterns and potential changes in soil diversity and ecological integrity. The potential effects to the terrain VEC is discussed in terms of the potential changes in slope classes.

D.9.3.1 Soil Profile Disturbance

Application Case

Disturbance of the soil profile during construction and reclamation has potential to impact soil quality. During Project construction, potential impacts to the soil resource will be limited to the proposed areas of disturbance. Soil salvage, transport, storage (long term and short term) and replacement may have an environmental effect with respect to soil quality. Soil profile disturbance is evaluated through an assessment of soil quantity (soil thickness, volume of available material at reclamation) and forested land capability (LCCS ratings assess soil productivity).

The soil salvage and replacement procedures to be utilized for Phase 2 are discussed in Part E. With implementation of these procedures the potential changes in LCCS ratings are as follows:

- Class 2 – pre-development 165.7 ha (33.0%); post reclamation 133.6 ha (26.6%);
- Class 3 – pre-development 51.9 ha (10.3%); post reclamation 48.4 ha (9.6%);
- Class 4 – pre-development 31.5 ha (6.3%); post reclamation 26.6 ha (5.3%);
- Class 5 – pre-development 250.8 ha (50.0%); post reclamation 235.1 ha (46.8%);
- Note Rated – pre-development 2.1 ha (0.4%); post reclamation 1.8 ha (0.4%); and
- Water - pre-development 0 ha; post reclamation 56.5 ha (11.3%).

The discrepancy between pre- and post reclamation areas is a result of the water bodies/shallow wetlands created through borrow pit development associated with Phase 2. All reclaimed areas are expected to meet target equivalent land capability as per the land capability classification system (LCCS).With utilization of the soil salvage and handling procedures discussed in Part E, the effects on the soil resource for the Application Case are rated as Low Impact.

Planned Development Case

It is expected that existing and potential future developments within the RSA that disturb the soil resource as a part of the development will be required to conserve topsoil and complete reclamation as per all regulatory and operating requirements. Compliance with regulatory requirements for planning, construction, and reclamation of developments will minimize any impacts to soil quality and quantity (productivity) by ensuring appropriate conservation and reclamation planning is in place that addresses soil handling, storage, replacement, and mitigation and monitoring post reclamation.

With effective soil salvage and handling, and mitigation and monitoring, the impacts to the RSA as a result of development of Phase 2 and existing current developments are expected to be Low Impact with respect to productivity (as relating to LCCS).

D.9.3.2 Erosion

Application Case

The potential impacts of wind and water erosion on soil quality are of concern throughout development and final reclamation. The loss of soil via erosion during soil salvage, soil storage, and after soil replacement is a potential impact. The risk of erosion to surface soils is greatest during the soil salvage and storage stages of site construction, and during the soil replacement phase of the reclamation process.

Erosion of stockpiled soil may occur by wind and water. Salvaged soil material will be stored in stockpiles with slopes graded to a maximum slope of 3H:1V. The topsoil stockpiles will be stabilized, and vegetated after placement. It is anticipated that the length of time over which stockpiled soil material will be at risk to soil erosion due to lack of vegetative cover will be brief and not significant with respect to the life of Phase 2.

Soil materials replaced during reclamation are at risk of erosion by wind and/or water during soil handling activities and immediately after replacement. The risk of erosion remains relatively high until a vegetative cover is established, particularly as slopes increase.

The reclaimed landscapes over which the salvaged soil material will be replaced are estimated to be similar to pre-disturbance conditions with respect to slopes and slope lengths. Site recontouring will provide similar landscapes and drainage patterns to pre-disturbance conditions. Within the Phase 2 Project footprint, approximately 0.2% (0.8 ha) of the landscapes contain slopes >10% that may be at risk of water erosion post reclamation (prior to vegetation establishment). With appropriate revegetation and erosion control activities during Phase 2, it is expected that the soil loss due to erosion will be minimal and have a Low Impact on the soil resource.

Planned Development Case

The resultant environmental effects pertaining to soil erosion for the PDC are anticipated to be equivalent to the Application Case. Distribution of soil types and landforms within the RSA are similar to the LSA. A majority of the soils in the RSA (47,229.1 ha or 59.3%) have a negligible risk of wind or water erosion; the remaining 30,338.9 ha or 38.1% consist of soils that have a negligible or low wind erosion potential and variable water erosion potentials that are dependent on slope steepness.

It is anticipated that similar mitigative measures and monitoring described to minimize erosion for the Application Case are currently being used for existing disturbances within the RSA and will be used in potential future projects (as required to ensure soil conservation). Minimization and mitigation of soil erosion is a regulatory requirement to ensure soil conservation and to protect water bodies. The resultant residual effects to the soil resource due to potential soil erosion for the PDC (RSA) are anticipated to be equivalent to the Application Case and will be Low Impact.

D.9.3.3 Accidental Releases

Application Case

Impacts to soil quality caused by accidental releases and operational incidents within the development footprint have the potential to alter chemical and physical attributes of soils. This includes (but is not limited to); equipment failures, line failures, tank releases; and surface releases from operations activities. Accidental releases may occur as one time releases, or as cumulative releases that occur over longer periods of time. With the appropriate environmental management plans in place (Section B.9), accidental releases and subsequent clean up will result in a Low Impact on soil quality.

Planned Development Case

It is anticipated that type, frequency, severity, and potential methods of accidental releases for existing and proposed future development is expected to be similar in nature to the Application Case. Projects currently operating in the RSA are similar to the proposed Project with respect to infrastructure, processes, and in some cases, chemicals or products handled.

The assessment of impacts to the soil resource as a result of accidental releases for the PDC is anticipated to be equivalent to the Application Case. The resultant residual effects are seen as Low Impact.

D.9.3.4 Biodiversity

Application Case

The potential effect to soil biodiversity will be discussed in terms of the effects of Phase 2 on the spatial distribution of soil patterns and potential changes in soil diversity and ecological integrity. The Phase 2 footprint (Initial and Future development) will disturb approximately:

- 250.5 ha of organic soils, this equates to approximately 9.0% of the organic soils in the LSA and 0.5% of the estimated organic soils in the RSA;

- 207.5 ha of upland soils, this equates to approximately 9.4% of the upland soils in the LSA and 1.0% of the estimated upland soils in the RSA; and,
- 43.6 ha of transitional mineral soils (Gleysols), this equates to approximately 8.9% of the transitional soils in the LSA and 0.5% of the estimated transitional soils in the RSA.

Common soils in the LSA and RSA include Luvisols and Brunisols in upland and mid slope positions, Gleysols in transitional areas, and shallow to deep Organics in the poorly drained level landscapes. Based on soil information for the LSA and RSA, there were no soil profiles or patterns found in the Phase 2 footprint that are not commonly found within the LSA and RSA.

Ecological integrity with respect to soil and landscapes is related to the vegetation communities and habitats that are formed as a result of the relationship between soil and landscape patterns and corresponding moisture and nutrient regimes. Reclamation of soil and landscape patterns to provide similar forest soil capability will allow for the eventual formation of suitable habitats that meet desired end land use objectives.

Ecological integrity of disturbed lands from a soil and terrain perspective is potentially impacted by removal of the natural soil profile and alteration of the associated terrain. Proper soil salvage, storage and replacement at reclamation coupled with appropriate recontouring will ensure reclaimed soil - landscape patterns blend with adjacent undisturbed lands. Establishment of reclaimed soil and landscape patterns that are conducive to the formation of desired vegetation communities will allow for the eventual formation of suitable reclaimed habitat that meets desired end land use objectives, conforms to adjacent undisturbed soil – landscape patterns, and is self sustaining.

No change in soil diversity or ecological integrity with respect to soil types and landscape patterns is expected from a regional perspective, and Phase 2 is expected to have a Low Impact on soil biodiversity.

Planned Development Case

In general, the soil types and distribution of soil and landscapes within the RSA are similar to that of the LSA as determined by the baseline RSA and LSA soil maps. The assessment of impacts to soil biodiversity for the PDC is anticipated to be equivalent to the Application Case.

Mitigative measures and monitoring described to minimize decreases in soil biodiversity for the Application Case are based on regulatory requirements for reclamation objectives, including equivalent land capability and end land use objectives. As such, development of lands in the RSA that require soil disturbances will likely be required to address similar requirements with respect to the reclamation of disturbed lands.

No change in soil diversity or ecological integrity with respect to soil types and landscape patterns is expected from a regional perspective, and Phase 2 is expected to have a Low Impact on soil biodiversity.

D.9.3.5 Terrain

Application Case

Development of Phase 2 also results in disturbances to the terrain types within the Phase 2 Project footprint. A total of 8.8% of the LSA will have terrain disturbances as a result of Initial and Future development.

At reclamation the developed area will be recontoured to blend into the surrounding terrain. There will be some permanent loss of upland terrain to water bodies/shallow wetlands due to the development of the borrow pits. Depending on the preferred method of organic material salvage for various Project components, it is likely that various organic areas will be reclaimed to drier upland landscapes, offsetting the loss of mineral landscapes as a result of borrow pit development. However, a majority of the organic landforms will likely be padded over for Project development and pad removal would occur at reclamation. The alteration of terrain is expected to have a Low Impact on the soil resource.

Planned Development Case

The soil and landscape patterns within the RSA and LSA are similar. The expected impacts to terrain types disturbed by existing Projects in the RSA are negligible. A permanent loss of upland terrain to water bodies/shallow wetlands due to the development of borrow pits is likely. However, it is expected that throughout the RSA, various organic landforms padded over for development will be reclaimed to drier upland landscapes, offsetting the loss of mineral landscapes as a result of borrow pit development. The alteration of terrain within the RSA as a result of Phase 2 and estimated current disturbances is expected to have a Low Impact on overall productivity (as relating to LCCS).

It is expected that existing and potential future developments within the RSA that disturb the soil resource as a part of the development will be required to complete reclamation as per all regulatory and operating requirements. This includes appropriate recontouring to ensure reclaimed landscapes blend with adjacent undisturbed lands. Compliance with regulatory requirements for planning, construction, and reclamation of developments will minimize the impacts to terrain types in the RSA. Therefore, evaluation of the impact to altered terrain types is the same as for the Application Case.

D.9.4 Mitigation and Monitoring

D.9.4.1 Mitigation

In order to reduce potential impacts of Phase 2 on soil and terrain STP will:

- salvage topsoil using best management practices including the supervision of salvage activities by a qualified individual;
- implement progressive reclamation on areas that are no longer in use;
- salvage subsoil from the plant site and well pads for use in reclamation;
- during construction, pad over areas of deep organic soil and then when reclaiming areas where the pad is removed, decompact the underlying organic material, or in areas where the pad is left in place decompact the pad and cover with 40 cm of salvaged peat (or other appropriate soil)
- store soil in a manner that minimizes soil loss or degradation through erosion;
- stockpile subsoil, topsoil and organic material separately;
- decompact all replaced soil profiles during reclamation to reduce potential growth and productivity restrictions;
- revegetate all reclaimed lands upon completion of soil placement to minimize soil loss via erosion (wind and water) and minimize the likelihood of weed infestations; vegetation establishment will occur through natural regeneration or, where required, through re-seeding or re-planting;
- apply for reclamation certification on fully reclaimed lands; and
- implement a corporate spill response plan.

D.9.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will:

- salvage and replace soil under the direct supervision of a qualified individual;
- monitor landscape characteristics and features to ensure appropriate drainage is maintained;
- monitor stockpiled or recently replaced soil material for potential erosion issues;
- monitor topsoil quality (*i.e.*, admixing) and quantity (depths) on reclaimed areas; and,
- assess vegetation communities after reclamation to determine if the appropriate seral communities are established.

D.9.5 Summary of VECs

A summary of residual effects and associated impact ratings on soil and terrain valued environmental components (VECs) is presented in Table D.9.5.

Table D.9.5 Summary of Impact Rating on Soil and Terrain Valued Environmental Components

Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent(1)	Duration(2)	Frequency(3)	Reversibility(4)	Magnitude(5)	Project Contribution(6)	Confidence Rating(7)	Probability of Occurrence(8)	Impact Rating(9)
1. Soil Quality											
Soil Profile Disturbance											
Impact on soil quality (via LCCS and soil quantity)	see Section D.9.4.1 and Part E	Application	LSA – Phase 2 footprint	Extended	Continuous, diminish with time	Reversible – long term	Moderate	Initially – Negative; Over time - Neutral	Moderate	Medium to High	Low
Impact on soil quality (via LCCS and soil quantity)	see Section D.9.4.1 and Part E	Cumulative Effects (related Infrastructure outside the LSA)	Regional	Extended	Continuous, diminish with time	Reversible – long term	Moderate	Initially – Negative; Over time - Neutral	Moderate	Medium to High	Low
Erosion											
Impact on soil quality	see Section D.9.4.1 and Part E	Application	LSA – Phase 2 footprint	Short	Occasional (unplanned)	Irreversible	Moderate to Low	Neutral	Moderate	High during salvage and replacement at reclamation decreasing to Low after veg. establishment	Low
Impact on soil quality	see Section D.9.4.1 and Part E	Cumulative Effects	Regional	Short	Occasional (unplanned)	Irreversible	Moderate to Low	Neutral	Moderate	High during salvage and replacement at reclamation decreasing to Low after veg. establishment	Low
Accidental Releases											
Impact on soil quality	see Section D.9.4.1 and Section B.9	Application	LSA – Phase 2 footprint	Long	Occasional (unplanned)	Reversible – short term	Low	Neutral	High	Medium to Low	Low
Impact on soil quality	see Section D.9.4.1 and Section B.9	Cumulative Effects	Regional	Long	Occasional (unplanned)	Reversible – short term	Low	Neutral	High	Medium to Low	Low

Table D.9.5 Summary of Impact Rating on Soil and Terrain Valued Environmental Components

Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent(1)	Duration(2)	Frequency(3)	Reversibility(4)	Magnitude(5)	Project Contribution(6)	Confidence Rating(7)	Probability of Occurrence(8)	Impact Rating(9)
2. Soil Biodiversity											
Impact on soil diversity (distribution of soils) and ecological integrity	see Section D.9.4.1 and Part E	Application	LSA – Phase 2 footprint	Extended	Continuous	Reversible – long term	Low	Negative	High	High	Low
Impact on soil diversity (distribution of soils) and ecological integrity	see Section D.9.4.1 and Part E	Cumulative Effects	Regional	Extended	Continuous	Reversible – long term	Low	Negative	High	High	Low
3. Alteration of Terrain											
Impact on terrain types	see Section D.9.4.1 and Part E	Application	LSA – Phase 2 footprint	Residual	Continuous	Irreversible	Low	Neutral	High	High	Low
Impact on terrain types	see Section D.9.4.1 and Part E	Cumulative Effects	Regional	Residual	Continuous	Irreversible	Low	Neutral	High	High	Low

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.10 VEGETATION, WETLANDS AND RARE PLANTS

D.10.1 Introduction and Terms of Reference

STP conducted an assessment of vegetation resources for the Phase 2 Project. The following section is a summary of the Vegetation and Wetlands Resource Assessment that was prepared by Millennium EMS Solutions Ltd. and included as Consultants Report #10 (CR #10). For full details of the assessment please refer to CR #10.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the vegetation and biodiversity component are provided in Section 3.6 and Section 3.9 and are as follows:

3.6 VEGETATION

3.6.1 Baseline Information

[A] Describe and map the vegetation communities, wetlands, rare plants, old growth forests, and communities of limited distribution. Identify the occurrence, relative abundance and distribution of any vegetation species, and also any vegetation species that are:

- *a) listed as "at Risk, May be at Risk and Sensitive" in The Status of Alberta Species (Alberta Sustainable Resource Development);*
- *b) listed in Schedule 1 of the federal Species at Risk Act;*
- *c) listed as "at risk" by COSEWIC; and,*
- *d) traditionally used species.*

[B] Describe and quantify the current extent of habitat fragmentation.

3.6.2 Impact Assessment

[A] Describe and assess the potential impacts of the Project on vegetation communities, considering:

- *a) both temporary (include timeframe) and permanent impacts;b) species richness, abundance and vigour;*
- *c) the potential for introduction and colonization of weeds and non-native invasive species;*
- *d) potential increased fragmentation and loss of upland, riparian and wetland habitats; and*
- *e) implications of vegetation changes for other environmental resources (e.g., terrestrial and aquatic habitat diversity and quantity, water quality and quantity, erosion potential).*

[B] Identify key vegetation indicators used to assess the Project impacts. Discuss the rationale for the indicator's selection.

[C] Discuss the mitigation measures to avoid or minimize impacts on vegetation communities. Clearly identify those mitigation measures that will be implemented and provide the rationale for their selection.

3.8 BIODIVERSITY

3.8.1 Baseline Information

[A] Describe and map the existing biodiversity.

[B] Identify the biodiversity metrics, biotic and abiotic indicators that are used to characterize the baseline biodiversity.

3.8.2 Impact Assessment

[A] Describe and assess the potential impacts of the Project to biodiversity considering:

the biodiversity metrics, biotic and abiotic indicators selected;
the effects of fragmentation on biodiversity potential;

The LSA encompasses the approved 10.5 section Phase 1 area with an additional 7.5 sections extending to the north and west (Figure C.2.1). It is sufficient in size to capture potential project effects to VECs that will result from direct disturbance and also, changes to vegetation outside the Phase 2 footprint as a result of alterations to physical components such as water quantity.

An 8 km buffer around the LSA was selected for the vegetation RSA (Figure C.2.2). The RSA was defined to ensure that it captured the furthest extent that project-specific effects are anticipated to act in combination with effects from other past, existing and anticipated future projects and activities.

A scoping exercise was undertaken to determine indicators that represent vegetation resources as a whole. Seven valued environmental components (VECs) were identified and incorporated into the assessment; (1) Terrestrial Vegetation; (2) Wetlands, including peatlands; (3) Old Growth Forests; (4) Non-native and invasive species; (5) Traditional Ecological Knowledge vegetation (TEK vegetation); (6) Biodiversity; and (7) Fragmentation.

As part of the vegetation and wetlands assessment the following environmental components were surveyed, assessed, mapped and reported vegetation and wetlands:

- terrestrial and aquatic vegetation species and ecosite phases;
- old growth forests;
- forestry resources;
- vegetation used by Aboriginal groups (TEK vegetation) for medicine, food, technological and other purposes;
- wetland (bogs, fens, marshes, swamps, open water/ponds) classification and occurrences;
- rare plants and rare plant habitat potential;
- rare ecological communities, and ecological communities of limited distribution;

- non-native and invasive vegetation species (noxious and noxious prohibited species); and
- biodiversity and fragmentation.

D.10.2 Baseline Conditions

D.10.2.1 Ecosite Phases

Before field surveys, preliminary ecosite phase maps were created depicting ecosite phases, based upon ecosystem interpretation, using aerial imagery of the area, and Alberta Vegetation Inventory (AVI) maps and data. The preliminary ecosite phase maps were then used to locate and stratify potential sample sites for detailed ecosite phase classification in the field. Sampling plot locations were selected to encounter the broadest range of ecosite phases within the Phase 2 footprint and LSA. Wherever possible, a minimum of five sample plots per potential ecosite phase was targeted.

The data collection protocols used for the vegetation surveys followed the guidelines outlined in the *Ecological Land Survey Site Description Manual* (AEP 1994). Detailed ecosite plots involved a complete survey of site and vegetation characteristics, including a 60 cm deep soil pit used to describe the general soil and site conditions, and an assessment of nutrient and moisture regime based on the edatope grid. All vegetation, including mosses and lichens, were identified to species level and their associated percent cover recorded to the nearest percent, with the exception of epiphytic species which were recorded as part of the rare plant survey but not as part of the detailed vegetation inventory.

In total, 445 vegetation species were observed and recorded during 2008, 2009, 2010 and 2011 vegetation surveys within the LSA. Of these, 254 were vascular plants, 90 were bryophytes and 101 were lichens (CR #10, Appendix 2). In total, 22 ecosite phases were mapped within the LSA (CR #10, Figure 4-3). Six ecosite phases b1, b4, c1, e1, f1, and l1 occupy the smallest areas (each <1%) of the LSA (Table D.10.1) and are considered to be of limited distribution.

Table D.10.1 Distribution of Ecosite Phases in the LSA and Footprint

Ecosite Phase	LSA		Footprint	
	Area (ha)	Proportion (%)[1]	Area (ha)	Proportion (%)
B1	0.9	0.01	0.3	0.1
B4	2.4	0.03	0.9	0.2
C1	76.6	0.96	7.6	1.5
D1	289.6	3.6	14.7	2.9
D2	1,461.1	18.3	171.5	34.2
D3	269.8	3.4	0.8	0.2

Table D.10.1 Distribution of Ecosite Phases in the LSA and Footprint

Ecosite Phase	LSA		Footprint	
	Area (ha)	Proportion (%)[(1)]	Area (ha)	Proportion (%)
E1	57.6	0.7	3.2	0.6
E2	90.6	1.1	0.4	0.1
E3	106	1.3	1.4	0.3
F1	26.9	0.3	0	0
F2	85.6	1.1	0	0
F3	138.2	1.7	7.1	1.4
G1	208.7	2.6	21.9	4.4
H1	133.8	1.7	5.8	1.2
I1	867.7	10.9	48.6	9.7
I2	617.5	7.8	47.1	9.4
J1	1,141.3	14.3	53.5	10.7
J2	614.7	7.7	27.1	5.4
K1	406.8	5.1	41.1	8.2
K2	523.6	6.6	25.6	5.1
K3	81.8	1	5.9	1.2
L1	6.9	0.09	0.1	0
NWF	6.8	0.09		
NWL	6.5	0.08	0.3	0.1
NWR	102.9	1.3		
CC	384.2	4.8		
CIW	46.3	0.6	7.5	1.5
AIH	105.3	1.3	9.7	1.9
ALL	111	1.4		
Total	**7,971.1**	**100**	**502.1**	**100**

(1) Ecosite Phases found in <1% of the LSA are limited in distribution

Alberta Vegetation Inventory (AVI) data was not available for describing the ecological landscape classification (ELC) for the RSA. STP used Alberta Ground Cover Classification (AGCC) data to describe, analyze and report on ELC for the RSA. Upland areas account for 36.6% of the RSA (22,192 ha), and lowland areas occupy 61.7% (37,412 ha) (Table D.10.2 and CR #10, Figure 4.5).

Table D.10.2 Alberta Ground Cover Classification in the RSA			
Alberta Ground Cover Classification	**Corresponding Ecosite Phase**	**Area (ha)**	**Percent (%)**
Upland			
Closed Pine	b4, c1	638.3	1.1
Closed White Spruce	d3, e3, f3	12,607.8	20.8
Closed deciduous	d2, e2, f2	7,967.5	13.1
Closed coniferous dominated mixedwood		222.5	0.4
Closed upland shrub		727.0	1.2
Open pine	b4, c1	29.2	0.05
Total Upland		**22,192.3**	**36.6**
Lowland			
Graminoid wetlands (sedges/grasses/forbs)	k3, l1	431.8	0.7
Shrubby wetlands (willow and birch)	j2, k2	7,003.1	11.5
Black spruce bog (sphagnum understorey)	i1	29,510.2	48.7
Lake, pond, reservoir, river and stream		467.3	0.8
Total Lowland		**37,412.3**	**61.7**
Athropogenic			
Vegetated linear feature - pipeline	2	22.9	0.04
Vegetated anthropogenic - wellsite	277	155.8	0.3
Non-vegetated linear feature - access road	195	573.7	0.9
Non-vegetated linear feature - all-season access	5	118.1	0.2
Borrow Pit	7	43.1	0.1
Petroleum Facility	4	116.1	0.2
Total Athropogenic	490	1,029.6	1.7
Total	**14,728**	**60,634.2**	**100**

D.10.2.2 Wetlands

Wetland sampling was incorporated into the general vegetation resources survey and as component of sampling. All plots were initially mapped as wetlands using the ecosite classification system (Beckingham and Archibald 1996) and were refined following field surveys using the Alberta Wetland Inventory Classification System (2004). Dominant wetland types in the LSA and Phase 2 footprint are listed in Table D.10.3 and shown in CR #10, Figure 4-6.

Wetlands also occupy 60.9% (36,945 ha) of the RSA with wooded bogs and fens being the most common wetland type (48.7% - 29,510 ha), followed by shrubby wetlands (11.6% - 7003 ha) (CR #10, Table 4.11).

Table D.10.3 Wetland Distribution in the LSA and Footprint

Wetland	LSA		Footprint	
	Area (ha)	Proportion (%)[1]	Area (ha)	Proportion (%)
BTNI	254.2	3.2	39.9	7.9
BTNN	1,219.6	15.3	55.8	11.1
BTXC	21.5	0.3		0.0
FONG	81.6	1.0	6	1.2
FONI	134.7	1.7	10.1	2.0
FONS	291.9	3.7	18.1	3.6
FTNI	123.8	1.6	5.3	1.1
FTNN	1,981.30	24.9	111.9	22.3
MONG	7.1	0.1	0.01	0.0
SFNN	1.6	0.0		0.0
SONS	136.8	1.7	1.8	0.4
STNN	69.4	0.9	8.6	1.7
WONN	13.3	0.2	0.3	0.1
TOTAL:	4,336.8	54.4	257.8	51.4

(1) Wetlands found in <1% of the LSA are limited in distribution

D.10.2.3 Rare Plants

The rare plant and rare ecological community survey was performed in accordance with ANPC guidelines (2000a). The data collection protocols used for this survey followed those outlined in the *Ecological Land Survey Site Description Manual* (Alberta Environmental Protection 1994) and the ANPC (2000a) guidelines. Within the Phase 2 footprint and LSA, a total of 146 rare plant plots were investigated between 2008 and 2011 (CR #10, Figure 3.1), using meander searches and some patterned searches.

Nine vegetation species were observed and recorded within the LSA (Table D.10.4) which are on the Alberta Rare Plant Tracking and Watch List and are considered rare. Of these, one was a vascular plant, one was a bryophyte, and seven were lichens. There was also one rare plant community, *Populus tremuloides/Rosa acicularis/ Apocynum androsaemifolium* (aspen, prickly rose/ spreading dogbane), occurrence in the LSA (CR #10, Figure 4.7).

Table D.10.4 Rare Plant Occurrences in the LSA					
Species	**Common Name**	**Type**	**Ecosite Phase**	**Alberta Rank**	**Global Rank**
Cladina stygia	black footed lichen	Lichen	C1	S2	G5
Polysporina arenacea	cobblestone lichen	Lichen	D2	S2	GNR
Brachythecium acutum	acute brachythecium moss	Bryophyte	E2	SU	GNRQ
Chrysosplenium iowense	golden saxifrage	Vascular	E2	S3	G3
Ramalina obtusata	hooded ramalina	Lichen	E3	S2	G5
Cladonia macrophylla	cladonia lichen	Lichen	F1	S2	GNR
Lecanora subintricata	rim-lichen	Lichen	I1	S2S4	G3G5
Cladonia rei	wand lichen	Lichen	K1	S2	G3G5
Usnea scabiosa	beard lichen	Lichen	K1	S1S2	GNR

D.10.2.4 Biodiversity & Fragmentation

Several measures of biodiversity were calculated that address the needs for assessment at the different levels of biodiversity. Biodiversity exists at several scales or levels, including genetic or species, community, and landscape level biodiversity.

Eleven ecosites and 22 ecosite phases were identified in the LSA. Within those, a total of 445 vegetation species (254 vascular and 191 non-vascular plant species (91 bryophyte species and 100 lichens)) were recorded within the LSA. Of the vascular and non-vascular species occurrences there are 17 rare plant species (with 41 occurrences), 105 unique species, and two noxious species with ecosite phases d2 and l1 having the greatest occurrences of unique species (CR #10, Table 4.15).

The diversity parameters (mean richness, mean Shannon Diversity Index, mean evenness) are provided Table D.10.5 for total vegetation species and vascular vegetation species within each ecosite phase of the LSA.

Table D.10.5 Species Richness, Diversity and Evenness of Ecosite Phases for LSA						
Level	**Species Richness**	**Shannon Diversity Index**	**Evenness**	**Species Richness**	**Shannon Diversity Index**	**Evenness**
	All Vegetation Species			**Vascular Vegetation Species**		
Ecosite Phase	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
b1	36.00	3.21	0.90	31.00	3.14	0.91
b4	30.00	3.02	0.89	24.00	2.90	0.91
c1	26.12	2.55	0.78	19.98	2.56	0.86
d1	34.26	3.18	0.90	30.53	3.08	0.90
d2	30.30	2.94	0.87	25.98	2.86	0.88
d3	31.78	3.17	0.92	26.57	3.20	0.98
e2	45.12	4.62	1.20	41.54	4.45	1.18
e3	28.53	2.84	0.85	25.43	2.73	0.85
f1	34.20	3.02	0.86	27.94	2.88	0.86
f2	32.16	3.87	1.11	29.56	3.85	1.13
f3	33.00	3.30	0.94	29.13	3.18	0.94
g1	25.69	2.78	0.86	19.57	2.61	0.88
h1	32.50	3.02	0.87	26.98	2.98	0.91
i1	18.72	2.12	0.74	11.50	1.99	0.85
i2	40.28	2.97	0.81	33.97	3.10	0.92
j1	29.53	2.93	0.87	22.32	2.87	0.93
j2	26.00	1.79	0.55	20.00	1.73	0.58
k1	33.22	2.98	0.87	26.07	2.97	0.92
k2	24.27	2.16	0.70	19.42	1.97	0.69
k3	16.14	1.47	0.52	13.83	1.39	0.53
L1	31.16	2.24	0.66	26.83	2.19	0.67

Table D.10.6 presents the biodiversity potential of all ecosite phases by area for each of the two biodiversity metrics assessed. Overall, the biodiversity potential class for the LSA is high, given high rich areas on average cover 43.1% of the LSA, and high diversity areas on average cover 57.6% of the LSA.

Table D.10.6 Biodiversity Potential for Vegetation by Ecosite Phase

Final Ranking	Ecosite Phase	LSA		Footprint	
		Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Low	i1	867.7	12.1	48.6	10.1
Low	k3	81.8	1.1	6	1.2
Moderate	e3	106	1.5	1.4	0.3
Moderate	g1	208.7	2.9	21.9	4.5
Moderate	j1	1,141.30	16.0	53.5	11.1
Moderate	j2	614.7	8.6	27.1	5.6
Moderate	k2	523.6	7.3	25.6	5.3
High	c1	76.6	1.1	7.6	1.6
High	d1	289.6	4.1	14.7	3.1
High	d2	1,461.10	20.4	171.5	35.6
High	d3	269.8	3.8	0.8	0.2
High	f2	85.6	1.2	0.4	0.1
High	f3	138.2	1.9	7.1	1.5
High	h1	133.8	1.9	5.8	1.2
High	k1	406.8	5.7	41.1	8.5
Very High	b1	1	0.0	0.3	0.1
Very High	b4	2.4	0.0	0.9	0.2
Very High	e2	90.6	1.3	0.4	0.1
Very High	f1	26.9	0.4	0	0.0
Very High	i2	617.5	8.6	47.1	9.8
Very High	l1	6.9	0.1	0.1	0.0
Total		7150.6	100	481.9	100

Baseline fragmentation metrics for the LSA are included in Table D.10.7. Fragmentation is a function of length of edge, patch size, perimeter area ratio and nearest neighbour. Results indicated that the best fragmentation rating, (very high (VH) - least fragmented, very low (VL) – most fragmented) was d1, d2, f3, i1, i2, j1, j2 and k2 which have larger patch edges, larger patch sizes, lower perimeter area ratios and less distance to the nearest neighbour patch. These ecosite phases combined cover 66.21% of the LSA.

Similar to the LSA, the majority (61.7%) of the RSA is classified as moderate biodiversity potential in the lowland areas, while there is a high class biodiversity potential for the upland areas which cover 36.6% of the RSA (CR #10, Table 4.20). Results indicated that a high fragmentation rating (least fragmented) was closed upland shrub and open pine, which have larger patch edges, larger patch sizes, lower perimeter area ratios and less distance to the nearest neighbour patch. Unlike fragmentation results from the LSA, wooded bogs and fens which cover 48.7% of the RSA, are rated as moderate (CR #10, Table 4.21). On a landscape level the baseline RSA Shannon Diversity Index (SDI) is 1.477, which correlates to a low biodiversity ranking. As well, the mean landscape level patch size is 4.4 ha which is ranked as high (low fragmentation), and the mean nearest neighbour is 124.9 m which is ranked as high (low fragmentation).

Table D.10.7 Baseline Fragmentation for Ecosite Phases in the LSA

Ecosite Phase	Area	Proportion	Ecosites of Limited Distribution	Number of Patches	Total Length of Edge (m)	Patch Size (ha)	Perimeter Area Ratio	Nearest Neighbour (m)	Fragment Rating
	(ha)	(%)	(ha)	(#)	(mean)	(mean)	(mean)	(mean)	
b1	0.93	0.01	0.99	1	865.00	0.93	926.99	N/A	VL
b4	2.49	0.03	2.39	2	1,630.00	1.25	689.53	12.50	L
c1	83.26	1.04	76.57	25	34,020.00	3.33	1,350.07	223.57	M
d1	299.12	3.75		57	90,487.50	5.25	1,548.50	169.06	H
d2	1,516.91	19.03		148	356,292.50	10.25	1,684.23	58.64	H
d3	282.80	3.55		43	97,615.00	6.58	2,354.41	229.51	M
e1	41.98	0.53	57.58	13	15,275.00	3.23	624.52	444.26	L
e2	43.36	0.54		15	20,225.00	2.89	506.27	503.16	VL
e3	108.21	1.36		27	50,742.50	4.01	849.01	300.21	M
f1	30.80	0.39	26.89	6	10,990.00	5.13	605.67	719.03	L
f2	111.42	1.40		16	30,125.00	6.96	4,396.79	470.97	L
f3	149.77	1.88		32	59,695.00	4.68	599.51	138.96	H
g1	138.27	1.73		52	54,150.00	2.66	2,006.10	209.22	VL
h1	77.94	0.98		34	34,895.00	2.29	1,314.83	365.37	L
i1	795.53	9.98		130	191,155.00	6.12	1,346.90	100.42	H
i2	626.74	7.86		86	121,530.00	7.29	1,719.11	89.98	H
j1	1,278.09	16.03		143	260,805.00	8.94	1,826.93	71.78	H
j2	618.82	7.76		91	155,070.00	6.80	993.44	77.14	VH
k1	303.70	3.81		74	89,462.50	4.10	2,238.91	162.12	L
k2	611.28	7.67		127	204,432.50	4.81	1,196.14	79.50	H
k3	88.81	1.11		28	39,400.00	3.17	1,653.48	408.60	L
l1	4.99	0.06	6.92	3	3,235.00	1.66	671.97	1,381.60	VL

Table D.10.7 Baseline Fragmentation for Ecosite Phases in the LSA

Ecosite Phase	Area (ha)	Proportion (%)	Ecosites of Limited Distribution (ha)	Number of Patches (#)	Total Length of Edge (m) (mean)	Patch Size (ha) (mean)	Perimeter Area Ratio (mean)	Nearest Neighbour (m) (mean)	Fragment Rating
CIW	46.32	0.58		81	27,200.00	0.57	621.42	357.00	
CC	384.22	4.82		44	71,745.00	8.73	1,305.56	68.42	
NWL	2.87	0.04		1	1,180.00	2.87	411.42	N/A	
NWR	100.15	1.26		2	67,610.00	50.08	708.81	40.70	
NWF	5.99	0.08		4	3,440.00	1.50	742.81	711.78	
AIH	105.41	1.32		41	195,232.50	2.57	2,957.55	205.66	
AII	110.99	1.39		2	6,505.00	55.50	131.39	2,531.61	
TOTALS	**7,971.18**	**100.00**	**171.34**	**1,328.00**	**M**	**M**	**M**	**L**	**M**

D.10.2.5 Forestry Resource

Forests comprise much of the Boreal Forest Natural Region, where the proposed Project is located. Forestry resources were determined using timber productivity ratings (TPR) from Alberta Vegetation Inventory (AVI) data within the LSA. The total forested area in the LSA is 6,491.5 ha with 3,517.8 ha being merchantable stands (Table D.10.8).

Table D.10.8 Timber Productivity Rating in the LSA

TPR	Cover Class	Area (ha)	Proportion (%)
Fair	C	953.00	12.0
	CD	3.62	0.0
	D	10.47	0.1
	DC	0.00	0.0
	Sub-Total	**967.09**	**12.1**
Moderate	C	2,440.76	30.6
	CD	67.09	0.8
	D	370.90	4.7
	DC	53.86	0.7
	Sub-Total	**2,932.61**	**36.8**
Good	C	316.14	4.0
	CD	31.01	0.4
	D	1,181.61	14.8
	DC	204.76	2.6
	Sub-Total	**1,733.52**	**21.8**
Unproductive	C	858.27	10.8
	CD	0.00	0.0
	D	0.00	0.0
	DC	0.00	0.0
	Sub-Total	**858.27**	**10.8**
Total		**6,491.48**	**81.5**

D.10.2.6 Old Growth Forest

Portions of the STP LSA and RSA have been recently burned by wildfire and much of the vegetation in the burned areas is in early succession stages. The presence of old growth forests was determined using the stand origin data from the 2005 AVI stand data. Old growth forests in the LSA are listed in Table D.10.8 and shown in CR #10, Figure 4-4.

Table D.10.9 Old Growth Forests

Leading Species	Ecosite Phase	Local Study Area		Footprint	
		Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Sw	d2, d3, e2, f2, f3	277	3.5	2.2	0.4
Aw	d1, d2, e2	202.1	2.5	0.7	0.1
Lt	j1, k1	188.4	2.4	0	0.0
Sb	g1,h1,j1	73.7	0.9	0	0.0
Pb	f1,e2	2.5	0.03	0	0.0
Total		**743.7**	**9.3**	**2.9**	**0.5**

D.10.2.7 Traditional Land Use

Vegetation species valued by Aboriginal groups have been identified as a VEC based on the result of Aboriginal consultation and several traditional land use and traditional knowledge studies which have taken place in the region and by multi-disciplinary scientists. The vegetative species identified as valuable for medicinal, food, technology, and other purposes have been listed, and ranked. The TEK vegetation ranking system is premised on the significance of the use of vegetation. Specifically, TEK vegetation has been categorized as critical medicinal vegetation (Rank 1), vegetation used for food (Rank 2), vegetation used for non-critical medicinal use and for other uses (Rank 3).

In total 81 of 131 vegetation species valued by Aboriginal groups in the region for food, medicinal use, and other uses were documented as occurring in the LSA during the 2008, 2009, 2010 and 2011 field surveys (CR #10, Appendix 4). The total percent of the LSA area in which Rank 1 TEK vegetation species will occur is 86.8%, Rank 2 TEK species occur in 90.4%, and Rank 3 TEK species occur in 90.4% (Table D.10.10).

Table D.10.10 Traditional Ecological Knowledge Vegetation Occurrences by Ecosite Phase within LSA with Percent of LSA Area

Ecosite Phase	Total	Number of Rank 1	Number of Rank 2	Number of Rank 3	Area Surveyed (ha)	Percent of Ecophase Area
b1 - blueberry Pj-Aw	23	0	8	15	1.0	0.01
b2 - blueberry Aw(Bw) (1)					0.0	0.00
b3 – blueberry Aw-Sw(1)					0.0	0.00
b4 – blueberry Sw-Pj	19	1	5	13	2.4	0.03
c1 - Labrador tea-mesic Pj-Sb	37	1	9	27	76.6	0.97
d1 - low-bush cranberry Aw	34	0	8	26	289.6	3.66

Table D.10.10 Traditional Ecological Knowledge Vegetation Occurrences by Ecosite Phase within LSA with Percent of LSA Area

Ecosite Phase	Total	Number of Rank 1	Number of Rank 2	Number of Rank 3	Area Surveyed (ha)	Percent of Ecophase Area
d2 - low bush cranberry Aw-Sw	59	3	16	40	1461.1	18.46
d3 - low bush cranberry Sw	35	1	10	24	269.9	3.41
e1 - dogwood Pb-Aw(1)						
e2 - dogwood Pb-Sw	46	1	13	32	90.6	1.14
e3 - dogwood Sw	46	1	11	34	106.0	1.34
f1 - horsetail Pb-Aw	32	2	8	22	26.9	0.34
f2 -horsetail Pb-Sw	31	1	7	23	85.6	1.08
f3 - horsetail Sw	46	1	11	34	138.2	1.75
g1 - Labrador tea –subhygric Sb-Pj	39	1	10	28	208.7	2.64
h1 - Labrador tea/horsetail Sw-Sb	39	2	9	28	133.8	1.69
i1 - treed bog	23	1	4	18	867.7	10.96
i2 - shrubby bog	33	1	8	24	617.5	7.80
j1 - treed poor fen	44	2	9	33	1141.3	14.42
j2 - shrubby poor fen	12	1	1	10	614.7	7.77
k1 - treed rich fen	34	3	7	24	406.8	5.14
k2 - shrubby rich fen	31	3	7	21	523.6	6.62
k3 - graminoid rich fen	16	2	2	12	81.8	1.03
l1 - marsh	38	4	10	24	6.9	0.09
TOTALS	717	32	173	512	7150.7	90.36

(1) Ecosite Phase not surveyed

D.10.2.8 Non-Native and Invasive Species

The baseline field surveys identified two occurrences of non-native noxious or noxious prohibited species within the LSA: creeping thistle and tall buttercup (Government of Alberta 2010). These were observed in areas that were surveyed in plots and are not associated with existing development (well pads, access roads, and cut lines)

D.10.2.9 Potential Acid Input

Acid effects on vegetation are not often considered directly because effects on soil and water occur earlier and are more easily measured (Clean Air Strategic Alliance 1999) and acid input usually affects vegetation indirectly through changes in soil or water chemistry. Plant communities on soils that are sensitive to potential acid input (PAI) may be affected depending on the rates of deposition and changes in soil chemistry. An increase in acid deposition from air emissions could result in acidification of the surface horizon of sensitive mineral and organic soils. When a critical PAI load is exceeded, soil chemistry might be adversely affected.

The potential for soil acidification on vegetation was: 1) assessed through comparison of the modelled PAI isopleths (CR #1, Section 3.6 and Section D.1.3.3) against the critical loads assigned to particular soil map units; and 2) then assessed by using the sensitivity of ecosites to PAI deposition conversion table (Table D.10.11).

Table D.10.11 Sensitivity of Ecosites to PAI Critical Loads

Dominant/Co-dominant Soil Series	Hectares	AGCC Class	Ecosite	Critical Load
WNF – Winifred MIL – Mildred FIR - Firebug	WNF - 62.9141 MIL - 151.74 FIR - 6.2	Closed Deciduous and Coniferous Closed Upland Shrub Mixed Grassland Open Deciduous	B & C	0.55
KNS – Kinosis MNS – Moonshine STP – Steepbank BMT - Bitumont	KNS - 609.80 MNS - 185.71 MNS - 391.76 BMT - 34.80	Closed Deciduous Closed White Spruce	D-H	0.97
MRN - Marianna	MRN - 3813.60	Black Spruce Bog	I	0.8
MUS - Muskeg	MUS - 1252.43	Shrubby Wetlands	J	0.6
MLD - Mildred	MLD - 3835.23	Graminoid Fen	K	1.1

D.10.3 Predicted Conditions

D.10.3.1 Ecosite Phases

Application Case

Construction of Phase 2 will result in the disturbance of approximately 502 ha of vegetation and wetlands within the LSA (Table D.10.1). With the exception of l1 (marsh), b4, f1, f2, f3 and e2, no other ecosite phases identified within the LSA are considered limited in distribution within the Boreal Mixedwood ecological area (BMEA). The area of marsh that will be disturbed is relatively minor (0.13 ha of the 6.9 ha found in the LSA).

In total, ecosite phases of limited distribution currently occupy 171.3 ha within the LSA and Phase 2 will result in the disturbance of approximately 12.1 ha of these ecosites. None of the ecosite phases of limited distribution will be completely removed from the LSA, and a proportion of each are expected to be re-established during reclamation.

Reclamation will be aimed at the re-establishment of pre-disturbance ecosite phases. Ecosite is defined by the site conditions (moisture and nutrient regimes) relative to the regional climate. Ecosite phase, that includes the plant community, naturally changes with time (succession) and initially after reclamation may not be representative of the future composition; nonetheless, over time should resemble pre-disturbance ecosite phases.

Within the LSA, areas will be assigned the expected future ecosite phases premised on landscape position and soil conditions, this assignment will be used for prescriptions for achieving a reclaimed and re-vegetated landscape. Initially, a reclaimed ecosite will have a different understory species composition compared to naturally occurring ones, due to the application of the soil stabilizing seed mix. Consequently, reclaimed lands will first be dominated by annual graminoid and legume species from the mix applied. With time, planted trees, shrubs and forbs are expected to exert an influence on the understory microclimate conditions and ecosystem function. As the canopy closes, the coverage of native species will increase, and the lands will commence resembling native ecosite phases.

With the implementation of mitigation measures Phase 2 is predicted to have Low Impact on ecosite phases found within the LSA.

Planned Development Case

The STP Project footprint covers 502.0 ha (0.83%) of the RSA (CR #10, Table 5.2). Within the RSA, cover classes which are limited distribution that will be affected by the Project include closed coniferous dominated mixedwood, open pine and graminoid wetlands, corresponding to d2, e2, f2, b4, c1, k3 and l1 (respectively). The removal of ecosite phases for the construction of Project facilities will result in a 0.83% change within the RSA. In total, ecosite phases of limited distribution currently occupy 1.1% of the RSA (683.5 ha).

The Athabasca Oil Sands Corp. (now Dover Operating Corp.) MacKay Project is also located within the project RSA; consequently, ecological landscape cover (ELC) removed from the Project Footprint is hereby assessed for cumulative effects. The Dover Operating Corp. Project Footprint is estimated to cover 823.3 ha (1.36%) of the RSA (CR #10, Table 5.2).

Cumulatively, the two Projects (STP and Dover) will remove 1,325.3 ha (2.2%) of the RSA. Of that area, 27.2 ha (0.04%) is ecological landscape cover which is limited in distribution in the RSA (CR #10, Table 5.3). In addition, there is an existing project, STP Phase 1, which encompasses 127.8 ha (0.2%) of the RSA, with 7.7 ha (0.01%) of limited distribution landscape cover. In total, the three projects have a cumulative footprint of 1,453.1 ha which equates to 2.4% of the RSA, of which 34.9 ha is limited distribution ecological landscape cover.

The impact rating, following mitigation, for ecosite phases (ecological landscape cover) removed by the cumulative footprint (STP McKay Project Footprint (Phase 1 and 2), Athabasca/Dover project footprint) is Low.

D.10.3.2 Wetlands

Application Case

The area of wetlands that will be disturbed by the development of Phase 2 is 258.0 ha and is 5.9% of the LSA wetlands (Table D.10.2). Approximately 10.7 ha of wetlands which are limited in distribution in the LSA that will be disturbed. None of the wetland types of limited distribution in the LSA will be completely removed from the LSA. The wetland type with the greatest area removed by the Phase 2 footprint, is AWIS wetland type FTNN, which is considered a peatland.

Peatlands represent an important wetland type in the Boreal Mixedwood ecological area as these wetland types are difficult to reclaim and slow to recover following disturbance. Mitigation measures, including: 1) the maintenance of the integrity of the hydrologic regime of (drainage patterns) of wetlands; and, 2) minimization of the Phase 2 footprint where wetlands occur are recommended. If these mitigation measures are implemented, the effect of the reduction of peatland area, as a result of Phase 2 is expected to be negligible. Further, during construction, peat and topsoil materials from wetlands, will be salvaged and stored for replacement during reclamation.

MONG is limited in distribution within the LSA and RSA, and is considered to be limited in distribution in the Boreal Mixedwood ecological area. Due to the very small area of removal of MONG wetland (0.13 ha – 0.003% of the LSA), with mitigation it is expected that an equivalent area (at least) will be re-established at closure. As well, it is proposed that additional areas of MONG be developed, using appropriate depression areas created during reclamation.

Based on topography, native wetland marsh ecosite phases will be reclaimed and re-vegetated to have an emergent vegetation zone which will act as a transition zone between open water and existing wetland ecosite phases. This emergent zone will best resemble the marsh ecosite phase (l1) emergent zone which previously existed before the Phase 2 Project. Vegetation typical of this plant community is expected to quickly establish on the mineral soil along the margins of this class of wetland.

While the marsh ecosite phase (l1) may be regionally limited in distribution, it is expected that areas of marsh wetlands will be created following reclamation and re-vegetation. Where appropriate, disturbed areas will be reconfigured and contoured with appropriate slopes surrounding a central open water area to support a 3 m emergent zone (less than 1 m deep) that will promote the growth of emergent vegetation species.

With the implementation of mitigation measures Phase 2 is predicted to have Low Impact on wetlands.

Planned Development Case

The development of Phase 2 will disturb approximately 257.8 ha (0.7%) of the wetlands found within the RSA. As with the Application Case it is expected that during reclamation marsh ecosite phases will be created.

A total of 257.8 ha (0.7%) of RSA wetlands will be removed by the Project (CR #10, Table 5.6), and a total of 922.2 ha (2.5%) of the RSA wetlands will be removed by the cumulative (STP McKay Project, Phase 1 and 2, and AOSC MacKay) footprint.

Given the small area of wetlands to be disturbed and the implementation of mitigation measures, Phase 2 is predicted to have a Low Impact on wetlands within the RSA.

D.10.3.3 Rare Plants

Application Case

Construction of Phase 2 will result in the removal of two rare lichens (*Cladina stygia*, and *Usnea scabiosa*) (CR #10, Figure 4.7). Construction of Phase 2 is not expected to result in the removal of the rare plant community observed within the LSA given the plant community is not located in the vicinity of the Phase 2 footprint. The tracked (rare) ecological community *Populus tremuloides/Rosa acicularis/Apocynum androsaemifolium* is ranked S1/S2 in Alberta.

All but the vascular species and a few of the rare bryophytes and lichens reported in the rare plant survey are not field identifiable species and require a microscope and special stains for positive identification. The involvement of a lichen specialist in the Phase 2 Project rare plant survey resulted in considerably more "rare" lichens being found than with similar surveys. Because the level of sampling undertaken for the Phase 2 Project is generally not done outside of academic studies, and the results are not consistently reported to tracking bodies (*e.g.*, ANHIC), reports of abundance and distribution of these species is at best incomplete (Natureserve 2009). Also, because S-ranks are largely determined by the number of times a species is detected in the province, low profile and hard to identify species are more likely to be listed as rare (ABMI 2007). Consequently, it is impossible to determine if some species are in fact rare, are at the edge of their natural range and only appear to be rare, or are taxonomically uncertain having been previously misidentified or described as subspecies. Some of these hard to identify species were found a number of times outside the Phase 2 footprint. The multiple occurrences of several of the species supports the conclusion that many of these small inconspicuous species present on the tracking lists are in fact not rare.

Reclamation activities will focus on the re-establishment of ecosites c, g, h, i and j where rare plant occurrences were noted. In time, as these reclaimed ecosites begin to function like mature ecosite phases, it is expected that the potential for these sites to support rare plants will increase.

With the implementation of mitigation measures Phase 2 is predicted to have Low Impact on rare plants found within the RSA.

Planned Development Case

Given that Phase 2 is predicted to have Low Impact on rare plants in the Application Case it is predicted that Phase 2 will also have Low Impact for the PDC.

D.10.3.4 Biodiversity & Fragmentation

Application Case

The biodiversity VEC was assessed at three levels. Species biodiversity was assessed to address the effect of removing plant species from the LSA. Community biodiversity was assessed to address the effect of removing ecosite phases or biodiversity potential (based on ecosite phases) from the LSA. Landscape biodiversity was assessed to address the effect of Phase 2 on biodiversity in the RSA.

Species Diversity

Construction and operation of Phase 2 will result in the removal of approximately 3.7% (297.8 ha) of ecosite phases with very high and high biodiversity in the LSA (Table D.10.5) and 0.5% of the high and very high biodiversity ecosite phases in the RSA.

Community and Landscape Diversity

Fragmentation was considered in the assessment of community and landscape level biodiversity given the inverse relationship between fragmented landscapes and biodiversity (*i.e.*, where fragmentation increases, biodiversity decreases).

Phase 2 will result in an increase in the number of patches, a decrease in patch area per ecosite phase, and an increase in perimeter area ratio in both the LSA and RSA (CR #10, Table 5.6 and Table 5.8). These results depict that often the mean nearest neighbour increased due to patches being split via linear disturbance of Phase 2. The statistical result is that there are a greater number of smaller patches, with a mean smaller distance between them. For landscape level fragmentation as a whole the SDI is 2.81 with Phase 2 (Application Case) and 2.65 without Phase 2 (Baseline Case) for the LSA (Table D.10.12)

Within the LSA, ecosite phases with the highest level of fragmentation effect, as a consequence of Phase 2 (application scenario), are c1, d2, i1, i2, j1, j2, k1 and k2 (CR #10, Table 5.7). Ecosite phase b4 which is limited in distribution will be impacted even though there is an increase of one patch.

Table D.10.12 Application Case Landscape Level Fragmentation in the LSA

LSA	Number of Patches (#)	Percent of LSA (%)	Largest Patch Index (%)	Total Edge Perimeter (m)	Mean Patch Size (ha)	Mean Nearest Patch Neighbour (m)	Shannon's Diversity Index
Baseline	1328	16.66	2.19	1,147,505.0	6.00	165.11	2.65
Application	1570	19.70	2.19	1,180,407.5	5.08	156.94	2.81
Difference	**242**	**3.04**	**0.00**	**32,902.50**	**-0.92**	**-8.17**	**-0.16**

After closure, species richness is expected to be lower than naturally developing ecosites. The current STP reclamation practice is to promote natural revegetation where possible and seed annual grass and legume species to stabilize reconstructed soils where required. Since the seeded species are quick to establish and form a dense turf layer, native species ingress and regeneration will be initially limited due to competition. Nonetheless, native species cover is expected to increase over time.

Measures taken to mitigate for the reduction in area of terrestrial vegetation, wetlands, old growth forests, and non-native and invasive species will effectively mitigate for potential Project effects on biodiversity. As well, an ongoing re-vegetation program which aims at re-establishment of pre-disturbance ecosite phases would result in a negligible effect on long term biodiversity (overall species richness, diversity and evenness).

Project effects related to fragmentation will decrease, following the implementation of mitigation measures set out in the Part E, Conservation and Reclamation Plan. For example, long term impacts on community and landscape level biodiversity in the LSA and the RSA, following mitigation are negligible given no ecosite phase will be lost or added from the LSA or RSA as a result of implemented mitigation measures. Given Phase 2 will be developed in phases with sequential reclamation occurring throughout the life of Phase 2 (Part E) the actual maximum expected biodiversity impact is likely less than anticipated.

With mitigation, application case effects are local in extent, extended in duration, continuous in frequency, reversible in the long term, of low magnitude, and have a neutral contribution. The confidence rating of the assessment is high, the probability of the effect is high, and overall, the effect is Low.

Planned Development Case

Within the RSA, ecological landscape cover (ELC) with the highest level of fragmentation are wooded bogs and fens (i1, j1 & k1), closed white spruce (d3, e3 & f3), shrubby wetlands (i2, j2 & k2) and closed deciduous (d1, e1, & f1) respectively (CR #10, Table 5.9). Of the limited distribution ELC areas, graminoid wetlands (k3 & l1) are affected the most by fragmentation from Phase 2. For example, in graminoid wetlands, there are eight new patches created, and an increase in perimeter area ratio from 1,252.0 to 1,596.1 (an increase of 344.1). Of these, l1 is the only limited in distribution ecosite phase in the Boreal Mixedwood ecological area.

For the RSA, the landscape level fragmentation SDI is 1.52 with Phase 2 and 1.48 without Phase 2 (Table D.10.13). The SDI was calculated using patches not species; accordingly, the landscape level results reflect that fragmentation has increased at the landscape level in both the LSA and RSA.

Table D.10.13 Application Case Landscape Level Fragmentation in the RSA

RSA	Number of Patches (#)	Percent of LSA (%)	Largest Patch Index (%)	Total Edge Perimeter (m)	Mean Patch Size (ha)	Mean Nearest Patch Neighbour (m)	Shannon's Diversity Index
Baseline	13894	22.91	4.65	6,913,040.0	4.36	124.91	1.48
Application	14130	23.30	4.65	7,006,317.5	4.29	120.59	1.52
Difference	**236.00**	**0.39**	**0.00**	**93,277.50**	**-0.07**	**-4.32**	**-0.04**

Overall, Phase 2 will have a negligible impact on community level biodiversity as most of the ecosite phases that will be affected are relatively common in the region. Phase 2 will result in the removal of ecosite phases and wetlands that are regionally limited in distribution.

At the landscape level, the mean number of patches increases from the baseline to application (236), and then from application to planned (485), and overall from baseline to planned (cumulative footprint) the mean number of patches increases by 721 (CR #10, Table 5.13). As well, overall: the total edge perimeter increased by 228,630 m, mean patch size decreased, patch richness increased, the nearest neighbour decreased, the mean Shannon's Evenness Index decreased, and the mean Shannon's Diversity Index increased.

D.10.3.5 Forestry Resource

Application Case

Forested land represents 81.4% (6,491.5 ha) of the LSA, and 91.0% (456.8 ha) of the Phase 2 footprint. Phase 2 will result in the removal of 5.7% (456.8 ha) of forested land from the LSA, and 0.75% from the RSA. Productive land (merchantable timber) represents 59.5% (271.6 ha) of the forested area in the Phase 2 footprint. Construction of the Phase 2 will remove all timber from the Phase 2 footprint.

The impact rating, following mitigation, for forest resources is Low given forest resources will only be removed from the Phase 2 footprint, and will be used by the appropriate Forest Management Agreement (FMA) holder.

Planned Development Case

Forest resources were not assessed for the RSA given no Alberta Vegetation Inventory (AVI) was available.

D.10.3.6 Old Growth Forest

Application Case

The total amount of old growth forest in the LSA is 743.7 ha (Table D.10.9). Phase 2 will result in the removal of 0.38% (2.8 ha) of old growth in the LSA and an undetermined amount in the RSA. The old growth in the Phase 2 footprint is a small area (2.9 ha) of white spruce and aspen within d2 ecosite phase, and small areas of white spruce in f3.

Within the LSA, construction and operation of Phase 2 will result in the removal of 0.38 % (2.8 ha) of ecosite phases with moderate potential to support old growth (CR #10, Table 4.5). Reduction in area of ecosite phases with moderate potential within study areas will be negligible.

The amount of old growth and ecosite phases with the potential to support old growth forests that are to be removed from the Phase 2 footprint is negligible and will not have an effect on the ability for these forests to regenerate after Project closure. As the model of future age class distribution shows, there will be no difference in the development of old age class forests with or without Phase 2

The Phase 2 Project effect on old growth is Low considering a small amount will be removed from the Phase 2 footprint.

Planned Development Case

The area represented by old growth forests in the RSA was not estimated because the Alberta Cover Class data is not suitable for determining the age, height, species, or density of stands.

The Phase 2 Project effect on old growth is Low considering a small amount will be removed from the Phase 2 footprint.

D.10.3.7 Traditional Land Use

Application Case

Ecosite phases where Traditional Ecological Knowledge (TEK) vegetation species occur are summarized in Table D.10.10. Project effect results for TEK vegetation occurring within the Phase 2 footprint and the LSA are listed in Table D.10.14.

Table D.10.14 Traditional Ecological Knowledge Ecosite Ranking Results

Effect	Ecosite Phases		
	Rank 1 (Critical Medicinal Use)	Rank 2 (Food Use)	Rank 3 (Other Use)
Low Effect	d1, d3, e2, e3, f2, f3, g1, i1, i2 and j2	i1, j2 and k3	
Moderate Effect	d2, h1, j1, k1, k2, and k3	d1, f2, h1, i2, j1 k1 and k2	d1, d3, f2, g1, h1, i1, i2, j2, k1, k2, and k3
High Effect		d2, d3, e2, e3, f3, and g1	d2, e2, e3, f3 and j1
Ecosite Phases of Limited Distribution			
Low Effect			
Moderate Effect	b4 and c1		
High Effect	f1 and l1	b1, b4, c1, f1 and l1	b1, b4, c1, f1 and l1

The distribution of ecosite phases which support TEK vegetation will be accessible in both the LSA and the RSA following removal of ecosite phases by the Phase 2 footprint. With the implementation of mitigation measures the Phase 2 Project impact is expected to be Low in the LSA and the RSA.

Planned Development Case

One ecosite phase, l1 (marsh) appears limited in distribution within the RSA. The availability of TEK vegetation which requires a marsh plant community may be limited within the RSA. This is not related to this Project. The effect of the cumulative (the STP McKay Project, Phase 1 and 2, Dover – McKay) footprint for TEK vegetation is extrapolated from the LSA TEK vegetation results. Specifically, it is estimated that the plant communities in the LSA are similar in distribution to the plant communities in the RSA; consequently, the cumulative effects of the three projects in the RSA, are moderate (as they are in the LSA or the Application Case).

D.10.3.8 Non-Native and Invasive Species

Application Case

Two non-native and invasive plants (noxious species) were noted in the LSA. Species noted were minimal given occurrences of vegetation species were recorded only within survey plots and not along or within existing disturbance. As well, only noxious and noxious prohibited species were keyed out in from the survey plot database, and not nuisance or agronomic species.

With the implementation of mitigation measures (including a weed management and monitoring program), Phase 2 is not expected to have a local or regional effect on the establishment and spread of non-native and invasive species.

Potential Project effects are related to the establishment and spread of non-native and invasive species resulting from construction and operation of Phase 2. With the implementation of mitigation measures, application case effects are local in extent, extended in duration, periodic in frequency, reversible in the long term, of low magnitude, and have a neutral contribution. The confidence rating of the assessment is high, the probability of the effect is high, and overall, the effect is Low.

Planned Development Case

Non-native and invasive vegetation species were not assessed for the RSA.

With the implementation of mitigation measures (including a weed management and monitoring program), Phase 2 is not expected to have a local or regional effect on the establishment and spread of non-native and invasive species.

D.10.3.9 Potential Acid Input

Application Case

The potential for soil acidification on a soil type is assessed through comparison of the modelled PAI isopleths (Section D.1) against the critical loads assigned to particular soil map units. Based on a review of the Application Case PAI isopleths for the Phase 2 Project, there are no PAI isopleths which contain values that trigger critical load thresholds for soils within the RSA (MEMS 2011b). The largest Application Case PAI isopleths (worst case) within the RSA is a point source location (STP) with a PAI of 0.23 keq/ha/yr (Section D.1.3). The locations where PAI isopleths are 0.23 keg/ha/yr occur within ecosites b and c, and equate to a conversion factor of PAI critical load of .55 keq/ha/yr for vegetation.

Planned Development Case

Based on a review of the PDC PAI isopleths, there are no PAI isopleths that contain values that trigger critical load thresholds for the soils within the RSA (Section D.1.3). The largest PDC PAI isopleths (worst case) within the RSA is a point source location (AOSC MacKay River North Oil Sands Facility) with a PAI of 0.40 keq/ha/yr, for soils which converts to a PAI critical load of 0.55 keq/ha/yr for ecosites b and c. The impact of Phase 2 with respect to potential soil acidification is negligible at the local and regional scale for all assessment cases; consequently, PAI is not considered to pose a potential cumulative impact to vegetation within the LSA or RSA.

The impact of the Phase 2 Project with respect to potential soil acidification is negligible at the local and regional scale for the PDC assessment. Consequently, PAI isopleths are not considered to pose a potential impact to vegetation (which is linked to soil types and condition) within the LSA or RSA. Accordingly, the impact rating for PAI is Low.

D.10.4 Mitigation and Monitoring

D.10.4.1 Mitigation

In order to reduce potential impacts of Phase 2 on vegetation and wetlands STP will:

- implement re-vegetation programs that aim at the reestablishment of healthy ecosite phases removed by development;
- preserve habitat adjacent to the development footprint by minimization of the area required for construction and operation;
- seed stockpiled topsoil with a suitable species mix to ensure long term stability of the piles, and control of invasive or noxious weeds;
- where natural regeneration is insufficient plant select with tree, shrub and forb seedlings with the aim of re-establishing baseline ecosite phases, and providing structure for enhancing biodiversity;
- use best practice construction and reclamation to mitigate erosion, maintain drainage patterns, and preserve the integrity of wetland areas outside the Phase 2 footprint;
- where appropriate will remove fill material placed over organics with the aim of re-establishment of wetlands;
- consider salvaging and direct placing soil salvaged from areas identified as being high or very high biodiversity;
- reclaim borrow areas to wetlands, or transition area ecosite phases, where possible;

- utilize opportunities to direct place peat materials from peatland areas scheduled for development with the aim of maintaining those materials as a living peat substrate and a propagule source for wetland revegetation;
- allow Aboriginal groups the opportunity to provide input into the development of mitigation and monitoring plans with the aim of facilitating re-establishment of vegetation used for medicinal, food and other uses; and
- perform fill planting in areas where there is poor survival of seedlings.

D.10.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will:

- monitor reclaimed sites to assess the success of reestablishment of ecosite phases removed by the footprint;
- perform survival, growth and health assessment surveys to monitor the success of revegetation efforts;
- conduct a rare plant survey on any new development areas not included in this assessment;
- monitoring and maintenance of drainage control structures to ensure water flow and flow patterns are maintained in wetlands adjacent to the development footprint;
- monitoring of reclaimed wetlands until reclamation certification is achieved in order to ensure healthy wetlands are being created;
- ensure regular site inspections are being conducted to identify if non-native and invasive (noxious) vegetation species are establishing;
- complete post revegetation surveys on revegetated sites to assess success and to allow for adaptive management strategies for subsequent stages of revegetation.

D.10.5 Summary of VECs

A summary of residual effects and associated impact ratings on vegetation and wetland valued environmental components (VECs) is presented in Table D.10.15.

Table D.10.15 Summary of Impact Rating on Vegetation and Wetland Valued Environmental Components

Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent of Impact or Effect[1]	Duration of Impact or Effect[2]	Frequency of Impact or Effect[3]	Ability for Recovery from Impact or Effect[4]	Magnitude of Impact or Effect[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Impact or Effect Occurrence[8]	Impact Rating[9]
1. Terrestrial Vegetation/Ecosite Phases											
Reduction in area	see Section D.10.4.1	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	Low
2. Wetlands											
Reduction in Area	see Section D.10.4.1	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	Low
3. Old Growth Forests											
Removal of Old Growth forests	see Section D.10.4.1	Application	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Low	Neutral	High	High	Low
4. Non-native and invasive species											
Invasions into cleared areas in the PF	see Section D.10.4.1	Application	Local	Extended	Periodic	Reversible Long Term	Low	Neutral	High	High	Low
		Cumulative	Local	Extended	Periodic	Reversible Long Term	Low	Neutral	High	High	Low
5. Traditionally Used Plants											
Removed from PF	see Section D.10.4.1	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	High	High	Low
6. Biodiversity											
Reduction in Genetic-Species Diversity	see Section D.10.4.1	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	Moderate	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	Moderate	High	Low

Table D.10.15 Summary of Impact Rating on Vegetation and Wetland Valued Environmental Components

Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent of Impact or Effect[1]	Duration of Impact or Effect[2]	Frequency of Impact or Effect[3]	Ability for Recovery from Impact or Effect[4]	Magnitude of Impact or Effect[5]	Project Contribution[6]	Confidence Rating[7]	Probability of Impact or Effect Occurrence[8]	Impact Rating[9]
Reduction of Community Diversity	see Section D.10.4.1	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	Moderate	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	Moderate	High	Low
Reduction of Landscape Diversity	see Section D.10.4.1	Application	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	Moderate	High	Low
		Cumulative	Local	Extended	Continuous	Reversible Long Term	Moderate	Neutral	Moderate	High	Low

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.11 WILDLIFE

STP conducted a wildlife assessment for Phase 2. The following section is a summary of the Wildlife Assessment that was prepared by Millennium EMS Solutions Ltd. and is included as Consultant Report #11 (CR #11). For full details of the assessment, please refer to CR #11.

Alberta Environment issued the final ToR for Phase 2 on July 22, 2011. The specific requirements for the wildlife component are provided in Section 3.7, and are as follows:

3.7.1 BASELINE INFORMATION

[A] Describe and map the wildlife resources (amphibians, reptiles, birds and terrestrial and aquatic mammals). Describe species relative abundance, distribution and their use and potential use of habitats. Also identify any species that are:

- *a) listed as "at Risk, May be at Risk and Sensitive" in The Status of Alberta Species (Alberta Sustainable Resource Development);*
- *b) listed in federal Species at Risk Act;*
- *c) listed by COSEWIC; and*
- *d) traditionally used species.*

[B] Describe and map existing wildlife habitat and habitat disturbance (including exploration activities). Identify those habitat disturbances that are related to existing and approved Project operations.

[C] Identify the key wildlife and habitat indicators used to assess Project impacts. Discuss the rationale for their selection.

3.7.2 IMPACT ASSESSMENT

[A] Describe and assess the potential impacts of the Project to wildlife and wildlife habitats, considering:

- *a) how the Project will affect wildlife relative abundance, habitat availability, mortality, movement patterns, and distribution for all stages of the Project;*
- *b) how improved or altered access may affect wildlife, including potential obstruction of daily and seasonal movements, increase vehicle-wildlife collisions and increased hunting pressures;*
- *c) how increased habitat fragmentation may affect wildlife considering edge effects, the availability of core habitat and the influence of linear features and infrastructure on wildlife movements and predator-prey relationships;*
- *d) the spatial and temporal changes to habitat availability and habitat effectiveness (types, quality, quantity, diversity and distribution);*
- *e) potential effects on wildlife resulting from changes to air and water quality, including both acute and chronic effects to animal health;*
- *f) potential effects on wildlife from the Proponent's proposed and planned exploration, seismic and core hole activities, including monitoring/4D seismic; and*

g) the resilience and recovery capabilities of wildlife populations and habitats to disturbance.

[B] Discuss mitigation measures to avoid or minimize the potential impact of the Project on wildlife and wildlife habitat and the potential effectiveness of the proposed mitigation. Clearly identify those mitigation measures that will be implemented and provide the rationale for their selection.

The LSA was used to account for the direct and indirect effects of the Phase 2 Project on wildlife. Most baseline wildlife surveys were conducted within the LSA to evaluate the effects of the Phase 2 Project on wildlife and wildlife habitat although several wildlife surveys (owls, amphibians, and breeding birds) were also conducted on STP's south lease located approximately 5 km south of the LSA. A regional study area (RSA) was established for most wildlife VECs which included the area within 8 km of the LSA. This area was selected because it represents the approximate diameter of a moose home range in northeastern Alberta and includes the home ranges of other selected wildlife VECs. To assess cumulative effects on woodland caribou, the RSA was extended to 30 km beyond the LSA. This distance was selected because it represents the average diameter of one caribou home range in northeastern Alberta.

A number of sources of existing information were reviewed to obtain background information on the Phase 2 Project area and surrounding region including:

- Fish and Wildlife Management Information System (FWMIS);
- Alberta Natural Heritage Information System (ANHIC);
- Alberta Biodiversity Monitoring Institute (ABMI);
- Alberta Caribou Committee (ACC);
- Federation of Alberta Naturalists; and
- Various environmental assessments.

The wildlife assessment focused on seven species selected as Valued Environmental Components (VECs) including:

- amphibians - Canadian Toad;
- birds - Cape May warbler, Sandhill crane;
- ungulates - woodland caribou and moose;
- beaver; and
- predators - Canada lynx.

An additional 44 special status species whose ranges overlap with the Phase 2 Project, and for which there was suitable habitat, were also considered.

D.11.2 Baseline Conditions

D.11.2.1 Wildlife Habitat

Ecosite phases for the LSA were grouped into broader wildlife habitat classes based on their vegetation species composition, moisture regime, topographic position, and general value to wildlife. Because of the varying importance of young and mature/old forests for wildlife, stand age was also incorporated into the habitat classes. Twelve habitat types (CR #11, Figure 2-8) representing 23 ecosite phases (CR #11, Figure 2-9) along with several classes of water bodies and anthropogenic disturbances were identified in the LSA (CR #11, Table 2-6).

Existing habitat types in the LSA form a fairly heterogeneous landscape providing habitat for a variety of boreal wildlife including moose, Canada lynx, snowshoe hare, American marten, fisher, greater yellowlegs, ruby-crowned kinglet, Tennessee warbler, Swainson's thrush, boreal chorus frogs, and wood frogs. Lowland shrub and lowland treed habitats typically have lower wildlife diversity than other habitat types but may provide critical habitat for woodland caribou (ASRD and Alberta Conservation Association 2010). Habitat found in the LSA, RSA and the caribou RSA (CRSA) is listed in Table D.11.1. The habitat availability in the LSA and RSA for each VEC is provided in Table D.11.2.

Table D.11.1 Extent of Wildlife Habitat Associated in the LSA, RSA, and CRSA.

Habitat Type	Footprint (ha)	LSA		RSA		CRSA	
		Area (ha)	% Habitat Loss	Area (ha)	% Habitat Loss	Area (ha)	% Habitat Loss
Jack Pine	1.2	77.5	1.5	638.3	0.2	6,345.1	0.0
Open Pine	0.0	0.0	0.0	29.2	0.0	366.2	0.0
White Spruce	9.7	514.0	1.9	12,607.8	0.1	86,461.5	0.0
Deciduous/ Mixedwood	193.4	1,525.9	12.7	7,967.5	2.4	74,941.0	0.3
Mixed Coniferous	35.8	138.4	25.9	222.5	16.1	2,323.2	1.5
Closed Upland Shrub	0.0	0.0	0.0	727.0	0.0	2,818.0	0.0
Sedge Meadow/Marsh	6.1	69.3	8.8	431.8	1.4	1,310.6	0.5
Lowland Shrub	100.9	1,103.9	9.1	7,003.1	1.4	41,584.7	0.2
Lowland Treed	146.6	1,720.6	8.5	29,510.2	0.5	155,661.1	0.1
Waterbody	0.3	93.4	0.3	467.3	0.1	3,473.5	0.0
Cutblock	0.0	247.8	0.0	0.0	0.0	0.0	0.0
Wildfire	0.0	0.0	0.0	0.0	0.0	5,323.4	0.0
Disturbance	8.4	264.1	3.2	1,029.6	0.8	16,757.6	0.1
Totals [(1)]	**502.4**	**5,754.9**	**8.7**	**60,634.2**	**0.8**	**397,365.9**	**0.1**

(1) Because of rounding, total values may not equal the sum of the individual values.

Table D.11.2 Habitat Availability for each VEC

Species	Habitat Quality	LSA				RSA			
		Baseline (ha)	Application (ha)	Change (ha)	% Change	Baseline (ha)	Application (ha)	Change (ha)	% Change
Canadian Toad	Habitat	21.8	18.3	-3.5	-16.1	184.3	180.8	-3.5	-1.9
	Nil	5,713.1	5,716.6	+3.5	+0.1	60,449.9	60,453.4	+3.5	0.0
	Effective (ha)	**21.8**	**18.3**	**-3.5**	**-16.6**	**184.3**	**180.8**	**-3.5**	**-1.9**
	Effective (%)	**0.4**	**0.3**			**0.3**	**0.3**		
Cape May warbler	High	316.0	272.6	-43.4	-13.7	9,827.2	9,725.4	-101.8	-1.0
	Moderate	790.7	585.4	-205.3	-26.0	25,317.6	24,868.6	-449.0	-1.8
	Low	2,024.0	1,563.4	-460.6	-22.8	13,060.7	12,662.1	-398.6	-3.1
	Nil	2,604.3	3,313.6	+709.3	+27.2	12,428.8	13,378.1	+949.3	+7.6
	Effective (ha)	1,106.7	858.0	-248.7	-22.5	35,144.7	34,634.0	-510.7	-1.5
	Effective (%)	**19.2**	**14.9**			**58.0**	**57.1**		
Sandhill crane	High	1340.0	947.5	-392.5	-29.3	32,159.1	31,656.4	-502.7	-1.6
	Moderate	1,115.2	920.4	-194.8	-17.5	5,359.9	5,160.6	-199.3	-3.7
	Low	2,384.5	2,067.3	-317.2	-13.3	19,672.6	19,705.7	+33.1	+0.2
	Nil	895.3	1,799.8	+904.5	+101.0	3,442.6	4,111.5	+668.9	+19.4
	Effective (ha)	**2,455.2**	**1,867.9**	**-587.3**	**-23.9**	**37,519.0**	**36,817.0**	**-702.0**	**-1.9**
	Effective (%)	**42.7**	**32.5**			**61.9**	**60.7**		
Woodland caribou	High	106.4	64.4	-42.0	-39.5	114,701.8	114,386.6	-315.2	-0.3
	Moderate-high	313.6	142.1	-171.5	-54.7	16,992.2	16,847.6	-144.6	-0.9
	Moderate	641.4	274.0	-367.4	-57.3	59,248.6	58,673.2	-575.4	-1.0
	Low	1037.0	662.2	-374.8	-36.1	6,274.9	6,657.6	+382.7	+6.1
	Very low	1,523.4	1,141.8	-381.6	-25.0	118,470.0	118,336.6	-133.4	-0.1
	Nil	2,113.2	3,450.5	+1,337.3	+63.3	81,678.4	82,464.4	+786.0	+1.0
	Effective (ha)	**1,061.4**	**480.5**	**-580.9**	**-54.7**	**190,942.6**	**189,907.4**	**-1,035.2**	**-0.5**
	Effective (%)	**18.4**	**8.3**			**314.9**	**313.2**		
Moose	High	917.7	661.5	-256.2	-27.9	13,841.7	13,439.6	-402.1	-2.9
	Moderate-high	817.9	745.4	-72.5	-8.9	1,869.0	1,985.7	+116.7	+6.2
	Moderate	1,338.0	1,239.5	-98.5	-7.4	203.3	285.2	+81.9	+40.3
	Low	1202.6	956.5	-246.1	-20.5	38,135.0	37,484.8	-650.2	-1.7
	Very low	964.3	973.2	+8.9	+0.9	5,840.7	5,936.2	+95.5	+1.6
	Nil	494.5	1,158.8	+664.3	+134.3	744.5	1502.7	+758.2	+101.8
	Effective (ha)	**3,073.6**	**2,646.4**	**-427.2**	**-13.9**	**60,634.2**	**15,710.5**	**-203.5**	**-1.3**
	Effective (%)	**53.4**	**46.0**			**100.0**	**25.9**		

Table D.11.2 Habitat Availability for each VEC

Species	Habitat Quality	LSA				RSA			
		Baseline (ha)	Application (ha)	Change (ha)	% Change	Baseline (ha)	Application (ha)	Change (ha)	% Change
Beaver	High	90.1	83.8	-6.3	-7.0	787.1	787.1	0.0	0.0
	Moderate	351.6	330.3	-21.3	-6.1	8,049.3	7,898.4	-150.9	-1.9
	Low	3,221.7	2,901.9	-319.8	-9.9	7,723.5	7,680.1	-43.4	-0.6
	Nil	2,071.6	2,419.0	+347.4	+16.8	44,074.3	44,268.6	+194.3	+0.44
	Effective (ha)	**441.7**	**414.1**	**-27.6**	**-6.2**	**8,836.4**	**8,685.5**	**-150.9**	**-1.7**
	Effective (%)	**7.7**	**7.2**			**14.6**	**14.3**		
Canada lynx	High	1,177.8	897.9	-280.0	-23.8	186.6	180.4	-6.2	-3.3
	Moderate-high	1,094.5	752.8	-341.7	-31.2	35,796.3	35,278.7	-517.6	-1.4
	Moderate	969.7	827.3	-142.4	-14.7	6,285.8	6,180.8	-105.0	-1.7
	Low	1,128.6	769.7	-358.8	-31.8	13,491.6	12,973.6	-518.0	-3.8
	Very low	464.3	604.9	+140.6	+30.3	1,807.9	1,776.8	-25.2	-1.4
	Nil	900.2	1,882.4	+982.2	+109.1	3,072.0	4,244.0	+1,172	+38.2
	Effective (ha)	**3,242.0**	**2,477.9**	**-764.0**	**-23.6**	**42,268.7**	**41,639.8**	**-628.8**	**-1.5**
	Effective (%)	**56.3**	**43.1**			**69.7**	**68.7**		

D.11.2.2 Biodiversity

Most of the LSA (42.8%) was considered to have potential for moderate bird biodiversity (CR #11, Table 2-28, Figure 2-17). Moderate bird biodiversity potential was associated with both old and young lowland treed habitats, and old mixed coniferous, old white spruce, and young mixedwood habitats. Water bodies had the highest diversity ranking, with 88 bird species potentially occurring in or near them (*i.e.*, riparian habitats). High bird diversity potential comprised only 2.8% of the LSA and included mostly marsh, old mixedwood, and riparian habitats associated with water bodies. These habitats support a range of listed species including black-throated green warbler and Canada warbler. Similarly, moderate-high bird diversity potential was found in old mixed coniferous, old white spruce, old lowland treed, old mixedwood, sedge meadow, and marsh habitats. Mature to old forests usually have higher avian species richness and diversity than younger forests (Hobson and Bayne 2000); therefore, diversity is expected to be higher in these habitat types. Low bird diversity potential was recorded in cutblock and disturbance habitats, while jack pine, lowland shrub, young white spruce, and mixedwood habitat had moderate-low bird diversity.

The greatest diversity of mammals and herptiles occurs in sedge meadows, old jack pine, old mixedwood, and most old white spruce habitats (CR #11, Appendix 1). These habitats contain a wide variety of amphibians, reptiles, and mammals and account for 12.1% of the LSA. Moderate-low to moderate-high ranks accounted for most (77.5%) of the mammal and herptile diversity (CR #11, Table 2-32). Marshes, lakes, old mixed coniferous, old lowland treed, old lowland shrub, old deciduous, some old white spruce, young jack pine, young mixedwood, young lowland shrub, young white spruce, most young mixed coniferous, and most young lowland treed habitats were associated with these diversity ranks (CR #11, Appendix 1). Low diversity for mammals and herptiles was associated with cutblocks, disturbance habitats, rivers (NWR), flooded areas (NWF), young deciduous, some young mixed coniferous, and some young lowland treed habitats (CR #11, Appendix 1).

Overall, most of the LSA (60.5%) was classified as having moderate to moderate-low wildlife biodiversity (Table D.11.3, CR #11, Figure 3-1).

Table D.11.3 Wildlife Biodiversity in the LSA.

Biodiversity Rank	Area (ha)	% of LSA
High	543.3	9.5
Moderate-high	1,203.0	21.0
Moderate	1,509.1	26.3
Moderate-low	1,961.2	34.2
Low	518.5	9.0
Total	**5,735.0**	**100.0**

D.11.2.3 Birds

Cape May Warbler

Cape May warblers prefer to nest in mature and old-growth, white spruce-dominated forests, although black spruce forests may also be used. Cape May warblers tend to select spruce forests over 10 m in height, with a number of very tall conifers rising above the canopy. These tall conifers are likely used as singing posts to attract mates and defend territories. Tree density does not appear to be an important factor in habitat selection by the Cape May warbler.

Under existing conditions, the LSA contains 1,106.7 ha (19.3%) of effective habitat for Cape May warblers (Table D.11.2). Most of this moderate and high quality habitat is located in the northeast corner of the LSA, as well as along the river in the north half of the LSA (CR #11, Figure 3-2). Of the 1,106.7 ha of potential Cape May warbler habitat available at baseline within the LSA, 754.3 ha is old-growth. In comparison, 58.0% (35,144.7) of the RSA is considered effective habitat for Cape May warblers under existing conditions (Table D.11.2). Most of this high and moderate quality habitat is located in the eastern third of the RSA (CR #11, Figure 3-3).

Although Cape May warbler breeding territories typically encompass up to 1 ha of effective habitat (Norton 2001, New Brunswick Natural Resources 2005), there is evidence that songbird territories need to be surrounded by a contiguous habitat patch of at least 10 ha in size (Schmiegelow and Hannon 1999, Butcher et al. 2010). Therefore, habitat patches need to be ≥ 10 ha in size to be considered effective for Cape May warblers. Under existing conditions, the habitat model predicted that the LSA contains 26 (893 ha) patches of effective habitat (CR #11 Figure 3-4) large enough to support breeding Cape May warblers while the RSA contains 152 (33,691 ha) habitat patches (CR #11, Figure 3-5). The average density of Cape May warblers in optimal habitat in western Canada is 0.07 pairs/ha (Kirk et al. 1996, 1997). Therefore, the LSA can support an estimated 63 pairs of Cape May warblers under baseline conditions, while the RSA can support approximately 2,358 pairs.

Sandhill Crane

Sandhill cranes nest in isolated bogs, marshes, swamps, meadows and other secluded freshwater wetlands. Effective sandhill crane habitat is widely distributed throughout the LSA (CR #11, Figure 3-6) under baseline conditions, accounting for about 43% of the LSA (Table D.11.2). In comparison, almost 62% of the RSA provides effective habitat for sandhill cranes under existing conditions (Table D.11.2.2, CR #11, Figure 3-7). It appears that sandhill crane breeding habitat is unlikely to be limiting in either the LSA or RSA prior to Project development.

D.11.2.4 Semi-Aquatic Wildlife

Canadian Toad

Canadian toads are considered "May be at Risk" in Alberta. Optimal breeding conditions are in shallow, stagnant water including shores of lakes, rivers, marshes, and other temporary bodies of water (Garcia et al. 2004). After the breeding season, Canadian toads move to upland forest habitats where they spend the rest of the year and hibernate from September to April.

Under existing conditions, the LSA contains 21.8 ha of effective breeding habitat for Canadian toads (Table D.11.2). Most of this habitat is located in the northern half of the LSA and along the MacKay River (CR #11, Figure 3-8). Similarly, only 0.3% of the RSA is considered effective habitat for Canadian toads at baseline. In the RSA, most of effective habitat is located in small patches along the MacKay River, in several larger patches in the south, and in several small patches in the west (CR #11, Figure 3-9).

Beaver

The beaver is listed as a Priority 2 species by the CEMA and is considered a keystone species in Alberta because of its close relationship with riparian areas and water bodies. The beaver is also important from a socio-economic perspective and is a key component for the traditional way of life. Beaver are associated with streams, lakes, ponds and marshes in forested areas. Waterbodies at least 1.5 m deep are preferred and stable shorelines are required for dam, lodge or burrow construction. Areas with abundant deciduous vegetation, including aspen, poplar, willow and alder, within 200 - 250 m of a waterbody are generally considered high quality habitat for beaver.

Potential beaver habitat is restricted to riparian areas, and as such, effective habitat at baseline represents < 8.0% of the LSA (Table D.11.2, CR #11, Figure 3-10). This is primarily a result of the lack of suitable water bodies in the LSA. More suitable habitat (14.6%) is found within the RSA (Table D.11.2, CR #11, Figure 3-11).

D.11.2.7 Predators

Canada lynx

The Canada lynx occurs at low densities throughout the boreal forest of Alberta (Pattie and Fisher 1999). While the lynx is designated as "Not at Risk" of extinction at the federal level, it is considered "Sensitive" in Alberta because of recent population declines, and concerns over habitat loss and fragmentation.

Lynx are highly dependent upon snowshoe hares; therefore, they tend to select habitats with a high density of hares (Bayne et al. 2008). The track surveys indicate that snowshoe hare frequency was relatively high in all habitats that lynx were present, indicating that lynx preference of habitat type is related to prey availability. Lynx prefer to hunt in regenerating forest stands (Koehler and Aubry 1994), but also use mature stands (Murray et al. 1994, O'Donoghue et al. 1998). Lynx were more frequently detected within the LSA than in many other studies in the region (CR #11, Appendix 2, Table 2-12), likely because snowshoe hare densities were at or near their peak in 2009 and 2011, which occurs every nine to ten years (Boutin 1995).

Effective lynx habitat was very common and widespread, accounting for 56.5% of the LSA (Table D.11.2, CR #11, Figure 3-12). These results reflect the abundance of early-successional forests, considered good quality habitat for both lynx and snowshoe hare. High quality habitat represents 20.5% of the LSA under existing conditions, and therefore lynx are anticipated to be relatively common when they are at the peak of their ten-year cycle. Similarly, effective habitat for lynx accounted for 69.7% of the RSA (Table D.11.2, CR #11, Figure 3-13).

D.11.2.5 Ungulates

Moose

Moose are widely distributed throughout the forested portion of the province. Moose occur in a variety of habitats often in close association with deciduous, shrub, riparian and especially with wetland habitats. The habitat suitability model predicts that 53.6% of the LSA and 26.2% of the RSA functions as effective habitat for moose during the winter (Table D.11.2). Effective habitat is widely scattered throughout the LSA (CR #11, Figure 3-14), with relatively large patches of high quality habitat located primarily along the MacKay River. In the RSA, habitat is more evenly distributed throughout the region (CR #11, Figure 3-15).

Core security habitat for moose was considered as all effective habitat (high, moderate-high and moderate quality) located outside of the disturbance ZOIs. This core habitat is of high value for moose because it provides adequate forage in areas safe from human disturbance and potentially predation. Core security habitat was mapped for the winter only, when forage availability is most limiting. Core security habitat is distributed throughout the LSA, although the southwest corner of the LSA lacks suitable moose habitat (CR #11, Figure 3-16). One-hundred and forty-five core habitat patches were identified in the LSA, most of which were 5 – 10 ha in size (Table D.11.4). Core habitat represented 35.8% of the LSA for moose, and 19.6% of the RSA. Although core habitat in the RSA is composed mostly of small patches there were 22 patches >100 ha in size present in the RSA.

Table D.11.4 Moose core security habitat patch metrics

Patch Size	Number			Total Area (ha)		
	Baseline	Application	Change	Baseline	Application	Change
LSA						
5 - 10 ha	80	80	0	539.1	554.3	+15.2
10-50 ha	62	45	-17	1,225.2	837.8	-387.4
50-100 ha	2	2	0	134.3	121.0	-13.3
≥ 100 ha	1	1	0	156.6	156.6	0
Totals	**145**	**128**	**-17**	**2,055.2**	**1,669.7**	**-385.5**
RSA						
5 - 10 ha	223	203	-20	1,571.8	1,438.6	-133.2
10-50 ha	231	202	-29	4,884.2	4,200.5	-683.7
50-100 ha	28	24	-4	2,093.9	1,783.8	-310.1
≥ 100 ha	25	22	-3	5,435.3	4,459.2	-976.1
Totals	**507**	**451**	**-56**	**13,985.2**	**11,882.1**	**-2,103.1**

A number of disturbance features in the LSA and RSA were identified that could affect moose movement at baseline including the CPF and associated infrastructure for the Phase 1 Project and the all-season access road. These anthropogenic features are expected to have relatively low permeability to moose because of high levels of traffic and human activity which may deter moose from moving between the northern and southern portions of the LSA and RSA. Within the RSA, the Phase 2 Project is unlikely to affect moose movements because of the presence of more effective and highly permeable habitats surrounding Phase 2 (CR #11, Figure 3-17). This should facilitate moose movement around Phase 2 rather than through it. For the most part moose are expected to be able to move in the RSA with relative ease under baseline conditions.

Mortality risk to moose may result from with improved access associated with development of the Phase 1 Project. Of primary concern are the effects of increased hunting pressure, increased sensory disturbance, increased moose-vehicular collisions, and increased levels of predation, and their associated effects on health or recruitment.

Woodland caribou

The CRSA overlaps with the WSAR caribou range within the Athabasca Planning Area (ASRD/ACA 2010). The caribou population in this range was estimated at between 204 and 272 animals in 2011 (EC 2011b) and has declined by about 22% between 2008 and 2009 (ASRD/ACA 2010). Caribou are designated as a "Threatened" species federally under the *Species at Risk Act* and provincially under the *Wildlife Act*.

Almost 19% of the LSA is considered as effective habitat for caribou, although only 1.9% of this is rated as high quality (Table D.11.2). Most of the high quality habitat is located in the southern portions of the LSA (CR #11, Figure 3-18). In comparison, approximately 48% of the CRSA contains effective caribou, although only about 30% of is rated as high quality habitat. Most of the effective caribou habitat is available in the vicinity of the Phase 2 Project and western portions of the CRSA at baseline.

Core security habitat was defined as effective habitat located outside of the disturbance ZOIs. Patches of all sizes ≥ 5 ha were considered to be potential core habitat. It was assumed that although large habitat patches are best because animals can save energy by foraging in one location for an extended period, caribou can use smaller patches of effective habitat (Johnson et al. 2004), provided they are secure from predation and human disturbance.

Results of the analysis indicate that the LSA contained 53 core habitat patches at least 5 ha in size, while the CRSA contained 3,783 patches (Table D.11.5). Most core habitat patches were < 50 ha in size in the LSA and CRSA although 251 core habitat patches > 100 ha occurred within the CRSA. In the LSA, the larger patches of core habitat were sparsely distributed primarily in the south central and southern portions of the LSA although there were several patches located in the northern portion of the LSA (CR #11, Figure 3-20). In comparison, most of the core habitat patches for caribou occurred in the central and southwest areas of the CRSA (CR #11, Figure 3-21).

Permeability of the landscape is anticipated to be affected by disturbance features within the CRSA (CR #11, Table 3-18). The most significant barriers to caribou movement are plants, gravel pits, above ground pipelines without crossing structures, and camps. Winter access routes and larger seismic lines within the RSA were rated as moderately permeable during the winter because of human and predator presence.

Table D.11.5 Caribou core security habitat patch metrics in the LSA and CSA

Patch Size	Number			Total Area (ha)		
	Existing	Application	Change	Existing	Application	Change
LSA						
5 – 10 ha	37	14	-23	248.6	84.0	-164.6
10 – 50 ha	15	6	-9	246.3	75.0	-171.3
50 – 100 ha	1	1	0	69.1	69.1	0
≥ 100 ha	0	0	0	0.0	0.0	0
Total ≥ 5 ha	53	21	-32	564.0	228.1	-335.9
CSA						
5 – 10 ha	1,679.0	1,565.0	-114.0	11,678.4	10,877.2	-801.2
10 – 50 ha	1,630.0	1,523.0	-107.0	34,180.5	32,266.3	-1,914.2
50 – 100 ha	222.0	214.0	-8.0	15,439.7	14,592.6	-847.1
≥ 100 ha	251.0	239.0	-12.0	98,195.1	92,278.0	-5,917.1
Total ≥ 5 ha	3782.0	3541.0	-241.0	159,493.7	150,014.1	-9,479.6

In the LSA, caribou movement is primarily impeded by facilities and infrastructure associated with the Phase 1 Project (CR #11, Figure 3-20). These same disturbance features are also present in the CRSA, but affect a much smaller proportion of the core caribou habitat (CR #11, Figure 3-21). Winter access routes are considered moderately permeable to caribou, but may represent a greater barrier when these corridors are plowed and actively used by large vehicles (*e.g.*, during a winter core hole program). In this case, core habitat patches bounded by access routes would be relatively inaccessible to caribou. LIS lines also contribute to uncertainty regarding permeability of the LSA to caribou (Athabasca Landscape Team 2008) and our assumption that LIS lines are completely permeable to caribou may result in an underestimation of the number of potential barriers in the LSA.

D.11.3 Predicted Conditions

Phase 2 has the potential to affect wildlife in a number of ways, including direct and indirect habitat loss, habitat fragmentation, altered movement patterns, and increased mortality. Effects on habitat availability may be either direct (*e.g.*, vegetation clearing) or indirect (*e.g.*, avoidance of habitat due to sensory disturbance). The following section describes predicted changes of Project development on the various groups of wildlife, focusing on species identified as VECs.

D.11.3.1 Birds

Application Case

Habitat Availability

Because the Cape May warbler is dependent upon mature or old forest stands, they are expected to occur at low densities within the LSA. Phase 2 is predicted to result in the loss of 248.7 ha (22.5%) of effective habitat for Cape May warbler in the LSA (Table D.11.2, CR #11, Figures 3-22 and 3-23). It is important to note that the LSA provides only 1,106.7 ha of effective habitat for Cape May warbler. The number of patches of suitable nesting habitat will also decrease with the Phase 2 Project as a result of habitat loss and fragmentation. The number of effective habitat patches in the LSA suitable for nesting Cape May warblers is anticipated to decrease by six with Project development, representing a loss of 215.7 ha (CR #11, Table 3-22, Figure 3-24). Overall, Phase 2 is expected to have a Low Impact on effective Cape May warbler habitat.

Effective sandhill crane breeding habitat is far more abundant than habitat for other forest-dependent VECs, and accounts for 42.8% (or 2,455.2 ha) of the LSA (5,734.9 ha) at baseline (Table D.11.2, CR #11, Figure 3-26). Project development will result in the loss of 587.3 ha (23.9%) of effective sandhill crane habitat, however, 32.6% of the LSA (1,867.9 ha) is still considered effective under predicted conditions. Unlike the Cape May warbler, patch size is not considered important for sandhill crane (Cooper 1996), and since most of the effective habitat occurs outside of the disturbance ZOIs, all of this effective habitat will still be available to sandhill cranes after Project development. Decommissioning and reclamation will create habitat for sandhill crane in the short-term. Overall, Phase 2 is expected to have a Low Impact on effective sandhill crane habitat.

Wildlife Movement

Effects of Phase 2 on bird movement will be most pronounced for forest songbirds, such as Cape May warbler, particularly along cleared rights-of-way and well pads. Although breeding songbirds can incorporate narrow (< 6 m) clearings into their territories (Machtans 2006), wider (≥ 8 m) corridors may be used as territorial boundaries and crossed less frequently (Bayne et al.

2005), possibly because of increased predation risk (Lima and Dill 1990). Although Bélisle and St. Clair (2001) noted that movement of yellow-rumped warblers was delayed when crossing multiple linear corridors, including a 60 - 100 m wide highways, most individuals (86%) were still able to cross. Effects on movement are assumed to be higher during construction when human activity will be most intense. The Phase 2 Project is not anticipated to have major effects on movements of Cape May warbler or other forest songbirds.

Sandhill crane movement is unlikely to be significantly affected by the Phase 2 Project during either the construction or operations phases. In fact, sandhill cranes are likely to use the reclaimed footprints, which will initially resemble meadows and early seral stands, as sources of forage and possibly movement corridors.

Wildlife Health and Mortality

The primary mechanism through which the Phase 2 Project could affect avian health and mortality is vegetation clearing and consequent destruction of nests. Disturbance will be minimized by clearing vegetation outside of the breeding season and using noise-reducing technology where possible to minimize noise levels.

The Phase 2 Project could also increase predation rates for birds nesting along habitat edges, although evidence for this is limited in western Canada (Schmiegelow and Hannon 1999). Brown-headed cowbird parasitism of songbirds is also believed to be minimal in western boreal forests (Schmiegelow and Hannon 1999). Effects may be greater in areas where forests are surrounded by agriculture (Kremsater and Bunnell 1999). Reproductive potential of songbirds, including the Cape May warbler, is not likely to change with Phase 2. The same is also likely true for the sandhill crane.

Although avian health is not likely to be affected by air emissions or changes in water quality, there is potential for small numbers of birds to be affected by accidental spills or contaminant releases. Accidental spills will be mitigated by restricting refueling activities to areas set away from water bodies and by implementing an effective Emergency Spill Response Plan.

Other potential sources of mortality include hunting/poaching and vehicular collisions, but these are not anticipated to affect Cape May warblers or sandhill cranes. Overall, Phase 2 is expected to have a Low Impact on mortality risk and health of Cape May warblers and sandhill cranes.

Abundance

Project-related changes in abundance were calculated based on the average density of birds in effective habitat as follows: Cape May warbler 0.07 birds/ha (Kirk et al. 1996, 1997) and sandhill crane 0.04 birds/ha (Armbruster 1987). Results indicate that < 0.1% of provincial populations will be affected by the Phase 2 Project (CR #11, Table 3-23), suggesting that regional populations of Cape May warbler or sandhill crane will not be affected by the Phase 2 development. Birds displaced by the Phase 2 Project will likely move into other unoccupied habitats, assuming that populations are not at carrying capacity. Overall, the Phase 2 Project is expected to have a Low Impact on the abundance of Cape May warblers and sandhill cranes.

Planned Development Case

Habitat that would be directly affected by planned development represents a very small proportion of habitat available in the RSA at baseline. For forest interior species that require mature and old-growth habitats, represented in this assessment by the Cape May warbler, habitat loss and fragmentation is expected to reduce the number of effective habitat patches by 6.5% and the total area of effective habitat by 7.1% (Table D.11.2, CR #11, Figure 3-44). By Project closure, forest stands, particularly deciduous-leading, will have matured sufficiently to be used by some mature forest bird species. Therefore, habitat availability may actually increase over time for Cape May warbler even with Project development. The overall effects of planned development on the abundance of the Cape May warbler in the RSA are rated as low. Because of the abundance of suitable habitat in the RSA, the effects of planned development on the sandhill crane are also rated Low.

D.11.3.2 Ungulates

Application Case

Habitat Availability

Availability of effective habitat in the LSA during winter, considered the most restrictive period for ungulates, is predicted to decrease by and 13.9% for moose (Table D.11.2, CR #11, Figure 3-34) and 54.7% for caribou (Table D.11.2, CR #11, Figure 3-35), respectively. The higher habitat loss for caribou reflects the routing of the footprint through mature stands that provide habitat for caribou. Under predicted conditions, 46.0% and 8.3% of the LSA represents effective habitat for moose and caribou, respectively. In the RSA, the Phase 2 Project is predicted to reduce the amount of effective habitat by 1.3% for moose (Table D.11.2.2, CR #11, Figure 3-36) and 0.5% for caribou (Table D.11.2, CR #11, Figure 3-37).

The distribution of effective habitat in the LSA is also anticipated to change with Project development. For moose, Project development will fragment core habitat into smaller patches, with an overall loss of 385.5 ha (18.8%) of core security habitat (Table D.11.4, CR #11, Figure 3-38). Although loss of larger habitat patches could lead to greater energy expenditures for foraging, the areal loss of core habitat is relatively small for moose. The total area of core security habitat (effective habitat outside the disturbance ZOIs) is predicted to decrease by 335.9 ha (59.6%) for caribou, with all of this reduction occurring in 5 – 50 ha patches (Table D.11.5, CR #11, Figure 3-39). This equates to a loss of 32 core habitat patches, all of which are ≤ 50 ha in size. It is anticipated that caribou will be affected by changes in habitat distribution if movement among remaining core patches is altered by Phase 2 because of the loss of 59.6% of their habitat in the LSA.

Reclamation of disturbed areas to natural ecosites will occur progressively throughout the life of the Phase 2 Project. Reclaimed areas will initially resemble open meadows, and will provide effective habitat for moose over the short-term. Increased use of the area by moose may attract wolves, for which moose are the primary prey (Cumming et al. 1996), which in turn, would increase mortality risk for caribou (Athabasca Landscape Team 2009). An important component of the reclamation program is reclaiming linear disturbances as quickly as possible to reverse the effects of habitat fragmentation on woodland caribou.

Phase 2 is expected to have moderate effects on habitat availability for caribou and moose. Caribou appear to be relatively resilient to natural changes in habitat structure (*e.g.,* wildfire; Dalerum et al. 2007), while moose will see almost immediate benefits from progressive reclamation. Most of the habitat loss will occur indirectly through sensory disturbance, although once operations have ceased and the areas have been reclaimed, these habitats will become functional again. For caribou, residual effects associated with the Phase 2 Project footprint will occur for > 40 years after closure because of the preference of this species for forest stands > 50 years old (Dalerum et al. 2007).

Wildlife Movement

The ability of ungulates to access core habitat is believed to be just as important as the availability of such habitat. Permeability of the LSA will be reduced by the Phase 2 Project footprint, particularly by road and utility corridors with adjacent above-ground pipelines. STP will mitigate the barrier effect of above-ground pipelines by increasing the height of the pipeline at regular intervals or by installing ramp-style wildlife crossing structures, which have been found successful for moose (Dunne 2007) and barren-ground caribou (Cronin et al. 1994).

The Phase 2 Project will create an additional 26.1 km of linear features (0.5 km/km^2). Although this by itself is below the thresholds of 1.8 km/km^2 and 1.2 km/km^2 identified for caribou by Francis et al. (2002) and Weclaw and Hudson (2004), combined with existing linear disturbance, the resulting linear disturbance density in the LSA (3.1 km/km^2 excluding LIS lines) will exceed these thresholds for caribou. Although designing and installing effective wildlife crossings at correct locations (*i.e.,* at known wildlife trails or in areas of high quality habitat) will mitigate the barrier effects of above-ground pipelines for caribou and other ungulates, it is expected that the high linear feature density and the overall sensory disturbance profile associated with a SAGD development will cause caribou to alter their natural movement patterns to avoid the development. Because Phase 2 is located along the eastern edge of the WSAR herd range, Phase 2 can be expected to cause a contraction of the herd's range but should not affect movements of caribou through the remainder of the herd's range. In the case of moose, the primary concern is the potential effects of the Phase 2 Project on seasonal movements. In northeastern Alberta, research has shown that moose often undergo seasonal movements of up to 20 km between summer and winter ranges. It is expected that these movements would occur along corridors of suitable habitat, such as the riparian and deciduous stands found along the MacKay River. ASRD has identified portions of the MacKay River valley as key habitat for moose. Consequently, the impacts on movements of both caribou and moose are rated as moderate.

Wildlife Health and Mortality

Increased access could increase the risk of ungulate mortality associated with hunting and poaching, and potentially even predation. STP will also employ an Access Management Plan to control access along Project access roads; therefore, hunting and poaching are not anticipated to be significant factors. Hunting by traditional land-users will not be affected.

Vehicular collisions could result in injury or mortality of ungulates, but can be minimized by controlled traffic speeds, road signage and employee education. There is also potential for increased predation rates with improved access for wolves and bears along seismic lines, and higher numbers of predators attracted to garbage or waste that may be present at the camps and other facilities. STP will mitigate the attraction of wildlife to camps and other facilities by implementing a Waste Management Plan for the Phase 2 Project. STP is also committed to early roll-back and reclamation of linear corridors, which is anticipated to have long-term benefits to caribou (reduction in human and wolf travel in core habitats). Overall, the Phase 2 Project is expected to have a low effect on moose mortality and health while a moderate effect on caribou mortality and health is predicted.

Wildlife Abundance

Changes in habitat availability, movement corridors and mortality risk have the potential to adversely affect ungulate populations in both the LSA and RSA. Effects on the abundance of moose in the region are rated as Low. However, because of their threatened population status, the overall effects of increased mortality risk on caribou abundance are rated as moderate.

Planned Development Case

Woodland Caribou

The most recent population data available for caribou in the WSAR herd indicate that the herd has declined from an estimated 300-400 animals in 2005/2006 to 204-272 animals in 2009 (ASRD and ACA 2010). The reasons for declining caribou populations in the region are complex and are still not completely understood. Although predation is thought to be the primary cause of recent population declines, habitat changes that have resulted from land use development (timber harvesting, petroleum, agriculture, residential and infrastructure) are believed to have contributed to this problem (Athabasca Landscape Team 2009).

Planned Development is expected to reduce caribou core security habitat by 9,479.6 ha and over half (62.4%) of the core security habitat that will be lost involves patches that are larger than 100 ha (CR #11, Table 3-10). While direct habitat losses by planned development in the CRSA are relatively small, there is concern that development of a regional road network, that will include some high volume resource access roads, will reduce habitat connectivity within the WSAR herd range (CR #11, Figure 3-50) and increase mortality risks to the herd due to vehicle collisions and increased hunting and poaching. High traffic roads act as barriers or partial barriers to caribou movement (Dyer et al. 2002). SAGD type oil sands developments also have potential to disrupt movements of caribou and other ungulates because of the need for above-ground pipeline networks to transport steam and bitumen between processing plants and well pads. Recent research on the effectiveness of well-designed, wildlife overpasses appears encouraging, although it is too soon to know how these projects will affect caribou movements and habitat use over the longer term.

At this time, there is considerable uncertainty about the extent to which the WSAR herd uses this portion of its range. Because of its proximity to the edge of the WSAR range, the Phase 2 Project area itself may not represent core habitat for caribou. Although the number of animals affected might be relatively low, the overall cumulative effects on caribou in the CRSA were rated as moderate, reflecting the current status and vulnerability of this herd.

Moose

Moderate impacts on moose are predicted for the Planned Development Case. This is based on expected losses of effective habitat through the construction of processing site, well pads, roads and utility corridors; changes in habitat connectivity as a result of the partial barriers created by roads and above-ground pipelines; and increased hunting and poaching due to improved access. In the case of Phase 2, there is particular concern about loss of important wintering habitat and habitat connectivity along the MacKay River valley.

Although direct habitat losses in the RSA are predicted to be relatively small under the Planned Development scenario, fragmentation effects are expected to cause a measurable change in the availability of effective habitat for moose. Current and future development is expected to cause an 11.0% decrease in the number of patches of core security habitat in the RSA and a 15.0% decrease in the total area of core security habitat (CR #11, Table 3-29, Figure 3-49). Almost one-half (46.4%) of the core security habitat that will be lost involves patches that are larger than 100 ha. Overall impacts on moose under the Planned Development Case are rated as moderate.

D.11.3.3 Aquatic Wildlife

Application Case

Habitat Availability

Potential habitat for beaver is limited to riparian areas within 60 m of watercourses and water bodies, and is therefore, relatively uncommon in the LSA under baseline conditions. The Phase 2 Project is anticipated to result in a maximum direct loss of 27.6 ha (6.2%) of effective habitat (Table D.11.2, CR #11, Figure 3-28). Most of the foraging occurs close to watercourses therefore habitat loss will be mitigated by leaving at least a 50 m buffer around watercourses with defined channels. Beaver typically have low sensitivity to disturbance, and therefore, indirect habitat loss is likely negligible.

Potential habitat for Canadian toad is limited by suitable hibernation areas within 1.4 km of suitable water bodies, such as. The Phase 2 Project is expected to remove 3.5 ha (16.1%) of effective Canadian toad habitat in the LSA (Table D.11.2, CR #11, Figure 3-30).

Habitat loss will be mitigated by leaving at least a 50 m buffer around watercourses with defined channels. Use of these buffers will reduce the amount of habitat lost for Canadian toad and further minimize Project effects. Canadian toad typically have low sensitivity to disturbance, and therefore, indirect habitat loss is likely negligible. Overall, Project effects on habitat availability for beaver and Canadian toad are anticipated to be of low magnitude following mitigation.

Movement

Although beaver typically remain close to their lodge for most of year, kits disperse in spring and travel along streams or through upland areas. Phase 2 will involve the installation of bridges and culverts over watercourses. These crossing structures will be constructed so as to accommodate movement of wildlife, including beaver. Therefore, the Phase 2 Project is expected to have little effect on beaver and Canadian toad movement in the LSA.

Wildlife Health and Mortality

The Phase 2 Project has the potential to cause mortality of beaver and Canadian toad through vehicular collisions along road and utility corridors. Effects of sensory disturbance on beaver are assumed to be negligible, but these disturbances may affect the breeding calls of Canadian toads in the spring. Since beavers and Canadian toads are usually diurnal, artificial night lights from Phase 2 should not be an issue. Contamination of water from accidental spills has the potential to affect beaver and Canadian toad health. However, because emissions are predicted to be too low to contaminate water or vegetation, and spills will be controlled by restricting refueling activities to designated areas away from water courses, effects on health and mortality of these species was rated as Low.

Wildlife Abundance

The Phase 2 Project is not likely to affect beaver or Canadian toad habitat availability, movement, or health and mortality, and therefore, effects on the abundance of beaver or Canadian toad are rated Low.

Planned Development Case

Habitat losses resulting from the Phase 2 Project would affect only a small portion of effective habitat for beaver and Canadian toad in the RSA (Table D.11.2). This amount will be further reduced with the application of riparian buffers (ASRD 2008). Canadian toad effective habitat is less than 1.0% of the total RSA (Table D.11.2) because of their limited breeding and hibernating habitat requirements.

Similarly, effective habitat for beavers represents only 1.3% of the RSA under cumulative conditions because they are limited to riparian areas and prefer deciduous vegetation as forage. Although beaver are known to be common throughout the region, the population status of the Canadian toad is poorly known. Beaver and Canadian toad are considered relatively tolerant of human disturbance therefore additional habitat loss through sensory disturbance is unlikely.

Because cumulative emissions from developments in the RSA are predicted to be too low to contaminate air or water, beaver and Canadian toad health is unlikely to be affected. Overall, cumulative effects on beaver and Canadian toad are considered to be Low.

D.11.3.4 Predators

Application Case

Habitat Availability

Availability of effective habitat in the LSA is predicted to decrease following Project development by 764.0 ha (23.6%) for lynx (Table D.11.2.2). Lynx habitat is common and widespread throughout the LSA, so despite a relatively high degree of interaction with the Phase 2 Project, 43.2% of the LSA should still provide effective foraging habitat during operations (Table D.11.2). Distribution of lynx may be temporarily affected by aspects of the Phase 2 Project, but these effects are expected to be short-term and will likely have no long-term effects on lynx recruitment or reproduction.

Wildlife Movement

Lynx have large home ranges and typically travel five to 15 km/night along traditional routes. Road and utility corridors are not likely to impede lynx movement. With low traffic speeds, lynx movement in the LSA is unlikely to be affected by the Phase 2 Project.

Wildlife Health and Mortality

Increased mortality of predators could result from increased hunting and trapping, vehicular collisions, and vegetation clearing. Since vegetation clearing is scheduled for the winter and will follow the "early-in, early-out" principle, denning animals are unlikely to be disturbed.

It is unlikely that trapping or hunting will increase significantly with the Phase 2 Project since STP will implement an Access Management Plan to control recreational use. Overall, Project effects on lynx mortality and health are expected to be of Low following mitigation.

Wildlife Abundance

Because the Phase 2 Project is anticipated to have relatively minor effects on habitat availability, movement or mortality of lynx, the overall effects on the abundance of this wildlife VEC is rated as Low.

Planned Development Case

A very low proportion of predator habitat will be affected by the Phase 2 Project at the scale of the RSA, with losses of just 1.5% of the effective habitat for lynx (Table D.11.2, CR #11, Figure 3-48). Post-project development, 68.7%, of the RSA will contain effective habitat.

There is no information on the abundance of lynx in the RSA, but trends will likely be similar to those discussed for the LSA. Given the predominance of regenerating forest, lynx are likely abundant (and currently at or near the peak of a population cycle). Planned development is unlikely to have major effects on mortality rates or abundance of lynx.

Overall, cumulative effects on lynx are anticipated to be Low.

D.11.4 Mitigation and Monitoring

D.11.4.1 Mitigation

In order to reduce potential impacts of Phase 2 on wildlife STP will:

- schedule site preparation and construction activities for fall and early winter to avoid disruption of nesting birds, in accordance with the *Migratory Birds Convention Act* (Regulation 12:1). If site clearing cannot be accomplished during this period nest searches will be conducted by a wildlife biologist prior to clearing, and appropriate setbacks distances maintained;

- develop an annual Caribou Protection Plan;
- avoid development on mature and old-growth forest as much as possible to minimize impacts on species dependent on this habitat, including woodland caribou and old-growth forest birds;
- make effort to maintain an effective wildlife movement corridor along the MacKay River valley by prohibiting development within 100 m of the river and where possible minimizing development within 250 m of the river;
- avoid riparian areas and water bodies, where possible, to preserve habitat for amphibians, water birds, and many other species. Vegetated buffers will be retained around watercourses and water bodies to protect the watercourse, allow wildlife movement, and provide habitat for amphibians and water birds;
- implement an Access Management Plan to reduce disturbance of wildlife and minimize the creation of packed snowmobile trails in winter. This Plan will include, but will not be limited to, the following:
- restrict recreational use of snowmobiles and ATVs in the LSA by project employees;
- restrict hunting or harassment of wildlife by Project employees in the LSA; and
- consultation with First Nations to maintain access to the LSA for traditional land uses.
- participate in the Alberta Biodiversity Monitoring Initiative (ABMI) to assist with monitoring regional cumulative effects on biological resources;
- implement a Waste Management Plan to minimize the attraction of bears and other predators to the area, which could increase mortality rates of bears and ungulates, as well as potentially endanger site personnel. STP will adhere to the Best Management Practices for Camps, Fences and Barriers as described in the Bear Smart: Best Management Practices for Camps (ASRD 2004), and ensure waste is stored in secure wildlife-proof containers;
- implement an Emergency Spill Response Plan in the event of accidental spills. Environmental consequences of spills will be minimized by restricting fuel storage and use to designated areas at least 100 m from water bodies and watercourses;
- enforce low speed limits along all access roads, and posting signs at wildlife crossings to minimize vehicle-wildlife collisions. Vehicles will yield to all wildlife crossing access roads;
- place wildlife crossing structures, in locations that maximize the chances of use, to facilitate wildlife movement;

- conduct pre-construction surveys to identify important wildlife areas and trails, to facilitate the correct placement of wildlife crossings;
- mark wildlife crossings to prevent wildlife-vehicular collisions;
- breaks will be placed in the snow piled during road clearing to allow for wildlife crossing;
- become a member of the ACC, and will provide the Committee with any pertinent data collected during the monitoring program;
- reclaim sites progressively as discussed in Part E; and
- identify areas of induced access (winter roads and seismic lines) that are no longer required and initiate reclamation to offset some of the adverse effects on woodland caribou.

D.11.4.2 Monitoring

In order to verify that the mitigation measures have been effective STP will:

- develop a wildlife monitoring program to be put in place during operations and decommissioning phases of the Phase 2 Project.

D.11.5 Summary of VECs

A summary of the significance of potential impacts and effects on wildlife valued environmental components (VECs) for the different assessment cases is provided in Table D.11.6.

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Table D.11.6 Summary of Impact Rating on Wildlife Valued Environmental Components

VEC	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent [1]	Duration [2]	Frequency[3]	Reversability[4]	Magnitude [5]	Project Contribution[6]	Confidence Rating[7]	Probability of Occurrence[8]	Impact Rating[9]
1. Canadian Toad												
	Habitat Availability	see Section D.11.4.1	Application	Local	Extended	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Extended	Continuous	Long-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Movement		Application	Local	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Mortality Risk and Health		Application	Regional	Long	Periodic	Short-term	Low	Negative	Low	Moderate	Low
			Cumulative	Regional	Long	Periodic	Short-term	Low	Negative	Low	Moderate	Low
	Wildlife Abundance		Application	Local	Long	Continuous	Long-term	Low	Negative	High	Low	Low
			Cumulative	Regional	Long	Continuous	Long-term	Low	Negative	Low	Moderate	Low
2. Cape May warbler												
	Habitat Availability	see Section D.11.4.1	Application	Regional	Extended	Continuous	Long-term	Moderate	Negative	High	High	Low
			Cumulative	Regional	Extended	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Low
	Wildlife Movement		Application	Regional	Extended	Continuous	Long-term	Low	Negative	High	Moderate	Low
			Cumulative	Regional	Extended	Continuous	Long-term	Low	Negative	High	Moderate	Low
	Wildlife Mortality Risk and Health		Application	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Abundance		Application	Local	Extended	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Extended	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Low
3. Sandhill crane												
	Habitat Availability	see Section D.11.4.1	Application	Regional	Extended	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Extended	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Movement		Application	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Mortality Risk and Health		Application	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Abundance		Application	Local	Extended	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Extended	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
4. Woodland caribou												
	Habitat Availability	see Section D.11.4.1	Application	Regional	Residual	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
			Cumulative	Regional	Residual	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
	Wildlife Movement		Application	Regional	Long	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
			Cumulative	Regional	Long	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Moderate

Table D.11.6 Summary of Impact Rating on Wildlife Valued Environmental Components

VEC	Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Impact or Effect	Geographical Extent [1]	Duration [2]	Frequency[3]	Reversability[4]	Magnitude [5]	Project Contribution[6]	Confidence Rating[7]	Probability of Occurrence[8]	Impact Rating[9]
	Wildlife Mortality Risk and Health		Application	Regional	Long	Periodic	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
			Cumulative	Regional	Long	Periodic	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
	Wildlife Abundance		Application	Local	Residual	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
			Cumulative	Regional	Residual	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
5. Moose												
	Habitat Availability	see Section D.11.4.1	Application	Regional	Long	Continuous	Short-term	Moderate	Negative	High	High	Moderate
			Cumulative	Regional	Long	Continuous	Short-term	Moderate	Negative	Moderate	Moderate	Moderate
	Wildlife Movement		Application	Regional	Long	Continuous	Short-term	Moderate	Negative	Moderate	Moderate	Moderate
			Cumulative	Regional	Long	Continuous	Short-term	Moderate	Negative	Moderate	Moderate	Moderate
	Wildlife Mortality Risk and Health		Application	Regional	Long	Periodic	Long-term	Moderate	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Periodic	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
	Wildlife Abundance		Application	Local	Long	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Continuous	Long-term	Moderate	Negative	Moderate	Moderate	Moderate
6. Beaver												
	Habitat Availability	see Section D.11.4.1	Application	Local	Long	Continuous	Long-term	Low	Negative	High	Moderate	Low
			Cumulative	Regional	Long	Continuous	Long-term	Low	Negative	High	Moderate	Low
	Wildlife Movement		Application	Local	Long	Continuous	Short-term	Low	Negative	High	Moderate	Low
			Cumulative	Regional	Long	Continuous	Short-term	Low	Negative	High	Moderate	Low
	Wildlife Mortality Risk and Health		Application	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Abundance		Application	Local	Long	Continuous	Short-term	Low	Negative	High	Moderate	Low
			Cumulative	Regional	Long	Continuous	Short-term	Low	Negative	High	Moderate	Low
7. Canada lynx												
	Habitat Availability	see Section D.11.4.1	Application	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Movement		Application	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Mortality Risk and Health		Application	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Periodic	Short-term	Low	Negative	Moderate	Moderate	Low
	Wildlife Abundance		Application	Local	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low
			Cumulative	Regional	Long	Continuous	Short-term	Low	Negative	Moderate	Moderate	Low

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.12 Greenhouse Gas and Climate Change

A greenhouse gas (GHG) is any gas that contributes to potential climate change. Common GHGs include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). GHGs absorb heat radiated by the earth and subsequently warm the atmosphere, leading to what is commonly known as the greenhouse effect. This section has been prepared to discuss the GHGs and climate change potential for Phase 2.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the greenhouse gas and climate change component are provided in Section 2.5 and are as follows:

2.5 Air Emissions Management

[B] Provide emission profiles (type, rate and source) for the Project's operating and construction emissions including point and non-point sources and fugitive emissions.

d) the Project's contribution to total provincial and national greenhouse gas emissions on an annual basis;

e) the Proponent's overall greenhouse gas management plans;

3.1 Air Quality, Climate and Noise

3.1.2 Impact Assessment

[B] Identify stages or elements of the Project that are sensitive to changes or variability in climate parameters, including frequency and severity of extreme weather events and discuss the potential impacts over the life of the Project.

D.12.2 Greenhouse Gas

D.12.2.1 Project GHG Emissions

Table D.12.1 summarizes the annual greenhouse gas (GHG) emissions for Phase 2. The emission estimates of CO_2, CH_4, and N_2O are based on emission factors and estimated fuel consumption rates. At full operation, Phase 2 will generate 1.09 Mt/yr of CO_2e. Additional information on GHG emissions estimations is included in CR #1.

Table D.12.1 Summary of Greenhouse Gas Emissions

Project Phase	Direct Emission Rates				Indirect Emission Rates	Overall Total
	CO_2	CH_4	N_2O	CO_2e[3]	CO_2e[3]	CO_2e[3]
Emission Rates [t/y]						
Construction Phase	38,037	2	16	42,953	n/a[4]	42,953
Operations Phase	1,064,928	607	46	1,091,830	n/a	1,091,830
Reclamation Phase[1]	38,037	2	16	42,953	n/a[4]	42,953
Total Emissions – Project Lifetime [kt]						
Construction Phase	38	2E-03	0.016	43	n/a	43
Operations Phase[2]	26,623	15	1.1	27,296	n/a	27,296
Decommissioning Phase	38	2E-03	0.016	43	n/a	43
Project Total	26,699	15	1.1	27,382	n/a	27,382

(1) Annual direct GHG emission rates are based on 98% plant availability. Total emissions are based on a Project life of 25 years.
(2) SF6 and chlorofluorocarbon emissions were considered negligible.
(3) CO_2e = carbon dioxide equivalent.
(4) Indirect emission rates/ electricity consumption not available.

Table D.12.2 shows the contribution of Phase 2 operations to total 2009 provincial and national GHG emissions on an annual basis.

Table D.12.2 Contribution of Phase 2 to 2009 Provincial and National GHG Emission Inventories During Operations

GHG Emissions	GHG Emissions [Mt CO_2e/year]	% of Alberta Total	% of Canada Total
McKay Phase 2	1.09	0.47%	0.16%
Alberta Total	234[1]		
Canada Total	690[1]		

(1) Source: Environment Canada (2011) National Inventory Report 1990 to 2009: Greenhouse Gas Sources and Sinks in Canada.
Shaded cells indicate that comparisons between inventories not made.

The GHG emission intensity is defined as the amount of GHG emissions generated per barrel of bitumen produced, on an annual average basis. The production profile was unavailable at the time of writing, so the greenhouse gas emission intensity was calculated using the maximum GHG annual production, based on a maximum bitumen production 24,000 bpd for 25 years. At full build-out, the Project is expected to generate 1,092 kt of CO_2e for a theoretical lifetime production of 219 MMbls (million barrels) of bitumen – a GHG operations emission intensity of 125 kg CO_2e per barrel of produced bitumen. This emission intensity is consistent with values ranging from 99 to 176 kg CO_2e/bbl synthetic crude oil (SCO) estimated for in-situ project (Charpentier *et al.*, 2009). It should be noted that the emission intensity factors presented in the Charpentier paper are based on upgraded product. If they were converted to a per barrel of bitumen basis by assuming 85 bbls of SCO is produced per every 100 bbls of bitumen, the range would become 116 to 207 kg CO_2e/bbl bitumen. Thus, the GHG emission intensity for the Project, without accounting for construction/decommissioning and indirect emissions, is near the low end of this range.

D.12.2.2 Greenhouse Gas Management Strategy

STP is committed to environmental stewardship and environmental protection initiatives including energy management and emissions reduction.

In development of the GHG management plan, STP has considered and adopted elements of the national Climate Change Plan for Canada and Alberta's Climate Change Action Plan. And considering the complexity of the climate change issue, the company believes that a flexible management plan is appropriate.

In general, the GHG management options available to STP for the Phase 2 Project fall into four broad categories, although not all may be feasible. These are:

- continuous improvement in technologies (particularly combustion technologies) during the operational phase and particularly in those technologies that promote improved energy efficiency and reduced emissions;
- carbon injection and storage;
- trading of GHG offsets; and
- contribution to the Climate Change and Emissions Management Fund.

At the heart of the approach is the development of an energy conservation team and initiatives tracking system to identify, measure and internally report on opportunities for energy conservation.

<u>Continuous Improvement</u>

On an ongoing basis STP considers opportunities for GHG reductions. The approach to managing GHG emissions includes:

- prepare annual estimates of greenhouse gas emissions as part of regulatory programs in effect;
- use continuous improvement to address direct emissions from facilities under STP's operational control, and specifically to monitor and measure performance, compare

actual performance against the initial design plan and identify gaps and opportunities for further improvement;
- periodically review corporate and project goals for GHG reductions; and
- continue to improve corporate and operational knowledge of technologies that lead to emission reduction, leading edge management policies and other factors.

For Phase 2, a number of initiatives are currently being proposed to reduce emissions. These design and continuous improvement initiatives are consistent with the national Climate Change Plan for Canada and Alberta's Climate Change Action Plan. Design measures to reduce GHG emissions in Phase 2 include:

- optimizing and continuously improving energy efficiency in the design and operation of processes and facilities;
- using natural gas to produce steam, which is the most economical fossil fuel energy source with the lowest GHG emissions;
- using a VRU to reduce the loss of hydrocarbon vapours;
- continuing to refine and improve the efficiency of the thermal recovery process in the reservoir, thereby reducing the SOR and fuel consumption;
- replacing the fleet of vehicles transporting bitumen and diluent in Phase 1 with a pipeline system;
- incorporating cogeneration of steam and electricity at the central plant; and
- monitoring its operations for greenhouse gas leaks and, where feasible, initiating actions to minimize or eliminate identified fugitive emissions.

Other measures may include optimizing piping systems to reduce pumping energy requirements, optimizing motor sizes and insulating piping to conserve energy.

<u>Carbon Injection and Storage</u>

In STP's view, existing carbon capture technologies are not viable for projects the size of Phase 2 with low pressure, low concentration CO_2 emissions. However, STP will continue to monitor ongoing developments in carbon capture technology and evaluate options as they develop.

<u>Offsets</u>

The Alberta Climate Change and Emissions Management Act established offset trading as one of a range of mechanisms for achieving compliance with GHG emission reduction obligations.

Should STP ever be in a position where carbon offsets may be required, it will investigate a number of potential solutions; these could include: investment in technology to increase facility and operational efficiencies, carbon offset purchases and possibly contributions to Alberta's Climate Change and Emissions Management Fund.

D.12.3 Climate Change

This section qualitatively identifies impacts to air quality on all stages of Phase 2, from projected changes in climate factors. Climate change may affect construction, operation, decommissioning, and reclamation stages of the development.

A large number of institutions have developed global climate models (GCM) that address a wide range of potential climate change scenarios based on various global growth and technology implementation approaches (IPCC 2001; Nakicenovic and Swart, 2000). The effect of global warming on climate variables in Alberta have been assessed by the Prairie Adaptation Research Collaborative (PARC) using the Intergovernmental Panel on Climate Change (IPCC) growth scenarios and various international GCMs (Barrow and Yu, 2005).

PARC predictions for Alberta include projections for climate change between the baseline period (1961-1990) and the 2020s, the 2050s, and the 2080s using median GCM/emissions scenarios. Barrow and Yu selected five scenarios for the Alberta model that represented potential climate futures: cooler and wetter, cooler and drier, warmer and wetter, warmer and drier, and the median.

The climate change assessment for Phase 2 included the following elements:

- determine projections for climate parameters during Phase 2 lifetime;
- identify potential effects of climate change on Project stages; and
- identify implications that climate change may have on Phase 2.

The existing and projected changes to the selected climate parameters are provided for the region near Phase 2. The selected parameters are:

- average annual temperature;
- annual precipitation;
- degree days; and
- moisture index (an increase indicates additional moisture stress).

Predicted changes in the 2050s for these parameters near the expected end of the Phase 2 Project lifetime are listed in Table D.12.3.

Table D.12.3 Projected Climate Parameters near Fort McMurray Based on the Median Change Scenario of the Alberta Climate Model (Barrow and Yu, 2005)

Parameter	Baseline Value (1961 – 1990)	Median Prediction, 2050s	Change (%) Baseline to Median
Mean Annual Temperature (°C)	0.1	2.4	0.8
Annual Precipitation (mm)	473	524	11
Degree Days > 5°C	1311	1781	36
Annual Moisture Index	2.7	3.3	22

The most recent assessment undertaken by the Intergovernmental Panel on Climate Change (IPCC, 2007a, b) and prepared after the Barrow and Yu (2005) report concluded that "*warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level*". Based on the updated assessment, Barrow (2009) found little change in the median climate scenarios in northern Saskatchewan compared to the original assessment. A similar conclusion is expected for northeastern Alberta.

D.12.3.1 Construction

For the construction phase of Phase 2, extreme weather conditions may affect fugitive dust emissions and the frequency of windblown dust. However, construction would take place in the near term, when climatic conditions will be similar to today's, the impact is low, duration of the construction phase is short (*i.e.*, less than 2 years), and construction of the access road, central processing facility, and initial pads will occur early in the Phase 2 Project life when potential climate changes are relatively small. Thereafter, there will be periodic, small scale infield road and well pad construction. Dust generation is mitigated by the wet landscape. Any increases in dust can be readily managed with appropriate dust control. Therefore, there will be negligible impact of climate change on construction.

D.12.3.2 Operation

Following are potential climate change impacts on operations:

- an increase in mean temperature will have no impact on the plant, as it is designed for operation in a broad range of temperatures. There may be a small effect on ozone and VOC concentrations, depending on the seasonality of the temperature changes. Biogenic VOC emissions may increase slightly if the temperature increases occur in summer, resulting in slightly higher background concentrations. Increased VOCs could increase ozone formation. In addition, ozone production increases quickly with increased temperature and solar radiation;

- increases in the frequency of extreme temperature will result in an increased frequency of high ozone concentrations, through the temperature/radiation increase and possibly through increases in biogenic emissions;
- increased precipitation may reduce fugitive dust from access and infield roadways and disturbed borrow pits, possibly balanced by additional drying from increased temperature. Mitigation by road watering could adapt to changes as they occur. $PM_{2.5}$ concentrations, which arise largely from combustion, are not expected to change. Fugitive particulate emissions are mitigated by wet ground conditions managed with appropriate dust control; and
- increased precipitation may also affect the ratio between dry and wet deposition, but the magnitude is expected to be low and may only result in a shifting of the location of the predicted deposition pattern. Increased rainfall may increase acid (wet) deposition near the Phase 2 Project and, as a consequence, dry deposition would decrease near the plant. Changes in the frequency of extreme precipitation events would not be expected to change air quality.

D.12.3.3 Decommissioning and Reclamation

For the decommissioning phase of Phase 2, climate change may impact reclamation and re-vegetation activities, potentially increasing fugitive dust emissions at the same time that precipitation is predicted to increase. These impacts are anticipated to be low and can be readily managed with appropriate dust control. Overall, the change in climate will have low to no impact on air quality associated with Phase 2.

D.13 Land and Resource Use

D.13.1 Introduction

STP conducted an assessment of land and resource use within and adjacent to the Phase 2 Project Area. The following section summarizes the land and resource uses that may be impacted by the development of Phase 2. Baseline conditions will be assessed and the level of potential impact determined. Where required, potential mitigation techniques will be implemented.

Alberta Environment issued the ToR for Phase 2 on July 22, 2011. The specific requirements for the greenhouse gas and climate change component are provided in Section 3.10 and are as follows:

3.10 Land Use and Management

3.10.1 Baseline Information

[A] Describe and map the current land uses in the Project Area, including all Crown land and Crown Reservations (Holding Reservation, Protective Notation, Consultative Notation).

[B] Indicate where Crown land dispositions may be needed for roads or other infrastructure for the Project.

[C] Identify and map unique sites or special features in the Project Area and Local Study Area such as Parks and Protected Areas, Heritage Rivers, Historic Sites, Environmentally Significant Areas, culturally significant sites or areas and other designations (World Heritage Sites, Ramsar Sites, Internationally Important Bird Areas, etc).

[D] Describe and map existing Metallic and Industrial Mineral Permits and related surface accesses.

[E] Describe and map land clearing activities, showing the timing of the activities.

[F] Describe the status of timber harvesting arrangements, including species and timing.

[G] Describe existing access control measures.

3.10.2 Impact Assessment

[A] Identify the potential impacts of the Project on land uses, including:

- *a) unique sites or special features;*
- *b) changes in public access arising from linear development, including secondary effects related to increased hunter, angler and other recreational access and facilitated predator movement;*
- *c) aggregate reserves that may be located on land under the Proponent's control and reserves in the region;*
- *d) existing Metallic and Industrial Mineral Permits and related surface accesses. Discuss how these Permits have been considered with project development and how existing surface accesses can be shared.*
- *e) development and reclamation on commercial forest harvesting and fire management in the Project Area;*
- *f) the amount of commercial and non-commercial forest land base that will be disturbed by the Project, including the Timber Productivity Ratings for the Project Area. Compare the baseline and reclaimed percentages and distribution of all forested communities in the Project Area;*
- *g) how the Project impacts Annual Allowable Cuts and quotas within the Forest Management Agreement area;*
- *h) impact (type and extent) to the topography, elevation and drainage pattern within the Project Area; and*
- *i) access control for public, regional recreational activities, aboriginal land use and other land uses during and after development activities.*

[B] Provide a fire control plan highlighting:

- *a) measures taken to ensure continued access for firefighters to adjacent wildland areas;*

b) forest fire prevention, detection, reporting, and suppression measures, including proposed fire equipment;
c) measures for determining the clearing width of power line rights-of-way; and
d) required mitigative measures for areas adjacent to the Project Area based on the FireSmart Wildfire Assessment System.

[C] Discuss mitigation strategies to minimize the potential impact of the Project on land uses.

The LSA for land and resource use includes those lands that could be impacted by the Phase 2 surface and subsurface development and is shown in Figure C.2.2.

The land and resource use VECs include:

- oil sands leases;
- petroleum and natural gas licences;
- metallic and industrial mineral leases;
- forestry resources;
- public lands surface dispositions;
- sand and gravel resources;
- infrastructure;
- trapping resources;
- fishing resources; and
- hunting resources.

The lands within the LSA are administered by Alberta Sustainable Resource Development (SRD). The Phase 2 development is located within the Regional Municipality of Wood Buffalo in the Athabasca Oil Sands region. The Phase 2 Project is located outside the boundaries of existing sub-regional integrated resource plans (IRP). Portions of the West Side Athabasca River caribou range and a key moose zone are found within the Phase 2 Project Area (Figure A.1.1). These resource management initiatives were taken into consideration when assessing the potential impacts to wildlife (Section D.11 and CR #11).

D.13.2 Baseline Conditions

Baseline data collection included a search for surface public land and crown mineral dispositions and activities found on Alberta Energy's Land Status Automated System. The subsurface and surface dispositions found within the LSA are shown on Figure D.13.1 and D.13.2.

Additional baseline information has been obtained through a review of the results of STPs public consultation program and environmental reports completed as part of the EIA.

D.13.2.1 Oil Sands Leases

The study area contains seven Oil Sands Leases (Figure D.13.1, Table D.13.1).

Table D.13.1 Oil Sands Leases

Disposition	Disposition Holder	Location
OSL 0747406080067	Grizzly Oil Sands ULC	06-091-14-W4M 01-091-15 W4M
OSL 0747406080068	MacKay Operating Corp.	03, and 05-091-14-W4M
OSL 0747407010571	CNPC International (Canada) Ltd.	28, and 29-091-14-W4M
OSL 0747407030888	Southern Pacific Resource Corp.	07, 08, 09, 10, 15, 16, 17, and 18-091-14-W4M
OSL 0747407050222	Southern Pacific Resource Corp.	25, 26, 27, 34, 35, and 36-091-14-W4M
OSL 0747407070554	Marathon Oil Canada Corporation	20-091-14-W4M
OSL 0747407080270	Southern Pacific Resource Corp.	21, and 22-091-14-W4M

D.13.2.2 Petroleum and Natural Gas Licences

The LSA has one Petroleum and Natural Gas Licence (Figure D.13.1, Table D.13.2). Licences are managed by Alberta Department of Energy, Mineral Development and Strategic Resources, and do not expire.

Table D.13.2 Petroleum and Natural Gas Licences

Disposition	Disposition Holder	Location
PNG 0545495110071	Perpetual Energy Operating Corp.	15, 16, 21, 22, 26, 27, 34, and 35-091-14-W4M

D.13.2.3 Metallic and Industrial Mineral Development

There are two Metallic and Industrial Mineral (MIM) permits (Figure D.13.1, Table D.13.3) within the study area. These dispositions are on Crown land and are administered by the Government of Alberta.

Table D.13.3 Metallic and Industrial Mineral Permits

Disposition	Disposition Holder	Location
MIM 0939302050136	977554 ALBERTA LTD.	16, 17, 18, 20, and 21- 091-14-W4M
MIM 0939306011170	Geolink Exploration Ltd.	01, and 12-091-15-W4M

D.13.2.4 Forestry Resources

The entire LSA is located in a Forestry Management Agreement area held by Alberta Pacific Forest Industries Inc. (Al-Pac) (Figure D.13.2, Table D.13.4).

Table D.13.4 Timber Allocations

Disposition	Disposition Holder	Location
FMA 9100029	Alberta Pacific Forest Industries Inc.	Township 091-13-W4M Township 091-14-W4M Section 01 and 12-091-15-W4M

D.13.2.5 Public Lands Surface Leases

Exploration and delineation of minerals has been performed through the drilling of exploration wells in the area. Within the study area, there are nine Mineral Surface Lease (MSL) dispositions. In addition, there are nine Miscellaneous Lease (MLL) dispositions and one Pipeline Agreement (PLA) disposition. One MSL is held by Perpetual Energy Operating Corp. and the remainder are STP dispositions. All public lands dispositions are listed in Table D.13.5 and shown in Figure D.13.2.

Table D.13.5 Public Lands Dispositions

Disposition	Disposition Holder	Description	Location
MSL 960129	Perpetual Energy Operating Corp.	Wellsite	NW-15-091-14 W4M
MSL 110538	Southern Pacific Resource Corp.	Wellsite	NE-18-091-14 W4M
MSL 110537	Southern Pacific Resource Corp.	Wellsite	NW-18-091-14 W4M
MSL 110535	Southern Pacific Resource Corp.	Wellsite	SW-18-091-14 W4M
MSL 110534	Southern Pacific Resource Corp.	Wellsite	SE-18-091-14 W4M
MSL 110532	Southern Pacific Resource Corp.	Wellsite	SW-18-091-14 W4M
MSL 110531	Southern Pacific Resource Corp.	Wellsite	SE-18-091-14 W4M
MSL 100930	Southern Pacific Resource Corp.	Wellsite Pad Site	N-7-091-14 W4M NW-8-091-14 W4M NE-12-091-15 W4M
MSL 072454	Southern Pacific Resource Corp.	Wellsite Remote/Off Lease Sump	NE-17-091-14 W4M
MLL 110013	Southern Pacific Resource Corp.	Water Well	NE-8-091-14 W4M
MLL 110010	Southern Pacific Resource Corp.	Water Well	NE-8-091-14 W4M
MLL 100064	Southern Pacific Resource Corp.	Plant Site	N-7-091-14 W4M
MLL 100063	Southern Pacific Resource Corp.	Industrial Campsite Access Road	N-7-091-14 W4M SW-7-091-14 W4M

Table D.13.5 Public Lands Dispositions			
Disposition	**Disposition Holder**	**Description**	**Location**
MLL 100062	Southern Pacific Resource Corp.	Industrial Campsite Laydown Area	NE-7-091-14 W4M
MLL 090117	Southern Pacific Resource Corp.	Industrial Campsite Access Road Laydown	SE-9-091-14 W4M
MLL 080232	Southern Pacific Resource Corp.	Water Well	NE-8-091-14 W4M
MLL 080230	Southern Pacific Resource Corp.	Water Well	SE-8-091-14 W4M
MLL 080228	Southern Pacific Resource Corp.	Water Well	SW-8-091-14 W4M
PLA 100696	Southern Pacific Resource Corp.	Pipeline	NE-3-091-14 W4M NE-7-091-14 W4M N-8-091-14 W4M N-9-091-14 W4M NW-10-091-14 W4M S-10-091-14 W4M

D.13.2.6 Sand and Gravel Resources

There is one Surface Material Lease (SML) disposition for sand and gravel located within the LSA. There is also one Surface Material Licence (SMC), and two Surface Material Exploration (SME) dispositions (Figure D.13.2, Table D.13.6).

Table D.13.6 Public Lands Dispositions			
Disposition	**Disposition Holder**	**Description**	**Location**
SML 100073	Southern Pacific Resource Corp.	Sand and Gravel Non-Manufacturing Clay	N-7-091-14 W4M NW-8-091-14 W4M NE-12-091-15 W4M
SMC 100027	Southern Pacific Resource Corp.	Non-Manufacturing Clay Sand and Gravel	NE-9-091-14 W4M
SME 090088	Mincon International Ltd./Mincon International Ltee	Exploration	SE-25-091-14 W4M
SME 090244	1447537 Alberta Ltd.	Exploration	NE-25-091-14 W4M SE-36-091-14 W4M

D.13.2.7 Infrastructure

Power Transmission Lines

There are two dispositions for high voltage transmission lines and two for communication cables within the LSA (Figure D.13.2, Table D.13.7).

Table D.13.7 Easements

Disposition	Disposition Holder	Description	Location
EZE 100117	Southern Pacific Resource Corp.	Powerline	N-8-091-14 W4M SE-8-091-14 W4M
EZE 100121	Southern Pacific Resource Corp.	Communications Cable	N-8-091-14 W4M SE-8-091-14 W4M N-9-091-14 W4M NW-10-091-14 W4M S-10-091-14 W4M
EZE 110046	Southern Pacific Resource Corp.	Communications Cable	NE-8-091-14 W4M
EZE 110053	Southern Pacific Resource Corp.	Powerline	NE-8-091-14 W4M

Roads

There are twenty Licence of Occupation (LOC) dispositions within the study area. These are listed in Table D.13.8 and shown in Figure D.13.2.

Table D.13.8 Licenses of Occupations

Disposition	Disposition Holder	Description	Location
LOC 050102	Perpetual Energy Operating Corp.	Access Road	N-15-091-14 W4M SE-22-091-14 W4M
LOC 082141	Athabasca Oil Sands Corp.	Access Road	E-9-091-14 W4M W-15-091-14 W4M SE-16-091-14 W4M
LOC 082562	Southern Pacific Resource Corp.	Access Road	NW-9-091-14 W4M W-16-091-14 W4M
LOC 082564	Southern Pacific Resource Corp.	Access Road	E-8-091-14 W4M
LOC 082566	Southern Pacific Resource Corp.	Access Road	S-8-091-14 W4M
LOC 091171	Southern Pacific Resource Corp.	Other Industrial Monitoring Sites	N-7-091-14 W4M
LOC 100630	Southern Pacific Resource Corp.	Access Road	NW-8-091-14 W4M W-17-091-14 W4M
LOC 100632	Southern Pacific Resource Corp.	Water Pipeline Source Water Pipeline	NE-7-091-14 W4M E-8-091-14 W4M NW-8-091-14 W4M
LOC 100634	Southern Pacific Resource Corp.	Access Road	NE-3-091-14 W4M N-8-091-14 W4M N-9-091-14 W4M7 NW-10-091-14 W4M S-10-091-14 W4M

Table D.13.8 Licenses of Occupations

Disposition	Disposition Holder	Description	Location
LOC 110114	Southern Pacific Resource Corp.	Access Road Coal/Oil San/Qrry/Hea Oil	NE-8-091-14 W4M
LOC 110201	Southern Pacific Resource Corp.	Water Pipeline	NE-8-091-14 W4M
LOC 110514	Southern Pacific Resource Corp.	Access Road Coal/Oil San/Qrry/Hea Oil	NE-7-091-14 W4M SE-18-091-14 W4M
LOC 110515	Southern Pacific Resource Corp.	Access Road Coal/Oil San/Qrry/Hea Oil	S-18-091-14 W4M
LOC 110517	Southern Pacific Resource Corp.	Access Road Coal/Oil San/Qrry/Hea Oil	SE-18-091-14 W4M
LOC 110518	Southern Pacific Resource Corp.	Access Road Coal/Oil San/Qrry/Hea Oil	S-18-091-14 W4M
LOC 110520	Southern Pacific Resource Corp.	Access Road Coal/Oil San/Qrry/Hea Oil	NW-18-091-14 W4M
LOC 110521	Southern Pacific Resource Corp.	Access Road Coal/Oil San/Qrry/Hea Oil	NW-17-091-14 W4M NE-18-091-14 W4M
LOC 110550	Southern Pacific Resource Corp.	Drainage and Irrigation Drainage Ditch	N-7-091-14 W4M NW-8-091-14 W4M
LOC 811146	Perpetual Energy Operating Corp.	Access Road	W-12-091-15 W4M
LOC 931259	Perpetual Energy Operating Corp.	Access Road	N-15-091-14 W4M N-16-091-14 W4M SW-16-091-14 W4M N-17-091-14 W4M N-18-091-14 W4M

Area Operations Agreement

Perpetual Energy Operating Corp. holds an Area Operations Agreement (AOA 060028) with Alberta Sustainable Resource Development (ASRD) covering Township 91-14 W4M and Township 91-15 W4M.

Water Source Facilities

STP has two water source wells that were drilled at LSD 8 and 16 of Section 8, Township 94, Range 14 W4M which are located on MLL080230 and MLL080232. Since the date the LSAS search was conducted STP has installed another well in the same area. One future well is also planned in the same Section in order to meet the water needs of the Project.

D.13.2.8 Trappers

There are two Trapping Area (TPA) dispositions within the study area, which are listed in Table D.13.9 and shown in Figure D.13.2.

Table D.13.9 Trapping Areas

Disposition	Location
TPA 2894	Township 91-13 W4M Township 91-14 W4M
TPA 2900	Township 91-15 W4M

D.13.2.9 Fishing

The watercourses in the Phase 2 Project Area contain primarily small-bodied fish species or juvenile life stages of large-bodied and sportfish species. Therefore, it is also expected that fishing pressure will be low given Phase 2 is in an area primarily consisting of lower-order streams with few sportfish species reaching length-classes that meet SRD regulations for catch limits.

D.13.2.10 Hunting

Phase 2 is located in the Fort McMurray Fish and Wildlife District where moose and black bear are the primary species hunted.

D.13.2.11 Other

There are eight Temporary Field Authorization (TFA) dispositions and one Miscellaneous Permit (MLP) disposition (Table D.13.10) within the study area (Figure D.13.2).

Table D.13.10 Licenses of Occupations

Disposition	Disposition Holder	Description	Location
MLP 080067	Grizzly Oil Sands ULC	Industrial Campsite Access Road	SW-12-091-15 W4M
TFA 071276	Perpetual Energy Operating Corp.	Land Spraying	W-12-091-15 W4M
TFA 084035	Southern Pacific Resource Corp.	Sump Site	NE-17-091-14 W4M
TFA 091363	Southern Pacific Resource Corp.	Pump-Off Disposal Method	E-8-091-14 W4M
TFA 092339	Southern Pacific Resource Corp.	Pump-Off Disposal Method	NE-17-091-14 W4M
TFA 092340	Southern Pacific Resource Corp.	Pump-Off Disposal Method	NE-17-091-14 W4M
TFA 092360	Southern Pacific Resource Corp.	Pump-Off Disposal Method	NE-17-091-14 W4M
TFA 111978	Southern Pacific Resource Corp.	Additional Activity	SE-28-091-14 W4M
TFA 112460	Southern Pacific Resource Corp.	Additional Activity	NE-7-091-14 W4M NW-8-091-14 W4M

D.13.3 Predicted Conditions

The following section outlines the potential impacts of Phase 2 on land and resource use.

D.13.3.1 Oil Sands Leases

A portion of the Phase 2 surface development is located over oil sands leases held by Grizzly Oil Sands ULC and MacKay Operating Corp. The Phase 2 development will not impact the oil resources held by either of these companies. STP is currently working with both Grizzly Oil Sands ULC and MacKay Operating Corp. to minimize the potential impacts of Phase 2 on the development of the adjacent oil sands leases.

D.13.3.2 Petroleum and Natural Gas Licences

There is one petroleum and natural gas licence within the LSA that is held by Perpetual Energy Operating Corp. (Perpetual). Based on the information included in Section B.3.5 STP believes that the McMurray Formation is not capable of commercial gas production on the Perpetual licence area and therefore the Phase 2 Project should not have an impact on P&NG rights.

D.13.3.3 Metallic and Industrial Mineral Development

Two MIM permits are located within the study area. One is held by 977554 Alberta Ltd and another by Geolink Exploration Ltd. As required in accordance with the Public Lands Act, STP will notify these companies prior to applying to SRD for the surface dispositions required for the Phase 2 facilities.

D.13.3.4 Forestry

The LSA is located completely within the Al-Pac FMA. Trees will be cleared in order to develop Phase 2 facilities. Timing of tree clearing will be consistent with the development schedule discussed in Section A.3 and Section B.3.3.

STP will work with Al-Pac to ensure that any merchantable timber located within the study area is salvaged and made available to the operator. An assessment of potential impacts to forestry resources and the proposed mitigation measures is included in Section D.10.

D.13.3.5 Public Lands Surface Leases

STP will be required to apply to SRD for the surface dispositions required for the individual development components associated with Phase 2 as shown on Figure A.1.3.

STP will continue to consult with all other disposition holders in the Phase 2 Project Area. STP will initiate discussions to ensure that lease development activities will address potential conflicts.

D.13.3.6 Sand and Gravel

There are currently four dispositions related to sand and gravel dispositions within the Phase 2 Project Area two of which are held by STP. The other dispositions are for exploration activities. If exploration results in identification of a sand and gravel resource STP will consult with the sand and gravel developers in order to minimize potential resource conflicts.

D.13.3.7 Infrastructure

Several LOCs are held by Perpetual Energy Operating Corp and Athabasca Oil Sands Corp for winter access roads throughout the study area. STP will continue to consult with these holders of LOC dispositions within the study area.

D.13.3.8 Trappers

TPA holders 2894 and 2900 have trapping agreements within the study area and may be affected by the development of Phase 2. STP has conducted notification and consultation with these agreement holders and will continue to consult with them in the future in order to minimize the effect of Phase 2 on the trapping resource. STP will also work with the trappers to allow access onto lands that are not being developed by Phase 2.

D.13.3.9 Fishing

Sportfish, primarily walleye and northern pike, have a low probability of capture in most streams with the exception of the MacKay River. The MacKay River can be expected to have a much higher probability of all types of fish and much more diverse species assemblage than the lower order streams that flow into this river. While many fish populations in the RSA, particularly the MacKay River, are sensitive to angling pressure, and while the workforce may potentially catch additional fish, it is expected that the mitigation and management measures proposed in Section D.2.4 will mean that these effects of increased angling on LSA fish populations will be Low.

D.13.3.10 Hunting

STP will control access in the vicinity of direct disturbance and also restrict hunting activity in that area. STP will work closely with ASRD to ensure the wildlife resources in and around the Phase 2 Project Area do not become over-exploited as a result of increased access created by Phase 2.

D.13.3.11 Other

TFA permit holder, Perpetual Energy Operating Corp, will be consulted as appropriate. STP will also work closely with Grizzly Oil Sands ULC, who possesses an MLP within the study area.

D.13.4 Mitigation and Monitoring

D.13.4.1 Mitigation

In order to mitigate potential impacts to land and resource users STP will:

- apply to SRD for surface dispositions required to support Phase 2;
- notify other industrial users of development plans that have potential to impact other resource development;
- continue with existing Trappers Compensation Program;
- development and implementation of an annual fire control plan based upon ASRD's *Firesmart Guidebook for the Oil and Gas Industry* (2008). The fire control plan, when deemed to be required, will:
- provide contact information for STPs McKay Thermal Project, adjacent industrial partners, and community and provincial fire response;
- specify fuel types and fire risk levels;
- list permanent and temporary worksites that are occupied during fire season, providing type of worksite and maximum number of workers;

- specify firefighting equipment and its location, as required for the worksite/activity as per the *Forest and Prairie Protection Act;*
- specify location of any exterior sprinkler systems and/or water reservoirs;
- specify location and type of any industrial hazards not typical to a thermal project;
- provide a map of evacuation/access routes and evacuation staging areas;
- specify specific mitigation requirements, including clearing/thinning requirements; and
- require that all contractors be given orientation on the fire control plan.

D.13.4.2 Monitoring

No additional monitoring specific to land resource use is required.

D.13.4 Summary

A summary of the significance of potential impacts and effects on land and resource use valued environmental components (VECs) for the different assessment cases is provided in Table D.13.11.

Table D.13.11 Summary of Impact Rating on Land and Resource Use Valued Environmental Components

Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent(1)	Duration(2)	Frequency(3)	Reversibility(4)	Magnitude(5)	Project Contribution(6)	Confidence Rating(7)	Probability of Occurrence(8)	Impact Rating(9)
1. Oil sands leases											
	see Section D.14.3.1	Application	Local	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
2. Petroleum and natural gas licences											
	see Section D.14.3.1	Application	Local	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
3. Metallic and industrial mineral leases											
	see Section D.14.3.1	Application	Local	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
4. Forestry resources											
	see Section D.14.3.1	Application	Local	Extended	Continuous	Reversible – long term	Moderate	Negative	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Extended	Continuous	Reversible – long term	Moderate	Negative	High	High	Low
5. Public lands surface dispositions											
	see Section D.14.3.1	Application	Local	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
6. Sand and gravel resources											
	see Section D.14.3.1	Application	Local	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
7. Public infrastructure											
	see Section D.14.3.1	Application	Local	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Long	Continuous	Reversible – short term	Low	Neutral	High	High	Low

Table D.13.11 Summary of Impact Rating on Land and Resource Use Valued Environmental Components

Nature of Potential Impact or Effect	Mitigation/ Protection Plan	Type of Effect	Geographic Extent(1)	Duration(2)	Frequency(3)	Reversibility(4)	Magnitude(5)	Project Contribution(6)	Confidence Rating(7)	Probability of Occurrence(8)	Impact Rating(9)
8.Ttrapping resources											
	see Section D.14.3.1	Application	Local	Extended	Continuous	Reversible – long term	Moderate	Negative	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Extended	Continuous	Reversible – long term	Moderate	Negative	High	High	Low
9. Fishing resources											
	see Section D.14.3.1	Application	Local	Long	Continuous	Reversible – long term	Low	Negative	High	Medium	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Long	Continuous	Reversible – long term	Low	Negative	High	Medium	Low
10. Hunting resources											
	see Section D.14.3.1	Application	Local	Extended	Continuous	Reversible – long term	Moderate	Negative	High	High	Low
	see Section D.14.3.1	Cumulative Effects	Regional	Extended	Continuous	Reversible – long term	Moderate	Negative	High	High	Low

(1) Local, Regional, Provincial, National, Global
(2) Short, Long, Extended, Residual
(3) Continuous, Isolated, Periodic, Occasional (Accidental, Seasonal)
(4) Reversible in short term, Reversible in long term, Irreversible – rare
(5) Nil, Low, Moderate, High
(6) Neutral, Positive, Negative
(7) Low, Moderate, High
(8) Low, Medium, High
(9) No Impact, Low Impact, Moderate Impact, High Impact

D.14 CONSTRAINTS MAPPING

Constraints mapping is an approach used by SAGD operators in the Fort McMurray oil sands region to identify potential areas of sensitivity related to project development. Typically as part of the application process, companies collect baseline information for all the major environmental disciplines. This is where the areas of sensitivity are identified. Constraints mapping is the formalized method of bringing all these sensitivities together on a single map. STP has provided a constraints map (Figure D.14.1) that consolidates the environmental, social, cultural and resource development areas of sensitivity.

The total footprint of Phase 2 encompasses approximately 488.3 ha of surface disturbance in the Phase 2 Project Area. The proposed footprint for these activities forms the basis of the constraints mapping exercise.

D.14.1 Approach

STP identified the environmental and social sensitivities along with resource development requirements early in the Phase 2 Project design. Early planning activities were able to minimize environmental impacts and maximize resource recovery. Most of this was done well in advance of the formal constraints mapping exercise. The key components of this approach include:

- collecting comprehensive environmental and cultural information from within the study area;
- defining and mapping the environmental constraints;
- addressing each constraint "individually or in conjunction with others" if overlap occurred, rather than provide a weighted ranking. Overlapping constraints were evaluated to determine the impacts on one or all, if the disturbance occurred; and
- demonstrating that planning and design considered the constraints while optimizing resource recovery.

If a constraint was identified within the study area, the first action would be avoidance and subsequent actions would be minimizing the impact with appropriate mitigation and monitoring. The constraints mapping approach assists to validate the environmental assessment conclusions including focused mitigation and monitoring programs to neutralize effects.

D.14.2 Constraints Criteria – Environmental Considerations

Constraints were identified as environmental, social or cultural sensitivities that exist within the study area (Table D.14.1) as identified by the various Consultant Reports that support the application. Constraints that were non-spatial in nature were not included in this exercise since they cannot be mapped.

D.14.2.1 Aquatic Resources

The aquatic resource assessment for Phase 2 is included in CR #2 and summarized in Section D.2. Potential impacts to surface water quality and fisheries resources occur primarily from the introduction of foreign substances into the water courses. Substances of concern would be the introduction of suspended solids through surface runoff or the introduction of contaminants due to product spills. The maintenance of a minimum 100 m buffer on the MacKay River and 50 m buffer on all other watercourses should provide sufficient watershed protection along with erosion control measures, including revegetation activities. Spill prevention and emergency response plans mitigate the product spill potential.

<u>Mapping Constraint</u>

- minimum 100 m buffer on the MacKay River and 50 m buffer on all other watercourses.

D.14.2.2 Hydrology

The hydrology assessment for Phase 2 is included in CR #6 and summarized in Section D.6. The main area of concern related to hydrology that was considered as a constraint is the potential for surface runoff/sedimentation. The identification of a 100 m buffer along the MacKay River and 50 m buffer along all other watercourses should be sufficient protection from surface runoff and the resulting sedimentation.

<u>Mapping Constraint</u>

- minimum 100 m buffer on the MacKay River and 50 m buffer on all other watercourses.

D.14.2.3 Vegetation and Wetlands

The vegetation and wetlands assessment for Phase 2 is included in CR #10 and summarized in Section D.10. There are five potential constraints related to vegetation and wetlands:

- uncommon or sensitive ecosites;
- uncommon or sensitive wetlands;
- riparian areas;
- rare plants or communities; and
- old growth forests.

A target of retaining 1% of the ecosites with limited distribution within the study area is the objective in an attempt to ensure the sustainability of sensitive ecosite and wetland areas. If this target cannot be achieved through avoidance, then the appropriate mitigation measures must be implemented. Eight ecosites of limited distribution were found in the study area:

- b1 - blueberry / jack pine-aspen;
- b4 - blueberry white spruce-jack pine;
- c1 - Labrador tea – mesic / jack pine-black spruce;
- e1 - dogwood / balsam poplar-aspen;
- f1 - horsetail / balsam poplar-aspen; and
- l1 – marsh.

All but one of these ecosites (f1) are found within the Phase 2 footprint. The Phase 2 footprint will result in the removal of 2.4% of the LSA limited distribution ecosite phases (12.1 ha). None of the ecosite phases of limited distribution will be completely removed from the LSA, and a proportion of each are expected to be re-established during reclamation (Section E.6.4). No mitigation other than revegetation to similar ecosites during reclamation and minimization of the Phase 2 footprint where possible is recommended.

There are five wetland types of limited distribution found within the study area:

- BTXC - wooded bogs with permafrost & collapsed scar;
- MONG - marsh, open, non-patterned, graminoid cover;
- SFNN - swamps forested;
- STNN - swamps wooded; and
- WONN - open water.

None of these wetlands of limited distribution are found within the Initial Development footprint. A very small portion of STNN, WONN and MONG are found within the Future Development Footprint. None of the AWIS wetland types of limited distribution in the LSA (10.7 ha) will be completely removed from the LSA.

Two rare plant observances were made within the Phase 2 footprint; both were lichens (*Cladina stygia*, which has a S2 rank, and *Usnea scabiosa* which has a S1S2 rank). Rare plant occurrences are identified on the constraints map for reference purposes only as mitigation for disturbance of these species is not required as stated in Section D.10.3.3.

There was one tracked (rare) ecological community found in the LSA (*Populus tremuloides/Rosa acicularis/Apocynum androsaemifolium).* Phase 2 is not expected to result in the removal of the rare plant community observed within the LSA given the plant community is not located in the vicinity of the Phase 2 footprint.

Several stands of old growth forest are found in the Study area with approximately 2.8 ha within the Phase 2 footprint. However, because of the small area of old growth that is to be disturbed, the removal of these stands for the construction of Phase 2 is not considered significant and no mitigation beyond revegetation during reclamation is recommended.

Mapping Constraints

- uncommon ecosites - none recommended;
- uncommon wetlands – none recommended;
- riparian areas - maintain a 100 m buffer on the MacKay River and 50 m buffer on all other watercourses;
- rare plants – none recommended; and
- old growth forest – no mapping constraints recommended.

D.14.2.4 Soils and Terrain

The soil and terrain assessment for Phase 2 is included in CR #9 and summarized in Section D.9. There are three main constraints for soils and terrain which include:

- riparian areas;
- sensitive soils (*i.e.*, soil with poor reclamation suitability); and
- steep slopes which may be prone to erosion or slumping.

Maintenance of a 100 m buffer on the MacKay River and 50 m buffer on all other watercourses will protect the riparian areas. One soil unit has been identified as sensitive due to coarse soil material. No soil unit with poor reclamation suitability was identified, however, one soil unit (ZUN18/I3h) with moderate to high erosion risk was identified as a result of coarse textured soil and relatively steep slopes.

Mapping Constraints

- riparian areas maintain a 100 m buffer on the MacKay River and 50 m buffer on all other watercourses;
- sensitive soils – none identified in study area; and
- steep slopes that have moderate to high erosion potential – the ZUN18/I3h Map Unit.

D.14.2.5 Wildlife

The wildlife assessment for Phase 2 is included in CR #11 and summarized in Section D.11. The wildlife discipline is one which is difficult to spatially reference. In an attempt to include this in the constraints mapping process, STP has chosen to focus on the wildlife habitat for sensitive species. STP has identified riparian areas as a potential constraint as it adds high quality habitat for a number of species. A 100 m buffer on the MacKay River and 50 m buffer on all other watercourses will account for this and other values such as water quality and hydrology.

Mapping Constraint

- 100 m buffer on the MacKay River and 50 m buffer on all other watercourses.

4.12.2.6 Historical Resources

A historical resource assessment for Phase 2 has been conducted and the results are summarized in Section D.4. The historical resource assessment included a file search of available literature and development of an archaeological potential model. Constraints include areas of known historical significance and areas of moderate and high archaeological potential. Any known sites to be identified will have a 50 m buffer put in place to ensure protection. Areas that have not been investigated and that have a moderate to high probability of occurrence will be identified and protected. For areas that have not been investigated and fall into a low potential for occurrence no further action is required.

Mapping Constraint

- 50 m buffer around known archaeological sites – none identified in the study area; and
- areas of moderate and high archaeological potential.

Table D.14.1 Environmental and Resource Utilization Constraints

Constraint	Identifier
Surface Water Quality	
Watercourses with defined channel	100 m buffer on the MacKay River and 50 m buffer on all other watercourses
Hydrology	
Watercourses with defined channel	100 m buffer on the MacKay River and 50 m buffer on all other watercourses
Vegetation	
Riparian areas	100 m buffer on the MacKay River and 50 m buffer on all other watercourses
Old Growth Forest	Area of Old Growth identified within study area
Ecosites of Limited Distribution (<1% of study area)	Eight types found within study area

Table D.14.1 Environmental and Resource Utilization Constraints

Constraint	Identifier
Rare Plants	Eight species found within study area
Wetlands of Limited Distribution (<1% of study area)	Five types found within study area
Soil Resources	
Soils with poor reclamation suitability	None identified
Riparian areas	100 m buffer on the MacKay River and 50 m buffer on all other watercourses
Steep slopes that have moderate to high erosion potential	ZUN18/I3h map unit
Wildlife	
Habitat – riparian areas	100 m buffer on the MacKay River and 50 m buffer on all other watercourses
Historical Resources	
Identified historical sites	None identified
Potential areas of high or moderate potential for occurrence	Areas of moderate and high potential within study area
Resource Utilization	
Developable Bitumen	14 m Net Process Pay Isopach

D.14.3 Constraints Criteria – Resource Considerations

D.14.3.1 Resource Utilization and Bitumen Recovery

A key consideration during the site selection process is the maximization of resource utilization. The prime target of the SAGD bitumen reservoir development in the study area is shown on Figure D.14.1. The bitumen reservoir that STP is proposing to develop is irregularly shaped and as such provides some challenges to resource optimization. In many cases there is only minor flexibility with respect to placement of the well pads locations; shifting of locations in any significant way could lead to the stranding of resources

Prior to finalizing the location of any SAGD components STP attempted to balance constraint avoidance with resource recovery. Consideration was given to a number of options that attempted to maximize the bitumen reservoir while avoiding socially and environmentally sensitive areas.

D.14.3.2 Project Costs

The capital and operating costs of the Project are always an important consideration and factor significantly into siting the SAGD development footprint. Each of the major project components had to be considered from a logistical, operational and cost perspective throughout the life of the Project:

- construction;
- drilling;
- operations;
- decommissioning; and
- reclamation.

D.14.3.3 Footprint

Another major consideration is the selection of the most advantageous access corridor; one that satisfies the resource recovery needs and minimizes impacts to identified constraints, while at the same time allowing for flexibility with respect to future development plans. Three major access corridor considerations are:

- minimizing conflict with respect to resource recovery;
- utilization of common access corridors wherever possible; and
- minimizing the requirements for new vegetation clearing.

D.14.4 Constraints Evaluation

The design and placement of Project facilities must also take into account opportunities for sharing of infrastructure with future developments. A simple rating system was developed to address the non-environmental based criteria. Each of the Initial Development components were rated based on how the proposed location achieves the resource utilization and bitumen recovery, project cost and footprint criteria. Four categories were developed to assist in determining the final site selection:

0. No Activity
1. Fair
2. Good
3. Best

The rating system used for each of the major environmental disciplines was presence or absence. Table D.14.2 summarizes the ratings for both environmental and non-environmental based criteria.

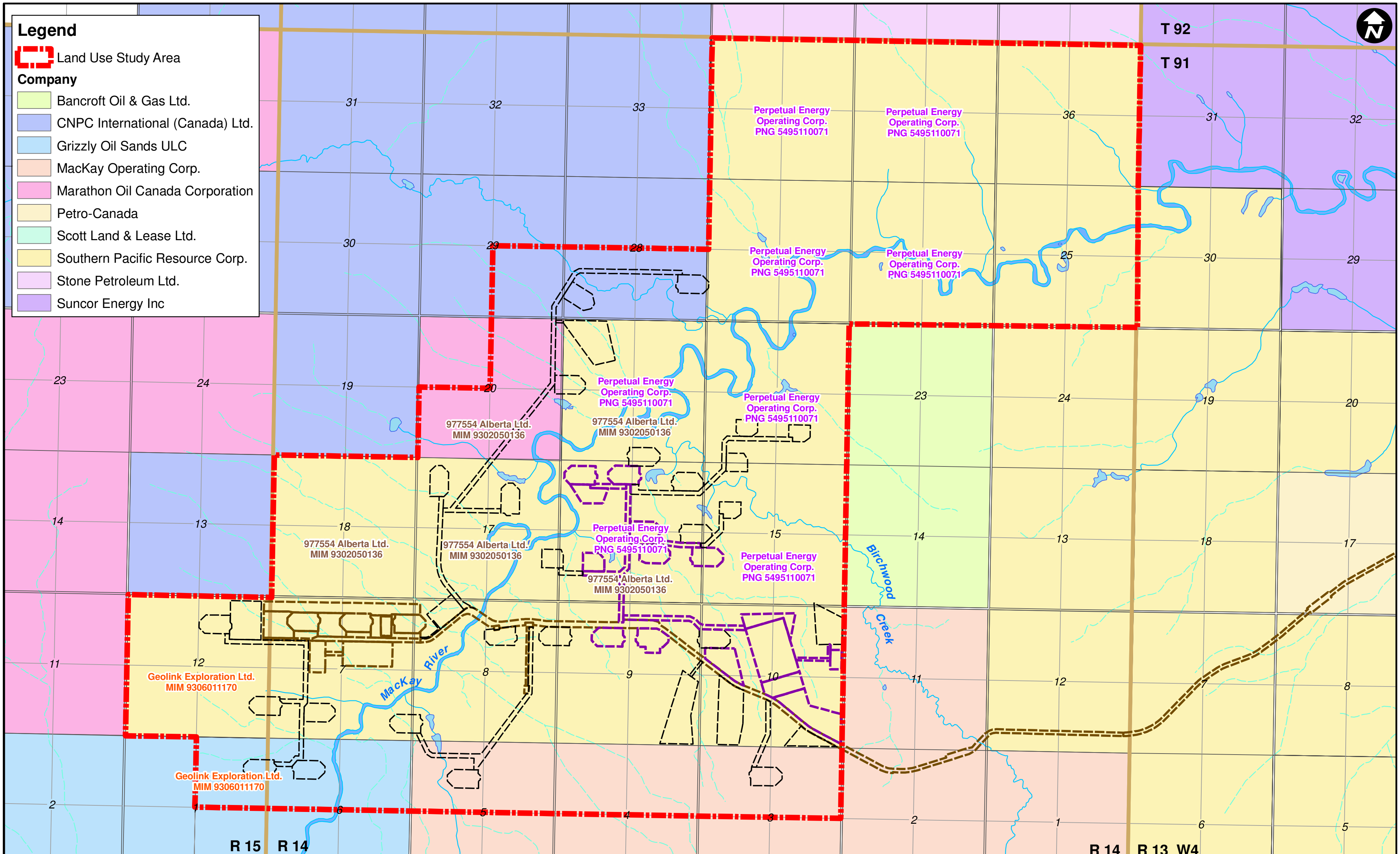
Table D.14.2 Constraints Evaluation STP McKay Thermal Project – Phase 2 Initial Development

Facility Component	Breakdown			Costs			Footprint			Rating	Environmental Constraints (Present or Absent)[1]							
			Bitumen Recovery	Drilling	Construction	Reclamation	Minimize Resource Conflict	Common Corridor	Minimize New Clearing	Total	Hydrology	Surface WQ	Vegetation & Wetlands	Rare Plants	Soils and Terrain	Wildlife	Historical	Mitigation Required
Central Processing Facility	Pad	Proposed	3	0	3	3	3	0	2	**14**	A	A	P	P	A	A	A	N
		Alternate	2	0	3	3	3	0	2	13	A	A	P	P	A	A	A	N
Access Corridor	Corridor	Proposed	0	0	3	3	3	2	2	**13**	P	P	P	A	A	A	A	Y
		Alternate	0	0	3	3	3	2	2	13	P	P	P	A	A	A	A	Y
Well Pad 201	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	P	A	A	A	A	N
		Alternate	1	3	2	2	3	3	3	17	A	A	A	A	A	A	A	N
Well Pad 202	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	P	A	A	A	A	N
		Alternate	1	3	2	2	3	3	3	17	P	P	A	A	A	P	A	Y
Well Pad 203	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	A	A	A	A	A	N
		Alternate	1	3	2	2	3	3	3	17	A	A	A	A	A	A	A	N
Well Pad 204	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	A	A	A	A	P	N
		Alternate	1	3	2	2	3	3	3	17	P	P	A	A	A	A	P	Y
Well Pad 205	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	P	A	A	A	A	N
		Alternate	1	3	2	2	3	3	3	17	P	P	A	A	A	A	A	N
Well Pad 206	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	A	A	A	A	A	N
		Alternate	1	3	2	2	3	3	3	17	A	A	A	A	A	A	A	N

Table D.14.2 Constraints Evaluation STP McKay Thermal Project – Phase 2 Initial Development

Facility Component	Breakdown		Bitumen Recovery	Costs			Footprint			Rating	Environmental Constraints (Present or Absent)(1)							Mitigation Required
				Drilling	Construction	Reclamation	Minimize Resource Conflict	Common Corridor	Minimize New Clearing	Total	Hydrology	Surface WQ	Vegetation & Wetlands	Rare Plants	Soils and Terrain	Wildlife	Historical	
Well Pad 207	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	A	A	A	A	A	N
		Alternate	1	3	2	2	3	3	3	17	A	A	A	A	A	A	A	N
Well Pad 208	Pad	Proposed	3	3	2	2	3	3	3	**19**	A	A	P	A	A	A	A	N
		Alternate	1	3	2	2	3	3	3	17	A	A	P	A	A	A	A	N
Borrow Pit #1	Pit	Proposed	2	0	2	2	3	3	3	**15**	A	A	P	A	A	A	A	N
		Alternate	2	0	1	2	3	3	3	14	A	A	A	A	A	A	A	N
Borrow Pit #2	Pit	Proposed	2	0	2	2	3	3	3	**15**	A	A	A	A	A	A	A	N
		Alternate	2	0	1	2	3	3	3	14	A	A	A	A	A	A	A	N
Borrow Pit #3	Pit	Proposed	2	0	2	2	3	3	3	**15**	A	A	P	A	A	A	A	N
		Alternate	2	0	1	2	3	3	3	14	A	A	A	A	A	A	A	N
Camp	Camp	Proposed	0	0	2	2	3	3	3	**13**	A	A	A	A	A	A	A	N
		Alternate	0	0	2	2	3	3	3	13	A	A	A	A	A	A	A	N
Soil Storage	Storage	Proposed	0	0	2	2	3	3	3	**13**	A	A	P	A	A	A	A	N
		Alternate	0	0	1	2	3	3	3	12	A	A	P	A	A	A	A	N

(1) P – Sensitivity or constraint present A – Sensitivity or constraint absent Y – Mitigation required N – Mitigation not required



Legend

- Existing Phase 1 Development
- Proposed Initial Phase 2 Development
- Proposed Future Development
- Streams with defined channels
- Drainages without defined channels

0 0.6 1.2 2.4
Kilometres

REF: Abacus Datagraphics Ltd., 2011.

PROJECT:

SOUTHERN PACIFIC
RESOURCE CORP.

STP McKay Thermal Project - Phase 2

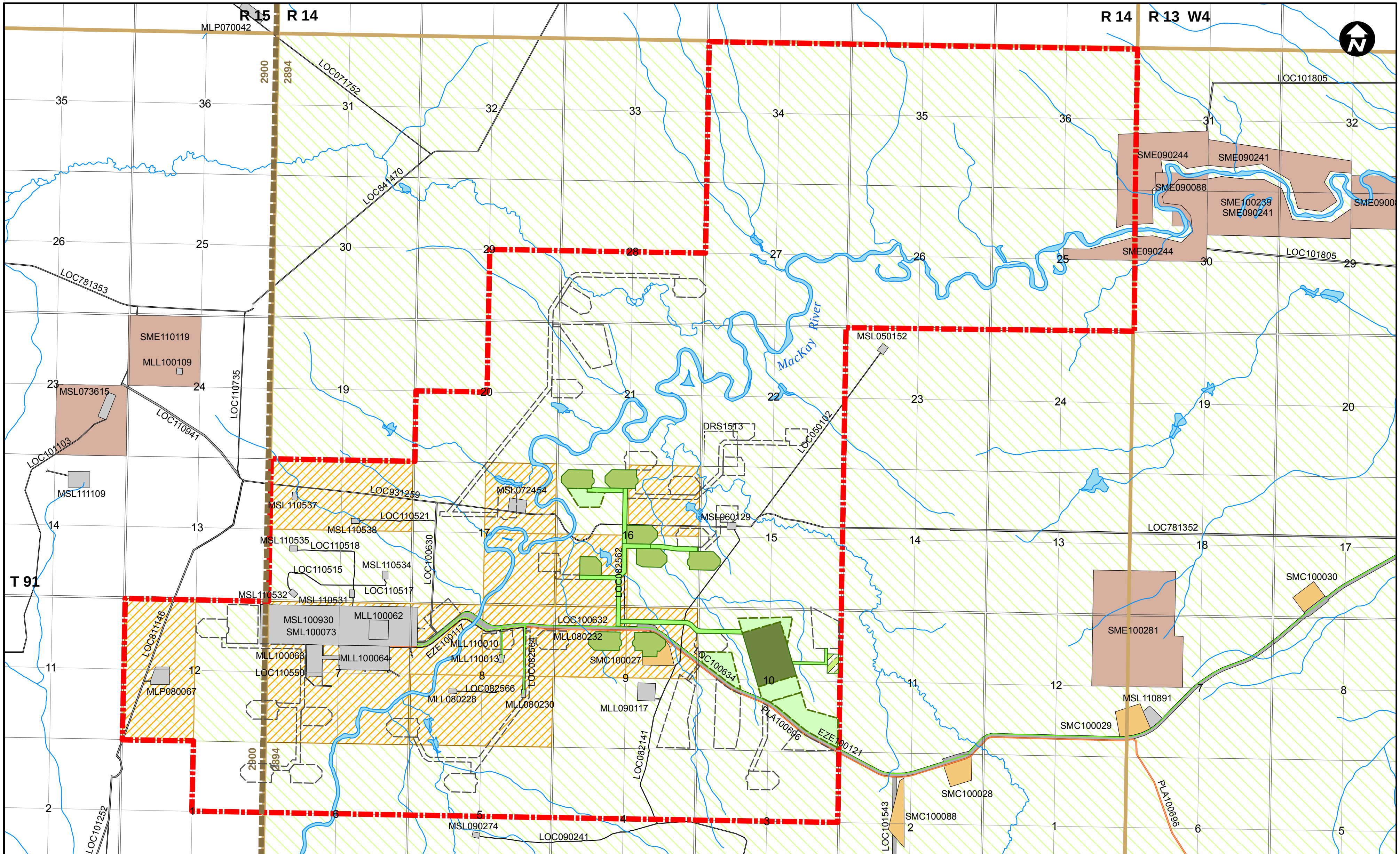
TITLE:

Subsurface Dispositions

DRAWN:	PS
CHECKED:	KY
DATE:	Oct 31/11
PROJECT:	10-037

FIGURE:

D.13.1



Legend

- Land Use Study Area
- Temporary Field Authorizations (TFA)
- Timber Allocations - FMA 910029
- Trapline
- Future Development

REF: David Loucks Consulting Drifter Projects Ltd., 2011; AltaLIS, 2011.

Proposed Phase 2 Development

- CPF
- Operations Camp
- Utility Corridor
- Well Pad
- Borrow Pit

0 0.6 1.2 2.4
Kilometers

PROJECT:

SOUTHERN PACIFIC
RESOURCE CORP.

STP McKay Thermal Project - Phase 2

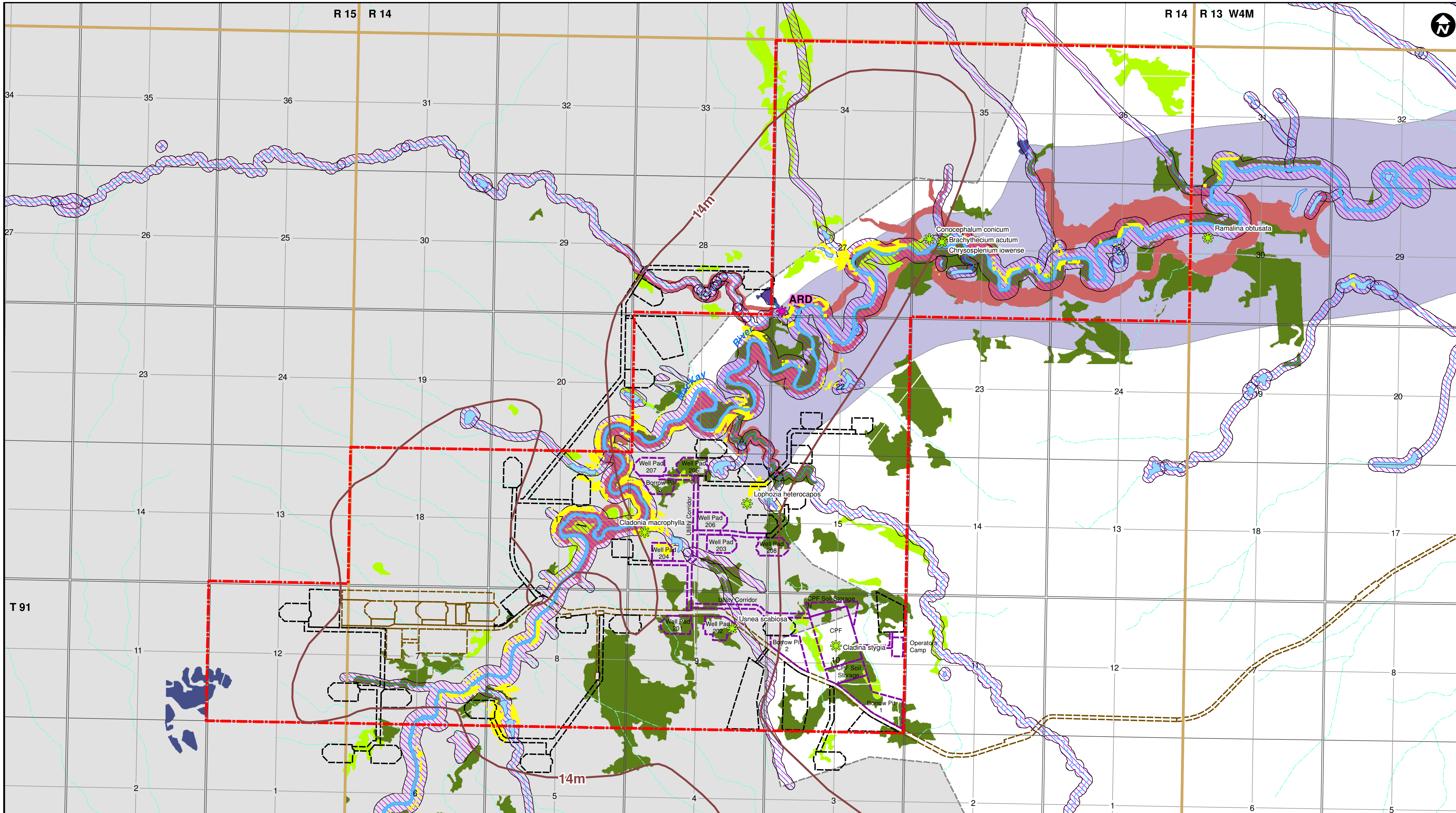
TITLE:

Surface Dispositions

DRAWN:	JG/PS
CHECKED:	FC
DATE:	Oct 30/11
PROJECT:	10-037

FIGURE:

D.13.2



Legend

- Proposed Project Area
- Existing Phase 1 Development
- Proposed Initial Phase 2 Development
- Proposed Future Development
- Streams with defined channels
- Drainages without defined channels
- Net Bitumen Pay (14m)

Constraints

- Rare Plant Location
- Rare Plant Community Location
- Ecosites of Limited Distribution
- Wetlands of Limited Distribution
- Caribou Zone
- Moose Zone
- Sensitive Soil with Steep Slopes
- Hydrology Buffer (50m)
- Moderate to High Archaeological Potential

0 0.5 1 2
Kilometres

REF:David Loucks Consulting Drifter Projects Ltd., 2011; NHC (Hydrology) 2011.

SOUTHERN PACIFIC
RESOURCE CORP.

STP McKay Thermal Project - Phase 2

TITLE:
Constraints Map

DRAWN:	PS
CHECKED:	KY
DATE:	Oct 31/11
PROJECT:	10-037

FIGURE:
D.14.1